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INTERNATIONAL RESERVE MANAGEMENT, GLOBAL FINANCIAL SHOCKS, AND FIRMS' INVESTMENT IN EMERGING MARKET ECONOMIES

Joshua Aizenman
Yin-Wong Cheung
Xingwang Qian

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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 positively affects firm investment - the effect strengthens with the magnitude of adverse external financial shocks. Second, financially constrained firms, compared to unconstrained ones, are less responsive to active IRM. Third, our results suggest that the country credit spread is a plausible causal channel of the positive IRM effect on firm investment. Fourth, the policies of capital controls and exchange rate managements are complementary to the IRM – it is beneficial to form a macro policy mix that includes active IRM to safeguard firm investment against global financial shocks. Further, our results indicate the IRM effect on firm investment is of both statistical and economical significance and is relevant to the aggregate economy.

Joshua Aizenman
Economics and SIR
University of Southern California
University Park
Los Angeles, CA 90089-0043
and NBER
aizenman@usc.edu

Yin-Wong Cheung
Department of Economics
University of California
Santa Cruz, CA 95064
cheung@ucsc.edu

Xingwang Qian
Economics and Finance Department
SUNY Buffalo State
1300 Elmwood Ave
Buffalo, NY 14222
qianx@buffalostate.edu

1 Introduction

The 2008 financial crisis originated in the US had 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 good 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 - cause a spike in the level of 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 spillover across sectors and economies.[4] Dominguez et al. (2012) and Aizenman and Jinjarak (2020), for example, find that central banks' active IRM policy is an effective stabilizer against external financial shocks and improves, on average, an EME's economic

[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), Gourinchas and Obstfeld (2012) 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.

performance.[5] However, the macro-based evidence presented by these authors does not shed light on the active IRM policy effect at the firms' level.

This paper studies the empirical effect of active IRM on firm investment in EMEs in the presence of global financial market shocks. The quantitative assessment is conducted by applying a canonical Tobin-Q investment framework (Hayashi, 1982; Eberly et al., 2009) and using annual data for 21,447 publicly listed firms in 46 EMEs from 2000 to 2018. Because of the absence of official data, [6] we construct alternative measures of active IRM – two measures are based on the simulation approach of Dominguez, Hashinmoto, 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. Using OLS regressions with various strategies to address the endogeneity issue, we find that active IRM has positive impacts on firm investment in EMEs.

Importantly, we use a multiplicative regression setup (Brambor *et al*., 2006) to study the individual and interaction effects of IRM and ΔVIX on firm investment. We find that the marginal impact of IRM depends on the type and magnitude of global financial shocks. In the presence of an adverse global financial shock, the marginal IRM effect increases with the magnitude of the adverse shock. If the global financial shock is favorable, the marginal IRM effect is inversely associated with the magnitude of the favorable shock. Further, the proxy for global financial shocks reduces firm investment even though IRM mitigates its impact.

Firm investment can be deterred by global financial shocks that heighten market uncertainty and increase financing costs (Christiano *et al*., 2014; Gilchrist *et al*., 2014; Arellano *et al*., 2019). Arguably, financially constrained firms are vulnerable to elevated financing costs. To assess the implications of a firm's financial conditions, our study considers three alternative ways to characterize financially constrained and unconstrained firms; namely, the capacity to

[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 Jinjarak (2020) find that an active IRM policy can contribute up to about 3% of GDP during their sample period. An IRM policy 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 reserves transactions (Dominguez et al., 2012).

access external financing (Rajan and Zingales, 1998), tangible assets coverage (Claessens and Laeven, 2003), and the shadow cost of external financing (Whited and Wu, 2006). 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 is about 40% smaller for financially constrained firms compared with unconstrained firms.[7]

Country spreads (or sovereign premiums) widen with unfavorable global financial shocks (Uribe and Yue, 2006; Akinic, 2013) and are a component of international borrowing costs faced by firms.[8] A high level of international reserves can alleviate the impact of global financial shocks on country spreads by acting as a buffer against speculative attacks triggered by these shocks (Ben-Bassat and Gottlieb, 1992; Cheung and Qian, 2009; Bianchi et al., 2018). Thus, we stipulate the active IRM policy affects firm investment via the country spread channel. Using the causal mediation analysis method (Krull and MacKinnon, 2001; Imai et al., 2010) with the country spread as the intermediate variable, IRM as the treatment, and firm investment as the outcome variable, we find statistical evidence that the IRM effect on investment is mediated through country spreads. The mediation effect differs across financially constrained and unconstrained firms – the former group has a level of 31% IRM effects channeled through country spreads, the latter group 17%, and the average across all firms 25%.

Capital controls and exchange rate management are two policies deployed by EMEs to rein in the adverse effect of global financial shocks (Han and Wei, 2018; Obstfeld et al., 2019).[9] Our results show that countries with capital controls, compared to those without, display a more substantial IRM effect on firm investment. On the other hand, a flexible exchange arrangement reduces the downside effect of adverse external shocks. An IRM policy alone does not completely insulate an economy from external shocks; capital controls and flexible exchange management play a complementary role in alleviating the impact of adverse global financial shocks. These findings suggest a coordinated policy that integrates these macro-management measures to achieve efficient insulation of investment from global financial shocks.

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[7] The result is in line with Ottonello and Winberry (2020). They show in a New Keynesian model that low-risk firms (similar to non-financially-constrained firms in this paper) are responsive to monetary shocks because of their relatively flat marginal cost of financing investment.

[8] 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.

[9] Bussière et al. (2015) and Acharya and Krishnamurthy (2018), for example, find capital controls complement international reserves in insuring against sudden stops.

In addition to the firm level impact, we assess the macroeconomic link between IRM and aggregate investment using a structural vector autoregression model that includes global financial shocks and country spreads. The country-level data also reveal the positive effect of active IRM on aggregate investment; specifically, EMEs on average increase their aggregate investment per GDP by 0.3 percent in two years in response to a one-standard deviation increase in active IRM. The country-level data also affirm the country spread causal channel effect revealed by firm level data – an adverse (favorable) global financial shock widens (narrows) country spreads, and deters (promotes) investment.

Our study makes several contributions. First, we identify the roles of IRM, global financial shocks, and their interactions in determining investment at the firm level in EMEs.[10] We extend the typical analysis of effects of international reserves on the macroeconomy[11] to firm level behavior. Second, we provide evidence of differential active IRM policy effects on financially constrained and unconstrained firms. Third, we hypothesize and verify that credit spreads are a channel through which an active IRM policy can alleviate adverse effects of global financial shocks on firm investment. In addition, our results suggest that active IRM is complementary to two other macro management policies, capital controls and exchange rate management, in terms of stabilizing firm investment in the face of global financial shocks.

The remainder of the paper is organized as follows. Section 2 outlines channels and ways that IRM and global financial shocks can interact and affect firm investment. Section 3 introduces the alternative measures of active IRM policies and global financial shocks. Section 4 presents the main empirical specification and results on the effects of IRM and ∆VIX on firm investment. The results pertaining to financially constrained and unconstrained firms and country spreads are also reported. Section 5 provides additional analyses based on alternative measures of IRM and global financial shocks, and different sample configurations to assess the sensitivity of our results. Section 6 discusses the roles of capital controls and exchange rate management in determining the link between IRM and firm investment, and Section 7 assesses the macroeconomic relevance of our findings. Some concluding remarks are offered in Section 8.

[10] Existing studies usually consider domestic or firm level investment uncertainty (Abel and Eberly, 1994; Bernanke, 1983; Bertola and Caballero, 1994; Caballero and Pindyck, 1996), macroeconomic and policy uncertainty (Aizenman and Marion, 1993; Beaudry et al., 2001; Bloom, 2009; Gulen and Ion, 2016; Kim and Kung, 2017), political uncertainty (Julio and Yook, 2012; Jens, 2017), and monetary policy uncertainty (Husted et al., 2019; Ottonello and Winberry, 2020).

[11] See, for example, Dominguez et al. (2012), Qian and Steiner (2014; 2017) and Aizenman and Jinjarak (2020).

2 The Plausible Theoretical Mechanism

In this section, we first review related studies on the precautionary role of international reserves, uncertainty shocks, and investment. We then summarize the plausible theoretical mechanism through which IRM affects firm investment. The discussion and the theoretical IRM effect on firms established in the literature provide the underpinning of our empirical exercise. Instead of re-creating a theoretical model of effects of IRM on firm investment, our analysis focuses on empirically identifying and estimating the effect of IRM on investment and the fraction of IRM effect that works through the channel of credit spreads.

2.1 **The theories on uncertainty and investment**

There are two main theories that explain how uncertainty shocks impact investment. One is the "wait and see" theory suggesting 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[12], and the option value increases with uncertainty through the possibility of bad outcomes.

The other theory is based on the financial friction that limits firms' borrowing capacity. Uncertainty shocks increase the likelihood of default on their debt and drive-up firms' credit spread, thus causing firms to reduce capital expenditure. The financial friction theory has gained increasing attention since the havoc of the 2008 global financial crisis in the global financial market, which caused a plummet in global investment and other economic activities[13]. Several influential papers provide theoretical mechanisms by which financial uncertainty shocks can impact real economy activities through the channel of financial friction. Gilchrist et al. (2014) model financial friction as a conduit through which uncertainty shocks affect investment. In their model, jumps in uncertainty reduce the collateral value of firms' capital assets, thus decreasing the firms' debt capacity and leading to widening credit spreads, which induces firms to simultaneously slash capital expenditures.

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[12] See Bernanke (1983), Bloom, Bond, and Van Reenen (2007) and McDonald and Siegel (1986), among others.

[13] 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.

Through the interest rate channel, Christiano et al. (2014) construct financial friction in their model 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. These shocks, labeled as risk, are idiosyncratic and random. In a DSGE model, credit spreads are allowed to fluctuate with the changes in risk. When risk is high, credit spreads are high and the firm’s borrowing ability is low. Investment then falls as a result.

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

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 all model uncertainty shocks to bind firms’ financial friction that increases credit spread and reduce their borrowing capacity, thus reducing investment. This financial friction mechanism is particularly applicable for EME firms that rely on external finance to invest, but usually are bound by financial constraints. 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.

2.2 Theories on international reserves and country spreads

The second avenue of literature relates to the precautionary role of international reserves and country spreads. 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, ensuing financial and real economic stability.

The literature usually models 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, thus leading to lower sovereign borrowing costs and improving welfare. 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. They demonstrate 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 IRM 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 are modeled to 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 may have to fire-sale their assets, where reserves are used to buy fire-sale assets. Thus, 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 these two avenues of theories discussed in sections 2.1 and 2.2, we can postulate that external uncertainty shocks widen the country spreads of EMEs, whereas IRM narrows their country spreads. This results in an equilibrium credit spread that balances the opposite impacts of uncertainty shocks and IRM, in turn, determines the level of investment, other things being equal.

3 Measurements for Key Variables

3.1 **Measurements for IRM**

It is easy to describe but difficult to measure an active IRM strategy that accumulates international reserves in tranquil times while selling reserves assets during crisis periods. Several issues complicate the measurement of IRM. First, central banks do not disclose the time and amount of their purchases and sales of international reserves; second, changes in reserves assets calculated from official international reserves data may incorrectly measure active IRM, as the changes in reserves may stem from the interest income of reserve assets and the valuation effect (two passive management components of IRM); third, central banks usually do not report reserve assets investment income and the valuation effect. Further, it is difficult to estimate these passive management components of IRM as central banks typically do not disclose reserve assets investment portfolio and the currency composition of international reserves. Finally, some countries with large international reserve holdings tend to "under-report" reserves to deflect criticism of mercantilist motives and excessive reserves.

Against this backdrop, we use two methods, a simulation and a detrend method, to estimate the measurement data for active IRM. The simulation method follows Dominguez et al. (2012) (DHI hereafter) to calculate IRM by adjusting the simulated passive management portion from the total change in international reserves. This simulated IRM, in US dollars, is then scaled by GDP (in the current US dollar) to create the first IRM measurement[14], labeled as IRM-DHI-1. In addition, we extend the DHI approach by adjusting the valuation effect estimated from the currency composition of international reserves to create the second IRM measurement. We subsequently label this IRM-DHI-2 after being scaled by GDP.

The detrend method purges passive management components of IRM by using a linear regression to detrend the international reserves data; the remainder is considered as the active management components of IRM. The rationale here is that international reserves data contain a secular trend, which is partly due to two passive management components of IRM – the

[14] Dividing GDP to the dollar term IRM is to make different IRM measurements comparable across EMEs varying economy sizes.

compounded interest income and the valuation effect on reserve assets. Detrending data may remove these passive management components from international reserves data. We detrend three types of trends, namely, a simple linear time trend, a time trend with a structure break at the 2008 global financial crisis (Aizenman et al., 2014; Bussiere et al., 2015), and a time trend after the reserve data has been adjusted for the valuation effect. These detrended reserves data are then scaled by GDP to create measurements for active IRM. We label them IRM-1, IRM-2, and IRM-3, respectively. The detail constructions of IRM measurements using both simulation and detrend methods are presented in Appendix A, in which we also use figures (See Figures A1 – A4) to analyze the similarities across these measurements and their comparability to those of Dominguez et al. (2012). Overall, these IRM measurements reveal the general pattern of active IRM – central banks accumulate reserves during good times and use them during crisis periods (See Figure A5 in Appendix E).

Between two groups of IRM measurements, we expect that the IRM measurements simulated from the DHI approach to be more reliable than the detrended IRM measurements. This is because DHI primarily uses the actual data to obtain the IRM data, whereas the estimated IRM measurements are regression estimated data. However, the DHI simulations are based on data from different data sources that might entail data compatibility issues. In addition, many EMEs do not subscribe to the IMF SDDS template, and thus they do not have the data required to simulate for IRM. Furthermore, some subscribers to SDDS only started to report IR data in the 2010s. For example, China began to report its reserves data in 2015. These data availability issues could reduce 1/4 of our original sample size. On the other hand, the data used for regression estimated IRM measurements, although associated with possible estimation errors, is reported for most EMEs from 2000 to 2018 by the IMF IFS database. For these reasons, we will use the regression estimated IRM measurements to run main regression analyses and use the DHI simulated IRM to check for robustness.

3.2 Measurements for global financial shocks

To empirically investigate how global financial shocks impact firm investment across EMEs, it is essential to have a measurement of global financial shocks that is exogenous to both firm and country specific conditions. Shocks that stem from center countries (e.g., the US) and have a global scale impact may meet the exogeneity condition.

We first use 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, 2019; 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 creates global impacts. For example, Miranda-Agrippino and Rey (2020) identify a global factor that explains 20% of international risky assets prices and comoves with the VIX index.

Using ΔVIX as opposed to the VIX index itself as a measurement for global financial shocks is motivated by literature findings that it is the shock/innovation to uncertainty that impacts economic activities including investment, regardless of uncertainty level (Gilchrist et al., 2014)[15]. Some analyses also use a simple time dummy variable to capture the notable financial shocks, such as the 2008 global financial crisis (Bloom, 2009). We argue that, relative to the time dummy measurement, using ΔVIX to measure global financial shocks is advantageous because the changes in the VIX index not only indicate the timing of global financial shocks, but also quantify the relative magnitude of those shocks. Further, it can suggest whether an external shock is favorable or adverse (i.e., we identify a shock to be adverse if ΔVIX > 0 when the global financial uncertainty increases).

Second, we use the changes in the intra-annual volatility compiled according to Merton (1980) from daily data of the S&P 500 index (Appendix C provides details of data construction). Contrasting to the VIX index that measures the implied volatility of S&P 500 stock option, the intra-annual volatility provides a representative measure for the perceived volatility.

Third, using both the VIX and intro-annual volatility limit our study to the standard practice that the US equity market is the center of global finance. To broaden the “global” sense, we compile a “risk-on/risk off” (RORO) index that captures the variation of risk aversion of various asset markets across the US and Europe to measure shocks in the global financial market. Following Chari et al. (2020), we build the RORO index by extracting the first principal component of the daily data across several asset markets (e.g., treasury market, corporate bond market, equity market, and funding liquidity both in the US and in the Euro Area). To build a

[15] Other papers include, for example, Caballero et al. (2019) use ΔVIX to measure global credit market shocks that affect the association between EME economic activities and their corporate bond spread. Similarly, Bloom’s (2009) analysis suggests that large changes in uncertainty have an important impact on investment and hiring behavior. Arellano et al. (2018) show that “hiring inputs is risky because financial frictions limit firms’ ability to insure against shocks. An increase in volatility induces firms to reduce their inputs to reduce such risk.”

multifaceted index that reflects various risky asset markets, we include data of 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 returns and implied volatility in the US and Europe: the additive inverse of daily total returns on the S&P 500 and STOXX50, together with the VIX and the VSTOXX index; and 3) funding liquidity: changes in the TED spread and the bid-ask spread on 3-month Treasuries.

Fourth, we apply the percentage changes of the Federal fund rate as an alternative measurement for global financial shocks to EMEs. The US monetary policy is well documented to impose a substantial spillover effect on the global financial market (Gilchrist et al., 2019; Obstfeld et al., 2020). When the Federal Reserve Bank tightens its policy, risky asset prices surge, accompanied by strong deleveraging of global banks and a surge of risk averse behavior in global asset markets. This ensures 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 could 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).

Finally, we use the US monetary policy uncertainty index (MPU) of Baker et al. (2016) to measure global uncertainty shocks. This is a news-based index that captures the degree of policy uncertainty that the public perceives about the Federal Reserve's monetary policy stance and their possible consequences. As a high MPU implies high uncertainty shocks emanated from the center country to EMEs, we expect MPU to impose spillover effects on firm investment in EMEs.

4 Empirical Methodologies

4.1 The base model for firm investment

In this section, we examine the firm level evidence on how IRM affects investment in EMEs based on the canonical investment-Q framework (Hayashi, 1982; Eberly et al, 2009) as follows:

$$Invest_{i,t} = \alpha + \mu_j + \theta_t + \beta_1 IRM_{c,t} + \beta_2 \Delta VIX_t + \gamma X_{c,t} + \delta Z_{i,t} + \varepsilon_{i,t} \quad (1)$$

where the dependent variable $Invest_{i,t}$ is firm investment. Following the literature, we use $\frac{Captial\ expenditure_{i,t}}{Total\ Assets_{i,t-1}}$, the ratio of firms' capital expenditure on plants, properties, and equipment to total assets at the beginning of the year to measure firm investment[16] (Julio and Yook, 2012; Panousi and Papanikolaou, 2012; Gulen and Ion, 2016; Husted et al, 2019). $IRM_{c,t}$ is the active reserve management variable. We first use IRM-1 as the IRM measurement for regression analyses. ΔVIX_t measures shocks to global financial markets (Results obtained from other measurements for IRM and global financial shocks are checked for consistency in Section 5). Undersubscriptions *c*, *i*, and *t* index country, firm, and year, respectively. Time invariant effects are included in μ_j, including country, industry sector (SIC-3 digit), and firm effect; the year effect is found in θ_t.

Following the literature, we control for two domestic macroeconomic factors that impact firm investment (Julio and Yook, 2012; Gulen and Ion, 2016; Husted et al, 2019) in $X_{c,t}$, namely, the real GDP growth rate ($RGDPG$), which captures domestic investment opportunity, and investment risk profile ($Risk\ profile$), which measures the institutional risk of domestic investment. Using $Risk\ profile$ captures the institutional risk and avoids potential collinearity with ΔVIX_t. Although our study focuses on shocks in the global financial market, country specific domestic financial shocks can affect firm investment as well. An appropriate investment regression therefore needs to include both global and domestic financial shocks. However, including both financial shocks simultaneously gives rise to collinearity issues, as global shocks spillover into the domestic financial risks[17]. To address this issue, we use a domestic institutional risk factor, proxied by the "investment profile" index from the ICRG to measure the domestic investment risk environment. Our investment profile index contains three risk components, contract viability, profits repatriation, and payment delays, which capture the institutional aspect of domestic investment risk and are less likely to be associated with short-term financial risk shocks.

[16] Appendix D provides summary statistics for the investment data. Figure 6 of Appendix E shows the pattern of average firm investment in EMEs from 2000 – 2018 and its plausible association with both the IRM and global financial shocks.

[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.

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; *CF* measures the cash flows generated from business operation on a firm's assets and reflects the marginal product of capital (Gilchrist et al, 2014); and *Sales growth* measures business growth. Literature found that firms invest more, when Tobin's Q (the shadow price of installed capital) 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 equation (1) on cross-firm annual data using the pooled OLS regression controlling for country, industry sector, firm and year effects. Firm level data are obtained from annual accounting statements of 21,447 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 exclude financial, insurance, real estate, public administration, and non-classifiable industry sectors in the SIC code system and countries that have less than 15 listed companies from the dataset. We winsorize 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 for the base model are reported in column (1) of Table 1. The active reserve management ($IRM_{c,t}$) is positively associated with investment, and global financial shocks (ΔVIX_t) are negatively associated with firm investment. Both findings are consistent with those reported in the literature discussed in Section 2. 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

[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 C displays variable definitions and data sources; Appendix D shows summary statistics.

growth rate are found to invest more. These results are all in accordance with literature findings. The regression explains 10.8% of firm investment variation[19].

The specification of equation (1), however, may estimate the correlation between IRM and firm investment, rather than the causal effect of IRM due to the endogeneity issues that, for example, arise from the omitted variables. We pursue three strategies to address the possible endogeneity.

First, we lag the IRM variable one year to create a predetermined IRM variable to run the regression. In column (2) we report similar results as those in column (1).

Second, we generate an IRM variable purged of plausible common factors that affect both IRM and investment simultaneously. These common factors include relative income levels, net capital inflows, and competitive depreciation to maintain exports advantage (the mercantilist motive of IR), all of which tend to lead central banks to accumulate more reserves and firms to invest more. To purge the common factor effect, we run a regression of IRM on 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), as well as the country and year effect. The residual of the regression is obtained as the IRM variable purged of the common factors effect. Column (3) of Table 1 reports the results with IRM purged of common factors. The IRM is estimated to be a significant and higher coefficient than that in column (1).

Third, we adopt the IV approach to isolate the IRM effect on firm investment. The instrumental variable is given by a dummy variable that assumes a value of one when there is a bilateral swap line between an EME central bank 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 states. That is, the dummy variable is correlated with IRM. On the other hand, the Fed offered these swap lines to its allies during the 2008 financial crisis to alleviate global dollar shortages, and not to boost investment in these countries.[20]

[19] The R-squared we obtained is comparable to those of related literature papers; for example, Julio and Yook (2012) estimated an R-squared of 7%, Gulen and Ion (2016) reported 3%, and Ottonello and Winberry (2020) estimated 12%.

[20] The US had swap line agreements with some EMEs after the 2008 crisis. However, these swap line arrangements can be related to specific economic conditions in these countries and, thus, do not yield a good instrumental variable.

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 variables, namely, the share of trade with the US (*Trade_us*) and the external debt to GDP ratio (*Ext_debt*), to control the trade link with the US and an EME's financial fundamentals, respectively.

The two-stage IV regression results based on the firm samples of Brazil, Korea, Mexico, and Singapore[21], are reported under columns (4) and (5). The first stage regresses IRM on the instrument variable, *Swap*, and other control variables in equation (1). The swap line 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 coefficient estimate while the latter a positive one. The estimates are in line with the precautionary motive of holding international reserves. The fitted value from the first stage regression is then obtained to replace IRM in equation (1) for the second stage regression. In column (4), we show that IRM positively affects the behavior of 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 during the global financial crisis reveals a stronger IRM effect.

Overall, the positive effect IRM has on firm investment reported under column (1) is robust to the use of predetermined IRM, the IRM purged common factors, and the IV approach that addresses endogeneity. Particularly, the IV approach may provide valid causal inference of the IRM effect on firm investment in EME (Angrist et al., 1996).

4.2 **The interaction between IRM and global financial shocks**

To quantify the total effect of IRM on firm investment contingent on the presence of global financial shocks, we augment Equation (1) with an interaction term, $IRM_{c,t} \times \Delta VIX_t$, thus specifying a multiplicative regression (Brambor et al., 2006) as the follows:

$$Invest_{i,t} = \alpha + \mu_j + \theta_t + \beta_1 IRM_{c,t} + \beta_2 \Delta VIX_t + \beta_3 IRM_{c,t} \times \Delta VIX_t + \gamma X_{c,t} + \delta Z_{i,t} + \varepsilon_{i,t} \qquad (2)$$

[21] Brazil, Korea, Mexico, and Singapore are the only EMEs in our sample that had a swap line arrangement with the US during the 2008 global financial crisis. We also ran regressions on the full sample and got qualitatively similar results – the coefficient estimate of the swap dummy variable is -0.025 in the first stage and that of IRM is 0.295 in the second stage. Both are significant at the 1% level.

The total effect of IRM on investment estimated from Equation (2) is given by $\partial Invest/\partial IRM = \beta_1 + \beta_3 * \Delta VIX_t$, which implies that the marginal effect of IRM depends on financial shocks, ΔVIX_t. The corresponding standard errors are calculated by $\hat{\sigma} = \sqrt{var(\hat{\beta}_1) + \Delta VIX_t^2 var(\hat{\beta}_3) + 2\Delta VIX_t cov(\hat{\beta}_1, \hat{\beta}_3)}$. Similarly, the effect of ΔVIX_t is given by $\partial Invest/\partial \Delta VIX_t = \beta_2 + \beta_3 * IRM_{c,t}$, indicating that the marginal effect of financial shocks on investment is conditional on active IRM.

Column (1) in Table 2 reports the results for the effect of IRM conditional on global financial shocks. Both β_1 and β_3 are estimated positively and significantly. The marginal effect of IRM is therefore evaluated at 0.017+0.062*ΔVIX_t, suggesting that IRM is positively associated with firm investment, and the total effect depends on global financial shocks. In the presence of a one-standard-deviation adverse financial shock ($\Delta VIX_t = 0.28$), a one percent increase in IRM is associated with about 3.4% higher firm capital expenditure to total assets ratio. To assess the economic significance of IRM effects, we take the median size firm in the median GDP country (The Philippines [22]) in our data sample to calculate the aggregate effect of IRM on a country's firm investment. We find that a one billion US dollar active IR accumulation is associated with about 1.05 million more firm investment in the presence of one standard deviation VIX shock[23]. For a total of 222 Philippines firms in our data sample, the aggregate effect of one billion IRM in the Philippines is associated with about 230 million more in investment made by these publicly listed firms located in the Philippines[24].

For a better interpretation of the effect of IRM conditional on global financial shocks, we plot the linear relation between the marginal effect of IRM and ΔVIX_t in the upper panel of

[22] The median GDP country is the Philippines with an average GDP in 2000 – 2018 of about 199 billion USD and the median size of Philippines firms is about 6 billion. There are in total 222 Philippines firms in our data sample.
[23] We calculate the dollar value of a 1 billion IRM effect on firm investment according to the following formula: capital expenditure/total assets of the median firm = (0.017 + 0.062 * standard deviation of ΔVIX) * (1 billion / GDP of the median country), where total assets of the median firm = 6 billion, the standard deviation of ΔVIX is 0.28, and median country GDP is 199 billion USD. We can solve capital expenditure in the US dollar term for the effect of 1 billion US dollar IRM on individual firm investment. Additionally, as the distributions of country GDP and firm size within a country are not normally distributed, the median size firm and country are different from the average size firm and country. In our data sample, the average GDP country is Poland, which had an average annual GDP of 406 billion US dollars and listed 620 public companies with an average size of about 1.36 billion US dollars in 2000 - 2018. Using the data of the average firm in Poland, our results suggest that 1 billion of IRM in Poland is associated with 71 million in investments in Polish publicly listed companies.
[24] The effect is likely to be understated as we do not account for firms other than publicly listed companies in the Philippines.

Figure 1. The solid line represents the linear relation, showing that the IRM effect becomes stronger as the magnitude of global shock increases. In the adverse shock zone ($\Delta VIX_t > 0$), where firms receive an adverse shock, active IRM has a positive effect on firm investment, regardless of the magnitude of realized global financial shocks. Moreover, as the shock worsens, the marginal effect IRM on firm investment becomes stronger. Specifically, the marginal effect of IRM increases about 0.062, as the VIX index increases one percent.

On the other hand, in the favorable shock zone ($\Delta VIX_t < 0$), the positive effect of IRM diminishes as the favorable shock increases in magnitude (i.e., ΔVIX_t becomes more negative). In fact, the effect of IRM may become insignificant if there are sufficient improvements in the risk aversion of global financial markets. This occurred in 2009 when the global financial market stabilized after the turmoil of the 2008 financial crisis.

In addition to the direct analyses concerning the effect of IRM on firm investment, the multiplicative regression results suggest how IRM affects investment by reducing the downside effect of global financial shocks. We estimate in column (1) that the marginal effect of ΔVIX_t on investment is $-0.088 + 0.062 * IRM_{c,t}$, a term indicating that the marginal effect of ΔVIX_t depends on the level of IRM. That is, one percent more IRM reduces the effect of an adverse shock by 0.062. Evaluating this effect of IRM on investment in US dollars, we show that 1 billion dollars more of IRM in the median GDP country tends to mitigate the downside impact of global shocks on firm investment by about 1.9 million in a median size firm. This result is economically significant and suggests that IRM provides a buffer stock service to reduce the negative effect of global financial shocks[25].

The marginal effect of ΔVIX_t on investment at different levels of IRM is plotted in the lower panel of Figure 1, which shows that ΔVIX_t negatively impacts firm investment irrespective of the level of active IRM. The plot implies that the adverse spillover from global financial shocks is not completely insulated, if EMEs rely on active IRM alone. Policy makers perhaps need to invoke other macro-tools to achieve their goals of maintaining the stability of the financial and real economy in EMEs (Ostry et al., 2012).

[25] Although the buffer stock effect is estimated to be economically significant, it is possible that we under-estimate it, namely because we do not explicitly account for the devastating crises avoided by countries that hold sufficient international reserves.

In columns (2) and (3), we report the results using the predetermined IRM and the IRM measurement purged of common factors. The results are similar to those in column (1) except that both IRM and the interaction term variables display larger coefficients; particularly, the purging of common factors effect makes the estimated effect of IRM more prominent.

4.3 Firm heterogeneity in financial frictions

Firms, especially the corporate sector in emerging economies, tend to borrow externally to finance their investment, a trend that has increased considerably since the early 2000s (Caballero et al., 2019). However, EME firms' accessibility to 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 in credit spreads, respond strongly to global financial risk shocks emanating from world capital markets, resulting in lower economic activities in EMEs. Issues related to how adverse external shocks heighten firm financial friction and can reduce investment has been discussed in several recent papers (e.g., Christiano et al., 2014; Gilchrist et al., 2014; Arellano et al., 2019). Firms that are heterogenous in financial constraints are found to invest differently during uncertainty shocks.

In this section, we investigate how the investments of firms with heterogenous financial constraints respond to active IRM differently at the presence of global financial shocks. To do so, we augment Equation (2) with a firm level financial constraint variable, $FinCnstr_{i,t}$, and its interaction terms with IRM, ΔVIX, and $IRM_{c,t} * \Delta VIX_t$ as follows:

$$\begin{aligned} Invest_{i,t} = {} & \alpha + \mu_j + \theta_t + \beta_1 IRM_{c,t} + \beta_2 \Delta VIX_t + \beta_3 IRM_{c,t} * \Delta VIX_t + \theta_1 FinCnstr_{i,t} \\ & + \theta_2 FinCnstr_{i,t} \times IRM_{c,t} + \theta_3 FinCnstr_{i,t} \times \Delta VIX_t \\ & + \theta_4 FinCnstr_{i,t} \times IRM_{c,t} \times \Delta VIX_t + \gamma X_{c,t} + \delta Z_{i,t} + \varepsilon_{i,t} \qquad (3) \end{aligned}$$

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 financially unconstrained. Dummy variables are created based on the following three firm level financial constraint measurements, each of which is included in $FinCnstr_{i,t}$ in Equation (3) for regressions, respectively.

The first of these financial constraint measures is based on a firm's capacity to access external financing (both liabilities and equities) for investment given by the ratio of *external financing* to *capital expenditure*.[26] A large external financing access ratio indicates that a firm is less financially constrained. Therefore, we construct a dummy variable, *Ext fin*, for which a value of 1 is assigned when a firm's external financing access ratio is smaller than the average ratio of the associated SIC-3-digit-sector in the country. This serves to indicate that the firm is relatively financially constrained. Otherwise, the firm is unconstrained and the *Ext fin* variable has a value of 0.

The second measurement is the ratio of tangible assets to long-term liabilities (Claessens and Laeven, 2003; Rajan and Zingales, 1998). Tangible assets can be used as collateral to reduce the default risk of long-term debt; thus, a high tangible asset to long-term debt ratio suggests lower default risk and borrowing costs. When credit is scarce as is the case during global financial shocks, firms with high tangible asset to long-term debt ratios are expected to be less impacted than low-ratio firms in terms of their ability to borrow externally and finance their investments. Accordingly, we generate a dummy variable, *Tangi*, and assign a value of 1 if the ratio of tangible assets to long-term liabilities is less than the country-industry sector (SIC 3-digit) average ratio. Otherwise, we set *Tangi* equal to 0 to indicate financially unconstrained firms.

The third measurement is the shadow cost of external financing. We use the Whited and Wu (2006) financial constraint index that is estimated based on a structural model:

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

where CF_{it} is 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; $LNTA_{it}$ measures the size of the firm; ISG_{it} is the sales of SIC three-digit industry sales growth; and SG_{it} represents total sales growth. A high shadow cost of external financing reduces firms' adjustment ability of investment when the global financial condition worsens. We generate a dummy variable, *WW* = 1 to indicate that a firm is financial constrained if *WW_cost* is higher than the

[26] Rajan and Zingales (1998) uses (*Capital expenditure - CF*)/*Capital expenditure* to measure a firm's external finance dependence.

country-industry sector (SIC 3-digit) average level of WW_cost; otherwise, the firm is labeled as financially unconstrained and we let $WW = 0$.

Table 3 reports the results where column (1) shows how financially constrained firms (measured by *Ext fin*) invest differently than financially unconstrained firms in response to active IRM in the presence of global financial shocks. Although all firms positively respond to IRM, the investments of financially constrained firms are less responsive to IRM than those of unconstrained firms. The total effect of IRM on financially unconstrained firms is estimated to be $0.033 + 0.097*\Delta VIX$, whereas for financially constrained firms it is $0.007 + 0.038*\Delta VIX$. Applying these results to the median size firm in the median GDP country for a comparison in US dollars, our results suggest that the financially constrained median size firm invests 0.54 million in response to a 1 billion US dollar increase in IRM when there is a one standard deviation global financial shock. Meanwhile the median size unconstrained firm responds to IRM by investing as much as 1.8 million US dollars. These contrasting effects on the two types of firms is also exhibited in the upper panel of Figure 2, where the solid and dashed lines plot the total effect of IRM at different magnitudes of global financial shock for financially constrained and unconstrained firms, respectively. Financially unconstrained firms are shown to be more responsive to IRM irrespective of the magnitude of external shock. On average, financially unconstrained firms are 3.3 times more responsive than financially constrained firms. In addition, the responses of unconstrained firms' investment to IRM intensify sharply as the magnitude of adverse shocks increases. By 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. These results are consistent with Ottonello and Winberry (2020) who find that low default risk firms are more responsive to monetary policy stimulus shocks because the marginal cost curve of low-risk firms is relatively flat.

Regarding how financially constrained firms respond differently to global financial shocks than unconstraintED firms, the lower panel of Figure 2 shows that global financial shocks reduce investment in both types of firms regardless of the level of active IRM. However, this detrimental effect of global financial shocks is markedly alleviated in financially unconstrained firms, but not in firms that are financially constrained as the level of IRM increases. This contrasting result implies that financially unconstrained firms are more responsive to IRM than financially constrained firms in terms of IRM's role in reducing the downside effect of global financial shocks.

Similar results are estimated in columns (2) and (3), where *Tangi* and *WW* are used to define financially constrained firms, respectively. In addition, although *Ext fin*, *Tangi* and *WW* measure financial constraint from different perspectives, they perhaps share a common dimension that aligns with firms' overall level of financial constraints. To capture this common dimension, we use principal component analysis (PCA) to extract the first principal component of three firm financial constraint measurements. The first principal component is then used to create a dummy variable, *Fin constr*, that categorizes financially constrained and unconstrained firms for Equation (3). The results of this regression reported in column (4) are comparable to those in columns (1) – (3), except that both effects of IRM are smaller for both financially constrained and unconstrained firms.

In summary, active IRM extends a positive effect on firm investment in EMEs, the degree of which, however, differs across firms that are 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 how macro-management policies, such as active IRM, affect financial and real economic activities. Macro management policies may be not very effective if firms are financially constrained; thus, to ensure policy effectiveness, EME policy makers may need to consider the distribution of firms based on their financial constraints.

4.4 A plausible causal channel

Thus far, we have documented empirical evidences that active IRM positively affects firm investment. A further question is: what is the causal channel through which active IRM increases firm investment in EMEs? In this section, we test a plausible causal channel.

The literature discussed in Section 2 suggests that active IRM lowers country spread, which is a key component of a firm's finance cost and, hence its credit spread.[27] Thus, IRM can affect a firm's finance cost via country spread and its investment. Because of the paucity of data on firm level credit spreads, we use data on country spreads to assess the conjecture that the IRM effect

[27] 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. Also, sovereign yield is a component of corporate yield. They are found to be positively associated (Mendoza and Yue, 2012; Bevilaqua et al., 2020).

transmits via the credit spread channel. Our use of country spread data is in line with Uribe and Yue (2006) and Akinci (2013). These authors show that the effect of international financial conditions on EME economic activities is driven by their impact on sovereign spreads/country spreads.

To test this plausible causal effect, we apply the causal mediation analysis approach (Krull and MacKinnon, 2001; Imai et al., 2010). Mediation analysis quantitatively evaluates the causal mechanism through which an intervention (central banks' active IRM strategy) affects an outcome (firm investment). It is able to separate the total intervention effect into an indirect effect that operates through observed mediators (country spread) and a direct effect that directly affect the outcome without going through the mediators. This analytic approach has been used in economics to produce an early macro-econometric model used by the US (Klein and Goldberger, 1955), to develop economic forecasts and policy (Theil, 1958), and, more recently, to study the effect of trade integration between China and Eastern Europe on voting in Germany (Dippel et al., 2015) as well as to examine how the 1990s trade liberalization in Brazil affected 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 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:

$$Country\ spread_{c,t} = \alpha + \mu_c + \theta_t + \beta_1 IRM_{c,t} + \beta_2 \Delta VIX_t + \beta_3 IRM_{c,t} * \Delta VIX_t + \gamma_1 X_{c,t} + \varepsilon_{c,t} \quad (4)$$

$$Investment_{i,t} = \alpha + \mu_j + \theta_t + \beta_4 IRM_{c,t} + \beta_5 \Delta VIX_t + \beta_6 IRM_{c,t} * \Delta VIX_t + \tau\ \widehat{Country\ spread}_{c,t} + \gamma_2 X_{c,t} + \delta Z_{i,t} + \varepsilon_{i,t} \quad (5)$$

Equation (4) is the country level regression examining the marginal effect of IRM on country spreads. As discussed in Section 2, global financial shocks drive up EME credit spreads[28], while active IRM lowers them. We include IRM, ΔVIX, their interaction terms; two macro factors, *RGDPG* and *Risk profile*; and the country and year effects as the determinants of country spreads.

Equation (5) augments Equation (2) with the mediator variable, $\widehat{Country\ spread}_{c,t}$. Due to endogeneity concerns, we do not directly include the $Country\ spread_{c,t}$ variable to be the mediator variable as suggested by the standard specification of causal mediation regression. Rather, we obtain the error terms of Equation (4) that are orthogonal to $IRM_{c,t}$, ΔVIX_t, and $IRM_{c,t} * \Delta VIX_t$, label it as $\widehat{Country\ spread}_{c,t}$ and add it to Equation (5). $X_{c,t}$ controls for country level variables, *RGDPG* and *Risk profile*; $Z_{i,t}$ controls for firm level factors, *Tobin Q*, *CF*, *Size*, and *Sales growth*. We also include the country, industry sector, firm and year effects.

The average causal mediation effect (ACME) that mediated through country spreads is captured by $\beta_1 * \tau$, and the total effect of IRM is $\beta_1 * \tau + \beta_4$. Therefore, the percentage of total effect of IRM on firm investment explained by the ACME is $\beta_1 * \tau / (\beta_1 * \tau + \beta_4)$. The standard errors of ACME are computed according to the Delta method (Oehlert, 1992).

The regression results are reported in Table 4, where column (1) shows the mediation analysis results for full samples. We estimate the ACME of IRM to be 0.008 and significant at 1%, suggesting a significant causal effect of IRM on firm investment through country spreads – for a median size firm, one billion US dollar IRM causes about 0.26 million more investment through the channel of country spreads. The total effect of IRM on firm investment is estimated to be 0.032; therefore, our model suggests that about 25% of the total effect of IRM on firm investment in EMEs is mediated through country spreads.

Columns (2) to (4) report mediation regression results for financially unconstrained firms and columns (5) – (7) report results for firms that are financially constrained. The total effect of IRM estimated in columns (2) – (4) are, on average, higher and statistically more significant than those in columns (5) – (7). Although there is a higher total effect of IRM in financially unconstrained firms, the percentage of total effect of IRM that is mediated through the country

[28] Other papers examining the effect of global financial condition on EME credit spreads include Arora and Ceisola (2001), Gonzalez-Rozada and Levy-Yyati (2008), Ciarlone et al. (2009), Akinic (2013), de Giovanni et al. (2017), and Gilchrist et al. (2019).

spread is lower than that in financially constrained firms – on average, 17% of the total effect is mediated in unconstrained firms compared to 31% in financially constrained firms. This perhaps is attributed to the more responsive characteristics of country spread in financially risky countries to global financial shocks. For example, Gilchrist et al., (2019) find that a tightening in conventional US monetary policy leads to a significant widening of credit spreads on sovereign bonds issued by countries with speculative-grade credit rating. The differed causal mediation effect between financially constrained and unconstrained firms reinforces the importance of financial friction that policy makers in EMEs need to consider in order to implement macro-policies, such as active IRM, effectively.

The estimates for other independent variables in Equation (5) are consistent with those in Section 4.2. As expected, high country spread is negative and significantly associated with firm investment. Interestingly, compared to Table 2, adding country spread modifies the interaction term, $IRM_{c,t} * \Delta VIX_t$, to be mostly negative but insignificant. This may empirically confirm that active IRM and global financial shocks interact and trade off their opposite effects to determine credit spreads. The result that the country spread variable deprives the significance of $IRM_{c,t} * \Delta VIX_t$ also justifies why we do not include a country spread variable in Equation (2) – because country spread and $IRM_{c,t} * \Delta VIX_t$ are correlated and could cause multicollinearity issues. Importantly, including $IRM_{c,t} * \Delta VIX_t$ as opposed to country spreads reveals richer findings as discussed in Section 4.1 and 4.2.

5 Additional Analyses

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.

5.1 **Alternative IRM measurements**

We discussed different measurements for IRM and compared their advantages and disadvantages in Section 3.1 and in Appendix A. In this subsection, we use other IRM measurements to check the sensitivity of our results. Columns (1) – (4) in Table 5 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 with a few differences. The values of some coefficients are slightly different and the significance of interaction terms turn from 1% to 5%.

The largest difference is that ΔVIX_t is estimated to be insignificant, yet still negative, in column (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 IRM. To address this issue, we use the IRM/IR ratio, measured as the ratio of the active changes in reserves based on the DHI approach to total international reserves excluding gold, 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.

5.2 **Alternative measurements for global financial shocks**

In this subsection, we use four alternative measurements[29] 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 impose 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 (ΔAlt_shocks) in Table 6. 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 ΔAlt_shocks, respectively. These results are comparable to those in Table

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[29] The definitions and data compilations of these alternative measurements for external shock are discussed in Section 3.2.

2, although the estimated coefficients for ΔAlt_shocks are larger than ΔVIX, but $IRM \times \Delta Alt\_shocks$ are smaller than $IRM \times \Delta VIX$ in Table 2.

5.3 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 financial risk shock (i.e., the VIX index spiked 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&Tapper* (= 1 if year == 2007, 2008, 2009, 2013 and 2014; otherwise, 0) to indicate 2008 the financial crisis and the Fed's tapering[30]. 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 of Table 6. As we replace a continuous variable (ΔVIX) with a dummy variable (*Crisis&tapper*), the regression changes from a multiplicative regression to a difference-in-differences regression. The interpretation of economic meaning therefore is slightly different from that in Table 2. We show that, during the 2008 financial crisis and the Fed's taper tantrum, EME firms dropped their investment by about 2.2 percent. Firms responded to a one percent increase of IRM in non-crisis-and-taper periods with 3 percent additional investment. However, during crisis and taper periods, the positive effect of IRM on

[30] 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.

investment was reduced by more than by 50% (i.e., -0.016/0.030) relative to that in normal periods. This is because EMEs sold international reserves to defend themselves against financial instability during the 2008 financial crisis and taper periods (Figure A5), more than half of the IRM effect is traded off by the adverse effect of crisis and tapering.

5.4 Possible sample selection bias

In this section, 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 in the Worldscope database. However, this is 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. Using this identifier, we identify 4304 such 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 to domestic investment samples only. Our firm investment data studied in previous sections are total investments of a firm that do not differentiate the domestic investment from the foreign investment. However, the Worldscope database allows us to identify whether a firm has foreign subsidiaries by checking whether the firm reports consolidated accounting statements. We assume a firm invests 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 B for commodity country samples).

The results of these regressions are reported in Table 7. Overall, regressions using different firm samples yield results comparable to that of Table 2. Column (1) reports full sample results. The results are similar, yet the coefficients of *IRM* and ΔVIX are slightly larger than those in Table 2, indicating that both active IRM and global financial shocks affect 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 0.014 at 5% significance, compared to 0.017 in Table 2), suggesting that large firms are less responsive to IRM as they might have other means 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 system 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 0.061 + 0.378 * ΔVIX, compared to 0.017 + 0.062 * ΔVIX 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, ΔVIX and IRM × ΔVIX become smaller.

6 Coordination with Capital Controls and Exchange Rate Arrangements

The Mundell-Fleming trilemma theory suggests that a country can insulate external shocks and achieve monetary independence if it adopts either flexible exchange rate or controls cross-border capital mobility, suggesting the importance of coordination among macroeconomic policies to achieve macroeconomic stability. Emerging markets traditionally use macro-management policies, such as capital controls and exchange rate flexibility, to insulate global financial shocks.

The insulation of capital controls against global financial shocks is evident (Han and Wei, 2018; Zeev, 2017). Ostry et al. (2012) find emerging markets with restrictions on financial openness Better endured the 2008 global financial crisis. In fact, many EMEs re-engaged the capital controls (Eichengreen and Rose, 2014) after the 2008 financial crisis, and the IMF suggests considering capital controls as a viable policy tool to better stabilize financial systems in emerging markets.

Regarding exchange rate regime, the literature suggests that it influences the sensitivity of developing countries to policy shocks from center countries (Aizenman et al, 2016). Flexible exchange rate was identified as a shock absorber as early as Friedman (1953). Emerging economies with flexible exchange rate regimes help mitigate the susceptibility to real and financial vulnerability and the occurrence of global financial instability (Gosh, et al., 2015; Obstfeld et al., 2019).

In addition to directly insulating shocks, capital controls and flexible exchange rate regime are complementary to international reserves in insulating EMEs from global shocks (Bussière et al., 2015; Acharya and Krishnamurthy, 2018). It is therefore policy relevant to examine how the effect of IRM on firm investment in EMEs may differ among countries that manage capital controls or adopt a flexible exchange rate regime from those do not have capital controls or with a pegged exchange rate regime.

To do so, we augment Equation (2) with capital controls and exchange rate regimes as follows:

$$
\begin{aligned}
Invest_{i,t} = \alpha + \mu_j + \theta_t + \beta_1 IRM_{c,t} + \beta_2 \Delta VIX_t + \beta_3 IRM_{c,t} \times \Delta VIX_t + \varphi_1 MacroMNGM_{c,t} \\
+ \varphi_2 MacroMNGM_{c,t} \times IRM_{c,t} + \varphi_3 MacroMNGM_{c,t} \times \Delta VIX_t \\
+ \varphi_4 MacroMNGM_{c,t} \times IRM_{c,t} \times \Delta VIX_t + \gamma X_{c,t} + \delta Z_{i,t} \\
+ \varepsilon_{i,t} \qquad (6)
\end{aligned}
$$

where $MacroMNGM_{c,t}$ includes variables that measure whether a country has capital controls or adopts flexible exchange rate regime, or both. Other independent variables are the same as in Equation (2). As in Section 4.3, we follow the heterogeneity-based difference-in-difference methodology and use dummy variables that categorize countries with capital controls or the implement flexible exchange rate regimes.

To generate a dummy variable for capital controls (*KC*) countries, we rely on the Chinn-Ito index. We let *KC* = 1 to indicate that a country manages capital controls, if the country has a Chinn-Ito index value < 0.065 (the mean of the Chinn-Ito index in our data sample); for those countries that have a Chinn-Ito index > 0.065, we assign *KC* = 0, indicating they do not control capital mobility. Similarly, we generate a category dummy variable, *Xchg*, to categorize flexible exchange rate regimes versus peg exchange rate regimes. *Xchg* is measured based on the coarse classification index of exchange rate regime in Ilzetzki et al. (2019). We set *Xchg* = 1 if the index > 3 to indicate countries that adopt flexible exchange rate regimes, and *Xchg* = 0 to mark countries that endorse pegged exchange rate regimes.

We report the results in Table 8. Columns (1) and (2) provide results dealing with capital controls and flexible exchange rate regimes, and column (3) shows the results with countries that apply both capital controls and flexible exchange rates. In column (1), the effect of IRM is estimated as 0.004 + 0.042 $*$ ΔVIX, but is insignificant, implying that firm investment in EMEs without capital controls do not respond to active IRM. Although no significant effect of IRM is found, IRM seems to reduce the downside effect of global financial shocks (ΔVIX is negative and the interaction term gets a coefficient 0.042, at 1% significance). On the other hand, countries that impose capital controls are found to invest more, and the effect of IRM is significantly stronger relative to those in no capital control countries. The marginal effect of IRM in capital-controlled counties is 0.039 + 0.078$*$ ΔVIX; at the average level of ΔVIX, a one percent increase in IRM is associated with about 4 percent higher firm investment. These results are in accordance with the complementary role of capital controls on international reserves identified in the literature. The detrimental effect of global financial shocks on investment is smaller in countries with capital controls compared to those with no capital control – confirming the shock insulation role of capital control. However, we find no statistical evidence that the role of IRM in reducing the downside impact of global financial shocks is different between countries with or without capital controls (i.e., $KC \times IRM \times \Delta VIX$ is not statistically significant).

Regarding exchange rate arrangements, we find in column (2) that IRM has a positive effect on firm investment in countries with a pegged exchange rate system (the coefficient to IRM and $IRM \times \Delta VIX$ are both positive and significant). There is more firm investment in countries with flexible exchange regimes. However, exchange rate regimes do not have implication for IRM effect on firm investment (both $Xchg \times IRM$ *and* $Xchg \times IRM \times \Delta VIX$ are not significant). Perhaps IRM plays an important role in maintaining financial stability regardless of exchange rate arrangements. Similar to Obstfeld et al. (2020), we find evidence that a flexible exchange rate can insulate adverse global financial shocks on firm investment; the estimate of $Xchg \times \Delta VIX$ is significantly positive.

For countries that combine policies of capital controls and flexible exchange rate [column (3)], we find that IRM exserts a stronger positive effect on firm investment than countries that have either capital controls or flexible exchange regimes, or neither (the sum of coefficients to $KC\&Xchg \times IRM$ and $KC\&Xchg \times IRM \times \Delta VIX$ is 4.08, significant at 1%). These results may imply that a well-coordinated macro-management policy mix is more effective in insulating adverse global financial shocks.

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): $\theta_1 Fin\ constr_{i,t} + \theta_2 Fin\ constr_{i,t} \times IRM_{c,t} + \theta_3 Fin\ constr_{i,t} \times \Delta VIX_t + \theta_4 Fin\ constr_{i,t} \times IRM_{c,t} \times \Delta VIX_t$, where $Fin\ constr_{i,t}$ is the first principal component extracted from *Ext fin*, *Tangi* and *WW*. Results are reported in columns (4) – (6). All firm financial constraint variables are estimated to be significantly negative as in Table 3. Importantly, controlling for firms' financial constraints does not change our results in a meaningful way, except that the R-squares marginally increase from 0.108 to 0.116.

7 Macroeconomic Significance

To gauge the macroeconomic significance of our findings in firm level data, we use a structural VAR model to study the causal relation among IRM, external shocks, country spreads, and investment in country-level aggregate data. We obtained an annual data set that includes 55 emerging economies[31] from 2000 – 2018. The aggregate investment is proxied by gross fixed capital formation[32] as a percentage of GDP. Following Sims (1980), who suggests that VAR models provide a coherent and credible approach to macro-data description, macroeconomic structural inference, and macro-policy analysis, we use a structural VAR model to examine how and the degree to which a country's aggregate investment responds to active IRM, external shocks, and country spreads. The reduced form of the VAR model is specified as follows:

$$Y_{c,t} = \{\Delta VIX_t, IRM_{c,t}, Country\ spread_{c,t}, Aggregate\ investment_{c,t}\} \tag{7}$$

where, as in Section 4, ΔVIX_t measures global financial shocks; $IRM_{c,t}$ is represented by IRM-1; and $Country\ spread_{c,t}$ is measured by EMBI+ spread.

Following Bloom (2009) as well as Carrière-Swallow and Céspedes (2013), we ordered ΔVIX to be the first component in the VAR model, assuming that global financial shocks are exogenous to local variables of emerging economies. We then place IRM after ΔVIX, because global shocks may trigger EME central banks' IRM behavior to self-insure against the shocks. Following the theoretical mechanism outlined in Section 2 that IRM and global financial shocks impose the opposite effect on country spreads and thereby affect investment, we order $Country\ spread$ after IRM and position $Aggregate\ investment$ last. A significant response of $Country\ spread$ to ΔVIX and IRM and the response of $Aggregate\ investment$ to $Country\ spread$, ΔVIX and IRM can validate the effect of IRM on investment along with its effect that mediates through country spreads to affect investment in the macroeconomic scope.

[31] Due to better availability of country level data, we include 9 more countries than previous sections using firm level data. Excluding these 9 additional countries yields similar results.
[32] According to the World Bank, gross fixed capital formation, formally called gross domestic fixed investment, includes land improvements (fences, ditches, drains, and so on); plant, machinery, and equipment purchases; and the construction of roads, railways, and the like, including schools, offices, hospitals, private residential dwellings, and commercial and industrial buildings. According to the 1993 SNA, net acquisitions of valuables are also considered capital formation.

The contemporaneous and two lags of each variable are included in the model. We use the panel data VAR to obtain impulse response function (IRF) and confidence intervals that use Monte-Carlo simulation repeating 200 times. Figure 3 reports the orthogonalized IRF at the 95% confident interval to one standard deviation shocks. Panel A shows the responses of IRM, country spreads, and aggregate investment to one-standard deviation of ΔVIX_t. In line with the precautionary theory of IRM, EMEs immediately sell about 0.3% of their reserves/GDP to defend against an adverse global financial shock and follow up by accumulating to replenish reserve stockpiles (see Figure "IRM" in Panel A). The country spread responds to the VIX spike by widening about 1.5 percent of interest rate spreads (Figure "Credit spread" in Panel A). By contrast, the aggregate investment does not respond to the VIX shock immediately; rather, it takes the aggregate investment two years to respond to a one-S.D. spike of global financial shocks by reducing investment about 0.4% of GDP. This sluggish yet significant response of the aggregate investment to global financial shocks is consistent with the finding of Bertola and Caballero (1994), who state that the aggregate investment behavior is characterized as sluggish and continues adjustment[33].

In Panel B, we show that, in response to a one-S.D. increase in active IRM, EMEs boost their aggregate investment by 0.3% in two years, suggesting significant macroeconomic evidence for the positive effect of IRM on investment. In responding to a positive shock in active IRM, country spreads are found to narrow about 0.9% immediately. This result, combined those in the Figure "Country spread" of Panel A that demonstrate an adverse VIX shock widens country spreads, implies that adverse global shocks and active IRM impose opposite effects on country spreads and that IRM offsets the adverse effect of global financial shocks in determining the level of country spreads, other things being equal.

In fact, country spreads are found to go on to affect aggregate investment. Figure "aggregate investment" of Panel C shows that EMEs reduce about 0.2% aggregate investment in response to a one-S.D. widening shock in their country spreads (Panel C). These results are consistent with those reflecting the mediator role of country spread in the effects of IRM on firm investment (in Section 4.3).

Overall, this section confirms the positive effect of active IRM on investment at the macroeconomic level and validates the macroeconomic significance of our findings. These

[33] Similar findings are found in Uribe and Yue (2006), Bloom (2009), and Carrière-Swallow and Céspedes (2013).

results are consistent with the findings in of Dominguez et al. (2012) and Aizenman and Jinjarak (2020).

8 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 spreads are a significant channel through which IRM exerts positive effects on firm investment. The country spread mediation effect is stronger for financially constrained firms than for non-constrained ones.

Further, active IRM is shown to be complementary to two other macro management policies, namely capital controls and exchange rate management, in terms of stabilizing firm investment in the face of 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 hoarding international reserves 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 than normal periods, and a low level can limit the ability to conduct active IRM during a crisis. As with any policy tool, overdoing hoarding international reserves in good times may backfire, leading to possible moral hazard concerns,[34] and growing opportunity costs associated with accumulating low yielding international reserves instead of hoarding a balanced international portfolio in a well-run Sovereign Wealth Fund. These issues left for future research.

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

Appendices:

Appendix A: Data construction for 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 [35]. 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 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

[35] 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.

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:

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

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

$$valuation\_BOP = \Delta IR - Res_{BOP} = \Delta^{val}SEC + \Delta^{val}DEPO \quad (A5)$$

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:

$$valuation\_EXR = \sum_{j=1}^{3} ForexR * CurrencyShare_j * \Delta exr_j \quad (A6)$$

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[36], 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

[36] 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.

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. (2014), there was a pattern change in reserve holding behavior after the 2008 global financial crisis, because some newly identified factors[37] 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.

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

[37] 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.

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 5 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 and 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 B: 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 C: Variable descriptions

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 A 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 percentage 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.

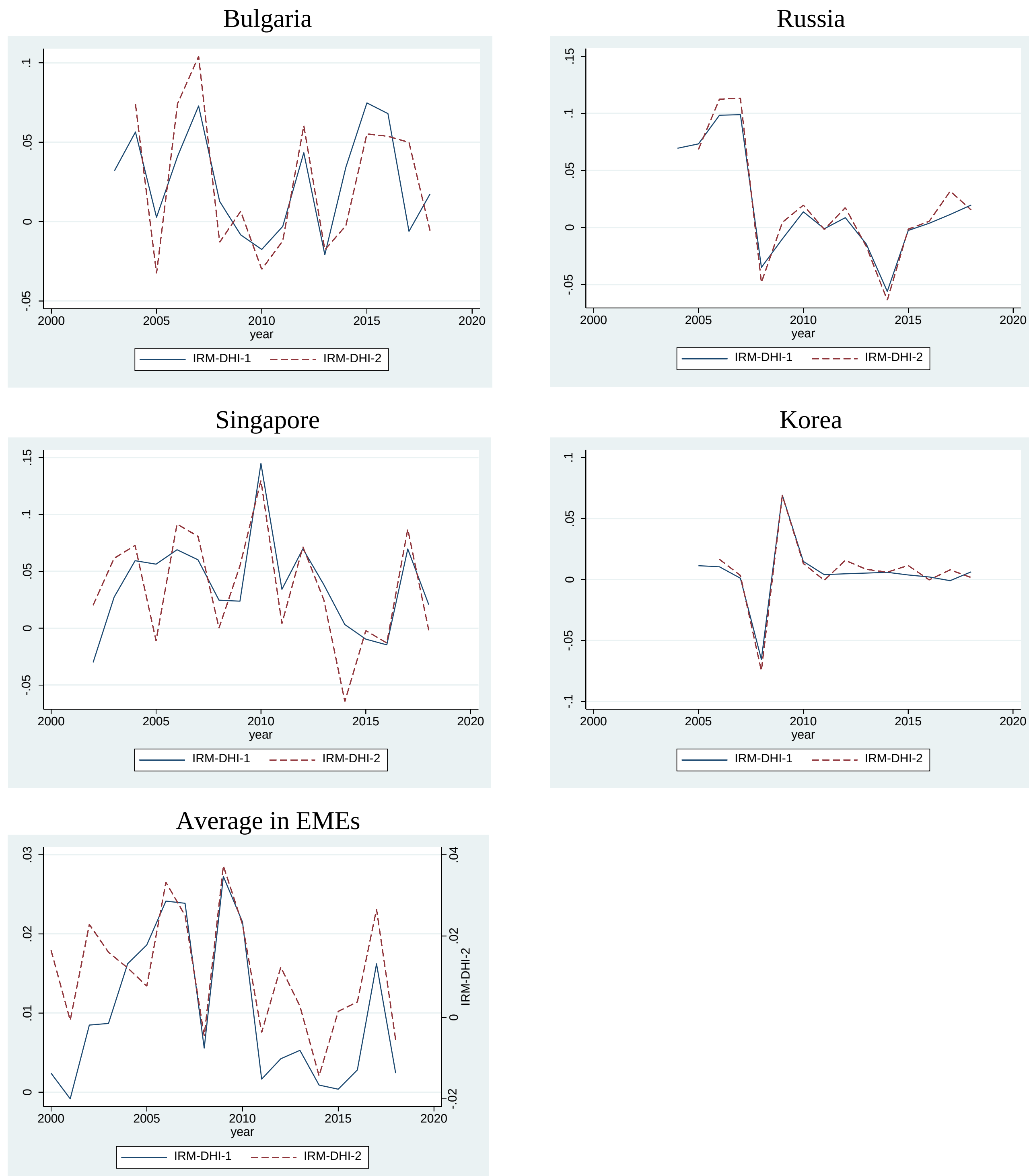
<u>Alternative measurements for global financial risk:</u>	
S&P500	An alternative measurement for global financial shocks, measured as the intra-annual volatility of S&P500 index, computed from S&P500 daily data according to Merton (1980). To construct these data, we first compute the daily contribution 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 www.policyuncertainty.com.

Appendix D: 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	120,912	.95588	3.4493	-5.0568	55.7375
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

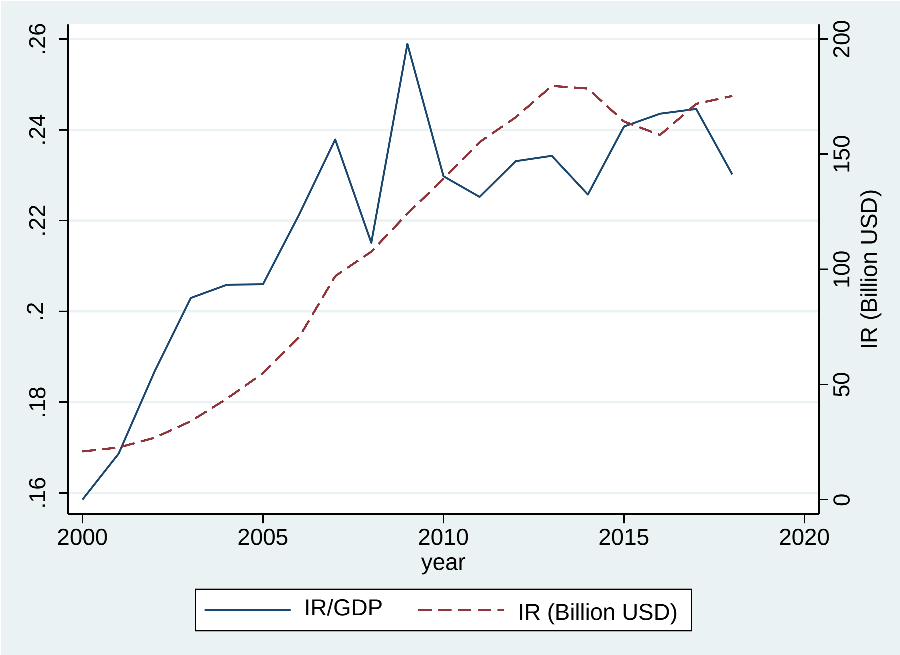
Notes: this table shows summary statistics of main variables. Country level and time series data are matched with the firm level panel data that winsorize the investment variable at the 1st and 99th percentiles.

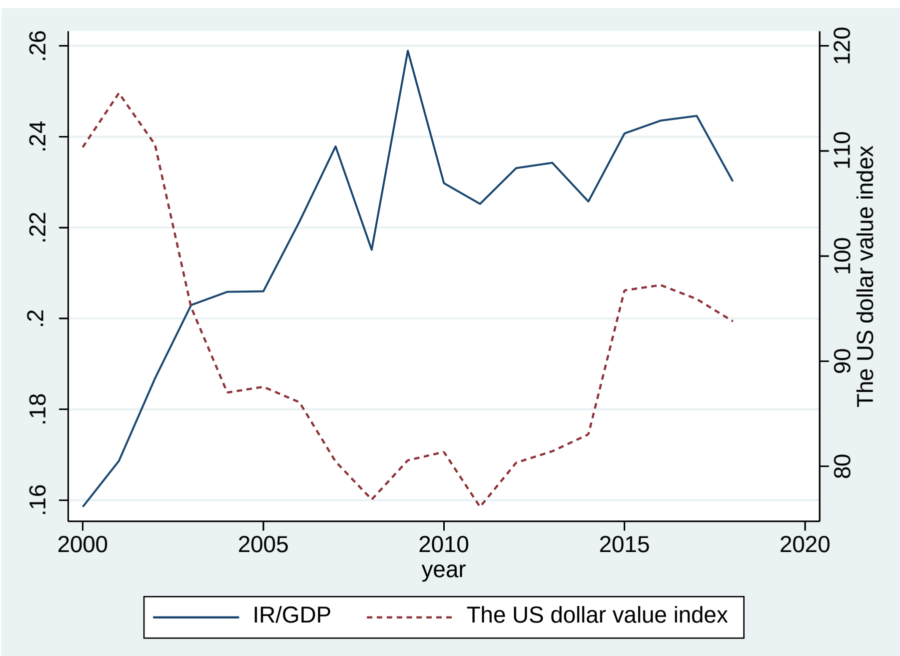
Figure A1: The simulated active IRM data using the DHI method



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).

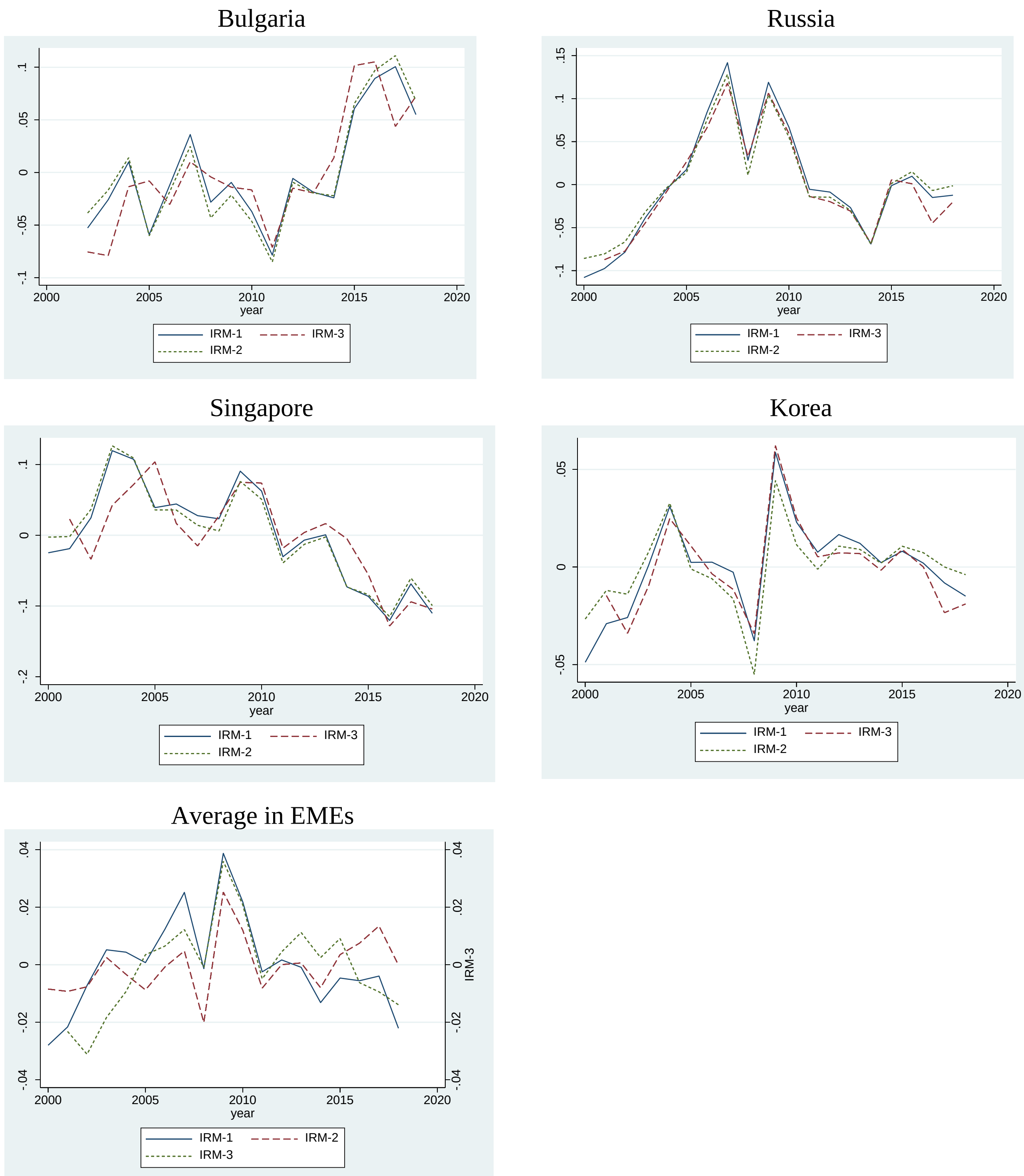
Figure A2: The average level of international reserves holding in EMEs





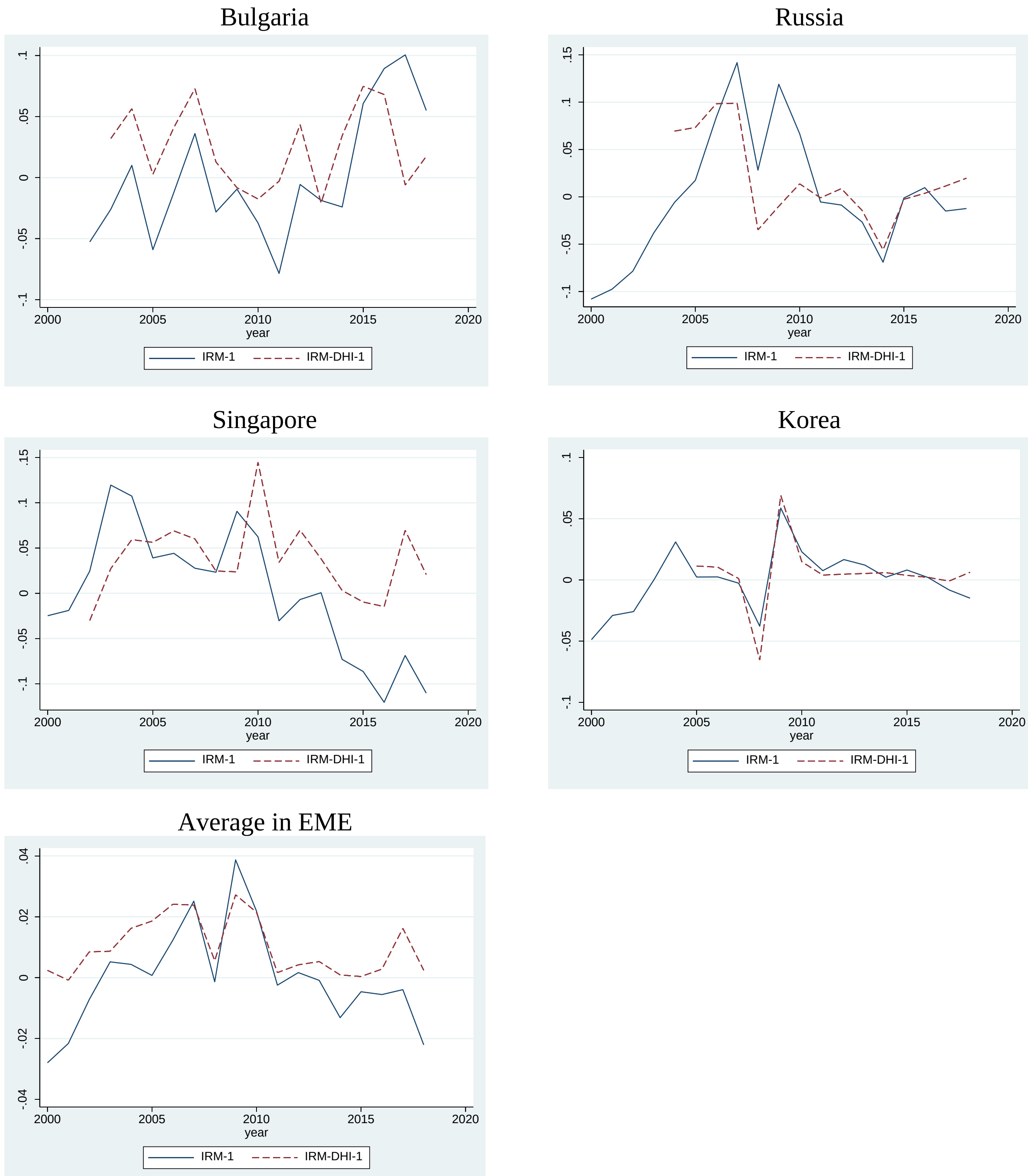
Notes: This figure shows the different pattern in international reserves (IR) holding behavior in EMEs before and after the 2008 global financial crisis. The solid line plots the average of IR/GDP ratio (left scale); the long-dash line in the top panel plots the average IR holding in EMEs (in Billion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



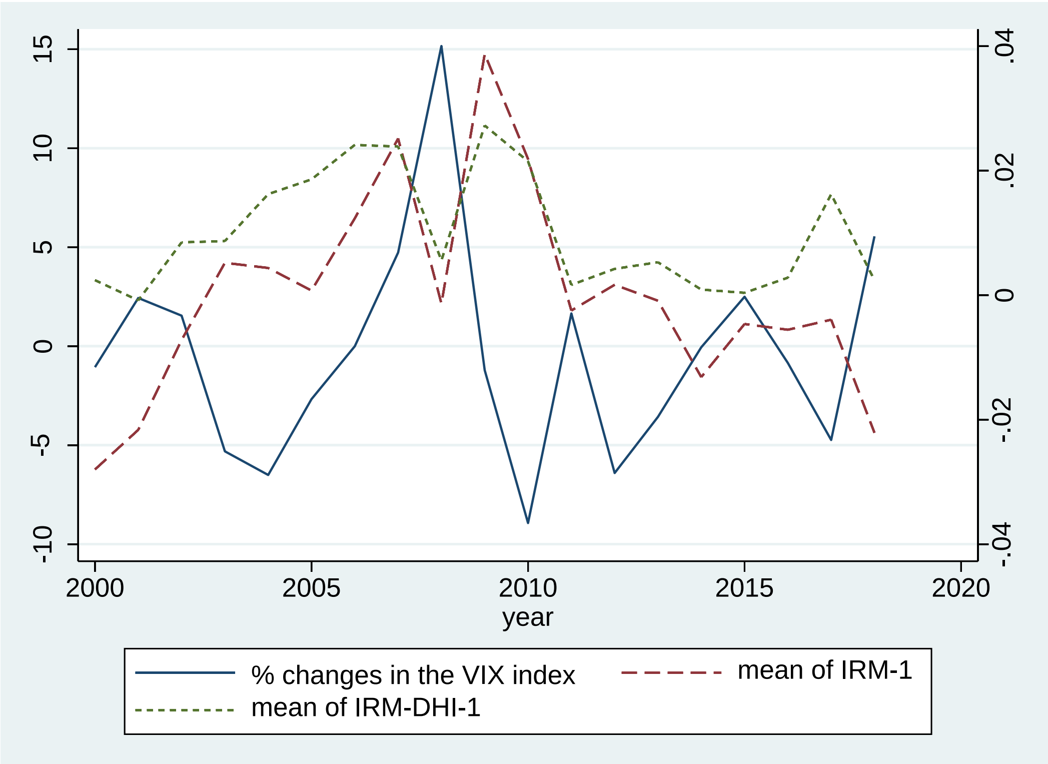
Notes: This figure plots the estimated IRM of four EMEs (Bulgaria, Russia, Singapore, and South Korea) and the average level in EMEs. The solid line shows the linearly detrend IR/GDP ratio (IRM-1); the dot line shows the detrended IR/GDP with a structure break at year 2008 (IRM-2); and the dashed line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

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



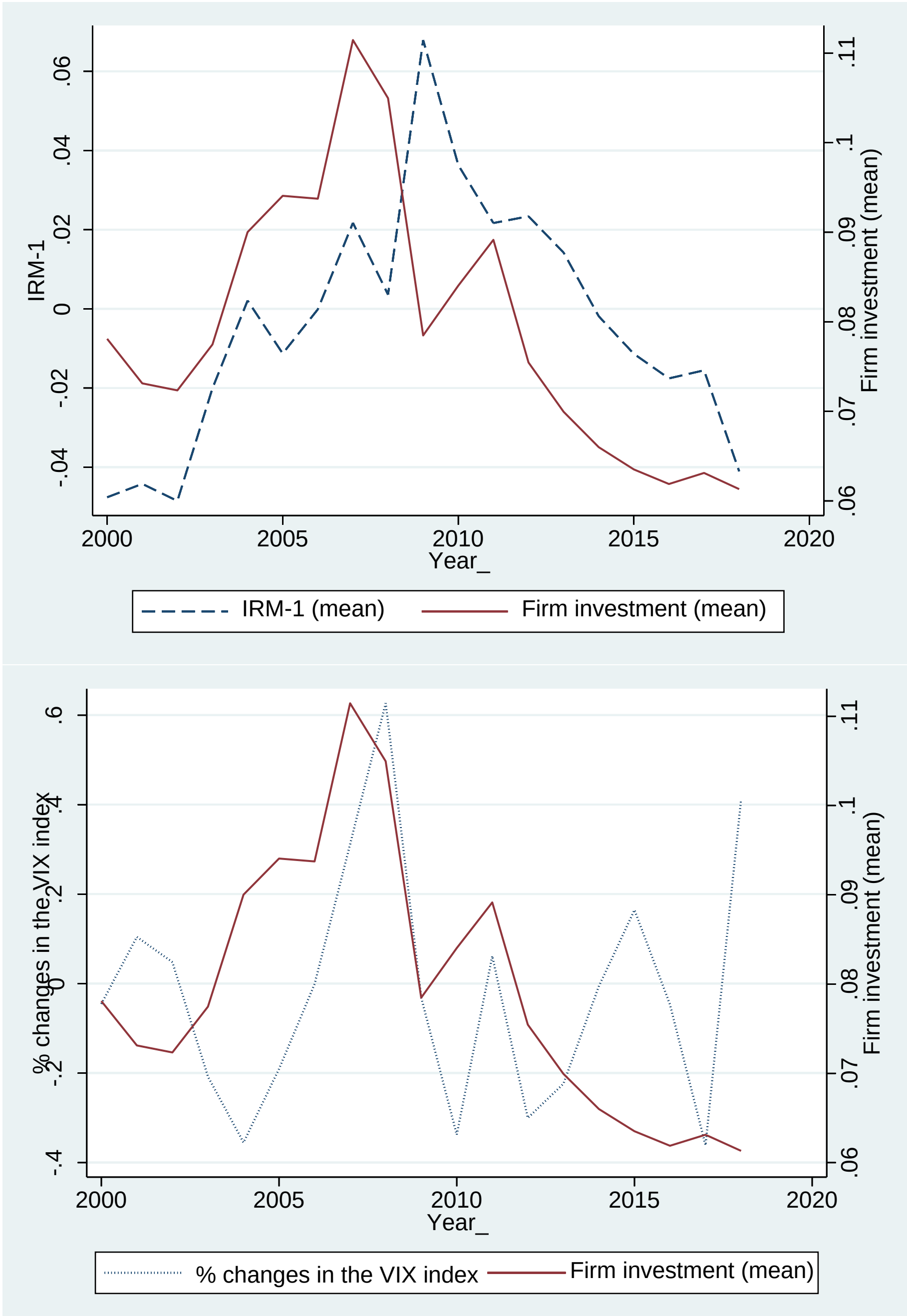
Notes: This figure plots the simulated and estimated data for IRM in four EMEs (Bulgaria, Russia, Singapore, and South Korea) and the average IRM in EMEs. The solid line plots IRM-1 and the dot line shows IRM-DHI-1.

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.

Figure A6: Active IRM, Firm investment and global financial shocks



Notes: the solid line plots the mean of firm investment in our data sample (right scale). The long-dash line is the mean of IRM-1 in EMEs (left scale). The dot line is the percentage change in the VIX index (left scale).

References:

Abel, Andrew B., and Janice C. Eberly. 1994. "A Unified Model of Investment Under Uncertainty." *American Economic Review* 84(5): 1369.

Acharya, Viral V., and Arvind Krishnamurthy. 2018. "Capital flow management with multiple instruments." National Bureau of Economic Research.

Aghion, Philippe, Philippe Bacchetta, and Abhijit Banerjee. 2004. "Financial development and the instability of open economies." *Journal of Monetary Economics*, 51(6), pp.1077-1106.

Aguiar, Mark, Satyajit Chatterjee, Harold Cole, and Zachary Stangebye. 2016. "Quantitative models of sovereign debt crises." In Handbook of Macroeconomics (Vol. 2, pp. 1697-1755). Elsevier.

Aizenman, Joshua. 2008. "International Reserve Management and the Current Account." Central Banking, Analysis, and Economic Policies Book Series, in: Kevin Cowan & Sebastián Edwards & Rodrigo O. Valdés & Norman Loayza (Series Editor) & Klaus Schmid (ed.), Current Account and External Financing, edition 1, volume 12, chapter 11, pages 435-474 Central Bank of Chile.

Aizenman, Joshua, Yin-Wong Cheung, and Hiro Ito. 2015. "International reserves before and after the global crisis: Is there no end to hoarding?" *Journal of International Money and Finance*, 52, pp.102-126.

Aizenman, Joshua, Sebastian Edwards, and Daniel Riera-Crichton. 2012. "Adjustment patterns to commodity terms of trade shocks: the role of exchange rate and international reserves policies." *Journal of International Money and Finance*, 31(8), pp.1990-2016.

Aizenman, Joshua, and Yothin Jinjarak. 2020. "Hoarding for stormy days – Test of international reserves providing financial buffer services." Forthcoming *Review of International Economics*.

Aizenman, Joshua, Yothin Jinjarak, and Donghyun Park. 2011. "International reserves and swap lines: Substitutes or complements?" *International Review of Economics & Finance*, 20(1), pp.5-18.

Aizenman, Joshua, and Jaewoo Lee. 2007. "International reserves: precautionary versus mercantilist views, theory and evidence." *Open Economies Review* 18(2): 191-214.

Aizenman, Joshua, and Nancy P. Marion. 1993. "Macroeconomic uncertainty and private investment." *Economics Letters* 41(2): 207-210.

Aizenman, J., Menzie D. Chinn, and Hiro Ito. 2016. "Monetary policy spillovers and the trilemma in the new normal: Periphery country sensitivity to core country conditions." *Journal of International Money and Finance*, 68, pp. 298-330.

Aizenman, Joshua, and Gurnain Kaur Pasricha. 2010. "Selective swap arrangements and the global financial crisis: Analysis and interpretation." *International Review of Economics & Finance,* 19(3), pp.353-365.

Aizenman, Joshua, and Daniel Riera-Crichton. 2008. "Real exchange rate and international reserves in an era of growing financial and trade integration." *The Review of Economics and Statistics*, 90(4), pp.812-815.

Akıncı, Özge. 2013. "Global financial conditions, country spreads and macroeconomic fluctuations in emerging countries." *Journal of International Economics*, 91(2), pp.358-371.

Amiti, Mary, Patrick McGuire, and David E. Weinstein. 2019. "International bank flows and the global financial cycle." *IMF Economic Review*, 67(1), pp.61-108.

Angrist, Joshua D., and Alan B. Krueger. 2001. "Instrumental variables and the search for identification: From supply and demand to natural experiments." *Journal of Economic perspectives*, 15(4), pp.69-85.

Angrist, Joshua D., Guido W. Imbens, and Donald B. Rubin. 1996. "Identification of causal effects using instrumental variables." *Journal of the American statistical Association*, 91(434), pp.444-455.

Arellano, Cristina, Yan Bai, and Patrick J. Kehoe. 2019. "Financial frictions and fluctuations in volatility." *Journal of Political Economy*, 127(5), pp.2049-2103.

Avdjiev, Stefan, Cathérine Koch, Patrick McGuire, and Goetz Von Peter. 2018. "Transmission of monetary policy through global banks: Whose policy matters?" *Journal of International Money and Finance*, 89, pp.67-82.

Avdjiev, Stefan, Leonardo Gambacorta, Linda S. Goldberg, and Stefano Schiaffi. 2020. "The shifting drivers of global liquidity." *Journal of International Economics*, 125, p.103324.

Baker, Scott R., Nicholas Bloom and Steven J. Davis. 2016. "Measuring Economic Policy Uncertainty." *The Quarterly Journal of Economics* 131(4): 1593-1636.

Ben-Bassat, Avraham, and Daniel Gottlieb. 1992. "Optimal international reserves and sovereign risk." *Journal of international Economics*, 33(3-4), pp.345-362.

Bernanke, Ben S. 1983. "Irreversibility, uncertainty, and cyclical investment." *The Quarterly Journal of Economics* 98(1): 85-106.

Bertola, Guiseppe, and Ricardo J. Caballero. 1994. "Irreversibility and aggregate investment." *The review of economic studies* 61(2): 223-246.

Beaudry, Paul, Mustafa Caglayan, and Fabio Schiantarelli. 2001. "Monetary instability, the predictability of prices and the allocation of investment: An empirical investigation using UK panel data." *American Economic Review*, 91(3), 648–662.

Bevilaqua, Julia, Galina B. Hale, and Eric Tallman. 2020. "Corporate yields and sovereign yields." *Journal of International Economics* 124, 103304.

Bianchi, Javier, Juan Carlos Hatchondo, and Leonardo Martinez. 2018. "International reserves and rollover risk." *American Economic Review*, 108(9), pp.2629-70.

Bloom, Nicholas. 2009. "The Impact of Uncertainty Shocks." *Econometrica* 77, 623-685.

Bloom, Nicholas. 2014. "Fluctuations in uncertainty." *Journal of Economic Perspectives*, 28(2), pp.153-76.

Bloom, Nicholas. 2017. "Observations on uncertainty." *Australian Economic Review*, 50(1), pp.79-84.

Bloom, Nick, Stephen Bond, and John Van Reenen. 2007. "Uncertainty and investment dynamics." *The review of economic studies*, 74(2), pp.391-415.

Brambor, Thomas, William Roberts Clark, and Matt Golder, 2006. "Understanding Interaction Models: Improving Empirical Analyses." *Political Analysis* 14:1, 63-82.

Bruno, Valentina, and Hyun Song Shin. 2015a. "Capital Flows and the Risk-Taking Channel of Monetary Policy." *Journal of Monetary Economics*, 71, pp. 119–132.

Bruno, Valentina, and Hyun Song Shin. 2015b. "Cross-border banking and global liquidity." *The Review of Economic Studies* 82(2): 535-564.

Bruno, Valentina, and Hyun Song Shin. 2017. "Global dollar credit and carry trades: a firm-level analysis." *The Review of Financial Studies* 30(3): 703-749.

Bocola, Luigi, and Guido Lorenzoni. 2020. “Financial crises, dollarization, and lending of last resort in open economies.” *American Economic Review*, 110(8), pp.2524-57.
Bussière, Matthieu, Gong Cheng, Menzie D. Chinn, and Noëmie Lisack. 2015. "For a few dollars more: Reserves and growth in times of crises," *Journal of International Money and Finance,* vol. 52(C), pages 127-145.
Caballero, Ricardo J., and Stavros Panageas. 2008. “Hedging sudden stops and precautionary contractions.” *Journal of Development Economics*, 85(1-2), pp.28-57.
Caballero, Ricardo J., and Robert S. Pindyck. 1996. “Uncertainty, Investment, and Industry Evolution.” *International economic review* 37(3): 641-662.
Caballero, Julián, Andrés Fernández, and Jongho Park. 2019. "On corporate borrowing, credit spreads and economic activity in emerging economies: An empirical investigation." *Journal of International Economics* 118: 160-178.
Carrière-Swallow, Yan, and Luis Felipe Céspedes. 2013. “The impact of uncertainty shocks in emerging economies.” *Journal of International Economics*, 90(2), 316–325.
Cetorelli, Nicola, and Linda S. Goldberg. 2011. “Global banks and international shock transmission: Evidence from the crisis.” *IMF Economic review*, 59(1), pp.41-76.
Chari, Anusha, Karlye Dilts Stedman, and Christian Lundblad. 2021. “Taper Tantrums: Quantitative easing, Its aftermath, and emerging market capital flows.” *The Review of Financial Studies*, 34(3), pp.1445-1508.
Chari, Anusha, Karlye Dilts Stedman, and Christian Lundblad. 2020. “Capital Flows in Risky Times: Risk-on/Risk-off and Emerging Market Tail Risk.” National Bureau of Economic Research.
Chinn, Menzie D. and Hiro Ito. 2006. "What Matters for Financial Development? Capital Controls, Institutions, and Interactions," *Journal of Development Economics*, Volume 81, Issue 1, Pages 163-192
Cheung, Yin-Wong, and Xingwang Qian. 2009. “Hoarding of international reserves: Mrs Machlup's wardrobe and the Joneses.” *Review of International Economics* 17(4): 824-843.
Christiano, Lawrence J, Motto, Roberto, Rostagno, Massimo. 2014. “Risk shocks.” *American Economic Review* 104(1): 27-65.
Claessens, Stijn, and Luc Laeven. 2003. “Financial Development, Property Rights, and Growth.” *Journal of Finance* 58(6), p.2401-36.
Claessens, Stijn, Hui Tong, and Shang-Jin Wei. 2012, “From the financial crisis to the real economy: Using firm-level data to identify transmission channels.” *Journal of International Economics*, Volume 88, Issue 2, 2012, Pages 375-387.
Di Giovanni, Julian, Şebnem Kalemli-Özcan, Mehmet Fatih Ulu, and Yusuf Soner Baskaya. 2017. “International spillovers and local credit cycles.” National Bureau of Economic Research.
Dippel, Christian, Robert Gold, Stephan Heblich, and Rodrigo Pinto. 2017. “Instrumental Variables and Causal Mechanisms: Unpacking the Effect of Trade on Workers and Voters.” National Bureau of Economic Research (NBER) Working Paper 23209.
Dix-Carneiro, Rafael, Rodrigo R. Soares, and Gabriel Ulyssea. 2018. “Economic Shocks and Crime: Evidence from the Brazilian Trade Liberalization.” *American Economic Journal: Applied Economics,* 10 (4): 158-95.
Dooley, Michael P., David Folkerts-Landau, and Peter M. Garber. 2003. “An essay on the revived Bretton Woods System.” NBER Working paper No. 9971.

Dominguez, Kathryn ME, Yuko Hashimoto, and Takatoshi Ito. 2012. “International reserves and the global financial crisis.” *Journal of International Economics*, 88(2), pp.388-406.

Eberly, Janice, Sergio Rebelo, and Nicolas Vincent. 2009, “Investment and value: A neoclassical benchmark.” NBER working paper No. 13866.

Eberly, Janice, Sergio Rebelo, and Nicolas Vincent. 2012. “What explains the lagged investment effect.” *Journal of Monetary Economics*, 59, 370–380.

Eichengreen, Barry and Andrew Rose. 2014. “Capital controls in the 21st century.” *Journal of International Money and Finance*, 48, pp.1-16.

Forbes, Kristin J., and Francis E. Warnock. 2012. “Capital flow waves: Surges, stops, flight, and retrenchment.” *Journal of International Economics*, Elsevier, vol. 88(2), pages 235-251.

Friedman, Milton, 1953. “The case for flexible exchange rates.” In: essays in positive economics. University of Chicago Press, 157–203.

Gilchrist, Simon, and Charles P. Himmelberg. 1995. “Evidence on the Role of Cash Flow for Investment,” *Journal of Monetary Economics*, 36, 541–572.

Gilchrist, Simon, Sim, Jae W., Zakrajšek, Egon. 2014. “Uncertainty, financial frictions, and investment dynamics.” National Bureau of Economic Research.

Gilchrist, Simon, Vivian Yue, and Egon Zakrajšek. 2014, U.S. “Monetary Policy and Foreign Bond Yields.” paper presented at the 15th Jacques Polak Annual Research Conference Hosted by the International Monetary Fund, Washington DC, November.

Gilchrist, Simon, Vivian Yue, and Egon Zakrajšek. 2019. “US monetary policy and international bond markets.” *Journal of Money, Credit and Banking*, 51, pp.127-161.

Ghosh, Atish R., Jonathan D Ostry, and Mahvash S Qureshi. 2015. “Exchange Rate Management and Crisis Susceptibility: A Reassessment.” *IMF Economic Review*, vol. 63(1), pages 238-276, May.

González‐Rozada, Martin, and Eduardo Levy Yeyati. 2008. “Global factors and emerging market spreads.” *The Economic Journal*, 118(533), pp.1917-1936.

Gourio, Francois, Michael Siemer, and Adrien Verdelhan. 2013. "International risk cycles." *Journal of International Economics* 89(2): 471-484.

Gulen, Huseyin, and Mihai Ion. 2016. "Policy uncertainty and corporate investment." *The Review of Financial Studies* 29(3): 523-564.

Han, Xuehui, and Shang-Jin Wei. 2018. “International transmissions of monetary shocks: Between a trilemma and a dilemma.” *Journal of International Economics*, 110, pp.205-219.

Hansen, Christian B. 2007. “Generalized least squares inference in panel and multilevel models with serial correlation and fixed effects.” *Journal of Econometrics*, 140(2):670–694.

Hayashi, Fumio. 1982. “Tobin's marginal q and average q: A neoclassical interpretation.” *Econometrica: Journal of the Econometric Society*: 213-224.

Hur, Sewon, and Illenin O. Kondo. 2016. “A theory of rollover risk, sudden stops, and foreign reserves.” *Journal of International Economics*, 103, pp.44-63.

Husted, Lucas, John Rogers and Bo Sun. 2019. “Monetary policy uncertainty.” *Journal of Monetary Economics,* in press.

Ilzetzki, Ethan, Carmen M. Reinhart, and Kenneth S. Rogoff. 2019. “Exchange arrangements entering the twenty-first century: Which anchor will hold?” *The Quarterly Journal of Economics* 134(2): 599-646.

Imai, Kosuke, Luke Keele, and Teppei Yamamoto. 2010. “Identification, Inference and Sensitivity Analysis for Causal Mediation Effects.” *Statistical Science* 25(1): 51-71, 21.

IMF. 2010. World Economic Outlook, rebalancing growth. International Monetary Fund.
Jeanne, Olivier. 2016. "The macroprudential role of international reserves." *American Economic Review*, 106(5), 570-73.
Jeanne, Olivier, and Romain Ranciere. 2011. "The optimal level of international reserves for emerging market countries: A new formula and some applications." *The Economic Journal*, 121(555), pp.905-930.
Jens, Candace E. 2017. "Political uncertainty and investment: Causal evidence from US gubernatorial elections." *Journal of Financial Economics* 124(3): 563-579.
Jermann, Urban, and Vincenzo Quadrini. 2012. "Macroeconomic effects of financial shocks." *American Economic Review*, 102(1), pp.238-71.
Julio, Brandon, and Youngsuk Yook. 2012. "Political uncertainty and corporate investment cycles." *The Journal of Finance* 67(1): 45-83.
Kalemli-Ozcan, Sebnem, Elias Papaioannou, and Fabrizio Perri. 2013. "Global banks and crisis transmission." *Journal of international Economics*, 89(2), pp.495-510.
Khan, Aubhik, and Julia K. Thomas, 2013. "Credit Shocks and Aggregate Fluctuations in an Economy with Production Heterogeneity." *Journal of Political Economy* 121(6): 1055-1107.
Kim, Hyunseob, and Howard Kung. 2017. "The asset redeployability channel: How uncertainty affects corporate investment." *The Review of Financial Studies* 30(1): 245-280.
Klein, Lawrence Robert, and Arthur Stanley Goldberger. 1955. "An Econometric Model of the United States, 1929–1952." Amsterdam: North-Holland Publishing Company.
Kose, M. Ayhan, Eswar S. Prasad, and Ashley D. Taylor. 2009. "Thresholds in the process of international financial integration". NBER working paper #14916.
Kroszner, Randall S., Luc Laeven, and Daniela Klingebiel. 2007. "Banking Crises, Financial Dependence, and Growth." *Journal of Financial Economics* 84(1), p.187-228.
Krull, Jennifer L., and David P. MacKinnon. 2001. "Multilevel modeling of individual and group level mediated effects." *Multivariate Behavioral Research*, 36(2), 249-277.
McDonald, Robert, and Daniel Siegel. 1986, "The value of waiting to invest." *Quarterly Journal of Economics* 101, 707–728.
McCauley, Robert N., Patrick McGuire and Vladyslav Sushko. 2015, "Global dollar credit: links to US monetary policy and leverage," *Economic Policy*, vol. 30, no. 82, pp. 187–229.
Mendoza, Enrique G., and Vivian Z. Yue. 2012. "A general equilibrium model of sovereign default and business cycles." *The Quarterly Journal of Economics*, 127(2), pp.889-946.
Merton, Robert C. 1980. "On estimating the expected return on the market: An exploratory investigation." *Journal of Financial Economics* 8(4): 323-361.
Miranda-Agrippino, Silvia and Helene Rey. 2015. "World Asset Markets and the Global Financial Cycle." CEPR Discussion Paper No. DP10936.
Miranda-Agrippino, Silvia and Helene Rey. 2020. "US monetary policy and the global financial cycle." *Review of Economic Studies* 87, 2754–2776.
Morais, Bernardo, José‐Luis Peydró, Jessica Roldán‐Peña, and Claudia Ruiz‐Ortega. 2019. "The international bank lending channel of monetary policy rates and QE: Credit supply, reach‐for‐yield, and real effects." *The Journal of Finance*, 74(1), pp.55-90.
Obstfeld, Maurice. 2014. "Trilemmas and Trade-offs: Living with Financial Globalization." paper presented at the Inaugural Asian Monetary Policy Forum, Singapore (May 2014)
Obstfeld, Maurice. 2020. "Global Dimensions of U.S. Monetary Policy." *International Journal of Central Banking*, vol. 16(1), pages 73-132.

Obstfeld, Maurice, Jay C. Shambaugh, and Alan M. Taylor. 2009. “Financial instability, reserves, and central bank swap lines in the panic of 2008.” *American Economic review*, 99(2), 480-86.

Obstfeld, Maurice, Jay C. Shambaugh, and Alan M. Taylor. 2010. “Financial stability, the trilemma, and international reserves.” *American Economic Journal: Macroeconomics* 2(2): 57-94.

Obstfeld, Maurice, Jonathan D. Ostry, and Mahvash S. Qureshi. 2019. “A tie that binds: Revisiting the trilemma in emerging market economies.” *Review of Economics and Statistics* 101(2): 279-293.

Oehlert, Gary W. 1992. “A Note on the Delta Method.” *The American Statistician* 46(1):27–29

Ostry, Jonathan D., Atish R. Ghosh, Marcos Chamon, and Mahvash S. Qureshi. 2012. “Tools for Managing Financial Stability Risks.” *Journal of International Economics* 88 (2012), 407–421.

Ottonello, Pablo, and Thomas Winberry. 2020. “Financial heterogeneity and the investment channel of monetary policy.” *Econometrica* 88, no. 6: 2473-2502.

Panousi, Vasia, and Dimitris Papanikolaou. 2012. “Investment, idiosyncratic risk, and ownership.” *The journal of finance* 67(3): 1113-1148.

Qian, Xingwang and Andreas Steiner. 2014. “International Reserves and the Composition of Equity Capital Inflows.” *Review of International Economics*, 22(2), pp.379-409.

Qian, Xingwang and Andreas Steiner. 2017. “International reserves and the maturity of external debt.” *Journal of International Money and Finance*, 73, pp.399-418.

Rajan, Raghuram, and Luigi Zingales. 1998. “Financial Dependence and Growth.” *American Economic Review* 88(3), p.559-86.

Rey, Helene. 2015. “Dilemma not trilemma: the global financial cycle and monetary policy independence.” National Bureau of Economic Research.

Rose, Andrew K., and Mark M. Spiegel. 2011. “Cross-country causes and consequences of the crisis: An update.” *European Economic Review* 55(3): 309-324.

Reinhart, Carmen M., Vincent Reinhart, and Christoph Trebesch. 2016. “Global cycles: capital flows, commodities, and sovereign defaults, 1815-2015.” *American Economic Review* 106.5: 574-80.

Sim, Christopher A.. 1980. “Macroeconomics and reality.” *Econometrica*, 48, pp. 1- 48.

Temesvary, Judit, Steven Ongena, and Ann L. Owen. 2018. “A global lending channel unplugged? Does US monetary policy affect cross-border and affiliate lending by global US banks?” *Journal of International Economics*, 112, pp.50-69.

Theil, Henri. 1958. “Economic Forecasts and Policy.” Amsterdam: North-Holland Publishing Company.

Uribe, Martin, and Vivian Z. Yue. 2006. “Country spreads and emerging countries: Who drives whom?” *Journal of international Economics*, 69(1), pp.6-36.

Whited, Toni M., and Guojun Wu. 2006. “Financial constraints risk.” *The Review of Financial Studies* 19(2): 531-559.

Zeev, Nadav Ben. 2017. “Capital controls as shock absorbers.” *Journal of International Economics*, 109, pp.43-67.

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

	OLS			IV	
	(1)	(2)	(3)	(4)	(5)
IRM	0.016***	0.021***	0.041***		0.116**
	(0.004)	(0.004)	(0.007)		(0.054)
ΔVIX	-0.091***	-0.092***	-0.095***	-0.359***	-0.057**
	(0.005)	(0.005)	(0.007)	(0.010)	(0.026)
IRM × ΔVIX					
Swap				-0.078***	
				(0.002)	
Trade_us				-1.253***	0.017
				(0.039)	(0.091)
Ext_debt				0.080***	-0.001
				(0.002)	(0.005)
RGDPG	0.079***	0.073***	0.077***	0.613***	0.045
	(0.015)	(0.015)	(0.017)	(0.026)	(0.043)
Risk profile	0.011***	0.011***	0.002	0.229***	-0.022
	(0.003)	(0.003)	(0.004)	(0.008)	(0.017)
Tobin Q	0.034***	0.034***	0.034***	0.005***	0.032***
	(0.002)	(0.002)	(0.002)	(0.001)	(0.004)
CF	0.018**	0.018**	0.016*	0.000	0.006
	(0.009)	(0.009)	(0.008)	(0.000)	(0.005)
Size	0.007***	0.007***	0.008***	0.001***	0.007***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)
Sales growth	0.022***	0.022***	0.021***	-0.001**	0.048***
	(0.006)	(0.006)	(0.007)	(0.000)	(0.004)
#Obs	196738	196779	167094	38931	38931
R^2	0.108	0.108	0.109	0.142	0.136

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 is used to instrument IRM. All regressions control for the country effect, 3-digid SIC industry sector effect, firm and year effects. Firm level clustered 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	0.017***	0.020***	0.040***
	(0.004)	(0.004)	(0.007)
ΔVIX	-0.088***	-0.091***	-0.095***
	(0.005)	(0.005)	(0.007)
IRM × ΔVIX	0.062***	0.034***	0.102***
	(0.012)	(0.011)	(0.019)
RGDPG	0.077***	0.072***	0.080***
	(0.015)	(0.015)	(0.017)
Risk profile	0.011***	0.011***	0.002
	(0.003)	(0.003)	(0.004)
Tobin Q	0.034***	0.034***	0.034***
	(0.002)	(0.002)	(0.002)
CF	0.018**	0.018**	0.016*
	(0.009)	(0.009)	(0.008)
Size	0.007***	0.007***	0.008***
	(0.000)	(0.000)	(0.000)
Sales growth	0.022***	0.022***	0.021***
	(0.006)	(0.006)	(0.007)
#Obs	196738	196779	167094
R^2	0.108	0.108	0.110

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. All regressions control for the country effect, 3-digid SIC industry sector effect, firm and year effects. Firm level clustered 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 firm heterogeneity in financial constraints

	(1)	(2)	(3)	(4)
IRM	0.033***	0.036***	0.033***	0.019***
	(0.006)	(0.008)	(0.007)	(0.004)
ΔVIX	-0.085***	-0.082***	-0.084***	-0.091***
	(0.005)	(0.005)	(0.005)	(0.005)
IRM × ΔVIX	0.097***	0.161***	0.125***	0.072***
	(0.020)	(0.024)	(0.021)	(0.012)
Ext fin	-0.008***			
	(0.001)			
Ext fin × IRM	-0.026***			
	(0.007)			
Ext fin × ΔVIX	-0.005***			
	(0.002)			
Ext fin × IRM × ΔVIX	-0.059**			
	(0.024)			
Tangi		-0.014***		
		(0.001)		
Tangi × IRM		-0.030***		
		(0.008)		
Tangi × ΔVIX		-0.012***		
		(0.002)		
Tangi × IRM × ΔVIX		-0.140***		
		(0.027)		
WW			-0.020***	
			(0.002)	
WW × IRM			-0.023***	
			(0.008)	
WW × ΔVIX			-0.014***	
			(0.002)	
WW × IRM × ΔVIX			-0.103***	
			(0.025)	
Fin constr				-0.010***
				(0.000)
Fin constr × IRM				-0.018***
				(0.004)
Fin constr × ΔVIX				-0.007***
				(0.001)
Fin constr × IRM × ΔVIX				-0.071***
				(0.012)
#Obs	196738	196738	196738	196738
R^2	0.109	0.111	0.114	0.116

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 the country effect, 3-digid SIC industry sector effect, firm and year effects. Firm level clustered robust errors are in parentheses. ***, **, * denote for 1%, 5% and 10% significance.

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

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Country spread	-0.0004***	-0.0003***	-0.0003***	-0.0004***	-0.0005***	-0.0005***	-0.0003***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
IRM	0.025***	0.039***	0.024***	0.030***	0.008	0.030**	0.020**
	(0.007)	(0.008)	(0.007)	(0.009)	(0.010)	(0.015)	(0.010)
ΔVIX	-0.088***	-0.076***	-0.087***	-0.068***	-0.101***	-0.069***	-0.123***
	(0.006)	(0.008)	(0.007)	(0.008)	(0.010)	(0.015)	(0.011)
IRM × ΔVIX	-0.008	-0.009	-0.021	-0.012	-0.009	0.052	0.015
	(0.022)	(0.028)	(0.023)	(0.029)	(0.033)	(0.050)	(0.032)
#Obs	104368	55842	76466	54563	48526	27902	49805
R^2	0.093	0.093	0.091	0.098	0.123	0.117	0.103
ACME	0.008***	0.005***	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	0.032***	0.044**	0.031***	0.037***	0.019*	0.038**	0.027**
	(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 (5). The "Country spread" variable is the estimated country spreads 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) – (4) report the results for the samples of financially unconstrained firms measured in *Ext fin*, *Tangi*, and *WW*, respectively. Columns (5) – (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 the country effect, 3-digid SIC industry sector effect, firm and year effects. Firm level clustered 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 on firm investment using alternative IRM measurements

	(1)	(2)	(3)	(4)	(5)
IRM	0.015***	0.016***	0.030***	0.042***	0.014***
	(0.004)	(0.004)	(0.009)	(0.007)	(0.003)
ΔVIX	-0.090***	-0.136***	-0.156***	-0.025	-0.156***
	(0.005)	(0.006)	(0.012)	(0.033)	(0.012)
IRM × ΔVIX	0.049***	0.057***	0.068**	0.060**	0.054***
	(0.010)	(0.010)	(0.030)	(0.026)	(0.009)
#Obs	196132	191480	137539	139208	136569
R^2	0.108	0.108	0.104	0.104	0.104

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 the country effect, 3-digid SIC industry sector effect, firm and year effects. Firm level clustered robust errors are in parentheses. ***, **, * denote for 1%, 5% and 10% significance.

Table 6: The effect of IRM on firm investment using alternative measurements for global financial shocks

	S&P500	RORO	Feds rate	US MPU	Crisis&Tapper
IRM	0.016***	0.016***	0.015***	0.015***	0.030***
	(0.004)	(0.004)	(0.004)	(0.004)	(0.005)
ΔAlt_shocks	-0.059***	-0.078***	-0.110***	-1.363***	-0.022***
	(0.003)	(0.004)	(0.006)	(0.077)	(0.002)
IRM × ΔAlt_shocks	0.034***	0.005**	0.010**	0.050***	-0.016*
	(0.006)	(0.002)	(0.004)	(0.009)	(0.009)
#Obs	196738	196738	196779	196779	206792
R^2	0.108	0.108	0.108	0.108	0.081

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&Tapper" 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 the country effect, 3-digid SIC industry sector effect, firm and year effects. Firm level clustered robust errors are in parentheses. ***, **, * denote for 1%, 5% and 10% significance.

Table 7: The effect of IRM on firm investment estimated from various firm and country samples

	(1)	(2)	(3)	(4)	(5)	(6)
IRM	0.026***	0.014**	-0.013	0.061**	0.039**	0.033**
	(0.005)	(0.006)	(0.018)	(0.025)	(0.018)	(0.016)
ΔVIX	-0.121***	-0.079***	-0.194***	-0.111***	-0.110***	-0.079***
	(0.006)	(0.006)	(0.026)	(0.016)	(0.016)	(0.013)
IRM × ΔVIX	0.060***	0.077***	0.161**	0.378***	0.125**	0.092**
	(0.013)	(0.019)	(0.072)	(0.075)	(0.056)	(0.047)
ΔCTOT					0.020	
					(0.020)	
#Obs	222012	99024	22821	22847	22395	24390
R^2	0.079	0.124	0.136	0.096	0.141	0.139

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. Column (5) reports 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 the country effect, 3-digid SIC industry sector effect, firm and year effects. Firm level clustered robust errors are in parentheses. ***, **, * denote for 1%, 5% and 10% significance.

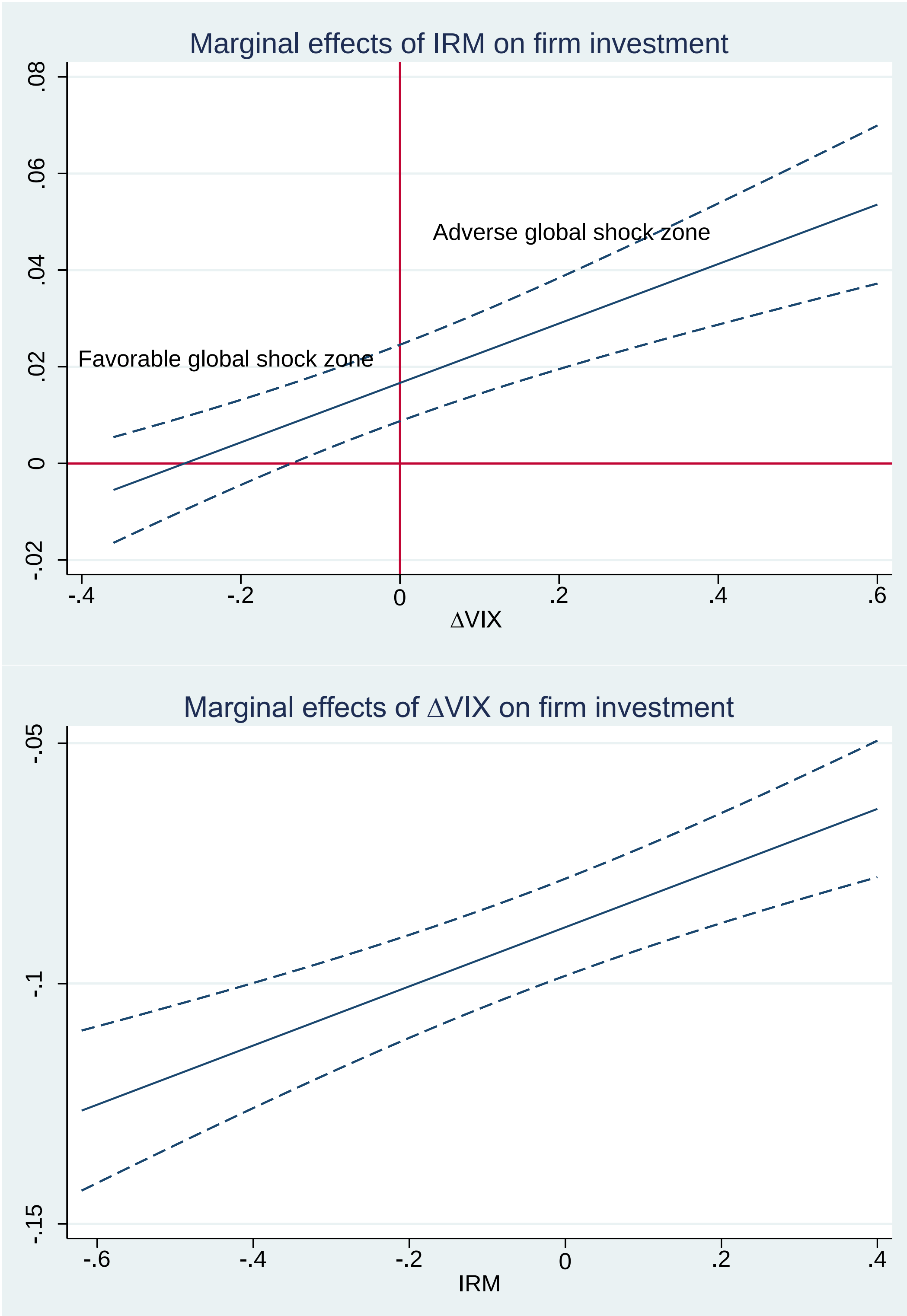
Table 8: The effect of IRM, capital controls, and exchange rate arrangement on firm investment

	(1)	(2)	(3)	(4)	(5)	(6)
IRM	0.004	0.015***	0.016***	0.005	0.017***	0.018***
	(0.005)	(0.004)	(0.004)	(0.005)	(0.005)	(0.004)
ΔVIX	-0.086***	-0.151***	-0.087***	-0.083***	-0.150***	-0.085***
	(0.005)	(0.018)	(0.005)	(0.005)	(0.018)	(0.005)
IRM × ΔVIX	0.042***	0.056***	0.060***	0.053***	0.064***	0.066***
	(0.014)	(0.016)	(0.012)	(0.014)	(0.016)	(0.012)
KC	0.004***			0.004***		
	(0.001)			(0.001)		
KC × IRM	0.035***			0.035***		
	(0.009)			(0.009)		
KC × ΔVIX	0.008***			0.008***		
	(0.002)			(0.002)		
KC × IRM × ΔVIX	0.036			0.021		
	(0.032)			(0.032)		
Xchg		0.017***			0.017***	
		(0.006)			(0.006)	
Xchg × IRM		0.066			0.053	
		(0.103)			(0.102)	
Xchg × ΔVIX		0.030**			0.032**	
		(0.014)			(0.014)	
Xchg × IRM × ΔVIX		-0.132			-0.112	
		(0.251)			(0.248)	
KC&Xchg			0.023***			0.023***
			(0.007)			(0.007)
KC&Xchg × IRM			0.138			0.127
			(0.118)			(0.116)
KC&Xchg × ΔVIX			0.164***			0.163***
			(0.035)			(0.034)
KC&Xchg × IRM × ΔVIX			4.064***			3.929***
			(0.846)			(0.836)

Fin constr				-0.010***	-0.010***	-0.010***
				(0.000)	(0.000)	(0.000)
Fin constr × IRM				-0.018***	-0.020***	-0.020***
				(0.004)	(0.004)	(0.004)
Fin constr × ΔVIX				-0.007***	-0.007***	-0.007***
				(0.001)	(0.001)	(0.001)
Fin constr × IRM × ΔVIX				-0.084***	-0.082***	-0.083***
				(0.013)	(0.013)	(0.013)
#Obs	196738	196738	196738	196738	196738	196738
R^2	0.108	0.108	0.108	0.116	0.116	0.116

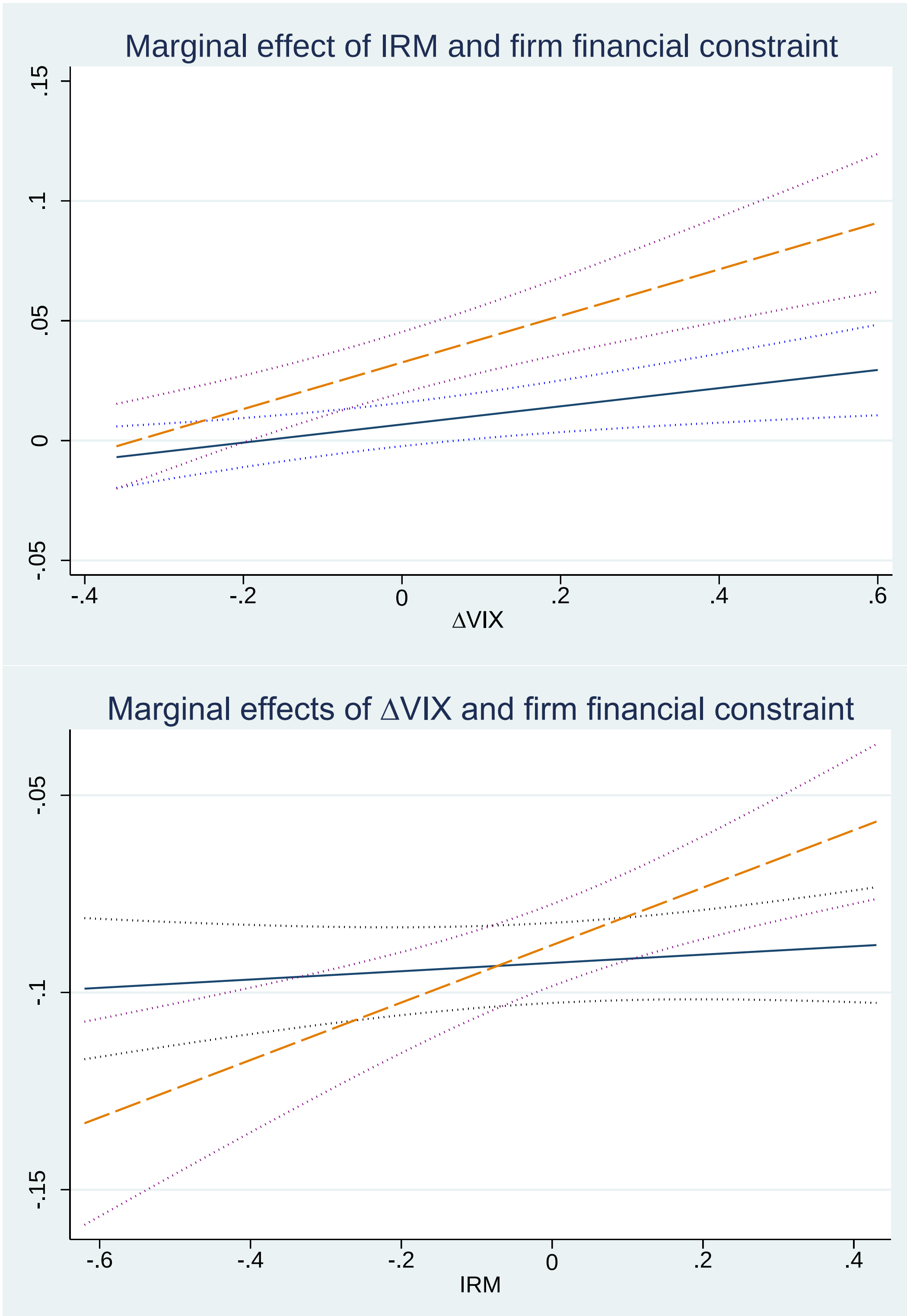
Notes: This table reports the results of regressions controlling for capital controls and exchange rage arrangements. KC is a dummy variable measuring capital control [*KC* = 1 if the Chinn-Ito index < 0.065 (the mean of Chinn-Ito index in our data sample); =0, otherwise]; *Xchg*, a dummy variable, indicates 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 the country effect, 3-digid SIC industry sector effect, firm and year effects. Firm level clustered robust errors are in parentheses. ***, **, * denote for 1%, 5% and 10% significance.

Figure 1: The marginal effects of IRM and ΔVIX on firm investment in the multiplicative model



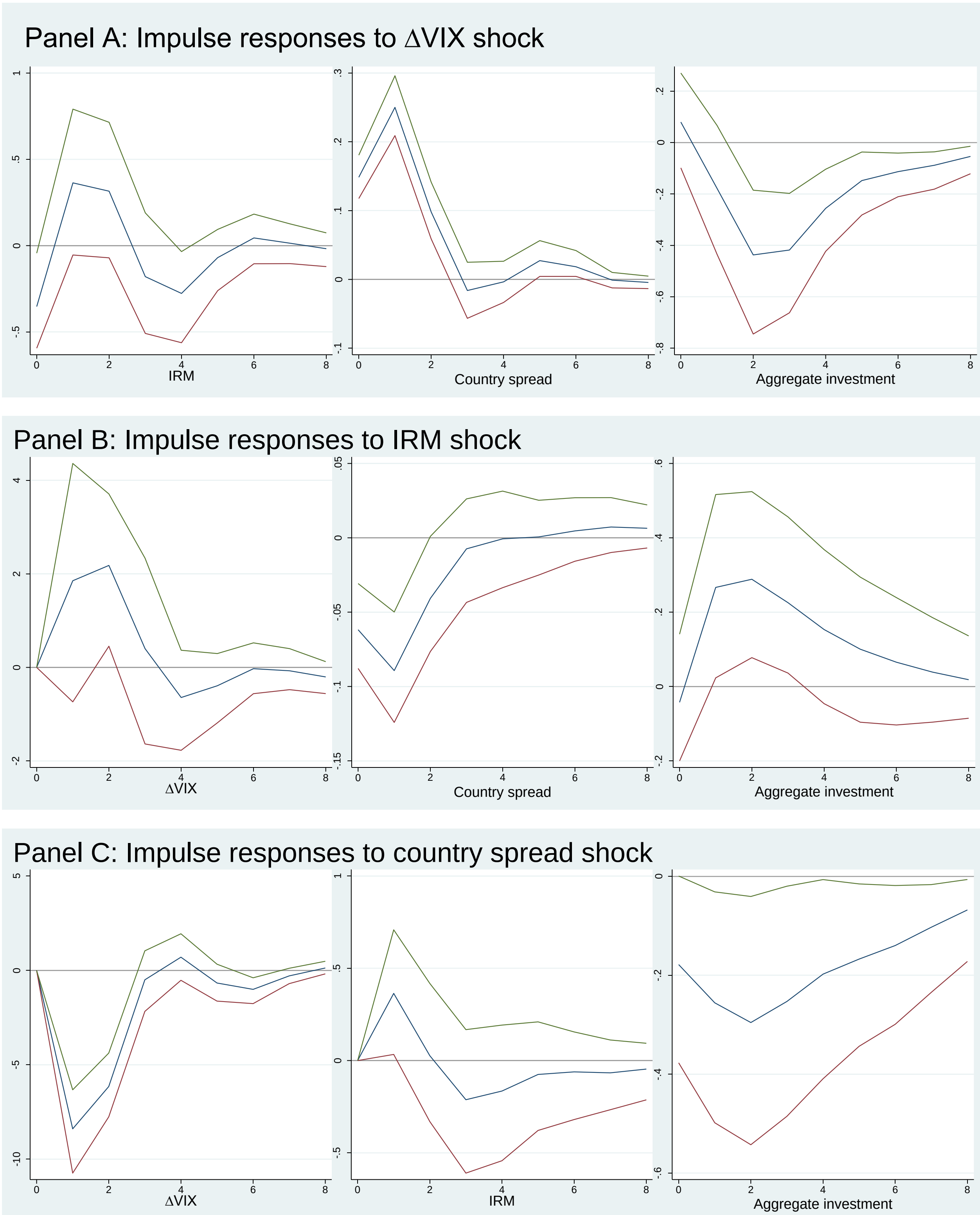
Notes: The upper figure shows the marginal effects of IRM on investment (y scale) at various level of ΔVIX (x scale). The lower figure depicts the marginal effects of ΔVIX on investment at different levels of active IRM. Dashed lines plot 95% confidence intervals.

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



Notes: Solid lines plot marginal effects in financially constrained firms and dashed lines plot marginal effects in financially unconstrained firms. Dot lines are 95% confidence intervals.

Figure 3: The IRF of ΔVIX, IRM, country spreads, and aggregate investment



Notes: This figure reports impulse response to one standard deviation of Cholesky shock with 95% confidence intervals.