Evolution of the International Monetary System from the Perspective of Trilemma Challenges [1]

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Abstract:
The paper develops a new set of indexes of exchange rate stability, financial market openness, and monetary policy independence for examining the issue of trilemma in international finance. More than one hundred sample economies are located in the trilemma triangle over time—a useful way to illustrate the state and evolution of trilemma combinations. An important byproduct of using the Frankel-Wei (1994) and Kawai-Pontines (2016) methods to obtain the index of exchange rate stability, which is the root mean square error (RMSE) of regressions, is that they allow the identification of anchor currencies and their importance 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 USD zone, still the largest in the world, has declined over time due to the emergence of the EUR zone and the recent rapid rise of the RMB zone. At the same time, the share of the world economy adopting exchange rate floating has expanded in size over time. Second, from the trilemma perspective, both advanced and emerging & developing economies have generally moved toward greater exchange rate flexibility and financial market openness, with some exceptions. Today, the number of countries adopting the "corner regime" of maintaining open financial markets and independent monetary policy with freely flexible exchange rates is rising among both advanced and emerging & developing countries. On the other hand, no advanced economy adopts another “corner regime” of high degrees of exchange rate stability and monetary policy independence with a closed financial market. Very few emerging & developing economies adopt the third “corner regime” of high degrees of exchange rate stability and financial market openness without monetary policy independence, while a group of advanced countries in Euro Area have adopted this corner. Most countries choose combinations outside of these three corners. Third, there is no single trilemma regime that delivers the best macroeconomic outcome for both advanced and emerging & developing economies.

Keywords: Exchange rate arrangement, trilemma in international finance, exchange rate stability, financial market openness, monetary policy independence, trilemma regime, macroeconomic performance

JEL codes: F 15, F 21, F31, F36, F41, O24

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1. Introduction

In an open economy, each country is considered to pursue stable and low-inflationary economic growth by choosing the best combination of international monetary arrangements, i.e., the degrees of monetary policy independence, financial market account openness, and exchange rate stability. This is the basic idea behind the principle of Robert Mundell's "impossible trilemma of international finance" (Mundell, 1963), which states that policymakers can choose among independent (or autonomous) monetary policy, perfect capital mobility, and stable exchange rates, but not all three at the same time.

Using this principle, one can explain 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 countries fixing their currencies to gold (thus making exchange rates stable) and allowing free cross-border movement of gold (thus maintaining free capital mobility), while abandoning independent monetary policy. The Bretton Woods system from 1945 to 1971 can be characterized by individual countries pegging their currencies to the U.S. dollar and restricting cross-border capital mobility, thereby retaining monetary policy independence. 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 countries allowing exchange rates to be determined by supply and demand in the currency markets, allowing cross-border capital flows and yet retaining monetary policy independence.

Based on the trilemma principle, one may numerically express each country's choice of international monetary arrangements by measuring the degrees of exchange rate stability, financial market openness, and monetary policy independence, and explain the evolution of the international monetary system over time. This paper attempts to do this for the last 50 years from 1970 to 2020. Several authors, such as Aizenman, Chinn, and Ito (2010, 2013) and Ito and Kawai (2014), have indeed attempted to quantify the trilemma variables. This paper constructs a new set of trilemma indexes, i.e., those for exchange rate stability, financial market openness, and monetary policy independence, and presents visually the evolution of the international monetary arrangements by plotting trilemma combinations in triangles over time.

This paper has three new values-added over the previous authors' attempts to construct such indexes and analyze the trilemma principle. First, it has extended the dataset to the most recent period for which data are available to allow analysis of the last 50 years. Second, it has constructed a new measure of exchange rate stability by considering the impact of the Chinese

yuan on various currencies' exchange rates. Third, it examines the evolution of the international monetary system graphically for groups of countries classified by income level (high-, middle- and low-income countries) and geographical region (East Asia and the Pacific, Europe and Central Asia, Latin America and the Caribbean, Middle East and North Africa, South Asia, and Sub-Saharan Africa). (Fourth, it divides trilemma combinations into 10 types, obtains key macroeconomic variables (such as the inflation rate, inflation rate volatility, GDP growth rate, and GDP growth rate volatility) for each type, and explores the macroeconomic characteristics of each.)

The index of exchange rate stability is measured by the root mean square error (RMSE) obtained from Frankel and Wei (1994) or modified Frankel-Wei regressions. RMSE has been proposed by Bleaney and Tian (2020) as a measure of exchange rate stability or flexibility. The modified Frankel-Wei regression is the one developed by Kawai and Pontines (2018) to consider the rising importance of the Chinese yuan, in addition to the traditional reserve currencies (i.e., the U.S. dollar, euro, U.K. pound and Japanese yen) in the currency baskets of various countries. As in the case of Ito and Kawai (2014), the index for monetary policy independence is measured by the degree to which each country's policy interest rate is explained by the Taylor rule or by the foreign interest rate (which is constructed by the estimated coefficients obtained from the Frankel-Wei or Kawai-Pontines regressions). The index for financial market openness is measured by the external assets and liabilities of individual countries, obtained from Lane and Milesi-Ferretti (2000, 2007, 2017), and adjusted for GDP and trade, rather than by legal and regulatory perspectives.

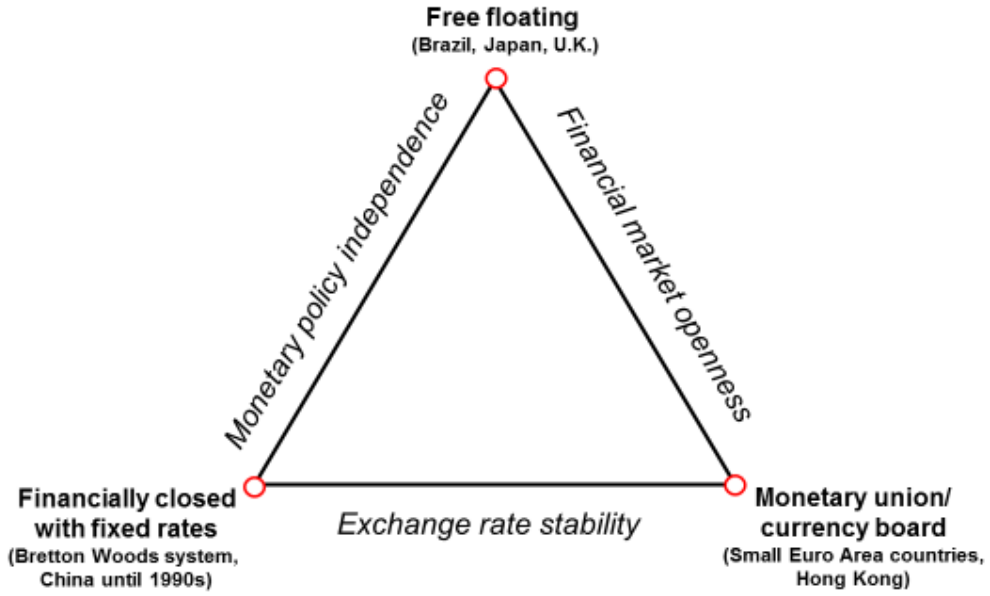
The paper is organized as follows. Section 2 briefly explains the trilemma principle, its significance for the international monetary system, and ways of constructing the trilemma indexes. Section 3 discusses the evolution of exchange rate regimes by identifying major anchor currencies for different countries in the global map and computing the size of major currency zones for the world as a whole and by region. Section 4 examines the evolution of the trilemma configurations by reviewing the trilemma indexes over time, analyzing the trilemma combinations of advanced and emerging & developing economies in the trilemma triangles, and charting the trilemma configurations of individual countries in the global map over time. Section 5 assesses the macroeconomic performance of different trilemma regimes by considering three corner regimes, six non-corner regimes, and the "middle convergence" that keeps the middle of all indexes. Section 6 concludes the paper.

2. The Trilemma in International Finance

2.1 Importance of the trilemma concept in international finance

Different countries have pursued different open macroeconomic policy goals. Configuring policy choices is never an easy task. However, complicated policy combinations can be captured 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 three policy goals – exchange rate stability, financial market openness and monetary policy independence.

Figure 1: Trilemma triangle



Source: Compiled by authors.

Since the time of the Gold Standard, different international monetary systems have attempted to achieve different combinations of two out of the three policy goals. In other words, history is full of "corner solutions." The Bretton Woods system sacrificed international capital mobility for monetary policy independence and exchange rate stability. The euro system is built upon the fixed exchange rate arrangement and free capital mobility, but essentially abandoned monetary policy independence of the small member countries.

Countries do not always have to adopt corner solutions. For example, a country can implement a combination to achieve one particular side without achieving any of the remaining two, in which case one of the policy frameworks is fully adopted and the other two are achieved only partially. Or a country can implement a combination of policy frameworks represented by a

"dot" inside the triangle.[2]

A high degree of monetary policy independence could help stabilize the economy against shocks, allowing monetary authorities to smooth inflation and output movements (at least in the short run in a world with price and wage rigidities), to play a lender of last resort function in the event of a banking sector crisis, or to monetize fiscal debt. Exchange rate stability could provide a nominal anchor or help increase the credibility of monetary authorities particularly when their non-inflationary credibility is low, thereby contributing to more stable output movement (Aizenman et al. 2012a). However, greater levels of exchange rate stability could also rid monetary authorities of a policy choice of using the exchange rate as a tool to absorb external shocks.[3] Financial liberalization can also have merits and demerits. Theoretically, a more open financial market should lead to more efficient resource allocation and more efficient risk sharing. However, it also becomes a destabilizing factor by exposing an economy more to volatile international capital flows and thereby externally driven boom-bust cycles.

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

2.2 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 policies simultaneously, because of the lack of metrics that systematically reflect the degree of implementation of the three policy frameworks.

To examine the development of international monetary arrangements of individual countries, Aizenman, Chinn, and Ito (2013) and Ito and Kawai (2014) developed a metrics of trilemma indexes, separately. Each set of the indexes has its own strengths and limitations.[4]

This paper joins these efforts of further developing and improving metrics to depict open macroeconomic policy arrangements based on the trilemma indexes by taking an approach

[2] See Ito and Kawai (2012) for details.
[3] 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.
[4] On the comparisons of these indexes, refer to Ito and Kawai (2012).

similar to Ito and Kawai (2014). Naturally, while there are no such things as perfect measures of the three indexes, the paper attempts to overcome the drawbacks of the previous indexes. Here, while relying on the methodologies introduced in the past literature and implementing theoretically reasonable methods, the paper attempts to create a set of indexes that may capture more subtleties of the aspects of the three policies in the trilemma hypothesis.

Broadly, starting from the set of the trilemma indexed developed by Ito and Kawai (2012 and 2014), the paper further refines such indexes by making major modifications to the measure of exchange rate stability, which also affects the way the degree of monetary independence is measured. The first modification made in measuring exchange rate stability is to adopt the root mean square error (RMSE) obtained from the Frankel and Wei (1994) 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. The second modification is to introduce the Kawai and Pontines (2016) method for the period when the RMB is considered to play an anchor currency role, for which the Frankel-Wei method does not deliver meaningful results.

More specifically, the degree of exchange rate stability is obtained by observing how tightly a country'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, GBP, and JPY. Currencies under a fixed exchange rate regime are expected to achieve a high level of exchange rate stability against an anchor currency (or a basket of anchor currencies), while currencies under a freely flexible exchange rate regime show a low level of exchange rate stability. To measure the tightness or looseness of the relationship between a country's exchange rates against the basket of major currencies, the root mean square error (RMSE) is obtained from the rolling regressions of the movement of the home currency on those of major international currencies.

In observing the tightness or looseness a country's exchange rate movement with the movements of major currency exchange rates, the Frankel-Wei method is employed for the period when the RMB was not considered as a major anchor currency. However, for the period when the RMB is judged to play a role of an anchor currency, the Kawai-Pontines method is used. The reason is that the movement of the RMB is closely associated with the movement of the US dollar, and the usual Frankel-Wei method involves severe multicollinearity problem if the RMB is included on the right-hand side of the Frankel-Wei regression. The Kawai-Pontines method addresses the multicollinearity problem and yields superior and more stable and robust estimates on US dollar and RMB weights in an economy's implicit currency basket

than the traditional Frankel–Wei method.[5] Appendix I provides detailed explanations of the Kawai–Pontines method as well as the more nuanced, improved ways of obtaining the trilemma indexes.

Financial market openness refers to the degree to which a country has liberalized capital account transactions and allowed free cross-border mobility of capital. Countries with a high level of financial market openness naturally hold large amounts of external assets and liabilities, and vice versa. As in the case of Ito and Kawai (2014), the degree of financial market openness 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 financial market openness, rather than a de jure measure such as the one developed by Chinn and Ito (2008).

Monetary policy independence means monetary authorities' ability to set policy instruments to pursue their policy objectives such as low inflation and stable economic growth. Countries a high degree of monetary policy independence can freely set monetary policy instruments (such as the short-term interest rate) to pursue stable economic growth at low and stable inflation, while countries with a low degree of monetary policy independence cannot do so—because of the adoption of a fixed exchange rate regime under free mobility of capital.

In constructing the index for monetary policy independence, this paper runs several regressions to explain the short-term interest rate and compares the extent to which domestic short-term interest rates are explained by domestic factors (the GDP gap, the inflation rate, etc.) and the extent to which they are explained by foreign interest rates. The paper assumes that the higher the degree of the former, the higher the degree of monetary policy independence, and vice versa. In other words, countries with high degrees of monetary policy independence are judged to set their policy interest rates with the aim of stabilizing their own economies using a method similar to the Taylor rule, while countries with low degrees of monetary policy independence set policy interest rates in a way linked to foreign interest rates. 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 monetary policy independence is provided in Appendix I, which compares multiple regressions that explain short-term interest rates and obtains a measure according to their relative explanatory

[5] With both the yuan and US dollar included on the right-hand side of the estimating equation, the traditional Frankel–Wei method faces the problem of severe multicollinearity as the yuan is managed heavily in relation to the dollar, and thus cannot provide stable and robust estimates for these currencies. In such a case the Kawai-Pontines method is more appropriate as it addresses the multicollinearity problem and yields estimates that are superior to, and more robust than, those obtained by the Frankel–Wei method.

power.

The pursuit of more nuanced approaches, however, comes at the expense of a smaller coverage of countries. The indexes are available for about 100 countries for the period 1970 to 2021. Appendix II lists these countries and periods for which data are available.

3. Evolution of the Exchange Rate Regime

One of the most useful byproducts of running the Frankel-Wei and Kawai-Pontines regressions is that they provide information on exchange rate regimes—including information on anchor currencies and measures of exchange rate stability or flexibility—for each country and overtime where data are available. Using this information, this section discusses the evolution of exchange rate regimes by identifying major anchor currencies for different countries and computing the size of the major currency zones for the world as a whole and by region over the last half century.

3.1 Mapping anchor currencies since 1970

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. The results include the estimated coefficients on the USD, EUR, GBP, JPY and RMB, standard errors, p-values and the root mean squared error (RMSE) of the regression. Each regressions is based on monthly observations with a 36-month window. The degree of exchange rate stability or flexibility is identified by the RMSE value as proposed by Bleaney and Tian (2020). A smaller value for RMSE means a higher explanatory power for the regression, a higher extent to which the target country's exchange rate is linked to the major anchor currency (or a basket of major currencies), and thus a higher degree of exchange rate stability, while a larger value for RMSE means a lower degree of exchange rate stability (or a higher degree of exchange rate flexibility). More specifically, foreign exchange regimes 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 $\geqq 0.03$.[6]

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

[6] 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.

estimated coefficients on anchor currencies but also the values of the RMSE and the exchange rate stability (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).[7]

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

Country	Year	USD		EUR		GBP		JPY		RMB		RMSE	ERS	FX 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

ERS = exchange rate stability; EUR = Euro; GBP = British pound; JPN = Japanese yen; RMB = Chinese 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 pegging or managing 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 1961-80, to managed, flexible, or highly flexible rate

[7] See Appendix I for detailed explanations.

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 anchor, followed by the EUR (or DEM before 2000) and then by 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 exchange rate anchor for many countries, including BRICS countries, since 2000, often in the context of flexible and highly flexible rate regimes.

Figure 2 provides snapshots on the evolution of exchange rate regimes over the past 50 years by focusing on anchor currencies and the degrees of exchange rate stability (or flexibility) for individual countries in the world.[8] Each country in the world map is colored based on the anchor currency with the statistically significant, highest estimated weight among the major currencies. The U.S. dollar is shown in blue, the euro in green, the British pound in orange, the Japanese yen in yellow, and the Chinese RMB in red. For example, in the 1975 world map, a number of countries (including Canada, Colombia, Indonesia, Mexico, Nigeria, and Thailand) are colored in dark blue because the estimated US dollar weight is the highest and the level of the RMSE is small (or the ERS index is large).

In the map, each color is tinted according to the level of the RMSE, which is categorized into three ranges of goodness of fit. A country with a small RMSE (or a high degree of exchange rate stability) is represented in a dark color, while a country with a large RMSE (or a low degree of exchange rate stability) is shown in a light color. More concretely, when the RMSE of the estimation for a certain country in a particular year is less than 0.01, the country is considered as having a high level of goodness of fit, i.e., a high degree of exchange rate stability, and thereby be painted with the darkest color.[9] The RMSE greater than 0.02 would be categorized as a low-level goodness of fit, i.e., a low degree of exchange rate stability (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 middle level. Accordingly, countries like Brazil, China, and Egypt are colored in lighter blue, while countries like Australia, Indonesia, and South Africa are colored in the lightest blue.

Painting each country with a different color density increases the nuance of the analysis. Many

[8] The 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.

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

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), and others apply the Frankel-Wei and/or Kawai-Pontines method to illustrate the development of the "RMB zone." However, they do not pay attention to the implications of the explanatory power of the estimating equation, measured by such statistics as the RMSE.

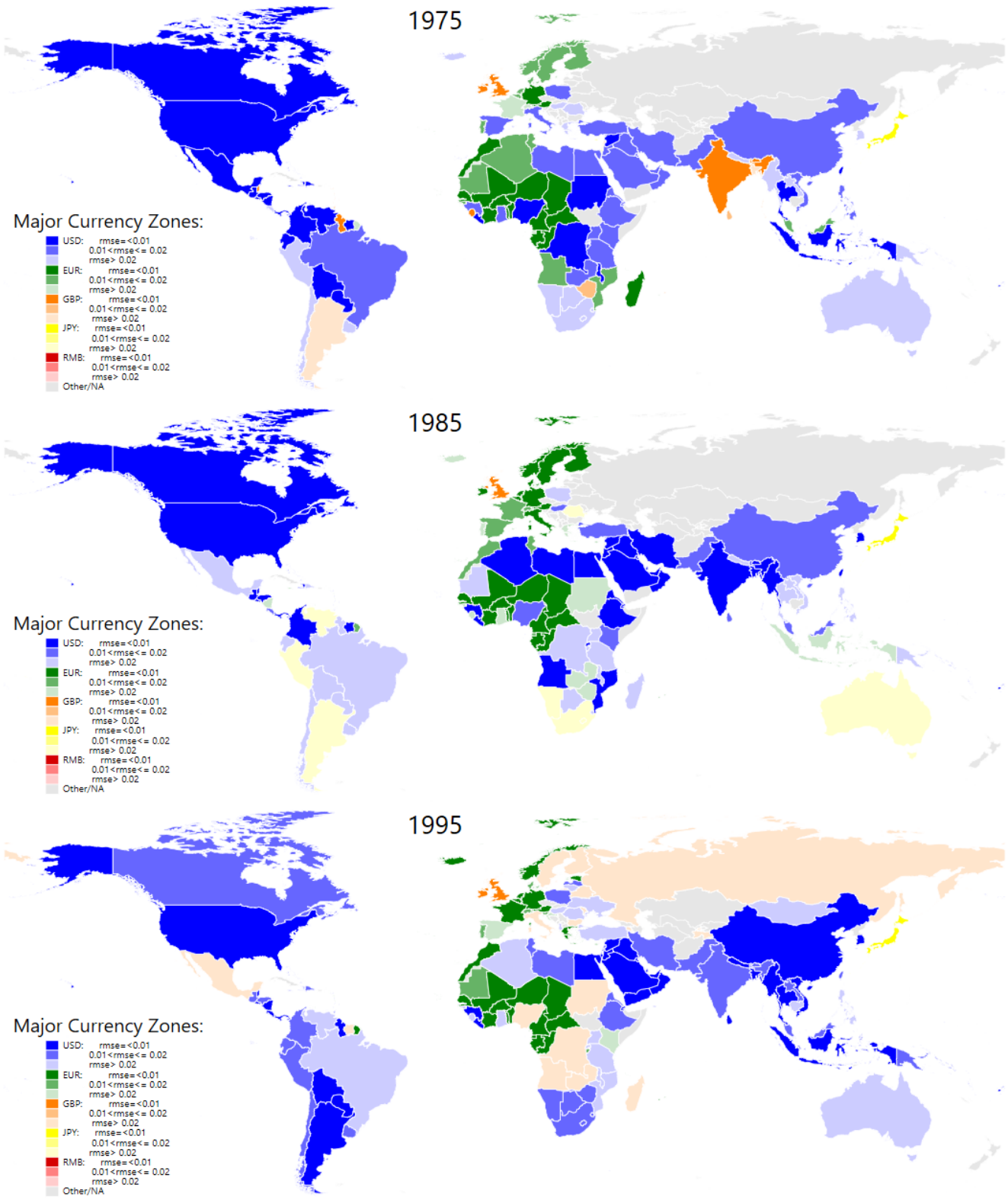
Figure 2 reveals several interesting observations. First of all, the USD has been the most dominant anchor currency in the last five decades. In the aftermath of the collapse of the Bretton Woods system in 1973, major advanced countries have shifted to flexible exchange rate regimes, but many emerging & 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 in the early years) solidified its hold in Western Europe and spread eastward in the 1990s and 2000s. Countries 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. Their sphere of influence is not comparable to that of the USD. This is consistent with what is suggested by other measures of the use of major currencies, such as the shares in trade invoicing, and international debt issuance, 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 euro is around 20%.

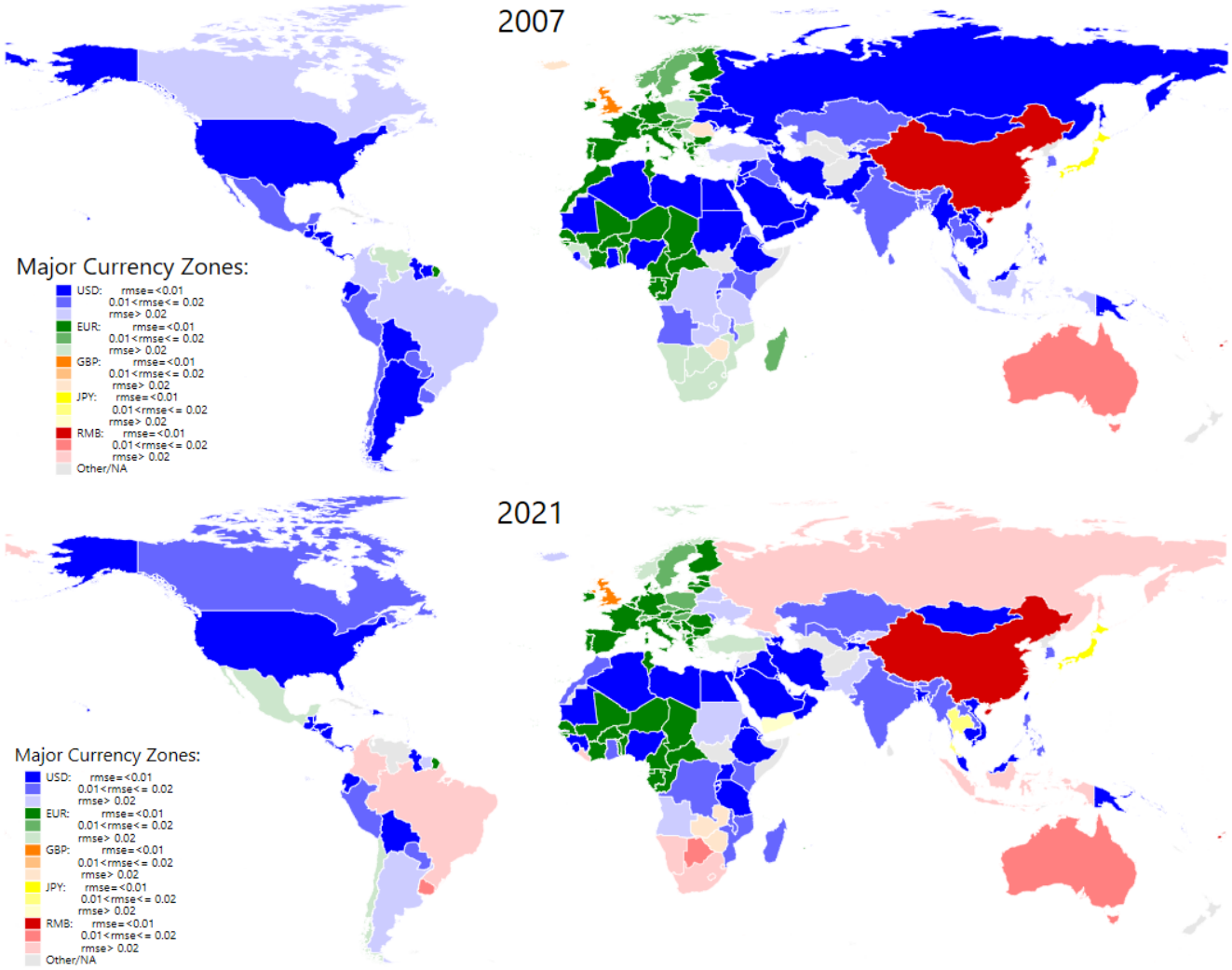
Third, the number of countries that use the U.K. pound and/or the Japanese yen as anchor currency have been limited in the last five decades. By the mid-1970s, the number of countries that stabilize exchange rates against mainly the U.K. pound has diminished (Schenk [2010], Schenk and Singleton [2015]). As of 1975, only Guyana, India, Ireland and Sierra Leone appeared to assign the highest weight to the U.K. pound among major currencies. As of 2021, there is virtually no country that does the same thing.

Figure 2: Evolution of the major currency zones

2A: Estimated currency zones based on the Frankel-Wei method: 1975, 1985, and 1995



2B: Estimated currency zones based on the Kawai-Pontines method: 2007 and 2021



Source: Compiled by authors from their estimations.

The Japanese yen does not have its own sphere of influence either. In 1985 when the Japanese economy was in its heyday, close to thirty countries (including Iran, Myanmar, Romania, Samoa, Singapore and Sweden) stabilized their currencies at least partially against the Japanese yen. Especially in Romania, Samoa, and Singapore, the yen had the highest weights as anchor among the major currencies. Since then the anchor currency role of the yen has declined, and about 20 countries and 7 countries used the yen as a partial anchor in 2020 and 2021, respectively. One interesting point is that, in Thailand in 2021, the estimated weight of the yen (0.410) barely exceeded that of the RMB (0.406) and the country 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 yen and RMB are very close to each other and it may be 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 countries that belong to the RMB zone. Recently, many researchers identify 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 countries (including Australia, Botswana, Brazil, Colombia, Indonesia, Russia, and Uruguay) are identified as assigning the highest weights to the RMB as anchor among the major currencies. However, the RMSEs of these economies are high so that their currencies are judged to be not 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.

3.2 Evolution of the economic size of major currency zones for the world as a whole

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 RMSE estimated by Frankel-Wei or Kawai-Pontines regressions. The calculation procedures adopted here are basically the same as those of Kawai and Akiyama (1998),[10] but a new innovation beyond them is introduced. First, each of the major currency countries or region (i.e., the United States, Euro Area, the United Kingdom, Japan, and 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 is assumed to play a possible major anchor currency role from 1999. Second, if any other country 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. Third, if a country stabilizes its exchange rate against a basket of major currencies, its economy is divided according to the estimated currency weights and distributed to the corresponding currency zones. The coefficients which are estimated to be positive and statistically significant, at least at the 10% level, are interpreted as the weights assigned to the corresponding major currencies.[11]

A new innovation adopted here, beyond the Kawai-Akiyama procedures, is that if a country tightly or loosely stabilizes its exchange rate against a major currency or a currency basket,

[10] At the time of the 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.

the degree of exchange rate stability or flexibility is taken into account in calculating the size of currency zones (see later for more detail). Accordingly, if a country does not stabilize its exchange rate against any major currency or currency basket and is judged to adopt a highly flexible exchange rate regime, its economy is considered not to belong to any currency zone. Even if a country assigns a statistically significant positive weight to a single major currency or a basket of major currencies, the regression equation may have a very low degree of exchange rate stability (with a very large RMSE) and the country may be judged as having a highly flexible exchange rate regime. In such a case, the country may be considered a floating zone without belonging to any currency zone.

Table 2 reports the estimated size of major currency zones in the world as % shares of world GDP. The world is comprised of 150-172 countries depending on the year. Table 2A shows results when the degree (i.e., “tightness” or “looseness”) of exchange rate stability 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 countries, which is the aggregated value across all non-major currency countries.

The difference between Tables 2A and 2B lies in the calculation of currency zones formed by other (i.e., non-major currency) countries as well as residuals. In Table 2A, the size of a major currency zone formed by other non-major currency countries is obtained by dividing each country into the five currency zones and the residual according to the estimated weights on major currencies, regardless of the degree of exchange rate stability, and aggregating these values across all non-major currency countries. A residual for each country is that part of the country not belonging to any currency zone.

In Table 2B, the size of a zone formed by other non-major currency countries is obtained by considering the degree of exchange rate stability. More specifically, the estimated currency weights themselves are used when the degree of exchange rate stability is high (with the value of RMSE less than 0.01); the estimated weights times two thirds (2/3) are used when the degree of rate stability is intermediate (with RMSE between 0.01 and 0.02); the estimated weights times one third (1/3) are used when the degree of rate stability is low (with RMSE between 0.02 and 0.03); and zero weights are used when the degree of exchange rate stability is very low (with RMSE greater than 0.3). So countries that adopt highly flexible rate regimes are considered not to belong to any major currency zone even when they assign positive, statistically significant weights to particular major currencies. This procedure is arbitrary, but is one way to capture the different degrees of exchange rate stability in calculating the size of currency zones.

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

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

Year	World GDP		USD zone			EUR zone			GBP zone			JPY zone			RMB zone			Residual
	USD Bill	%	Total	United States	Other	Total	Euro Area	Other	Total	United Kingdom	Other	Total	Japan	Other	Total	China	Other	
1961	1,252	100.0	71.8	45.0	26.8	7.9	6.8	1.2	14.2	6.2	8.0	4.3	4.3	0.0	--	--	--	1.7
1970	2,740	100.0	68.1	39.2	28.9	8.3	7.9	0.4	9.5	4.8	4.8	7.9	7.8	0.1	--	--	--	6.2
1980	10,790	100.0	51.4	26.5	24.9	26.0	11.4	14.6	8.6	5.2	3.3	12.0	10.2	1.7	--	--	--	2.1
1990	21,589	100.0	45.8	27.6	18.2	27.5	10.5	17.0	8.4	5.1	3.3	15.9	14.5	1.4	--	--	--	2.4
2000	33,002	100.0	44.6	31.1	13.5	22.9	19.0	3.9	5.6	5.0	0.5	15.3	15.1	0.3	6.7	3.7	3.1	4.9
2010	64,860	100.0	37.4	23.2	14.2	26.8	19.4	7.5	7.0	3.8	3.1	9.4	8.9	0.5	13.2	9.4	3.8	6.2
2020	82,989	100.0	38.3	25.2	13.1	21.1	15.7	5.4	4.2	3.3	0.9	6.4	6.1	0.3	25.6	17.7	7.9	4.4
2021	93,356	100.0	37.8	24.6	13.2	20.8	15.5	5.3	4.4	3.4	1.0	5.8	5.3	0.5	27.6	19.0	8.6	3.5

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

Year	World GDP		USD zone			EUR zone			GBP zone			JPY zone			RMB zone			Residual
	USD Bill	%	Total	United States	Other	Total	Euro Area	Other	Total	United Kingdom	Other	Total	Japan	Other	Total	China	Other	
1961	1,252	100.0	71.8	45.0	26.8	7.9	6.8	1.2	14.2	6.2	8.0	4.3	4.3	0.0	--	--	--	1.7
1970	2,740	100.0	68.1	39.2	28.9	8.3	7.9	0.4	9.5	4.8	4.8	7.9	7.8	0.1	--	--	--	6.2
1980	10,790	100.0	47.6	26.5	21.1	22.9	11.4	11.5	7.8	5.2	2.6	11.6	10.2	1.3	--	--	--	10.1
1990	21,589	100.0	41.0	27.6	13.4	25.8	10.5	15.4	8.2	5.1	3.1	14.8	14.5	0.3	--	--	--	10.3
2000	33,002	100.0	40.1	31.1	9.1	22.2	19.0	3.2	5.5	5.0	0.5	15.3	15.1	0.2	5.3	3.7	1.6	11.7
2010	64,860	100.0	30.5	23.2	7.3	22.4	19.4	3.0	4.5	3.8	0.7	9.1	8.9	0.2	10.1	9.4	0.8	23.3
2020	82,989	100.0	35.4	25.2	10.2	19.0	15.7	3.3	4.0	3.3	0.7	6.3	6.1	0.2	20.4	17.7	2.7	14.9
2021	93,356	100.0	35.5	24.6	10.9	18.9	15.5	3.4	4.1	3.4	0.7	5.6	5.3	0.3	22.3	19.0	3.3	13.6

EUR = Euro; GBP = British pound; JPN = Japanese yen; RMB = Chinese renminbi; RMSE = root mean square error; USD = U.S. dollar.
Note: Each currency zone includes the major currency country (or area) itself and other countries that assign a positive, statistically significant coefficient at the 10% level to that currency. EUR refers to DEM (Deutschemark) in 1961-1990, and Euro Area refers to Germany in 1961-1970 and Austria, Germany and Netherlands in 1980-1990, 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 country during 1961-1998. Residual is the part that cannot be explained by the identified currency weights and hence can be considered as a floating regime zone.
Source: Compiled by authors from their estimations.

Tables 2A and 2B provide the same message qualitatively, but there are some quantitative differences. The quantitative difference is that the economic size of major currency areas formed by other countries 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 Table 2B, which calculates the size of major currency zones by adjusting for the degree of exchange rate stability, delivers the result that the size of major currency zones becomes smaller than in the case of Table 2A, as the degree of exchange rate stability tends to decrease over time. This means that the residual which does not belong to any currency zone, shown in Table 2B, becomes larger than in Table 2A.

By focusing on Table 2B for interpretation of the results, one can observe several points. 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 since then to 35% in 2020-2021. The reason is that both the shares of the U.S. economy and other USD-zone countries in the world have declined. Second, the global share of the EUR zone (the DEM zone in early years) rose from 1961 to 1990, reaching 26%, as the share of other EUR-zone countries rose, but has gradually declined to 19% in 2020-2021 because the relative shares of both the Euro Area and other EUR-zone countries have decreased. Third, the share of the GBP zone, which was 14% in 1961, has declined as a trend overtime, 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 the continuous shrinkage of the share of the Japanese economy. The share of other JPY-zone countries, 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 2020-21, because of the sustained expansion of the Chinese economy and other RMB-zone countries. The RMB zone is now the second largest economy 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 2% in 1961 to 23% in 2010 and has maintained since then the close to 15% level 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 1999) expanded until around 1990 (and then began to decrease), the share of the yen 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 countries' GDP, well above the shares of the EUR and RMB zones (both 3%). In addition, the global economic share of a

zone that does not belong to any major currency zone and adopts a free floating regime expanded rapidly until 2010, has since declined slightly, but has remained high at 14% in recent years.

3.3 Evolution of the size of major currency zones by region

This subsection compares and examines the size of major currency zones for 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 adjusting for the degree of exchange rate stability. Information in this table differs from that in Table 2, as the table does not include major currency countries or region (i.e., the U.S., Euro Area, the U.K., Japan, and China).[12] In other words, the major currency zones in this table refer only to those formed by non-major currency countries.

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

3A. All non-major currency countries, including China during 1961-1990

	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	473	100.0	71.1	3.0	21.3	0.1	--	4.5	100.0	71.1	3.0	21.3	0.1	--	4.5
1970	1,108	100.0	71.6	1.1	11.8	0.3	--	15.2	100.0	71.6	1.1	11.8	0.3	--	15.2
1980	5,035	100.0	53.4	31.3	7.1	3.7	--	4.5	100.0	45.2	24.7	5.6	2.8	--	21.6
1990	9,143	100.0	43.0	40.2	7.9	3.3	--	5.6	100.0	31.5	36.3	7.3	0.6	--	24.3
2000	8,633	100.0	51.6	14.9	2.1	1.1	11.7	18.6	100.0	34.7	12.1	1.7	0.8	6.1	44.5
2010	22,913	100.0	40.1	21.1	8.9	1.4	10.9	17.5	100.0	20.7	8.6	1.9	0.6	2.2	66.0
2020	26,583	100.0	41.0	16.9	2.9	1.0	24.6	13.6	100.0	31.8	10.4	2.1	0.7	8.5	46.5
2021	30,008	100.0	41.1	16.3	3.2	1.7	26.8	10.9	100.0	33.9	10.5	2.2	1.1	10.2	42.2

3B. Advanced economies, excluding the US, the UK, Euro Area, 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	276	100.0	71.6	5.2	18.6	0.0	--	4.6	100.0	71.6	5.2	18.6	0.0	--	4.6
1970	625	100.0	75.8	0.5	8.2	0.0	--	15.5	100.0	75.8	0.5	8.2	0.0	--	15.5
1980	2,648	100.0	28.3	52.0	7.7	6.1	--	6.0	100.0	22.3	39.6	6.5	4.6	--	27.0
1990	5,619	100.0	25.7	59.7	10.6	0.1	--	3.9	100.0	18.1	55.0	9.7	0.1	--	17.1
2000	3,060	100.0	38.5	28.5	2.9	0.7	18.8	10.6	100.0	27.2	24.7	2.0	0.7	12.4	33.1
2010	6,068	100.0	23.5	34.1	18.3	2.5	8.7	12.8	100.0	8.5	15.9	2.4	0.8	3.1	69.2
2020	7,020	100.0	30.4	24.6	8.5	3.8	22.5	10.3	100.0	25.4	16.6	5.9	2.6	15.3	34.3
2021	8,184	100.0	28.1	20.3	8.1	3.0	27.9	12.6	100.0	23.8	15.1	5.6	2.0	18.4	35.1

3C. Emerging market and developing economies, including China during 1961-1990

	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	196	100.0	70.4	0.0	25.0	0.3	--	4.3	100.0	70.4	0.0	25.0	0.3	--	4.3
1970	483	100.0	66.2	1.8	16.5	0.6	--	15.0	100.0	66.2	1.8	16.5	0.6	--	15.0
1980	2,386	100.0	81.2	8.4	6.5	1.0	--	2.8	100.0	70.6	8.3	4.6	0.9	--	15.7

[12] As in Table 2, China is treated as a non-major currency country during 1961-1998 and is assumed to play a major anchor currency role from 1999.

1990	3,525	100.0	70.6	9.2	3.6	8.3	--	8.4	100.0	53.0	6.5	3.5	1.4	--	35.6
2000	5,573	100.0	58.7	7.5	1.6	1.3	7.9	23.0	100.0	38.9	5.2	1.6	0.9	2.6	50.8
2010	16,845	100.0	46.1	16.4	5.5	1.1	11.7	19.2	100.0	25.1	6.0	1.7	0.6	1.8	64.8
2020	19,563	100.0	44.8	14.2	0.8	0.0	25.4	14.8	100.0	34.1	8.2	0.7	0.0	6.0	51.0
2021	21,824	100.0	46.0	14.8	1.4	1.2	26.4	10.2	100.0	37.7	8.7	0.9	0.7	7.1	44.8

3Da. Emerging and developing Asia, including China during 1961-1990

	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	61.3	0.0	33.3	0.5	--	4.9
1970	188	100.0	54.8	0.4	29.7	0.0	--	15.1	100.0	54.8	0.4	29.7	0.0	--	15.1
1980	580	100.0	56.0	15.1	22.1	0.9	--	5.8	100.0	51.8	15.0	15.0	0.9	--	17.3
1990	1,032	100.0	86.8	1.1	9.3	1.2	--	1.7	100.0	73.1	0.4	9.2	1.1	--	16.1
2000	1,071	100.0	48.6	0.2	6.6	3.4	3.0	38.2	100.0	40.0	0.2	6.6	3.3	0.5	49.5
2010	3,672	100.0	46.5	16.2	0.5	2.2	10.6	23.9	100.0	23.4	6.1	0.4	1.5	1.4	67.2
2020	5,945	100.0	59.9	0.5	0.0	0.1	31.6	7.8	100.0	42.6	0.5	0.0	0.1	18.6	38.2
2021	6,565	100.0	58.5	0.3	0.1	3.2	32.5	5.5	100.0	44.4	0.3	0.1	2.1	17.7	35.5

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	195	100.0	100.0	0.0	0.0	0.0	--	0.0	100.0	60.7	0.0	0.0	0.0	--	39.3
1990	311	100.0	72.1	19.8	0.0	0.0	--	8.2	100.0	34.0	13.2	0.0	0.0	--	52.9
2000	885	100.0	56.5	31.1	0.0	0.0	9.4	3.0	100.0	13.8	17.8	0.0	0.0	2.7	65.7
2010	3,477	100.0	29.6	36.6	7.2	0.4	16.9	9.4	100.0	4.8	10.4	0.0	0.1	5.7	79.0
2020	3,669	100.0	4.7	32.1	1.1	0.0	40.2	21.9	100.0	0.6	25.5	0.7	0.0	0.0	73.1
2021	4,279	100.0	4.5	31.2	1.2	0.0	41.4	21.7	100.0	1.7	24.9	0.8	0.0	0.8	71.9

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	94.7	0.0	3.9	0.0	--	1.4
1970	163	100.0	72.3	0.0	1.6	0.0	--	26.1	100.0	72.3	0.0	1.6	0.0	--	26.1
1980	745	100.0	98.1	0.2	0.0	1.4	--	0.3	100.0	81.6	0.2	0.0	1.0	--	17.3
1990	1,043	100.0	58.9	0.0	0.6	23.6	--	17.0	100.0	37.4	0.0	0.4	0.5	--	61.7
2000	2,189	100.0	57.9	0.0	0.0	0.2	10.5	31.4	100.0	37.9	0.0	0.0	0.0	3.9	58.2
2010	5,172	100.0	31.9	2.5	11.7	0.0	16.5	37.3	100.0	13.9	0.1	4.5	0.0	0.1	81.5
2020	4,289	100.0	17.4	29.8	0.0	0.0	26.9	25.9	100.0	14.8	8.5	0.0	0.0	0.3	76.4
2021	4,963	100.0	25.0	32.1	0.0	0.4	27.5	15.0	100.0	17.2	10.7	0.0	0.3	3.4	68.3

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	17	100.0	67.6	0.0	20.3	0.0	--	12.0	100.0	67.6	0.0	20.3	0.0	--	12.0
1970	57	100.0	85.8	0.5	7.6	5.3	--	0.8	100.0	85.8	0.5	7.6	5.3	--	0.8
1980	590	100.0	84.7	9.5	1.3	0.8	--	3.7	100.0	84.6	9.5	1.3	0.8	--	3.9
1990	807	100.0	76.8	14.6	2.6	4.0	--	2.1	100.0	69.9	12.2	2.6	3.7	--	11.7
2000	1,035	100.0	82.4	8.1	1.9	3.0	1.6	3.0	100.0	70.4	7.6	1.8	1.4	0.5	18.2
2010	3,210	100.0	83.0	10.1	1.5	2.5	0.5	2.5	100.0	71.4	8.2	1.1	1.1	0.4	18.0
2020	4,042	100.0	83.2	1.9	3.0	0.1	1.6	10.1	100.0	65.7	1.4	2.8	0.1	1.1	28.9
2021	4,672	100.0	90.0	1.2	5.2	0.6	1.0	2.0	100.0	85.0	1.0	3.4	0.1	0.7	9.8

3De. Sub-Saharan Africa

Year	GDP USD Bill	Not adjusted for exchange rate stability/flexibility							Adjusted for exchange rate stability/flexibility						
		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	64.2	0.0	33.4	0.0	--	2.3
1970	57	100.0	56.4	13.2	29.1	0.0	--	1.3	100.0	56.4	13.2	29.1	0.0	--	1.3
1980	277	100.0	68.0	20.3	7.2	1.1	--	3.4	100.0	58.0	19.3	5.1	1.1	--	16.5
1990	332	100.0	40.5	40.1	0.7	0.8	--	17.9	100.0	16.8	25.7	0.7	0.7	--	56.1
2000	392	100.0	33.6	14.0	0.1	0.8	19.5	31.9	100.0	14.3	13.0	0.1	0.5	6.4	65.8
2010	1,314	100.0	54.4	34.3	0.3	0.4	8.8	1.8	100.0	15.0	11.9	0.1	0.3	2.9	69.8
2020	1,618	100.0	56.5	13.1	0.1	0.0	23.8	6.5	100.0	50.7	13.1	0.1	0.0	1.0	35.2
2021	1,344	100.0	41.2	17.8	0.3	0.0	33.1	7.6	100.0	31.0	17.8	0.2	0.0	11.5	39.5

EUR = Euro; GBP = British pound; JPY = Japanese yen; Res. = residual: RMB = Chinese renminbi; USD = U.S. dollar.
Note: Each currency zone here includes only part of those countries that assign a positive, statistically significant coefficient at the 10% level to that currency. EUR refers to DEM (Deutschemark) in 1961-1990. Euro Area refers to Germany in 1961-1970, Austria, Germany and Netherlands in 1980-1990, 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 country 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 not during 2000-2021. Residual is the part that cannot be explained by the identified currency weights and hence can be considered as a floating regime zone.
Source: Compiled by authors from their estimations.

Table 3A reports results for all non-major currency countries, excluding the U.S., Euro Area, the U.K., and Japan for the entire period as well as 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 overtime to 38% (without adjusting for exchange rate stability) or 36% (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 28% without adjusting for exchange rate stability, while it is smaller at 22% with such adjustment. This suggests that countries that select the RMB as exchange rate anchor do not necessarily pursue high degrees of exchange rate stability.

Another interesting observation is that the residual is much larger with exchange rate stability adjustment than without. For example, the share of the residual used to be only 5% in 1961, began to rise over time to 18% (without adjustment for exchange rate stability) or 66% (with adjustment) in 2010 and has since declined to 11% (without adjustment) or 42% (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 residual economy being more than 40% in recent years when adjusted for exchange rate stability may be surprisingly high.

These basic observations carry over to the remainder of Table 3, but there are also differences in results across country groups classified by income and region. The following

discussion focuses on the case where the degree of exchange rate stability is adjusted 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 larger than that of emerging & developing economies, but since 1980, the share of the USD zone in emerging & developing economies has been larger. Second, the shares of the EUR and RMB zones are generally larger in advanced economies than in emerging & developing economies. Third, the share of the residual is generally larger in emerging & developing economies than in advanced economies, with some exceptions. This suggests that emerging & developing economies tend to adopt higher degrees of exchange rate flexibility than advanced economies. However, at the time of the global financial crisis of 2010, advanced economies also preferred greater exchange rate flexibility, as indicated by the high share of the residual in regional GDP.

In the emerging & developing world, some clear differences across regions can be observed. In emerging & developing Asia, the share of the USD zone has been persistently high, reaching a peak of 73% in 1990. Although the share of the USD zone has decreased since then, it still maintains a relatively high level of 44% in 2021. The share of the RMB zone is the highest in Asia among all regions, recording 18% in 2021. In emerging and developing Europe, the share of the USD zone was very high (61% to 100%) in 1961-1980, but fell sharply after 1990, and was replaced by the share of the EUR zone, which has become the largest currency area in the region, accounting for 25% (with the residual accounting for 72%) in 2021. In Latin America and the Caribbean, the share of the USD zone was also very high at over 70% in 1961-1980, but has declined since 1990, reaching 17% in 2021. In the region, the EUR-zone share has gradually increased, recording 11% in recent years. In the Middle East and Central Asia, the share of the USD zone has remained consistently very high, recording 85% in 2021. In Sub-Saharan Africa, the share of the USD zone was high at around 60% in 1961-1980, and although it has declined since then, it has been relatively high, registering 31% in recent years. In the early years, the share of the GBP zone was also relatively large, 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 the largest in emerging & developing Europe as well as LAC while it is the smallest in Middle East and Central Asia. This suggests that emerging & developing economies in Europe and LAC adopt relatively high degrees of exchange rate flexibility,

while countries in the Middle East and Central Asia adopt relatively high degrees of exchange rate stability. The degrees of exchange rate stability/flexibility in Sub-Saharan Africa and emerging & developing Asia are in-between those of the above two groups.

To summarize, the global share of the USD zone is trending downward following the emergence of the euro and the recent rapid rise of the RMB. Nevertheless, the USD zone remains the world's largest currency zone, particularly since 1980, in emerging & developing regions such as the Middle East and Central Asia and emerging & developing Asia. The share of the EUR zone is large among advanced economies, and it was indeed larger than the share of the USD zone during the period 1980-2010 but was surpasses by the USD zone in 2020-2021. Among the emerging & developing regions, Europe has the largest EUR zone. The share of the EMB zone is also large among advanced economies, and in 2021, it became the second largest currency zone among these economies. Among the emerging & developing regions, Asia has the largest RMB zone and in 2020-2021 it became the second largest currency zone in the region after the US dollar zone. In Sub-Saharan Africa, the importance of the RMB zone is also rising. The residual part of the world economy, which does not belong to any major currency zone and is judged to adopt floating exchange rate regime, has been expanding mainly in emerging & developing regions, especially in Europe and Latin America and the Caribbean.

4. Evolution of the Trilemma Combination

As explained in Section 2, trilemma indexes are constructed based on the methodology in Appendix I for more than 100 countries for which data are available. This section examines how the combinations of trilemma indexes in these countries have changed over time. This allows us to understand the evolution of the international monetary system over the past 50 years from the trilemma perspectives.

4.1 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 countries, low-income countries, and the Association of South East Asian Nations (ASEAN) countries.[13] A few points need to be kept in mind when creating the trilemma index. The index for exchange rate stability (ERS) for major currency

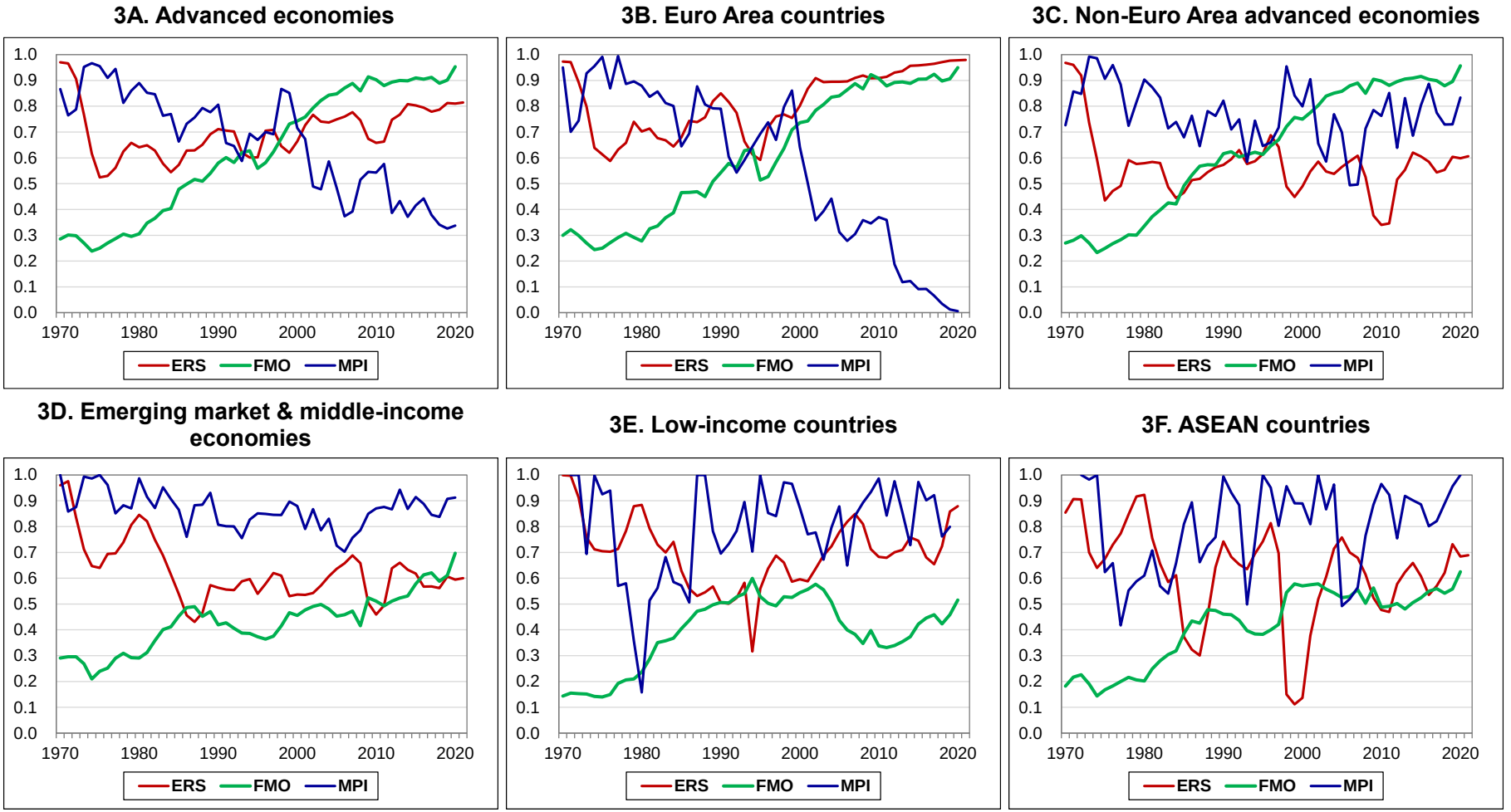
[13] The groupings of “advanced economies,” “emerging market & developing economies,” and “low-income countries” are based on the IMF’s classification. ASEAN countries include Brunei Darussalam, Cambodia, Indonesia, Lao PDR, Malaysia, Myanmar, Philippines, Singapore, Thailand, and Vietnam, but Lao PDR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

countries belonging to advanced economies is constructed from the RMSE obtained by regressing the exchange rates of the EUR, GBP, and JPY on the USD rate. Thus, the ERS is a common value for the Euro Area member countries. Regarding the index for RMB exchange rate stability in China, which belongs to emerging & middle-income countries, the ERS is constructed from the RMSE obtained by regressing the RMB exchange rate on the USD, EUR, GBP, and JPY rates. The Frankel-Wei method is applied to both. In addition, the index for monetary policy independence (FMO) 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 domestic factors (GDP gap, inflation rate, etc.) in each country or the USD short-term interest rate.

Figure 3A shows that advanced economies have achieved a high degree of financial market openness over the past 50 years. 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, the advanced economies adopted a trilemma combination of maintaining relatively high levels of exchange rate stability and monetary policy independence by restricting financial market openness. Over time, they have shifted to another trilemma combination of a relatively high level of exchange rate stability and a high degree of financial market openness with a low level of monetary policy independence. A low level in monetary policy independence for advanced economies is surprising, but this is largely due to the fact that the Euro Area countries maintain tight intraregional exchange rate stability and a high degree of financial market openness by abandoning monetary policy independence (Figure 3B). On the other hand, advanced economies outside Euro Area have adopted a trilemma combination of maintaining a low degree of exchange rate stability, a high degree of financial market openness and a relatively high level of monetary policy independence (Figure 3C).

Emerging market & middle-income countries have consistently maintained relatively high levels of monetary policy independence while steadily increasing financial market openness and maintaining some degree of exchange rate stability (Figure 3D). Exchange rate stability was at a relatively high level in the 1970s, declined in around 1980, and has remained at moderate levels since then. In the 1970s, the degree of financial market openness was at a low level, almost the same as that of the advanced economy group, and did not rise from the 1980s as fast as that of the advanced economies, reaching only the middle level in recent years. Nonetheless, the degree of monetary policy independence is high, especially at a level comparable to or higher than that of the advanced economies outside Euro Area.

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 countries" are based on the IMF's classification. Appendix II lists the sample economies and indicates categorization.
Source: Authors' estimations and compilation.

Low-income countries have restored relatively high levels of exchange rate stability since the 2000s, after experiencing declining stability in the 1980s and 1990s, and maintained relatively high levels of monetary policy independence by limiting a rise in financial market openness (Figure 3E). In recent years, exchange rate stability has been higher and financial market openness has been lower than in the emerging & middle-income countries, as the latter declined from around 2000 to 2010 and has not recover sufficiently since then. Interestingly, monetary policy independence declined sharply in around 1980, but has since recovered and remains at a relatively high level.

The development of the trilemma indexes in the ASEAN group shows a relatively similar pattern to that of the emerging and middle-income country group, except for the sharp drop in the exchange rate stability index in the mid-1980s and late 1990s, the time of the Asian financial crisis (Figure 3F). The degree of exchange rate stability in ASEAN countries has shown large ups and downs with a gradual declining trend over the past 50 years, and has remained at a moderate level with an upward trend for the past decade. The degree of financial market openness rose in two phases in the mid-1980s and in the late 1990s, then stopped rising and has hovered at moderate levels in recent years. ASEAN countries, unlike low-income countries, have not reversed financial market openness even in the aftermath of the Asian and global financial crises. Nevertheless, the level of financial market openness lags far behind that for advanced economies, suggesting that there is room for further opening. Although the index for monetary policy independence exhibits greater fluctuations than that for the emerging & middle-income country group, it has achieved a level higher than those for this group and the advanced economy group, implying that ASEAN has been strengthening its capacity to stabilize the economy

4.2 Analysis using the trilemma triangle

The most intuitive way to illustrate the evolution of a combination of trilemma indexes for a country is to plot it in a trilemma triangle and see how it moves over time, as is done in Figure 4.[14] No previous literature, except the current authors' work such as Ito and Kawai (2014, 2021), has plotted the combination of the three indexes in a trilemma triangle.

Figure 4 A shows trilemma combinations in trilemma triangles for different economy groups for three five-year periods: 1986–1990, 2001–2005, and 2016–2020. Countries and economies are classified into three economic groups, i.e., advanced economies, emerging market &

[14] In order to plot the trilemma combination in a trilemma triangle, the sum of the three indexes must equal two. As the constructed indexes do not always sum up to two, an adjustment is needed to ensure that the sum of the three adjusted indexes is *exactly* equal to two. Essentially, as the sum of the three indexes can be expressed as $ERS_{it} + FMO_{it} + MPI_{it} = 2B_{it}$, adjusted indexes are obtained by dividing the original indexes by B_{it}, where subscript *i* refers to a country and *t* a year.

middle-income countries (EMMICs), and low-income countries (LICs). We can make several interesting observations. From this figure, one can observe several characteristics on trilemma combinations for each economic group.

With regard to advanced economies, various combinations of trilemma indexes are observed in the late 1980s and early 2000s but, in the late 2010s, they began to exhibit a higher degree of financial market openness. As a result, advanced economies are classified roughly into three groups. The first group, which attempts to achieve the right-bottom corner of the triangle, seeks high levels of exchange rate stability and financial market openness without monetary policy independence and is made up in particular of Euro Area countries. The second group which realizes the upper corner of the triangle by abandoning exchange rate stability (or adopting flexible exchange rates) and maintaining high levels of financial market openness and monetary policy independence, consists of such countries as Iceland, Japan, Norway, and the United Kingdom. The third group, which sets the three indexes at middle levels and does not aim for any corner, consists of Czech Rep., Israel, and Singapore. Interestingly, there are several advanced economies that achieve the left-bottom corner of the triangle by maintaining high levels of exchange rate stability and monetary policy independence while closing financial markets in the early periods, but such advanced economies no longer exist in the most recent period.

Emerging market & middle-income countries allow varying levels of exchange rate stability tend to have less open financial markets and a greater degree of monetary policy independence than advanced economies. Looking at the first half of the 2000s, emerging & middle-income countries can be broadly divided into two groups. The first group consists of countries that maintain high levels of monetary policy independence under varying degrees of exchange rate stability and financial market openness. The second group consists of countries with relatively stable exchange rates, limited degrees of financial market openness, and relatively independent monetary policy. In the second half of the 2010s, all groups generally reduced exchange rate stability and increased the degree of financial market openness to some extent. Several countries, especially within the first group, have moved to the upper corner of the triangle, achieving high levels of exchange rate flexibility and financial market openness to maintain monetary policy independence (including Argentina, Brazil, Mexico, Russia, South Africa, and Turkey). There are still a few countries in the left-bottom corner of the triangle (such as Algeria, Guatemala, Morocco, and Romania), but there are only a limited number of countries in the right-bottom corner of the triangle (although not shown due to data limitations, Bahrain is considered one such countries).

The combinations of trilemma indexes in low-income countries differ from those in advanced

economies and emerging & middle-income countries. Low-income countries have not opened up their financial markets as much as advanced economies and appear to value exchange rate stability more than emerging & middle-income countries. In addition, although they tend to achieve relatively high levels of monetary policy independence, their levels do not seem to be as high as in emerging & middle-income countries. As a result, the combinations of the trilemma indexes are generally located at the positions close to the left-bottom corner of the triangle (which achieves high levels of exchange rate stability and monetary policy independence by greatly limiting financial market openness) throughout the periods. In the late 1980s, there was a country in the upper corner of the triangle (Nigeria), but since the 2000s there has been no such country. Moreover, there is no low-income country in the right-bottom corner of the triangle.

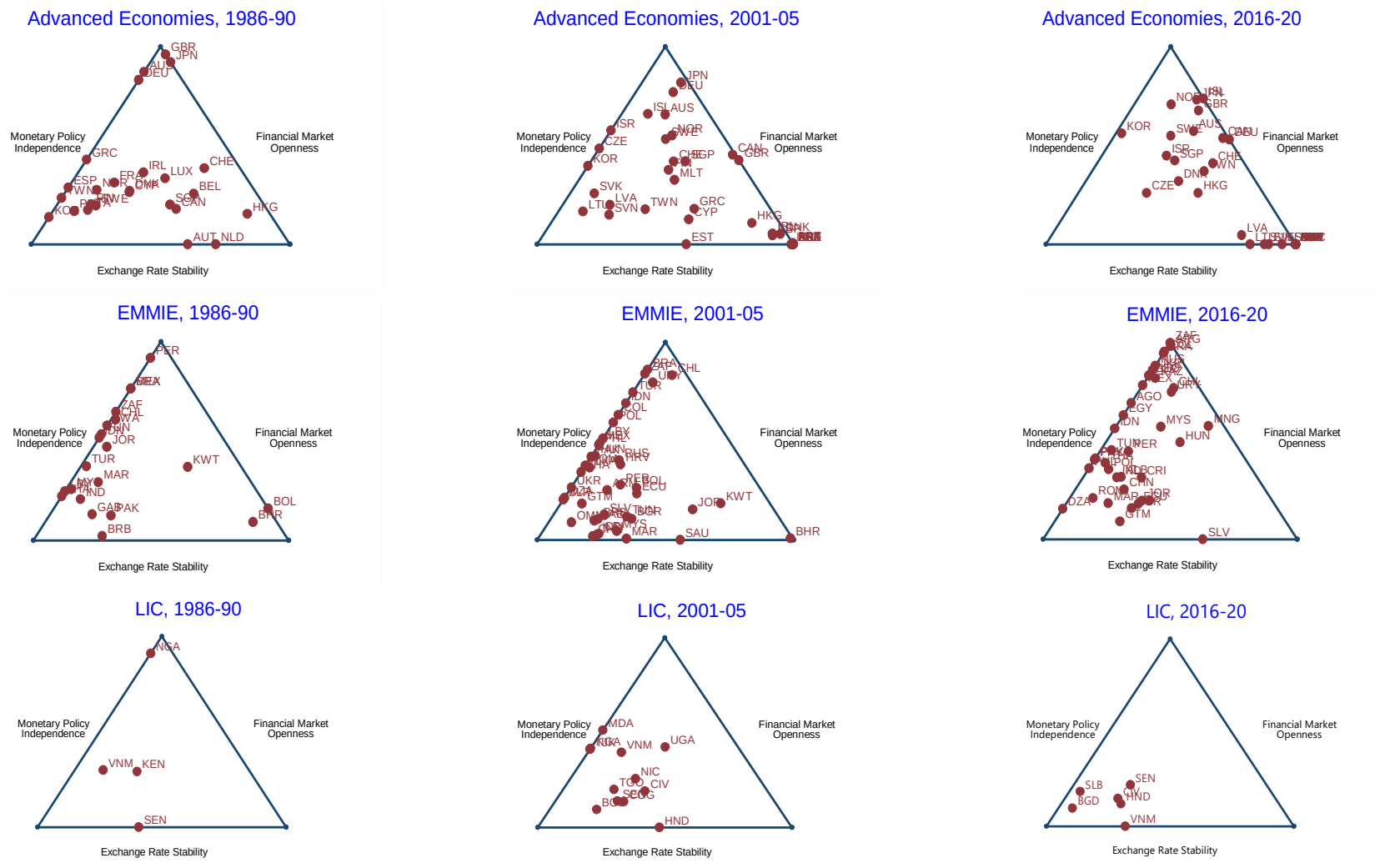
Figure 4B illustrates the trilemma combinations of several regional groups for the emerging market & developing world (including both middle- and low-income countries), each for the three periods of 1986-90, 2001-05, and 2016-20.[15]

The 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 countries in the region seek varying levels of exchange rate stability, financial market openness, and monetary policy independence. ASEAN countries, in particular, are mostly located outside the corners and combine the trilemma indexes in various ways. In contrast, Japan, China and Hong Kong have realized three different corners. Japan has achieved the top corner of the triangle by maintaining a low level of exchange rate stability and high levels of financial market openness and monetary policy independence. China has achieved the left-bottom corner of the triangle by maintaining a high level of exchange rate stability, a low level of financial market openness, and a high level of monetary policy independence.[16] Hong Kong, by contrast, is characterized as an economy in the right-bottom corner of the triangle, adopting high levels of exchange rate stability and financial market openness without monetary policy independence. Interestingly, however, in the recent period (2016-2020), both China and Hong Kong have moved away from their respective corners and approached the middle ground of the triangle.[17]

[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 last period (2016-20), Hong Kong maintains high degrees of both exchange rate stability and financial market openness (values of 0.96 and 1.00, respectively) while achieving a high degree of monetary policy independence (value of 0.66). This may suggest that the Hong Kong Monetary Authority is trying to defy the trilemma constraint. By adjusting all the three indexes so that their sum becomes 2, Hong Kong's position turns out to be closer to the middle ground rather than the right-bottom corner.

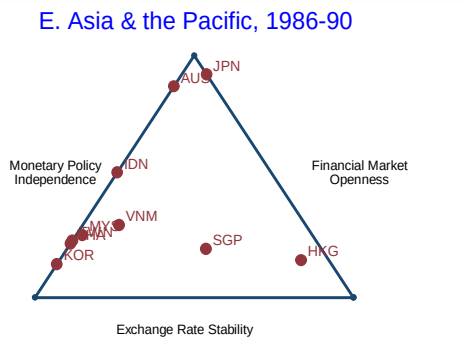
Figure 4: Trilemma combinations using trilemma triangles (income groups, regional groups, and selected Asian economies)

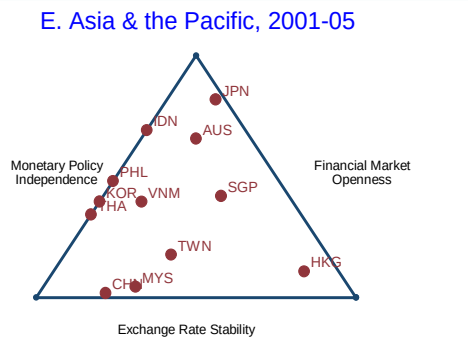
4A: Trilemma triangles – countries in the world by income group for three periods

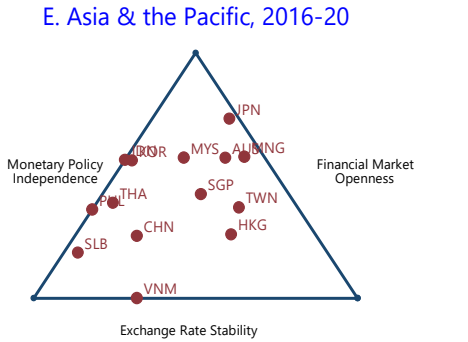


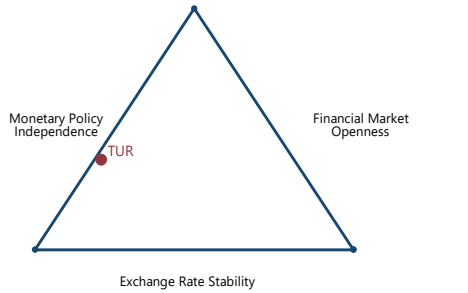
Source: Authors' estimation and compilation.

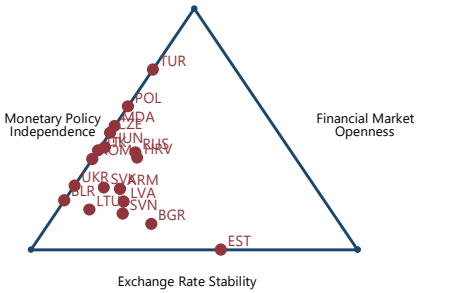
4B: Trilemma triangles – emerging market & developing countries by regional group for three periods

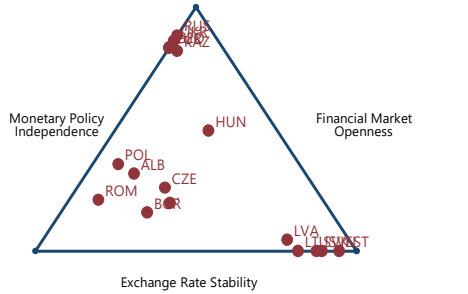


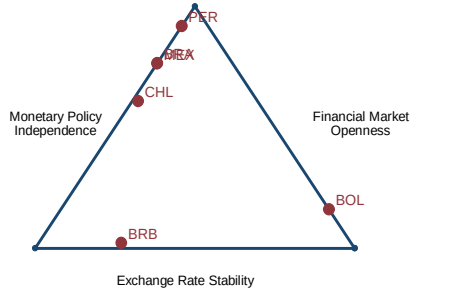


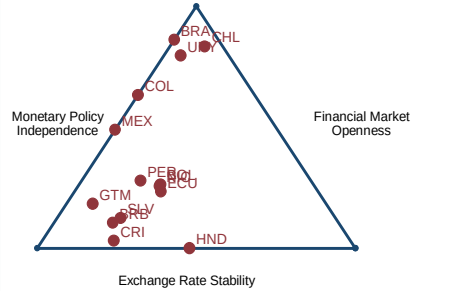


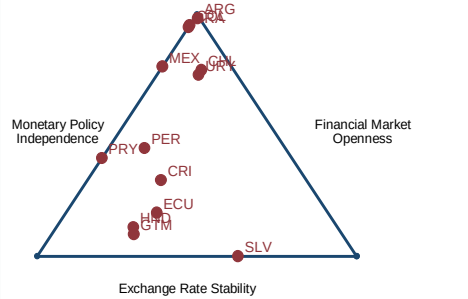






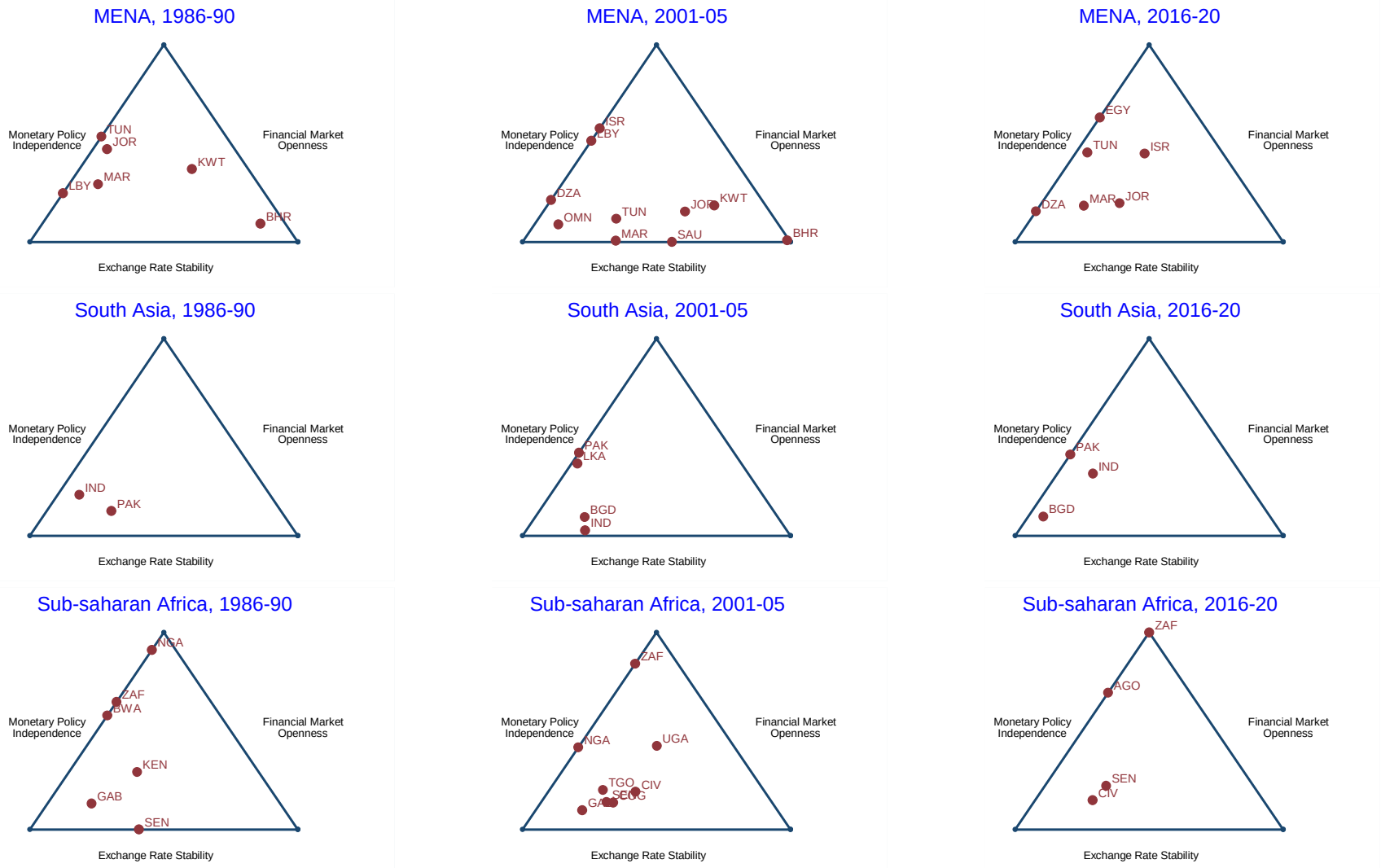






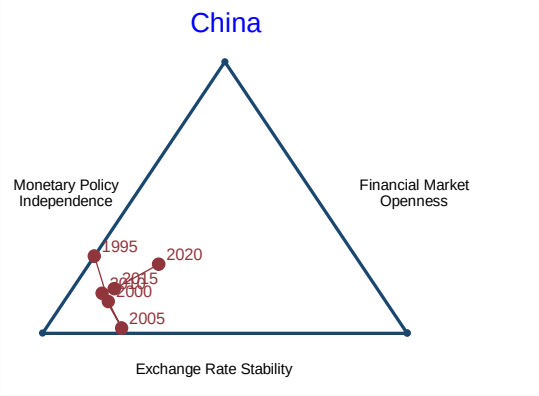
Source: Authors' estimation and compilation.

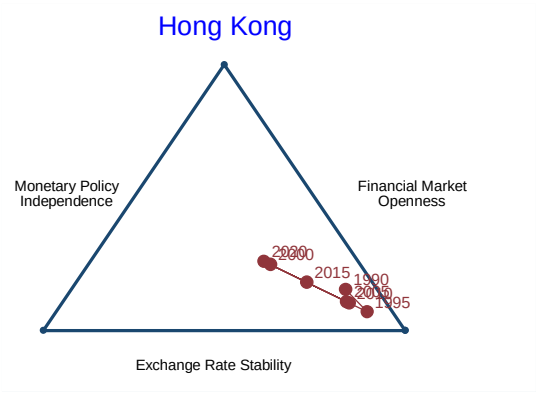
4B: Trilemma triangles – emerging market & developing countries by regional group for three periods (continued)

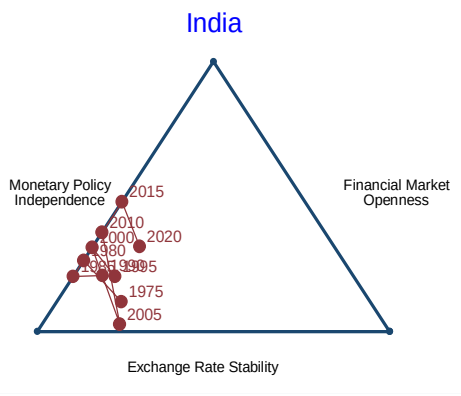


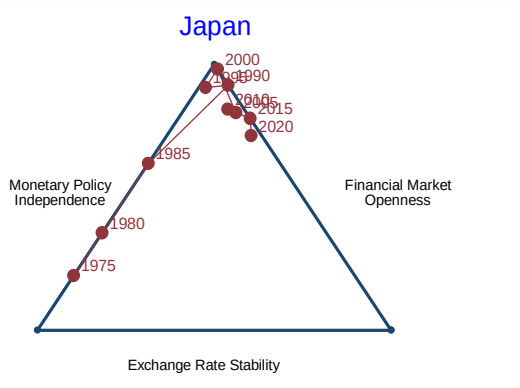
Source: Authors' estimation and compilation.

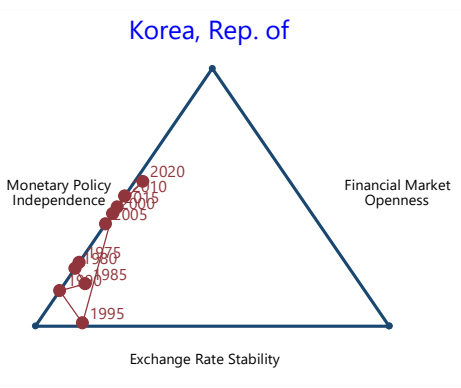
4C: Trilemma triangles – evolution for selected economies in Asia, 1975 – 2020

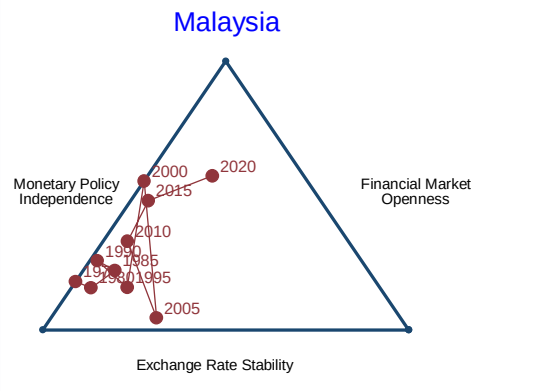


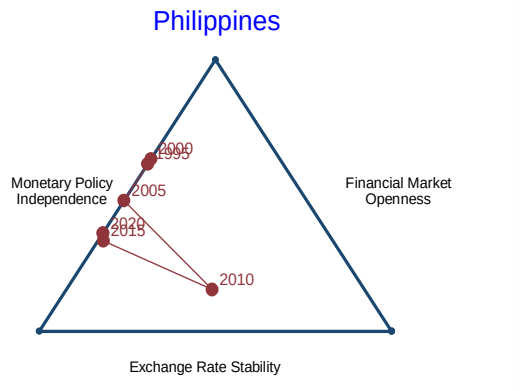


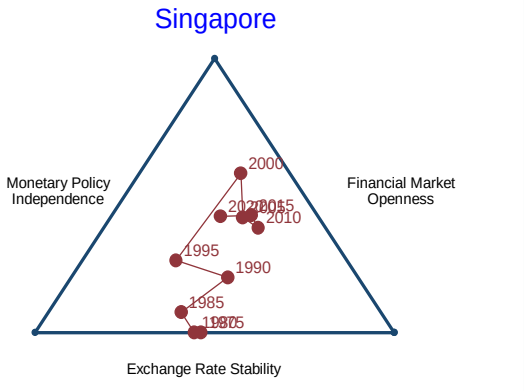


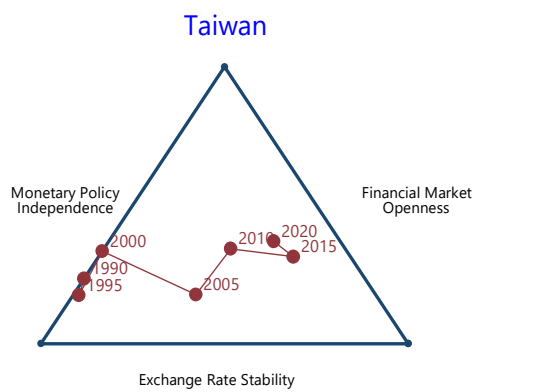


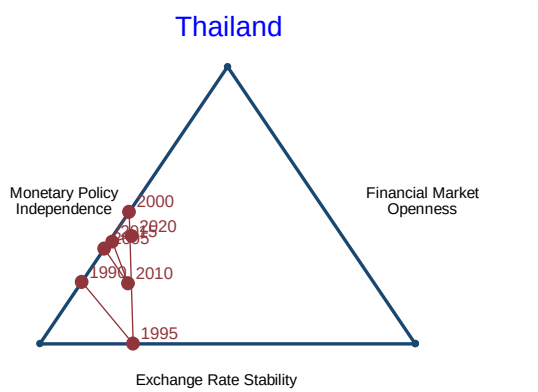


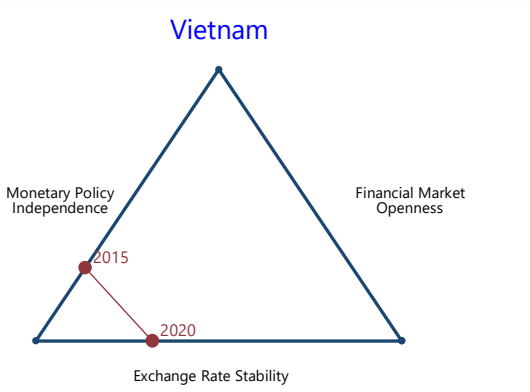












Source: Authors' estimation and compilation.

Countries in Europe and Central Asia, mostly composed 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 countries in the region limited financial market openness, which is not surprising given the fact that many of them were formerly under central planning.[18] They largely retained monetary policy independence, which is shown with a cluster of dots at the left-side of the triangle. As of the latest period (2016-20), countries in the region can be classified into three groups. One group includes countries that have adopted greater exchange rate flexibility at the top corner of the triangle (Georgia, Kazakhstan, Russia, Turkey, and Ukraine). The second group includes countries that have pursued higher levels of exchange rate stability and financial market openness, thereby achieving the right-bottom corner, through currency stabilization against the euro or participation in Euro Area (Estonia, Latvia, Lithuania, and Slovenia). The third group includes countries that maintain the middle ground by achieving some degrees of exchange rate stability, financial market openness and monetary policy independence (Czech Rep. and Hungary).

Some countries in Latin America and the Caribbean already had relatively low levels of exchange rate stability and high levels of financial market openness early in the sample period (1986–90). However, some of these countries seem to have retrenched from financial market openness in the following periods while at the same time pursuing greater exchange rate stability since the beginning of the millennium. In the latest period (2016-20), countries in the region can be divided to two groups. One group includes countries at the top corner with free floating regimes (Argentina, Brazil, Chile, Colombia, Mexico, and Uruguay). The other group includes countries with relatively high degrees of exchange rate stability with limited financial market openness and a relatively high level of monetary policy independence, located close to the middle ground (Costa Rica, Ecuador and Peru).

The Middle East and North Africa, 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 of the similarities is that most of the plotted points are located in the left half of the triangle. This means that financial markets are not sufficiently open in these regions. Another is that no country is located in the right-bottom corner of the triangle in any region (however, as mentioned earlier, Bahrain in the Middle East and North Africa is possibly located in the right-bottom corner even in the most recent period). One of the regional differences is that many countries in the Middle East and North Africa adopted high levels of exchange rate stability with varying degrees of financial market

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

openness during the early 2000s (but some have reduced the level of exchange rate stability in the late 2010s). Another difference is that South Africa in Sub-Saharan Africa has maintained a free floating regime since the 2000s by realizing the top corner of the triangle, but as far as the available data show, there is no such country in the other two regions.

Figure 4C illustrates the evolution of trilemma combinations for selected countries in Asia over the period 1975-2020. The trilemma index combinations plotted in the triangles in the figure represent the average values for the past five years, including the year indicated. From this figure, various trilemma trajectories can be observed across different economies in Asia. The general trend is that the trilemma combinations move away from the left-bottom corner (or the right-bottom corner for Hong Kong and roughly midway down the bottom for Singapore) over time, by increasing degrees of exchange rate flexibility and financial market openness. ASEAN countries have increased the degrees of exchange rate flexibility and maintained relatively high degrees of monetary policy independence after the Asian currency crisis but, with the exception of Singapore, they still have not achieved sufficiently high levels of financial market openness.

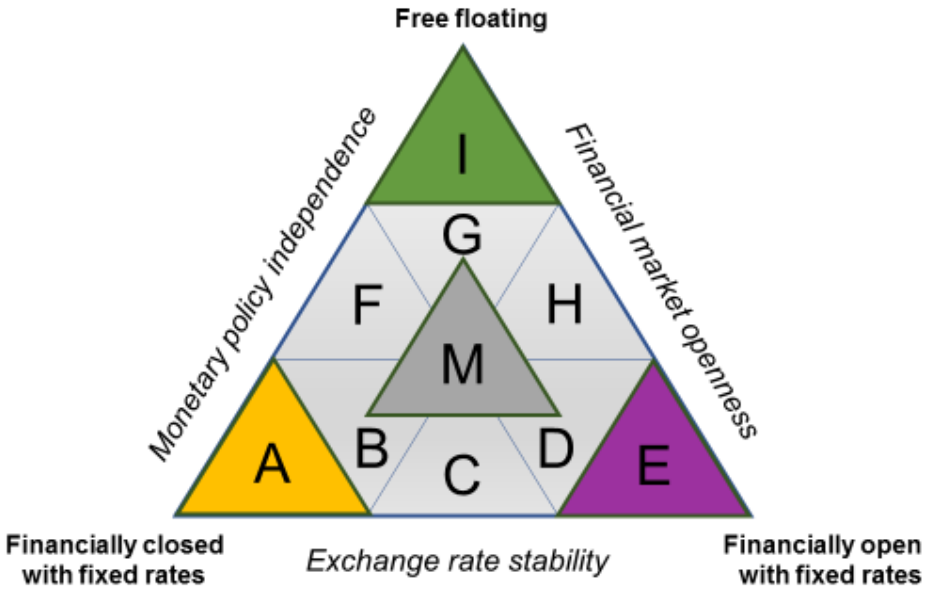
Asia's largest economies, China and Japan, have followed very different trilemma combination trajectories. China has long maintained the left-bottom corner of the triangle, which seeks to retain exchange rate stability and monetary policy independence while limiting the degree of financial market openness. Since the global financial crisis, the country seems to have moved toward the “middle ground” inside the triangle, with deliberate increases in exchange rate flexibility and financial market openness. Japan adopted a flexible exchange rate regime to gradually increase exchange rate flexibility in the early 1970s after the collapse of the Bretton Woods system, and achieved considerable degrees of capital account liberalization and financial market openness in the mid-1980s. As a result, Japan moved upwards along the left side of the triangle during the 1970s and the 1980s, and realized the top corner in the 1990s. Being large economies, both China and Japan have pursued monetary policy independence during most of the sample period.

4.3 Mapping the evolution of trilemma regimes

Next, this subsection draws the representative trilemma regimes in the world map and visibly depicts their evolution over time by focusing on the three corner areas and the middle ground. A trilemma regime is defined by the location 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.

Figure 5: Definition of ten trilemma regimes



Source: Authors' compilation.

The division of the large triangle into nine equal sized, smaller triangles reflects the procedure of defining three levels of exchange rate stability (ERS), financial market openness (FMO), and monetary policy independence (MPI), i.e., high, middle and low. For example, regime A is characterized by a combination of high ERS, low FMO, and high MPI, which approximates one of the three corners, that is, the regime of a financially closed economy with fixed exchange rates and independent monetary policy. Regime E represents a combination of high ERS, high FMO, and low MPI and matches another corner regime of a financially open economy with fixed exchange rates but without monetary policy independence. Regime I is marked by a combination of low ERS, high FMO, and high MPI and corresponds to the last corner regime of a financially open economy with flexible exchange rates and monetary policy independence.

There are seven non-corner regimes. For example, regime B represents a combination of high ERS, middle FMO, and high MPI. Regime M is presented as one of the trilemma regimes on the notion that all countries may not choose the corner regimes because some would prefer non-corner, middle ground combinations of trilemma indexes. Although this regime has overlaps with the other six non-corner regimes and does not constitute an

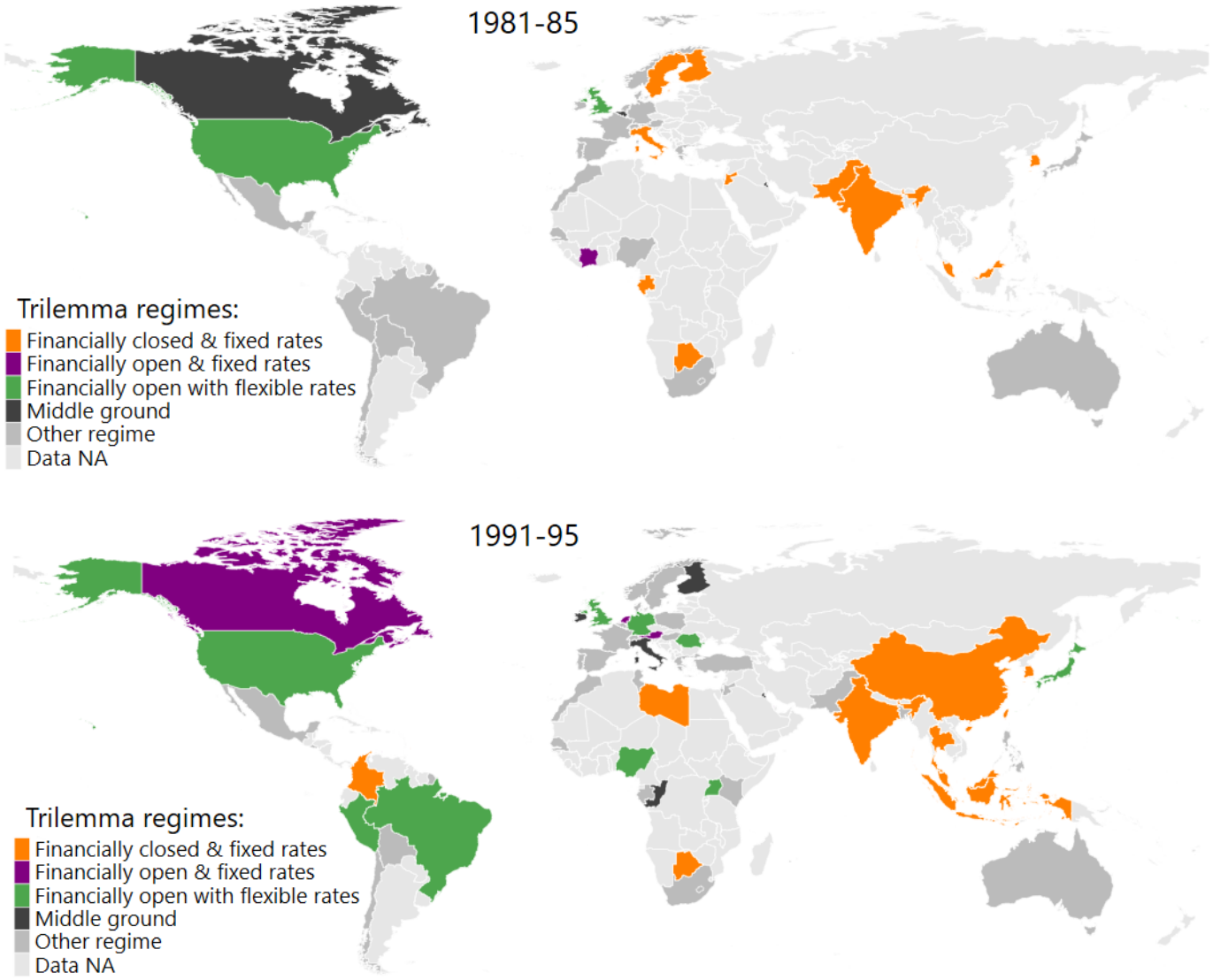
exclusive triangle, it deserves attention.

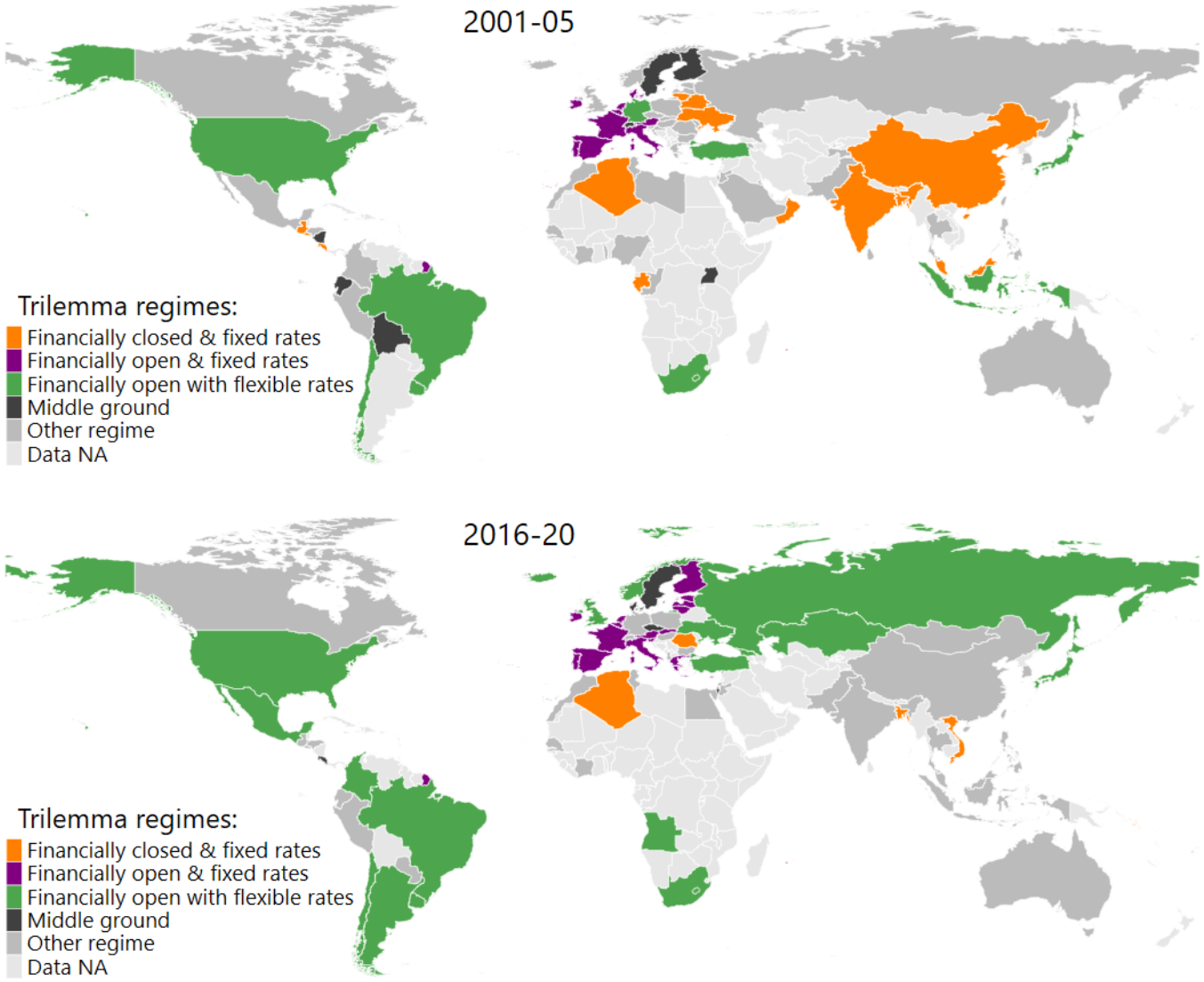
Figure 6 visually presents countries that have attained one of the three corner regimes, the middle ground, or one of the remaining six non-corner regimes in the global map for the four periods, 1981-85, 1991-95, 2001-05, and 2016-20. There are many countries where the trilemma regimes cannot be defined, 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 regime E and regime I has gained traction since the early 2000s. In the most recent period (2016-20), regimes E and I are roughly equally selected and regime A has been selected by only a few countries (Algeria, Bangladesh, and Romania). China and India, two large emerging economies, adopted regime A until the third period (2001-15), and have left this regime afterward. Regime E has gained traction because a large number of small countries joined the Euro Area to enjoy intraregional stable exchange rates through the adoption of a common currency, while maintaining open financial markets and giving up independent monetary policy. Regime I has been expanding in the world as an increasing number of emerging & developing countries (such as Argentina, Brazil, Mexico, Russia, South Africa, and Turkey) have adopted greater exchange rate flexibility and more open financial markets, thereby retaining monetary policy independence.

In contrast to the rising popularity of corner regimes E and I, the middle ground or regime M has not attracted much interest. Nonetheless, in the most recent period, several countries such as India, Israel, Poland, and Sweden adopt regime M. Other non-corner regimes are shared by a large number of countries, including both advanced economies and emerging & developing economies. The former include Australia, Canada, the ROK, and Taiwan and the latter include China, Egypt, Indonesia, Malaysia, Pakistan, and Peru.

Figure 6: Trilemma Regimes in the World, 1981-85, 1991-95, 2001-05, and 2016-20




2001-05
Trilemma regimes:
Financially closed & fixed rates
Financially open & fixed rates
Financially open with flexible rates
Middle ground
Other regime
Data NA
2016-20
Trilemma regimes:
Financially closed & fixed rates
Financially open & fixed rates
Financially open with flexible rates
Middle ground
Other regime
Data NA

5. Macroeconomic Performance in Different Trilemma Regimes

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

5.1 Macroeconomic performance variables

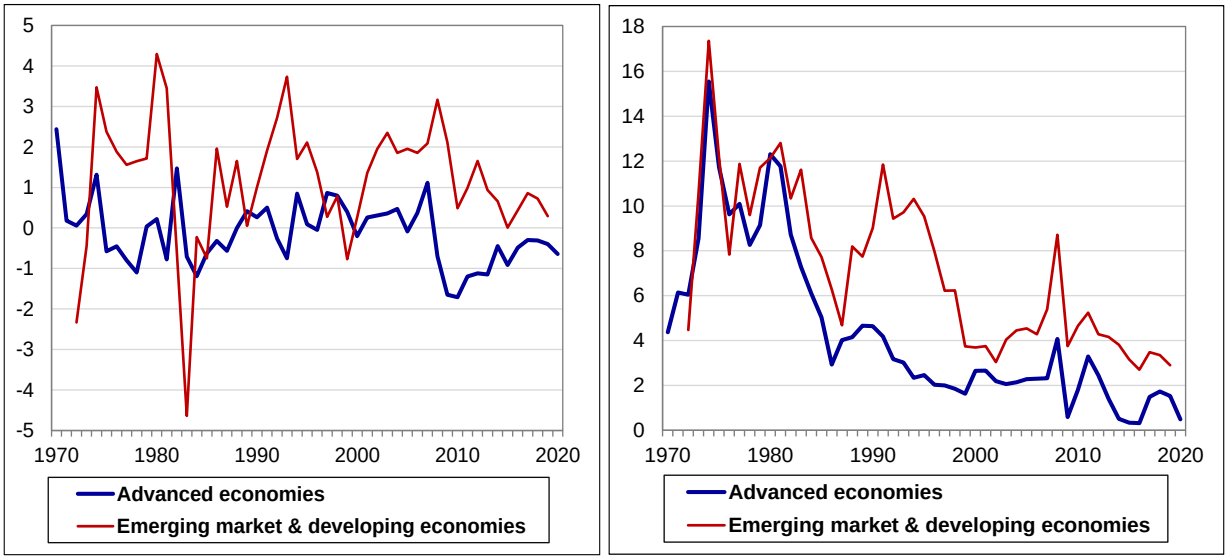
Macroeconomic performance of individual economies at different trilemma regimes can be judged by using real GDP growth rates and CPI inflation rates. Data for these macroeconomic variables are collected from the World Bank's database. The number of sample countries is 99 in total and varies across trilemma regimes. The sample period is 1970-2021 for countries with full data available and is shorter for countries with limited data availability.

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.

Figure 7: Median real GDP growth rate and inflation rate, 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.

To construct GDP growth and CPI inflation rate variables used for assessing macroeconomic performance across different trilemma regimes for the groups of advanced economies and emerging & developing economies, several additional steps need to be 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 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 monetary policy authorities attempt to achieve growth above the target growth rate and achieve the target inflation 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 country. So for convenience, the median values of the growth and inflation rates within each economic group are considered the authorities' monetary policy targets.

5.2 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 exchange rate stability (ERS), financial market openness (FMO), and monetary policy independence (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 variable for each of the ten trilemma regimes, by dividing the sample into advanced economies and emerging market & 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 deviation. 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.

Table 4: Summary of macroeconomic performance by trilemma regime

4A. Advanced economies

	Trilemma regime			No. obs.	Median (y)		SD (y)		Median (π)		SD (π)		Average rank
	ERS	FMO	MPI		Value	Rank	Value	Rank	Value	Rank	Value	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 market & developing economies

	Trilemma regime			No. obs.	Median (y)		SD(y)		Median (π)		SD (π)		Average rank
	ERS	FMO	MPI		Value	Rank	Value	Rank	Value	Rank	Value	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 market & 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.
Source: Authors' computation using data from World Bank, *World Development Indicators database*.

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 popular regimes are E and A, which are corner regimes, 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, which is 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, which is 1,416. The middle ground is not so popular for emerging & developing economies, accounting for only 5% of the total.

Another observation made in the table is that there usually is some trade-off among the macroeconomic performance variables. In evaluating macroeconomic performance, it would be reasonable to claim that: 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 right-bottom corner regime of the trilemma triangle. One of the worst performing regimes is A, at the left-bottom corner.

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 left-bottom 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 top 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 performance 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 results 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 a country 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 a rational country must be adopting the best regime given the various structural and other conditions that affect its trilemma choice. Thus, deviating from the chosen trilemma regime may make the country's macroeconomic performance worse. But if a country does not make a rational or appropriate choice, a shift to another regime may produce a better result.

6. Conclusion

This paper has examined the evolution of the international monetary system since the eve of the collapse of the Bretton Woods system, focusing on exchange rate arrangements and trilemma regimes. In particular, it has developed a quantitative approach by measuring new trilemma indexes. As there has been little systematic and quantitative analysis of the trilemma in international finance since Robert Mundell (1963) proposed its principle, this paper is an attempt to fill this research gap.

The paper has addressed three issues. First, it has examined various countries' exchange rate arrangements, by providing a new measure for the degree of exchange rate stability or flexibility as well as identifying anchor currencies, and calculated the economic size of major currency zones in the world and in each region of the world. The degree of exchange rate stability or flexibility has been measured by the root mean square error (RMSE) of the Frankel-Wei and/or Kawai-Pontines regression equations. The GDP size of major currency areas has been calculated by estimating the weights of anchor currencies for each country. One of the innovations of this paper is that the weights of anchor currencies are adjusted according to the value of RMSE when calculating the size of major currency zones.

This 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 Deutschmark 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. As a result, the size of the RMB zone has risen in recent years, supplementing the roles played by the USD, EUR, GBP and JPY. Nevertheless, the USD remains the most dominant anchor currency among non-major currency countries, 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. These regions have increased their exchange rate flexibility over time, and in recent years they have made their exchange rates more flexible to a higher level than advanced economies (except for the United States, Euro Area, the United Kingdom, and Japan). In particular, Europe and Latin America have highly flexible exchange rate arrangements, while the Middle East and Central Asia have very stable exchange rate regimes. The size of the USD zone is very large in the Middle East and Central Asia at 85% of regional GDP, 44% in Asia, 31% in Sub-Saharan Africa, and 17% in Latin America. The size of the EUR zone is the 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, this paper has analyzed the global trends of trilemma combinations over the past 50 years and their differences between advanced and emerging & developing economies as well

as among emerging & developing regions, by presenting the combinations in trilemma triangles. The index of exchange rate stability has been measured by the root mean square error (RMSE) of the Frankel-Wei and/or Kawai-Pontines regression equation. The degree of financial market openness has been measured by the ratios of the sum of each country's external assets and liabilities to GDP and to trade. The degree of monetary policy independence has been indicated by the extent to which countries' short-term interest rates respond to foreign interest rates and/or domestic variables (GDP gaps and inflation rates). Since any of the trilemma indexes ranged between 0 and 1, the three indexes have been adjusted so that their sum equals 2.

The analysis of trilemma combinations has demonstrated that countries in the world, with some exceptions, have generally moved in the direction of greater exchange rate flexibility and more open financial markets, particularly in emerging & developing regions. Advanced economies, which include countries with exceptional exchange rate stability, can be divided into three types. The first type includes countries such as Iceland, Japan, and Norway, which have achieved a "corner regime" (the top of the triangle), maintaining high levels of exchange rate flexibility, financial market openness, and monetary policy independence. The second includes Euro Area countries that pursue a different "corner regime" (the right-bottom corner of the triangle) with high levels of exchange rate stability and financial market openness but no monetary policy independence. The third includes such countries as Israel, Singapore, and Sweden that opt for a "middle ground" with some degrees of exchange rate stability, financial market openness, and monetary policy independence. There is no advanced economy that adopts the remaining "corner regime" (the left-bottom corner of the triangle) of maintaining a high degree of exchange rate stability, closed financial markets, and monetary policy independence.

Emerging & developing countries have steadily increased their exchange rate flexibility and financial market openness. In the 1970s and 1980s, most of them adopted a "corner regime" (the left-bottom corner of the triangle), or a regime close to it, of retaining monetary policy independence under relatively stable exchange rates and strict capital and exchange controls. While many emerging & developing economies still maintained this corner regime during the 1990s and 2000s, some countries subsequently increased their exchange rate flexibility, a trend that has intensified since 2010. In the most recent period, emerging & developing countries can be divided into three types. The first includes Argentina, Brazil, Russia, South Africa, and Turkey that adopt the "corner regime" (the top corner) of maintaining a free exchange rate float and open financial markets. The second includes such countries as Algeria, Bangladesh, and Romania that are still stick to the traditional "corner regime" (the left-bottom corner). The third includes China, Egypt, India, Indonesia, Pakistan, and Thailand, which take

non-corner regimes including the "middle ground" of maintaining some degrees of exchange rate stability, financial market openness, and monetary policy independence. Interestingly, few emerging & developing countries today adopt the remaining "corner regime" (the right-bottom corner).

In Asia, diverse trilemma regimes coexist today. Japan has long achieved the "corner regime" (the top corner of the triangle) of maintaining monetary policy independence under freely floating exchange rates and open financial markets. The ROK, Indonesia, Malaysia, and the Philippines appear to be approaching this corner over time. Singapore has attained the "middle ground" of maintaining some degrees of the three policy frameworks. China has long kept another "corner regime" (left-bottom corner) of maintaining monetary policy independence under stable exchange rates and a closed financial market until recently, 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 openness. Hong Kong has long kept the remaining "corner regime" (right-bottom corner) of preserving fixed exchange rates and an open financial market and abandoning monetary policy independence, but in recent years it appears shifting toward the "middle ground" by allowing some monetary policy independence.

Finally, this paper has compared and evaluated macroeconomic performance under ten different trilemma regimes. The analysis has revealed that there is no common trilemma regime that guarantees the best macroeconomic performance 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, one of the "corner regimes" (the left-bottom corner of the triangle) of maintaining monetary policy independence under stable exchange rates and closed financial markets performs well for emerging & developing countries, but performs badly for advanced economies. Another "corner regime" (the top corner) of free floating exchange rates with open financial markets yields neutral macroeconomic outcomes for advanced economies, but worst outcomes for emerging & developing economies. Interestingly, the "middle ground" regime does not produce good outcomes for either advanced or emerging & developing economies.

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 exchange rate stability, the methodology first introduced by Haldane and Hall (1991) and popularized by Frankel and Wei (1994) is employed.[19] Frankel and Wei (1994) investigated the extent of influence of major currencies on the exchange rate of country *j* using the following estimation model:

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

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.[20] The currencies included in the right-hand side of the estimation equation, such as the US dollar, the euro (or the Deutsche mark before 1999), the British pound, and the yen, can be thought of comprising an implicit basket of major currencies in the mind of monetary authorities. Therefore, $\hat{\beta}_{kjt}$, 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 currency *i* is pegged to a major currency or a basket of major currencies, it must be either $\hat{\beta}_{kjt} = 1$ or $\sum_{k=1}^{K'} \hat{\beta}_{kjt} = 1$ 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.[21]

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 countries and over time. The major currencies included in the estimation equation are often held by monetary authorities as

[19] Haldane and Hall (1991) applied their technique to sterling over a period that included both Bank of England management and relatively free floating, while FW (1996) 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), and Ito and Kawai (2021).

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

[21] The constraint of $\sum_{k=1}^{K} \hat{\beta}_{kjt} = 1$ 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.

foreign exchange reserves. In the years before the introduction of the euro in 1999, the Deutsche mark is included in place of the euro. For the former French or Belgian colony countries, the French franc and Belgian franc were the target currencies for exchange rate stabilization, respectively, but the Deutsche mark is used instead of the francs.[22]

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.[23] In other words, $\hat{\beta}_{kjt}$'s, the weights of the major currencies in the implicit basket become time-varying because it is assumed that monetary authorities 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 no question that the RMB has become a major anchor currency in the sense of influencing the movements of a number of countries' exchange rates together with other major currencies.[24] However, merely including the exchange rate movements of the RMB in equation (1) would be problematic. The RMB used to be pegged to the US dollar 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 the four other major currencies, using 36-month windows, as follows:

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

The estimation of equation (2) provides the estimated residual, $\hat{\omega}_{jt}$, as:

$$\hat{\omega}_{jt} = \Delta ln\left(\frac{RMB}{NZD}\right)_t - [\,\hat{\phi}_{0jt} + \hat{\phi}_{1jt}\Delta ln\left(\frac{USD}{NZD}\right)_t + \hat{\phi}_{2jt}\Delta ln\left(\frac{EUR}{NZD}\right)_t + \hat{\phi}_{3jt}\Delta ln\left(\frac{GBP}{NZD}\right)_t + \hat{\phi}_{4jt}\Delta ln\left(\frac{JPY}{NZD}\right)_t\,] \quad (3)$$

Thus, the estimated residual, $\hat{\omega}_{jt}$, removes that part of the RMB movement that is affected by

[22] 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 sample 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.
[23] As a result, the estimation results for every 3 years would become the same as the results using non-overlapping 3-year panels.
[24] See Kawai and Pontines (2015), Ito (2017), Ito and McCauley (2017), Tovar and Nor (2018), and Ito and Kawai (2021).

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

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

One may consider estimating equation (4), but doing so does not necessarily yield good results, so Kawai and Pontines (2026) propose to estimate the following equation by subtracting $\widehat{\omega}_{jt}$ from both sides of equation (4). This estimation yields results that are more robust, stable and accurate.

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

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 of 1999. Before that period, the rolling regressions do not include the RMB, so the constraint becomes: $\gamma_1 + \gamma_2 + \gamma_3 + \gamma_4 = 1$.

The RMSE for the exchange rate stability index

The root mean square error (RMSE) is chosen as a measure of exchange rate stability, because the RMSE reflects how tightly monetary authorities stabilize or manage exchange rates against 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 (4) are time-varying (with 36-month windows), so is the RMSE.[25] The annual average of the time-varying RMSE is used to measure the level of exchange rate stability (*ERS*).[26]

This paper also construct indexes for exchange rate stability for major currencies other than the U.S. dollar. For the euro, U.K. pound, and Japanese yen, the RMSEs are obtained by regressing each exchange rate only on the U.S. dollar 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. In all cases,

[25] In a similar context, Kawai and Akiyama (1998) chose the standard error of a regression similar to equation (1) and Ito and Kawai (2012, 2014) used the adjusted R^2 instead.

[26] 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.

the Frankel-Wei regression equation is used. For the U.S. dollar, which is treated as the world's most important anchor currency, an index for its exchange rate stability is not constructed.

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 face exchange rate *flexibility.* To make use of RMSE to construct the measure of exchange rate *stability,* convert RMSE is converted as follows:

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

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

I-2: Financial market openness

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

Lane and Milesi-Ferretti normalize the sum of "total assets" and "total liabilities" as ratios of GDP and total trade volume (that is, exports plus imports) and use these ratios as the measures of financial openness. In this paper, several modifications are made. First, normalizing assets and liabilities as ratios of GDP and trade has both merits and demerits, so this paper uses the average of these two ratios.[27]

Second, including foreign exchange reserves as part of total assets for the purpose of creating an index of financial market openness can be problematic because official investment by monetary authorities should not be treated in the same way as private investment. One can think about China and other East Asian economies, which may appear as "financially open" if their massive foreign exchange reserves are included as part of their total assets, when in fact

[27] Normalizing the sum of total assets and liabilities as a ratio of GDP would make the financial openness index susceptive to business cycles. Also, it would make the index appear unnecessarily low for large economies such as the U.S. 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 U.S. which has presumably one of the most open financial markets in the world. Normalizing the sum of total assets and liabilities as a ratio of total trade volume, on the other hand, would make the index of financial openness less susceptive to business cycles and help correct distortions arising from the country being a financial center. It, however, tends to penalize too harshly economies that are highly open to international trade such as Singapore.

they have tight controls on international capital flows.

Third, the index of financial market openness based on total external assets and liabilities tends to have an explosive path, which needs to be addressed. Indeed, Quinn, et. al. (2010) show that the index 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 financial market openness that falls between 0 and 1.

Given these observations, the index of financial market openness is constructed in the following way. First, calculate two indexes of financial market openness are calculated in a way similar to Lane and Milesi-Ferretti 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 defined. That is,

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

Then, advanced economies are assumed as a group to have achieved full financial market openness as of the late 1990s. Using this assumption, the financial market openness index for advanced economies in the period from 1995 to 1999 is calculated as FMO_1_{ADV} and regarded as the highest level of financial market openness.[28] Finally, FMO_1_{jt} obtained from (7) is normalized as a ratio of FMO_{ADV}, which defines the financial market openness (FMO) index as follows:[29]

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

Essentially, the FMO index is a de facto measure, not a de jure index as has been developed by Chinn and Ito (2008), and ranges between the value zero (lowest degree of financial market openness) and one (highest degree).

I-3: Monetary policy independence

To construct the index of monetary policy independence, the following estimation models for the short-term interest rate in country *j* are considered:

[28] Luxembourg is excluded from the calculation since it is an extreme outlier due to its role as an international financial center. The *de jure* index 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.

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

$$\Delta i_{jt|t-12} = \varphi_{jyt}\tilde{y}_{jt} + \varphi_{j\pi t}\tilde{\pi}_{jt} + \varphi_{jy_Gt}y_{Gt} + \varphi_{joil\pi t}oil\pi_{jt} + D_j'\Phi_D + \varepsilon_{jt} \quad (9)$$

$$\Delta i_{jt|t-12} = \gamma_{jt}\Delta i*_{jt|t-12} + D_j'\Phi_D + \upsilon_{jt} \quad (10)$$

$$\Delta i_{jt|t-12} = \gamma_{jt}\Delta i*_{jt|t-12} + \varphi_{jyt}\tilde{y}_{jt} + \varphi_{j\pi t}\tilde{\pi}_{jt} + \varphi_{jy_Gt}y_{Gt} + \varphi_{joil\pi t}oil\pi_{jt} + D_j'\Phi_D + \nu_{jt} \quad (11)$$

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

where $\Delta i_{jt|t-12}$ and $\Delta i*_{jt|t-12}$ refer to the changes in the domestic and foreign short-term interest rates, respectively, over a 12-month period;[30] $\tilde{y}_{jt}$ 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) countries); $oil\pi_{jt}$ 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.[31]

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 foreign economic conditions (foreign output and oil prices). Inclusion of the domestic output and inflation gaps in (9) is supposed to control for the domestic conditions monetary authorities in country *j* would consider in setting the policy interest rate, 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 4 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). Dummies D are also included in equation (10). 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 foreign economic conditions.

To define the measure of monetary policy independence, the explanatory powers, represented

[30] 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 adjusted R^2. Second and more importantly, estimating the equation using month-to-month changes is essentially the same as assuming that the home country must react to a change in the foreign interest rate *i** within one month, which may be too restrictive an assumption.

[31] 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.

by the R^2's, of equations (9), (10) and (11) are used. That is, if the domestic monetary authorities set the domestic 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 domestic authorities are judged to have monetary policy independence. On the other hand, if the domestic monetary authorities closely follow the monetary policy of the countries included in the currency basket, the goodness of fit of equation (10) must be high, which means domestic monetary policy is *de*pendent on the (weighted average) monetary policy of the major countries, and the authorities do not have monetary policy independence.

Using these estimation models and focusing on their R^2's, the following two types of measures for the level of monetary policy independence 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 foreign 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 monetary policy independence. 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 lower the second term of equation (14) is. Hence, the higher the value of *MPI*_2 is, the higher the level of monetary policy independence.

To decide which measure to choose between (13) and (14), the following approach is adopted for each sample country. First, if the adjusted R^2 of equation (9) is sufficiently greater than that of equation (10), then *MPI*_1 is chosen as 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. 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.[32]

[32] 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 the two MPI measures is chosen as the MPI index.

Appendix II: Country List and Trilemma Index Data Availability

	Country Name	cn	AE	EMMIE	LIC	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
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; LIC= low income country; and MPI = monetary policy independence.

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