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Determinants of the Trilemma Policy Combination

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Abstract

We present a theoretical framework for policy making based on the "impossible trinity" or the "trilemma" hypothesis. A simple optimization model shows that placing more weight in terms of preference for each of the three open macroeconomic policies—exchange rate stability, financial market openness, and monetary policy independence—contributes to a higher level of achievement in that particular policy. We then develop the first empirical framework in the literature to investigate the joint determination of the triad open macroeconomic policies based on the trilemma hypothesis. Specifically, we estimate the three policy indexes under the trilemma constraint that they must add up to a constant. By applying the seemingly unrelated regression (SUR) estimation method and employing other robustness checks, we demonstrate that simple economic and structural fundamentals determine the trilemma policy combinations. Last, we examine how deviations from the "optimal" trilemma policy combinations evolve around the time of a financial crisis. Policy combinations seem to violate the trilemma constraint when a currency, banking, or debt crisis breaks out. These findings suggest that deviations from the trilemma hypothesis would create policy stress, which would have to manifest itself in a crisis unless policy makers adjust the policy combination in a way consistent with the trilemma constraint.

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

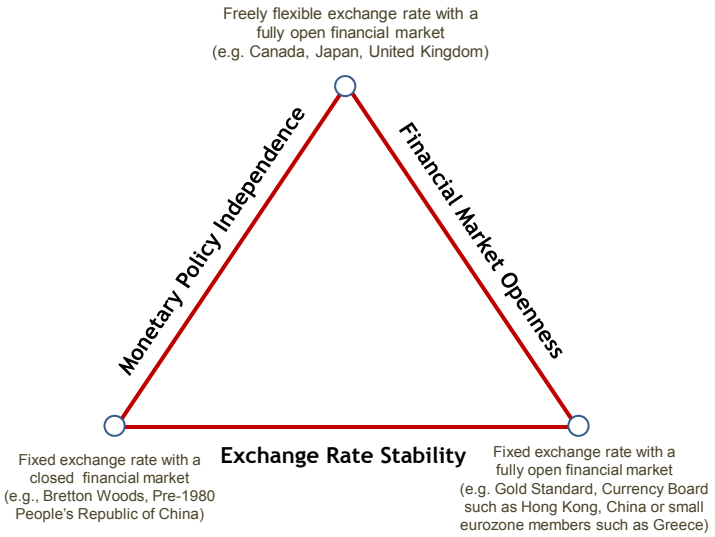
Contents

1. INTRODUCTION

Achieving noninflationary, stable economic growth is one of the most important mandates of macroeconomic policy makers. Guiding policies toward more stable exchange rates or adopting a fixed exchange rate regime could help achieve price stability by providing an inflation anchor. It would also foster international trade and investment by lowering risk premiums and mitigating currency risks. In a globalized world, countries can share risks and help smooth consumption, investment, and/or output over time by opening financial markets. Retaining monetary policy independence, i.e., implementing monetary policy without being constrained by other economies' macroeconomic shocks and policies, could also help contribute to economic stabilization. Conceptually, higher levels of exchange rate stability, financial market openness, and monetary policy independence would all help stabilize the economy, but policy makers cannot achieve all three policy goals to their full extent at any one time. This is the fundamental hypothesis—the "impossible trinity" or the "trilemma"—that dominates open macroeconomic policy making.

The trilemma is often illustrated using an equilateral triangle as shown in Figure 1, with the three sides representing exchange rate stability, financial market openness, and monetary policy independence, respectively. While it is possible to achieve the full extent of two policy goals, i.e., standing at one of the corners in the triangle, it is impossible to do so for all three sides simultaneously. As only two—out of three—policy goals can be achieved to their full extent, we observe three distinctive policy combinations: a fully open financial market and full monetary policy independence (thereby forcing the country authorities to adopt a freely flexible exchange rate regime); a fixed exchange rate regime and full monetary policy independence (thereby forcing the authorities to close the financial market); and a fixed exchange rate regime and a fully open financial market (thereby forcing the authorities to give up monetary policy independence).

Figure 1: The Trilemma Triangle



Source: Authors' configuration.

While history is full of episodes with systems that represent such "corner solutions" as the Gold Standard, Bretton Woods, and more recently the eurozone, countries may adopt an intermediate combination of the three policy goals. In other words, the authorities could adopt a policy that can be represented by *any* "dot" inside the triangle. There are an infinite number of such policy combinations. The reason that policy makers may select such a dot is that they have to compromise by not fully achieving all three desirable policy goals, that is, they face a double-edged sword in selecting the level of attainment in each of the three policy goals. For example, greater exchange rate stability can lead to the loss of monetary policy independence under full financial market openness, or perfect capital mobility.[1] Highly open financial markets would make the economy vulnerable to external financial shocks and capital flow volatility, creating boom and bust cycles or financial crises. High levels of monetary policy independence could damage fiscal discipline through monetization of sovereign debt.

Thus, an ostensibly simple hypothesis of the trilemma could easily turn into complex policy management in the open macroeconomic setting. The "trilemma constraint" states that policy makers have to select the levels of attainment for at most two out of the three policy choices with the last one automatically determined. This essentially means that the indexes constructed to measure the extent of attainment for each of the three policy goals are linearly related, i.e., they add up to a constant (Mundell 1963). Given this trilemma constraint, policy makers are expected to select a policy combination that is the most suitable by taking into account their country's economic, structural, and other conditions.

Some questions naturally emerge: What would be an optimal set of the triad policies for a country's authorities? In other words, what factors would determine where the country's best "dot" is in the trilemma triangle? And, what would happen if policies deviate from the trilemma constraint? This paper attempts to provide answers to these.

We will first present a simple theoretical framework that enables us to analyze how policy makers might select the "optimal" combinations of the three open macroeconomic policies based on the trilemma constraint. A simple optimization model will lead us to conclude that the higher the weight of preference a policy maker places on a particular policy choice, the higher the level of attainment in that policy. We then empirically investigate the determinants of the "optimal" policy combinations, using an estimation model that carefully incorporates the policy constraint based on the trilemma hypothesis. Our estimation results indicate that economic and structural fundamentals jointly determine the extent of attainment in the triad policy choices.

The rest of the paper is organized as follows. In Section 2, we introduce a simple theoretical framework for optimization under the trilemma constraint. Section 3 explains the trilemma indexes we use to measure the extent of achievement in the three open macroeconomic policies. In Section 4, we conduct an empirical investigation of the joint determination of the trilemma indexes under the linear trilemma constraint. Section 5 examines the deviations from the trilemma optimality over the period when a financial crisis breaks out. Finally, we conclude in Section 6.

[1] In addition, fixed exchange rates could also make policy makers blind to appropriate market signals and therefore may make their economies prone to instability.

2. SIMPLE OPTIMIZATION UNDER THE TRILEMMA CONSTRAINT

We construct a simple theoretical model that enables us to predict the optimal combination of the three policies under the trilemma constraint. For this purpose, we make two assumptions. First, despite their double-edged sword nature, policy makers tend to focus only on the positive aspects of the triad open macroeconomic policies—exchange rate stability, financial market openness, and monetary policy independence—and pursue higher levels of attainment in all three policies. That is, they believe higher attainment levels in these policies will help them better stabilize their economies. Second, policy makers are constrained by the linear relationship of the three policies. In other words, if achievement in the three policy goals can be measured by some normalized indexes, the sum of the three indexes must be a constant. More specifically, if each of the indexes is assumed to range from 0 to 1, the sum of the three indexes must be 2.[2] With these assumptions, we formulate the policy maker's optimization problem in the following way:

$$\min_{ES,FO,MI} \kappa_1(1-ES)^2 + \kappa_2(1-FO)^2 + \kappa_3(1-MI)^2 \qquad (1)$$

$$\text{subject to}$$

$$0 \le ES, FO, MI \le 1 \qquad \text{and} \qquad ES + FO + MI = 2,$$

where *ES*, *FO*, and *MI* are the variables that measure the extent of exchange rate stability, financial market openness, and monetary policy independence, respectively. The parameters κ_j (*j* = 1, 2, 3 and $\kappa_j \ge 0$) refer to the weights the policy maker places on each of the three policy goals.

A country's policy maker would select an optimal combination of the three policies, but such a combination would depend on his or her preferences, which reflect the economic and structural conditions of the country with whose policy management he or she is charged. For example, a policy maker in a small open economy may place higher weights on exchange rate stability and financial market openness than on monetary policy independence. A policy maker in a financially developed economy may place higher weights on financial market openness than on the other policy goals. Essentially, the parameters κ_j help determine the optimal levels of *ES*, *FO*, and *MI*.

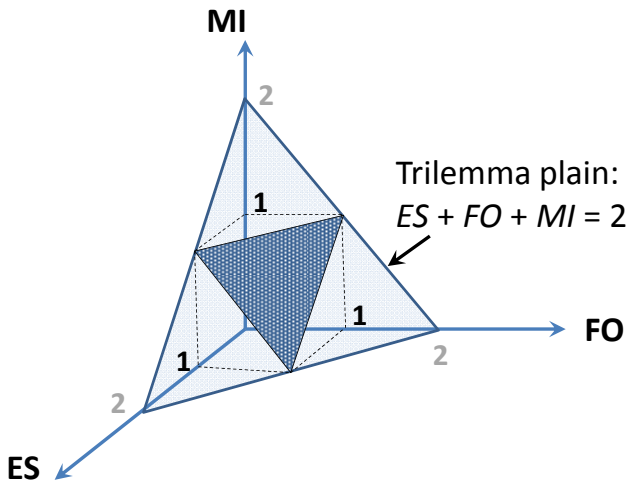
This optimization problem may be interpreted as a result of the well-known stabilization problem of achieving noninflationary, stable economic growth in an open macroeconomic model. The three policy choices—the extent of exchange rate stability, financial market openness, and monetary policy independence—are expected to affect economic growth and inflation rates given the country's economic and structural conditions. The usual optimization problem for a policy maker—to minimize deviations of output from potential output and actual inflation from target inflation—can be expressed as optimization problem (1).

[2] Geometrically, having the three indexes each normalized to range from 0 to 1 means that the trilemma triangle shown in Figure 1 becomes equilateral and its height is 1. Ito and Kawai (2012) geometrically show why the sum of the three indexes in the equilateral triangle must be 2.

2.1 Graphical Presentation

Figure 2 provides an intuitive illustration of the optimization problem, showing the trilemma triangle in a three dimensional domain. The trilemma triangle in Figure 1 is equivalent to the shaded part of the equilateral triangular surface (i.e., the dark-shaded triangle) of a pyramid that has the base and the sides of isosceles right triangles with a height of 2 in each corresponding axis. The shaded plain of the equilateral triangle itself has a height of 1, which corresponds to the assumption that the metrics for the three policy choices range from 0 to 1. Hence, in this shaded triangle also, as one moves vertically toward one of the three sides of the triangle, a higher degree of attainment of the policy represented by that side is achieved, as in the case of Figure 1. Likewise, any policy combination can be shown as a dot on the shaded trilemma plain including the three corners of the triangle. As long as it remains on the triangle plain, it is subject to the trilemma constraint that the sum of the three metrics is always 2 (i.e., *ES* + *FO* + *MI* = 2).

Figure 2: Three-Dimensional Visualization of the Trilemma Plain



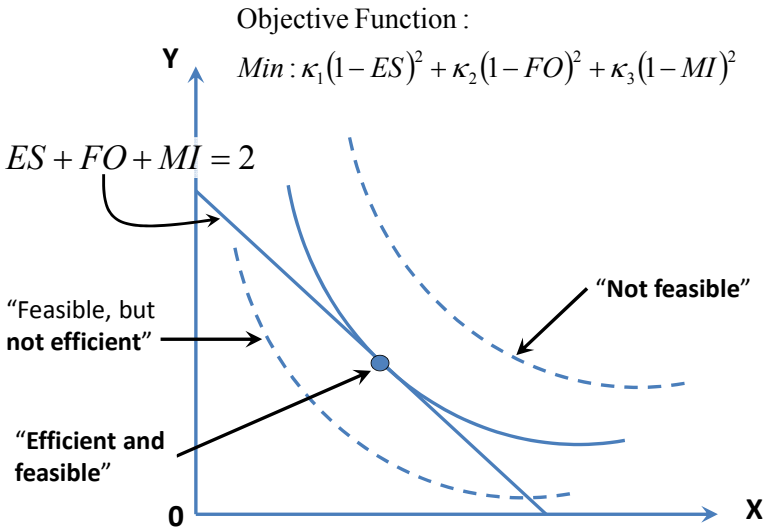
Source: Authors' configuration.

Any policy combination below the trilemma plain toward the origin (or inside the remainder of the cube that is shaved off by the trilemma plain) is also feasible because the sum of the three indexes for such a policy combination would be less than 2 (i.e., *ES* + *FO* + *MI* < 2). However, such a policy combination would not be efficient. In contrast, a policy combination above the trilemma plain away from the origin (or outside the cube shaved off by the trilemma plain) is not feasible as the sum of the three indexes for such a policy combination would be greater than 2 (i.e., *ES* + *FO* + *MI* > 2).

With the constraint represented by the trilemma plain, the policy maker's objective function has a concave ellipsoid shape, comparable to the shape of a football with a smooth surface. The curvature or shape of the ellipsoid is determined by the weights on the three policies κ_j (j = 1, 2, 3) that represent the policy maker's preferences. The policy maker has an incentive to choose the ellipsoid that is as close to its center as possible to achieve as high a level of attainment in each of the policy choices as possible, but at the same time, they are bound by the trilemma constraint. In other

words, the policy maker tries to choose the ellipsoid that touches the trilemma plain and thus minimizes the distance from its center. Hence, if the ellipsoid is placed outside the trilemma constraint, without being tangent to the trilemma plain, such a policy combination is infeasible. If it is placed in a way that the ellipsoid crosses the trilemma plain, without tangency, such an outcome is inefficient, i.e., the policy maker is not utilizing all the opportunities available, though it is feasible. A two-dimensional analogous picture is displayed in Figure 3. As the figure demonstrates, the objective function with the ellipsoid shape is analogous to the utility function and the trilemma constraint to the budget constraint.

Figure 3: Optimization in the Two Dimensions



Source: Authors' configuration.

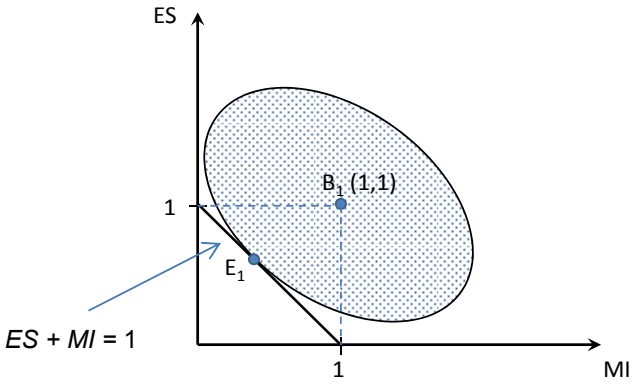
Figure 4 again illustrates the optimization in two dimensions. Here, the objective function and the trilemma plain are drawn for a given level of a third variable, which is financial market openness (*FO*) in this case. Figure 4.A illustrates the optimization problem when *FO* = 1. In this case, the ellipsoid has its center at (1, 1), and point E_1, where the ellipsoid is tangent to the trilemma plain, determines how the remaining value of 1 should be divided between exchange rate stability (*ES*) and monetary policy independence (*MI*).[3] In other words, the trilemma collapses into a dilemma between exchange rate stability and monetary policy independence in the case of a country with full financial market openness.[4] The optimal location E_1 is determined by the three κ_j weights.

[3] One can think of the isosceles right triangle created by the budget constraint and the two axes in Figure 4.A as the same isosceles right triangle as the one that appears at *FO* = 1 in Figure 2.

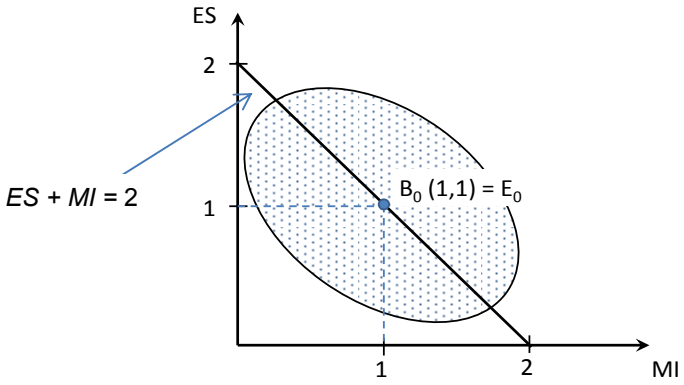
[4] This is what Rey (2013) depicts as the current situation of the global economy. However, one needs to be aware that the collapse of the trilemma to the dilemma happens only if the full extent of financial openness is achieved, which applies to developed countries and a limited number of emerging economies globally.

Figure 4: Optimization under the Trilemma Constraint

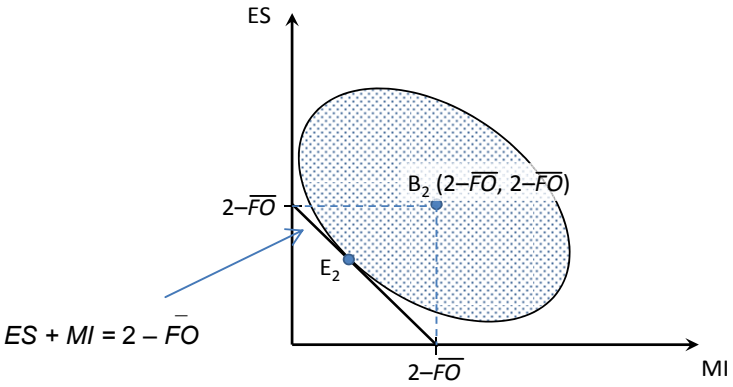
4.A: When *FO* = 1



4.B: When *FO* = 0



4.C: When *FO* = $\bar{FO}$ where 0 < $\bar{FO}$ < 1



Source: Authors' configuration.

Figure 4.B illustrates the optimization when *FO* = 0. In this case, the objective function (i.e., the ellipsoid) and the trilemma constraint are no longer tangent to each other. The center of the ellipsoid is located at (1, 1), which is also on the trilemma constraint so that the policy maker can achieve the maximum value of 1 for both *ES* and *MI*, realizing his or her full level of satisfaction. Figure 4.C illustrates the case when *FO* takes an intermediate value, $0 < \overline{FO} < 1$. This case is similar to Figure 4.A, but the center of the ellipsoid has shifted to ($2–\overline{FO}$, $2–\overline{FO}$). Again, the optimal location E_2 is determined by the three κ_j for a given level of $\overline{FO}$.

2.2 First Order Conditions and Comparative Statics

Solving the optimization problem, we obtain the first order conditions as follows:

$$ES = \frac{\kappa_1(\kappa_2 + \kappa_3)}{\kappa_1\kappa_2 + \kappa_2\kappa_3 + \kappa_1\kappa_3},$$
$$FO = \frac{\kappa_2(\kappa_1 + \kappa_3)}{\kappa_1\kappa_2 + \kappa_2\kappa_3 + \kappa_1\kappa_3},$$
$$MI = \frac{\kappa_3(\kappa_1 + \kappa_2)}{\kappa_1\kappa_2 + \kappa_2\kappa_3 + \kappa_1\kappa_3}.$$

Thus, the optimal combination of *ES*, *FO*, and *MI* is determined entirely by the three κ_j. Using the first order conditions, we can conduct a comparative static analysis with respect to each κ_j. As we see below, the results of the comparative statics are quite straightforward:

$$\frac{dES}{d\kappa_1} \geq 0, \quad \frac{dES}{d\kappa_2} \leq 0, \quad \frac{dES}{d\kappa_3} \leq 0,$$
$$\frac{dFO}{d\kappa_1} \leq 0, \quad \frac{dFO}{d\kappa_2} \geq 0, \quad \frac{dFO}{d\kappa_3} \leq 0,$$
$$\frac{dMI}{d\kappa_1} \leq 0, \quad \frac{dMI}{d\kappa_2} \leq 0, \quad \frac{dMI}{d\kappa_3} \geq 0.$$

Basically, placing a higher weight κ_j on a policy choice raises the level of attainment in that policy while reducing the levels of attainment in the other two policy choices. Considering that the sum of the three policy indexes must be a constant (i.e., 2), these results are quite natural.

The policy weights κ_j are unobservable to the researcher, though they are known to the policy maker. A natural question that then arises is: what factors affect the weights κ_j? If we know the economic and structural factors affecting the weights κ_j, we should be able to find out how the "optimal" levels of *ES*, *FO*, and *MI* are determined by these factors.

We first develop some metrics for the three trilemma policies. Next, we identify the factors that likely affect the weights κ_j and thus determine the metrics of the three policies, and then conduct econometric analysis. In the next section, we explain the metrics we use for the three policy choices.

3. PRESENTING THE NEW TRILEMMA INDEXES

The empirical testing of the trilemma hypothesis requires clearly measurable definitions of the three trilemma policies. Until recently, there was a paucity of metrics that would systematically measure the extent of attainment in each of the three policies to be implemented by policy makers.

Aizenman, Chinn, and Ito (2008) developed a set of "trilemma indexes" that measure the degree of three policy choices with respect to the trilemma. In their metrics, the index for exchange rate stability was defined by an inverse of the annual standard deviation of the monthly rate of change in nominal exchange rates vis-à-vis the base country's currency. The degree of financial market openness was measured by the capital account openness index developed by Chinn and Ito (2006).[5] The monetary policy independence index was based on the time series correlation of a country's interest rate with its base country's interest rate.

While their systematic approach allows the indexes to cover a large number of countries, their simple approach may fail to depict the subtlety of the policy arrangements. First, on the exchange rate stability index, standard deviations of a simple pair-wise exchange rate may not reflect the reality of the exchange rate arrangement for a country that manages its currency value against a basket of major currencies, not a single base country's currency. Second, a *de jure* measure of financial openness may not reflect the actual degree of financial market openness, which may be better captured by *de facto* measures based on observed volumes of cross-border capital flows or some price co-movements in financial assets, such as interest rate parity.[6] Third, simple correlations for the monetary policy independence index may be spurious if they are not properly controlled.

In our study, we use the indexes developed by Ito and Kawai (2012). As will be explained briefly, these indexes attempt to capture more subtleties of the trilemma policies. However, the pursuit of more nuanced approaches comes at the expense of a smaller coverage of countries; data are available for about 80 countries for the period 1970–2010.

While we refer the reader to Ito and Kawai (2012) for the details of how the trilemma indexes are constructed, we provide a brief explanation on each of the three indexes.

3.1 Index for Exchange Rate Stability

To construct the index for exchange rate stability (*ES*), we employ the methodology first introduced by Frankel and Wei (1994), using the following estimation model:

$$\Delta e_{it} = \alpha_i + \beta_{iUS}\Delta e_{US\,t} + \beta_{iJP}\Delta e_{JP_t} + \beta_{iER}\Delta e_{ERt} + \ldots + \beta_{iH}\Delta e_{H\,t} + \varepsilon_{it}\,. \qquad (2)$$

Here, e_{ht} is the nominal exchange rate of the home currency ($h = i$), the US dollar (h = US), the yen (h = JP), the euro (h = ER; or the deutsche mark [DM] before the introduction of the euro), and other major currencies, all against the Special Drawing

[5] More details on the construction of these indexes can be found in Aizenman, Chinn, and Ito (2008).

[6] The issue of whether the *de facto* or *de jure* approach would be better to measure the extent of financial market openness has long been debated in the literature. For the review, refer to Kose et al. (2006), Chinn and Ito (2008), and Quinn, Schindler, and Toyoda (2010).

Rights (SDR) as the numéraire currency.[7] The major currencies on the right-hand side of the estimation equation can be thought of as comprising an implicit basket of these currencies in the mind of the home country's policy makers. Therefore, $\hat{\beta}_{ih}$, the estimated coefficient on the rate of change in the exchange rate for major currency *h*, represents the weight of currency *h* in the implicit basket. If the home currency is pegged to a major currency or a basket of major currencies, it must be either $\hat{\beta}_{ih} = 1$ or $\sum_{h=1}^{H} \hat{\beta}_{ih} = 1$ for the *H* major currencies included in the implicit basket. Also, in such a case, the goodness of fit of the above estimation model must be high. If the home currency is under a floating exchange rate regime, the goodness of fit of the estimation should be low. For our purposes, we apply the estimation model to each of our sample currencies, but estimate it over rolling windows of 36 months.[8] We use the annual average of the time-varying adjusted R^2 as the measure of exchange rate stability.

3.2 Index for Financial Market Openness

We present the index for financial market openness (*FO*) using the dataset compiled by Lane and Milesi-Ferretti (2001, 2007, and updates) in the following manner.[9] We obtain the sum of external assets and liabilities less official foreign exchange reserve assets, calculate this value as percentage ratios of gross domestic product (GDP) and of total trade (exports and imports), and then take the average of these two ratios to define an index of financial market openness as

$$FO*_{it} = \frac{1}{2}\left\{\frac{\text{Total Assets}_{it} + \text{Total Liabilities}_{it} - \text{Official Reserve Assets}_{it}}{GDP_i} + \frac{\text{Total Assets}_{it} + \text{Total Liabilities}_{it} - \text{Official Reserve Assets}_{it}}{(EX + IM)_{it}}\right\}. \quad (3)$$

This computation is somewhat different from those of other researchers. First, we subtract official foreign exchange reserve assets from total external assets as financial market openness should be driven by private investment activity rather than central bank activity. This would make the *FO** index smaller for economies with large reserves; for example, the People's Republic of China's index for *FO** in 2010 would be smaller by 66 percentage points when reserves are subtracted than when they are included. Second, we take the average of the ratios of GDP and total trade to mitigate

[7] 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 colonies, the French or Belgian franc is instead included, respectively.

[8] In other words, the coefficients $\hat{\beta}_{ih}$ are time-varying to reflect the assumption that the policy makers keep updating their information sets. To get more precise estimates, we conduct the estimation in two stages. First, after running the initial estimation, the estimates whose *p*-values are greater than 20% are dropped from the equation. When all of the right-hand side variables turn out to be statistically insignificant (with all the *p*-values greater than 20%), the major currency that has the lowest *p*-value is retained in the estimation. Our rationale is that, even when the policy maker adopts a freely flexible exchange rate regime, he or she usually has a target currency, or a base country's currency, in mind, in the same spirit as Shambaugh (2004) and Aizenman, Chinn, and Ito (2008).

[9] Lane and Milesi-Ferretti's dataset covers international investment positions for about 180 countries between 1970 and 2010. For each country, total assets comprise 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 reserve assets, while total liabilities include FDI liabilities, portfolio equity liabilities, debt liabilities, and financial derivatives liabilities.

biases involved with the respective ratios. For example, when normalizing the sum of total assets and liabilities, net of reserves, by GDP, the resultant index would become unnecessarily small for large economies such as the United States or extremely large for international financial centers such as Ireland, Luxembourg, Singapore, and Hong Kong, China. Normalizing the sum of total assets and liabilities, net of reserves, by total trade volume, on the other hand, would make this index too small for economies that are highly open to international trade, such as Malaysia. Hence, we take a middle course by obtaining the average of the two ratios.

Finally, assuming that developed countries as a group achieved full financial market openness as of the late 1990s, we normalize the above *FO** by the 1995–1999 average of *FO** for the developed countries, or FO^*_{DEV}, the latter of which we regard as the highest level of financial market openness. In addition, when the observed value for *FO** exceeds FO^*_{DEV}, we have defined FO^*_{it} = FO^*_{DEV}. That is,

$$FO_{it} = \frac{FO^*_{it}}{FO^*_{DEV}} \quad \text{where } 0 \leq FO_{it} \leq 1 . \tag{4}$$

The resultant fraction *FO* is an index between 0 and 1, and we treat it as the index for financial market openness.

3.3 Index for Monetary Policy Independence

To construct the index for monetary policy independence (*MI*), we consider the following set of three estimation equations:

$$\Delta i_{it|t-12} = \gamma_{it}\Delta i^*_{it|t-12} + \phi_{iyt}\tilde{y}_{it} + \phi_{i\pi}\tilde{\pi}_{it} + \phi_{iy_G t}y_{Gt} + \phi_{ioil\pi}oil\pi_{it} + D_i'\Phi_D + \varepsilon^I_{it}, \tag{5}$$

$$\Delta i_{it|t-12} = \phi_{iyt}\tilde{y}_{it} + \phi_{i\pi}\tilde{\pi}_{it} + \phi_{iy_G t}y_{Gt} + \phi_{ioil\pi}oil\pi_{it} + D_i'\Phi_D + \varepsilon^{II}_{it}, \tag{6}$$

$$\Delta i_{it|t-12} = \gamma_{it}\Delta i^*_{it|t-12} + D_i'\Phi_D + \varepsilon^{III}_{it}. \tag{7}$$

Here, $\Delta i_{it|t-12}$ and $\Delta i^*_{it|t-12}$ refer to the change in the home and foreign interest rates, respectively, over a 12-month period. The foreign interest rate is the weighted average of the interest rates of the major countries whose currencies are included in equation (2) with the weights based on the coefficients $\hat{\beta}_{ih}$. The variable $\tilde{y}_{it}$ is a proxy for the output gap measured by the year-over-year growth rate of industrial production; $\tilde{\pi}_{it}$ is a proxy for the inflation gap measured by the year-over-year rate of change in the consumer price index (CPI); y_{Gt} is a proxy for the world's output gap measured by the weighted average year-over-year growth rate in industrial production of the countries in the Group of Seven (G7) and BRIC (Brazil, the Russian Federation, India, and the People's Republic of China); and $oil\pi_{it}$ is the year-over-year rate of change in the price of crude oil. *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 index (Eichengreen, Rose, and Wyplosz 1995, 1996).

These three equations differ among each other depending on whether the foreign interest rate $\Delta i^*_{it|t-12}$ is included to explain the home interest rate (equations 5 and 7) and whether factors other than the foreign interest rate—such as domestic factors ($\tilde{y}_{it}$, $\tilde{\pi}_{it}$) and global factors (y_{Gt}, $oil\pi_{it}$)—are included (equations 5 and 6).

Using the adjusted R^2 of these estimation models, we come up with the following two types of metrics for the level of monetary policy independence:

$$MI\_1 = \frac{Adj.R^2 \text{ of Eq. 6 (non - } \Delta i^* \text{ factors only)}}{Adj.R^2 \text{ of Eq. 5 (} \Delta i^* \text{ and non - } \Delta i^* \text{ factors)}} \quad (8)$$

$$MI\_2 = 1 - \frac{Adj.R^2 \text{ of Eq. 7 (} \Delta i^* \text{ only)}}{Adj.R^2 \text{ of Eq. 5 (} \Delta i^* \text{ and non - } \Delta i^* \text{ factors)}} \quad (9)$$

The first metric, *MI_1,* is based on the view that the less explanatory power the foreign interest rate has in equation (5) and the more explanatory power other factors have in equation (6), the higher the level of monetary policy independence. Therefore, a higher value of *MI_1* indicates greater monetary policy independence. In contrast, the second metric, *MI_2,* reflects the view that the less explanatory power other factors have in equation (5) and the more explanatory power the foreign interest rate has in equation (7), the lower the level of monetary policy independence. Thus, a higher value of *MI_2* (or a lower value of the second term of the metric) indicates greater monetary policy independence.

Either of these two metrics or their average is used to measure the extent of monetary policy independence. It would be appropriate to focus on the explanatory power of the equations, represented by the adjusted R^2, if the vector of domestic and global factors and the foreign interest rate are orthogonal to each other. This condition cannot be ensured in general as domestic and foreign policy makers may face similar shocks and react similarly to them.[10]

Hence, we take the following procedure for each of our sample economies. If the adjusted R^2 of equation (6) is greater than that of equation (7), we use *MI_1* as the index for monetary policy independence. In this case, we can see how much additional explanatory power the foreign interest rate would have in equation (5) compared to equation (6). In contrast, if the adjusted R^2 of equation (6) is less than that of equation (7), we use *MI_2* for the MI index. In this case, we can see how much additional explanatory power the vector of domestic and global factors would have in equation (5) compared to equation (7). If the adjusted R^2 of equations (6) and (7) are sufficiently close to each other, we use the average of *MI_1* and *MI_2* for the MI index.[11]

[10] For example, when the home country is geographically close to the foreign country, thereby subject to similar shocks, the home policy maker with full monetary policy independence could behave similarly to the foreign policy maker and thus, may appear to set the home interest rate in response to the foreign interest rate. This means that even when equation (6) is the true specification, equation (7) could deliver a good fit because the foreign interest rate and the vector of domestic and global factors could be highly correlated. On the other hand, even when equation (7) is the true specification, the goodness of fit of equation (6) could still be high if home and global factors on the right hand side of (6) are highly correlated with the foreign interest rate.

[11] We further make additional adjustments to each of these indexes to correct the distorted or lopsided distribution of their time series. The additional adjustments are carefully explained in Ito and Kawai (2012), who also discuss statistical properties and stylized facts of the three indexes.

4. INVESTIGATION OF THE DETERMINANTS OF THE TRILEMMA POLICIES

4.1 Estimation Model

We now identify econometrically the determinants of the three trilemma policy combinations, i.e., exchange rate stability, financial market openness, and monetary policy independence, for which we use as proxies the trilemma indexes as explained in the previous section.

The literature on empirical investigations of the determinants of some of the trilemma policy choices is voluminous. In particular, a large number of studies exist that analyze the determinants of the degree of exchange rate stability or exchange rate regimes. There are also studies on the determinants of financial market openness but to a lesser extent than on exchange rate stability. Empirical studies on the determinants of monetary policy independence, however, are quite limited.[12]

Concerning past efforts to identify the determinants of the triad open macroeconomic policies, we raise two crucial points on the estimation. First, none of the studies has treated the three policy indexes of the trilemma to be determined jointly. Studies in the literature usually involve investigations of one of the triad policies while controlling for one or the other two of the trilemma indexes. However, as we have discussed in the theoretical section, the three policies are determined jointly by a policy maker under the linear trilemma constraint. A joint determination of the policy combinations has not been attempted in past empirical studies. Here, we identify the determinants of the three policy indexes in a set of three equations. This also means that we must assume that the error terms for the estimation equations are correlated. For this reason, we utilize the seemingly unrelated regression (SUR) estimation method to account for cross-equation correlations of error terms.

Second, past studies have not incorporated the linear constraint with regard to the trilemma policy indexes. In our estimation, we impose the linear constraint based on the trilemma across the three equations. Aizenman, Chinn, and Ito (2008) have shown that the sum of the three metrics that measure the extent of attainment in the three policies must be a constant. In particular, if each metric takes on a value between 0 and 1, the sum must be 2 (Ito and Kawai 2012). We impose the constraint that the three indexes must add up to 2 in our SUR estimation.[13]

Against this backdrop, we regress the three trilemma indexes, *ES*, *FO*, and *MI*, by using exogenous explanatory variables in a set of three joint equations:

$$ES_{i,t} = \alpha_{ES} + X'_{i,t} B_{ES} + \varepsilon^{ES}_{i,t},$$

[12] For studies of exchange rate regimes, refer to Ghosh, Gulde, and Ostry (1997), Levy-Yeyati and Sturzenegger (2003), and Eichengreen and Leblang (2003). The empirical literature on the determinants of financial market openness or financial liberalization is surveyed by Edison et al. (2004), Prasad et al. (2003), Henry (2006), Kose et al. (2006), and Prasad and Rajan (2008). For the determinants of monetary policy independence, refer to Frankel, Schmukler, and Serven (2004), Shambaugh (2004), Obstfeld, Shambaugh, and Taylor (2005), and Bluedorn and Bowdler (2010) among others.

[13] Even if we impose the linear trilemma constraint, we still allow for short-term (i.e., annual) deviations from the constraint as this constraint is assumed to be binding in the long run (Aizenman, Chinn, and Ito 2008). Thus, we do not assume that the error terms add up to 0 each year though they can be correlated across equations.

$$FO_{i,t} = \alpha_{FO} + X'_{i,t}B_{FO} + \varepsilon_{i,t}^{FO}, \quad (10)$$
$$MI_{i,t} = \alpha_{MI} + X'_{i,t}B_{MI} + \varepsilon_{i,t}^{MI}.$$

Here, *X* is a vector of the common explanatory variables; *B* is a vector of corresponding coefficients; and $cov(\varepsilon^j, \varepsilon^k) \neq 0$ for j or $k = \{ES, FO, MI\}$. The theoretical rationale for this estimation is that the exogenous variables $X_{i,t}$ jointly determine the three policy choices through their effects on the policy weights κ_j. Since we assume that the linear dependence of the three indexes holds in the long run, we impose the following two constraints in the estimation:

$$\alpha_{ES} + \alpha_{FO} + \alpha_{MI} = 2 \quad \text{and} \quad B_{ES} + B_{FO} + B_{MI} = 0 \quad (11)$$

In other words, we impose the constraints that the estimated intercepts of the three regression equations add up to 2 and that the estimated coefficients on each explanatory variable add up to 0. With these constraints, the sum of the three equations (10) collapses to the value of 2 plus the sum of the three error terms, $\varepsilon_{i,t}^{ES}$ + $\varepsilon_{i,t}^{FO}$ + $\varepsilon_{i,t}^{MI}$, which has a zero mean value but can deviate from 0 in each period.

The vector of explanatory variables $X_{i,t}$ includes the following variables: economic size (the share of world GDP in purchasing power parity [PPP] terms); relative per-capita income (per capita GDP in PPP as a percentage of the US level); trade openness (the sum of exports and imports as a percentage of GDP); foreign exchange reserves held (excluding gold, as a percentage of GDP); concentration of trade partners (the share of trade with top-5 trading partners as a percentage of total trade); proportion of commodity exports (the share of commodity exports in total exports); financial development (private credit as a percentage of GDP); domestic savings (gross domestic savings as a percentage of GDP); and terms of trade (TOT) shocks (standard deviations of TOT over the past 5 years). We use a panel dataset comprising 78 countries over the period 1970–2010. The data sources are explained in Appendix 1 and a list of economies included in the estimation is provided in Appendix 2.

We intentionally include the same set of explanatory variables in the right-hand side of all three equations because of the joint determination of the trilemma indexes under the linear trilemma constraint. These explanatory variables are chosen among the variables that are most commonly used in the past literature.

Because of the way the model is set up—including the imposition of the linear trilemma constraint—and the relatively long sample period, we can think of the estimation as that for the long-run equilibrium relationship between the economic and structural variables and the three trilemma indexes. Moreover, to ensure that the explanatory variables are exogenous, we define them as the annual data averaged over the period *t*–1 through *t*–5, except for TOT shocks which are already defined over the same period.[14]

4.2 Predictions on the Signs of the Estimated Coefficients

Table 1 summarizes the predicted signs of the explanatory variables. These predictions are based on theoretical considerations and the findings of the past empirical studies. In the table, while most of the variables, especially those for exchange rate stability (*ES*) and financial market openness (*FO*), have a priori predictions on the signs of the determinants, several variables, particularly those for monetary policy independence (*MI*), either have ambiguous predictions or do not have any prior predictions. A large

[14] Because of the averaging, we lose the first years of observations for the estimation.

number of empirical studies exists on the determinants of exchange rate stability (*ES*), or exchange rate regimes, but such studies are limited on the determinants of financial market openness (*FO*) and much more so on the determinants of monetary policy independence (*MI*). Thus, sign predictions for the determinants of *FO* and *MI* in the table are largely based on theoretical considerations. Even though some variables lack any theoretical foundations, we keep them in the estimation, as they are still expected to affect at least one trilemma index from the theoretical perspectives. When a variable is predicted to have a positive, negative, ambiguous, or theoretically undetermined impact, we show the expression "+," "–," "+/–," or "?" in each cell of the table.

Table 1: A Priori Predictions on the Signs of the Explanatory Variables

	Exchange Rate Stability (*ES*)	**Financial Market Openness** (*FO*)	**Monetary Policy Independence** (*MI*)
Economic size	–	+/–	+
Relative per-capita income	–	+	+
Trade openness	+	+	–
Foreign exchange reserves	+	+	+
Concentration of trading partners	+	?	?
Proportion of commodity exports	+	+	?
Financial development	–	+	?
Domestic savings	+	–	?
Terms of trade shocks	+/–	+/–	+

Notes: The sign indicates the sign of the effect of each explanatory variable based on theoretical predictions. +/– means theoretically ambiguous, while "?" means no prediction is provided by the theory.

Source: Authors' summary of predictions.

We expect economic size to have a negative impact on *ES*, an ambiguous impact on *FO*, and a positive impact on *MI*. Theory suggests that larger economies may afford to absorb external shocks even under floating exchange rates due to the large size of nontradables sectors, while smaller economies tend to be affected by shocks coming from exchange rate fluctuations. Hence, policy makers in larger economies are less likely to adopt exchange rate stability. Juhn and Mauro (2002) demonstrate that the most robust determinant of exchange rate regimes would be the size of the economy; larger economies tend to prefer floating regimes and not to peg. A number of other studies, such as Heller (1978), Rizzo (1998), Poirson (2001), Meon and Rizzo (2002), and von Hagen and Zhou (2007), have also arrived at similar findings. The theoretical ambiguity on the impact of economic size on *FO*—which we denote as "+/–" in the table—comes from the expectation that policy makers in large economies can make better use of scale economies and thereby afford to open their financial markets to foreign investors and financial institutions, while those in smaller economies may also be tempted to keep their financial markets open and invite foreign financial service providers. Johnston and Tamirisa (1998) find that larger economies tend to impose capital controls on both capital inflows and outflows, thus limiting financial market openness. Policy makers in larger economies are expected to maintain greater monetary policy independence for domestic stabilization purposes, while those in smaller economies can more easily give it up and follow larger economies' monetary policy.

Relative per-capita income is expected to have a negative impact on *ES* and positive impacts on *FO* and *MI*. Higher-income economies tend to be equipped with more

developed institutions and legal systems that are more capable of coping with external shocks, better even under floating exchange rates. Hence, policy makers in higher-income economies tend to adopt greater exchange rate flexibility than those in lower-income economies. Indeed, Edwards (1996), Holden, Holden, and Suss (1979), and Savvides (1990) find that economies with higher income levels tend to prefer floating exchange rate regimes. Theory also suggests that policy makers in higher-income economies can afford to open their financial markets because they tend to have better policy and institutional capacities to absorb the impact of external financial shocks. Alesina, Grilli, and Milesi-Ferretti (1994), Grilli and Milesi-Ferretti (1995), and Leblang (1997) demonstrate that less developed countries tend to impose capital controls, i.e., pursue lower degrees of financial market openness, suggesting a positive coefficient on relative per-capita income in the *FO* equation. Policy makers in higher-income economies are expected to pursue greater monetary policy independence because of their higher levels of policy credibility and capacities to use monetary policy for short-term stabilization.

Trade openness is expected to have positive impacts on *ES* and *FO* and a negative impact on *MI*. The optimum currency area (OCA) theory predicts that policy makers in more open economies tend to adopt greater exchange rate stability. Heller (1978), Dreyer (1978), Holden, Holden, and Suss (1979), Bernhard and Leblang (1999), and von Hagen and Zhou (2007), among others, have indeed found that greater trade openness leads to the adoption of a more stable or fixed exchange rate regime. However, Collins (1996), Berger, Sturm, and De Haan (2000), and Meon and Rizzo (2002) present the opposite result: economies more open to trade tend to adopt floating or non-peg exchange rate regimes. Poirson (2001) and Juhn and Mauro (2002) show that trade openness is neither robust nor relevant to the choice of an exchange rate regime. Despite the empirically mixed findings, we predict the impact of trade openness on *ES* to be positive, following the OCA theory. Trade openness is often perceived as a precondition for financial market openness, according to the optimal sequencing literature of financial market opening (see McKinnon 1991). Johnston and Tamirisa (1998), Tornell, Westermann, and Martinez (2004), and Chinn and Ito (2006) find that economies more open to international trade tend to have more open financial markets, though Quinn and Inclan (1997) find no such evidence. As for monetary policy independence (*MI*), it is more difficult for open-economy policy makers to implement independent monetary policy as the Philips curve would become flatter and monetary policy would become less effective (Razin and Binyamini 2007).[15] Thus, trade openness is expected to lead to a lower level of *MI*.

We expect the size of foreign exchange reserves to have positive impacts on *FO*, *ES,* and *MI*, although all the three impacts cannot be positive at the same time under the trilemma constraint. In general, authorities with larger amounts of foreign exchange reserves can enjoy the credibility of their exchange rate regimes, especially if they pursue more fixed exchange rates. Poirson (2001) finds that economies with lower levels of foreign exchange reserves tend to adopt greater exchange rate flexibility. Obstfeld, Shambaugh, and Taylor (2009) show that countries with larger international reserves experienced smaller sizes of currency depreciation during the global financial crisis of 2008, suggesting that large war chests of reserves would help stabilize exchange rate movements. Theoretically, larger amounts of foreign exchange reserves can also allow policy makers to open their financial markets more easily because

[15] Loungani, Razin, and Yuen (2001) find that countries with greater restrictions on capital mobility face steeper Phillips curves.

reserves could be mobilized to fight against external shocks or speculative attacks that may arise due to financial openness. Monetary authorities with higher levels of reserves could also conduct sterilized interventions more actively and thereby retain greater monetary policy independence. However, as indicated earlier, foreign exchange reserves cannot have positive coefficients in all three equations. Therefore, we should empirically find out which equation will have a negative coefficient.

Concentration of trade with top-5 trading partners is predicted to have a positive impact on *ES* and undetermined impacts on *FO* and *MI*. As the OCA theory suggests, economies with more concentrated groups of trading partners prefer greater exchange rate stability against currencies of these major trading partners. Von Hagen and Zhou (2007), Dreyer (1978), Rizzo (1998), and others find positive effects of trade concentration on exchange rate stability. No obvious theory predicts the impact of trade partner concentration on the extent of financial market openness (*FO*) or monetary policy independence (*MI*). Thus, we put question marks "?" in the corresponding cells of the table.

The proportion of commodity exports is expected to have positive impacts on *ES* and *FO* and an undetermined impact on *MI*. Because commodity prices are usually quoted in US dollar, policy makers in countries with high proportions of commodity exports should prefer more stable exchange rates against the US dollar so that their exporters can secure stable home currency-denominated revenues. Thus, the commodity export proportion is expected to have a positive coefficient in the *ES* equation. Similarly, once commodity-exporting countries obtain revenues in a major hard currency (again, mostly the US dollar), they would be tempted to invest overseas and thus prefer to have more open financial markets. No theory suggests the sign of the impact of the commodity export proportion on the extent of monetary policy independence (*MI*).

We expect the degree of financial development to have a negative impact on *ES*, a positive impact on *FO*, and an undetermined impact on *MI*. Policy makers with more developed financial markets should be more tolerant with exchange rate fluctuations because such financial markets would be more resilient to exchange rate volatility. Lin and Ye (2011) empirically show that countries with less developed financial markets tend to adopt fixed exchange rate regimes.[16] However, von Hagen and Zhou (2007) argue that countries with broader and deeper financial markets tend to adopt fixed exchange rate regimes because they can afford to stabilize exchange rates. Despite these empirically mixed findings in the literature, we follow the theoretical prediction that the impact of financial development on *ES* is negative. Theory suggests that policy makers with more developed financial markets are more prone to open their financial markets as they are more resilient to external financial shocks, suggesting a positive coefficient on financial development in the *FO* equation. There is no particular theory regarding the prediction of the impact of financial development on the extent of *MI*.

Domestic savings are predicted to have a positive impact on *ES*, a negative impact on *FO*, and an undetermined impact on *MI*. Economies with higher domestic savings tend to run more favorable current account balances, which would make it easier for them to maintain stable exchange rates. Such economies do not face strong needs to open their financial markets to have access to foreign savings, while economies with lower domestic savings may need to borrow from abroad by opening financial markets.

[16] They also show that financial development leads a country to exit from a pegged exchange rate regime toward a flexible one, though the degree of financial development would matter only for orderly exits, not disorderly exits (i.e., currency crises).

Theory does not provide any predictions on the impact of domestic savings on monetary policy independence (*MI*).

Finally, we expect TOT shocks to have ambiguous impacts on *ES* and *FO* and a positive impact on *MI*. Policy makers facing greater TOT shocks would prefer more flexible exchange rate regimes to absorb shocks, while at the same time such policy makers may try to stabilize their economies by maintaining greater exchange rate stability. Frieden, Ghezzi, and Stein (2000) find that economies facing larger TOT shocks tend to prefer greater stability in exchange rates,[17] while Rizzo (1998) and Poirson (2001) find that countries exposed to larger TOT shocks tend to adopt greater exchange rate flexibility, which would function as a shock absorber. Thus, the predicted impact of TOT shocks on *ES* is ambiguous. The impact of TOT shocks on financial market openness (*FO*) is also ambiguous. The reason is that policy makers subject to large TOT shocks may want to keep their financial markets closed so as to shun the effect of external shocks, while they may also prefer keeping their financial markets open to benefit from risk sharing. Such policy makers would prefer retaining monetary policy independence (*MI*) as they need to actively stabilize their economies in the face of TOT shocks.

4.3 Estimation Results

Table 2 reports the results of the joint SUR estimation of the three policy indexes with the trilemma constraints imposed on the estimates. We can see that the signs of most of the estimates are consistent with prior predictions summarized in Table 1, although there are several deviations from these predictions.

The estimation results show that the impacts of economic size on *ES* and *FO* are negative (though the impact on *FO* is statistically insignificant), and its impact on *MI* is positive.[18] The results on *ES* and *MI* are consistent with both theoretical considerations and findings of a large number of empirical studies as suggested by Juhn and Mauro (2002). Larger economies' preference for greater exchange rate flexibility and higher levels of monetary independence implies that these economies can have more open financial markets, but the estimated coefficient of economic size on *FO* is negative, though statistically insignificant. It turns out that the positive impact of economic size on *MI* is highly robust in our estimations, as we will show later.

We find relative per-capita income to lower the levels of *ES* and *MI* and to increase the level of *FO*. The negative impact of relative per-capita income on *ES* and its positive impact on *FO* are consistent with both theoretical predictions and the bulk of past empirical studies, and turn out to be relatively robust results in our other estimations to be discussed later. The result on the negative impact of per capita income on *MI*—that is, policy makers in higher-income economies tend to prefer lesser degrees of monetary policy independence—is surprising and in contrast to the prior prediction. This is one of the puzzling results found in our study.[19]

[17] However, their analysis only includes Latin American countries.

[18] In what follows, when we say the impact is positive or negative, it means statistically significantly positive or negative unless otherwise stated.

[19] This result is not driven by the member countries of the eurozone (or the European Monetary Union). When we exclude the eurozone member countries, the estimate on the relative income variable still remains significantly negative. However, when we reestimate the model excluding the countries that are members of the eurozone (after 1999) and the European Exchange Rate Mechanism (between 1978

Table 2: Seemingly Unrelated Regression Estimations of the Determinants of the Three Policy Choices

(Annual Data, 1970–2010, Full Sample)

	Exchange Rate Stability (*ES*)	Financial Market Openness (*FO*)	Monetary Policy Independence (*MI*)
Economic size	-3.714	-0.094	3.808
	(0.456)***	(0.377)	(0.490)***
Relative per-capita income	-0.094	0.179	-0.085
	(0.027)***	(0.022)***	(0.029)***
Trade openness	0.082	0.076	-0.158
	(0.025)***	(0.021)***	(0.027)***
Foreign exchange reserves	-0.529	0.001	0.528
	(0.094)***	(0.077)	(0.101)***
Concentration of trading partners	0.246	-0.287	0.041
	(0.062)***	(0.051)***	(0.067)
Proportion of commodity exports	-0.188	0.247	-0.058
	(0.035)***	(0.029)***	(0.038)
Financial development	-0.102	0.304	-0.202
	(0.022)***	(0.018)***	(0.024)***
Domestic savings	0.433	-0.471	0.038
	(0.092)***	(0.076)***	(0.098)
Terms of trade shocks	0.519	-1.204	0.685
	(0.240)**	(0.199)***	(0.258)***
Constant	0.743	0.374	0.883
	(0.030)***	(0.025)***	(0.032)***
N	1,550		

Notes: * $p<0.1$; ** $p<0.05$; *** $p<0.01$. The table shows the results of the seemingly unrelated regression (SUR) estimations with the constraints that the estimated intercepts of the three regression equations add up to 2 and that the estimates of each explanatory variable add up to 0. For the explanatory variables, we use the annual data averaged over the period *t*–1 through *t*–5, except for terms of trade shocks, which are the standard deviations of the original data over the same period. No country or yearly fixed effects are included in the estimations.

Source: Authors' computation.

Our evidence supports the OCA theory, that is, trade openness raises the levels of *ES* and *FO* and reduces the level of *MI*. The positive impacts of trade openness on *ES* and *FO* are consistent with the findings of many past empirical results, particularly von Hagen and Zhou (2007) and Chinn and Ito (2006). The negative impact of trade openness on *MI* is consistent with the theoretical prediction made by Razin and Binyamini (2007). It turns out that the positive impact on *ES* and the negative impact on *MI* are highly robust in our other estimations, as will be shown later.

The estimated impact of foreign exchange reserves on *ES* is negative, and its impacts on *FO* and *MI* are positive (though insignificant for *FO*). The negative impact on *ES* is a surprising finding and is not consistent with the prior prediction that larger amounts of foreign exchange reserves leads to more stable exchange rates.[20] This is somewhat

and 1998), the statistical significance drops to a *p*-value of 13.5. When we exclude all the developed countries, the estimate becomes virtually 0.

[20] Even when we exclude the countries that experienced currency crises and redo the estimations, the signs and the statistical significance of the estimates remain intact.

puzzling. The positive impacts of foreign reserves on *FO* and *MI* are consistent with prior predictions, and the positive impact on *MI* turns out to be a robust result in our other estimations.

More concentrated trade in terms of trading partners, our results show, leads to higher levels of *ES* and *MI* (though the impact on the latter is statistically insignificant) and a lower level of financial market openness. The positive impact of trading partner concentration on *ES* is consistent with the OCA theory and earlier empirical results, and turns out to be quite robust in our later estimations. As discussed earlier, no theory can explain the negative and positive impacts on *FO* and *MI*.

We find economies with higher commodity export proportions to prefer lower levels of *ES* and *MI* (though the impact on *MI* is statistically insignificant) and a higher level of *FO*. The negative impact of commodity exports on *ES* is not consistent with the prior prediction, another puzzling result reported in Table 2. The positive impact on *FO* is in line with the prior prediction.

Financial development has negative impacts on *ES* and *MI* and a positive impact on *FO*. The negative impact on *ES* is consistent with both theoretical considerations and recent empirical studies, particularly by Lin and Ye (2011)—though not with results obtained by von Hagen and Zhou (2007). The positive impact on *FO* is consistent with the prior prediction, and this turns out to be one of the most robust findings of our empirical analysis. We cannot explain theoretically the negative impact of financial development on *MI*.

We find domestic savings to affect *ES* and *MI* positively (though the impact on *MI* is statistically insignificant) and *FO* negatively. The positive impact of domestic savings on *ES* and its negative impact on *FO* are consistent with prior predictions, and these are highly robust results in our other estimations. The behavior of the People's Republic of China toward both the exchange rate regime and financial market opening in the presence of its massive amount of domestic savings—that accounts for about half of its GDP—is consistent with these findings.

The impacts of TOT shocks on *ES* and *MI* are positive while the impact on *MI* is negative. It turns out, however, that these results are not necessarily robust, except for the positive impact on *MI*.

4.4 Robustness Checks

4.4.1 Estimations with Fixed Effects

It is possible that both country-specific characteristics and global common shocks affect the trilemma policy combinations, which our estimation model may not have fully captured. Hence, we reestimate the SUR model by controlling for country-specific effects, yearly effects, or both and report the results in Table 3. The signs of the estimates remain mostly intact with these fixed effects with a few exceptions, although the statistical significance of the estimates generally drops in the estimations with country fixed effects or country and yearly fixed effects.

Considering that many of the right-hand side variables tend to evolve relatively slowly over time, it is reasonable to see weaker estimation results with these fixed effects. It is noteworthy, however, that compared with the baseline model most of the estimates remain statistically significant, with similar magnitudes of coefficients.

More specifically, the estimates reported in Table 3 confirm the robustness of our major findings, which are mostly consistent with prior predictions. However, a few results are

somewhat different from the baseline results reported in Table 2. First, the impact of economic size on *FO* is not stable, taking on both negative and positive values depending on specifications, which supports the predicted ambiguity of this impact, as explained earlier. Second, the impact of foreign exchange reserves on *FO* is unstable, again taking on negative and positive values depending on specifications, in contrast to the prior prediction that it is positive. Third, the impact of domestic savings on *MI* is significantly negative when both yearly and country effects are included, in contrast to the baseline estimation where the estimate was insignificantly positive. Finally, the impacts of TOT shocks on *ES* and *FO* are negative and positive, respectively, when country and yearly fixed effects are included, which, together with the baseline estimations, supports the ambiguous predictions.

4.4.2 TOBIT Estimation

Given that the dependent variables are normalized to range between 0 and 1, a nonlinear model might be more appropriate because the BLUE conditions of a linear estimation could be violated with the dependent variable being bound by 0 and 1. Hence, as another robustness test, we implement the TOBIT estimation method with the truncated dependent variables.[21]

As columns (a) through (c) of Appendix 3 show, the TOBIT estimation yields similar results to those of the baseline SUR estimation in terms of both signs and statistical significance of the estimates, except for a few instances. Hence, even when we incorporate the possible nonlinearity of the dependent variables, our results remain robust.

A notable exception is the impact of the commodity export proportion on *MI*, however. Its estimated coefficient is now significantly positive, in contrast to the negatively estimated coefficients in the baseline estimation (though not statistically significant) as well as in the estimation with country and yearly fixed effects (with statistical significance).

4.4.3 2SLS Estimation

Last, although we have tried to ensure the exogeneity of the explanatory variables and to avoid simultaneity problems by using the 5-year averages of the explanatory variables over t–5 through t–1, it is still possible that some of the right-hand side variables are endogenous. One such candidate is the variable for foreign exchange reserves (as a ratio to GDP). For example, policy makers may wish to accumulate foreign exchange reserves today with the objectives of adopting a particular exchange rate regime in the future. In this sense, the level of reserves today can be affected by a future policy choice and thus might become an endogenous variable.

[21] We applied the TOBIT estimation to each of the three equations separately. Unlike the SUR estimation where the estimation is conducted jointly for the three equations, we do not impose the constraint of joint determination or the trilemma linearity.

Table 3: Seemingly Unrelated Regression Estimations of the Determinants of the Three Policy Choices with Fixed Effects

(Annual Data, 1970–2010, Full Sample)

	With country fixed effects			With yearly fixed effects			With both country and yearly fixed effects		
	Exchange Rate Stability	Financial Market Openness	Monetary Policy Independence	Exchange Rate Stability	Financial Market Openness	Monetary Policy Independence	Exchange Rate Stability	Financial Market Openness	Monetary Policy Independence
	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)
Economic size	-0.739	-11.307	12.047	-4.712	1.839	2.873	-3.379	-2.400	5.779
	(1.472)	(1.221)***	(1.682)***	(0.450)***	(0.308)***	(0.488)***	(1.518)**	(1.034)**	(1.695)***
Relative per-capita income	-0.096	0.007	0.089	-0.185	0.354	-0.170	-0.116	0.027	0.089
	(0.112)	(0.093)	(0.128)	(0.028)***	(0.019)***	(0.030)***	(0.109)	(0.075)	(0.122)
Trade openness	0.071	0.167	-0.238	0.063	0.111	-0.174	0.049	0.044	-0.093
	(0.048)	(0.040)***	(0.055)***	(0.024)***	(0.017)***	(0.026)***	(0.050)	(0.034)	(0.056)*
Foreign exchange reserves	-0.650	0.298	0.352	-0.402	-0.282	0.684	-0.580	-0.283	0.862
	(0.095)***	(0.079)***	(0.109)***	(0.092)***	(0.063)***	(0.100)***	(0.102)***	(0.070)***	(0.114)***
Concentration of trading partners	0.681	-0.949	0.269	0.243	-0.277	0.035	0.554	-0.328	-0.226
	(0.174)***	(0.144)***	(0.198)	(0.060)***	(0.041)***	(0.065)	(0.177)***	(0.121)***	(0.198)
Proportion of commodity exports	0.020	-0.054	0.034	-0.208	0.263	-0.055	-0.233	0.533	-0.299
	(0.076)	(0.063)	(0.087)	(0.035)***	(0.024)***	(0.037)	(0.083)***	(0.057)***	(0.093)***
Financial development	-0.115	0.409	-0.294	-0.020	0.136	-0.115	-0.053	0.125	-0.072
	(0.027)***	(0.022)***	(0.031)***	(0.023)	(0.016)***	(0.025)***	(0.031)*	(0.021)***	(0.034)**
Domestic savings	0.543	-0.401	-0.142	0.477	-0.523	0.045	0.562	-0.135	-0.427
	(0.165)***	(0.136)***	(0.188)	(0.088)***	(0.060)***	(0.096)	(0.162)***	(0.110)	(0.181)**
Terms of trade shocks	-0.389	0.025	0.364	0.116	-0.310	0.194	-0.516	0.590	-0.073
	(0.246)	(0.204)	(0.281)	(0.244)	(0.167)*	(0.264)	(0.254)**	(0.173)***	(0.284)
N	1,550			1,550			1,550		

Notes: * $p<0.1$; ** $p<0.05$; *** $p<0.01$. The table shows the results of the seemingly unrelated regression (SUR) estimations with the constraints that the estimated intercepts of the three regression equations add up to 2 and the estimates of each explanatory variable add up to 0. As we include country, yearly, or country and yearly fixed effects, there is no common constant term in each regression equation. For the above regressions, we use the annual data averaged over the period *t*–1 through *t*–5, except for terms of trade shocks, which are the standard deviations of the original data over the same period.

Source: Authors' computation.

To deal with this possible endogeneity problem, we conduct another robustness check by implementing a two-stage least squares (2SLS) estimation, which instruments the reserve variable with several exogenous variables that may affect the level of reserve holding. The instruments used are the volume of commodity imports (as a percentage of GDP); trade volatility (standard deviation of trade as a percentage of GDP during *t*–1 and *t*–5); and the number of past experiences with currency, banking, and debt crises.[22]

Results of the 2SLS estimation reported in columns (d) through (f) in Appendix 3,[23] are mostly similar to those obtained from the baseline and other estimation methods, though there are some exceptions. The impact of economic size on *ES* is now positive (at the 10% significance level) and the impact of trade openness on *FO* is now negative. In addition, the impacts of the commodity export proportion on *ES* and *FO* are now significantly positive and negative, respectively.[24] These results, which are contrary to those found in the baseline and fixed effects estimations, may be driven by potentially high correlations between the concerned variables and the instrumental variables chosen. Nonetheless, they call for some caution in drawing definitive conclusions about the impacts of these variables on *ES* and *FO*. Table 4 summarizes our overall findings.

Table 4: Predicted versus Estimated Effects of the Explanatory Variables

	Exchange Rate Stability (*ES*)	**Financial Market Openness** (*FO*)	**Monetary Policy Independence** (*MI*)
Economic size	– (–)	+/– (–)	+ (+***)
Relative per-capita income	– (–**)	+ (+**)	+ (–*)
Trade openness	+ (+**)	+ (+)	– (–**)
Foreign exchange reserves	+ (–***)	+ (+/–)	+ (+**)
Concentration of trading partners	+ (+**)	? (–**)	? (0/+)
Proportion of commodity exports	+ (–)	+ (+)	? (+/–)
Financial development	– (–**)	+ (+***)	? (–**)
Domestic savings	+ (+***)	– (–**)	? (0/–)
Terms of trade shocks	+/–(+/–)	+/– (–)	+ (+)

Notes: The sign on the left-hand side indicate the sign of the effect of each explanatory variable based on theoretical predictions and past empirical studies, where "+/–" means ambiguous and the question mark "?" means undefined by theory. The sign in each parenthesis is the observed trend among the results from different estimation techniques used by the authors, where "+/–" indicates mixed results and "0" indicates that most of the coefficients are statistically insignificant. The asterisks *, **, and *** indicate "weak," "strong," and "very strong" trends in the estimation results, respectively.

Source: Authors' predictions and computation.

[22] The volume of commodity imports is normalized by GDP and averaged over *t*–1 through *t*–5. Trade volatility is the 5-year standard deviations of the monthly data of total trade and multiplied by the ratio of total trade to GDP. To ensure exogeneity, the number of past crisis experiences is counted over *t*–1 through *t*–5 for each type of crisis, though counting them over *t*–1 through *t*–10 or *t*–6 through *t*–10 does not change the results significantly. The identification of the crises is based on Aizenman and Ito (2013). Their banking crisis data essentially come from Laeven and Velancia (2008, 2010, 2012). All these variables are found to be positive contributors to foreign exchange reserves held, except for the currency crisis variable which is found to reduce reserves.

[23] We employ the SUR method for 2SLS and impose the trilemma coefficient restrictions across the equations.

[24] The positive coefficient on the commodity export proportion in the *ES* equation is consistent with the prior prediction and, therefore, somewhat mitigates one of the puzzles of the baseline estimation results.

5. DEVIATIONS FROM THE TRILEMMA AND FINANCIAL CRISES

Now that we have estimated the determinants of open macroeconomic policy choices under the trilemma constraint, one important question is whether policy makers can challenge the trilemma constraint. Anecdotally, we sometimes observe policy makers trying to implement an "inconsistent" policy combination that violates the trilemma constraint. For example, authorities of an economy experiencing large capital inflows and an economic boom under a fixed exchange rate regime may try to tighten monetary policy to cool off the economy—by exercising monetary policy independence—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 regime, or implement (or tighten) capital controls. In other words, the authorities may deviate from the trilemma constraint in the short run, but not over many years; thus, a policy that persistently deviates from the trilemma constraint will eventually have to come to an end. Otherwise, market forces will punish the authorities by creating a financial crisis or some form of economic or financial turbulence, or force them to alter policies in a way consistent with the trilemma constraint.

As we have discussed, our estimation framework is built to incorporate the long-run trilemma constraint while allowing short-term deviations. This also means that we can treat the predicted values of *ES*, *FO*, and *MI* based on the SUR estimation as the long-run optimal levels of attainment in the three policy choices. Then, if deviations from such an optimal policy combination persist, they have to be corrected by either policy changes or financial crises (or turbulence). This section examines whether there is any link between deviations from the trilemma constraint and the occurrence of financial crises, based on the estimation results we have obtained above.

Using the predicted values of *ES*, *FO*, and *MI* based on the above baseline SUR estimation and the actual values of these indexes, we define a measure of deviations from the optimal trilemma policy combination as

$$d_{i,t} = \left(ES_{i,t} - \widehat{ES_{i,t}}\right) + \left(FO_{i,t} - \widehat{FO_{i,t}}\right) + \left(MI_{i,t} - \widehat{MI_{i,t}}\right). \quad (12)$$

The trilemma constraints, shown in equation (11), indicate that $d = 0$ in the long run. If d is persistently nonzero, especially greater than 0, such a policy combination would have to be perceived by the markets as "unsustainable," which must be corrected by policy changes or a financial crisis (or disruption).

The hypothesis we set up and examine here is the following: If persistent deviations from the trilemma constraint create "stress" that would not be accompanied by policy corrections, they must be followed by disruptions such as a currency, banking, and debt crisis. In other words, the measure of deviations from the trilemma constraint d must rise before a crisis and peak around the time of the breakout of a crisis, followed by a decline in the post-crisis period down to 0 or below 0. Because the long-run average of d should be 0, it is expected that the value of d should rise above 0 in the "turbulent times" and tends to be below 0 on average during the "tranquil times."

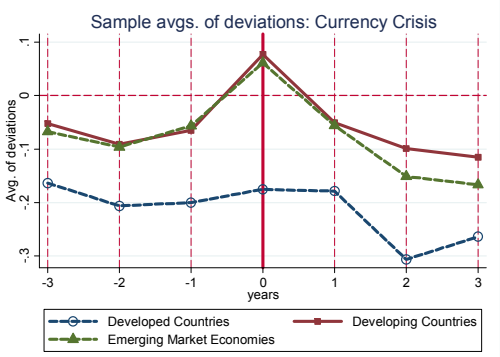
We first examine the estimated value of d around the time of a currency, banking, and debt crisis. We construct d using the results from the baseline SUR estimation earlier reported in Table 2. Figure 5 depicts the averages of d for different country groups

around the time of three different types of crises.[25] For all three types of financial crises, we can observe a humped shape for the development of *d* around the time of the breakout of a crisis, which is generally consistent with our prior expectations.

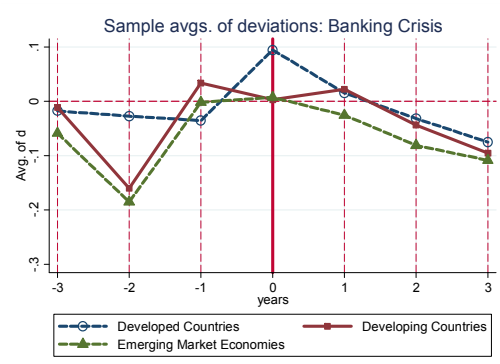
As for a currency crisis, we can see that when policy "stress" from trilemma constraint deviations is mounting, this period coincides with the time when a currency crisis breaks out for developing and emerging economies. We cannot observe such a phenomenon for developed countries, however. The stress starts disappearing once a currency crisis occurs. For a banking crisis, we can observe a more noticeable hump shape of *d* with the peak at year 0 for developed countries, while the peak occurs in year –1 and remains until year +1 for developing countries and year 0 for emerging market economies. In the case of a debt crisis, deviations from the trilemma constraint start in year –1 and peak at the exact year of the breakout of a debt crisis.[26] The deviations from the trilemma constraint dwindle immediately after a debt crisis. The extent of deviations appears the largest for debt crises, followed by currency crises and banking crises.

Figure 5: Deviations from the Trilemma Constraint around Financial Crises

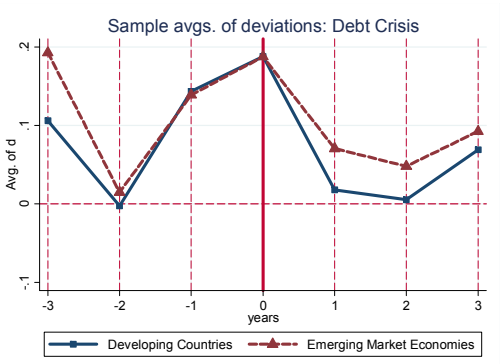
5.A: Currency Crisis



5.B: Banking Crisis



5.C: Debt Crisis



Source: Authors' calculations.

[25] In Figure 5, "year 0" refers to the year of the breakout of the crisis, or the first year of a crisis when the crisis persists for longer than a year. The panels in the figure depict the country group averages of d around the time of the "breakout" of a crisis.

[26] Because the dataset ends in 2010, there is no observation of sovereign debt crises among the eurozone member countries in our sample.

With these results, we can conclude that open macroeconomic policy combinations that challenge the trilemma constraint could eventually encounter the occurrence of a financial crisis.

6. CONCLUSION

In this paper, we have shed light on one of the most fundamental issues in international macroeconomics and finance, that is, the hypothesis of the "impossible trinity" or the "trilemma." The paper has made the first attempt in the literature to identify the joint determinants of trilemma policy combinations.

We have first presented a simple theoretical framework for policy making based on the trilemma, involving the choice of exchange rate stability, financial market openness, and monetary policy independence. A simple optimization model has led us to show that a higher policy preference weight on one of the trilemma policies contributes to a higher level of achievement in it and lower levels of achievement in the other policies.

Second, we have investigated how economic and structural fundamentals could jointly determine the three policy combinations through their effects on policy preference weights. We have used the new trilemma indexes and estimated the determinants of three indexes by imposing the trilemma constraint, that is, the indexes for the three policy choices must add up to 2. Applying the SUR estimation method, and employing other estimation techniques for robustness check, we have demonstrated that a country's economic and structural fundamentals jointly determine a combination of the three trilemma policy choices. Most of the estimation results are consistent with theoretical predictions and earlier empirical results in the literature that used single equations to identify the determinants of trilemma policies, though there are a few exceptions. Some of these, particularly on the impacts on financial market openness and monetary policy independence, are quite new.

Several highly robust findings are as follows: policy makers in larger economies tend to prefer more stable exchange rates and retain larger degrees of monetary policy independence; policy makers in richer economies tend to adopt greater exchange rate flexibility, keep more open financial markets, and retain lesser degrees of monetary policy independence—the last of which is a surprising finding; policy makers in more open economies in terms of trade tend to prefer more stable exchange rates, more open financial markets, and lesser degrees of monetary policy independence; policy makers with larger foreign exchange reserves tend to prefer greater exchange rate flexibility—which is another surprising finding—and greater monetary policy independence; policy makers in economies with a higher concentration of trading partners tend to prefer greater exchange rate stability and less open financial markets; policy makers in financially more developed economies tend to prefer greater exchange rate flexibility, more open financial markets, and lesser degrees of monetary policy independence; and policy makers in economies with larger domestic savings tend to prefer more stable exchange rates and less open financial markets.

Finally, we have used the estimation results to examine how deviations from the "optimal" trilemma policy combinations could evolve around the time of a financial crisis. We have demonstrated that policy combinations tend to violate the trilemma constraint when a currency crisis breaks out for developing and emerging economies and when a banking crisis breaks out for all country groups. In the case of debt crises, for developing and emerging economies, deviations occur in the year before the breakout of a crisis, not just the year of the breakout. All these findings suggest that

large and/or persistent deviations from the trilemma constraint could create stress in the policy combination, which would have to be released through policy changes if the authorities wish to avoid a financial crisis.

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APPENDIX 1: DATA SOURCES

Variable	Data Source
Index for exchange rate stability	Ito and Kawai (2012)
Index for monetary policy independence	Ito and Kawai (2012)
Index for financial market openness	Ito and Kawai (2012)
Economic size (the share of world GDP in PPP)	Penn World Table (PWT) 7.1
Relative per-capita income (per capita GDP in PPP as % of the US level)	PWT 7.1
Trade openness (the sum of exports and imports as % of GDP)	World Bank, *World Development Indicators (WDI)*
Foreign exchange reserves held (excluding gold, as % of GDP)	World Bank, *WDI*
Concentration of trading partners (share of trade with top-5 trading partners as % of total trade)	International Monetary Fund (IMF), *Direction of Trade*
Proportion of commodity exports (as % of total exports)	World Bank, *WDI*
Financial development (private credit as % of GDP)	World Bank, Financial Structure Database
Domestic savings (gross domestic savings as % of GDP)	World Bank, *WDI*
Terms of trade (TOT) shocks (standard deviation of TOT over the past 5 years of *t*–1 and *t*–5)	World Bank, *WDI*
Commodity imports (as % of GDP)	World Bank, *WDI*
Trade volatility (5-year standard deviations of the monthly data of total trade, multiplied by the ratio of total trade as % of GDP)	IMF, *International Financial Statistics;* Authors' calculation
Currency crisis dummy	Aizenman and Ito (2013)
Banking crisis dummy	Laeven and Valencia (2008, 2010, 2012)
Debt crisis dummy	Aizenman and Ito (2013)

GDP = gross domestic product, PPP = purchasing power parity, US = United States.

APPENDIX 2: LIST OF ECONOMIES INCLUDED IN THE ESTIMATIONS

1 Algeria
2 Argentina**
3 Armenia
4 Australia*
5 Austria*
6 Bangladesh**
7 Belgium*
8 Bolivia
9 Brazil**
10 Côte d'Ivoire**
11 Canada*
12 Chile**
13 China, People's Rep. of**
14 Colombia**
15 Croatia
16 Cyprus
17 Czech Republic**
18 Denmark*
19 Egypt, Arab Rep.**
20 El Salvador
21 Estonia
22 Fiji
23 Finland*
24 France*
25 Gabon
26 Germany*
27 Greece*
28 Hong Kong, China**
29 Hungary**
30 Iceland*
31 India**
32 Indonesia**
33 Ireland*
34 Israel**
35 Italy*
36 Jamaica**
37 Japan*
38 Jordan**
39 Kazakhstan
40 Kenya**
41 Korea, Rep. of**
42 Latvia
43 Lithuania**
44 Macedonia, FYR
45 Malawi
46 Malaysia**
47 Malta*
48 Mexico**
49 Moldova
50 Morocco**
51 Netherlands*
52 New Zealand*
53 Norway*
54 Oman
55 Pakistan**
56 Peru**
57 Philippines**
58 Poland**
59 Portugal*
60 Romania
61 Russian Federation**
62 Saudi Arabia
63 Senegal
64 Singapore**
65 Slovak Republic**
66 Slovenia**
67 South Africa**
68 Spain*
69 Sri Lanka**
70 Sweden*
71 Tanzania
72 Thailand**
73 Trinidad and Tobago**
74 Tunisia**
75 Turkey**
76 United Kingdom*
77 Uruguay
78 Venezuela, RB**

Notes: Economies without asterisks are developing countries, economies with a single asterisk "*" are developed countries, and economies with double asterisks "**" are emerging market economies.

APPENDIX 3: ALTERNATIVE ESTIMATIONS OF THE DETERMINANTS OF THE THREE POLICY CHOICES

(Annual Data, 1970–2010, Full Sample)

	TOBIT			2SLS with IVs		
	Exchange Rate Stability	**Financial Market Openness**	**Monetary Policy Independence**	**Exchange Rate Stability**	**Financial Market Openness**	**Monetary Policy Independence**
	(a)	(b)	(c)	(d)	(e)	(f)
Economic size	-5.112	-0.444	5.580	1.818	-5.634	3.816
	(0.721)***	(0.489)	(1.045)***	(1.044)*	(1.016)***	(0.933)***
Relative per-capita income	-0.171	0.197	-0.115	-0.521	0.740	-0.219
	(0.043)***	(0.028)***	(0.061)*	(0.082)***	(0.080)***	(0.073)***
Trade openness	0.157	0.119	-0.223	1.091	-1.031	-0.059
	(0.040)***	(0.027)***	(0.056)***	(0.155)***	(0.151)***	(0.138)
Foreign exchange reserves	-0.646	0.077	1.174	-5.120	4.963	0.156
	(0.154)***	(0.102)	(0.213)***	(0.704)***	(0.685)***	(0.629)
Concentration of trading partners	0.472	-0.284	0.286	-0.085	0.087	-0.002
	(0.097)***	(0.065)***	(0.144)**	(0.106)	(0.103)	(0.094)
Proportion of commodity exports	-0.058	0.410	0.164	0.191	-0.267	0.076
	(0.056)	(0.038)***	(0.081)**	(0.085)**	(0.083)***	(0.076)
Financial development	0.001	0.482	-0.222	-0.156	0.273	-0.116
	(0.035)	(0.027)***	(0.050)***	(0.033)***	(0.032)***	(0.030)***
Domestic savings	0.547	-0.636	-0.127	1.013	-1.104	0.090
	(0.149)***	(0.096)***	(0.208)	(0.182)***	(0.177)***	(0.162)
Terms of trade shocks	0.118	-1.842	0.130	-0.221	-0.584	0.805
	(0.385)	(0.251)***	(0.550)	(0.442)	(0.430)	(0.395)**
Constant	0.610	0.252	0.914	0.517	0.669	0.814
	(0.048)***	(0.032)***	(0.069)***	(0.057)***	(0.056)***	(0.051)***
N	1,550	1,550	1,550	1,095		

IV = instrumental variable.

Notes: * $p<0.1$; ** $p<0.05$; *** $p<0.01$. The table shows the results of the TOBIT and two-stage least squares (2SLS) estimations. The seemingly unrelated regression (SUR) method is employed for 2SLS with the coefficient restrictions across equations. For the above regressions, we use the annual data averaged over the period of *t*–1 through *t*–5, except for terms of trade shocks that are the standard deviations of the original data over the same period. No country or yearly fixed effects are included in the estimations.

Source: Authors' computation.