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## The “Impossible Trinity” Hypothesis in an Era of Global Imbalances: Measurement and Testing

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## The “Impossible Trinity” Hypothesis in an Era of Global Imbalances: Measurement and Testing

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### Abstract

We outline new metrics for measuring the trilemma aspects: exchange rate flexibility, monetary independence, and capital account openness, taking into account recent substantial international reserve accumulation. Since 1990, the trilemma variables in emerging markets have converged towards intermediate levels, characterizing by managed flexibility, using sizable international reserves as a buffer while retaining some degree of monetary autonomy. We test the linearity of the trilemma, and find that the weighted sum of the three trilemma variables adds up to a constant. Thus, a rise in one trilemma variable should be traded-off with a drop of the weighted sum of the other two.

*JEL Classification Nos.:* F31, F36, F41, O24

*Keywords:* Impossible trinity; international reserves; financial liberalization; exchange rate regime.

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# **The “Impossible Trinity” Hypothesis in an Era of Global Imbalances: Measurement and Testing**

## **Abstract**

We outline new metrics for measuring the trilemma aspects: exchange rate flexibility, monetary independence, and capital account openness, taking into account recent substantial international reserve accumulation. Since 1990, the trilemma variables in emerging markets have converged towards intermediate levels, characterizing by managed flexibility, using sizable international reserves as a buffer while retaining some degree of monetary autonomy. We test the linearity of the trilemma, and find that the weighted sum of the three trilemma variables adds up to a constant. Thus, a rise in one trilemma variable should be traded-off with a drop of the weighted sum of the other two.

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## 1. Introduction

A fundamental contribution of the Mundell-Fleming framework is the “impossible trinity,” or the “trilemma,” which states that a country may simultaneously choose any two -- but not all -- of the following three goals: monetary independence, exchange rate stability and financial integration. The trilemma is illustrated in Figure 1. Each of the three sides – representing monetary independence, exchange rate stability, and financial integration – depicts a potentially desirable goal, yet it is not possible to be simultaneously on all three sides of the triangle.<sup>1</sup>

Over the last 20 years, most developing countries, that in the 1970s elected a policy combination of monetary policy autonomy and a fixed exchange rate regime (shown as the top vertex of the triangle), have opted for increasing financial integration. The trilemma implies that a country choosing this path must choose whether to forgo exchange rate stability or monetary independence depending on its policy preferences.

A key message of the trilemma is that policy makers face a tradeoff; increasing one trilemma variable would induce a drop in the weighted average of the other two. Yet, to our knowledge, the validity of this tradeoff among the three trilemma variables has not been empirically tested properly. A possible concern is that the trilemma framework does not impose an exact functional restriction on the association between the three trilemma policy variables. Furthermore, it is quite difficult to create systematic metrics that measure the extent of achievement in the three policy goals of the trilemma.

To fill this gap, we first introduce the “trilemma indexes,” that measures the extent of achievement in each of the three policy goals pertaining to the trilemma, namely monetary independence, exchange rate stability, and financial integration. These indexes allow us to trace

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<sup>1</sup> See Obstfeld, Shambaugh, and Taylor (2005) for further discussion and references dealing with the trilemma.

the evolving configurations of the international financial architecture during the post Bretton-Woods period.

Second, using these indexes, we examine whether external shocks such as institutional changes in the international financial architecture (e.g., the collapse of the Bretton Woods system) and large-scale financial crises (e.g., the Mexican debt crisis and the Asian financial crisis) have affected countries' preferences over the three trilemma policy goals.

Lastly, we examine whether the constraints based on the trilemma are binding. That is, using a simple linear specification that links the three trilemma indexes, we test whether the linear combination of the three indexes adds up to a constant. If this is found to be true, it indicates that the notion that countries can only pursue two out of the three policy goals is correct, and that a rise in one trilemma variable should be traded-off with a drop of the weighted sum of the other two.

We close the paper by applying a regression analysis to test the validity of the simplest functional specification for the trilemma: whether the three trilemma policy goals are linearly related. It is important to note that the trilemma predictions are not a mathematical tautology, and are testable. Specifically, a linear version of the Trilemma predicts that each of the trilemma coefficients is positive [such that a rise in one variable should be traded off with a drop in the weighted sum of the other two], and that the explanatory power of the equation is high enough that higher order terms are insignificant. Of independent interest is the  $R^2$ , accounting what portion of the variability is explainable, and the stability of the equation. For this purpose, we examine and validate that the weighted sum of the three trilemma policy variables adds up to a constant with all three positive weights so that we can confirm the notion that a rise in one trilemma variable should be traded-off with a drop of a linear weighted sum of the other two trilemma variables.

Section 2 outlines the methodology for the construction of our “trilemma indexes” that measure the extent of achievement in the three policy goals. This section also presents summary statistics of the indexes and examines whether the indexes entail any structural breaks corresponding to major global economic events. Section 3 tests the validity of a linear specification of the trilemma indexes to examine whether the notion of the trilemma can be considered to be a trade-off and binding. Section 4 concludes the paper.

## 2. Measures of the Trilemma Dimensions

### 2.1 Construction of the Trilemma Measures

#### *Monetary Independence (MI)*

The extent of monetary independence is measured as the reciprocal of the annual correlation of the monthly interest rates between the home country and the base country. Money market rates are used.<sup>2</sup>

The index for the extent of monetary independence is defined as:

$$MI = 1 - \frac{\text{corr}(i_i, i_j) + 1}{2}$$

where  $i$  refers to home countries and  $j$  to the base country. By construction, the maximum and minimum values are 1 and 0, respectively. Higher values of the index mean more monetary policy independence.<sup>3,4</sup>

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<sup>2</sup> The data are extracted from the IMF’s *International Financial Statistics* (60B..ZF...). For the countries whose money market rates are unavailable or extremely limited, the money market data are supplemented by those from the Bloomberg terminal and also by the discount rates (60...ZF...) and the deposit rates (60L..ZF...) series from *IFS*.

<sup>3</sup> The index is smoothed out by applying the three-year moving averages encompassing the preceding, concurrent, and following years ( $t - 1$ ,  $t$ ,  $t + 1$ ) of observations.

<sup>4</sup> We note one important caveat about this index. For some countries and some years, especially early in the sample, the interest rate used for the calculation of the MI index is often constant throughout a year, making the annual correlation of the interest rates between the home and base countries ( $\text{corr}(i_i, i_j)$  in the formula) undefined. Since we treat the undefined corr the same as zero, it makes the MI index value 0.5. One might think that the policy interest rate being constant (regardless of the base country's interest rate) is a sign of monetary independence. However, it could reflect the possibility that the home country uses other tools to implement monetary policy, rather than manipulating the interest rates (e.g., manipulation of required reserve ratios and providing window guidance; or

Here, the base country is defined as the country that a home country's monetary policy is most closely linked with as in Shambaugh (2004). The base countries are Australia, Belgium, France, Germany, India, Malaysia, South Africa, the U.K., and the U.S. For the countries and years for which Shambaugh's data are available, the base countries from his work are used, and for the others, the base countries are assigned based on the IMF's *Annual Report on Exchange Arrangements and Exchange Restrictions (AREAER)* and the *CIA Factbook*.

### ***Exchange Rate Stability (ERS)***

To measure exchange rate stability, annual standard deviations of the monthly exchange rate between the home country and the base country are calculated and included in the following formula to normalize the index between zero and one:

$$ERS = \frac{0.01}{0.01 + stdev(\Delta(\log(exch\_rate)))}$$

Merely applying this formula can easily create a downward bias in the index, that is, it would exaggerate the "flexibility" of the exchange rate especially when the rate usually follows a narrow band, but is de- or revalued infrequently.<sup>5</sup> To avoid such downward bias, we also apply a threshold to the exchange rate movement as has been done in the literature. That is, if the rate of monthly change in the exchange rate stayed within +/-0.33 percent bands, we consider the exchange rate is "fixed" and assign the value of one for the ERS index. Furthermore, single year pegs are dropped because they are quite possibly not intentional ones.<sup>6</sup> Higher values of this

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financial repression). To complicate matters, some countries have used reserves manipulation and financial repression to gain monetary independence while others have used both while strictly following the base country's monetary policy. The bottom line is that it is impossible to fully account for these issues in the calculation of MI. Therefore, assigning an MI value of 0.5 for such a case appears to be a reasonable compromise. However, we also undertake robustness checks on the index.

<sup>5</sup> In such a case, the average of the monthly change in the exchange rate would be so small that even small changes could make the standard deviation big and thereby the ERS value small.

<sup>6</sup> The choice of the +/-0.33 percent bands is based on the +/-2% band based on the annual rate, that is often used in the literature. Also, to prevent breaks in the peg status due to one-time realignments, any exchange rate that had a percentage change of zero in eleven out of twelve months is considered fixed. When there are two re/devaluations in

index indicate more stable movement of the exchange rate against the currency of the base country.

### ***Financial Openness/Integration (KAOPEN)***

Without question, it is extremely difficult to measure the extent of capital account controls.<sup>7</sup> Although many measures exist to describe the extent and intensity of capital account controls, it is generally agreed that such measures fail to capture fully the complexity of real-world capital controls. Nonetheless, for the measure of financial openness, we use the index of capital account openness, or *KAOPEN*, by Chinn and Ito (2006, 2008). *KAOPEN* is based on information regarding restrictions in the IMF's *Annual Report on Exchange Arrangements and Exchange Restrictions (AREAER)*. Specifically, *KAOPEN* is the first standardized principal component of the variables that indicate the presence of multiple exchange rates, restrictions on current account transactions, on capital account transactions, and the requirement of the surrender of export proceeds (see Chinn and Ito, 2008). Since *KAOPEN* is based upon reported restrictions, it is necessarily a *de jure* index of capital account openness (in contrast to *de facto* measures such as those in Lane and Milesi-Ferretti (2006)). The choice of a *de jure* measure of capital account openness is driven by the motivation to look into policy intentions of the countries; *de facto* measures are more susceptible to other macroeconomic effects than solely policy decisions with respect to capital controls.<sup>8</sup>

The Chinn-Ito index is normalized between zero and one. Higher values of this index indicate that a country is more open to cross-border capital transactions.

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three months, then they are considered to be one re/devaluation event, and if the remaining 10 months experience no exchange rate movement, then that year is considered to be the year of fixed exchange rate. This way of defining the threshold for the exchange rate is in line with the one adopted by Shambaugh (2004).

<sup>7</sup> See Chinn and Ito (2008), Edison and Warnock (2001), Edwards (2001), Edison et al. (2002), and Kose et al. (2006) for discussions and comparisons of various measures on capital restrictions.

<sup>8</sup> *De jure* measures of financial openness also face their own limitations. The private sector often circumvents capital account restrictions, nullifying the expected effect of regulatory capital controls (Edwards, 1999). Also, IMF-based variables are too aggregated to capture the subtleties of actual capital controls, that is, the direction of capital flows (i.e., inflows or outflows) as well as the type of financial transactions targeted.

The dataset covers 184 countries, but data availability is uneven among the three indexes.<sup>9</sup> Both MI and ERS start in 1960 whereas KAOPEN in 1970. All three indexes end in 2010. The data set we examine does not include the United States, since we believe the U.S. is the “Nth country” which is not subject to the constraints of the trilemma.

## **2.2 Tracking the Indexes**

### ***Variations across Country Groupings***

Comparing these indexes provides some interesting insights into how the international financial architecture has evolved over time. However, just looking at the evolution of open macro policies through the lens of the three trilemma policies may not be sufficient; it is increasingly important to shed light on the role of international reserve (IR) holding.

Over the last two decades, while a growing number of developing countries have opted for greater flexibility in exchange rate, IR/GDP ratios increased dramatically, especially in the wake of the East Asian crises, and most evidently among emerging market countries [see Figure 2]. Between 1990 and 2011, global reserves increased from about USD 1 trillion to more than USD 10 trillion. While the IR/GDP ratio of industrial countries has been relatively stable at approximately 6-8%, the IR/GDP ratio of developing countries increased from about 10% to about 25%. Today, about three quarters of the global IR are held by developing countries, geographically concentrating in Asia, where reserves increased from about 10% in 1980 to about 34% in 2010 (or 33% even after excluding China). The most dramatic changes occurred in China, increasing its IR/GDP ratio from about 1% in 1980, to about 48% in 2010.

Many researchers have pointed out the increasing importance of financial integration as a determinant for IR hoarding (Aizenman and Lee, 2007, Cheung and Ito, 2007, and Obstfeld, et

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<sup>9</sup> *MI* is available for 172 countries; *ERS* for 181; and *KAOPEN* for 182. Details on data availability can be found in the Appendix of the working paper version.

al., 2008), suggesting a link between the changing configurations of the trilemma and the level of international reserves.

In fact, holding an adequate amount of IR may indeed allow an economy to achieve a certain target combination of the three trilemma policies. For example, a country pursuing a stable exchange rate and monetary autonomy may try to liberalize cross-border financial transactions while determined not to give up the current levels of exchange rate stability and monetary autonomy. In such a case, the monetary authorities may try to hold a sizeable amount of IR so that they can stabilize the exchange rate movement while retaining monetary autonomy. Or, an economy with open financial markets and fixed exchange rate could independently relax monetary policy, though temporarily, as long as it holds a massive amount of IR.

For this purpose, the “diamond charts” are most useful and intuitively insightful in summarizing development of trilemma policy combinations while incorporating IR holding. Figure 3 illustrates the trends for different income-based or geographical groups of countries.<sup>10</sup> Each country’s configuration at a given instant is summarized by a “generalized diamond,” whose four vertices measure monetary independence, exchange rate stability, IR/GDP ratio, and financial integration. The origin has been normalized so as to represent zero monetary independence, pure float, zero international reserves, and financial autarky.

Panels of figures reveal that, over time, industrialized countries and emerging market countries have moved towards deeper financial integration while non-emerging market developing countries have only inched toward financial integration.<sup>11</sup> While pursuing greater financial openness, industrialized countries have lost monetary independence, as have emerging

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<sup>10</sup> The emerging market countries (EMG) are defined as the countries classified as either emerging or frontier during the period of 1980-1997 by the International Finance Corporation, plus Hong Kong and Singapore.

<sup>11</sup> The diamond chart for the group of industrialized countries, but excluding the Euro member countries, appears similar to the one for the group of industrialized countries shown in Figure 3 (not shown, but available in the working paper version). However, compared to the full group of industrialized countries, the group of non-Euro countries has lower levels of exchange rate stability and slightly higher levels of monetary independence in most of the sample periods.

market countries but to a much smaller extent. Emerging market countries, after giving up some exchange rate stability during the 1970s, have not changed their stance on the exchange rate stability at an intermediate level whereas non-emerging market developing countries seem to be remaining at, or slightly oscillating around, a relatively high level of exchange rate stability. Interestingly, emerging market countries stand out from other groups by achieving a relatively balanced combination of the three macroeconomic goals by the 2000s, i.e., middle-range levels of exchange rate stability and financial integration while not losing as much of monetary independently as industrialized countries, but substantially increasing its IR holding on average.

Emerging market countries in Latin America (LATAM) and Asia have moved somewhat toward exchange rate flexibility in the 1970s, a contrast from the group of non-emerging market developing countries. LATAM countries have rapidly increased financial openness although Asian emerging market economies have retained a stable level of financial openness through the sample period. One distinctive characteristic of the group of Asian emerging market economies is that it holds much more international reserves than any other group while having achieved a balanced combination of the three policy goals. With these findings, one can easily suspect that it is the high volume of IR holding that may have allowed this group of countries to achieve such a trilemma configuration. We will revisit this issue later on.

### ***Patterns in a Balanced Panel***

Figure 4 again presents the development of trilemma indexes for different subsamples while focusing on the time dimension of the development of the indexes, but also restricts the entire sample to include only the countries for which all three indexes are available for the entire time period. By balancing the dataset, the number of countries included in the sample declines to 60 countries, of which 41 are developing countries (22 of which are in turn emerging market countries).

In the three panels of figures, we can observe distinctive differences not only between IDCs and LDCs but also between EMGs and non-EMGs. For the industrialized countries, financial openness accelerated after the beginning of the 1990s and exchange rate stability rose after the end of the 1990s. The extent of monetary independence has experienced a declining trend, especially after the early 1990s, all reflecting the introduction of the euro in 1999.

For emerging market countries, up to the mid-1980s, exchange rate stability was the most pervasive policy among the three, though it has been on a declining trend since the early 1970s, followed by monetary independence that has been relatively constant during the period. Between the mid-1980s and 2000, monetary independence and exchange rate stability became the most pursued policies while the level of financial openness kept rising rapidly in the 1990s. Most interestingly, toward the end of the 1990s, all three indexes converged to the middle ground with the rapid raise in financial openness. This result suggests that developing countries may have been trying to cling to moderate levels of both monetary independence and financial openness while maintaining higher levels of exchange rate stability. This trend is essentially leaning against the trilemma in other words, possibly putting much stress on the open macro policies adopted by this group of countries. Above all, this trend of convergence to the middle ground may explain why some of these economies hold sizable international reserves, potentially to buffer the stress arising from the trilemma (Willett, 2003).

None of these observations are applicable to non-emerging developing market countries. For this group of countries, exchange rate stability has been the most pervasive policy throughout the period, though there is some variation, followed by monetary independence. There is no discernible trend in financial openness for this subsample.

### **2.3. Identifying Structural Breaks**

To shed more light on the evolution of the index values, we investigate whether major international economic events have been associated with structural breaks in the index series. We conjecture that major events – such as the breakdown of the Bretton Woods system in 1973, the Mexican debt crisis of 1982 (indicating the beginning of 1980’s debt crises of developing countries), and the Asian Crisis of 1997-98 (including sudden stop crises of other emerging market economies) – may have affected economies in such significant ways that they opted to alter their policy choices.

We identify the years of 1973, 1982, and 1997-98 as candidate structural breaks, and test the equality of the group mean of the indexes over the candidate break points for each of the subsample groups and periods.<sup>12</sup> The results are reported in Table 1. The first and second columns of the top panel indicate that after the breakdown of the Bretton Woods system, the mean of the exchange rate stability index for the industrialized country group fell, statistically significantly, from 0.71 to 0.43, while the mean of financial openness slightly, but statistically significantly, increase from 0.43 to 0.47. Non-emerging market developing countries, on the other hand, did *increase* the level of fixity of their exchange rates over the same time period while they became less monetarily independent and more financially open. Although emerging market economies reduced the level of monetary independence, they did also move toward more flexible exchange rates while not changing the extent of financial openness.

Even after the Mexican debt crisis, industrialized countries slightly, but significantly increased the level of exchange rate stability and significantly increased the level of financial openness, while holding constant the level of monetary independence. In contrast, the debt crisis led *all* developing countries to pursue further exchange rate flexibility, most likely reflecting the fact that crisis countries could not sustain fixed exchange rate arrangements. However, these

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<sup>12</sup> The data during the candidate structural break years are not included in the group means either for pre- or post-structural break years.

countries also simultaneously pursued slightly more monetary independence. Interestingly, non-emerging developing market countries tightened capital controls as a result of the debt crisis while emerging market countries did not follow suit.

The trilemma indexes seems to have changed their nature around the time of the Asian crisis in 1997-98. The level of industrialized countries' monetary independence dropped significantly while their exchange rates became much more stable and their efforts of capital account liberalization continued, all reflecting the European countries' movement toward economic and monetary union. Non-emerging market developing countries on the other hand increased the level of all three indexes. Emerging market countries also started liberalizing financial markets, though much more significantly, though they lost monetary independence and slightly gained exchange rate stability.

Several other major events can also be candidates for inducing structural breaks identified. For example, anecdotal accounts date globalization at the beginning of the 1990s, when many developing countries began to liberalize financial markets. Also, China's entry to the World Trade Organization in 2001 was, in retrospect, the beginning of the country's rise as *the* world's manufacturer. Because the effect of these events may have often been conflated with that of the Asian crisis we also test whether the years of 1990 and 2001 can be structural breaks by conducting the same mean-equality tests (results not reported).

Armed with the mean equality test results for different candidate structural breaks, we can now compare the t-statistics across the different structural breaks for each of the indexes and subsamples. Given that the balanced dataset is used in this exercise, the largest t-statistics should indicate the most significant structural break for each of the index series for each subsample.

The furthest right column of Table 1 reports the most significant structural break for each of the subsamples and the indexes. For the group of industrialized countries, industrial countries'

monetary independence and exchange rate stability series have the largest t-statistics when the structural break of 1997-98 is tested. For financial openness, however, the year of 1990 is identified with the most significant structural break.<sup>13</sup> For the group of non-emerging market developing countries, the structural break of 1990 is the most significant for financial openness while it is the years of 2001 and 1973 for exchange rate stability and monetary independence, respectively. For emerging market countries, however, the most significant structural break is found to have occurred in 2001 for monetary independence, in 1982 for exchange rate stability, and in 1997-98 for financial openness.

### **3 Theoretical Validity of the Trilemma Indexes**

#### **3.1 Linearity among the Trilemma Indexes**

While the preceding analyses are quite informative on the evolution of international macroeconomic policy orientation, we have not shown whether these three macroeconomic policy goals are “binding” in the context of the impossible trinity. That is, it is important for us to confirm that countries have faced the trade-offs based on the trilemma. A challenge facing a full test of the trilemma tradeoff is that the trilemma framework does not impose any obvious functional form on the nature of the tradeoffs between the three trilemma variables.

Despite the lack of any specific functional form to express the relationships between the three policy goals, we can conceptualize the linear hypothesis of the trilemma by placing a simplex on a plane in a third-dimensional domain constructed by the three indexes (as the axes).

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<sup>13</sup> The finding that both monetary independence and exchange rate stability entail structural breaks around the Asian crisis can be driven merely by the countries that adopted the euro in 1999. We repeat the same exercise using the industrial countries sample without the euro countries, and find that the structural breaks for monetary independence and financial opens remain the same as in the full IDC sample (1997-98 and 1990, respectively), but that the exchange rate stability series is found to have a structural break in 1973, the year when the Bretton Woods system collapsed.

A combination of the three policy goals may be expressed as a point within or on (one of the three vertexes or sides of) the simplex whose coordinates are determined by the three indexes.

That means a trilemma linear version implies that the weighted sum of the three trilemma policy variables adds up to a constant. In which case, a rise in one of the three trilemma variables leads to a drop in the weighted sum of the other two – corresponding to a move from one point to another within or on the generalized triangle. Hence, we can test the validity of the trilemma hypothesis using a simple linear functional form such as equation (1):

$$1 = a_j MI_{i,t} + b_j ERS_{i,t} + c_j KAOPEN_{i,t} + \varepsilon_t \quad (1) \text{ where } j \text{ can be either IDC, ERM, or LDC.}$$

Because we have shown that different subsample groups of countries have experienced different development paths, we allow the coefficients on all the variables to vary across different groups of countries – industrialized countries, the countries that have been in the European Exchange Rate Mechanism (ERM), and developing countries – allowing for interactions between the explanatory variables and the dummies for these subsamples.<sup>14</sup> The regression is run for the full sample period as well as the subsample periods identified in the preceding subsection.

The rationale behind this exercise is that policy makers of an economy must choose a weighted average of the three policies in order to achieve a best combination of the two. Hence, if we can find the goodness of fit for the above regression model is high, it would suggest a linear specification is rich enough to explain the trade-off among the three policy dimensions. In other words, the lower the goodness of fit, the weaker the support for the existence of the trade-off, suggesting either that the theory of the trilemma is wrong, or that the relationship is non-linear.

Secondly, the estimated coefficients in the above regression model should give us some approximate estimates of the weights countries put on the three policy goals. However, the

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<sup>14</sup> The dummy for ERM countries is assigned not only for the ERM I countries but also for the ERM II countries.

estimated coefficients alone will not provide sufficient information about “how much of” the policy choice countries have actually implemented. Hence, looking into the predictions using the estimated coefficients and the actual values for the variables (such as  $\hat{a}MI$ ,  $\hat{b}ERS$ , and  $\hat{c}KAOPEN$ ) will be more informative.

Thirdly, by comparing the predicted values based on the above regression, i.e.,  $\hat{a}MI + \hat{b}ERS + \hat{c}KAOPEN$ , over a time horizon, we can get some inferences about how “binding” the trilemma is. If the trilemma is found to be linear, the predicted values should hover around the value of 1, and the prediction errors should indicate how much of the three policy choices have been “not fully used” or to what extent the trilemma is “not binding.”<sup>15</sup>

Table 2 presents the regression results. The results from the regression with the full sample data are reported in the first column, and the others for different subsample periods are in the following columns. First of all, the adjusted R-squared for the full sample model as well as for the subsample periods is found to be above 95%, which indicates that the three policy goals are linearly related to each other and add up to a constant. Hence, we have evidence that countries face the trade-off among the three policy options. Across different time periods, the estimated coefficients vary, suggesting that countries alter over time the weights on the three policy goals.

Figure 5 illustrates the goodness of fit from a different angle. In the panels of figures, the solid lines show the means of the predicted values (i.e.,  $\hat{a}MI + \hat{b}ERS + \hat{c}KAOPEN$ ) based on the full sample model in the first column of Table 2 for the groups of industrial countries (left) and developing countries (right). To incorporate the time variation of the predictions, the subsample mean of the prediction values as well as their 95% confidence intervals (that are shown as the

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<sup>15</sup> If the trilemma is not binding, i.e., the predicted value based on equation (1) is below the value of one, such a policy combination can be shown as a point within the space between the origin and the triangle plain in the three dimensional domain. A policy combination that yields the prediction above the value of 1 would be located somewhere “outside” the triangle (from the origin), so that it would be an “infeasible” policy combination.

shaded areas) are calculated using five-year rolling windows. The panels also display the rolling means of the predictions using the coefficients and actual values of only two of the three trilemma terms –  $\hat{a}MI + \hat{b}ERS$ ,  $\hat{a}MI + \hat{c}KAOPEN$ ,  $\hat{b}ERS + \hat{c}KAOPEN$ . The regression results allow a simple description of the changing ranking of policy combinations (of the two out of the three trilemma policy goals) overtime.

From these figures, we can first see that the predicted values based on the model hover around the value of one closely for both subsamples. For the group of industrial countries, the prediction average is statistically below the value of one in the late 1970s through the beginning of the 1990s. However, since then, one cannot reject the null hypothesis that the mean of the prediction values is one, indicating that the trilemma is “binding” for industrialized countries. For developing countries, the model is under-predicting from the end of the 1970s through the late 1990s. However, unlike the IDC group, the mean of the predictions becomes statistically smaller than one in the early 2000s and goes back to around the value of one in the last few years of the sample period. More importantly, for both subsamples, the mean of the predictions never rises above the value of one in statistical sense, implying not only that the three macroeconomic policies are linearly related with each other, but also that countries have never implemented an infeasible combination of policies.<sup>16</sup>

### **3.2 Development of Policy Preferences**

The figures also show that, among industrialized countries, the policy combination of increasing exchange rate stability and more financial openness rapidly became prevalent after the beginning of the 2000s. Among developing countries, the policy combinations of monetary independence and exchange rate stability has been quite dominant throughout the sample period

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<sup>16</sup> We also repeat the exercise using the regression models (whose results shown in Table 2) for each of the subsample period (excluding the break years). The results (not reported) are qualitatively the same as in Figure 5.

while the policy combination of exchange rate stability and financial openness has been the least prevalent over, most probably reflecting the bitter experiences of currency crises.

### 3.3 Robustness Checks

#### 3.3.1 *Different Estimation Specifications*

One may question the uniqueness of this regression exercise since our estimation model has an identity scalar as the dependent variable. As a robustness check, we ran a regression of  $MI_{i,t}$  on  $ERS_{i,t}$  and  $KAOPEN_{i,t}$ . Using the estimated coefficients for  $ERS$  and  $KAOPEN$ , we recover the estimates for  $a_j$ ,  $b_j$ , and  $c_j$  in equation (1), and recreate the panels of figures shown in Figure 5. These alternative figures appear to be very much comparable to Figure 5 (not reported) and therefore confirm our conclusions about the linearity of the trilemma indexes as well as the development of the subsample mean of prediction values based on equation (1).

Showing the linearity of the three trilemma indexes using a pooled panel estimation method may be misleading. A rise in one index for one country can involve a fall in the weighted sum of the other two for *another* country, which can still be captured as a linear relationship among the three indexes in a panel context. Hence, we test the linearity of the three indexes for each of our sample countries. The results confirm our prior findings. Among the countries tested, the smallest adjusted R-squared is 89%, followed by the second smallest adjusted R-squared of 92%. The mean adjusted R-squared is 97%, and more than 90% of the sample countries have the adjusted R-squared over 95%. These findings reconfirm the linearity of the three indexes.

Although all three indexes range between zero and one, it is possible that these indexes are not stationary, in which case estimation results could be spurious. However, even if the indexes are non-stationary, if one could show that they are cointegrated, the linearity of the indexes still holds. Hence, we conduct cointegration tests for each of the sample countries to show the linearity of the three indexes. Following Johansen's (1991) method, we conduct

multiple trace tests to find the rank of the cointegration relationship, i.e., the number of cointegration equations, among *MI*, *ERS*, and *KAOPEN* in a vector error correction (VECM) specification.<sup>17</sup> Here, the rank of three would mean that all three indexes for that particular country are stationary. The rank of either one or two would mean the indexes are linearly related while the rank of zero means there is no linear relationship among the three indexes.

When we apply this cointegration test to each of the sample countries in the balanced dataset, 13 out of 60 countries (or 22%) are found to have the rank of three, meaning that all the indexes are stationary for these countries, for which the previous simple linear analysis is sufficient. 29 countries, or 48%, of the sample are found to have either one linear relationship (23 countries) or two linear relationships (6 countries).<sup>18</sup> For eighteen countries, or 30% of the sample, the three indexes are not cointegrated. If we use information criteria to determine the number of cointegration equations, the proportion of no cointegration drops. When the Schwarz Bayesian information criterion is used, 45 countries out of 60 yield one or two cointegration ranks (i.e., 25% of the sample countries have no cointegration), whereas the Hannan and Quinn information criterion yields 8 countries (13%) having no cointegration relationship.

### ***3.3.2 Revisit of the Role of International Reserves Holding***

Given the rapid increase in the importance of IR holding in the financial globalized world, we may need to think about the relationship among the three trilemma policy goals in terms of not just the trilemma, but the quadrilemma (See Aizenman, 2011).<sup>19</sup>

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<sup>17</sup> Since our primary focus is not an intensive time series analysis, we systematically implement this analysis for each of our sample countries while assuming the lag length to be 2.

<sup>18</sup> Given the nature of the indexes, it is possible that one or some of the three indexes do not change values at all for some time period, which creates the issue of (perfect) multicollinearity among the indexes and which therefore makes it impossible for the cointegration test to be executed using all the three indexes. In such a case, we would remove the variable that is apparently causing the multicollinearity and apply the cointegration test to the remaining two variables. Or, we would apply the cointegration test (while using all three indexes) only to the period when there appears to be no multicollinearity if multicollinearity is an issue in a short period.

<sup>19</sup> Aizenman, et al. (2010) empirically show that pursuing greater exchange stability can be increasing output volatility for developing economies, but that that can be mitigated by holding a greater amount of IR than the threshold of about 20% of GDP. Aizenman, et al. (2011) find that Asian emerging market economies seem to have

That said, we reestimate the modified version of equation (1) that includes a variable for IR holding (as a share of GDP) along with its interactions with the LDC and ERM dummies (results not reported). Several findings must be noted. First, including the variable for IR holding barely improves the goodness of fit of the estimations. The adjusted R-squared for the full sample (as well as for the subsample periods) goes up only by one percentage point (from 95% to 96%). Second, the coefficient on the IR holding variable is significant for the subsample periods that start in 1983 or later, suggesting that the role of IR holding is important in the context of the trilemma, but after the 1980s. Third, the role of IR holding in the trilemma seems to be more limited among developing countries – when the LDC subgroup has a significantly different coefficient on IR holding than industrialized countries, the magnitude of the coefficient is usually smaller than that of industrialized countries.

These findings indicate that the linearity does exist primarily for the original three policy variables under the trilemma, i.e., monetary independence, exchange rate stability, and financial openness. Despite the increasing importance of IR holding, the role of IR holding in the linear relationship among the trilemma policy goals is limited. It may be possible that the role of IR holding in the context of the trilemma is increasing in the last two decades of financial globalization, but scrutinizing the changing role of IR holding is outside the scope of this paper.

#### **4. Concluding Remarks**

In this paper, we have described a methodology to trace the changing patterns in the configurations of the trilemma that have taken shape. Our methodology reveals the striking differences in the choices that industrialized and developing countries have made over the 1970-

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adopted a policy combination of the three trilemma policies and IR that allow these economies to lessen output volatility through reduced real exchange volatility. Aizenman and Ito (2012) show that high levels of IR holding may allow countries to choose a policy combination from a wider range of spectrum of policy combinations without affecting the levels of output volatility.

2010 period. The recent trend suggests that among emerging market countries, the three dimensions of the trilemma configurations: monetary independence, exchange rate stability, and financial openness, are converging towards a “middle ground” with managed exchange rate flexibility, which they attempted to buffer by holding sizable international reserves, while maintaining medium levels of monetary independence and financial integration. Industrialized countries, on the other hand, have been experiencing divergence of the three dimensions of the trilemma and moved toward the configuration of high exchange rate stability and financial openness and low monetary independence as most distinctively exemplified by the euro countries’ experience.

The system has evolved over time, it would be a mistake to think of the process as being smooth and continuous. Rather, there have been a number of discrete, structural breaks associated with significant events: the collapse of the Bretton Woods system, the debt crisis of 1982, and the Asian crisis of 1997-98. For both industrialized and developing countries, the major events in the last decade, such as the emergence of rapid globalization and the rise of China, have also impacted the policy arrangements significantly.

We also tested the linearity of the three macroeconomic policy goals to examine whether countries do face the trade-offs based on the trilemma. Our results confirmed that countries do face the binding trilemma. That is, a change in one of the trilemma variables would induce a change with the opposite sign in the weighted average of the other two. In that sense, we have provided substantial content to the hypothesis of the “impossible trinity.”

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**Table 1: Tests for Structural Breaks in the Trilemma Indexes**

			1970-72	1974-81	1983-96	1999-2010	Structural Breaks	
<b>Industrial Countries</b>	Monetary Independence	Mean	0.379	0.408	0.393	0.149	1997-98	
		Change						+0.029
		t-stats (p-value)						1.32 (0.11)
	Exchange Rate Stability	Mean	0.705	0.430	0.466	0.671	1997-98 (1973 for non-Euro Countries)	
		Change						-0.274
		t-stats (p-value)						7.68 (0.00)***
	Financial Openness	Mean	0.430	0.468	0.704	0.955	1990	
		Change						+0.038
		t-stats (p-value)						1.95 (0.04)**
<b>Non-Emerging Developing Countries</b>	Monetary Independence	Mean	0.500	0.422	0.448	0.485	1973	
		Change						-0.078
		t-stats (p-value)						1.75 (0.06)*
	Exchange Rate Stability	Mean	0.756	0.804	0.687	0.803	2001	
		Change						+0.048
		t-stats (p-value)						0.74 (0.76)
	Financial Openness	Mean	0.232	0.330	0.287	0.364	1990	
		Change						+0.098
		t-stats (p-value)						3.79 (0.00)***
<b>Emerging Market Countries</b>	Monetary Independence	Mean	0.524	0.466	0.514	0.440	2001	
		Change						-0.058
		t-stats (p-value)						2.21 (0.03)**
	Exchange Rate Stability	Mean	0.834	0.697	0.499	0.543	1982	
		Change						-0.136
		t-stats (p-value)						4.35 (0.00)***
	Financial Openness	Mean	0.212	0.230	0.243	0.483	1997-98	
		Change						+0.018
		t-stats (p-value)						5.03 (0.04)**

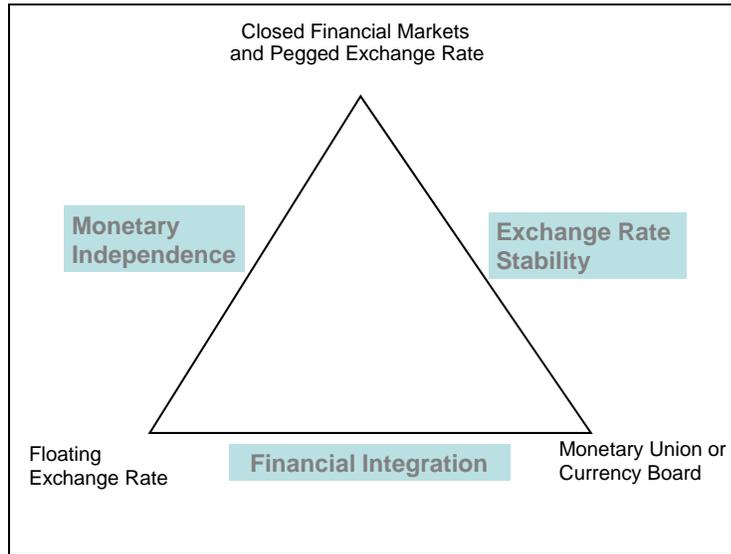
Note: \* significant at 10%; \*\* significant at 5%; \*\*\* significant at 1%

**Table 2: Regression for the Linear Relationship between the Trilemma Indexes:  $1 = a_j MI_{i,t} + b_j ERS_{i,t} + c_j KAOPEN_{i,t} + \varepsilon_t$**

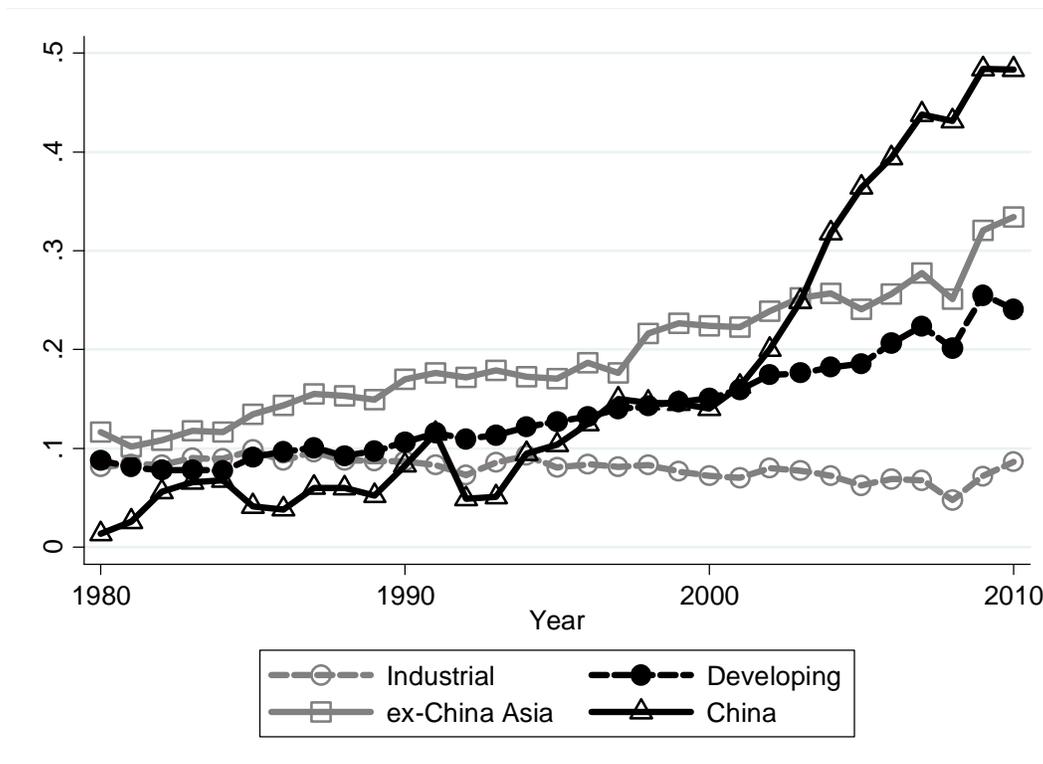
	(1) FULL	(2) 1970-72	(3) 1974-81	(4) 1983-96	(5) 1999-2010	(6) 1983-89	(7) 1991-2010	(8) 1983-2000	(9) 2002-2010
Monetary Independence	1.084 (0.040)***	0.932 (0.132)***	1.354 (0.068)***	0.970 (0.065)***	0.708 (0.128)***	1.150 (0.077)***	0.680 (0.080)***	0.923 (0.063)***	0.773 (0.136)***
Exch. Rate Stability	0.568 (0.030)***	0.640 (0.075)***	0.582 (0.084)***	0.665 (0.050)***	0.077 (0.081)	0.648 (0.065)***	0.320 (0.070)***	0.637 (0.049)***	0.098 (0.082)
KA Openness	0.457 (0.020)***	0.398 (0.047)***	0.295 (0.062)***	0.415 (0.033)***	0.817 (0.056)***	0.324 (0.047)***	0.714 (0.038)***	0.459 (0.030)***	0.788 (0.059)***
ERM x MI	-0.175 (0.073)**	–	0.356 (0.343)	-0.232 (0.119)*	-0.379 (0.150)**	-0.462 (0.321)	-0.158 (0.101)	-0.078 (0.090)	-0.660 (0.145)***
ERM x ERS	-0.024 (0.053)	–	0.299 (0.189)	0.024 (0.075)	0.017 (0.080)	0.170 (0.120)	-0.092 (0.078)	-0.093 (0.065)	-0.071 (0.076)
ERM x KAOPEN	0.013 (0.049)	–	-0.282 (0.131)**	0.041 (0.057)	0.094 (0.058)	0.174 (0.151)	0.062 (0.051)	0.006 (0.053)	0.188 (0.054)***
LDC x MI	0.149 (0.045)***	0.532 (0.163)***	-0.102 (0.095)	0.364 (0.070)***	0.333 (0.132)**	0.243 (0.086)***	0.458 (0.084)***	0.396 (0.068)***	0.235 (0.141)*
LDC x ERS	-0.151 (0.033)***	-0.398 (0.091)***	-0.142 (0.091)	-0.254 (0.053)***	0.399 (0.079)***	-0.269 (0.070)***	0.130 (0.072)*	-0.233 (0.052)***	0.395 (0.079)***
LDC x KAOPEN	-0.185 (0.027)***	-0.222 (0.075)***	-0.082 (0.080)	-0.144 (0.048)***	-0.485 (0.064)***	0.045 (0.063)	-0.423 (0.045)***	-0.256 (0.043)***	-0.439 (0.069)***
Adjusted R-squared	0.95	0.98	0.95	0.96	0.96	0.96	0.96	0.96	0.96
Observations	2,450	180	480	840	710	420	1,190	1,080	530

Robust standard errors in brackets \* significant at 10%; \*\* significant at 5%; \*\*\* significant at 1%

NOTES: The dummy for ERM countries is assigned for the countries and years that corresponds to participation in the ERM (i.e., Belgium, Germany, France, Ireland, Italy, and Luxembourg from 1979 on; Spain from 1989; U.K. only for 1990-91; Portugal from 1992; Austria from 1995; Finland from 1996; and Denmark and Greece from 1999) or ERM II (Estonia, Lithuania, and Slovenia from 2004; and Cyprus, Latvia, Malta, and Slovak Rep. from 2005).

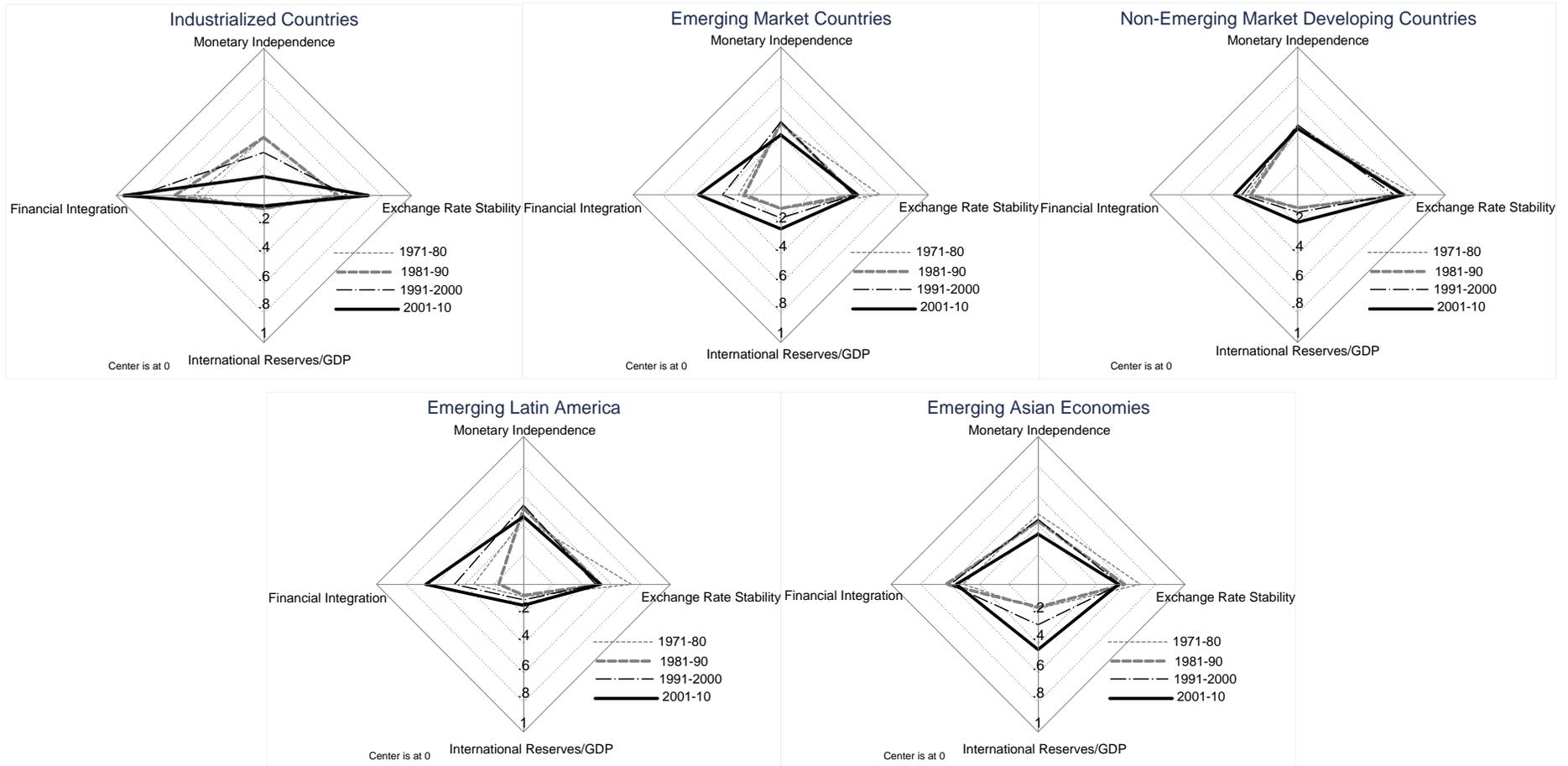


**Figure 1: The Trilemma**

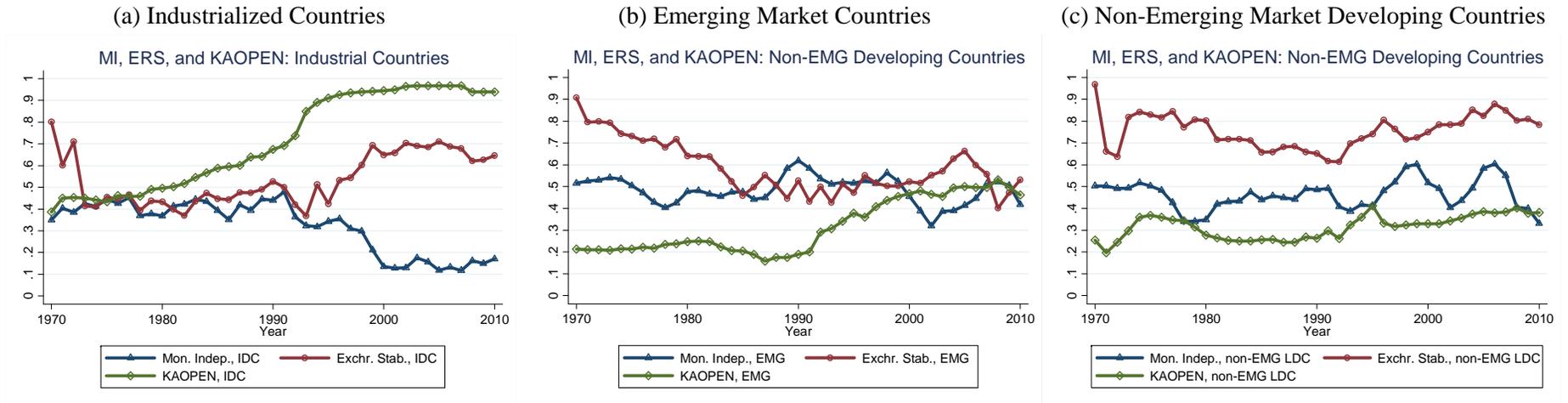


**Figure 2: International Reserves/GDP, 1980-2010**

**Figure 3: The Trilemma and International Reserves Configurations over Time**



**Figure 4: The Evolution of Trilemma Indexes**



**Figure 5: Policy Orientation of IDCs and LDCs**

