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New Measures of the Trilemma Hypothesis: Implications for Asia

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Abstract

We develop a new set of indexes of exchange rate stability, monetary policy independence, and financial market openness as the metrics for the trilemma hypothesis. In our exploration, we take a different and more nuanced approach than the previous indexes developed by Aizenman, Chinn, and Ito (2008). We show that the new indexes add up to the value two, supporting the trilemma hypothesis. We locate our sample economies' policy mixes in the famous trilemma triangle—a useful and intuitive way to illustrate the state and evolution of policy mixes. We also examine if the persistent deviation of the sum of the three indexes from the value two indicates an unsustainable policy mix and therefore needs to be corrected by economic disruptions such as economic and financial crises. We obtain several findings. First, such a persistent deviation can occur particularly in emerging economies that later experience an inflation (or potentially a general or a currency) crisis, and dissipates in the postcrisis period. Second, there is no evidence for this type of association between deviations from the trilemma constraint and general, banking, or debt crises. Third, Thailand experienced such a deviation from the trilemma constraint in the period leading to the baht crisis of 1997, but not other East and Southeast Asian economies. This last result suggests that the main cause for the Thai baht crisis was an unsustainable policy mix in the precrisis period, while other affected economies experienced crises mainly due to contagion from Thailand.

JEL Classification: F15, F 21, F31, F36, F41, O24

Contents

1. INTRODUCTION

Facing a fragile recovery of the world economy from the global financial crisis of 2008–2009, policymakers around the globe are contemplating what would be an optimal mix of open macroeconomic policies that are effective enough to guide their economies to stable and sustainable economic development.

As of this writing, almost four years since the breakout of the crisis, the world economy is still full of unstable factors. Generally, the developed economies only show feeble, if any, recovery while the developing and emerging economies are performing well. The Greek debt and banking crisis are affecting other southern European economies such as Italy, Portugal, and Spain and posing threats to the euro area as a whole. The United States (US) economy is experiencing its own debt problem and "jobless recovery," unable to wipe out the possibility of a double-dip recession. The Japanese economy has been hit by the March 2011 triple disaster of the earthquake, tsunami, and nuclear plant failure and faces the challenge of generating sustained growth to cope with the population shrinking, an aging society, and the high public debt problem.

Unlike the Asian financial crisis of 1997–1998 or the Latin American debt crisis in the 1980s, developing and emerging economies are not facing a crisis of their own. Although they experienced a tsunami of crisis in 2008–2009 mainly through international financial and trade channels, in retrospect, the global financial crisis only dented the growth of developing and emerging economies.

However, the better performance of emerging economies, particularly those in Asia, could slip out of hand if the economic conditions in the euro area and the US deteriorate significantly. Many emerging economies have been experiencing volatile capital flows: large capital outflows due to US and European banking sector difficulties, causing shortages of international liquidity and sharp currency depreciation; and large capital inflows due to unusually lax monetary policy taken by developed economies' central banks, causing upward pressure both on their currency values and on the level of asset prices. Whether they deteriorate or recover, developed economies can rapidly change the direction of international capital flows, possibly causing disruptions in the capital markets of emerging economies. In short, regardless of what happens in the world, policymakers must think about how to keep their economies immune from the unstable parts of the world and sustain stable economic growth. Their task, however, is complex in such a globalized environment.

Despite the complexity of policy management, monetary authorities face a simple, old theoretical constraint, called the "impossible trinity," or "trilemma." This hypothesis, first made popular by Mundell (1963), states that a country may simultaneously choose any two, but not all, of the three goals of monetary policy independence, exchange rate stability, and financial market openness to the full extent. This hypothesis has been widely taught and recognized

since it is intuitive and helpful to understand the constraints policymakers face in an open economy setting.

Though recognized pervasively, the hypothesis has not been subjected to rigorous empirical scrutiny until recently. The main reason for that is because it is quite difficult to create systematic metrics that measure the extent of achievement in the three policy goals of the trilemma. If one does not know to what extent each of the policy choices has been achieved, it is difficult to understand the extent of other policy choices available.

Aizenman, Chinn, and Ito (2008) developed a set of "trilemma indexes" that measure the degree of achievement of the three policy choices for a wide coverage of countries and periods. Using the indexes, they empirically supported the hypothesis by showing that the three measures of the trilemma are linearly related to each other.

Although their indexes cover many countries and years, the systematic approach they employ to get a wider country coverage may have sacrificed some nuances, potentially exposing the metrics to debate. While there cannot be "perfect metrics" that depict the state of policy implementations with decent precisions and subtlety, the bottom line is that this sort of exercise must be an endless exploration for economists.

We join this exploration and develop a set of new indexes that measure the extent of exchange rate stability, monetary policy independence, and financial market openness. In our exploration, we take different, and more nuanced and detailed methodologies than Aizenman, Chinn, and Ito (2008), while building on the past literature and hopefully overcoming the weaknesses of the indexes developed previously. However, our efforts of aiming for a higher level of subtlety for the indexes come with a cost: the coverage of countries is smaller. The indexes are available for about 90 countries for 1970–2009 as those for developing and emerging economies tend to be missing in early years.

Once we construct the new indexes, we test if the indexes are consistent with the trilemma hypothesis, that is, if the indexes are linearly dependent with each other. Given that we normalize the indexes in such a way that each takes a value between zero and one, we can test the linearity by examining whether the sum of the three indexes is statistically different from the value of two. Our results show that policymakers do face the linear constraint of the three policy choices as theory suggests.

Extending this exercise, we also plot the policy mixes of our sample economies in the famous trilemma triangle, which is often illustrated in textbooks on international macroeconomics and is an intuitive way of showing how monetary authorities face the trade-off of choosing a mix of the three policies while having to stay inside the triangle. We believe that this attempt—to show the policy mix in the trilemma triangle using actual metrics of the three policy choices instead of drawing the triangle abstractly—is the first in the literature of international macroeconomics. The triangle that exhibits a combination of policy choices turns out to be

useful in illustrating the state of an economy's policy mix at a given moment in time and its evolution over time.

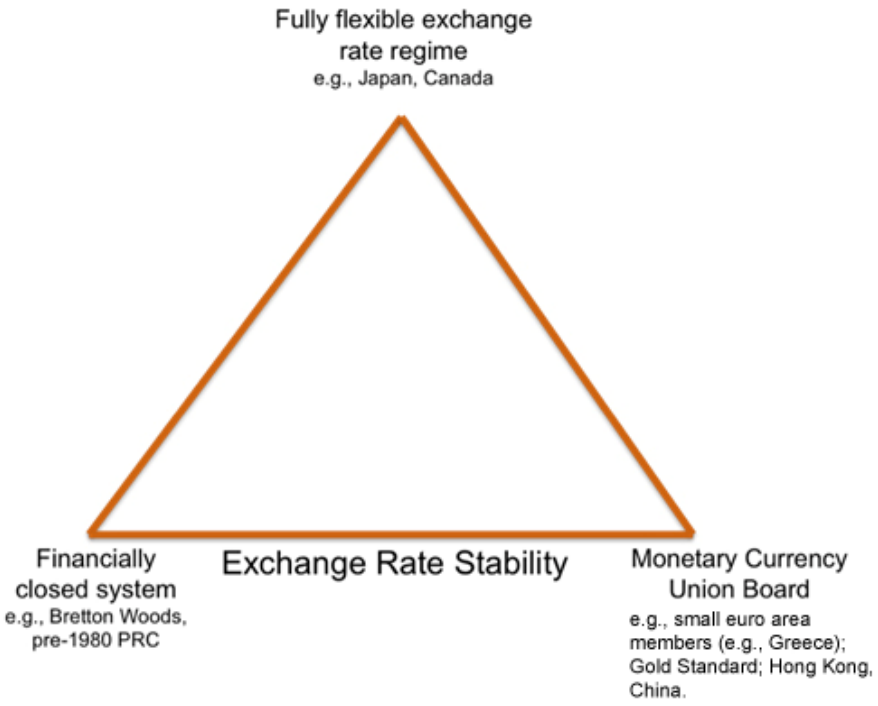
Although we show that the sum of the three indexes adds up to two *on average* for each economy, we do not exclude the possibility of the sum deviating from the value of two for a certain period. Conceptually, we could assume that if the sum of the three indexes exceeds the value of two for an extended period, such a policy combination is unsustainable. Furthermore, such an unsustainable combination of policies—if not addressed by policy actions—would be corrected by market forces through economic disruptions such as a currency crisis. We show how the sum of the three indexes behaves for a group of Asian economies at the time of the Asian financial crisis.

In what follows, we review the trilemma hypothesis in Section 2. In Section 3, we define our indexes of the trilemma by carefully discussing the methodologies for constructing the indexes. We also look into the linearity of the indexes by examining whether the sum of the three indexes statistically equals the value two. In Section 4, we make observations of the indexes for selected countries and country groups by plotting combinations of the three indexes in the famous trilemma triangle. In Section 5, we examine how the sum of the three indexes evolved for all economies over different types of crises as well as for Asian economies in the period before and after the time of the Asian financial crisis. In Section 6, we conclude the main findings of the paper and discuss future research agendas.

2. THE HYPOTHESIS OF THE "IMPOSSIBLE TRINITY" OR THE "TRILEMMA"

The trilemma is often illustrated using an equilateral triangle like the one shown in Figure 1. Each of the three sides represents monetary policy independence, exchange rate stability, and financial market openness. Starting from one corner, as we move vertically toward one of the three sides, we would achieve a higher degree of the outcome represented by that side. In other words, we can stand on one of the three sides only when we achieve the full extent of a policy, represented by the side. Hence, although it is possible to achieve the full extent of two policy goals, i.e., standing on one corner in the triangle, it is impossible to be on all the three sides simultaneously. The fact that a country may simultaneously choose any two, but not all, of the three goals of monetary policy independence, exchange rate stability, and financial market openness to the full extent signifies the trilemma. The top vertex in the triangle illustrated in the figure, labeled "fully flexible exchange rate regime," is, for example, associated with the full extent of monetary policy independence and financial market openness, and not exchange rate stability.

Figure 1: The Trilemma Triangle



Note: PRC = People's Republic of China.

Source: Compiled by the 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 policy to achieve one particular side without achieving any of the remaining two, in which case one of the goals is fully achieved and the other two goals are achieved only partially. Or a country can implement a policy combination represented by a "dot" inside the triangle, in which case the extent of achievement in the three goals can be measured by the vertical distance from a vertex to the dot—see the dot inside the equilateral triangle shown in Figure A2-1, which represents a policy combination of (a, b, c). In this case, any dot inside the triangle lies on the plane represented by the triangle. Hence, once two of the three distances from the

corners are determined, that would automatically determine the last one, that is, the one that would be sufficient to determine the whole policy combination.

The People's Republic of China (PRC) is a good example of a country represented by a "corner solution" initially, achieving a "side" afterwards, and a "dot inside the triangle" later. In the triangle of Figure 1, the PRC before 1980 could be shown as the country with the policy combination represented by the bottom left corner (that is, a financially closed system). When it started to open up its capital account in a cautious and step-by-step manner, the policy combination began to gradually move from the corner horizontally toward the right. Since the government exited from the dollar peg and gradually introduced some exchange rate flexibility in July 2005, the country's position in the triangle has been drifting toward the center, showing the possibility of either an increasingly open financial market with limited monetary policy independence or limited financial market openness with an increasingly independent monetary policy.

Thus, the trilemma is "binding" as long as the measures of the three policy choices are linearly related to each other, that is, as long as the dot is either on one of the three sides or inside the triangle. However, the fact that economies have adopted different policy combinations over time must mean that each of the three policy choices is an assortment of both merits and demerits for managing macroeconomic conditions.

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, Chinn, and Ito 2012). 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.[1] 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

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

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.

3. NEW MEASURES FOR THE TRILEMMA HYPOTHESIS

Aizenman, Chinn, and Ito (2008) developed a set of the "trilemma indexes" that measure the degree of three policy choices monetary authorities make with respect to the trilemma. Their most recent dataset covers more than 170 countries for 1970 to 2010 (Aizenman, Chinn, and Ito (2012b). The monetary policy independence index is based on the correlation of a country's interest rates with the base country's interest rate.[2] The index for exchange rate stability is an inversion of the exchange rate volatility, that is, a standard deviation of the monthly rate of exchange rate depreciation, where the exchange rate is defined between the home and the base country. The degree of financial market openness is measured by the capital controls index developed by Chinn and Ito (2006).

While their systematic approach makes it possible for the indexes to cover a large number of countries, their simple approach may fail to depict the subtlety of the policy arrangements. First, it can be argued that simple correlations for the monetary policy independence index may be spurious if they are not properly controlled. Or, if a country pegs its currency value to a basket of currencies, not to a particular base country currency, standard deviations of a simple pair-wise exchange rate may not reflect the reality of the exchange rate arrangement. Third, regulatory policies pertaining to international capital flows (*de jure* approach) may not reflect the actual degree of financial market openness, which can be captured by observed volumes of cross-border capital flows or by the price co-movements in financial assets including the interest rate parity (*de facto* approach).[3]

Responding to these limitations of the indexes used by Aizenman, Chinn, and Ito (2008; 2012a), we introduce new indexes of the trilemma. Naturally, while there are no such things as perfect measures of the three policy goals, we try to overcome the drawbacks of the previous indexes. Here, while basing our approaches on the methodologies introduced in the past literature and implementing theoretically reasonable methods, we attempt to create a set of indexes that may capture more subtleties of the aspects of the three policies in the trilemma hypothesis. The pursuit of more nuanced approaches, however, comes at the expense of a smaller coverage of countries. As Appendix 1 reports, the country list, for which we have the

[2] The base country is defined as the country that a home country's monetary policy is most closely linked with as in Shambaugh (2004); it is either Australia, Belgium, France, Germany, India, Malaysia, South Africa, the United Kingdom, or the US. More details on the construction of the indexes can be found in Aizenman, Chinn, and Ito. (2008).

[3] Quinn, Schindler, and Toyoda (2010) reviews a variety of indexes that measure the extent of financial market openness or capital controls.

indexes available, is shorter and includes only about 90 countries for 1970 to 2009. The reason is that the data needed to construct new measures are missing for developing and emerging economies in early years. We now explain the three indexes.

3.1 Exchange Rate Stability

To create an index that measures the degree of exchange rate stability, we employ the methodology first introduced by Frankel and Wei (1994). They investigate the extent of influence of major currencies in the Asian region using the following estimation model:

$$\Delta e_{it} = \alpha_i + \beta_{iUS}\Delta e_{US\,t} + \beta_{iJP}\Delta e_{JP\,t} + \ldots + \beta_{iK}\Delta e_{K\,t} + \varepsilon_{it}\,. \qquad (1)$$

where e_{kt} is the exchange rate of currency k (= i , *US*, *JP*, .., *K*) against some numéraire currency such as the Swiss franc and Special Drawing Rights (SDR). The currencies included in the right-hand side of the estimation equation, such as the US dollar, the yen, the Deutsche mark, the euro, or the British pound, can be thought of comprising an implicit basket of major currencies in the mind of monetary authorities. Therefore, $\hat{\beta}_k$, 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 $\hat{\beta}_k = 1$ or $\sum_{k=1}^{K'} \hat{\beta}_k = 1$ 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.[4]

To suit our purposes, we make several modifications to the Frankel and Wei estimation model. First, we apply the estimation model to each of our sample currencies, but estimate it over rolling windows of 36 months. In other words, $\hat{\beta}_k$'s, the weights of the major currencies in the implicit basket, become time-varying because we believe it is more realistic to assume that monetary authorities keep updating their information sets. Furthermore, to get more precise estimates, we conduct the estimation in two stages. That is, after running the initial estimation, the estimates whose *p*-values are greater than 20% are dropped from the estimation, which leaves only currencies with statistically significant estimates in the equation.[5] The estimates

[4] One may also consider imposing the constraint of $\sum_{k=1k}^{K'} \hat{\beta}_k = 1$ in the estimation. However, we decided not to do so. We would rather keep the estimation model as a general form because some currencies in our sample may have adopted fully flexible exchange rates which can be precluded by having the above constraint.

[5] When all of the right-hand side variables turn out to be statistically insignificant (with all the p-values greater than 20%), the currency that has the lowest p-value is retained in the estimation.

are now time-varying, so is the goodness of fit, or the adjusted R^2. We use the annual average of the time-varying adjusted R^2 as the measure of exchange rate stability (*ES*),[6] as in our analysis we focus on annual data observation.

The basic assumption of this exercise is that monetary authorities use an implicit basket of currencies as the portfolio of official foreign exchange reserves, but that the extent of response to the change in the value of the entire basket should vary over time and across countries. If the authorities want to maintain a certain level of exchange rate stability, whether against a single currency or a basket of several currencies, they should allow the currency value to adjust only in accordance with the change in the *entire* value of the basket of major currencies.[7]

As the explanatory variables in the estimation, we include the major currencies that are often held by monetary authorities as foreign exchange reserves, such as the US dollar, the British pound, the yen, and the euro. 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 or Belgian franc is included, respectively, instead of the Deutsche mark.[8]

3.2 Monetary Policy Independence

For the index on monetary policy independence, we consider the following simple estimation model:

$$i_{it} = \phi_i + \gamma_i i^*_{it} + u_{it} \ , \qquad (2)$$

[6] In a similar context, Kawai and Akiyama (1998) chose the standard error of a regression similar to equation (1).

[7] Even when the monetary authorities of a country adopt a floating exchange rate system, it is often the case that they usually have a target currency (which is the same as the "base country" in the context of Shambough 2004 and Aizenman, Chinn, and Ito 2008) in mind whose movement can affect the country's exchange rate. This target currency must be the currency that has the lowest p-value even if all the currencies on the right-hand side of the estimation are found statistically insignificant.

[8] Since Bhutan and Sri Lanka peg their currencies to the Indian rupee, the Indian rupee is also included in the estimation for these countries. For the same reason, the estimations equations for the currencies of Botswana, Lesotho, Namibia, and Swaziland include the South African rand as one of the right-hand side currencies. For several countries in the Pacific, the Australian dollar is included.

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, we include a dummy variable that takes the value of one in the first month after the introduction of the euro.

where, i^*_{it} is the "synthetic foreign interest rate," which is essentially the weighted average of the foreign interest rates, with the weights being the estimated $\hat{\beta}'s$ from the Frankel and Wei estimation given by equation (1). That is,

$$i^*_{it} = \hat{\beta}_{iUSt} i_{USt} + \hat{\beta}_{iJPt} i_{JPt} + \ldots + \hat{\beta}_{iKt} i_{Kt} \quad (3)$$

where we assume home monetary authorities consider a basket of *K* interest rates as the synthetic foreign interest rate.[9]

Similarly to the exchange rate estimation, we could use the adjusted R^2 of equation (2) for the measure of monetary policy independence.[10] However, merely the estimation based on equation (2) can be problematic for two reasons. First, either or both of i_{it} and i^*_{it} can be non-stationary, which makes γ_{it} spurious and, therefore, adjusted R^2 unreliable (Obstfeld, Shambaugh, and Taylor 2005). Second, a model like equation (2) can involve missing variable bias; it does not control for other factors that can affect the authorities' decisions on the policy interest rate, namely, domestic and global conditions. For example, when both the domestic and foreign authorities face common shocks, the estimated coefficient on the foreign interest rate could be spuriously significant and possibly close to one, even though the domestic authorities do not follow the foreign country's monetary policy.

Presuming that it is safe to assume non-stationarity in the interest rate level series,[11] and incorporating other factors, we modify equation (2) and consider the following 12-month difference estimation model:

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[9] Following the Frankel and Wei estimation for the exchange rate, only significant estimates (or the estimate that has the lowest p-value) are included.

[10] That is, if home country i closely follows the monetary policy of the countries included in the basket, the goodness of fit of equation (2) must be high (while γ_{it} should be close to the value of one), which means the home country's monetary policy is dependent on the (weighted average) monetary policy of the basket countries.

[11] Given the Fisher equation, the stationarity of the nominal interest rate series is conditional upon the stationarity of the expected rate of inflation series or that of the real interest rate series. Theoretically, it is difficult to argue the non-stationarity of the real interest rate, although the real interest rate series can involve structural breaks, causing non-stationarity in a statistical test (Huizinga and Mishkin 1984; Garcia and Perron 1996). Given the past

$$\Delta i_{it|t-12} = \gamma_{it}\Delta i^*_{it|t-12} + \phi_{iyt}\tilde{y}_{it} + \phi_{i\pi t}\tilde{\pi}_{it} + \phi_{iy_G t}y_{Gt} + \phi_{ioil\pi t}oil\pi_{it} + D_i'\Phi_D + \varepsilon_{it}, \quad (4)$$

where $\Delta i_{it|t-12}$ and $\Delta i^*_{it|t-12}$ refer to the change in the home and (synthetic) foreign interest rates, respectively, over a 12-month period.[12] Hence, we examine the correlation between the change in the home and foreign interest rates over a 12-month period. $\tilde{y}_{it}$ is a proxy of the output gap measured by the year-to-year growth rates of industrial production; $\tilde{\pi}_{it}$ is a proxy of the inflation gap, measured by the year-to-year consumer price index (CPI) inflation rates; 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 Brazil, Russia, India, and the PRC (BRIC countries); and $oil\pi_{it}$ is the year-to-year rate of change in the price of crude oil. Inclusion of $\tilde{y}_{it}$ and $\tilde{\pi}_{it}$ is supposed to control for the domestic conditions the monetary authorities in country *i* would consider in setting the policy interest rate so that equation (4) mimics the Taylor rule.[13] *D* is a vector of dummies to control for high- or hyper-inflation as well as for currency crises that are identified based on the often-used exchange market pressure (EMP) indexes first developed by Eichengreen, Rose, and Wyplosz (1995; 1996).[14]

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episodes of hyperinflation in many countries, the rate of inflation series can be non-stationary, as has been shown in many studies.

[12] We use the change in the policy rates over 12 months instead of month-to-month changes, that is, first-differences, 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 equation (2) in first-difference form 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.

[13] We do not necessarily assume all the countries in our sample follow the Taylor rule, as the domestic variables can be insignificant contributors to the decision-making of the policy rate in some countries.

[14] More specifically, we include 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. The currency crisis dummy takes the value of one when the EMP index exceeds the threshold of mean plus or minus 2 standard deviations of the index.

Along with equation (4), we also consider the following two other estimation equations:

$$\Delta i_{it|t-12} = \phi_{iyt}\tilde{y}_{it} + \phi_{i\pi t}\tilde{\pi}_{it} + \phi_{iy_G t}y_{Gt} + \phi_{ioil\pi t}oil\pi_{it} + D_i'\Phi_D + \varepsilon_{it} \quad (5)$$

$$\Delta i_{it|t-12} = \gamma_{it}\Delta i^*_{it|t-12} + D_i'\Phi_D + \varepsilon_{it} \quad (6)$$

Equation (5) is obtained by excluding the foreign interest rate from equation (4), while equation (6) is obtained by excluding the control variables that represent the domestic and global conditions from equation (4) though it still includes the vector of dummies. Using these estimation models and focusing on their adjusted R^2's, we come up with the following two types of measures for the level of monetary policy independence: [15]

$$MI\_1 = \frac{Adj.R^2 \text{ of Eq. } 5}{Adj.R^2 \text{ of Eq. } 4} \quad (7)$$

$$MI\_2 = 1 - \frac{Adj.R^2 \text{ of Eq. } 6}{Adj.R^2 \text{ of Eq. } 4} \quad (8)$$

The EMP index is constructed as the weighted average of monthly changes in the nominal exchange rate, the nominal interest rate, and foreign exchange reserves in percentage. The exchange rate is between the home currency and the currency of the base country (as defined in Shambaugh 2004). The changes in the nominal interest rate and foreign exchange reserves are included as the differentials from those of the "base country." For the countries whose base countries are not defined by Shambaugh (2004), we follow the definition made by Aizenman, Chinn and Ito (2008). The weights are inversely related to the variance of changes in each component for each of the sample countries. When we calculate the standard deviations of the EMP index for the threshold, we exclude the EMP values that are lower than the bottom one percentile or greater than the top one percentile because outliers of the EMP index can make the standard deviations unnecessarily large and thereby make the thresholds too unreliable for some countries, especially those which have experienced significant swings in their EMP indexes.

[15] A more straightforward way of measuring the extent of monetary policy dependence would be to use $\hat{\gamma}$ in equation (4). However, $\hat{\gamma}$ is found to be quite unstable (despite inclusion of the dummies). For some developing countries that have experienced episodes of high inflation, the estimated $\hat{\gamma}$ can easily surpass the value of one.

Here, *MI*_1 indicates that the higher this ratio is, the less explanatory power the foreign interest rate has in equation (4). Hence, the higher this ratio is, the higher the level of monetary policy independence. *MI*_2 is, on the other hand, based on the idea that the more the foreign interest rate explains the variation of the home interest rate, the closer the adjusted R^2 of equation (6) is to that of equation (4). Hence, the higher the value of *MI*_2 is, the higher the level of monetary policy independence.

The two measures of monetary policy independence above show the relative contributions the domestic and global conditions and the foreign interest rate make to explain the variation of the home interest rate. However, we need to be careful about which measure of monetary policy independence index (MI) to use. That is, the choice between *MI*_1 and *MI*_2 would be immaterial as they provide identical information only if the vector of domestic and global conditions and the foreign interest rate are completely independent from each other. That cannot be true in general as the domestic and foreign authorities may face similar shocks and react similarly to them. For example, when the domestic country is geographically close to the foreign country, thereby subject to similar shocks, the domestic authorities with full monetary policy independence could behave similarly to the foreign authorities and thus, may appear responding to the foreign interest rate. This means that even though equation (5) is the true specification, equation (6) could deliver a good fit because the foreign interest rate and the vector of domestic and global conditions could be highly correlated. On the other hand, even if equation (6) is the true specification, the goodness of fit of equation (5) could be high if domestic and global conditions on the right hand side of (5) are highly correlated with the foreign interest rate.

Hence, we take the following approach for each of our sample economies. We estimate both equations (5) and (6). First, if the adjusted R^2 of equation (5) is greater than that of equation (6), then we use *MI*_1 as in this case it is reasonable to conclude that the vector of domestic and global economic variables is not highly correlated with the foreign interest rate i^*. This procedure allows us to see how much additional explanatory power the foreign interest rate would have in equation (4) compared to equation (5), so *MI*_1 can be a good measure of monetary policy independence. Second, if the adjusted R^2 of equation (6) is greater than that of equation (5), then we use *MI*_2. In this case, we can see how much additional explanatory power the vector of domestic and global variables would have in equation (4) compared to equation (6). Finally, if the adjusted R^2's of equations (5) and (6) are sufficiently close to each other, we use the average of *MI*_1 and *MI*_2.[16]

[16] Specifically, we use the following rule: If the adjusted R2 of equation (5) is greater than the sum of the adjusted R2 of equation (6) and the standard error of the difference between the two adjusted R2's, then we take MI_1 as the MI index. If the adjusted R2 of equation (6) is greater than the sum of the adjusted R2 of equation (5) and the standard error of the difference between the two adjusted R2's, then we take MI_2 as the MI index. If the

3.3 Financial Market Openness

Here, we base our index of financial market openness on the *de facto* measure of financial openness developed by Lane and Milesi-Ferretti (2001; 2007; L-MF hereafter). L-MF compile the data for international investment positions for about 180 countries between 1970 and 2007. For each country, total assets are composed of foreign direct investment (FDI) assets, portfolio equity assets, debt assets (that is "debt equity" plus "other" investments such as bank loans and trade credit]), financial derivatives assets, and foreign exchange reserves, while total liabilities include FDI liabilities, portfolio equity liabilities, debt liabilities, and financial derivatives liabilities.

L-MF normalize the sum of "total assets" and "total liabilities" as ratios of gross domestic (GDP) and total trade volume (that is, exports plus imports) and use these ratios as the measures of financial openness. For our purpose, we observe the following points and consequently make several modifications. First, 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 US and make the one for an international financial center—such as Ireland; Luxemburg; Singapore; or Hong Kong, China—appear extremely high, much higher than that of the US 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. Hence, normalizing assets and liabilities as ratios of GDP and trade has both merits and demerits.

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 the PRC 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 they have tight controls on international capital flows.

Lastly, the index of financial openness based on the L-MF data may not be appropriate in the context of the trilemma hypothesis because the data seem to have an explosive trend. In fact, work by Quinn, Schindler, and Toyoda (2010) shows that the index series is non-stationary. Hence, there is a need to normalize and standardize the sum of total external assets and liabilities in both an economically and econometrically reasonable way.

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difference between the two adjusted R2's is within its standard error, then we use the average of the two MI indexes.

Given these observations, we create our index of financial market openness in the following way. We first calculate two indexes of financial market openness in a way similar to L-MF by normalizing the sum of external assets and liabilities, less official foreign exchange reserve assets, as ratios of GDP and total trade. We then take the average of the two. That is,

$$FO_{it} = \frac{1}{2}\left\{ \frac{\text{Total Assets}_{it} + \text{Total Liabilities}_{it} - \text{Official Reserve Assets}_{it}}{GDP_i} + \frac{\text{Total Assets}_{it} + \text{Total Liabilities}_{it} - \text{Official Reserve Assets}_{it}}{(EX + IM)_{it}} \right\}. \quad (9)$$

We finally assume that developed economies as a group achieved full financial market openness as of the late 1990s. Using this assumption, we calculate the financial market openness index for developed economies in the period from 1995 to 1999, define this as FO_{ADV}, and regard it as the highest level of financial market openness.[17] We normalize FO^* defined in (9) as a ratio of FO_{ADV} and define the index to be bound between zero and one.[18] That is,

$$FO_{it}^* = \frac{FO_{it}}{FO_{ADV}} \qquad \text{where } 0 < FO_{it}^* < 1 \quad (10)$$

In this way, our financial market openness index is a de facto measure, excluding official reserve assets, and ranges between zero and one.[19]

3.4 Technical Adjustments

In this exercise, our general approach is to "let the data speak themselves." However, while there is no theoretical basis for each of the three indexes to be normally distributed, we must also avoid any distorted or lopsided distribution given the need for each index to range

[17] We exclude Luxembourg from the calculation since it is an extreme outlier due to its role of 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.

[18] Any FOi* taking a value above one is assumed to be one.

[19] We also update the data on external assets and liabilities using the international investment positions data of the IMF's International Financial Statistics.

between zero and one. Based on this, we carefully examined the distribution of each index and identified the following two points. First, the index for exchange rate stability (ES) scarcely takes a value below 0.3. This can be driven by a statistical artifact of the estimation model that includes several dummy variables. We know that some developed economies hardly intervene in the foreign exchange markets, particularly in recent years, and this must mean that the exchange rate stability indexes for these economies are close to zero. Second, the index for financial market openness (FO) hardly falls below 0.1. Considering that we normalize actual volumes of external assets and liabilities (less foreign exchange reserves) by GDP and total trade, it is understandable for such a constructed index not to be close to zero. Even if the authorities ban international capital flows with regulatory controls, some cross-border capital flows do occur. However, we know that several economies have essentially closed financial markets, for which the financial market openness indexes must be zero.

To incorporate these two issues, we adjust the indexes for exchange rate stability and financial market openness as follows:

$ES_i^* = (ES_i - 0.30)/0.70$

$FO_i^{**} = (FO_i^* - 0.10)/0.90$

where ES and FO* are indexes constructed according to the procedure described previously.

These adjustments for ES and FO may create some downward bias in the new set of three trilemma indexes. As we discuss in the next subsection, in order for the indexes to have theoretical validity, the sum of the indexes must equal two, for which the newly created downward bias may be a little problematic. In fact, when we define $\overline{MI} + \overline{ES} + \overline{FO} = 2 \cdot A$, where $\overline{X} = \frac{1}{T}\frac{1}{I}\sum_{1}^{T}\sum_{1}^{I} X_{it}$, that is, the cross-country, cross-time average of variable X (= MI, ES, or FO), *A* is found to be smaller than 1.

Hence, we make a further adjustment to the set of the three indexes so that the sum of the indexes will not become far from theoretical predictions on the average over the entire sample. More specifically, we define the sum of the adjusted measures of exchange rate stability, monetary policy independence and financial market openness to be two by defining a new set of indexes as: X' = X/A where X = MI, ES, or FO.

4. ANALYSIS OF THE THREE INDEXES

4.1 Theoretical Validity of the New Indexes: Do They Add Up to Two?

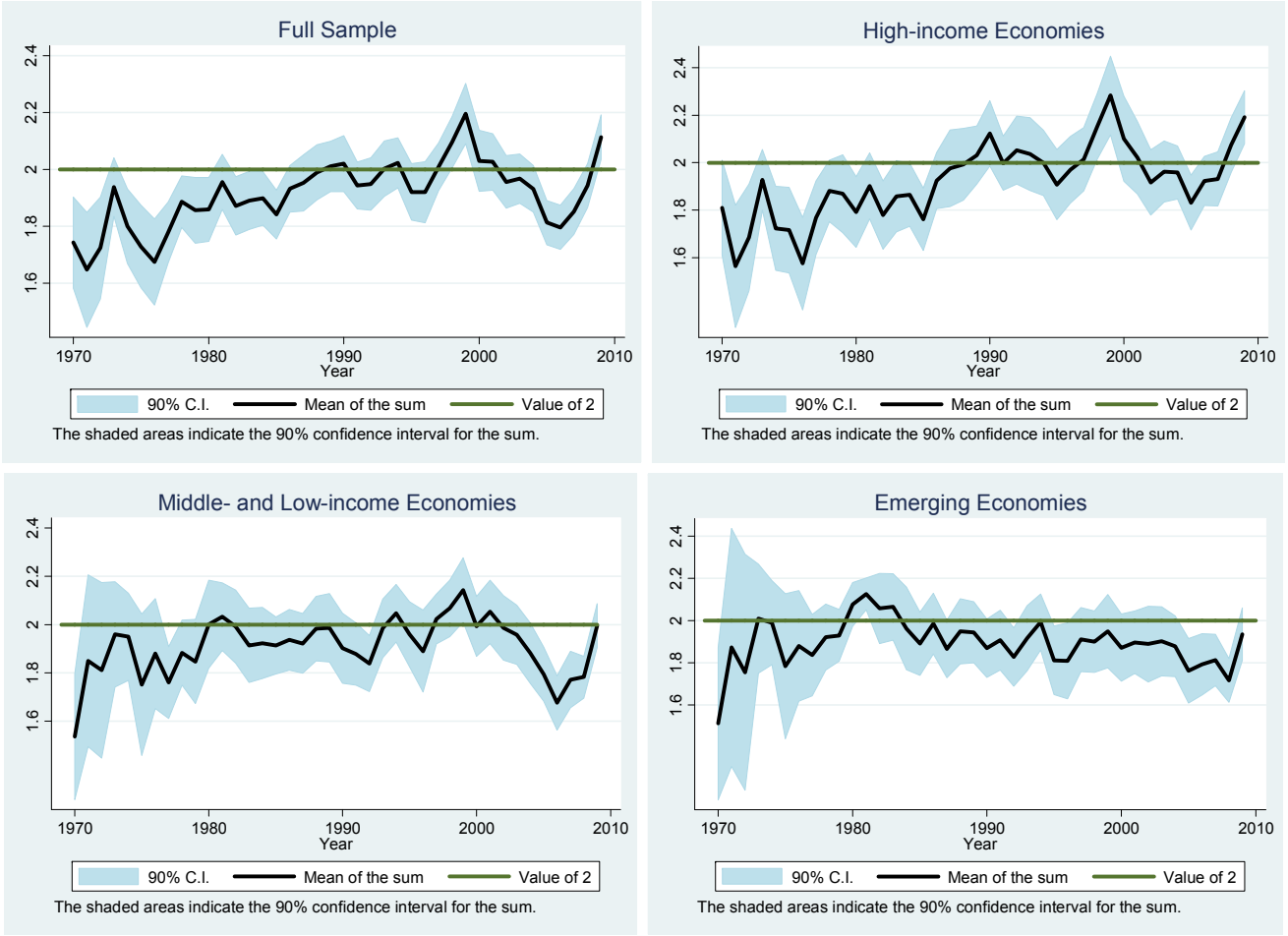
Before making observations of the newly defined indexes, we need to make sure that these indexes hold theoretical validity. Theory predicts that monetary authorities would have to face a trade-off of choosing two out of the three policy choices if they implement each to the full extent. If they do not implement any combination of two policies fully, they could achieve three policies partially. However, once they make policy choices in any two of the three areas, they cannot make an independent choice in the third area, as it is automatically determined. This means that the extent of achievement in the three choices must be linearly related to each other. As Appendix 2 shows, as long as we assume that the trilemma triangle is an equilateral triangle with the height of one, the three indexes must add up to two.

One may wonder if our exercise is tautological because we already made an adjustment to make the cross-time-country average of the three indexes equal to two. However, even if we make this adjustment, the sum of the three indexes is not guaranteed to be equal to two over a specific subsample period for a given country or country group, or across all countries in a given year. If the indexes are not in line with theoretical predictions, the sum of the three indexes could still deviate from the value of two in certain subsample countries and years even though the across-the-board average is two.

Figure 2 shows the evolution over time of the average sum of the three indexes for different income economy groups, that is, high-income, middle- and low-income, and emerging economies.[20] The shaded areas refer to the 90% confidence intervals of the mean of the sum. For the full sample, the sum is not statistically different from the value of two in the late 1980s, the first seven or so years of the 1990s, and the first several years of the 2000s. However, the sum deviates downward from the value two during most of the 1970s, the first half of the 1980s, and the mid-2000s, while it deviates upward from two in the late 2000s. So the sum of the three indexes for the full sample is not different from the value two in more than 50% of the

[20] "High-," "middle-," and "low-income" economy groups are based on the World Bank's classifications. "Emerging economies" refer to the economies included in the MSCI Emerging Markets Index. They are: Argentina; Brazil; Chile; the People's Republic of China; Colombia; Czech Republic; Egypt; Hungary; India; Indonesia; Israel; Jordan; Korea; Malaysia; Mexico; Morocco; Pakistan; Peru; Philippines; Poland; Russia; South Africa; Taipei,China; Thailand; Turkey; and Venezuela. See a list of 90 sample economies and their classifications in Appendix 1.

Figure 2: The Sum of the Three Indexes



Notes: The grouping of "high-," "middle-," and "low-income" economies is based on the World Bank's classifications. "Emerging economies" refer to the economies included in the MSCI Emerging Markets Index. They are Argentina; Brazil; Chile; the People's Republic of China; Colombia; Czech Republic; Egypt; Hungary; India; Indonesia; Israel; Jordan; the Republic of Korea (henceforth, Korea); Malaysia; Mexico; Morocco; Pakistan; Peru; Philippines; Poland; Russia; South Africa; Taipei,China; Thailand; Turkey; and Venezuela.

Source: Authors' estimations.

sample period. For high-income economies, the pattern of the sum of the three indexes is similar to that of the full sample, except that the sum is not statistically different from the value

of two during most of the 2000s. As a result, the sum is not different from two in more than 60% of the sample period. For the subgroups of middle- and low-income economies and emerging economies, the sum of the three indexes is not statistically different from two during most of the sample period, except that the sum for middle- and low-income economies exhibits a significant downward deviation from two during the 2000s. At any rate, the sum is not different from two in more than 85% of the sample period for these two subgroups of economies.

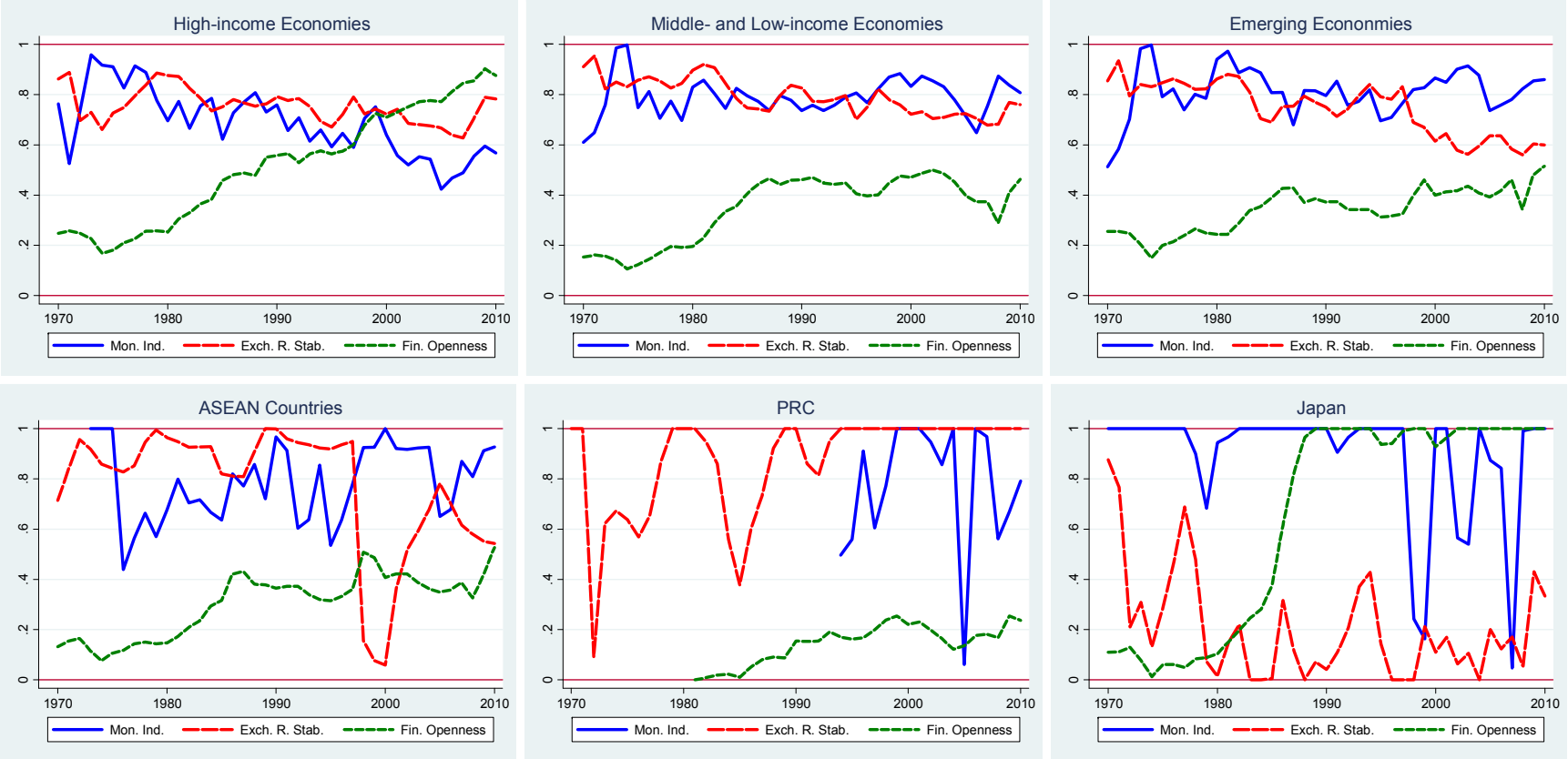
Overall, it is reasonable to conclude that the sum of the three indexes is largely close to the value of two, particularly for middle- and low-income economies and emerging economies, supporting the theoretical validity of the new indexes. However, the results suggest that the measurement of the three policy choices for high-income economies may contain some shortcomings. This however should not pose a problem to our analysis as we focus on middle- and low-income economies and emerging economies in the following sections.

4.2 Some Observations of the Indexes

Figure 3 illustrates the average value of each of the three indexes for different income and regional groups of economies. We observe that high-income economies have achieved significant financial market opening over the last forty years, starting from a low level comparable to those of the middle- and low-income economies and emerging economies in the 1970s to a very high level in the late 2000s. They also seem to have changed policy priorities from the combination of relatively high levels of exchange rate stability and monetary policy independence (with limited financial market openness) during the 1970s to that of slightly lesser exchange rate stability and lower monetary policy independence. The trend toward a lower degree of monetary policy independence for high-income economies is surprising, but this is largely because of the participation by a large number of European countries in the euro area. Essentially, most euro area countries chose to abandon monetary policy independence in favor of maintaining a degree of exchange rate stability.

Middle- and low-income economies have, on average, seen an increase in the level of financial market openness, which started with a low level, rose to an intermediate level in the 1980s, plateaued until the early 2000s, and fell slightly in the second half of the 2000s. They also pursued high levels of monetary policy independence and exchange rate stability over the sample period, with the level of exchange rate stability moderately declining as a trend over time.

Figure 3: Trilemma Indexes for Economy Groups



Notes: The groupings of "high-," "middle-," and "low-income" economies are based on the World Bank's classifications. "Emerging economies" refer to the economies included in the MSCI Emerging Markets Index. They are Argentina; Brazil; Chile; People's Republic of China; Colombia; Czech Republic; Egypt; Hungary; India; Indonesia; Israel; Jordan; Korea; Malaysia; Mexico; Morocco; Pakistan; Peru; Philippines; Poland; Russia; South Africa; Taipei,China; Thailand; Turkey; and Venezuela. ASEAN countries are Brunei Darussalam, Cambodia, Indonesia, Malaysia, Myanmar, Philippines, Singapore, Thailand, and Viet Nam (with the data for Lao People's Democratic Republic missing).

Source: Authors' estimations.

Emerging economies exhibit patterns similar to those of the middle- and low-income economies, except that their level of financial market openness has steadily risen to an intermediate level and their level of exchange rate stability has steadily declined as a trend. It is interesting to observe that they have maintained a relatively high level of monetary policy independence. In addition, emerging economies, on average, has chosen a smaller degree of exchange rate stability than other income-groups including high-income economies.

The development of the three indexes for the Association of Southeast Nations (ASEAN) economies is somewhat similar to that of the group of emerging economies, except that the level of exchange rate stability plummeted during the Asian financial crisis and for a few years in its aftermath. Interestingly, despite the loss of exchange rate stability in the immediate aftermath of the Asian financial crisis, emerging Asian economies seem to be regaining exchange rate stability as has been anecdotally discussed.[21] This seems to be accompanied by a sacrifice of monetary policy independence. Not surprisingly, these economies increased the level of monetary policy independence during both the Asian financial crisis and the global financial crisis, reflecting the stabilization efforts during the turmoil. The level of financial market openness has risen in two steps, one in the mid-1980s and another in the late 1990s. ASEAN economies appear different from other middle- and low-income economies and emerging economies in that they have been on a steady path for greater financial market openness, even in the aftermath of financial crises. Nonetheless, the level of financial market openness still lags behind other emerging economies such as those in Latin America, suggesting more room for further opening.

Not surprisingly, the two biggest economies in Asia—the PRC and Japan—appear to have cast distinctively different trajectories of open macro policy combinations. While the PRC has steadily pursued exchange rate stability especially since the beginning of the 1990s, Japan has adopted a flexible exchange rate regime since the breakdown of the Bretton Woods system in the early 1970s. Japan also started liberalizing its financial markets in the mid-1980s and completed its liberalization by the beginning of the 1990s. The PRC's financial liberalization efforts, on the other hand, have been minimal as has been argued anecdotally, appearing to still have much room for further financial liberalization. Since both economies are quite large, they have tended to pursue greater monetary independence for most of the (available) sample period.

[21] Emerging Asian economies include the PRC, Indonesia, Korea, Malaysia, the Philippines, Singapore, and Thailand.

4.3 The Trilemma Triangle

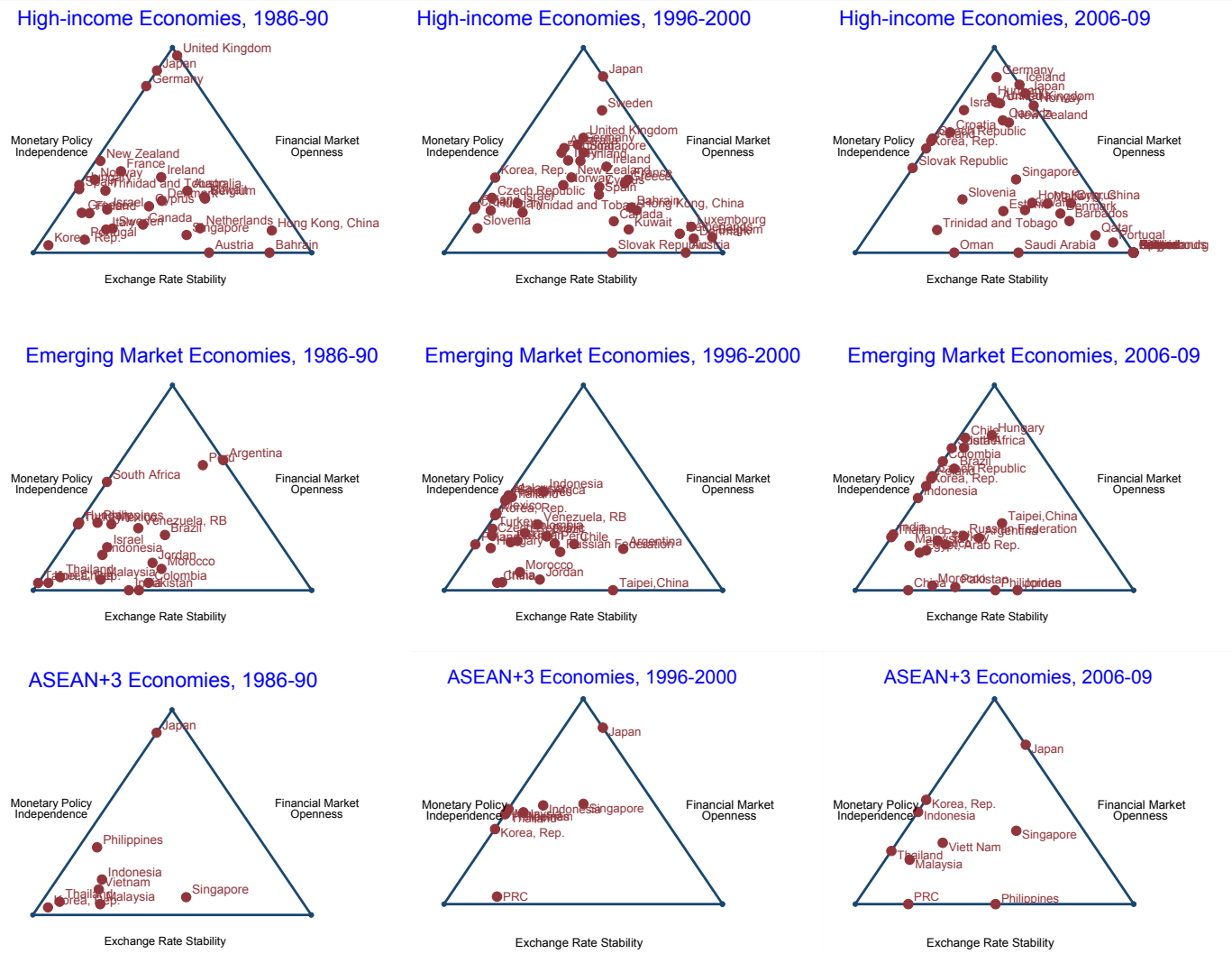
The most intuitive way of illustrating combinations of the three policies—monetary policy independence, exchange rate stability, and financial market openness—for a particular economy is to locate its policy combinations in the trilemma triangle shown in Figure 1.

However, to do this, the sum of the three policy indexes must *exactly* equal two for every year and every country. Although we have shown that the sum of the three indexes is statistically not different from the value of two particularly for middle- and low-income economies and emerging economies, it is often the case that the sum of the three indexes deviates from the value of two for a given economy and a certain period. Hence, we make an adjustment to ensure that the sum of the three indexes is equal to two for every country and every year as we spelled out in Appendix 2-2. Essentially, we divide each index by scalar B_{it} when $MI_{it} + ES_{it} + FO_{it} = 2B_{it}$, where subscript i refers to an economy and t a year.

With this adjustment, we are now able to show combinations of the three policies in the trilemma triangle using the metrics that represent the extent of actual achievement in the three policy goals. To our knowledge, plotting a combination of the three policies in a trilemma triangle is the first attempt in the literature of international macroeconomics.

Figure 4a shows the trilemma triangles with the converted three indexes for three five-year periods: 1986–1990, 1996–2000, and 2006–2009, and for different economy groups: high-income economies, emerging economies, and the ASEAN+3 economies (ASEAN plus the PRC, Japan, and the Republic of Korea [henceforth, Korea]). We can make several interesting observations. Generally speaking, while high-income economies used to have a wide variety of combinations of the three policies, these economies moved toward higher degrees of financial market openness over time. By the end of the 2000s, there are two types of high-income economies: one group composed of economies that have pursued higher levels of financial market openness and exchange rate stability, most notably the euro area economies, and the other composed of economies that have achieved greater degrees of monetary policy independence and financial market openness, with greater exchange rate flexibility, such as Germany, Iceland, Scandinavian countries, Japan, and Australia.

Figure 4a: Trilemma Triangle—Economy Groups



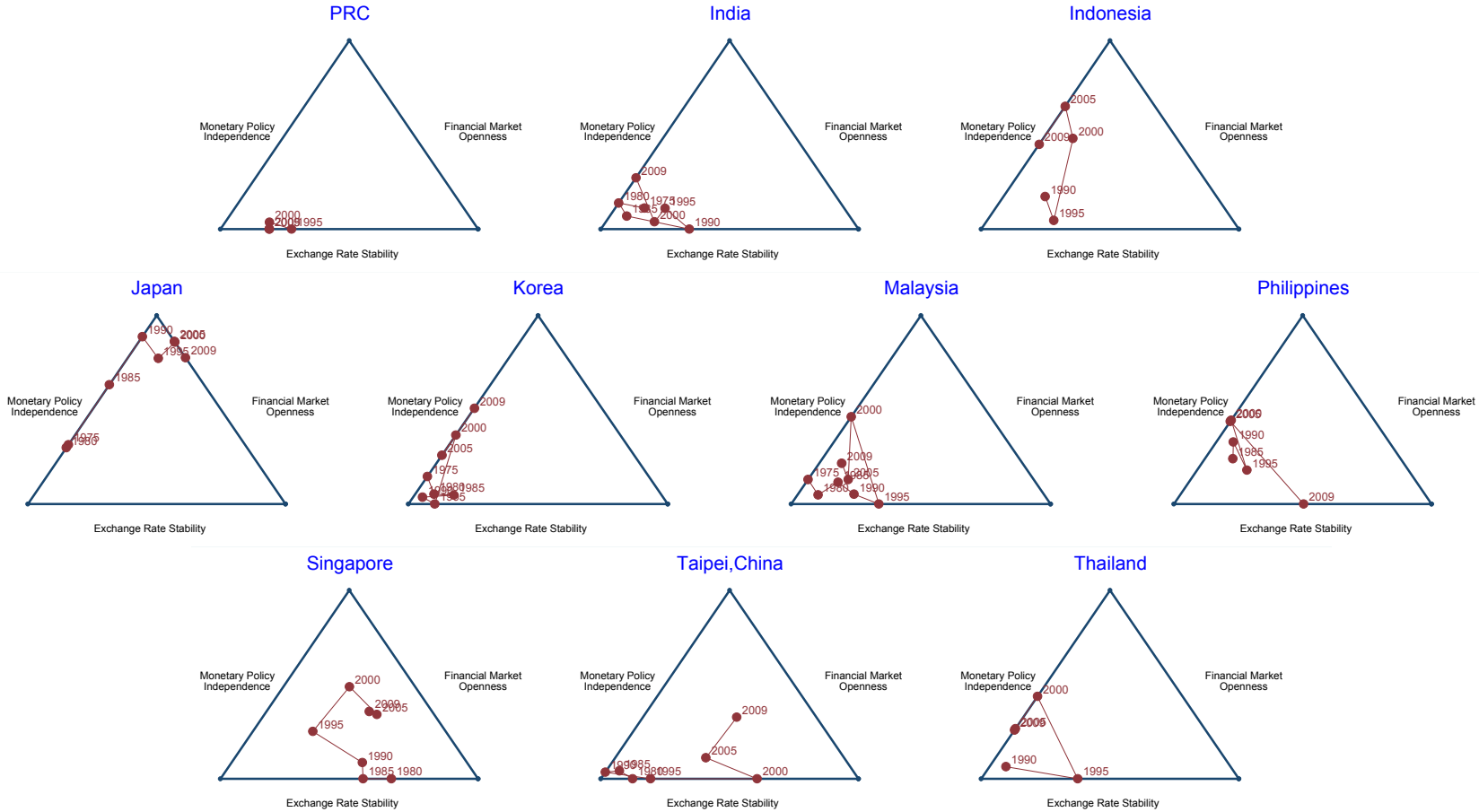
Source: Authors' estimations.

While most of the high-income economies have steadily increased the level of financial market openness, this is not generally the case for emerging economies. As in the second half of the 2000s, three groups of emerging economies are noticeable: one group composed of economies with full monetary policy independence but with varying degrees of exchange rate stability and financial market openness; the second group with full exchange rate stability but with varying degrees of monetary policy independence and financial market openness; and the third with intermediate levels in all three policy choices.

Among the ASEAN+3 economies, starting from the combination of relatively stable exchange rates and relatively independent monetary policy, that is, the left-bottom corner of the triangle, many economies tried to retain monetary policy independence while giving up exchange rate stability to some degree, partly reflecting the abortion of fixed exchange rate regimes in the aftermath of the Asian financial crisis. As of the last few years, there seems to be a wider variety of policy combinations among the ASEAN+3 economies with some clustering in the middle of the triangle.

Figure 4b illustrates the trilemma triangles for individual economies in Asia. The values of the trilemma indexes are five-year averages, and the year in the triangle refers to the last year of the five-year periods. As has been discussed widely, we can confirm that the PRC has maintained high levels of exchange rate stability and monetary policy independence, by limiting financial market openness. Despite the government's announcement to increase the level of exchange rate flexibility in 2005, the triangle plot suggests that the country has retained *de facto* rigid fixed exchange rates without significant openness of its financial market. Other Asian economies, on the other hand, seem to have reduced the level of exchange rate stability after the Asian financial crisis though they also seem to have continued to retain monetary policy independence. Emerging Asian economies do not appear to have been as financially open as has been discussed. Interestingly, many Southeast Asian economies appear to have increased the level of exchange rate stability in the last period without much increasing the level of financial market openness.

Figure 4b: Trilemma Triangle—Individual Asian Economies



Source: Authors' estimations.

5. CRISES AND THE TRILEMMA

Although the three indexes of the trilemma hypothesis must add up to two, in reality, actual policy arrangements of exchange rate stability, monetary policy independence, and financial market openness may deviate from the theoretical linear constraint. Anecdotally, we sometimes observe monetary authorities trying to implement an "inconsistent" policy that violates the trilemma constraint. For example, authorities of an economy experiencing large capital inflows and an economic boom may try to tighten monetary policy to cool off the economy—thereby retaining monetary policy independence—and yet maintain the (overvalued) fixed exchange rate without limiting financial market openness. The authorities in such a situation will eventually have to either lose control of monetary policy, abort the fixed exchange rate, or implement (or tighten) capital controls. In other words, the authorities may deviate from the constraint of the trilemma only in the short run, but not over many years. After all, a policy that deviates from the trilemma will eventually have to end. Otherwise, market forces will punish the authorities by creating a crisis and induce them to alter policies in a way consistent with the trilemma constraints.

Given this observation and using the indexes we have developed, we should be able to identify policy combinations that yield MI + ES + FO > 2 for a certain period and are "unsustainable." Once we do this, we can hypothesize that unsustainable policy combinations that cause deviations from the trilemma constraint must be corrected by macroeconomic policy changes or economic and financial disruptions, such as an economic and a financial crisis.

As one attempt, we will observe how the sum of the three indexes behave around the time of an economic or a financial crisis. Here we use the indexes before adjustment by B_{it}.

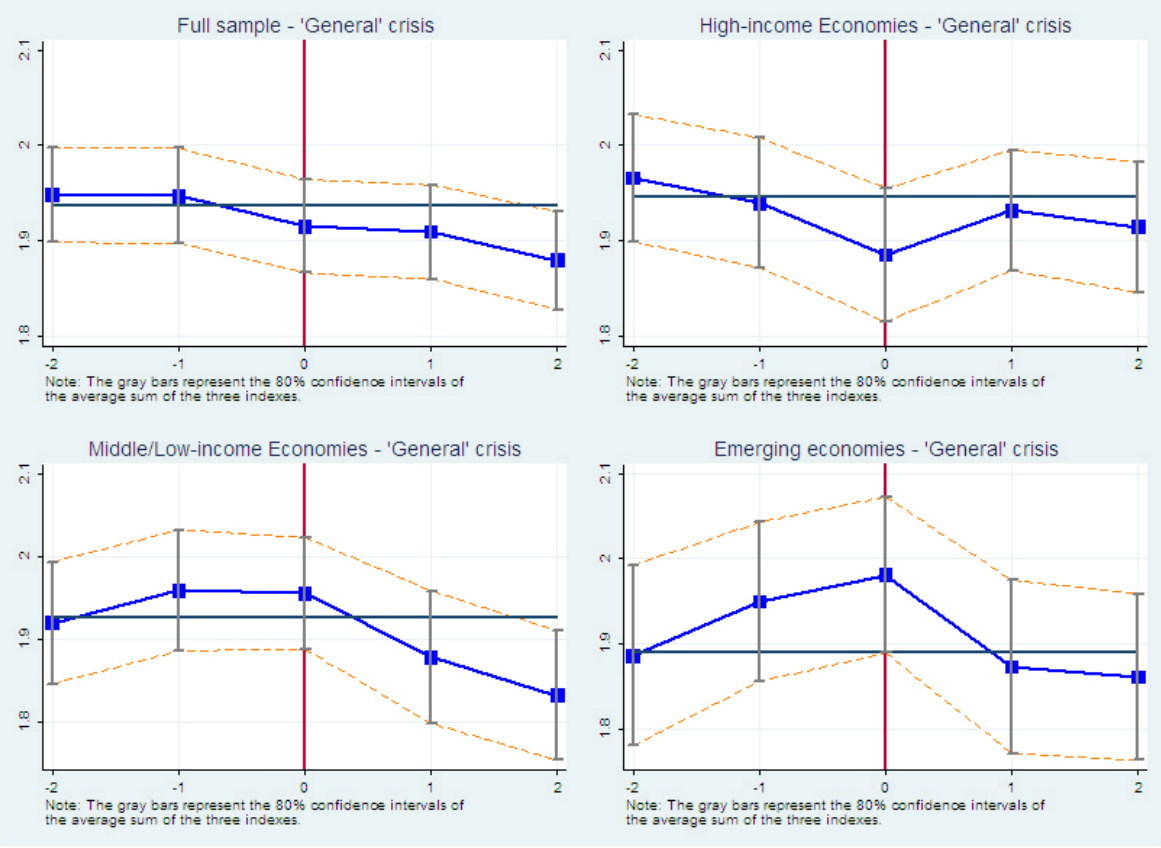
5.1 Overall Crisis Analysis

We identify the following five types of crises: (i) a general crisis; (ii) a currency crisis; (iii) a banking crisis; (iv) a debt crisis; and (v) an inflation crisis, and show how the sum of the three indexes evolve before, during, and after each type of the crisis. The hypothesis we set up and test here is that, if the trilemma constraint is indeed binding, sustained deviations from the trilemma constraint must be followed by economic disruptions as the means of policy corrections. In other words, in the pre-crisis period, the sum of the three indexes should be significantly higher than the value of two. Once an economic or a financial crisis occurs, it should be brought down close to or even below the value two.

Figure 5a illustrates the average sum of the three indexes in the period from two years before and after the occurrence of a "general" crisis for the economies that experience the crisis. We identify a general crisis when the growth rate of per capita income is more than

one standard deviation below its long-run mean.[22] We call this type of crisis merely a general crisis because we focus on the performance of per capita income growth without referring to the causes for the underperformance, which can be due to a currency, banking, or debt crisis, or by some political or geopolitical crisis. In the figure, we observe an inverted V-shape in the development of the sum of the three indexes over the crisis period for the group of emerging economies. The sum of the three indexes is not statistically different from the value two for any group of economies, even for the group of emerging economies. So there is no evidence of deviations from the trilemma constraint.

Figure 5a: Development of the Sum of the Three Indexes around the General Crisis

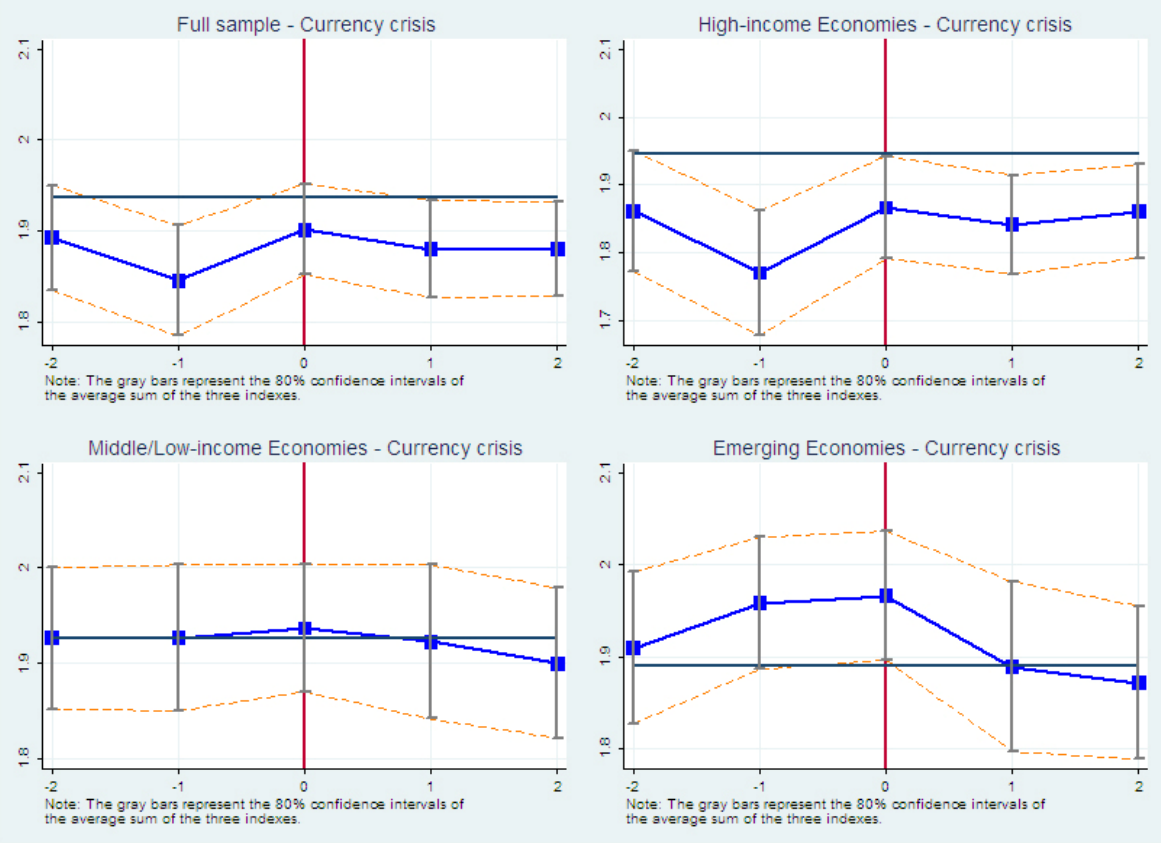


Source: Authors' estimations.

[22] This identification is the same as "excessively severe recession" in Aizenman, Chinn, and Ito (2012). The standard deviation is based on rolling five-year windows. The long-run average of per capita income growth is the average of the growth in the 1950–2009 period. The per capita income data are retrieved from Penn World Table 7.0.

Figure 5b repeats the same exercise for a currency crisis. We identify a currency crisis in the same way as suggested by Eichengreen, Rose, and Wyploz (1995; 1996).[23] Here, we again observe the inverted V-shape in the average sum of the three indexes for emerging economies. Again the sum of the indexes before or during the crisis is not statistically different from the value two, and no strong evidence is found for deviations from the trilemma constraint.[24]

Figure 5b: Development of the Sum of the Three Indexes around the Currency Crisis



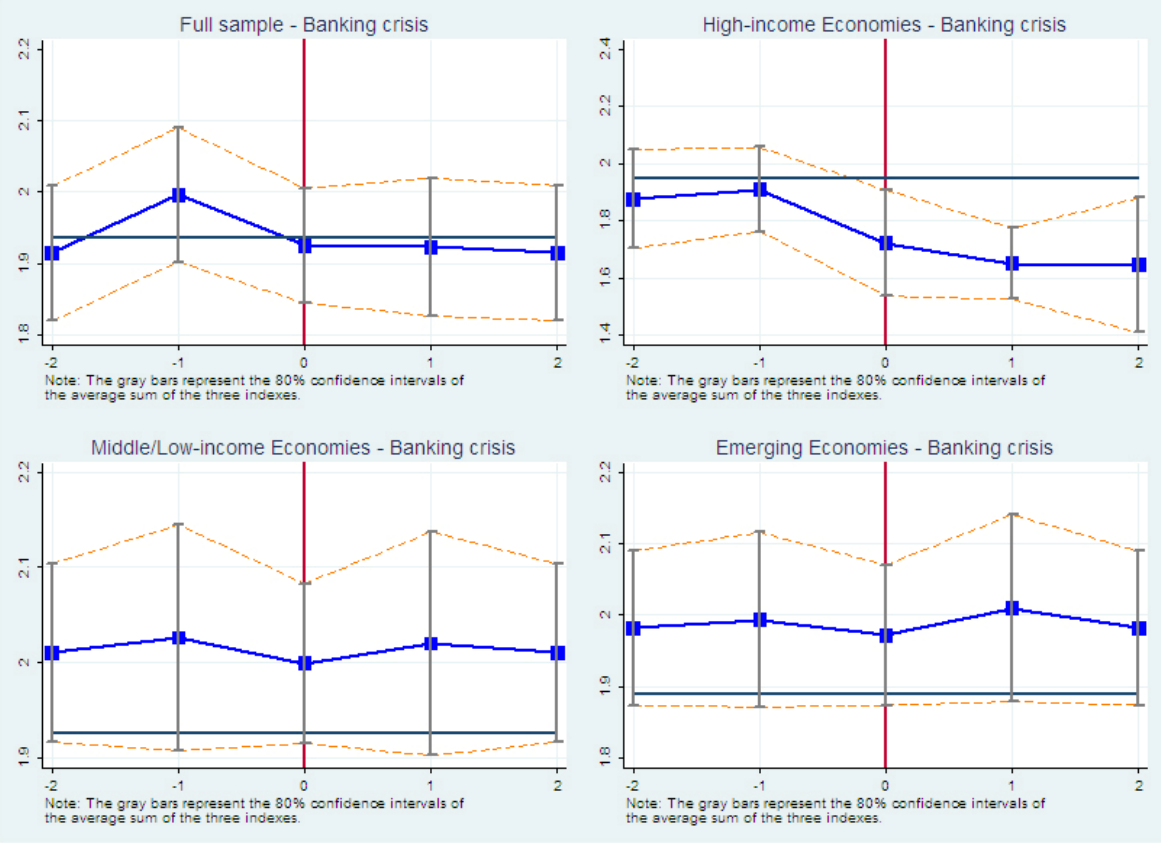
Source: Authors' estimations.

[23] It is also supplemented by the currency crisis identification by Reinhart and Rogoff (2009).

[24] However the sum of the three indexes for emerging economies is significantly greater than the subsample mean in the crisis year (t), with the statistical significance of 80%. Here the subsample mean of the sum of the three indexes is calculated for both crisis and non-crisis emerging economies over the entire period. So as far as a currency crisis in concerned, there is some, though weak, evidence that there may have been such a deviation if a benchmark is the sample mean, rather than the value two.

In the case of a banking crisis (Figure 5c) or a debt crisis (Figure 5d), [25] we do not observe any deviation of the sum of the three indexes from the value two in a way consistent with our prior. This result implies that a banking or a debt crisis is not related to "unsustainable" open macroeconomic management.

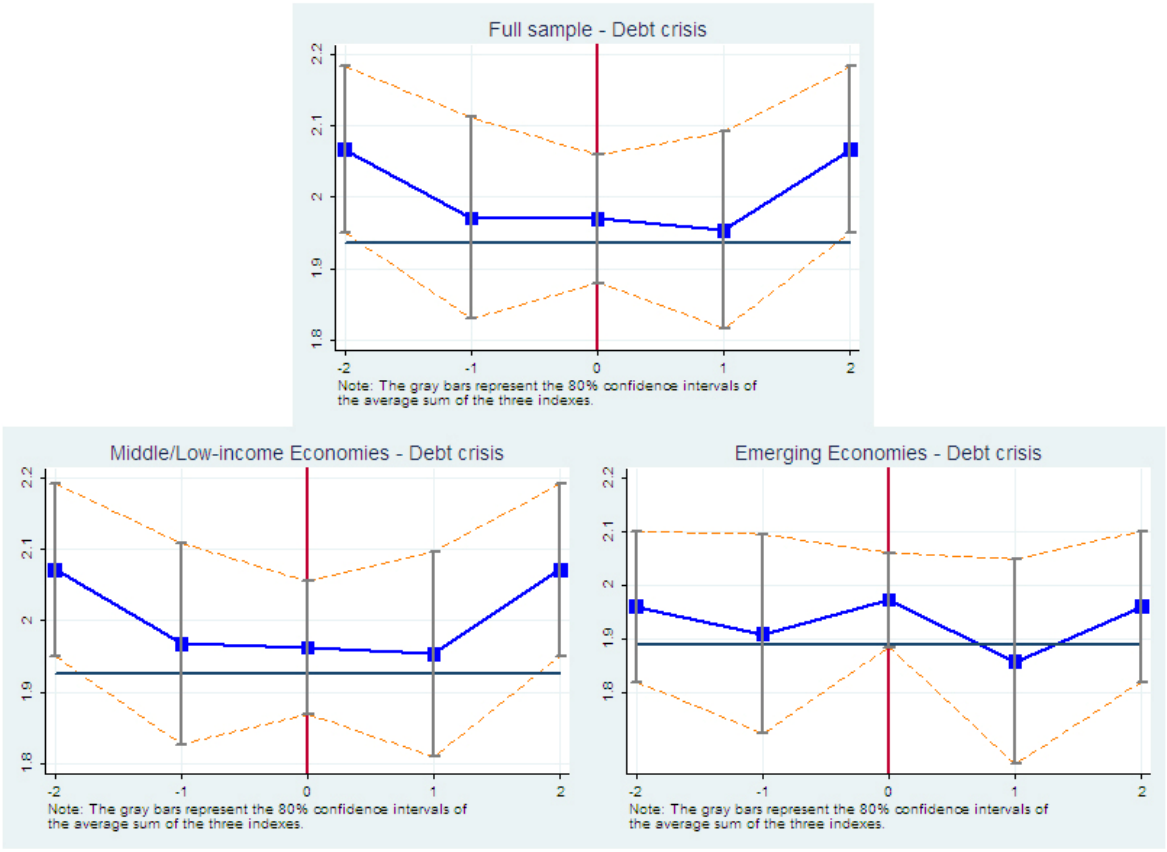
Figure 5c: Development of the Sum of the Three Indexes around the Banking Crisis



Source: Authors' estimations.

[25] We identify a banking crisis and a debt crisis, respectively, by using the datasets developed by Laeven and Valencia (2010) and used by Reinhart and Rogoff (2009).

Figure 5d: Development of the Sum of the Three Indexes around the Debt Crisis



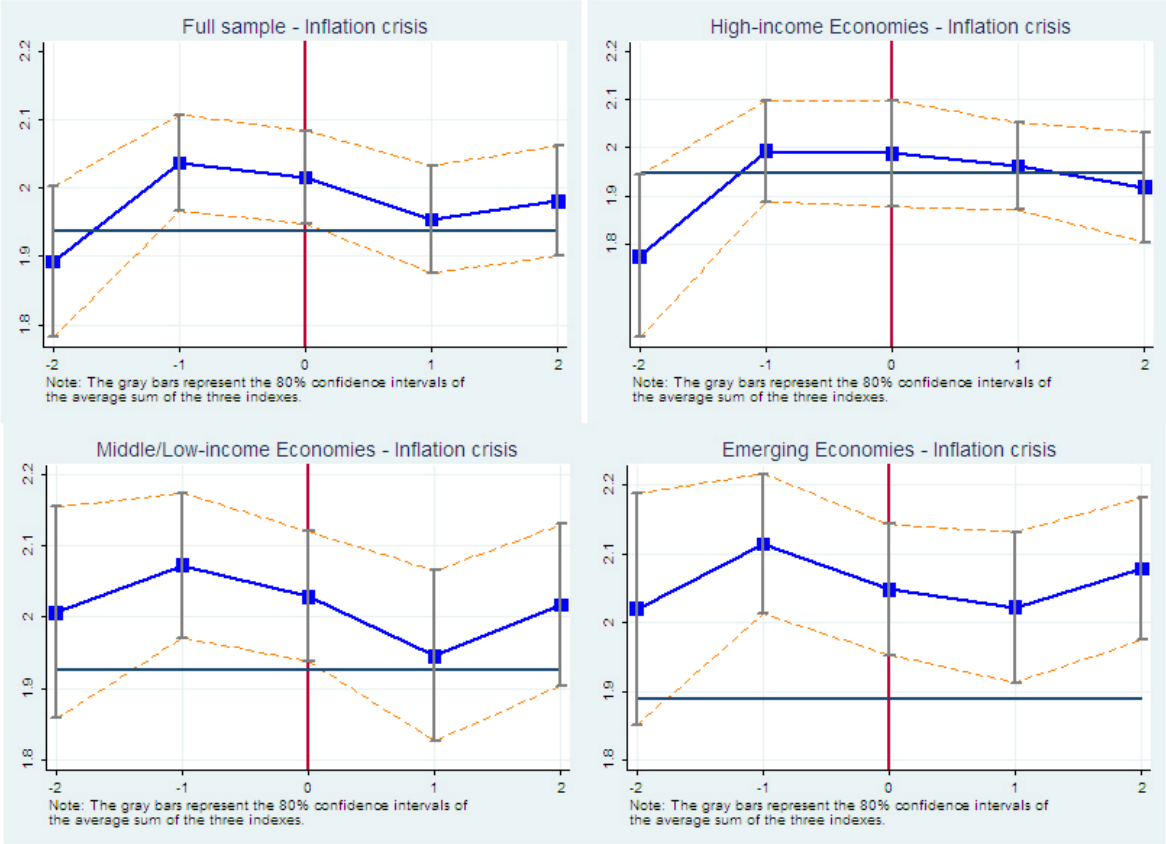
Source: Authors' estimations.

In the case of an inflation crisis (Figure 5e),[26] we find that the sum of the three indexes for emerging economies significantly exceeds the value two in the year preceding the crisis.[27] This result suggests that an inflation crisis can be associated with unsustainable international macroeconomic policies. This is consistent with the historical evidence that many small open economies, especially those in Latin America, experienced high or hyper-inflation in the 1980s when they implemented unsustainable open macroeconomic policies that included rapid financial liberalization and opening under fixed exchange rate regimes.

[26] We identify an inflation crisis if there are more than five months in a year when the annual growth rate of CPI is over 20%. This definition draws from Reinhart and Rogoff (2009).

[27] In addition, there is some evidence that the sum of the three indexes exceeds the subsample mean for crisis and non-crisis emerging economies over the entire period.

Figure 5e: Development of the Sum of the Three Indexes around the Inflation Crisis



Source: Authors' estimations.

5.2 Specific Crisis Analysis

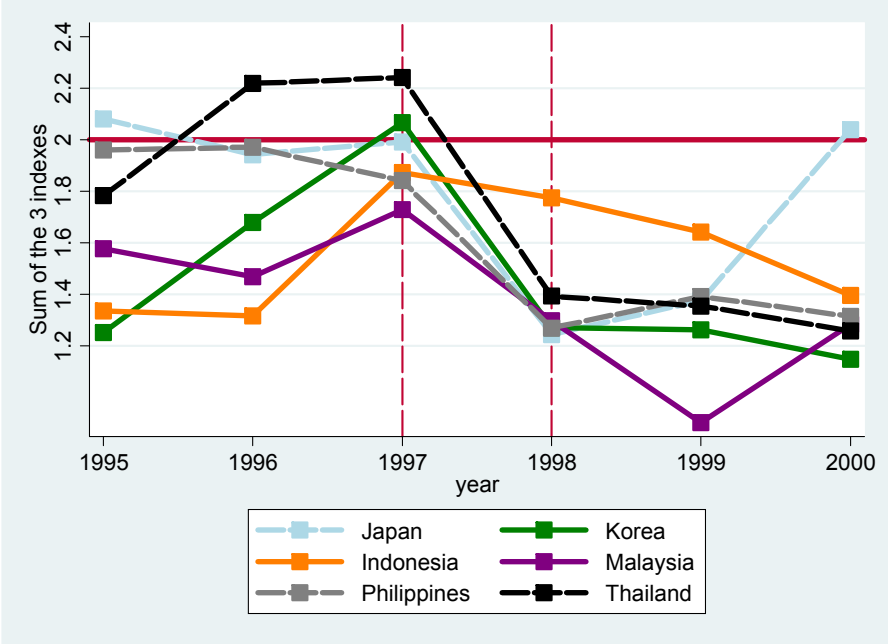
Now, let us observe the sum of the three indexes of Asian economies at the time of the Asian financial crisis of 1997–1998. In Figure 6a, we can see that the sum of Thailand's trilemma indexes surpasses the value two in 1996–1997, the period leading to the crisis, while others do not seem to have such policy combinations. In other words, Thailand, but not necessarily other crisis-affected countries, may have implemented unsustainable macroeconomic policies in the period immediately prior to the crisis. Also, once the financial crisis broke out, all countries appear to have lowered, or undershot, the sum of the three indexes as a reaction to the crisis. These results may indicate that Thailand's baht crisis was driven by the country authorities' mismanagement of open macroeconomic policies in the precrisis period, while other crisis economies were dragged to the currency crisis mainly through contagion from Thailand.

Looking at the experience of Latin American economies during the debt crisis period of the 1980s is also informative. Figure 6b suggests that many Latin American economies implemented unsustainable macroeconomic policy combinations throughout the 1980s, although the sum of the three policy indexes is in a declining trend toward the end of the decade in most of the countries. The lingering crisis situation of these economies can be attributed to their mismanagement of the three policies.

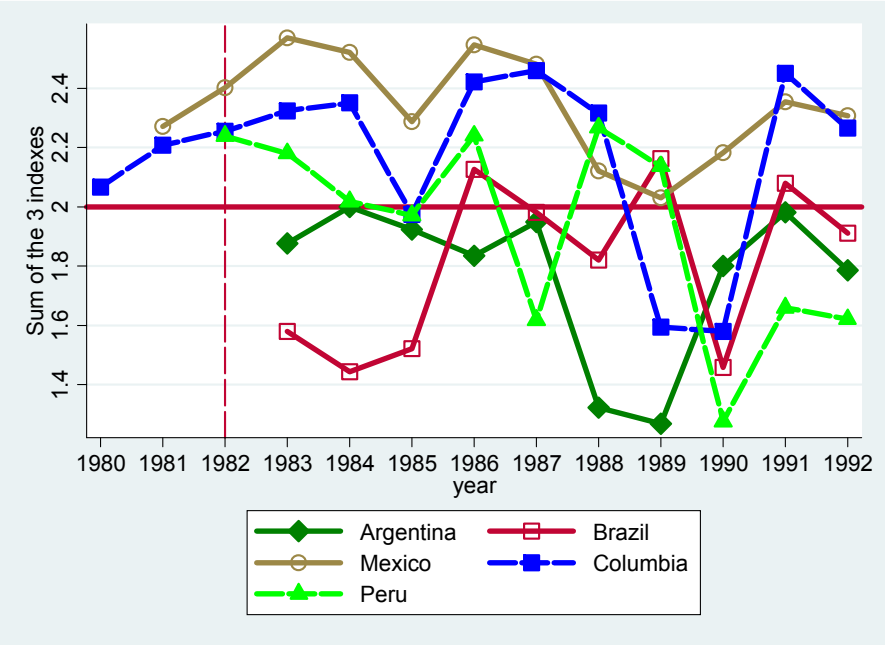
Although we must conduct a more formal analysis to reach more definitive conclusions, there seems to be some evidence that Thailand implemented unsustainable open macroeconomic policies prior to the baht crisis in a way similar to the Latin American economies during the debt crisis period of the 1980s.

Figure 6: The Sum of the Three Indexes over the Crisis Period

(a) Asian Economies Around the Asian Financial Crisis of 1997–1998



(b) Latin American Economies Around the Debt Crisis in the 1980s



Source: Authors' estimations.

6. CONCLUDING REMARKS

We have introduced a new set of indexes of exchange rate stability, monetary policy independence, and financial market openness, all of which are theoretically constrained as a trade-off as predicted by the famous impossible trinity or trilemma hypothesis. In our exploration, we have taken a different, and more nuanced approach than the previous indexes such as those developed by Aizenman, Chinn, and Ito (2008). We showed that as long as the indexes are normalized between zero and one, the three indexes of the trilemma must add up to the value of two to be consistent with the theory.

We tested if the new indexes are consistent with the trilemma hypothesis. We indeed found some statistical evidence for the sum of the three indexes being equal to the value two, particularly for middle- and low-income economies and emerging economies. This finding supported the view that monetary authorities do face the trilemma constraint in setting open macroeconomic policies as theory suggests.

For the first time in the literature, we presented our sample economies' policy mixes by plotting them in the famous trilemma triangle, which turns out to be useful in illustrating where policy mixes of a particular economy stand at a particular time and how they have evolved over time. We have shown that there is still much room for the ASEAN economies to further open financial markets, moving away from the current policy preferences of

maintaining relatively high levels of monetary policy independence and exchange rate stability with limited financial market openness.

While the sum of the newly defined indexes must add up to the value two theoretically, in reality it can deviate from two. The trilemma hypothesis suggests that a policy combination that creates a large, persistent deviation is unsustainable, and, hence, should be corrected by economic disruptions such as an economic or a financial crisis.

We examined how the sum of the three indexes evolved in crisis economies. We found that the average sum of the three indexes deviates from the value two for emerging economies that eventually experienced an inflation crisis, but not a general, banking, or debt crisis. Weak evidence may exist for such deviations for emerging economies that experienced a currency crisis. These results suggest that those economies that implement unsustainable open macroeconomic policies can face an inflation (or potentially a currency) crisis.

We looked at the Asian and Latin American economies at the time of the Asian financial crisis of 1997–1998 and the Latin American debt crisis in the 1980s. Before the baht crisis, Thailand seems to have implemented unsustainable policies, while other crisis-affected Asian economies do not seem to have had such unsustainable policies. Also, most Asian economies experienced a decline in the sum of the three indexes in the postcrisis period. Latin American economies seem to have had policies that were unsustainable throughout the 1980s, suggesting that mismanagement of open macroeconomic policies had a long-lasting impact on their economic performance.

These findings suggest that the new indexes of the trilemma we have developed can be used to identify the extent of an unsustainable policy mix at a country level. However, we still need to conduct a more formal analysis to unravel the nature of correlation between the indexes and the occurrences and severity of an economic and financial crisis. In addition, it would be useful to identify factors that affect the choice of policy combinations. We leave these as a future research agenda.

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APPENDIX 1: COUNTRY LIST

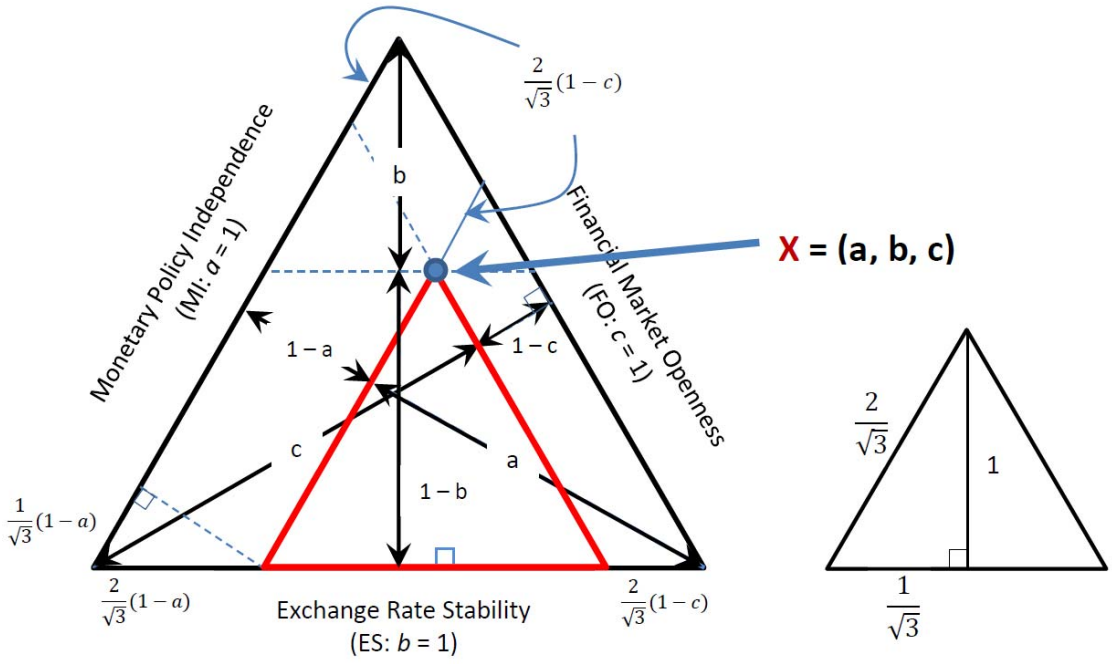
	Country Name	Code	High-income	Middle-income	Emerging.	Monetary Independence		Exchange Rate Stability		Financial Openness	
						First	Last	First	Last	First	Last
1	Algeria	612	0	1	0	1977	2010	1970	2010	1970	2007
2	Argentina	213	0	1	1	1983	2009	1970	2010	1970	2009
3	Armenia	911	0	1	0	1999	2010	1995	2010	1996	2009
4	Australia	193	1	0	0	1978	2010	1970	2010	1970	2008
5	Austria	122	1	0	0	1970	2010	1970	2010	1970	2009
6	Bahrain	419	1	0	0	1989	2004	1970	2010	1980	2007
7	Bangladesh	513	0	0	0	1997	2008	1975	2010	1973	2009
8	Barbados	316	1	0	0	1976	2010	1970	2010	2008	2009
9	Belgium	124	1	0	0	1970	2010	1970	2010	1970	2009
10	Bolivia	218	0	1	0	1998	2009	1970	2010	1970	2009
11	Botswana	616	0	1	0	1980	1996	1970	2010	1976	2009
12	Brazil	223	0	1	1	1983	2010	1970	2010	1970	2009
13	Côte d'Ivoire	662	0	1	0	1971	2007	1970	2010	1970	2009
14	Canada	156	1	0	0	1970	2010	1970	2010	1970	2009
15	Chile	228	0	1	1	1997	2010	1970	2010	1970	2009
16	China, People's Rep. of	924	0	1	1	1994	2010	1970	2010	1981	2009
17	Colombia	233	0	1	1	1970	2010	1970	2010	1970	2009
18	Congo, Rep.	634	0	1	0	1993	2006	1970	2010	1970	2007
19	Croatia	960	1	0	0	1996	2010	1995	2010	1996	2009
20	Cyprus	423	1	0	0	1973	2010	1970	2010	1980	2008
21	Czech Republic	935	1	0	1	1997	2010	1996	2010	1993	2009
22	Denmark	128	1	0	0	1970	2010	1970	2010	1970	2009
23	Egypt, Arab Rep.	469	0	1	1	2007	2010	1970	2010	1970	2009
24	El Salvador	253	0	1	0	2000	2005	1970	2010	1970	2009
25	Estonia	939	1	0	0	2001	2010	1995	2010	1992	2009
26	Fiji	819	0	1	0	1983	2008	1970	2010	1977	2007
27	Finland	172	1	0	0	1970	2010	1970	2010	1970	2009
28	France	132	1	0	0	1970	2010	1970	2010	1970	2009
29	Gabon	646	0	1	0	1981	2010	1970	2010	1970	2007
30	Germany	134	1	0	0	1970	2010	1970	2010	1970	2009
31	Greece	174	1	0	0	1970	2010	1970	2010	1970	2009
32	Hong Kong, China	532	1	0	0	1986	2010	1970	2010	1979	2009
33	Hungary	944	1	0	1	1988	2010	1971	2010	1982	2008
34	Iceland	176	1	0	0	2001	2010	1970	2010	1970	2009
35	India	534	0	1	1	1970	2010	1970	2010	1970	2009
36	Indonesia	536	0	1	1	1986	2010	1970	2010	1970	2009
37	Iran, Islamic Rep.	429	0	1	0	1970	1979	1970	2010	1970	2007
38	Ireland	178	1	0	0	1979	2010	1970	2010	1970	2009
39	Israel	436	1	0	1	1986	2010	1970	2010	1970	2009
40	Italy	136	1	0	0	1970	2010	1970	2010	1970	2009
41	Jamaica	343	0	1	0	1990	1990	1970	2010	1970	2009
42	Japan	158	1	0	0	1970	2010	1970	2010	1970	2009
43	Jordan	439	0	1	1	1979	2010	1970	2010	1976	2008
44	Kazakhstan	916	0	1	0	2005	2010	1996	2010	1994	2009
45	Kenya	664	0	0	0	1991	1996	1970	2010	1970	2007
46	Korea, Rep. of	542	1	0	1	1973	2010	1970	2010	1971	2009
47	Kuwait	443	1	0	0	1978	2010	1970	2010	1974	2008
48	Latvia	941	0	1	0	1997	2010	1995	2010	1992	2009

	Country Name	Code	High-income	Middle-income	Emerging.	Monetary Independence		Exchange Rate Stability		Financial Openness	
						First	Last	First	Last	First	Last
49	Lithuania	946	0	1	0	2000	2010	1995	2010	1992	2008
50	Luxembourg	137	1	0	0	1993	2010	1970	2010	1990	2009
51	Macedonia, FYR	962	0	1	0	2000	2010	1997	2010	1993	2008
52	Malawi	676	0	0	0	1983	2007	1970	2010	1970	2007
53	Malaysia	548	0	1	1	1974	2010	1970	2010	1970	2009
54	Malta	181	1	0	0	2008	2010	1970	2010	1970	2009
55	Mexico	273	0	1	1	1981	2010	1970	2010	1970	2009
56	Moldova	921	0	1	0	2007	2010	1995	2010	1994	2009
57	Morocco	686	0	1	1	1972	2010	1970	2010	1970	2009
58	Netherlands	138	1	0	0	1970	2010	1970	2010	1970	2009
59	New Zealand	196	1	0	0	1981	2010	1970	2010	1970	2009
60	Nigeria	694	0	1	0	1992	2008	1970	2010	1970	2009
61	Norway	142	1	0	0	1970	2009	1970	2010	1970	2009
62	Oman	449	1	0	0	2004	2010	1970	2010	1973	2007
63	Pakistan	564	0	1	1	1974	2010	1970	2010	1970	2009
64	Peru	293	0	1	1	1982	2010	1970	2010	1970	2009
65	Philippines	566	0	1	1	1984	2010	1970	2010	1970	2009
66	Poland	964	1	0	1	1994	2010	1970	2009	1990	2009
67	Portugal	182	1	0	0	1970	2010	1970	2010	1972	2009
68	Qatar	453	1	0	0	2006	2006	1970	2010	1994	2007
69	Romania	968	0	1	0	1998	2010	1970	2010	1990	2009
70	Russian Federation	922	0	1	1	1998	2010	1995	2009	1993	2009
71	Saudi Arabia	456	1	0	0	2002	2010	1970	2010	1970	2007
72	Senegal	722	0	1	0	1980	2010	1970	2010	1970	2008
73	Serbia, Rep. of	942	0	1	0	2006	2010	2004	2010	1999	2009
74	Singapore	576	1	0	0	1976	2010	1970	2010	1970	2009
75	Slovak Republic	936	1	0	0	2000	2010	1996	2010	1993	2009
76	Slovenia	961	1	0	0	1996	2010	1995	2010	1992	2009
77	South Africa	199	0	1	1	1970	2010	1970	2010	1970	2009
78	Spain	184	1	0	0	1970	2010	1970	2010	1970	2009
79	Sri Lanka	524	0	1	0	2006	2010	1970	2010	1970	2007
80	Sweden	144	1	0	0	1970	2004	1970	2010	1970	2009
81	Taipei,China	528	0	0	1	1974	2010	1973	2010	1977	2009
82	Tanzania	738	0	0	0	2002	2006	1970	2010	1990	2009
83	Thailand	578	0	1	1	1990	2010	1970	2010	1970	2009
84	Trinidad & Tobago	369	1	0	0	1972	2010	1970	2010	1970	2007
85	Tunisia	744	0	1	0	1991	2010	1970	2010	1970	2009
86	Turkey	186	0	1	1	1984	2010	1970	2010	1970	2009
87	United Kingdom	112	1	0	0	1970	2010	1970	2010	1970	2009
88	Uruguay	298	0	1	0	1985	2007	1970	2010	1970	2009
89	Venezuela, RB	299	0	1	1	1970	2002	1970	2010	1970	2009
90	Zimbabwe	698	0	0	0	1981	1998	1970	2008	1977	2007

APPENDIX 2: THE THREE TRILEMMA INDEXES AND THE TRILEMMA TRIANGLE

A2-1: The Linear Relationship of the Trilemma Indexes

Figure A2-1:



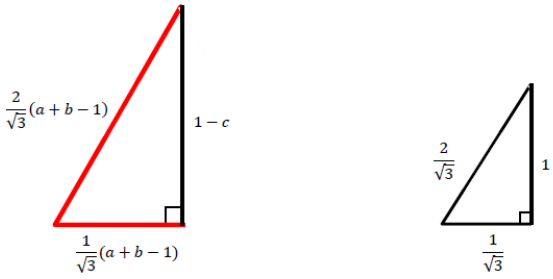
The equilateral triangle above depicts the trilemma hypothesis. The further away you are from any vertex vertically toward the side the vertex is facing, the higher the extent of achievement you will have in the policy represented by the side. In Figure A2-1, for example, the top corner of the triangle indicates that the economy of concern has a completely open financial market and full monetary policy independence (with a fully flexible exchange rate regime). The low-left corner of the triangle represents that the economy has full monetary policy independence and complete exchange rate stability (with a fully closed financial market). And the low-right corner indicates that the economy has full financial market openness and complete exchange rate stability (without any monetary policy independence). Thus, you can never achieve the *full* extent of *all three* policy choices simultaneously because you cannot stand on all of the three sides at one time. However, as long as you are

somewhere on the side of or inside the triangle, you are consistent with the trilemma hypothesis. Conversely, any international macroeconomic policy combination can be depicted as a location inside or on the triangle. The dot in the above triangle, for example, represents a policy combination of (MI, ES, FO) = (*a, b, c*), where *a*, *b*, and *c* depict the extent of achievement in monetary policy independence, exchange rate stability, and financial market openness, respectively, and therefore, represent vertical distances from each of the three corners.

We assume that the height of the triangle is one unit for convenience so that the vertical distances from each of the three corners are consistent with our indexes that are normalized between zero and one. With this assumption, the length of each side becomes $\frac{2}{\sqrt{3}}$ units as shown in the right-hand-side smaller triangle.

Using the dot (MI, ES, FO) = (*a, b, c*) in the triangle, we can show there is a linear relationship among the three policies based on the trilemma. For that, we can draw a smaller equilateral triangle that has the dot as the top of the triangle, i.e., the triangle in red. Because the extent of financial market openness is assumed to be c, the height of the triangle can be shown as 1 – *c.* Using other pieces of information and the fact that both the red triangle and the bigger, whole triangle are equilateral triangles, we can calculate the length of each side of the red triangle as:

$$\frac{2}{\sqrt{3}}(a+b-1)=\left\{\frac{2}{\sqrt{3}}-\frac{2}{\sqrt{3}}(1-a)-\frac{2}{\sqrt{3}}(1-b)\right\}.$$



When we compare the half of the red triangle from the bigger triangle in Figure 2A-1 and that of the smaller triangle on the right-hand side of Figure 2A-1, we can see the following:

$$\frac{1-c}{\frac{1}{\sqrt{3}}(a+b-1)} = \frac{1}{\frac{1}{\sqrt{3}}}$$

$$1-c = a+b-1$$

$$\therefore a+b+c = 2.$$

Hence, it must be that $a+b+c=2$ where $0 \le a,b,c \le 1$ or $1 \le a+b \le 2$, $1 \le b+c \le 2$, $1 \le a+c \le 2$.

A2-2: The Trilemma Triangle

We make adjustments to the trilemma indexes created in the initial step to make the sum of the three indexes equal to value two for every year and country so that any combination of the three indexes will lie inside the equilateral triangle.

More specifically,

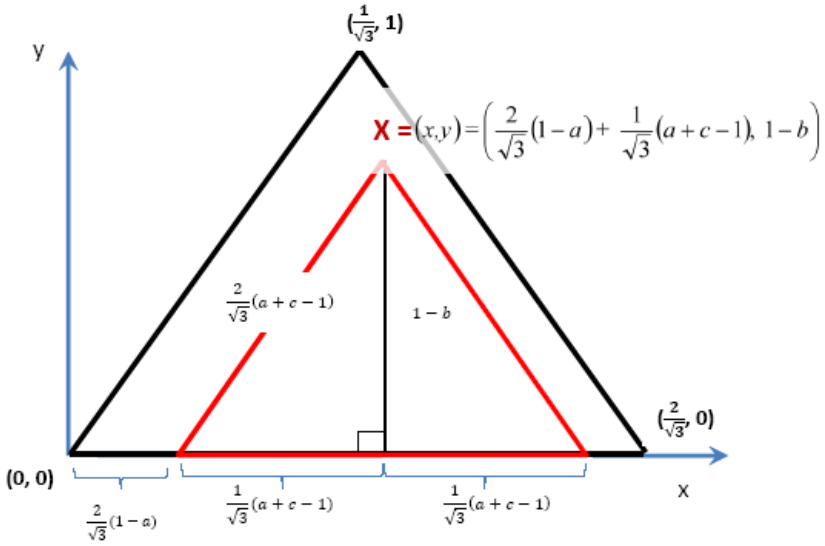
Assume $a_0 + b_0 + c_0 = 2*B$, where (a_0, b_0, c_0) = (MI, ES, FO).

Now, the combinations of the three indexes are modified as:

$(a^*_0, b^*_0, c^*_0) = \{a_0/B, b_0/B, c_0/B\}$.

To make it easier to draw the trilemma triangle, we can place the triangle in a two dimensional space so that the bottom left corner of the triangle is placed at the origin in the x-y domain (Figure A2-2).

Figure A2-2:



Now, as you can see in the graph above, the three corners can be depicted in the *x*-*y* domain as (0, 0), $(\frac{1}{\sqrt{3}},1)$, and $(\frac{2}{\sqrt{3}},1)$, clockwise. To find out the location for Point X, we can draw a smaller equilateral triangle, within the original trilemma triangle, that has Point X as the top (as in the red triangle). Because we assume an equilateral triangle with the height of one, we can find out the height of the smaller triangle and the length of its side in the *x*-*y* domain when X is (MI, ES, FO) = (*a*, *b*, *c*). That is, Point X should be located at:

$$(x,y)=\left(\frac{2}{\sqrt{3}}(1-a)+\frac{1}{\sqrt{3}}(a+c-1),\ 1-b\right).$$