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INTERNATIONAL RESERVE MANAGEMENT AND FIRM INVESTMENT IN EMERGING MARKET ECONOMIES

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ABSTRACT

We examine the effects of active international reserve management (IRM) conducted by central banks of emerging market economies (EMEs) on firm investment in the presence of global financial shocks. Using firm-level data from 46 EMEs from 2000 to 2018, we document four findings. First, active IRM is found to affect firm investment positively. The effect strengthens when the size of adverse external financial shocks increases. Second, financially constrained firms, compared to unconstrained ones, are less responsive to active IRM. Third, we quantify the causal effect of IRM on firm investment and find that 30% of it is mediated through the country spread channel. Fourth, capital controls and exchange rate management complement the IRM.

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1 Introduction

The 2008 US financial crisis emanated shock waves that wreaked havoc on economies and financial markets around the world. Emerging market economies (EMEs) were especially vulnerable and hit hard during the crisis.[1] In the presence of sudden spikes of global financial risk, EMEs can experience economic calamities, including sharp contractions, plunges in investment, credit supply crunches, widened credit spreads, sudden stops, capital flow reversals, and heightened speculation of a debt crisis.

The crisis experience, however, is not uniform across EMEs. An EME that holds a high level of international reserves and actively sells international reserve assets to stabilize its financial market during crisis periods tends to exhibit solid economic recovery post-crisis. Central banks implement active international reserve management (IRM) strategy akin to a 'leaning against the wind' policy – they accumulate international reserves during good times and sell them in challenging or crisis periods to provide a buffer against financial instability.[2] Under the counter-cyclical IRM policy, international reserves are hoarded in good times to self-insure against the probability of financial crises and sudden stops and provide resources for intervening and stabilizing financial markets to alleviate adverse impacts on the economy[3].

Global financial shocks could magnify uncertainty, heighten risk aversion among global investors, and result in a sharp contraction of global credit supply and capital flight from EMEs (Rey, 2015). These chain reactions can have detrimental effects on firm investment that spill over across sectors and economies.[4] Dominguez et al. (2012) and Aizenman and Jinjarak (2020), for example, find that central banks' active IRM is an effective stabilizer against external financial shocks and improves, on average, an EME's economic performance.[5] While these

[1] For example, Carrière-Swallow and Céspedes (2013) find that, relative to developed countries, EMEs suffer more severe falls in investment and consumption following an exogenous uncertainty shock and take longer time to recover.
[2] EMEs have accumulated an astonishing level of international reserves since the 1997 Asian financial crisis. The 2008 global financial crisis rekindled the accumulation trend. Reasons for excess hoarding of international reserves include the precautionary drive to self-insure against crisis, mercantilist motivation, and the Joneses effect, see, for example, Dooley et al., (2003), Aizenman and Lee (2007), Caballero and Panageas (2008), Cheung and Qian (2009), Jeanne and Rancière (2011), and Qian and Steiner (2017).
[3] In general, IRM refers to the practice that ensures authorities have sufficient international reserves to deploy for meeting a country's (established economic) objective. It is different from foreign exchange market intervention, which responds to certain market conditions.
[4] Bloom (2017), for example, suggests investment is the main channel that uncertainty shocks impact GDP growth.
[5] See also Jeanne (2016). Dominguez, Hashimoto, and Ito (2012) find that countries with a higher level of international reserves prior to the 2008 global financial crisis exhibit higher post-crisis GDP growth. Aizenman and

studies provide macro-based evidence, there is limited research on how active IRM impacts micro-agents' economic activities. An exception is Tong and Wei (2021) which analyzes corporate leverage responses to the level of international reserve accumulation in emerging markets.

In this paper, we fill a gap in the literature to study the effect of active IRM on firm-level investment in EMEs in the presence of global financial market shocks. The quantitative assessment is based on a canonical Tobin-Q investment framework (Hayashi, 1982; Eberly et al., 2009) and annual data for 19,715 publicly listed firms in 46 EMEs from 2000 to 2018. Because of the absence of official data, [6] we construct five alternative measures of active IRM. Two measures are based on the simulation approach of Dominguez, Hashimoto, and Ito (2012) and three measures are derived from the detrended official international reserves data from IMF. These alternative measures are adopted to capture different IRM attributes related to valuation effects, interest rate compounding effects, and break effects. Changes in the VIX index (ΔVIX) are used as a proxy for global financial shocks. We adopt a few estimation strategies to assess the causal effect of IRM on firm investment. One strategy is based on the instrumental variable (IV) approach where the swap lines with the US Federal Reserve Bank during the 2008 global financial crisis (GFC) are used as the instrumental variable. We find that active IRM positively affects firm investment in EMEs – one standard deviation increase in active IRM induces about 0.15% additional asset invested by an EME firm. Specifically, if we take the Philippines[7] as an example, an $1 billion active international reserve accumulation by the Central Bank of the Philippines (or the Philippine Central Bank) leads a median size Philippine firm to make an $0.6 million additional investment. For an $1 billion of active IRM, the 222 publicly listed Philippine firms in our sample aggregately add about $133 million in investment to the Philippine economy.

Literature suggests that IRM can alleviate the adverse effects of uncertainty shocks on investment.[8] We use a multiplicative regression (Brambor *et al*., 2006) to study the individual

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Jinjarak (2020) find that active IRM can contribute up to about 3% of GDP during their sample period. IRM may mitigate the impact of external adverse shocks and enhance economic performance via two channels; it a) lowers real exchange rate volatility induced by terms-of-trade shocks and b) provides self-insurance against sudden stops and fiscal shocks (Aizenman, 2008). In this paper, we focus on the latter – the self-insurance channel.

[6] Central banks of EMEs typically do not provide detailed information on their international reserve transactions (Dominguez et al., 2012).

[7] The Philippines is the median GDP country in our data sample. It has an average GDP of USD199 billion from 2000 – 2018. There are 222 publicly listed Philippines firms in our sample with the average asset about 6 billion.

[8] Appendix A overviews some studies on adverse effects of uncertainty on investment and the buffer stock role of international reserves.

and interaction effects of IRM and global financial shocks (ΔVIX) on firm investment. It is found that the marginal impact of IRM depends on the type and magnitude of global financial shocks. For instance, in the presence of an adverse global financial shock, the marginal IRM effect increases with the magnitude of the adverse shock. For favorable global financial shocks, the marginal IRM effect is inversely related to the magnitude of favorable shocks and tends to turn into insignificant as favorable shocks are sufficiently large.

Global financial shocks heighten market uncertainty, which deters firm investment by worsening firms' financial condition (Christiano *et al*., 2014; Arellano *et al*., 2019). To assess the implications of a firm's financial conditions on IRM effects in the presence of global financial shocks, we consider three alternative approaches to characterize firms into financially constrained and unconstrained ones. These approaches are a) the capacity to access external financing (Rajan and Zingales, 1998), b) tangible assets coverage (Claessens and Laeven, 2003), and the shadow cost of external financing (Whited and Wu, 2006). Conceivably, compared with unconstrained firms, financially constrained firms are less flexible to adjust their investment when facing changing financial conditions. Our results show that financial constraints can weaken a firm's response to the IRM policy and reduce the stabilizing IRM effect; the average positive effect of IRM on firm investment in financially constrained firms is about 32% of that in unconstrained firms.

Further, we hypothesize and test whether the country spread (or sovereign premium) is an economic channel through which active IRM induces firm investment in EMEs. Country spreads are a component of international borrowing costs faced by EME firms.[9] High country spreads elevate borrowing costs, thereby lowering firm investment. Both global financial shocks and international reserves impact country spreads. On one hand, unfavorable global financial shocks widen country spreads (Uribe and Yue, 2006; Akinic, 2013). On the other hand, international reserves provide a buffer against sudden stops and credit defaults triggered by unfavorable global financial shocks (Ben-Bassat and Gottlieb, 1992; Cheung and Qian, 2009; Bianchi et al., 2018) and thus can reduce country spread that is induced by these shocks. Using the causal mediation analysis method (Krull and MacKinnon, 2001; Imai et al., 2010), we reveal the empirical role of country spreads and quantify the portion of the IRM effect that mediates through the country

[9] Two basic cost components of borrowing internationally are country (or sovereign) premium and firm specific risk premium. The Japan premium, for example, is a well discussed phenomenon in the 1990s.

spread channel. Specifically, we treat the country spread as the intermediate variable, IRM as the treatment, and firm investment as the outcome variable. Results show that approximately 30% of the IRM effect is channeled through country spreads. The causal mediation effect differs across financially constrained and unconstrained firms with the former group having an average level of 35% IRM effects channeled through country spreads, and the latter group having 20%.

Besides active IRM, capital controls and exchange rate management are two macro-management tools deployed by EMEs to rein in the adverse effect of global financial shocks (Han and Wei, 2018; Obstfeld et al., 2019).[10] Our results show that countries with capital controls, compared to those without, display a higher IRM effect on firm investment. While a flexible exchange arrangement alone does not influence the IRM effect, the adoption of both flexible exchange arrangements and capital controls substantially enhances the effect of IRM on firm investment.

Our study makes several contributions. First, we extend the typical analysis of the effects of international reserves on the macroeconomy[11] to firm behavior and document the causal effect of IRM on firm-level investment. Second, we provide evidence of the interaction between IRM and global financial shocks in firm investment and differential IRM effects on financially constrained and unconstrained firms. Third, we reveal and quantify the empirical role of credit spreads in facilitating the active IRM effect on firm investment. In addition, our results suggest that, in terms of stabilizing firm investment in the face of global financial shocks, active IRM is complementary to two other macro management tools; namely, capital controls and exchange rate management.

The remainder of the paper is organized as follows. Section 2 introduces empirical measures of active IRM and global financial shocks. Section 3 presents the main empirical specification and results on the effects of IRM on firm investment controlling for global financial shocks. The results pertaining to financially constrained and unconstrained firms and country spreads are also reported. Section 4 discusses the roles of capital controls and exchange rate management in determining the link between IRM and firm investment. Section 5 concludes.[12]

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[10] Bussière et al. (2015) and Acharya and Krishnamurthy (2018), for example, find capital controls complement international reserves in insuring against sudden stops.
[11] See, for example, Dominguez et al. (2012), Qian and Steiner (2014; 2017) and Aizenman and Jinjarak (2020).
[12] The Appendices section includes an overview of the literature related to IRM effects, the construction of our empirical measures of active IRM and global financial shocks, and some robustness results on our findings.

2 Measuring IRM and Global Financial Shocks

2.1 Measuring active IRM

Several issues complicate the measurement of active IRM strategy, which involves accumulating international reserves in tranquil times while selling reserves assets during crisis periods. First, central banks seldom disclose the time and amount of their purchases and sales of international reserves pertaining to active IRM. Second, changes in official international reserves data comprise both active and passive management components, and can incorrectly represent active IRM. Investment/interest incomes of reserve assets and valuation effects, for example, contribute to the passive component of IRM. Third, central banks rarely disclose the investment portfolio and the currency composition of their international reserves, and the magnitudes of their investment incomes and valuation effects. Thus, it is difficult to estimate the passive management component of IRM.

Against this backdrop, we use two methods, a simulation, and a detrend method, to derive operational measures of active IRM. Dominguez et al. (2012) (DHI hereafter) propose to calculate active IRM by subtracting the simulated passive management component from the total change in international reserves. Our first active IRM measure labeled IRM-DHI-1 is given by the resulting IRM, in US dollars, scaled by GDP in the current US dollar.[13] Next, we modify the DHI approach by adjusting the valuation effect estimated from the currency composition of international reserves. The second DHI active IRM measure labeled IRM-DHI-2 is obtained by normalizing the modified IRM by current US dollar GDP.

Using a linear regression setup, the detrending method assumes the passive management components of IRM are the trend component of data on international reserves, and the active management components are represented by the remainder. The rationale is that international reserves data contain a secular trend, which is partly due to two passive management parts of IRM – the compounded interest income and the valuation effect on reserve assets. Detrending data may remove these passive management elements. We consider three types of trends, namely, a simple linear time trend, a time trend with a structural break at the 2008 global financial crisis (Aizenman et al., 2015; Bussiere et al., 2015), and a time trend after the reserve data has been adjusted for the valuation effect. The estimates of the three types of trends yield

[13] The GDP normalization facilitates the comparison of IRM measures from EMEs of varying economy sizes.

three different estimates of the passive component of IRM. Then, using the current US dollar GDP to normalize reserves data detrended by each of the three passive component estimates, we obtained three empirical measures of active IRM, labeled IRM-1, IRM-2, and IRM-3.

Appendix B contains a detailed discussion of the constructions of these five IRM measures and graphically compares these measures (Figures A1 – A4). Overall, these IRM measurements reveal the general pattern of active IRM – central banks accumulate reserves during good times and use them during crisis periods (Figure A5 in the Appendix). Since the IRM-1, IRM-2, and IRM-3 measures have fewer missing observations, we consider them in the main regression analyses and the IRM-DHI-1 and IRM-DHI-2 measures in the robustness check exercise.

2.2 Measuring global financial shocks

To empirically investigate the effect of global financial shocks on firm investment across EMEs, it is essential to have an operational measure of global financial shocks that is exogenous to both firm and country-specific conditions. One common candidate is shocks originating from large countries (e.g., the US) that have a global impact. In our exercise, we consider five alternative proxy measures of global financial shocks.

Our first measure of global financial shocks is ΔVIX; the percentage change of the VIX index. The VIX index is commonly used to measure global financial uncertainties and risk aversion (Forbes and Warnock, 2012; Rey, 2015; Di Giovanni et al., 2017). The VIX is the index for the implied volatility of the S&P 500 stock option. Despite being originated in the US, it displays global impacts. For example, Miranda-Agrippino and Rey (2020) show that the VIX index comoves with an identified global factor that explains 20% of prices of international risky assets. And, Gilchrist et al. (2014) find the measure impacts economic activities including investment, regardless of the level of uncertainty.[14] Using ΔVIX to measure global financial shocks is advantageous because changes in the VIX index not only indicate the timing of global financial shocks, but also quantify the relative magnitude of shocks. Further, it indicates whether an external shock is favorable (ΔVIX < 0) or adverse (ΔVIX > 0).

Our second measure of global financial shocks is the change in the intra-annual volatility compiled from daily data of the S&P 500 index (Merton, 1980; see also Appendix D). While the

[14] Other papers include Arellano et al. (2018), Bloom (2009), and Caballero et al. (2019).

VIX index reflects the implied volatility of the S&P 500 stock option, the intra-annual volatility provides a measure of the observed volatility.

Our third measure is a "risk-on/risk off" (RORO) index that captures the variation of risk aversion of various asset markets in the US and Europe. Following Chari et al. (2020), we build the RORO index by extracting the first principal component of the daily data on 1) credit risk captured by changes in the ICE BofA BBB Corporate Index, Option-Adjusted Spread for the United States and for the Euro Area, and Moody's BAA corporate bond yield relative to 10-year treasuries; 2) equity returns – the additive inverse of daily total returns on the S&P 500 and STOXX50 – and the VIX and the VSTOXX index; and 3) funding liquidity given by changes in the TED spread and the bid-ask spread on 3-month treasuries.

The percentage change of Federal fund rates is our fourth measure of global financial shocks to EMEs. The US monetary policy is well documented to exert a substantial spillover effect on global financial markets (Gilchrist et al., 2019; Obstfeld, 2020). When the Federal Reserve Bank tightens its policy, risky asset yields surge, accompanied by strong deleveraging of global banks and a surge of risk averse behavior in global asset markets. It triggers the contraction of the global credit supply and a strong retrenchment of international credit flows from emerging markets (Miranda-Agrippino and Rey, 2020). The spillover effect of U.S. monetary shocks can transmit through the global banking system (Cetorelli and Goldberg, 2011; De Hass and Van Horen, 2012; Kalemli-Ozcan et al., 2013; Morais et al., 2019) and the international debt market (Caballero et al., 2019; di Giovanni et al., 2019).

Our fifth measure of global uncertainty shocks is the news-based US monetary policy uncertainty index (MPU) that captures the degree of uncertainty about the Federal Reserve's monetary policy stance perceived by the public (Baker et al., 2016). A large MPU implies a perceived high level of uncertainty/shocks about the US monetary policy. Thus, we expect MPU has a negative impact on firm investment in EMEs.

3 Empirical IRM Effects

3.1 IRM effects on firm investment - The base model

In this subsection, we examine the IRM effect on firm level investment in EMEs using the canonical investment-Q framework (Hayashi, 1982; Eberly et al, 2009):

$$Invest_{i,t} = \alpha + \mu_i + \theta_t + \beta_1 IRM_{c,t} + \gamma X_{c,t} + \delta Z_{i,t} + \varepsilon_{i,t} \quad (1)$$

where undersubscriptions *c*, *i*, and *t* indicate country, firm, and year, respectively. The dependent variable $Invest_{i,t}$ is firm i's investment in year t given by the ratio of its capital expenditure (in year t) on plants, properties, and equipment to its total assets at the beginning of the year (Julio and Yook, 2012; Panousi and Papanikolaou, 2012; Gulen and Ion, 2016; Husted et al, 2019). [15] μ_i captures the time-invariant firm fixed effect and θ_t the year fixed effect. The global financial shock variable (ΔVIX_t) is not included in (1) due to its collinearity with θ_t. Its effect is considered in the next subsection. $IRM_{c,t}$ is the active IRM variable. The IRM-1 variable is used in regression analyses. Robustness checks obtained from other measures of IRM are presented in Appendix F.

The variable $X_{c,t}$ includes two domestic factors that affect firm investments. They are the real GDP growth rate ($RGDPG$) that captures domestic investment opportunities, and the investment risk profile ($Risk\ profile$) that measures the institutional risk of domestic investment (Julio and Yook, 2012; Gulen and Ion, 2016; Husted et al, 2019).[16] The use of the ICRG investment risk profile index mitigates the potential collinearity with our measure of global financial shocks ΔVIX_t,[17] while capturing the domestic investment risk environment. Specifically, the investment risk profile index contains three risk components (namely, contract viability, profits repatriation, and payment delays) which describe the institutional aspect of domestic investment risk and are less likely to be associated with short-term financial risk shocks.

Four commonly identified firm-specific factors that determine firm investment behaviors are included in $Z_{i,t}$: 1) Tobin's Q, 2) cash flow from operations (*CF*), 3) firm size (*Size*) represented by firm's total assets, and 4) sales growth rate (*Sales growth*). Tobin's Q measures the market to book value ratio of firm assets (also known as the shadow price of installed

[15] Appendix E presents the summary statistics of the investment data.
[16] There are other macro-factors that could affect firm investment. For parsimony purposes, we follow the literature to include these two key factors. We will address the related omitted variable issue later in this section.
[17] For example, Akinci (2013) shows that global financial shocks explain 20% of country sovereign spreads. Gourio et al. (2013) found there is an international risk cycle in which country specific financial risks highly correlated across countries; they comove.

capital); *CF* measures the cash flows generated from business operation and reflects the marginal product of capital; and *Sales growth* measures business growth. Studies found that firms invest more, when Tobin's Q is higher (Tobin, 1969; Able and Eberly, 1994), the firm size is larger, there are more cash flows from operations, and sales growth rate is higher (Julio and Yook, 2012; Gilcrist et al, 2014; Gulen and Ion, 2016; Ottonello and Winberry, 2020).

We estimate the pooled OLS regression (1) controlling for firm and year effects using firm-level annual data, which are obtained from annual accounting statements of 19,715 publicly listed companies in 46 EMEs from 2000 – 2018 in the Thomson Reuters Worldscope database[18]. Following the convention (Julio and Yook, 2012; Ottonello and Winberry, 2020; Husted et al., 2019), we excluded financial, insurance, real estate, public administration, and non-classifiable industry sectors and countries that have less than 15 listed companies from our sample. We winsorized the investment variable at the 1st and 99th percentiles in order to minimize the impact of data errors and outliers. Then we match firm-level data to global and country-level data for our regression analyses.

The estimation results from the base model are reported in column (1) of Table 1. The active reserve management ($IRM_{c,t}$) is positively associated with firm investment; specifically, one standard deviation increase in IRM is associated with 0.15% additional firm assets being invested in EMEs. To further assess the economic significance of the IRM effect, we look at the case of the Philippines. Our results indicate that an $1 billion of active IRM accumulation by the Central Bank of Philippines is associated with an $0.6 million additional investment by a median size Philippine firm, and about $133 million investment to the Philippine economy by the 222 publicly listed Philippine firms in our sample.[19].

Among other factors, we find that higher real GDP growth and lower institutional risk promote firm investment in EMEs. Firms that have a high Tobin's Q, more cash flows generated from operations, larger size, and higher sales growth rate are found to invest more. These results

[18] Thomson Reuters' Worldscope database provides firm level accounting data of publicly listed companies from more than 70 developed and emerging markets, and accounts for more than 96% of the market value of publicly traded companies across the globe. However, the data availability varies substantially across countries, particularly for emerging markets and developing countries. Due to the limited availability of quarterly data (for some countries and firms, there are more missing data points in the quarterly data than in the annual data), we used annual data in this paper. Appendix D displays variable definitions and data sources; Appendix E shows summary statistics.
[19] The effect is likely to be understated as we do not account for firms other than publicly listed companies in the Philippines.

are all in accordance with most existing studies. The regression explains 27.3% of firm investment variation[20].

The specification of equation (1), however, may yield the correlation between IRM and firm investment, rather than the causal effect of IRM due to endogeneity issues that, for example, arise from omitted variables that influence IRM and firm investment simultaneously. We pursue three strategies to shed additional light on the IRM causal effect.

First, we lagged the IRM variable one year to create a predetermined IRM variable to conduct analysis, and report the results under column (2). The results based on the lagged IRM variable are similar to those under column (1). Apparently, the reported IRM effect is not sensitive to endogeneity due to the use of the contemporary IRM variable.

Second, we generated an IRM variable net of common factors that affect both IRM and investment simultaneously. Specifically, IRM net of common factors is set to be the residual series from regressing IRM on, in addition to the country and year effects, the ratio of national income per capita to the US national income per capita, the net international investment position, and the ratio of purchasing power parity (PPP) conversion factor to exchange rate (a measure of the relative price level). These factors are likely to increase the holding of reserves and firm investment at the same time. It turns out that the IRM variable net of common factors garners a significant coefficient estimate with a magnitude larger than the original IRM variable (columns (3) and (1), Table 1). The reported IRM effect is not due to endogeneity, if any, associated with these three common factors.

The IV approach is the third strategy to isolate the causal effect of IRM on firm investment from other factors that affect both IRM and firm investment.[21] The instrumental variable is based on bilateral swap lines between EME central banks and the US Federal Reserve Bank during the 2008 global financial crisis (*Swap*). Aizenman and Pasricha (2010) and Obstfeld et al. (2009), for example, show that these bilateral swap lines and international reserves are substitutes during crisis periods. The US offered these swap lines to other central banks during the unexpected evolution of the 2008 financial crisis; and the purpose of these swap lines was to alleviate global dollar shortages, and not to boost investment in these countries (Bahaj and Reis,

[20] The R-squared we obtained is compared well to those of related studies. For example, Julio and Yook (2012) reported an R-squared of 7%, Gulen and Ion (2016) 3%, and Ottonello and Winberry (2020) 12%.

[21] Imbens and Angrist (1994), Angrist et al. (1996), and Angrist and Krueger (2001), for example, discuss the use of the IV approach to identify and estimate the causal effect.

2022). These swap lines have no direct impact on firm investment if there is no draw down of dollar liquidity from those swap facilities. In view of these, we consider two versions of the instrumental variable *Swap* – the first one *Swap1* is a dummy variable that assumes a value of 1 when an EME had a swap line with the US, and the second one *Swap2* is a dummy variable that assumes a value of 1 when an EME had a swap line with the US but did not use it during the 2008 GFC. [22]

One caveat is that the US offered swap lines to EMEs that have close trade linkages and sound fundamentals (Aizenman et al., 2011). To address this issue, we add two control variables, namely, the share of trade with the US (*Trade_us*) and the external debt to GDP ratio (*Ext_debt*) to account for the trade link with the US and an EME's financial fundamentals, respectively.

The two-stage IV regression results based on *Swap1* are reported under columns (4) and (5). The first stage regresses IRM on the instrument variable *Swap1* and other control variables in equation (1). The *Swap1* dummy variable is negatively correlated with IRM. This result is in accordance with the substitution effect between swap lines and international reserves during the crisis. The control variables, *Trade_us* and *Ext_debt,* are both significant; the former variable has a negative estimate while the latter has a positive one. The estimates are in line with the precautionary motive of holding international reserves. The second stage results in column (5) show that the instrumented IRM positively affects firm investment. The IRM effect is larger compared to that of the OLS regression under column (1); controlling for the substitution effect of swap lines and international reserves during the GFC reveals a stronger IRM effect. The results based on the instrumental variable *Swap2* (columns (6) and (7)) are qualitatively similar to those based on *Swap1*. These IV regression results underscore the empirical IRM causal effect[23].

[22] Brazil, Korea, Mexico, and Singapore are four EMEs that had a 30 billion USD swap line arrangement with the US during the 2008 global financial crisis. While Mexico and Korea drawn down dollars from the swap lines, Brazil and Singapore did not.

[23] Tong and Wei (2021) use the global commodity price to instrument the level of IR. The results of using the global commodity price as the IV in our exercise are qualitatively the same as those based on Swap1 and Swap2 reported in the text. We do not adopt the difference-in-difference regression based on separation of countries that implement an active IRM or not. Because 1) our data do not allow a definite way to define which country implements active IRM, and 2) the IRM practice can be endogenous.

3.2 The interaction between IRM and global financial shocks

The previous subsection did not consider the effect of the global financial shock variable (ΔVIX_t) due to its collinearity with the time dummy variable. Conceivably, its effects can interact with the IRM effect. In another word, active IRM can have a direct effect on firm investment as revealed in the previous subsection and an indirect effect via alleviating the adverse investment effect of global financial shocks (Appendix A). To assess the interaction effect, we introduce the interaction term, $IRM_{c,t} \times \Delta VIX_t$ and, thus, modify (1) to a multiplicative regression[24] (Brambor et al., 2006):

$$Invest_{i,t} = \alpha + \mu_i + \theta_t + \beta_1 IRM_{c,t} + \beta_2 IRM_{c,t} \times \Delta VIX_t + \gamma X_{c,t} + \delta Z_{i,t} + \varepsilon_{i,t}. \quad (2)$$

Equation (2) shows that the marginal effect of IRM on investment is given by $\partial Invest/\partial IRM = \beta_1 + \beta_2 * \Delta VIX_t$. That is, the marginal effect depends on global financial shocks, ΔVIX_t. The corresponding standard error is given by

$$\hat{\sigma} = \left[var(\hat{\beta}_1) + \Delta VIX_t{}^2 var(\hat{\beta}_2) + 2\Delta VIX_t cov(\hat{\beta}_1, \hat{\beta}_2)\right]^{\frac{1}{2}}.$$

Column (1) in Table 2 reports the results for the effect of IRM conditional on global financial shocks. The marginal effect of IRM, $\beta_1 + \beta_2 * \Delta VIX_t$, is estimated to be 0.02+0.056*ΔVIX_t. To visualize the estimated marginal effect of IRM, we plot the marginal effect of IRM against ΔVIX_t in Figure 1 (upper panel). The solid line, with two dash-line of 95% confidence intervals, represents the relation between the IRM effect and global financial shocks. It shows that the IRM exerts a positive effect on firm investment overall. However, the effect depends on the type (i.e. favorable or adverse shock) and the magnitude of global shocks. The positive effect of IRM is especially prominent when there are strong adverse global financial shocks - the severer the shock, the higher the positive effect of IRM on firm investment (the adverse shock zone in the upper panel of Figure 1). It implies that the buffer stock role of IRM strengthens as the global financial condition worsens. On the other hand, the effect of IRM is inversely related to the magnitude of shocks when the global financial risk attitude becomes

[24] Both ΔVIX_t and $IRM_{c,t} \times \Delta VIX_t$ need to be added to form a complete multiplicative regression. Due to multicollinearity between ΔVIX_t and the year effect, we drop ΔVIX_t from the regression equation (2). On the other hand, we could drop the year effect rather than ΔVIX_t. In this case, ΔVIX_t is negatively estimated suggesting the adverse effect of global financial shocks on firm investment in EMEs.

favorable ($\Delta VIX_t < 0$), and turns insignificant as favorable shocks are sufficiently large (the favorable shock zone at the upper panel of Figure 1).

To further assess how the effect of IRM depends on the characteristics of global financial shocks, we plot the distribution of annual global financial shocks (ΔVIX_t) during 2000 – 2018 (the lower panel of Figure 1). Although it is not normally distributed, the annual ΔVIX_t histogram indicates that there is about 60% of likelihood that the global financial market is either relatively stable or turbulent, during which IRM positively affects firm investment in EMEs. For the rest of 40% of likelihood (the left tail of the annual ΔVIX_t histogram), IRM does not play a significant role in influencing firm investment in EMEs. This situation happens when there are great improvements in global financial market sentiment, for example, during 2009 when the global financial market stabilized after the 2008 global financial crisis.

In summary, the effect of IRM on firm investment varies with the type and magnitude of global financial shocks. IRM is found to positively affect firm investment when the global market is relatively stable or in turbulent times and the positive effect strengthens as the magnitude of adverse global shocks rises. IRM does not exert significant effect on firm investment during the time when the sentiment of global financial market greatly improves. Our results imply that the main workhorse of the IRM effect is the buffer stock role of IRM to mitigate the detrimental impact of global financial shocks on firm investment during turbulent times.

Columns (2) and (3) of Table 2 present the results using the lagged IRM variable and the IRM measure net of common factors. These results are quite similar to those under column (1) except that both IRM and the interaction variables display larger coefficient estimates; specifically, the purging of common factor effects strengthens the estimated effect of IRM.

3.3 **Firm heterogenous financial frictions**

Firms, especially in the corporate sector in EMEs, tend to borrow externally to finance their investment – a trend that has increased considerably since the early 2000s (Caballero et al., 2019). However, the ability of EME firms to access the global capital markets is severely hampered by financial shocks and crises that interrupt global credit supply and the ensuing sudden stops. Caballero et al. (2019) find that external borrowing costs, reflected by credit spreads, increase with adverse global financial risk shocks in international capital markets and worsened economic activities in EMEs. Firms face heterogenous financial constraints and invest differently in the presence of uncertainty shocks. Issues related to adverse external shocks on firm financial frictions and investment have been discussed in, for example, Christiano et al., (2014) and Arellano et al., (2019).

In this section, we investigate the investment responses of firms with heterogenous financial constraints to active IRM in the presence of global financial shocks using the regression specification

$$Invest_{i,t} = \alpha + \mu_i + \theta_t + \beta_1 IRM_{c,t} + \beta_2 IRM_{c,t} * \Delta VIX_t + FinCnstr_{i,t} * \left(\theta_1 + \theta_2 IRM_{c,t} + \theta_3 \Delta VIX_t + \theta_4 IRM_{c,t} \times \Delta VIX_t\right) + \gamma X_{c,t} + \delta Z_{i,t} + \varepsilon_{i,t}. \quad (3)$$

Equation (3) extends equation (2) by including a firm level financial constraint variable, $FinCnstr_{i,t}$, and its interaction terms with IRM, ΔVIX, and $IRM_{c,t} * \Delta VIX_t$.

We follow the heterogeneity-based difference-in-difference methodology (Khwaja and Mian, 2008; Chodorow-Reich, 2014; Jimenez et al., 2014) to generate dichotomous dummy variables that categorize whether a firm is financially constrained or unconstrained. Dummy variables are created based on the following three financial constraint measures, and each of them is considered sequentially as the $FinCnstr_{i,t}$ variable in the regression exercise.

The first financial constraint measure is the ratio of *external financing* to *capital expenditure* that describes a firm's capacity to access external financing for investment. A large ratio indicates that a firm is less financially constrained. We consider a firm is financially constrained (unconstrained) if its external financing access ratio is smaller (larger) than the average ratio of the associated SIC-3-digit-sector in the country. A dummy variable, $Ext\ fin_{i,t}$, assumes the value of 1 (0) when firm *i* is financially constrained (unconstrained).

The second measure is the ratio of *tangible assets* to *long-term liabilities* (Claessens and Laeven, 2003; Rajan and Zingales, 1998). Tangible assets can be used as a collateral to reduce the default risk of long-term debts; thus, a large tangible asset to long-term debt ratio suggests a low default risk and borrowing costs. Compared with firms with small tangible asset to long-term debt ratios, firms with large ratios are expected to be in a better position to secure external funds to finance their investments; especially when credit supply is tight during global financial shocks. We consider a firm is financially unconstrained (constrained) if it has a ratio of tangible assets to long-term liabilities larger (less) than the average ratio of the country-specific industry sector (SIC 3-digit). Accordingly, we construct a firm specific dummy variable, $Tangi_{i,t}$, that assumes the value of 1 (0) if the firm's ratio is less (larger) than the average of its country-specific industry sector.

The third measure is the financial constraint index (Whited and Wu, 2006) which is a shadow cost of external financing calculated from

$$WW_{cost_{it}} = -0.091 * CF_{it} - 0.062 * \text{DIVPOS}_{it} + 0.021 * TLTD_{it} - 0.044 * LNTA_{it} + 0.102 * ISG_{it} - 0.035 * SG_{it},$$

where the subscript *i* is the firm index, CF_{it} is the cash flow to total assets ratio, $DIVPOS_{it}$ is a dummy variable indicating whether the firm pays cash dividend, $TLTD_{it}$ is the ratio of long-term debt to total assets, $LNTA_{it}$ is the firm size given by its total asset value, ISG_{it} is the sales growth of firm *i*'s SIC 3-digit industry; and SG_{it} is the firm's total sales growth. A high shadow cost of external financing implies a high cost of securing external funds to invest. We construct a dummy variable $WW_{i,t}$, which is set to 1 indicating a firm is financially constrained if its $WW\_cost_{i,t}$ is larger than the average level of *WW_cost* of the country-specific industry sector (SIC 3-digit), and is set to 0 when its financial constraint index is less than the average level indicating that it is financially unconstrained.

Table 3 reports the results. Column (1) shows that, when measured by *Ext fin*, the investment activities of financially constrained and unconstrained firms respond differently to active IRM. Specifically, the investment of financially constrained firms is less responsive to IRM than unconstrained firms. A plausible reason is that financially constrained firms, compared with financially unconstrained firms, incur higher financing/adjustment costs and, hence, are less likely to benefit from IRM. The total effect of IRM on financially unconstrained firms is estimated to be 0.035 + 0.095*ΔVIX, whereas for financially constrained firms it is 0.011 + 0.03*ΔVIX. Applying these results to median size firms in the median GDP country (the Philippines), our results suggest that, when there is a one standard deviation increase in global financial risk, a 1 billion US dollar increase in IRM will induce a financially *constrained* median size firm to increase its investment by 0.4 million US dollars and a financially *unconstrained* median size firm by as much as 1.7 million US dollars. These contrasting effects on the two types of firms is also exhibited in Figure 2, where the solid and dashed lines plot the total effect of IRM at different magnitudes of the global financial shock for financially constrained and unconstrained firms, respectively. Financially unconstrained firms are shown to be more responsive to IRM irrespective of the size of external shocks. On average, financially unconstrained firms are 3 times more responsive than financially constrained firms. In addition, the investment responses of unconstrained firms to IRM intensify sharply with the magnitude of adverse shocks. In contrast, the effect of IRM on investment in financially constrained firms appears to be relatively small and it becomes insignificant in the absence of adverse external shocks.

When the two alternative measures of financially constrained and unconstrained firms, *Tangi* and *WW,* are used to estimate equation (3), they generated results similar to those of *Ext fin* (columns (2) and (3)). While *Ext fin*, *Tangi* and *WW* measure financial constraints from different perspectives, they are likely to capture some common attributes of financial constraints faced by firms. To investigate this possibility, we extracted the first principal component of these three financial constraint measures, and used it to construct a dummy variable, *Fin constr*, for classifying financially constrained and unconstrained firms. The results based on *Fin constr* are reported in column (4), and they are qualitatively comparable to those in columns (1) – (3).

In summary, an active IRM displays a positive effect on investment of firms in EMEs, and the IRM effect differs across firms heterogenous in financial constraints. Financially unconstrained firms are substantially more responsive to the positive impact of IRM relative to financially constrained firms. These findings suggest the importance of considering firm heterogeneity in examining the implications of macro-management operations, such as active IRM, for financial and real economic activities. To evaluate effectiveness, EMEs may need to consider the distribution of financial constraints faced by firms for policymaking.

3.4 **A plausible channel of IRM effect**

In this subsection, we investigate a potential channel through which active IRM induces firm investment in EMEs. Specifically, we examine the role of country credit spreads.

Studies suggests that an active IRM can lower the credit spread of a country, which is a key component of a firm's credit spread (Appendix A).[25] Thus, via the country credit spread, IRM can affect the credit spread of a firm and, hence, its finance costs and investment behavior.

[25] A firm's international borrowing interest rate is the sum of the risk-free rate and its credit spread, which can be presented as the sum of country spread and the firm's specific risk premium. Sovereign yield is a component of corporate yield. They are found to be positively associated (Mendoza and Yue, 2012; Bevilaqua et al., 2020).

In this subsection, we use data on country credit spreads to investigate the credit spread channel of the IRM effect. Uribe and Yue (2006) and Akinci (2013), for example, show that the effect of international financial conditions on economic activities of EMEs is driven by their impact on country credit/sovereign spreads.

We adopted the causal mediation analysis approach (Krull and MacKinnon, 2001; Imai et al., 2010) to study the credit spread channel. Mediation analysis quantitatively evaluates the causal mechanism through which an intervention (in our case, the active IRM) affects an outcome (firm investment). It separates the total intervention effect into an indirect effect that operates through observed mediators (country credit spreads) and a direct effect that directly affect the outcome without going through mediators. This analytic approach has been used to produce an early US macro-econometric model (Klein and Goldberger, 1955) and to develop economic forecasts and policy (Theil, 1958). More recently, it is used to study the effect of trade integration between China and Eastern Europe on voting in Germany (Dippel et al., 2022) and to examine the effect of the 1990s trade liberalization in Brazil on crime through its impact on labor market conditions (Dix-Carneiro et al., 2018).

We use the J.P. Morgan Emerging Market Bond Spread Index (EMBI+) that reflects the difference between the yields of EME government bonds and those of the U.S. Treasury securities to measure country credit spreads. Since our data have two levels, the country and the firm level, we use Krull and MacKinnon’s (2001) multilevel mediation regression that allows firm data to cluster at the country level and accounts for within-country homogeneity in the error terms of the regression.

The multilevel mediation regressions are specified as follows:

$$Country\ spread_{c,t} = \alpha + \mu_c + \theta_t + \beta_1 IRM_{c,t} + \beta_2 IRM_{c,t} * \Delta VIX_t + \gamma_1 X_{c,t} + \varepsilon_{c,t}, \quad (4)$$

$$Investment_{i,t} = \alpha + \mu_i + \theta_t + \beta_3 IRM_{c,t} + \beta_4 IRM_{c,t} * \Delta VIX_t$$
$$+\tau\ \widehat{Country\ spread}_{c,t} + \gamma_2 X_{c,t} + \delta Z_{i,t} + \varepsilon_{i,t}. \quad (5)$$

Equation (4) is the country level regression examining the marginal effect of IRM on country credit spreads. As discussed in Appendix A, global financial shocks drive up EME credit spreads, whereas active IRM lowers them, we include IRM, the interaction term of IRM and

ΔVIX, two macro factors, *RGDPG* and *Risk profile*, and the country (μ_c) and year (θ_t) effects as the determinants of country credit spreads.

Equation (5) augments Equation (2) with the mediator variable, $\widehat{Country\ spread}_{c,t}$, which is the estimated error term of Equation (4) and is orthogonal to $IRM_{c,t}$ and $IRM_{c,t} * \Delta VIX_t$ to avoid endogeneity concerns.

The average causal mediation effect (ACME) that is mediated through country credit spreads is captured by $\beta_1 * \tau$. The standard errors of ACME are computed using the Delta method (Oehlert, 1992). The total effect of IRM is estimated as $\beta_3 + \beta_1 * \tau$.[26] The percentage of total effect of IRM on firm investment explained by the ACME is $(\beta_1 * \tau)/(\beta_3 + \beta_1 * \tau)$.

Table 4 reports the regression results. Column (1) shows the mediation analysis results for the full samples. The ACME estimate (Panel C) is 0.008 and significant at the 1% level; suggesting a significant causal effect of IRM on firm investment through country credit spreads – for a median size firm, one billion US dollar IRM induces about 0.26 million more investment through the channel of country credit spreads. The total estimated effect of IRM on firm investment is 0.028; therefore, our results suggest that about 30% of the total effect of IRM on firm investment in EMEs is mediated through country credit spreads.

Columns (2) to (4) report mediation regression results for financially unconstrained firms classified by, respectively, the *Ext fin*, *Tangi*, and *WW* measures. Columns (5) to (7) report corresponding results for firms that are financially constrained. The total effect of IRM estimates and their significant statistics in columns (2) to (4) are, on average, larger than the corresponding ones in columns (5) to (7). Despite displaying a higher total effect of IRM, financially unconstrained firms, compared with financially constrained firms, have a smaller percentage of total effect of IRM that is mediated through the country credit spread – on average, unconstrained firms have 22% of the total effect mediated while financially constrained firms have 35%.

The estimates of other independent variables in Equation (5) are qualitatively similar to those in Section 3.2. As stipulated, IRM reduces country credit spreads (Panel A). In Panel B, country credit spreads are found to have a significantly negative effect on firm investment.

[26] In the multiplicative regression (5), the completed expression for the total effect of IRM is $\beta_3 + \beta_4 \Delta VIX_t + \beta_1 * \tau$. Since the estimated β_4 is trivial and insignificant (Table 4), we drop $\beta_4 \Delta VIX_t$ and follow the conventional interpretation of the total effect to express it as $\beta_3 + \beta_1 * \tau$.

Interestingly, in the presence of the country credit spread variable, the interaction term, $IRM_{c,t} * \Delta VIX_t$ becomes mostly negative but insignificant. This may reflect the opposite implications of active IRM and global financial shocks for credit spreads (Appendix A).

4 Capital Controls and Exchange Rate Arrangements

The Mundell-Fleming trilemma suggests that a country can insulate external shocks and achieve monetary independence if it either adopts flexible exchange rate or controls cross-border capital mobility. The ability of capital controls to insulate against global financial shocks appears evident (Zeev, 2017; Han and Wei, 2018). Ostry et al. (2012) find emerging markets with restrictions on financial openness better endured the 2008 global financial crisis. Regarding exchange rate regime, Gosh et al., (2015) and Obstfeld et al., (2019) suggest that a flexible exchange rate regime helps emerging economies to mitigate real and financial vulnerability and global financial instability.

Capital controls and a flexible exchange rate regime are complementary to hoarding of international reserves in insulating EMEs from global shocks (Bussière et al., 2015; Acharya and Krishnamurthy, 2018). It is therefore of interest to examine the effect of IRM on firm investment across EMEs that have differential capital control and exchange rate policies.

To do so, we augment Equation (2) with variables capturing capital control policy or/and exchange rate regime arrangement:

$$Invest_{i,t} = \alpha + MacroMNGM_{c,t} * \left(\varphi_1 + \varphi_2 IRM_{c,t} + \varphi_3 \Delta VIX_t + \varphi_4 IRM_{c,t} \times \Delta VIX_t\right) + \mu_j + \theta_t + \beta_1 IRM_{c,t} + \beta_2 IRM_{c,t} \times \Delta VIX_t + \gamma X_{c,t} + \delta Z_{i,t} + \varepsilon_{i,t}, \quad (6)$$

where $MacroMNGM_{c,t}$ includes a capital control (*KC*) dummy variable or an exchange rate regime (*Xchg*) dummy variable. A country is considered "practicing" capital controls if the value of its Chinn-Ito index is less than 0.065 (the mean of the Chinn-Ito index in our data sample), and the *KC* variable of the country assumes a value of 1. Otherwise, the country is considered "not practicing" capital controls, and its *KC* variable has a value of zero. Similarly, we generate the *Xchg* dummy variable to categorize exchange rate regimes. The *Xchg* dummy variable uses the coarse classification index of exchange rate regime (Ilzetzki et al., 2019) to label a country with either a flexible or pegged exchange rate regime. Specifically, if a country has an index value larger than 3, then it is considered a flexible exchange rate country and its *Xchg* variable assumes the value of one. Otherwise, its *Xchg* variable has the value of zero; indicating a pegged exchange rate arrangement.

Again, equation (6) is estimated using the heterogeneity-based difference-in-difference methodology with the dummy variables that are based on capital control or exchange rate arrangement classifications. We report the results in Table 5. Columns (1) presents the results with the capital control dummy variable. The effect of IRM estimate for countries "practicing" capital controls (*KC* = 1) and countries "without capital controls" (*KC* = 0) are 0.052 + 0.084$*$ ΔVIX and 0.003 + 0.032 $*$ ΔVIX, respectively. The effect of IRM in both countries with or without capital controls depends on the presence of global shocks. But the effect of IRM is stronger in countries with capital controls than in those without. With a one-standard-deviation of ΔVIX shock, the marginal effect of IRM on firm investment in capital-control countries is about 7 times higher than those without capital controls.

Regarding exchange rate arrangements, countries with a pegged exchange rate system (*Xchg* =0) have a significant positive IRM effect given by 0.021+ 0.062* ΔVIX (column 2) that is comparable to those in Table 2. Both a flexible exchange regime and IRM benefit firm investment – the *Xchg* and *IRM* variables garner significantly positive coefficient estimates. However, their interaction variables (*Xchg* × *IRM and Xchg* × *IRM* × Δ*VIX*) exhibit statistically insignificant effect. Similar to Obstfeld et al. (2019), we find a flexible exchange rate insulates adverse global financial shocks on firm investment as the coefficient estimates of *Xchg* × Δ*VIX* is significantly positive.

Although a flexible exchange rate regime alone does not significantly influence the IRM effect, it substantially enhances the role of IRM in promoting firm investment in the presence of capital controls. As shown in column (3), for countries that implement both capital controls and a flexible exchange rate regime, IRM exserts a stronger positive effect on firm investment than countries that do not have capital controls or/and a flexible exchange regime.

Finally, we examine whether our results in columns (1) – (3) would change if we control for firm level financial constraints. To do so, we add the following terms to Equation (6): $Fin\ constr_{i,t} * \left(\theta_1 + \theta_2 IRM_{c,t} + \theta_3 \Delta VIX_t + \theta_4 IRM_{c,t} \times \Delta VIX_t\right)$, where $Fin\ constr_{i,t}$ is the first principal component extracted from *Ext fin*, *Tangi* and *WW*. Results are reported in columns

(4) to (6). The financial constraint coefficient estimates are comparable to those in Table 3. And the inclusion of the financial constraint does not materially alter the estimated effects of capital control and exchange rate arrangement. That is, effects of financial constraints, capital controls, and exchange rate arrangement on firm investment do not overlap with each other.

5 Concluding Remarks

Accumulating international reserves in good times to safeguard the economy against adverse global financial shocks is one of the recognized macro policy tools pursued by EMEs to manage their economies (Ostry et al., 2012; Acharya and Krishnamurthy, 2018). Aizenman and Jinjarak (2020), Aizenman and Lee (2007), Caballero and Panageas (2008), Dominguez, Hashimoto, and Ito (2012), Jeanne (2016), and Jeanne and Ranciere (2011), for example, theorize and illustrate the stabilizing effects of active IRM on the macro-economy. The current study extends the discussion of IRM by examining its implications for investment at the firm level; thus, it offers a glimpse of the micro-level mechanism with which the IRM alleviates the negative impact of global financial shocks.

Adopting a Tobin-Q type investment setup, we control for the canonical domestic and firm-specific factors and report the empirical roles of IRM, global financial shocks, and their interactions in determining investment at the firm level in EMEs. The IRM effect varies across firms with different financial conditions – financially constrained firms, compared with non-constrained ones, exhibit a smaller positive IRM effect on investment. The firm-level effect can be the underlying cause of the IRM effect on macro variables reported in the literature.

In accordance with the notion that an active IRM policy alleviates the impact of adverse global financial shocks on country credit spreads, our empirical results show that country credit spreads are a significant channel through which IRM exerts positive effects on firm investment. The country credit spread mediation effect is stronger for financially constrained firms than for non-constrained ones.

Further, active IRM is shown to be complementary to capital controls and exchange rate management, in terms of stabilizing firm investment under global financial shocks. That is, these macro policy tools play complementary roles in alleviating adverse global financial shock effects on firm investment in EMEs. These results suggest the benefits of combining these tools in insulating firm investment from global financial shocks.

While the current exercise has established the firm-level effect of IRM, IRM may have other effects beyond the scope of this paper. For instance, in addition to serving as a buffer during a crisis, a high level of international reserve hoarding can reduce the probability of speculative attacks. Another issue is that the IRM effect can be asymmetric; a high level of international reserves is probably more relevant during crisis periods than normal ones, and a low level can limit the ability to conduct active IRM during a crisis. Also, hoarding excessive international reserves in good times may backfire. It can lead to moral hazard concerns,[27] and incur significant opportunity costs associated with accumulating low yielding international reserve assets instead of holding a balanced portfolio in a well-run Sovereign Wealth Fund. These issues are left for future research.

[27] This may be the case when international reserves are used to sustain 'zombie' state banks and state enterprises.

6 Appendices:

Appendix A. The IRM effect (A Brief theoretical Overview)

In this section, we first briefly review the related literature on the precautionary role of international reserves, uncertainty shocks, and investment; then summarize the plausible theoretical mechanism through which IRM affects firm investment. The theoretical IRM effect on firms established in the literature provide the underpinning of our empirical exercise in the text which focuses on identifying the effect of IRM on investment and estimating the fraction of IRM effect that works through the channel of credit spreads.

1. The theories on uncertainty and investment

One of the central theories[28] related to how uncertainty shocks impact investment is based on the financial friction argument, which posits that uncertainty shocks can increase the likelihood of default on firms' debt and drive-up their credit spreads, consequently reducing firms' capital expenditure. The financial friction theory has garnered increasing attention since the havoc of the 2008 global financial crisis[29]. Several influential papers provide theoretical mechanisms by which financial uncertainty shocks can impact real economy activities through the channel of financial friction. For instance, Gilchrist et al. (2014) model financial friction as a conduit through which uncertainty shocks affect investment. According to the model, jumps in uncertainty reduce the collateral value of firms' capital assets, leading to a decrease in debt capacity and an increase in credit spreads, thus reducing firms' capital expenditures.

Christiano et al. (2014) model financial friction through the interest rate channel by allowing a firm to receive debt, the interest rate on which includes a premium to cover the costs of default when the firm suffers "bad" enough shocks. Credit spreads are allowed to fluctuate with the changes in risk shocks. In a DSGE model, the paper showed that, when risk is high, credit spreads are high and the firm's borrowing ability is low. Investment falls as a result.

Arellano et al. (2019) implement financial friction by assuming financial markets are incomplete and firms can only borrow state-uncontingent debt, on which the firm may default. Idiosyncratic shocks occur after firms' hiring of labor inputs, but before the realization of the revenues generated by labor inputs. An increase in uncertainty of idiosyncratic productivity shocks causes the revenues from any given amount of labor to be more volatile, therefore, a default is more likely, and borrowing costs is to increase. In equilibrium, the paper suggests that an increase in volatility leads firms to pull back on their hiring of inputs.

[28] The other main theory is the "wait and see" theory, which suggests that, due to the irreversibility of investment, firms tend to hold off on the investment and wait until the uncertainty is cleared before executing. This behavior creates an option value for the "wait and see" strategy, and the option value increases with uncertainty through the possibility of bad outcomes. See Bernanke (1983), Bloom et al. (2007), and McDonald and Siegel (1986), among others.

[29] The literature indicates that financial shocks play an increasingly important role in affecting economic activities. Jermann and Quadrini (2012) find that financial shocks that affect firms' ability to borrow is more important for macroeconomic fluctuations than productivity shocks. Akinci (2013) suggested that global financial risk shocks explain about 20% of the movements both in the country spread and in the aggregate activity in emerging economies. In their comprehensive empirical work, Obstfeld et al. (2019) point out that global financial shocks negatively affect both financial conditions in EMEs (e.g., credit growth, house price, stock returns, change in loan-to deposit (LTD) ratio, and net capital flows) and real economy GDP growth.

In a New Keynesian model, Ottonello and Winberry (2020) explain the role of financial frictions in determining how investment responds to monetary shocks among firms that are heterogenous in their default risk. They find that firms with low default risk are most responsive to monetary shocks because they face a flatter marginal cost curve for financing investment.

These papers model uncertainty shocks to bind firms' financial friction and investment through credit spreads and borrowing abilities. The financial friction mechanism is particularly applicable for EME firms that rely on external finance to invest, but are simultaneously constrained in financial conditions. Caballero et al. (2019) find that adverse external financial shocks create a spillover effect that drive up EME corporate bond spreads, worsen financial friction, and restrain firms' borrowing capacity, thus imposing a downside impact on output, consumption, and investment.

2. Theories on international reserves and country spreads

International finance literature relates the precautionary role of international reserves to sudden stops, debt default, and country spreads in emerging markets. EMEs usually deploy multiple macro-management tools to address the spillover from external uncertainty shocks (Ostry et al. 2012; Acharya and Krishnamurthy, 2018). One of these tools is the accumulation of international reserves that provide both self-insurance and buffer stock against external shocks to maintain financial and real economic stability. Typical theories model international reserves as self-insurance that lowers country/sovereign spreads by reducing the likelihood of *sudden stops* (either exogenous or endogenously generated in the model) or the risk of sovereign default, which leads to lower sovereign borrowing costs and improved welfare. For instance, Jeanne and Ranciere (2011) model international reserves as a state contingent security that pays off in an exogenous sudden stop in a welfare-maximization model. Similarly, Caballero and Panageas (2008) propose a model with a self-insured government financial instrument that is contingent upon income-growth shock. The model demonstrates a significant output gain from the financial instrument that self-insures against both the occurrence of sudden stops and the changes in the probability of sudden stops. Endogenizing sudden stops in an open economy version of the model by Diamond and Dybvig (1983), Aizenman and Lee (2007) show that reserves can serve as self-insurance to avoid costly liquidation of long-term projects susceptible to sudden stops. The welfare gain from the optimal reserves holdings is found to be significant. It reduces the output cost of sudden stop shocks from first order to second order magnitude.

In addition to sudden stops, international reserves play a role in lowering sovereign default/rollover risk. Bianchi et al. (2016) model along this perspective, suggesting that an indebted government is better off accumulating reserves when it borrows long-term debt that is susceptible to default risks. The mechanism is that a negative shock tends to increase sovereign spreads, making it costly for the government to rollover its debt. Holding reserves in the state of bad shock can hold off the impact of a shock by reducing the government's borrowing cost, hence mitigating the drop of consumption.

Related to IRM and global financial shocks, Jeanne (2016) outlines a welfare-based model of capital flow with banking friction. There is a possibility that banks fire-sale their assets and reserves are used to buy fire-sale assets. The fire-sale price, which can be considered as a country spread [or interest rate in Jeanne (2016)], is determined by the accumulated reserves and the probability of fire-sale. The model suggests that an EME government can mitigate financial friction by engaging in active IRM to gain social welfare benefits.

Summarizing two avenues of theories discussed in this section, we postulate that there are interactions between IRM and uncertainty shocks via country spreads, i.e. uncertainty shocks widen the country spreads of EMEs, whereas IRM narrows their country spreads, thus mitigating the impact of uncertainty shock on country spreads. Such interactions eventually yield an equilibrium credit spread, other things being equal. The equilibrium credit spread, as a proxy for borrowing cost, determines the level of investment.

Appendix B: Constructing the Empirical Measures of active IRM

1. The DHI simulation method

Reserve assets held in central banks include foreign exchange currencies and other non-currency assets, for example, SDR allocations, the reserve position in IMF, and other reserve assets [30]. Thus, the change in international reserves (ΔIR) is the sum of changes in foreign currency reserve ($ForexR$) and non-foreign currency assets ($nonCR$), i.e., $\Delta IR = \Delta ForexR + \Delta nonCR$. Foreign currency reserves can be further divided into two categories of financial assets: securities (*SEC*) and currency deposits (*DEPO*). Therefore, the change of *IR* can be expressed as follows:

$$\Delta IR = r_i^s * \sum_{i=1}^{n} SEC + r_i^d * \sum_{i=1}^{n} DEPO + \Delta SEC + \Delta DEPO + \Delta nonCR, \qquad (A1)$$

where r_i^s and r_i^d are the interest rates on currency i denominated securities and currency deposits that reserve assets invested, respectively. There are n different currency denominated reserve investments. Thus, $r_i^s * \sum_{i=1}^{n} SEC + r_i^d * \sum_{i=1}^{n} DEPO$ accounts for the total interest income from reserve asset investments; $\Delta SEC + \Delta DEPO$ is the value change in both securities and currency deposits, which can be further decomposed into the purchases and sales of reserve assets and the valuation changes. Thus,

$$\Delta IR = \left(r_i^s * \sum_{i=1}^{n} SEC + r_i^d * \sum_{i=1}^{n} DEPO \right) + (\Delta^{ps} SEC + \Delta^{ps} DEPO) + (\Delta^{val} SEC + \Delta^{val} DEPO) + \Delta nonCR, \qquad (A2)$$

where $\Delta^{ps} SEC + \Delta^{ps} DEPO$ measures active IRM on purchases and sales of IR assets; $\Delta^{val} SEC + \Delta^{val} DEPO$ is the valuation effect due to exchange rate changes. Let $Interest\ income\ = \left(r_i^s * \sum_{i=1}^{n} SEC + r_i^d * \sum_{i=1}^{n} DEPO \right)$, $IRM =\ (\Delta^{ps} SEC + \Delta^{ps} DEPO)$, and $Valuation\ effect\ = (\Delta^{val} SEC + \Delta^{val} DEPO)$, we could calculate IRM as the follows:

$$Active\ IRM = \Delta IR - \ Interest\ income - valuation\ effect - \ \Delta nonCR \qquad (A3)$$

As ΔIR and $\Delta nonCR$ have available data from IMF IFS, in order to measure active IRM, we need to estimate $Interest\ income$ and $Valuation\ effect$.

To pin down $Interest\ income$, we utilize IMF's Special Data Dissemination Standard (SDDS) Reserve Template data. Although SDDS does not provide data on the types of securities and deposits (by currency denomination) that we need to calculate $Interest\ income$, it does

[30] International reserves literature typically refers international reserves as the total international reserves excluding gold. To be consistent, we exclude gold when simulating IRM data in a departure from Dominguez et al. (2012) who include gold as part of international reserves.

offer data on the share of these reserves held in securities (*SEC*) and the share in currency deposits (*DEPO*). As no country specific information about the currency composition of these reserve assets is available, we use the aggregate currency composition of international reserve assets in “emerging and developing economy” to proxy. For simplicity, we use four major reserve currency shares, namely the US dollar, Euro, UK pound, and Yen, which account for more than 90% of total reserves in EMEs. These aggregate data on reserve currency shares are available from the Currency Composition of Official Foreign Exchange Reserves (COFER) database. Together with the interest rates of SEC and $DEPO$ that are proxied by returns to treasury securities (10-year bond yields issued by US, German, UK, and Japanese government) and deposits (3-month LIBOR rate on USD, Euro, Pound, and Yen), we can calculate $Interest\ income$.

Regarding $valuation\ effect$, we apply two approaches to simulate. The first one follows Dominguez et al. (2102) to use the IMF Balance of Payment Statistics (BOP) data to backout valuation changes in international reserves. The Reserve and Related Items category in the BOP records the market valued purchases and sales of reserve assets, which can be expressed as the follows:

$$Res_{BOP} = \left(r_i^s * \sum_{i=1}^{n} SEC + r_i^d * \sum_{i=1}^{n} DEPO \right) + (\Delta^{ps} SEC + \Delta^{ps} DEPO) + \Delta nonCR \qquad (A4)$$

Subtracting Res_{BOP} from ΔIR of Equation (A2), we backout the valuation effect, labeled as *valuation_BOP*, as the follows:

$$valuation_{BOP} = \Delta IR - Res_{BOP} = \Delta^{val} SEC + \Delta^{val} DEPO \qquad (A5)$$

The other approach directly estimates the total valuation change of foreign exchange currency reserves (*ForexR*) based on the information of currency composition in international reserves and exchange rate changes among four major reserves currencies. As before, we use COFER data of aggregate currency composition share in reserve holdings to proxy each country’s reserve currency composition, along with *ForexR* data from SDDS and the annual data of exchange rate changes from IMF IFS, we can estimate the valuation effect, labeled as *valuation_EXR*, as the follows:

$$valuation_{EXR} = \sum_{j=1}^{3} ForexR * CurrencyShare_j * \Delta exr_j, \qquad (A6)$$

where $CurrencyShare_j$ $(j = 1, 2, 3)$ are the currency share of Euro, Pounds, and Yen in international reserves. Δexr_j are the average annual exchange rate changes of Euro, Pounds, and Yen to the US dollar.

Subsequently, we use Equation (A3) to simulate two measures for active IRM by using valuation effects of (A5) and (A6), respectively. The simulated IRM, in US dollars, is then scaled by GDP (also in US dollars) to be comparable across EMEs with different economy size and to be compatible with other measurements of IRM that we will discuss later. We label these two measurement IRM-DHI-1 and IRM-DHI-2, respectively. Figure A1 plots IRM-DHI-1 and IRM-DHI-2 of four emerging market countries, namely Bulgaria, Russia, Singapore, and South

Korea[31], and the data of average IRM in EMEs from 2000 - 2018. On average, EMEs actively accumulated more reserves before 2008, but less so after the 2008 global financial crisis. Individual emerging market presents heterogenous pattern in their active IRM behaviors. For example, Bulgaria and Korea kept their IRM consistent before and after 2008, except the shape drop during the 2008 global financial crisis. Russia and Singapore, on the other hand, actively accumulated reserves before 2008, but slowed down the rate of accumulation after 2008. Adjusting the valuation effect in IRM-DHI-2 lead a temporary deviation from the IRM-DHI-1 measurement, it does not, however, alter the general pattern. Overall, these data patterns are comparable to the IRM data presented in Dominguez et al. (2012).

2. The detrend method

In our second approach, we use a linear regression to detrend international reserve data and estimate active IRM. Official international reserve data are stock data that appear to trend upwards over time. As shown in the upper panel of Figure A2, the level of reserve holdings in EMEs has been increasing persistently since 2000. In addition to the persistent active accumulation of international reserves, the passive management of international reserves may contribute to this trending pattern. As discussed earlier, the passive management components include interest incomes and the valuation effect. Interest incomes create the compounding effect that raises the value of total reserve assets over time, i.e., the value of total reserve assets is compounded over time based on the interest rates that the investment of reserve assets yields. Similarly, the valuation effect would increase the value of reserves assets over time if the US dollar depreciates against other reserve currencies. This is because the official international reserve data are denominated in US dollar and appreciation of other reserve currencies increases the dollar value of reserves. In fact, the consistent depreciation of the US dollar from 2000 – 2008 contributes to the upward trend in international reserve data (see the lower panel of Figure A2). Thus, detrending the international reserve stock data may effectively purge the passive management components from the official reserves data, and the remainder is likely to be the active IRM. We then use these detrended reserve data divided by GDP (in current US dollars) to measure active IRM, and we label it as IRM-1.

Although trending, there seems to have been a structure break point in the pattern of reserve accumulation process in EMEs around 2008. The upper panel of Figure A2 shows the secular increasing in reserves holding in EMEs before 2008 and a mitigated trend after the 2008 financial crisis. According to Aizenman et al. (2015), there was a pattern change in reserve holding behavior after the 2008 global financial crisis, because some newly identified factors[32] mitigate the reserve accumulation process in EMEs in the aftermath of the global financial crisis. To account for the structural break on reserve holding behavior in EMEs before and after the 2008 global financial crisis, we re-estimate the active IRM by imposing a break-point in the time trend at 2008. We create the estimated active IRM to GDP ratio as another measurement of active IRM and label this as IRM-2.

[31] For comparison purpose, we follow Dominguez et al. (2012) to use Bulgaria, Russia, Singapore, and South Korea as representative EMEs to demonstrate the data simulation.

[32] These factors include the saving rate, the accessibility to swap lines, implementations of macro-prudential policies, sovereign wealth fund, and the attitude towards outward FDI. Bussiere et al. (2015) find the slowing-down reserves accumulation may be related to the fact that most countries decelerated their accumulation of short-term debt after the global financial crisis.

Finally, as shown in the short-dash line in the lower panel of Figure A2, the US dollar value index has a clear depreciation trend before 2008 and an appreciation trend after 2008. Removing these patterns in the valuation effect helps better detrend the reserve data. Thus, after purging the down-and-up pattern of valuation effect from the international reserve stock data, we re-estimate an IRM, subsequently divided by GDP to obtain the third detrended measurement of active IRM. We label it as IRM-3.

Figure A3 shows the similarity of these detrended data measurements for IRM. IRM-1 and IRM-2 are virtually identical in all four EME countries. Although IRM-3 slightly deviates from the first two, they are highly correlated.

Thus far, we have obtained two groups of measurements for active IRM – the simulated and the regression detrended IRM. As they use different data sources and data compilation methods, we expect some differences and each may possess advantages and disadvantages in terms of applying to regression analyses. To compare the differences, we plot IRM-DHI-1 and IRM-1 for Bulgaria, Russia, Singapore, and Korea, along with the average measurement for EMEs in Figure A4. As shown in the fifth figure in Figure A4, for the average in EMEs, IRM-DHI-1 and IRM-1 comove with each other (the correlation is 0.83). Consistent with the finding of Dominguez et al. (2012), both measurements show active accumulation of international reserves in EMEs pre-crisis, a sale of reserves during the crisis, and a slowing-down in active accumulation of reserves aftermath the crisis. IRM-DHI-1 and IRM-1 for individual country display heterogeneity. From the perspective of individual country, they match well in Russia and Korea, but do not in Bulgaria and Singapore. However, all of them present the similar pattern of IRM before, during, and after the 2008 global financial crisis as shown in the “average in EMEs” figure.

To demonstrate how well our measurements reflect the strategy of active IRM in EMEs against global financial shocks, in Figure A5 we plot IRM-1 and IRM-DHI-1 along with the percentage changes in the VIX index (ΔVIX) – a large ΔVIX indicates a surge in global financial risk, hence a large shock in the global financial market. Both IRM measurements are negatively correlated with ΔVIX, implying that EME central banks moved to sell international reserves when global financial risk surged and accumulated international reserve assets when global financial market is stable. Moreover, a larger ΔVIX is matched by a larger opposite change in IRM measurements, which perhaps implies that, facing larger shocks in the global financial market, central banks responded by selling more reserve assets to stabilize financial markets.

Appendix C: Country samples

Emerging markets:
Argentina, Bangladesh, Brazil, Bulgaria, Chile, China, Colombia, Croatia, Czech Republic, Egypt, Hong Kong, Hungary, India, Indonesia, Israel, Jordan, Kazakhstan, Kenya, Korea, Kuwait, Latvia, Lithuania, Malaysia, Mexico, Morocco, Nigeria, Oman, Pakistan, Peru, Philippines, Poland, Qatar, Russia, Saudi Arabia, Singapore, Slovakia, Slovenia, South Africa, Sri Lanka, Thailand, Tunisia, Turkey, Ukraine, United Arab Emirates, Venezuela, Vietnam

Commodity exporter countries:
Chile, Colombia, Egypt, Indonesia, Kazakhstan, Kenya, Kuwait, Nigeria, Oman, Peru, Qatar, Russia, Saudi Arabia, South Africa, United Arab Emirates, Venezuela

Appendix D: Definition of Variables

Variable	Description
Firm characteristics:	
Investment	The measurement for investment using the ratio of capital expenditures on plants, properties, and equipment divided by the book value of total assets at the beginning of year, i.e., $\frac{Capital\ expenditure_{i,t}}{Total\ Assets_{i,t-1}}$.
Tobin Q	Tobin's q, measured as the market value of equity plus the book value of assets minus book value of equity plus deferred taxes, then divided by book value of assets - the ratio of market to book values of firm assets.
CF	The measurement for cash flows from operations, calculated as earnings before interest and tax plus depreciation and amortization divided by the book value of total asset. It is a proxy for marginal product of capital (Gilchrist et al., 2014).
Size	The logarithm of the book value of a firm's total assets.
Sales growth	Sale changes from last year divided by the book value of total assets at the beginning of year, $\frac{Sales_{i,t} - Sales_{i,t-1}}{Total\ Assets_{i,t-1}}$.
Ext fin	The category variable for financially constrained firms that are categorized based on firms' ability to access to external financing. The capacity of external finance access is calculated as external financing/Capital expenditure. External financing represents firms' financing from outside sources, including the issuance and retirement of stock and debt.
Tangi	The category variable for financially constrained firms that are categorized based on the collateral ratio of tangible assets on long-term debt. The collateral ratio is measured as the ratio of net plants, properties, and equipment in book-value to long-term debt (Claessens and Laeven, 2003; Rajan and Zingales, 1998).
WW	The category variable for financially constrained firms that are categorized based on the financial constraint index of Whited and Wu (2006), which measures the shadow cost of external financing.
Macroeconomic factors:	

ΔVIX	The percentage changes in the VIX index, calculated as $\log(VIX_t/VIX_{t-1})$. The VIX is Chicago Board Options Exchange S&P 500 implied volatility index, retrieved from FRED, Federal Reserve Bank of St. Louis.
IRM	Active international reserve management, measured the simulated data and the detrend data of international reserves excluding gold to GDP ratio. International reserves and GDP data are retrieved from IFM and the World Bank (see Appendix B for detail data constructions).
IRM/IR ratio	An alternative measurement for international reserve management, evaluated by the ratio of the simulated IRM divided total international reserves excluding gold.
Country spread	The EME sovereign bond spread, measured by the J.P. Morgan Emerging Markets Bond Spread Index (EMBI+), in decimal points.
Aggregate investment	Gross fixed capital formation (% of GDP), retrieved from WDI, the World Bank.
RGDPG	The percentage rate of real GDP growth, retrieved from WDI, the World Bank.
Risk profile	The index of domestic investment risk profile from ICRG. In logarithm value.
Swap	A time dummy variable that indicates each of four EMEs (Brazil, Korea, Mexico, and Singapore) established central bank swap agreement with the US Federal Reserve Bank during the 2008 global financial crisis (2007 – 2009). Source: Board of Governors of the Federal Reserve System.
Trade_us	The share of trade with the U.S. in a country’s total merchandise trade (imports and exports). Data are retrieved from Direction of Trade Statistics (DOTS), IMF.
Ext_debt	The ratio of external debt to GDP; WDI World Bank.
ToT	The commodity term of trade index, year 2012 = 100. Source: IMF, Commodity term of trade.
Xchg	The indicator for countries with flexible exchange rate arrangements. Xchg = 1 if the value of coarse classification codes in de facto exchange rate arrangement classification of Ilzetzki, Reinhart and Rogoff (2019) is greater than 3.

KC	The indicator for countries with capital controls. KC = 1 if the Chinn-Ito capital controls index is less than the average level of Chinn-Ito index in our EME samples.
<u>*Alternative measurements for global financial risk:*</u>	
S&P500	An alternative measurement for global financial shocks, measured as the intra-annual volatility of S&P500 index, computed from S&P500 daily data according to Merton (1980). To construct these data, we first compute the daily contribution to annual volatility by taking the squared first difference to the daily changes in S&P500 index after dividing by the square root of the number of trading days: $$\sigma_t = \left(100\frac{\Delta x_t}{\sqrt{\Delta\varphi_t}}\right)^2$$ where the denominator $\sqrt{\Delta\varphi_t}$ is to adjust the effect of calendar time elapsing between observations on the x process. Due to that no data are available on non-trading day, e.g., weekends and holidays, $\sqrt{\Delta\varphi_t} \in (1,5)$. For example, if data were generated on every calendar day, $\Delta\varphi_t = 1, \forall t$. The annual volatility of S&P500 index is defined as $\Phi_{t'}[x_t] = \sqrt{\sum_{t=1}^{T}\sigma_t}$ where the time index *t* is at the annual frequency.
RORO	The first principal component of daily data across several asset classes, including 1) credit risk: changes in the ICE BofA BBB Corporate Index Option-Adjusted Spread for the United States and for the Euro Area, and Moody's BAA corporate bond yield relative to 10-year Treasuries; 2) equity return and implied volatility in the US and Europe: the additive inverse of daily total returns on the S&P 500 and STOXX50, and the VIX and the VSTOXX index; 3) funding liquidity: changes in the TED spread and the bid-ask spread on 3- month Treasuries. The data compilation approach follows Chari et al. (2020).
Feds rate	The changes in the Fed's effective fund rate, retrieved from FRED, St. Louis Fed.
MPU	The changes in the US monetary policy uncertainty index (Baker et al., 2016), a news-based uncertainty index drawn from 10 major national and regional U.S. newspapers, retrieved from <u>www.policyuncertainty.com</u>.

Appendix E: Summary statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
Investment	211,371	.07777	.11807	0	1.0681
ΔVIX	197,386	-0.0100	0.2782	-0.3611	0.6266
IRM-1	208,875	0.0012	0.0758	-0.6233	0.4254
IRM-2	208,226	0.0058	0.0822	-0.5549	0.3946
IRM-3	207,151	0.0028	0.0846	-0.5442	0.3225
IRM-DHI-1	147,526	0.0120	0.0425	-0.1888	0.3246
IRM-DHI-2	149,324	0.0127	0.0455	-0.1577	0.3510
IRM/IR ratio	155,952	.02855	.11951	-1.8938	0.5803
GDP growth	210,207	0.0529	0.0312	-0.1481	0.2617
Risk profile	210,771	8.7847	1.7387	2.5	12
Country spread	103,159	.05515	.08606	-.00880	1.0948
Tobin's Q	211,371	0.2151	0.2548	1.00E-06	2.4250
CF	209,605	0.0704	0.2711	-37.6254	69.4896
Size	211,371	22.0740	2.9833	5.3927	33.4614
Sales growth	200,985	.0962417	.6330927	-84.9367	111.9956
External finance access	205,978	-0.0001	0.1653	-38.318	54.0414
Tangible assets to LT liabilities ratio	185,299	0.0102	0.3364	-120.235	28.7530
WW index	173,117	-0.0135	0.3768	-129.135	0.1152
S&P500 intr-annual volatility	211,371	15.3533	7.1617	6.2618	37.006
RORO	211,371	0.1638	1.3097	-3.6986	1.9119
Feds rate	211,371	1.1863	1.5226	0.07	5.24
MPU	211,371	128.2747	28.1732	70.0833	176.4167

Notes: this table shows summary statistics of main variables. Country level and time series data are matched with the firm level panel data that winsorize the investment variable at the 1st and 99th percentiles.

Appendix F: Robustness of Results

Here we undertake additional empirical analyses to test the sensitivity of our results to the following variations: 1) alternative measurements for active IRM, 2) alternative measurement for global financial shocks, and 3) different data samples.

1. Alternative IRM measurements

We discussed different measurements for IRM and compared their advantages and disadvantages in Section 2.1 and in Appendix B. In this subsection, we use other IRM measurements to check the sensitivity of our results. Columns (1) – (4) in Table A1 report the results using IRM-2, IRM-3, IRM-DHI-1, and IRM-DHI-2, respectively. In general, these results are similar to those in column (1) of Table 2, other than the values of some coefficients to IRM and the interaction term, IRM × ΔVIX, are larger, especially when using two simulated measurements for IRM in columns (3) and (4). Additionally, as all five previous IRM measurements are scaled by GDP, one may be concerned that the variation could be due to the changes in GDP as opposed to IR. To address this issue, we use the IRM/IR ratio, measured as the ratio of the active IRM based on the DHI approach to the total international reserves excluding gold[33], to run regression in column (5). The results remain consistent with other columns. Overall, these results do not materially change from those in column (1) of Table 2, suggesting that our results are robust to different measurements for IRM.

2. Alternative measurements for global financial shocks

In this subsection, we use four alternative measurements for shocks in the global financial market to check the sensitivity of our results. We first use the intra-annual volatility compiled according to Merton (1980) from daily data of S&P 500 index. Contrasting to the VIX index that measures the implied volatility of S&P 500 stock options, the intra-annual volatility provides a representative measure for the perceived volatility. We expect the shocks to the perceived volatility and those to the implied volatility produce comparable impact on firm investment in emerging economies.

Second, we use the RORO index as an alternative measurement for ΔVIX. Compared to the VIX index measure, RORO index is more "global" in that it includes risk information from different financial asset classes and across both the US and Europe financial markets. Third, we apply the percentage changes of the Fed's fund rate as alternative measurements for global financial shocks. The US monetary policy is well documented to have spillover effect on emerging markets (Miranda-Agrippino and Rey, 2020). We expect that US monetary policy shocks generate spillover effects over firm investment in EMEs. Finally, the news-based US monetary policy uncertainty index of Baker et al. (2016) is used to directly measure policy shocks from the center country to the global financial market.

We report the results using alternative measurements of global financial shocks (*Alt_shocks*) in Table A2. Columns "S&P500", "RORO", "Feds rate", and "US MPU", show the results for intra-annual volatility, RORO, percentage changes in the US Federal fund rate, and the US MPU index as *Alt_shocks*, respectively. These results are comparable to those in Table 2, although the estimated coefficients for *IRM × Alt_shocks* are smaller than *IRM × ΔVIX* in Table 2.

3. Extraordinary shocks: The 2008 global financial crisis and the Federal Reserve's "taper tantrum"

A number of influential papers related to uncertainty shocks use time dummy variables to capture extraordinary financial events to measure financial shocks (e.g., Bloom 2009). Both the 2008 global financial crisis and the Federal Reserve's "taper tantrum" triggered substantial global financial uncertainty. The 2008 global financial crisis highlights an extreme global

[33] This specification, in some degree, also addresses the concern that our results may be contaminated by the mercantilist role of IR which tends to positively affect firm investment as well. For example, the mercantilist IR lowers a country's exchange rate therefore promoting its firms' exports. The promoted exports are likely to induce more investment. With the current specification, we capture mercantilist effect with the trending variable of IR/GDP and the precautionary effect (leaning again the wind) with the detrend variable of IRM. A significantly positive estimation for IRM/IR suggests that the precautionary role of IR dominates the mercantilist role.

financial risk shock (i.e., the VIX index spiked to as high as 80%), which wreaked havoc on the global financial system and dried up the global credit supply in emerging markets. Similarly, the Federal Reserve's "taper tantrum" in 2013, which signaled the start of tapering its QE program, was marked by a sharp reversal of capital flows to emerging markets, a sharp decrease in credit supply together with rising credit spreads, and significant disruptions in EME financial markets (Avdjiev et al, 2020; Chari et al, 2020).

According to Gulen and Ion (2016), two thirds of corporate investment during 2008 financial crisis was attributed to surging uncertainty. To evaluate the impact of the 2008 financial crisis and the Fed's taper tantrum in 2013 on firm investment, we create an index variable, *Crisis&Taper* (= 1 if year == 2007, 2008, 2009, 2013 and 2014; otherwise, 0) to indicate 2008 the financial crisis and the Fed's tapering[34]. We use this time dummy variable as an alternative measurement for global financial shocks and repeat regressions (2) to examine the effect of IRM on firm investment in the presence of extraordinary financial shock events.

The results are reported in last column (Crisis&Taper) of Table A2 and are remarkably similar to those in other columns. We show that IRM positively affect firm investment in non-2008 crisis and taper tantrum periods. This positive effect is substantially higher during the 2008 financial crisis and the Fed's taper tantrum when the global financial risk level was extraordinarily high.

4. Possible sample selection bias

In this subsection, we check for possible sample selection bias issues. First, we include all firm samples from any available emerging economies in the Worldscope database (including small countries that list fewer than 15 companies; this adds about 12% observations). Second, we run regressions with the 50 largest firms (largest average total assets in sample periods) of each country to reduce the dominance of countries that have a large number of publicly listed firms.

Third, one may be concerned about the impact of firms that do not survive in sample periods. As non-survival firms are likely to be financially constrained, including these firm may down-bias our estimation results. Thus, we run regression on non-survival firm samples to check the possibility of survivorship bias. We identify a firm as a non-survivor if it was marked as "inactive" at any sample year. This is, however, a coarse identifier with caveats. The Worldscope database marks a firm "Inactive" if the firm stopped produce annual accounting reports for unspecified reasons. Thus, we are not able to distinguish whether a firm is bankrupt, de-listed or merged by another firm. Nonetheless, using this identifier, we identify 4304 non-survivor firms and run a regression on them to test the robustness of our previous results.

Fourth, it is possible that firms invest in their domestic market and foreign market simultaneously. The behaviors of domestic investment in response to IRM and global financial shocks presumably are different from that of foreign investment. For this reason, we test how sensitive our results are by using domestic investment samples only. Our firm investment data in previous sections are total investments of a firm that do not differentiate the domestic investment from the foreign investment. As the Worldscope database does not mark whether a firm invest in foreign market, we use an alternative identifier - whether a firm has foreign subsidiaries by checking whether the firm reports consolidated accounting statements. We assume a firm invests

[34] The NBER dated the 2008 global financial crisis from December 2007 to June 2009. We define the Fed's taper tantrum to be from June 2013, when Chairman Bernanke announced a "tapering" of the Fed's QE policies contingent upon continued positive economic data to October 2014 when the Fed halted its bond purchase program.

domestically only if it does not report consolidated annual accounting reports. After checking for such reports, we find about 10% of our firm samples are domestic investors.

Finally, we run a regression on the samples of firms from commodity exporting countries. Such countries may enjoy the buffer stock role of international reserves induced by term of trade shocks (Aizenman and Riera-Crichton, 2008). International reserve, in return, provides insulation to shocks of commodity term of trade (CTOT) in commodity countries (Aizenman et al., 2012). To investigate whether investment of commodity country firms responds to active IRM differently and how *CTOT* shocks may change the way active IRM affects firm investment, we add a *CTOT* shock variable, measured as the changes of commodity term of trade ($\Delta CTOT$), in the regression and use firm samples from 16 commodity exporting countries to run the regression (See Appendix C for commodity country samples).

The results of these regressions are reported in Table A3. Overall, regressions using different firm samples yield results comparable to that of Table 2. Column (1) reports the full sample results. They are similar to Table 2, yet the coefficients of *IRM* and the interaction term are slight larger than those in Table 2, indicating that active IRM affects firm investment in small EMEs in a manner as similar to major EMEs, but with a slightly larger impact. In column (2), which reports results for top 50 largest firms in each country, the effect of IRM seems to be smaller (i.e., the estimated coefficient of IRM is 0.013, compared to 0.02 in Table 2), suggesting that large firms are less responsive to IRM as they might have more tools to hedge financial instability.

Non-survivor firms do not significantly respond to active IRM as the IRM variable is estimated to be negative but statistically insignificant [column (3)]. Perhaps due to firm's specific dire situation, these firms have to reduce investment even when the financial market is stable and the economic outlook is good. Regarding firms that only invest domestically, we find that these firms are highly responsive to active IRM (the marginal of IRM in column (4) is $0.041 + 0.222 * \Delta VIX$, compared to $0.02 + 0.056 * \Delta VIX$ in Table 2).

Finally, we find in column (5) that commodity country firms seem to be more responsive to active IRM and global financial shocks than other firms. The CTOT shock is not significantly estimated, perhaps because CTOT shocks in commodity countries are closely associated with shocks in global financial markets (Reinhart et al., 2016). Adding ΔCTOT, although not estimated significantly, amplifies the buffer stock role of IRM. In fact, if we drop ΔCTOT from the regression [column (6)], the coefficients of IRM and IRM × ΔVIX become smaller.

Table A1: The effect of IRM on firm investment using alternative IRM measurements

	(1)	(2)	(3)	(4)	(5)
IRM	0.021***	0.024***	0.040***	0.048***	0.015***
	(0.003)	(0.003)	(0.008)	(0.007)	(0.002)
IRM × ΔVIX	0.060***	0.067***	0.126***	0.071***	0.068***
	(0.010)	(0.010)	(0.026)	(0.023)	(0.008)
#Obs	194243	189623	135890	137545	134916
R^2	0.273	0.275	0.277	0.277	0.277

Notes: This table reports regression results for Equation (2) using alterative IRM measurements. Column (1) uses IRM-2 measured by IR that detrends a time trend with a breakpoint at 2008 to GDP ratio; column (2) uses IRM-3, the ratio of a linearly detrended IR after been adjusted for the valuation effect to GDP; Column (3) and (4) uses IRM-DHI-1 and IRM-DHI-2, two simulated data series using Dominguez et al. (2012) approach. Column (5) uses IRM/IR ratio measured by the ratio of DHI simulated active IR accumulation to total international reserves excluding gold. Results of *RGDPG, Risk profile, Tobin Q, CF, Size*, and *Sales growth* are not reported. All regressions control for firm and year effects. Robust errors are in parentheses. ***, **, * denote for 1%, 5% and 10% significance.

Table A2: The effect of IRM on firm investment using alternative measurements for global financial shocks

	S&P500	RORO	Feds rate	US MPU	Crisis&Taper
IRM	0.019***	0.019***	0.019***	0.019***	0.014***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.004)
IRM × Alt_shocks	0.030***	0.005**	0.008**	0.049***	0.023***
	(0.006)	(0.002)	(0.004)	(0.010)	(0.007)
#Obs	194845	194845	194845	194845	194845
R^2	0.273	0.273	0.273	0.273	0.273

Notes: This table reports the results of regressions using alternative measurements for global financial shocks. Column "S&P500" uses the changes of Merton (1980) intra-annual volatility of S&P500 index; column "RORO" reports results using risk on/risk off measurement of Chari et al. (2020) to measure global financial shocks; column "Feds rate" uses the change of the Feds fund rate; column "US MPU" uses Baker et al. (2016) index of US monetary policy uncertainty; column "Crisis&Taper" uses a time dummy variable that captures the 2008 global financial crisis and the Federal Reserve's tapper tantrum to measure global uncertainty shocks. Results of *RGDPG, Risk profile, Tobin Q, CF, Size,* and *Sales growth* are not reported. All regressions control for firm and year effects. Robust errors are in parentheses. ***, **, * denote for 1%, 5% and 10% significance.

Table A3: The effect of IRM on firm investment estimated from various firm and country samples

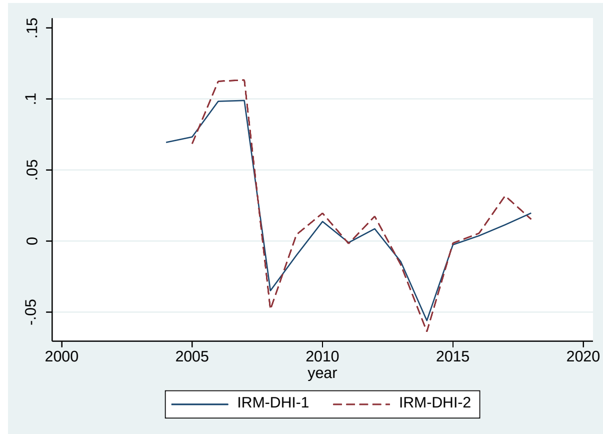
	(1)	(2)	(3)	(4)	(5)	(6)
IRM	0.034***	0.013***	-0.005	0.041*	0.036***	0.027**
	(0.003)	(0.004)	(0.014)	(0.022)	(0.014)	(0.012)
IRM × ΔVIX	0.060***	0.075***	0.157***	0.222***	0.093*	0.071*
	(0.012)	(0.016)	(0.060)	(0.069)	(0.048)	(0.042)
ΔCTOT					0.025	
					(0.018)	
#Obs	219399	98412	22316	21902	22133	24103
R^2	0.229	0.299	0.309	0.316	0.326	0.321

Notes: The table reports the result of Equation (2) with various firm and country samples. Column (1) uses full sample without censoring countries that listed less than 15 companies. Column (2) uses data of the top 50 largest firms (in terms of total assets) of a country. Column (3) uses firms that are inactive before 2018. Column (4) uses firms that only invest domestically. Columns (5) and (6) report results for firm samples in commodity exporter countries. Results of *RGDPG, Risk profile, Tobin Q, CF, Size,* and *Sales growth* are not reported. All regressions control for firm and year effects. Robust errors are in parentheses. ***, **, * denote for 1%, 5% and 10% significance.

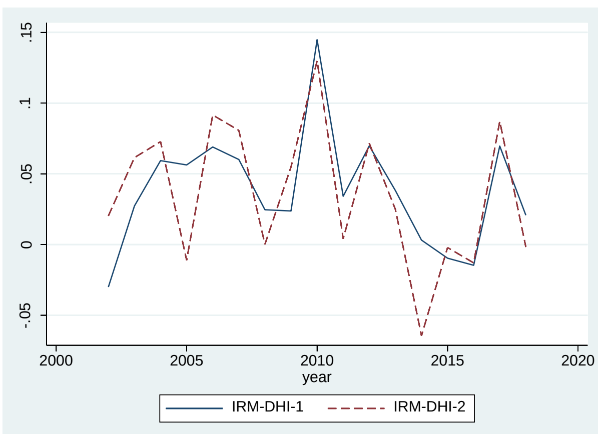
Figure A1: The simulated active IRM data using the DHI method

Bulgaria

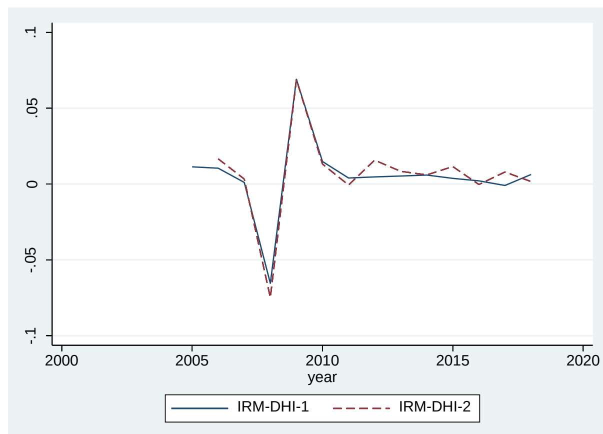
Russia



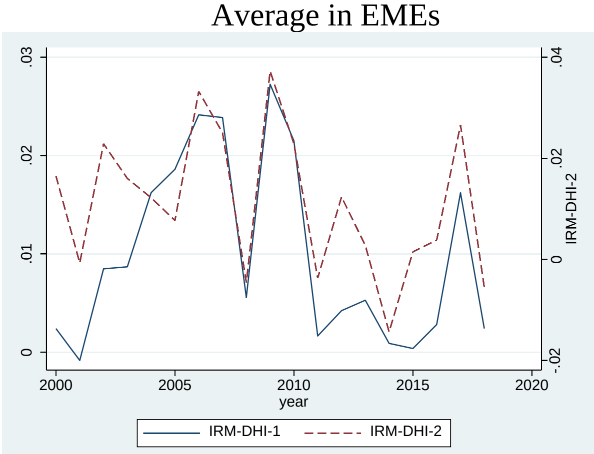
Singapore



Korea

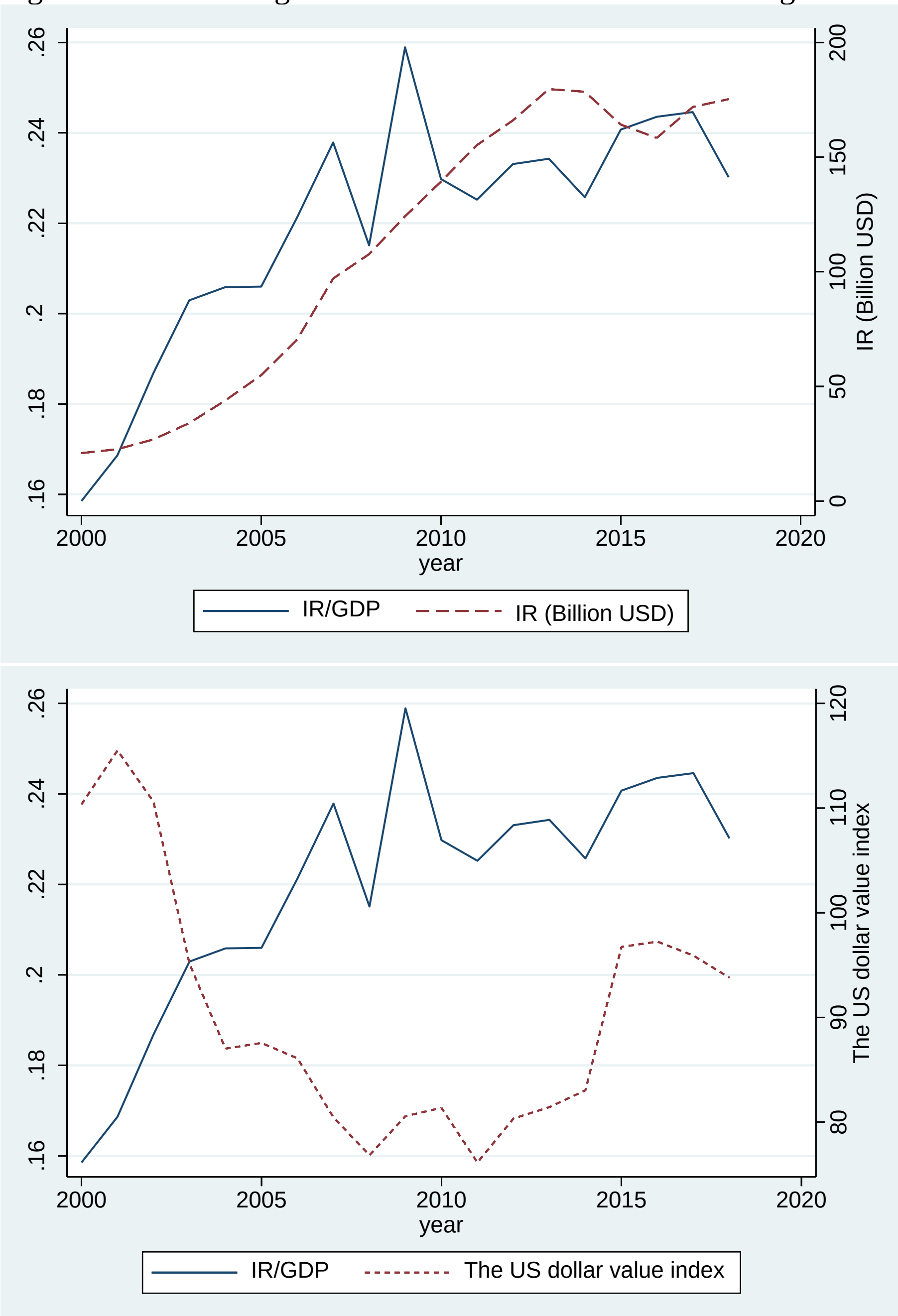


Average in EMEs



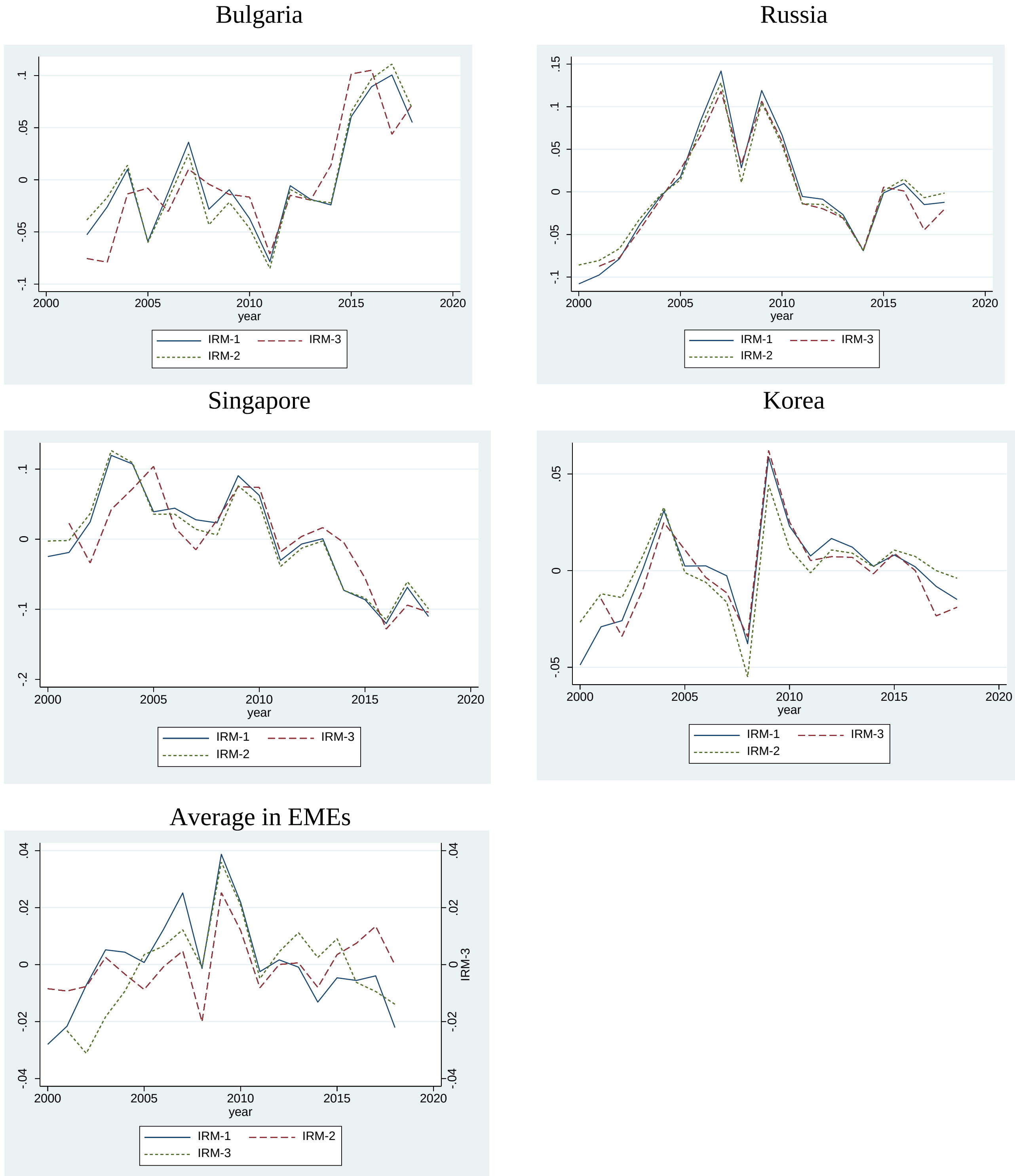
Notes: This figure plots the DHI method simulated IRM data of four EMEs (Bulgaria, Russia, Singapore, and South Korea). The solid line shows the simulated IRM data (IRM-DHI-1) that adjust the valuation effect using equation (A5); the dashed line shows the simulated IRM using valuation effect of equation (A6) (IRM-DHI-2).

Figure A2: The average level of international reserves holding in EMEs



Notes: This figure shows the different pattern in international reserves (IR) holding behavior in EMEs before and after the 2008 global financial crisis. The solid line plots the average of IR/GDP ratio (left scale); the long-dash line in the top panel plots the average IR holding in EMEs (in Billion USD, right scale); and the short-dash line in the bottom panel shows the US dollar value index.

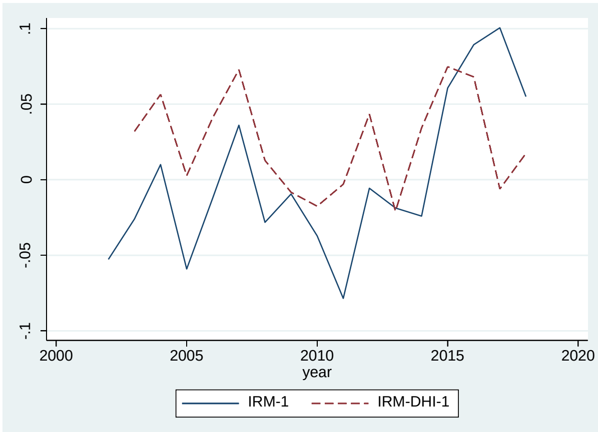
Figure A3: the estimated IRM using the detrend method



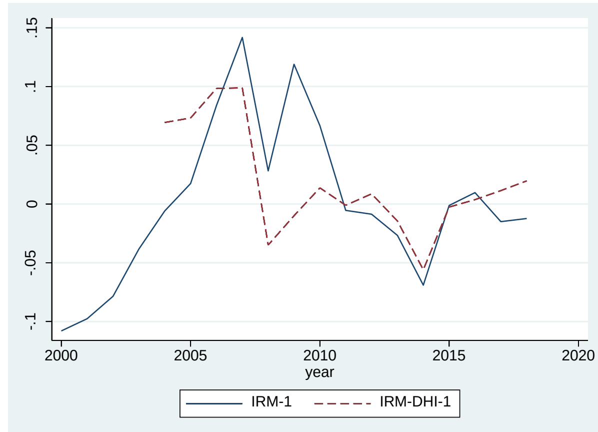
Notes: This figure plots the estimated IRM of four EMEs (Bulgaria, Russia, Singapore, and South Korea) and the average level in EMEs. The solid line shows the linearly detrend IR/GDP ratio (IRM-1); the dot line shows the detrended IR/GDP with a structure break at year 2008 (IRM-2); and the dashed line shows the detrended IR/GDP after adjusting for the valuation effect (IRM-3).

Figure A4: The comparison between IRM-1 and IRM-DHI-1

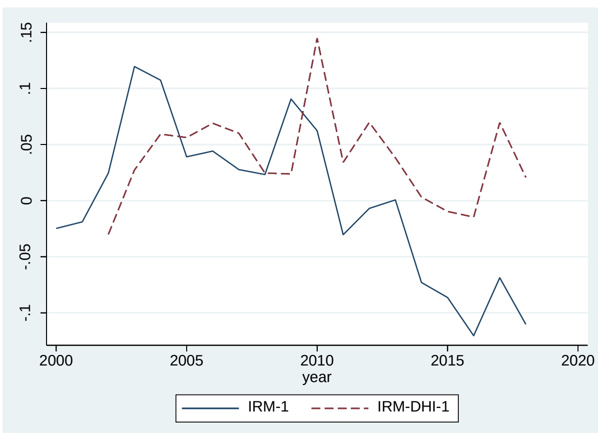
Bulgaria



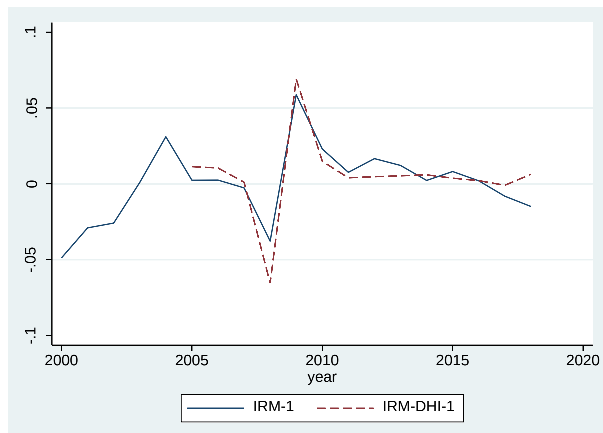
Russia



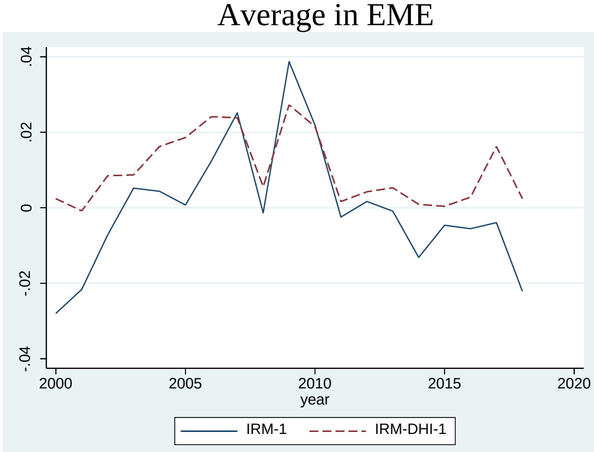
Singapore



Korea

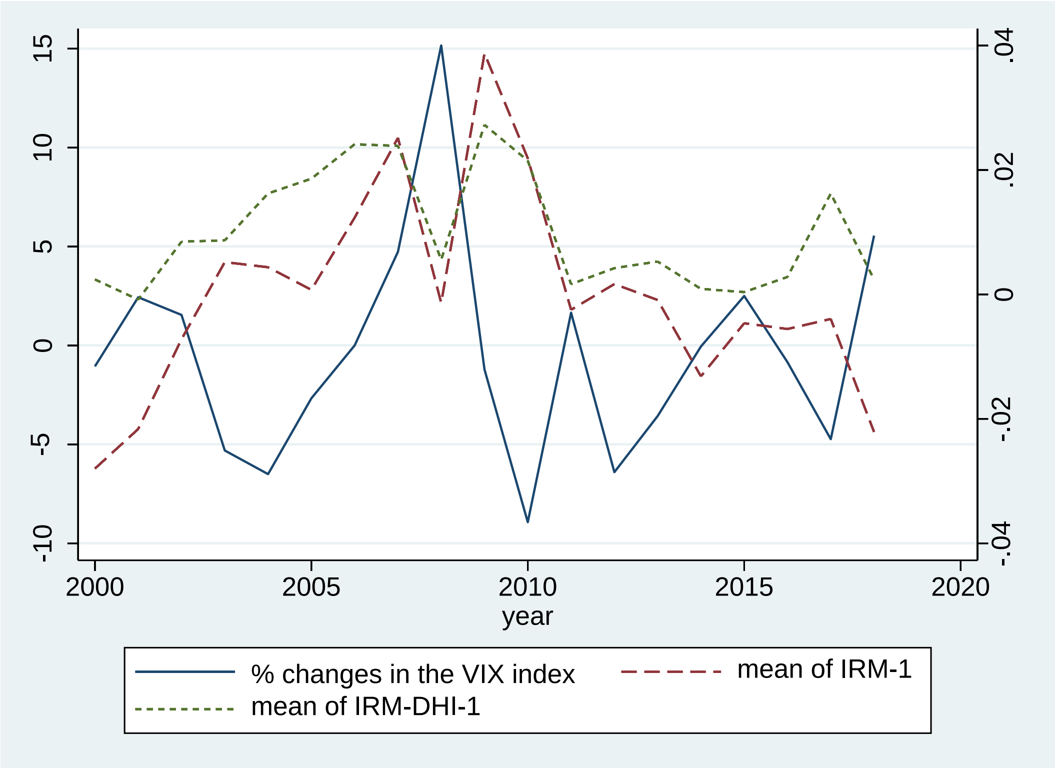


Average in EME



Notes: This figure plots the simulated and estimated data for IRM in four EMEs (Bulgaria, Russia, Singapore, and South Korea) and the average IRM in EMEs. The solid line plots IRM-1 and the dot line shows IRM-DHI-1.

Figure A5: The active IRM and global financial shocks



Notes: the solid line plots percentage changes in the VIX index (left scale). The long-dash line is the mean of IRM-1 in EMEs. The short-dash line is the mean of IRM-DHI-1 in EMEs.

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Table 1: The effect of active IRM on firm investment in EMEs

	OLS			IV			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
IRM	0.020***	0.022***	0.051***		0.118***		0.112***
	(0.003)	(0.003)	(0.006)		(0.031)		(0.032)
Swap				-0.062***		-0.062***	
				(0.001)		(0.001)	
Trade_us				-0.137***	-0.285***	-0.131***	-0.286***
				(0.013)	(0.018)	(0.013)	(0.018)
Ext_debt				0.882***	-0.088***	0.883***	-0.083***
				(0.005)	(0.028)	(0.005)	(0.028)
RGDPG	0.081***	0.074***	0.085***	0.293***	0.044***	0.298***	0.046***
	(0.012)	(0.012)	(0.013)	(0.008)	(0.015)	(0.008)	(0.015)
Risk profile	0.015***	0.015***	0.002	0.017***	0.010***	0.017***	0.010***
	(0.003)	(0.003)	(0.003)	(0.002)	(0.003)	(0.002)	(0.003)
Tobin Q	0.043***	0.042***	0.044***	0.014***	0.042***	0.014***	0.042***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
CF	0.006***	0.006***	0.006***	0.001*	0.006***	0.001*	0.006***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Size	0.017***	0.017***	0.018***	-0.003***	0.018***	-0.003***	0.018***
	(0.000)	(0.000)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)
Sales growth	0.020***	0.020***	0.019***	0.000	0.019***	0.000	0.019***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
#Obs	194845	194887	165508	194122	194122	194122	194122
R^2	0.273	0.273	0.279		0.03		0.03

Notes: This table reports regression results for Equation (1). Columns (1) - (3) report OLS regression results. IRM in column (1) is measured by IRM-1. Column (2) lags IRM for one year. Columns (3) uses IRM that purges the effect of the increase in relative national income, net capital inflows, and the mercantilist motive to depreciate currency value. Columns (4) and (5) report the first and second stage results of IV regression, where swap lines established with the US Fed during the 2008 global financial crisis (*Swap1*) is used to instrument IRM. Columns (6) and (7) use a dummy indicator for the establishment of swap lines the Fed but no drawing of swap during the 2008 GFC (*Swap2*) as the IV. All regressions control for firm and year effects. Robust errors are in parentheses. ***, **, * denote for 1%, 5% and 10% significance.

Table 2: The effect of active IRM on firm investment in EMEs in the presence of global financial shocks

	(1)	(2)	(3)
IRM	0.020***	0.022***	0.051***
	(0.003)	(0.003)	(0.006)
IRM × ΔVIX	0.056***	0.035***	0.064***
	(0.011)	(0.010)	(0.018)
RGDPG	0.080***	0.073***	0.087***
	(0.012)	(0.012)	(0.013)
Risk profile	0.015***	0.015***	0.003
	(0.003)	(0.003)	(0.003)
Tobin Q	0.042***	0.042***	0.044***
	(0.001)	(0.001)	(0.001)
CF	0.006***	0.006***	0.006***
	(0.001)	(0.001)	(0.001)
Size	0.017***	0.017***	0.018***
	(0.000)	(0.000)	(0.001)
Sales growth	0.020***	0.020***	0.019***
	(0.000)	(0.000)	(0.000)
#Obs	194845	194887	165508
R^2	0.273	0.273	0.279

Notes: This table reports regression results for Equation (2). IRM in column (1) is measured by IRM-1. Column (2) lags IRM for one year. Columns (3) uses IRM that purges the effect of the increase in relative national income, net capital inflows, and the mercantilist motive to depreciate currency value. ΔVIX is dropped due to collinearity with the year effect. All regressions control for firm and year effects. Robust errors are in parentheses. ***, **, * denote for 1%, 5% and 10% significance.

Table 3: The effect of IRM and global financial shocks on investment controlling for financial constraints

	(1)	(2)	(3)	(4)
IRM	0.035***	0.038***	0.049***	0.022***
	(0.005)	(0.006)	(0.005)	(0.003)
IRM × ΔVIX	0.095***	0.124***	0.105***	0.064***
	(0.017)	(0.019)	(0.018)	(0.011)
Ext fin	-0.015***			
	(0.001)			
Ext fin × IRM	-0.024***			
	(0.006)			
Ext fin × ΔVIX	-0.005***			
	(0.002)			
Ext fin × IRM × ΔVIX	-0.065***			
	(0.022)			
Tangi		-0.014***		
		(0.001)		
Tangi × IRM		-0.028***		
		(0.007)		
Tangi × ΔVIX		-0.011***		
		(0.002)		
Tangi × IRM × ΔVIX		-0.094***		
		(0.023)		
WW			-0.020***	
			(0.001)	
WW × IRM			-0.041***	
			(0.006)	
WW × ΔVIX			-0.014***	
			(0.002)	
WW × IRM × ΔVIX			-0.082***	
			(0.022)	
Fin constr				-0.012***
				(0.000)
Fin constr × IRM				-0.020***
				(0.003)
Fin constr × ΔVIX				-0.007***
				(0.001)
Fin constr × IRM × ΔVIX				-0.055***
				(0.010)
#Obs	194845	194845	194845	194845
R^2	0.275	0.276	0.277	0.281

Notes: This table reports the results of Equation (3) that considers firm heterogeneity in financial constraints. Column (1) is based on the firm level ability to access to external finance for investment (*Ext fin*); column (2) uses the collateral ratio of tangible assets to long-term debt as the measurement for a firm's financial constraints (*Tangi*); column (3) uses firm level Whited and Wu (2006) shadow cost index of external financing (*WW*) to measure a firm's financial constraints. *Ext fin*, *Tangi*, and *WW* are dummy variables. Column (4) extracts the first component of principal component analysis (PCA) on *Ext fin*, *Tangi*, and *WW* and uses it measure a firm's financial constraints. Results of *RGDPG, Risk profile, Tobin Q, CF, Size,* and *Sales growth* are not reported to save space. All regressions control for firm and year effects. Robust errors are in parentheses. ***, **, * denote for 1%, 5% and 10% significance.

Table 4: The country spread channel through which IRM affects firm investment: the causal mediation analysis

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
				Panel A			
IRM	-0.188***	-0.184***	-0.188***	-0.170***	-0.192***	-0.188***	-0.201***
	(0.003)	(0.004)	(0.003)	(0.004)	(0.004)	(0.005)	(0.004)
				Panel B			
Country spread	-0.041***	-0.031***	-0.035***	-0.047***	-0.052***	-0.050***	-0.035***
	(0.008)	(0.009)	(0.008)	(0.010)	(0.012)	(0.017)	(0.011)
IRM	0.021***	0.033***	0.019***	0.023***	0.005	0.026*	0.016*
	(0.007)	(0.008)	(0.007)	(0.009)	(0.010)	(0.015)	(0.010)
IRM × ΔVIX	-0.031	-0.033	-0.047**	-0.042	-0.029	0.039	-0.004
	(0.022)	(0.028)	(0.023)	(0.029)	(0.034)	(0.050)	(0.033)
				Panel C			
ACME	0.008***	0.006***	0.006***	0.008***	0.010***	0.009**	0.007**
	(0.002)	(0.002)	(0.002)	(0.002)	(0.003)	(0.004)	(0.003)
Total effect	0.028***	0.039***	0.029***	0.031***	0.015*	0.035**	0.024**
	(0.008)	(0.010)	(0.008)	(0.010)	(0.012)	(0.019)	(0.012)

Notes: This table reports the causal mediation effect regression results of Equation (4) in Panel A and Equation (5) in Panel B; Panel C reports the average causal mediation effect (ACME) and the total effect of IRM. The "Country spread" variable is the estimated residual term from equation (4) that are orthogonal to *IRM, ΔVIX, IRM* × *ΔVIX, RGDPG, Risk Profile*, and country and year effects. Column (1) reports the results estimated from the full samples. Columns (2) to (4) report the results for the samples of financially unconstrained firms measured in *Ext fin*, *Tangi*, and *WW*, respectively. Columns (5) to (7) report the results for the samples of financially constrained firms. Results of *RGDPG, Risk profile, Tobin Q, CF, Size,* and *Sales growth* are not reported. All regressions control for firm and year effects. Robust errors are in parentheses. The standard errors of ACME and Total effect is calculated with the Delta method. ***, **, * denote for 1%, 5% and 10% significance.

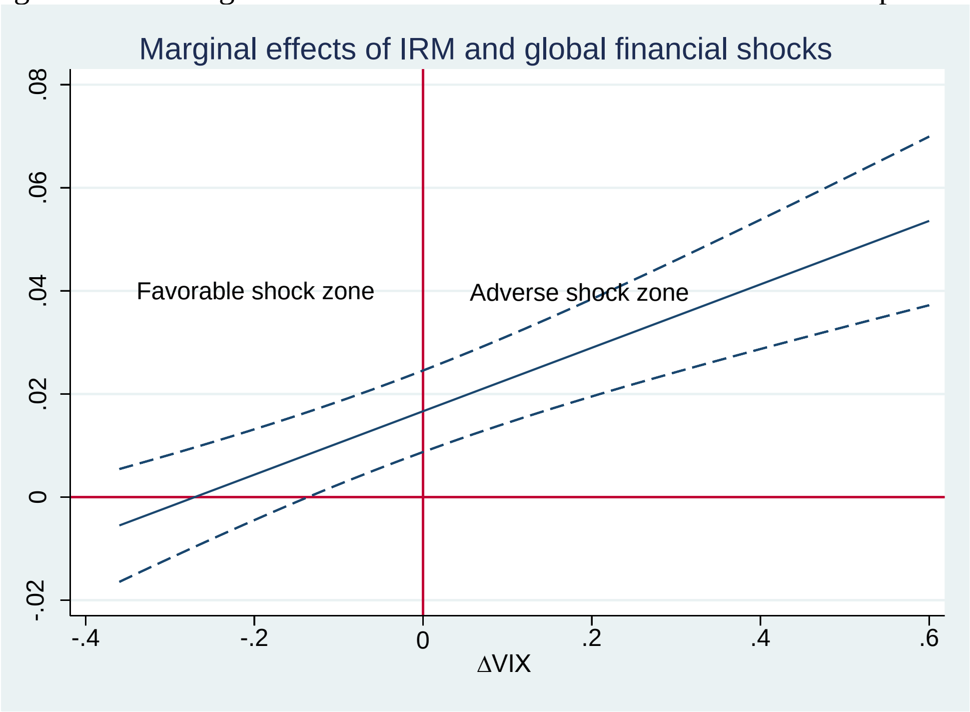
Table 5: The effect of IRM, capital controls, and exchange rate arrangement on firm investment

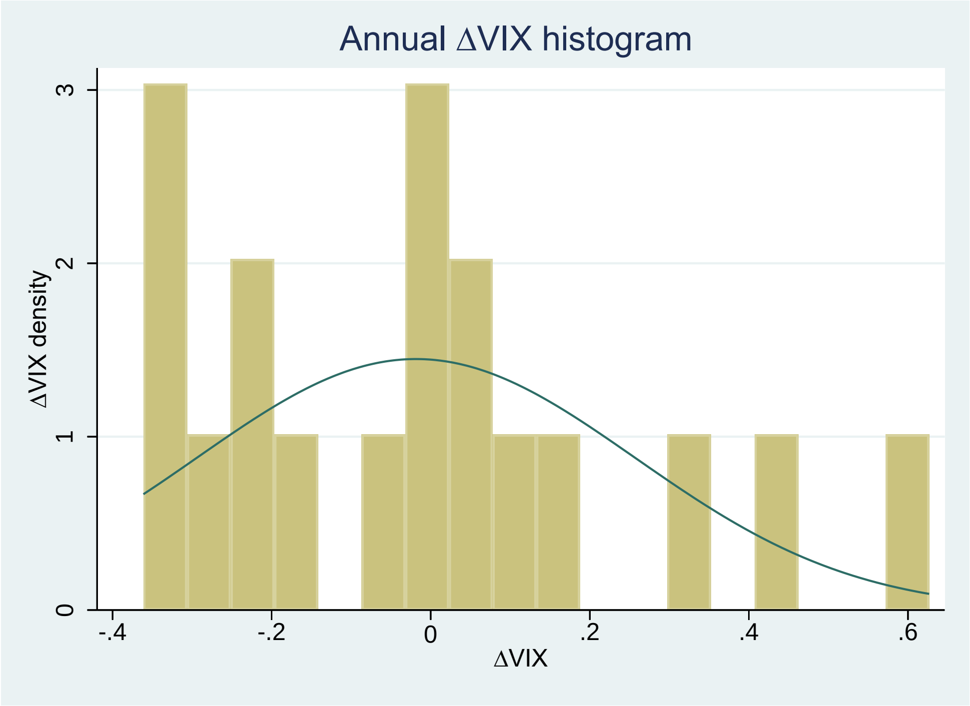
	(1)	(2)	(3)	(4)	(5)	(6)
IRM	0.003	0.021***	0.019***	0.006	0.023***	0.021***
	(0.004)	(0.003)	(0.003)	(0.004)	(0.003)	(0.003)
IRM × ΔVIX	0.032**	0.062***	0.055***	0.038***	0.067***	0.058***
	(0.014)	(0.013)	(0.011)	(0.014)	(0.013)	(0.011)
KC	0.004***			0.004***		
	(0.001)			(0.001)		
KC × IRM	0.049***			0.043***		
	(0.007)			(0.007)		
KC × ΔVIX	0.009***			0.009***		
	(0.002)			(0.002)		
KC × IRM × ΔVIX	0.052*			0.041		
	(0.028)			(0.028)		
Xchg		0.013***			0.012***	
		(0.004)			(0.004)	
Xchg × IRM		0.093			0.071	
		(0.079)			(0.078)	
Xchg × ΔVIX		0.033**			0.034**	
		(0.017)			(0.017)	
Xchg × IRM × ΔVIX		-0.253			-0.208	
		(0.193)			(0.192)	
KC&Xchg			0.022***			0.021***
			(0.005)			(0.005)
KC&Xchg × IRM			0.148*			0.119
			(0.087)			(0.087)
KC&Xchg × ΔVIX			0.135***			0.131***
			(0.032)			(0.032)
KC&Xchg × IRM × ΔVIX			3.013***			2.813***
			(0.925)			(0.920)
Fin constr				-0.012***	-0.012***	-0.012***
				(0.000)	(0.000)	(0.000)

Fin constr × IRM				-0.021***	-0.024***	-0.024***
				(0.003)	(0.003)	(0.003)
Fin constr × ΔVIX				-0.006***	-0.006***	-0.006***
				(0.001)	(0.001)	(0.001)
Fin constr × IRM × ΔVIX				-0.067***	-0.065***	-0.065***
				(0.010)	(0.010)	(0.010)
#Obs	194845	194845	194845	194845	194845	194845
R^2	0.273	0.273	0.273	0.281	0.281	0.281

Notes: This table reports the results of regressions controlling for capital controls and exchange rage arrangements. KC is a dummy variable measuring capital control [*KC* = 1 if the Chinn-Ito index < 0.065 (the mean of Chinn-Ito index in our data sample); =0, otherwise]; *Xchg*, a dummy variable, indicates exchange rate regime [Peg v.s. flexible regime; *Xchg* = 1 if the coarse index of Ilzetzki et al. (2019) >3; otherwise, = 0]; KC&Xchg measures countries that have both capital controls and flexible exchange rate. Columns (4) – (6) controls for firm level financial constraints. Results of *RGDPG, Risk profile, Tobin Q, CF, Size,* and *Sales growth* are not reported. All regressions control for firm and year effects. Robust errors are in parentheses. ***, **, * denote for 1%, 5% and 10% significance.

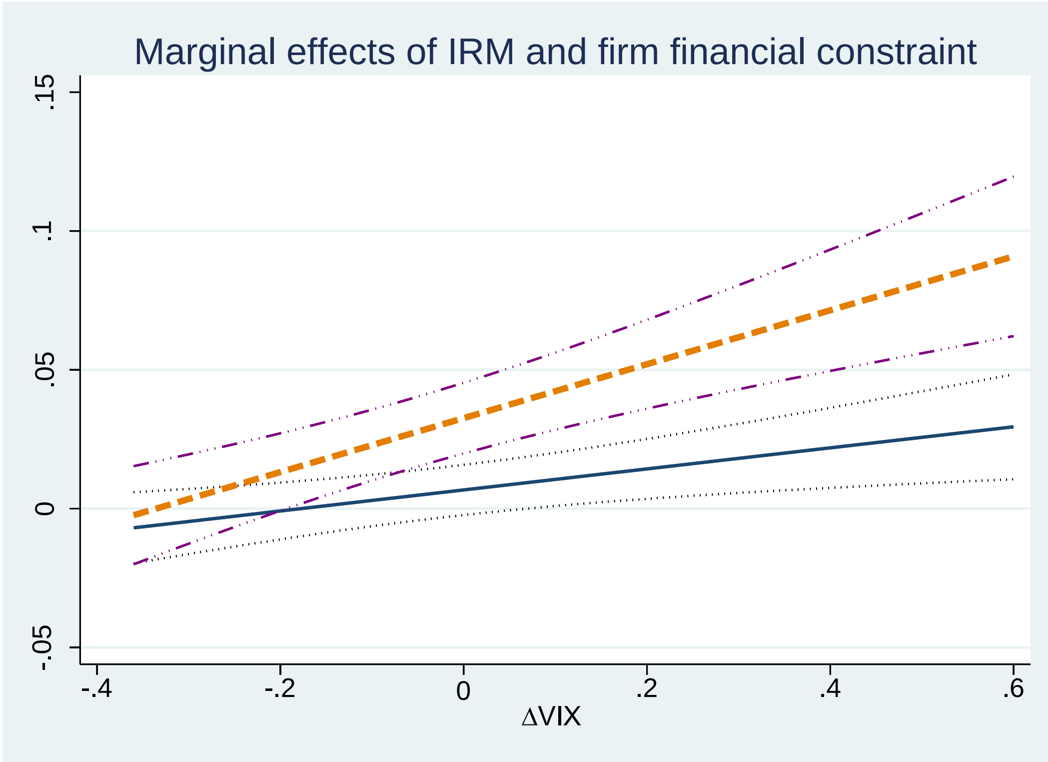
Figure 1: The marginal effects of IRM to firm investment in the multiplicative model





Notes: The upper figure shows the marginal effects of IRM on investment (y scale) at various level of ΔVIX (x scale). Dashed lines plot 95% confidence intervals. The lower figure shows the distribution of annual ΔVIX. The bell-shape curve simulates a normal distribution.

Figure 2: The differed marginal effects of IRM and ΔVIX - financially constrained versus unconstrained firms



Notes: The solid line plots marginal effects in financially constrained firms and the dashed line plots marginal effects in financially unconstrained firms. Dot lines are 95% confidence intervals.