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Capital controls and foreign reserves against external shocks: Combined or alone?

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ABSTRACT

Long considered suboptimal, capital controls and FX interventions are now recognized as prudential measures. Yet, whether they are used in combination remains an open question. Thanks to a rich dataset from 1950, we investigate how the response of FX reserves to an exogenous US monetary shock depends on capital controls. The response is insignificant with a very close capital account. By contrast, for a significant number of countries, FX reserves and capital controls are combined to tame the effects of an international financial shock. Yet, as countries open up financially, FX reserves replace capital controls. There is no one-sizes-fits-all recipe.

1. Introduction

Long considered as heterodox and suboptimal policies, capital controls and foreign exchange interventions are coming back to the forefront of the scene as respectable macroprudential policy measures (IMF (International Monetary Fund), 2020). Recent theoretical contributions provide new justifications for both instruments. They highlight their usefulness to mitigate the impact of destabilizing capital flows on the domestic economy and ensure monetary policy autonomy (Jeanne and Korinek, 2010; Schmitt-Grohé and Uribe, 2012, 2017; Farhi and Werning, 2014; Gabaix and Maggiori, 2015; Basu et al., 2020). Whereas standard international macroeconomic models have usually seen them as substitutes (Jeanne and Ranciere, 2011; Scott Davis et al., 2020), the new literature argues that these two tools can reinforce each other (e.g. Gabaix and Maggiori, 2015). However, the empirical question of whether capital controls and FX interventions are used in combination remains open. The new Integrated Policy Framework (IPF) of the IMF (International Monetary Fund) (2020) maintains a pragmatic approach that calls for more research: "optimal combinations depend on country conditions and shocks".

In this paper, we turn this literature to empirics and investigate whether countries with a higher level of capital controls experience a lower decrease in foreign exchange reserves in reaction to an exogenous international shock (i.e. a U.S. monetary policy shock). The purpose of this identification method is to assess if foreign reserves and capital controls are combined when an international shock drives capital outflows. These tools are combined when foreign reserves do react to an international shock in countries with capital controls.

A causal identification of a shock driving foreign reserves is necessary to address current policy issues. Examining the correlation between the level (or growth rate) of foreign exchange reserves and the intensity of capital controls would not provide an answer to the

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current debate on their macroprudential role. Bussière et al. (2015) and Arce et al. (2019) show that reserve holdings tend to be larger in economies with a more open capital account. This stylized fact, however, is uninformative about the actual use of foreign reserves in response to fluctuations in international capital flows and the exchange rate. Countries hold foreign reserves for many different reasons, besides their use as a buffer against international financial shocks (Obstfeld et al., 2010; Aizenman et al., 2015; Bussière et al., 2015; Monnet & Puy, 2020). These different motives can generate spurious correlations between FX reserves and the level of capital controls, unrelated to international financial shocks. In other words, it is possible that countries accumulate reserves but do not use them in response to an international financial shock that depreciates their exchange rate. Only an empirical design examining the evolution of foreign exchange reserves after an exogenous shock can tell us whether or not these reserves are combined with capital controls.

The value of our empirical approach comes from two original features. First, although the literature on the impact of exogenous U. S. monetary policy shocks on foreign countries is now very large (e.g. Dedola et al., 2017; Kalemli-Özcan, 2019; Miranda-Agrippino and Rey, 2020), this is the first paper to investigate the effects of such shocks on foreign exchange reserves. We use this standard identification strategy to tackle the issue of the combination between capital controls and foreign exchange reserves. Second, we use a new quarterly macro-financial dataset built by Monnet and Puy (2021) that covers 35 countries (both advanced and emerging economies) starting from 1950. This long time-span allows us to exploit a lot of within and between variation and heterogeneity in capital controls and exchange rate regimes, which is crucial for panel estimations with country fixed-effects.

We find strong evidence of non-linearity in the combination of capital controls and growth of foreign exchange reserves. In countries with a high level of capital controls, neither foreign reserves nor the foreign exchange rate react to a U.S. interest rate shocks. This finding is consistent with the prediction of the standard *trilemma* of international finance: countries with a closed capital account are protected from the global financial cycle. At the other end of the spectrum, foreign reserves react significantly in countries with an open capital account. In the middle, countries with a moderate level of capital controls show a similar reaction of foreign reserves and the exchange rate as in countries with an open capital account. Hence, countries stabilize their exchange rate using different combinations of foreign reserves and capital controls.

As we are interested in the use of capital controls as a policy variable and we need quarterly data over a long-time span, we use *de jure* measures of capital controls (from Quinn & Toyoda 2008 until 1970 and Chinn & Hiro, 2006, updated to 2018, thereafter). As for exogenous U.S. monetary policy shocks, we follow the standard literature and use the series of Romer & Romer (2004), expanded until 2007 by Miranda-Agrippino and Rey (2020). We also add a specification using the new US monetary policy shocks of Bauer & Swanson (2023) – available over a shorter time span – which leads to similar conclusions about the combination of FX reserves and capital controls. As the US monetary policy shock is built to be exogenous to business cycle developments, we estimate its impact through local projections. Country-fixed effects are estimated over the full sample, while countries can shift from one capital control group to another over time. In all our estimations, we control for the exchange rate regime as well as country-fixed effects and main macroeconomic variables (real GDP growth, inflation rate, credit growth, exchange rate).[1]

After presenting our main result, we provide a series of robustness checks. First, we add interest rates as control variable (it is not included in the baseline regression since the historical interest rate data are more limited). Second, we change the perimeter of the groups according to different definitions of capital controls. Third, we construct a new pseudo-exogenous measure of US monetary policy shock before 1969 (the year when the series of Romer & Romer starts) and thus include the 1950–1960s into the estimation sample. These changes do not modify our findings significantly. Fourth, we conduct the same estimations using the new IMF dataset on foreign exchange interventions starting in the 2000s (Adler et al. 2021). Using this variable also enables to control for potential biases related to valuation effects (i.e. the nominal changes in FX reserves due to movements in the prices of foreign securities and exchange rates rather than actual sale or purchase of reserves). This different dataset includes more countries but on a shorter time span. We find results that are consistent with our previous estimation.[2] Last, we provide evidence that *de jure* measures of capital controls do not react significantly to US monetary policy shock. It means that our main results are not driven by countries shifting from one capital control group to another in response to a US shock.

Our results thus reframe the debate on the relationship between the use of capital controls and foreign exchange reserves. On one hand, there is evidence that the two are often combined: a large number of countries (1/3 of our sample) have capital controls and experience a fall in foreign reserves after a U.S. interest rate shock. On the other hand, we find that countries rely more exclusively on foreign reserves as they open their capital account. Overall, our findings highlight the diversity across countries and thus support the new pragmatic approach of the IMF (International Monetary Fund) (2020) regarding the combination of capital controls and FX interventions.

Our identification strategy does not allow a precise distinction of the different factors explaining the reaction of the exchange rate to a US monetary policy shock. Yet, it is remarkable that the different sets of estimations show a similar reaction of the exchange rate between countries that rely exclusively on FX interventions and those that combine both tools (for a given level of exchange rate regime). If anything, when using the Adler et al. (2021) dataset, we find that combining both tools lead to a more muted reaction of the

[1] We control for the exchange rate regime using the de facto measure of Ilzetzki, Reinhart and Rogoff (2019). According to this measure, a country is fully floating if the exchange rate is very volatile, shows no difference across markets and is thus not affected by FX interventions. For this reason, we also find that countries that have a fully flexible de facto exchange rate regime do not use FX reserves (results not presented here). As Ilzetzki et al. (2019) remind us, such a flexibility concerns a minority of country even today.

[2] The topic of our paper is how all foreign reserves react to an international shock, that is the buffer role of these reserves. This is different from the literature on the effectiveness of exogenous foreign exchange interventions (Fratzscher et al. 2019, Arango-Lozano et al. 2020, Naef 2020).

exchange rate. Hence, in terms of efficiency, there is no *one sizes fits all* recipe either.

Another interesting result emerges when we separate the intermediate capital controls group into two subgroups. The subgroup of countries with a more open capital account (within the intermediate capital account openness group) shows no significant response of foreign exchange reserves while the exchange rate responds twice as much as in the other group. This suggests that, in countries with intermediate levels of capital controls, such controls may indeed require a response from foreign reserves to be fully effective. Other things being equal, countries that liberalize their capital accounts, but not yet fully, and stop using foreign exchange reserves, are those that suffer a stronger exchange rate response to the U.S. monetary policy shock. In contrast, countries that have fully liberalized their capital account still allow their foreign exchange reserves to react and thus manage to achieve a more moderate reaction of their exchange rate.

The literature on the determinants and consequences of capital controls is large (see Erten et al., 2019 for a recent survey). In this paper, we take the choice of capital controls as given. We justify this choice by showing that the *de jure* index of capital controls does not react to the US monetary policy shock (see also Arce et al., 2019). Thus, our results do not imply that countries with moderate capital control could achieve the same outcome if they would abolish these controls and rely on foreign exchange interventions only. The main conclusion drawn from our study is that some countries need both tools while others need only one to achieve the same outcome that is a similar reaction of the exchange rate to a U.S. monetary policy shock (conditional on the exchange rate regime). In our view, these conclusions support the recent approach of the IMF stating that the optimal choice and combination of these instruments may depend on countries' characteristics and exposure to shocks. It thus paves the way for further research investigating the nature of such characteristics and shocks.

Our paper speaks to three strands of literature. First, the literature on the complementarity or substitutability between capital controls and foreign reserves has been mostly theoretical. The influential paper of Gabaix and Maggiori (2015) states that the combination of FX interventions and capital controls increases the potency of the former because the latter exacerbate financial imperfections, thus further segmenting the currency market.[3] This argument has then been extended and integrated in a general equilibrium framework by Cavallino (2019), Fanelli and Straub (2019) and Basu et al. (2020). Basu et al. (2020) show that capital controls and FX interventions reinforce each other while having separately the same macroeconomic effects in response to a shock on capital flows (but through different channels). They do not discuss under which precise conditions these tools should be combined. Conversely, Arce et al. (2019) provide a model where more stringent capital controls make international reserves less needed.

An important empirical contribution on the matter preceded the development of this theoretical literature: Bussière et al. (2015) studied the relationship between capital controls and foreign reserves. Their method was very different from ours however. They looked at the impact of the 2008–2009 financial crisis on countries' GDP and find countries with a high level of foreign reserves suffered less from the crisis, particularly when associated with a less open capital account. Compared to their article, our work covers a much longer time span and uses a different methodology that focuses on the actual use of foreign exchange reserves in reaction to an exogenous shock on the exchange rate, rather than the link between the level of foreign reserves and GDP. Most important, our work is based on a precisely identified international financial shock and thus addresses directly the issues raised by the recent IMF's Institutional policy framework. That being said, both studies highlight the fact that FX reserves and capital controls are not mutually exclusive, at least for certain countries. Rincón and Toro (2010) also studied empirically the link between capital controls and foreign exchange interventions in the case of Colombia in 2008–2009 and find that the tools were more effective on the exchange rate when they were combined together. Acharya and Krishnamurthy (2018) reached the same results when studying the case of India between 2004 and 2014. Compare to these two papers, we present general evidence that the combination of both tools has been the norm for many countries that faced an international interest rate shock, and over a very long time span since the Second World War.

Our work is also directly related to the papers that investigate the impact of U.S. monetary policy on foreign countries (e.g. Rey 2015; Dedola et al. 2017; Kalemli-Özcan 2019). The depreciation of the domestic currency relative to the dollar is already a robust and well-known result in this literature. Our straightforward contribution to this literature is to use an exogenous monetary policy shock to investigate the joint impact of the exchange rate and foreign exchange reserves. Such empirical strategy had been previously used only for historical periods, pre −1914 in Bazot, Monnet, Morys (2019). Miniane and Rogers (2007) and Dedola et al. (2017) investigated whether capital controls were able to isolate domestic GDP or financial variables from US monetary policy, and found that the degree of capital controls did not matter. Yet, they separated financial openness in a dichotomous manner and did not study the behavior of FX reserves.

We contribute to the literature on the effects of global financial cycle on domestic financial systems (starting with Rey, 2015) by highlighting the various strategies countries can use to tame (partly) these adverse effects. Since our empirical results are conditional on the exchange rate regime, it is implicit that the exchange rate system alone is not enough to isolate countries against those shocks.

We present our empirical strategy in Section 1 and our dataset in Section 2. Key results appear in Section 3 and robustness checks in Section 4. The conclusion discusses policy implications.

1.1. Empirical strategy

1.1.1. Theoretical framework

The new theoretical and policy literature on capital controls and FX interventions emphasizes their macroprudential role "*to help*

[3] An earlier literature had previously shown that the effect of foreign-exchange interventions depends on the degree of imperfections on the bond market (e.g Dominguez and Frankel 1993).

countries respond to fluctuations in international capital flows" (IMF (International Monetary Fund), 2020). A challenge for empirical work is to show that these tools are indeed used for this purpose. It is especially true for foreign exchange reserves, as it is well-known that reserves are held for many different reasons: countries hold them as a share of their trade with the rest of the world to protect against devaluation, for mercantilist reasons, habits, to protect their banking system or to catch-up with neighbouring countries (Obstfeld et al., 2010; Aizenman et al., 2015; Jeanne and Sandri, 2023; Monnet and Puy, 2020). Thus, we cannot assume that a large level of foreign reserve holding implies that countries are using them to tame the effect of international capital flows on the domestic economy. It can even be argued that, if capital controls are enough to isolate a country from an international financial shock, FX interventions are useless and FX reserves are used for other purposes.

To address this empirical challenge, we rely on an identification strategy that has been widely used in the literature on global financial cycles but not yet in the literature on foreign exchange reserves. Following the seminal work of Hélène Rey (see also Dedola et al., 2017; Kalemli-Özcan, 2019; Miranda-Agrippino & Rey, 2020; Monnet & Puy, 2021), we consider that an exogenous U.S. monetary policy shock is an international financial shock that drives capital flows and credit cycles in other countries. As documented in this literature, an unexpected increase in the U.S. monetary policy rate attracts capital flows to the U.S. and thus depreciates foreign exchange rates relative to the dollar. Such US-driven fluctuations in international capital flows are exactly the type of shocks that FX interventions and capital controls are supposed to tame in the new Integrated Policy Framework of the IMF (International Monetary Fund) (2020).

We use the standard narrative measure of monetary policy shock by Romer and Romer (2004), extended to 2007 in Miranda-Agrippino and Rey (2020), as it is the only exogenous measure of U.S. shocks that covers a sufficiently long period.[4] We expect that, as documented in the global financial cycle literature (Rey, 2015; Dedola et al., 2017; Kalemli-Özcan, 2019; Miranda-Agrippino and Rey, 2020), the exchange rate reacts to this shock in countries that are relatively open financially. The question we ask is whether foreign exchange reserves also react to tame the effect on the exchange rate, and whether their reaction depends on the level of capital controls. The evolution of FX reserves in response to a foreign shock can either be driven by voluntary FX interventions of the central bank to stabilize the exchange rate, or by autonomous demand of banks that decide to convert their domestic currency into dollars to benefit from the higher US interest rate.

1.1.2. Estimation method

We aim at estimating and tracing over time the effect of an exogenous U.S. monetary policy shock on the foreign reserves, for a given exchange rate regime, and considering other macroeconomic shocks and country characteristics. For this purpose, we use impulse response functions (IRFs) through local projections (Jordà, 2005).

Local Projection IRFs has been widely used in the literature on the effect of external monetary shock (Jordà et al., 2020a; Schularick et al., 2021). New evidences also highlight that local projections are asymptotically valid uniformly over (i) both stationary and non-stationary data, and also over (ii) a wide range of response horizons; having the desirable property of being potentially robust to misspecification and fit properly to large samples (Montiel Olea & Plagborg-Møller, 2021). Furthermore, local projection is particularly desirable for panel analyses since it easily allows for fixed-effects specifications and thus to take into account group heterogeneity through state-dependent estimates.

Our baseline equation is as follows:

$$Y_{i,t+l} = \beta_l X_{i,t-p} + \varnothing_l K_{t-1} + \delta_l r_t^{US} + \alpha_i + \varepsilon_{i,t+l} \tag{1}$$

Where Y is our variable of interest expressed in percentage change. l ∈{0:4 quarters} is the horizon of projections. X is a set of country specific macroeconomic control variables, which includes for the baseline specification the growth rate of changes in foreign reserves, the growth rate of exchange rate, inflation rate, credit growth and real GDP growth. p ∈{1:4 quarters} indicates the time lag used in the model. As usual in the literature (Jordà, 2005), we used four lags for these macroeconomic variables to take into account the full business cycle.

K includes some other control variables, for which it is sufficient to use only one lag. K includes the exchange rate regime, an index of capital account openness, the level of country reserves relative to imports and the change in the trade balance. K also includes the three-month Treasury-bill rate, to control in particular for the valuation effects in the reserves, and a U.S. cycle variable calculated from the U.S. output gap. This variable is a proxy for the global business cycle.[5] r_t^{US} is the exogenous U.S. monetary shock variable (namely, the Romer and Romer shock). α_i is the country- fixed effect.

We then check how countries respond to the U.S. monetary shock according to their level of capital controls, i.e. whether their response is homogenous or heterogeneous. We re-estimate our baseline Eq. (1) above, making the distinction between three groups of countries, according to the strength of their capital controls. The estimator for each subsample is estimated by an interaction between our variables of interest (the growth of foreign exchange reserves and exchange rate) and a dummy variable that equals 1 when the

[4] Romer and Romer (2004) used archival records to infer the Federal Reserve's target of federal funds rate, the leading US monetary policy rate. This series is regressed on the Federal Reserve's internal forecasts of inflation, GDP and interest rates to derive a measure free of systematic monetary policy responses to business cycle developments. It thus captures a reaction of the central bank that is exogenous to future economic developments. As the federal funds rate stopped being used as the main policy variable of the Federal Reserve after the Global Financial Crisis of 2008, the series cannot be extended after this date.

[5] Using the global real business cycle of Monnet & Puy (2021) does not change the results.

country belongs to one of the three groups. Thus, the model is estimated using the full sample, but an impulse response function is calculated for each group thanks the interaction variable (Jordà et al., 2020b; Cezar et al., 2020). Our second equation to estimate the IRFs for each subgroup of countries is as follows:

$$Y_{i,t+l} = \sum_{g \in G} \left(\beta_l^g X_{i,t-p} + \alpha_l^g r_t^{US} + \varnothing K_{t-1} + \alpha_i \right) + \varepsilon_{i,t+l} \quad (2)$$

Where g ∈ G accounts for the grouping of countries according to the strength of their capital control measures (cf next section). Fixed effects are time variant and change according to the allocation of countries in each group. Note that in this equation, results are controlled for the contemporaneous level of capital controls by our interaction term g in addition to its lag (included in K). We use clustered standard errors at the country level.[6]

2. Data

2.1. Macroeconomic data

Our database consists of a quarterly panel of 35 advanced and emerging countries during the period between 1969 and 2007. The starting and ending dates of 1969 and 2007 are imposed by the availability of the Romer shocks. Yet, we will present results with a sample starting in 1950, using our own extension of U.S. policy shocks before 1969 (see below). The choice of such a long window allows to follow the sample over a multitude of periods when countries have experienced several external shocks, different monetary systems and exchange rate regimes. In addition, almost all countries changed their level of capital control measures in their capital account during the period. Results are thus not attributed to a specific event or circumstance, and we truly exploit the within-variation for a given country, instead of a cross section.

We use the dataset of Monnet & Puy (2021) that includes quarterly data on real GDP, bank credit and consumer prices inflation since 1950. This dataset was recently constructed and made available by these two authors using historical paper volumes of International Financial Statistics (from the IMF). These macroeconomic variables are essential to control for aggregate real and nominal fluctuations in our estimations. We merge this new dataset with historical data that had already been digitized and published online by the *International Financial Statistics*: exchange rate (in U.S. dollar), foreign exchange reserves (in U.S. dollar) and trade (imports and exports in U.S. dollar). We use the growth rate of these variables in our estimations.

2.2. Foreign exchange reserves

We use a comprehensive definition of FX reserves in order to account for all reserves that may react to international financial shocks and thus affect the balance sheets of financial intermediaries and the exchange rate. These are all official reserves declared by countries to the IMF. These are assets denominated in foreign currency, readily available to and controlled by monetary authorities. They include gold, reserve position in the IMF (i.e. the reserve tranche and/or any loan to the IMF that is readily available to the member country), special drawing rights (SDR) and foreign exchange reserves, that is assets held in foreign currencies (banknotes, bank deposits, bonds, treasury bills, and other government securities). Gold reserves are valued at a fixed price, rather than market price (to ensure that our results are not driven by the changes in the gold market price). Our results are not sensitive to the exclusion of gold reserves but we include them since our sample covers the Bretton Woods period. All reserves are valued in dollar.

2.3. Capital account openness

Data on the strength of capital control measures came from two different sources: Quinn & Toyoda (2008) for the period from 1950 to 1970 and the 2020 update of Chinn and Hiro (2006) dataset for the period between 1971 and 2018. The combination of these two datasets is necessary to obtain a measure of capital controls over our full sample, since the Quinn & Toyoda index stops in 2004 while Chinn & Ito starts in 1971. Both are *De Jure* indicators based on the IMF Annual Report on Exchange Arrangements and Exchange Restrictions (AREAER). The former is a text-based indicator; whereas the latter is constructed by the first principal component of four quantitative variables, namely the existence of multiple exchange rates, restrictions on current account, capital account transactions, and the existence of requirements of the surrender of export proceeds (Quinn et al. 2011). While we are aware that *de jure* indicators are limited, it is the only consistent methodology that allow us to use a measure of capital controls since 1950.[7]

We adopted the same Chinn-Ito five-level classification to assess the level of financial openness as their database covers most of our analyzed period. To make both indicators compatible for the whole period, we share the entire range of the Quinn-Toyoda indicator into five equal bands and assigned each country to the level corresponding to their indicator. Countries are then divided into three groups according to their degree of financial openness (see Table 1). Group 1 is composed of countries ranked 1 and 2 in our indicator, considered as closed economies. Those countries are in the bottom two quintiles of the distribution of the financial openness

[6] Driscoll and Kraay standard errors, instead of those with clusters at the country level, are slightly larger but do not change the interpretation of the results.

[7] Alternative de facto measures based on capital flows are usually available since the early 2000s only (Pasricha et al. 2018).

Table 1
Descriptive statistics by group of countries according to their financial openness index.

	Observations	Number of countries	Mean	Standard-deviation	Max	Min
	Group 1					
Reserves to imports	2752	30	1.33	0.97	8.53	0.109
FXI			2.7%	12.7%	78%	−54.8%
FX regime			3.1	1.8	6	1
FX			4.1%	13.1%	222%	−20.4%
GDP real growth			1.1%	1.9%	16.9%	−14.3%
Credit growth			6.5%	11.9%	159%	−47.0%
	Group 2					
Reserves to imports	2521	33	1.21	0.79	6.13	0.183
FXI			2.8%	10.6%	52.0%	−74.2%
FX regime			3.7	2.1	6	1
FX			1.2%	5.7%	61.1%	−15.7%
GDP real growth			1.0%	1.6%	10.8%	−14.4%
Credit growth			3.8%	5.6%	39.1%	−27.7%
	Group 3					
Reserves to imports	2050	26	1.15	0.85	5.83	0.0291
FXI			1.0%	9.2%	76.4%	−96.0%
FX regime			4.8	1.9	6	1
FX			0.2%	7.0%	168.0%	−57.2%
GDP real growth			0.8%	1.2%	9.0%	−7.9%
Credit growth			2.5%	2.7%	25.1%	−21.5%

FX regime: 6 = free floating, 1 = least flexible.
Note: FX regime comes from the last update of Reinhart and Rogoff (Ilzetzki et al. 2019), and is recalculated by authors in a matter that indicators value increases with the degree of exchange rate floating (1: least flexible and 6: freely floating). FXI stands for the growth rate of foreign reserves and FX for the growth rate of the exchange rate.

classification. Group 2 is composed of countries with an intermediate indicator (level 3 and 4) and are considered as semi-open economies. They are situated in the third and fourth quintile of the distribution. Finally, Group 3 recovers countries with the highest indicator level (5) and make up the group of open economies. This last group corresponds to the top quintile of our indicator.

Groups differ according to the level and average changes of their foreign exchange reserves (Table 1). On average over the period, countries can use their foreign reserves to finance a few more than one quarter of imports. Group 1 has the largest amount of reserves to imports, followed by Group 2, while open economies are those with the smallest reserves. Note that the most closed countries are also those holding relatively the most foreign reserves, which demonstrates the relevance of our identification method (cf previews section).

Furthermore, the growth rate of foreign reserves (FXI, which is our proxy for foreign exchange interventions in our baseline model) is on average of a similar size between Groups 1 and 2. In contrast, it is lower in Group 3, which might suggest that this group rely on FX interventions to a limited extent.

Such figures shall also be related to the volatility of exchange rates (measured in the table by the average of their growth rate and their standard deviation); which is higher in Group 1 and decreases as the degree of financial openness increases. Countries in Group 1 are more likely to be peggers (see below) but they might adjust their exchange rate so that the volatility of this variable is eventually higher than in the countries in Group 3 that are more likely to float. Exchange rate for Group 3 was comparatively highly stable over the period.

Another interesting aspect regards the exchange rate regimes. Based on the latest update of Reinhart and Rogoff's classification (Ilzetzki et al., 2019), the liberalization of the capital account is coupled with the flexibilization of the exchange rate regime. Group 3 have thus an average index of 4.8 (6 being the free-floating regime); while this same index equals 3.7 for Group 2 and 3.1 for Group 1 (1 indicates the least flexible regime). Yet, as emphasized by Ilzetzki et al. (2019), an exchange rate float remains an exception, even for countries with an open capital account. Group 3 cannot therefore be equated with a purely floating exchange rate regime, and there is significant heterogeneity in exchange rate choices within this group of countries without capital controls.

3. Key results

3.1. Full sample

Results from the estimation of Equation (1) are presented in Fig. 1. They show the impulse responses of our variable of interest – namely the growth rate of foreign reserves – and a set of dependent variables in reaction to an exogenous U.S. monetary shock. Our results thus provide evidence on the use of foreign reserves as a policy tool in a specific situation of protecting domestic economies from an exogenous external shock.

The results are consistent with theory and standard literature on the impact of U.S. shocks on the global financial cycle. Foreign exchange reserves experience a fall after an exogenous U.S. interest rate shock. Simultaneously, the exchange rate responds by depreciating against the U.S. dollar; and credit becomes tighter. Finally, this negative shock results in a decrease in real GDP. Note that

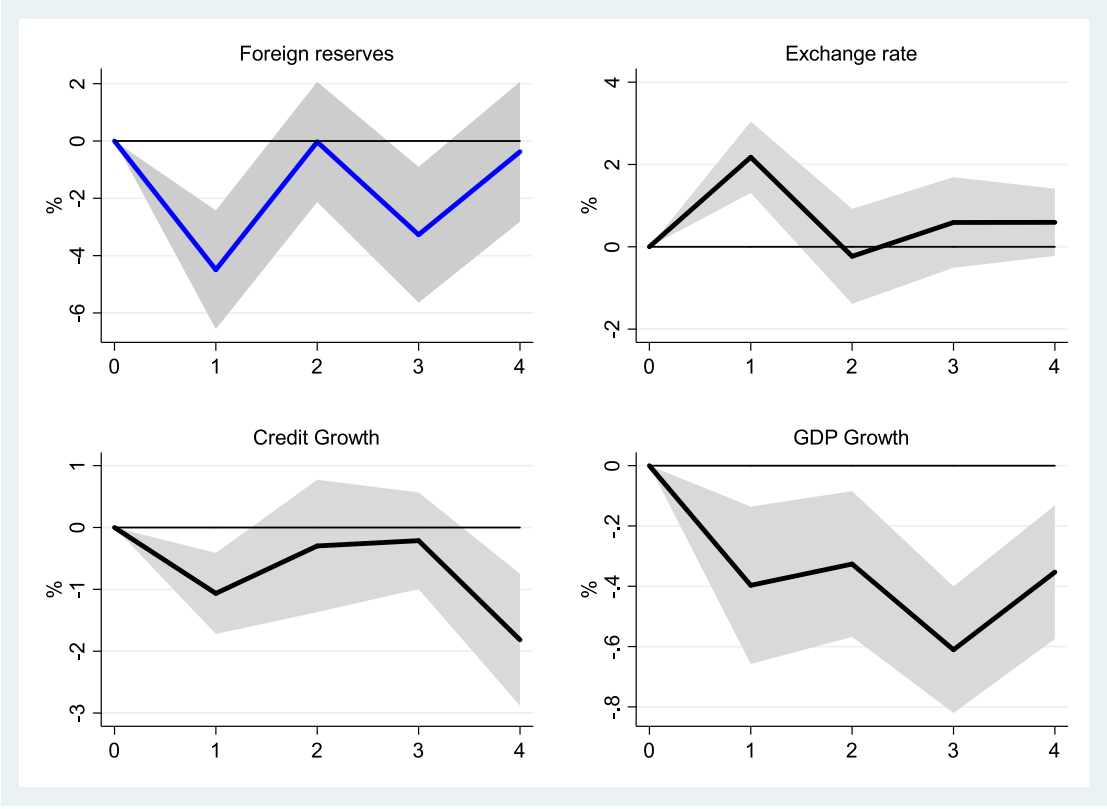

Fig. 1. Responses of foreign reserves, exchange rate, credit and GDP to a 100 basis-point shock to US monetary policy interest rate (1969–2007). Shaded areas denote 90 percent confidence bands with standard errors clustered by country. The shock occurs in t = 1. Time periods are measured in quarters.

the change in foreign exchange reserves seem to be effective to stabilize the exchange rate, as both variables rapidly return to their initial level, two quarters after the shock. However, the effect on GDP is slightly delayed and an improvement is only observed three quarters after the shock.

This first set of results gives a broad picture of the relationship we are interested in, and ensure the consistency of our identification procedure with the results found in the literature. Although no other work has focused on the effect of a U.S. monetary shock on changes in foreign exchanges reserves, others have addressed the impact of such a shock on a multitude of macroeconomic variables (Dedola et al. 2017; Miranda-Agrippino and Rey, 2020; Miniane and Rogers, 2007; Bazot et al., 2022).

3.2. Three groups

Thereafter, we test for the heterogeneity of the response to the exogenous external financial shocks in relation to the degree of capital control. Indeed, despite the overall results presented above, the response of reserves to an external shock may vary significantly depending on the strength of the financial openness of each country.

Fig. 2 presents the results of the estimation of Eq. (2) when the growth rate of foreign reserves and exchange rates are used as dependent variables. Groups are defined according to the degree of financial openness; Group 1 being composed of the most closed economies (harshest capital control measures), whereas Group 3 recovers the most open economies (see previous section).

Foreign exchange reserves respond differently depending on the level of capital controls employed by countries. Specifically, foreign reserves in countries with the strongest level of capital controls (the bottom two quintiles of the distribution) do not significantly respond to an exogenous rise in U.S. interest rates. In contrast, the Group 3 of the most open economies (top quintile) and Group 2 of an intermediate degree of openness (the third and fourth quintiles) respond to the same shock by a negative change in reserves. The response during the first period after the shock is stronger for Group 2 (−6.8%) than for Group 3 (−4.5%), but the difference is statistically small.

The same heterogeneity is also reflected in the response of exchange rates to the shock. While currencies of Group 2 and 3 depreciate in the period following the shock (coefficients in period 1 equal 2.7 and 2.8 respectively), the response of Group 1 (i.e. closed economies) is not significantly different from zero during the same period.

These suggest that the different strategies adopted by countries - using one or both tools combined - seem to be effective in counting

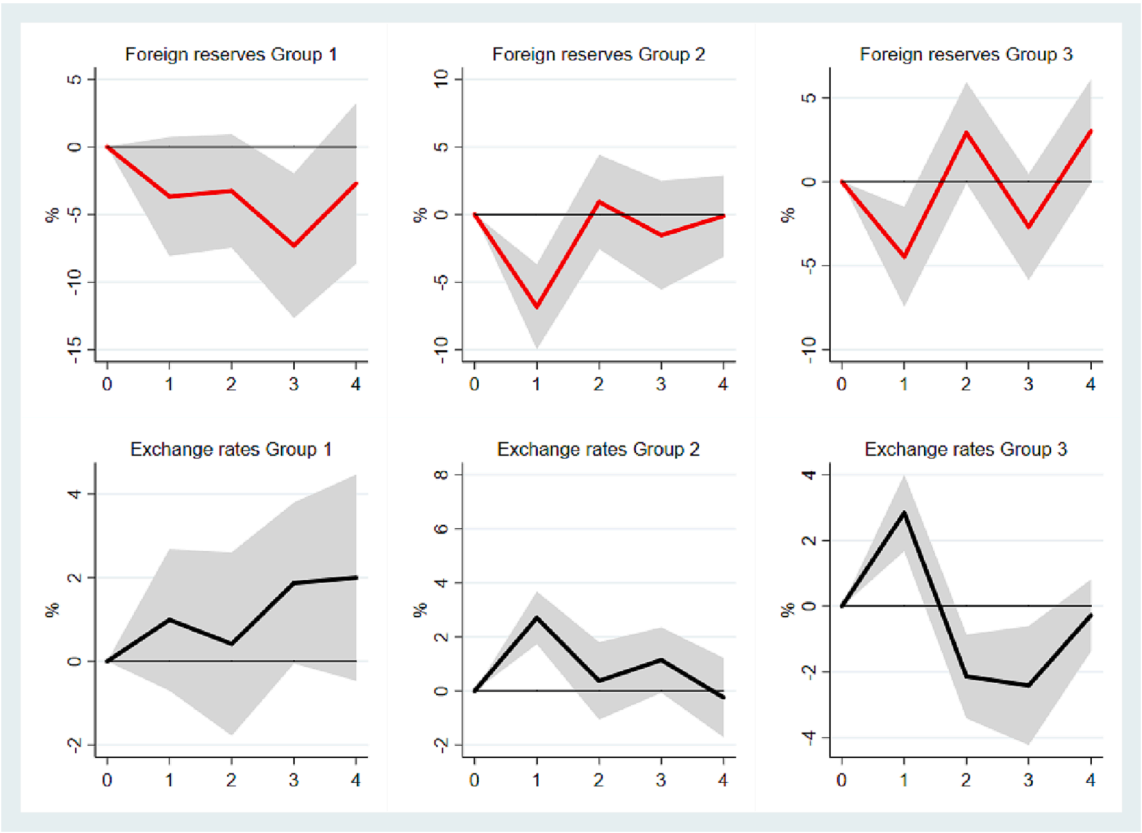

Fig. 2. Responses of foreign reserves and exchange rates, by capital control group, to a 100 basis-point shock to US monetary policy interest rate (1969–2007). Shaded areas denote 90 percent confidence bands with standard errors clustered by country. The shock occurs in t = 1. Time periods are measured in quarters. For details on Groups, see section II.C.

the effects of international shocks on their economies. During the period, relatively closed capital accounts seem to protect exchange rates from such international shocks since we do not find any significant impact for Group 1. For the other two groups of economies, the exchange rate response is temporary and opposite movements are observed in the period following the first impact of the shock, with a rapid return to the initial level. Movements in exchange rates for these both groups are similar, suggesting that both strategies are equally effective in dealing with an external shock.

Results give rise to a twofold interpretation. On one hand, t foreign exchange intervention and capital controls are combined in Group 2 (i.e. for approximatively 1/3 of our sample): countries have implemented capital controls and experience a fall in their foreign reserves after an exogenous U.S. interest rate shock. These countries use both macroprudential tools simultaneously in reaction to an external shock. FX reserves and capital controls are thus combined in these countries. On the other hand, for groups 1 and 3, foreign exchange reserves and capital controls are substitutes: countries rely exclusively on capital controls (Group 1) or foreign reserves (Group 3) according to the level of opening of their capital account. In other words, there is evidence of combination of FX reserves and capital controls for the intermediate group, but substitutability for the two groups at the opposite of the spectrum.

3.3. Five groups

In order to delve deeper into the varying responses to U.S. monetary policy shocks among countries with different capital control levels, we refine our analysis by shifting from three groups to five.

Fig. 3 illustrates the findings of Eq. (2)'s estimation, employing the five-group classification based on financial openness as per the Chinn & Ito index. Group 1 encompasses the most closed economies with the strictest capital controls, whereas Group 5 includes the most open economies. The intermediate groups (Groups 2, 3, and 4) represent the gradations of capital account openness between the two extremes, offering a broader perspective on the impact of financial openness levels on countries' responses to external monetary policy shocks.

An interesting finding emerges when we divide the intermediate capital controls group (former Group 2) into two distinct subgroups (Groups 3 and 4 in Fig. 3). The subgroup consisting of countries with a more open capital account (within the intermediate capital account openness group), i.e. new Group 4, exhibits no notable changes in foreign exchange reserves following the shock, while their exchange rates demonstrate a response twice as strong as the one of Group 3. This implies that for countries with intermediate

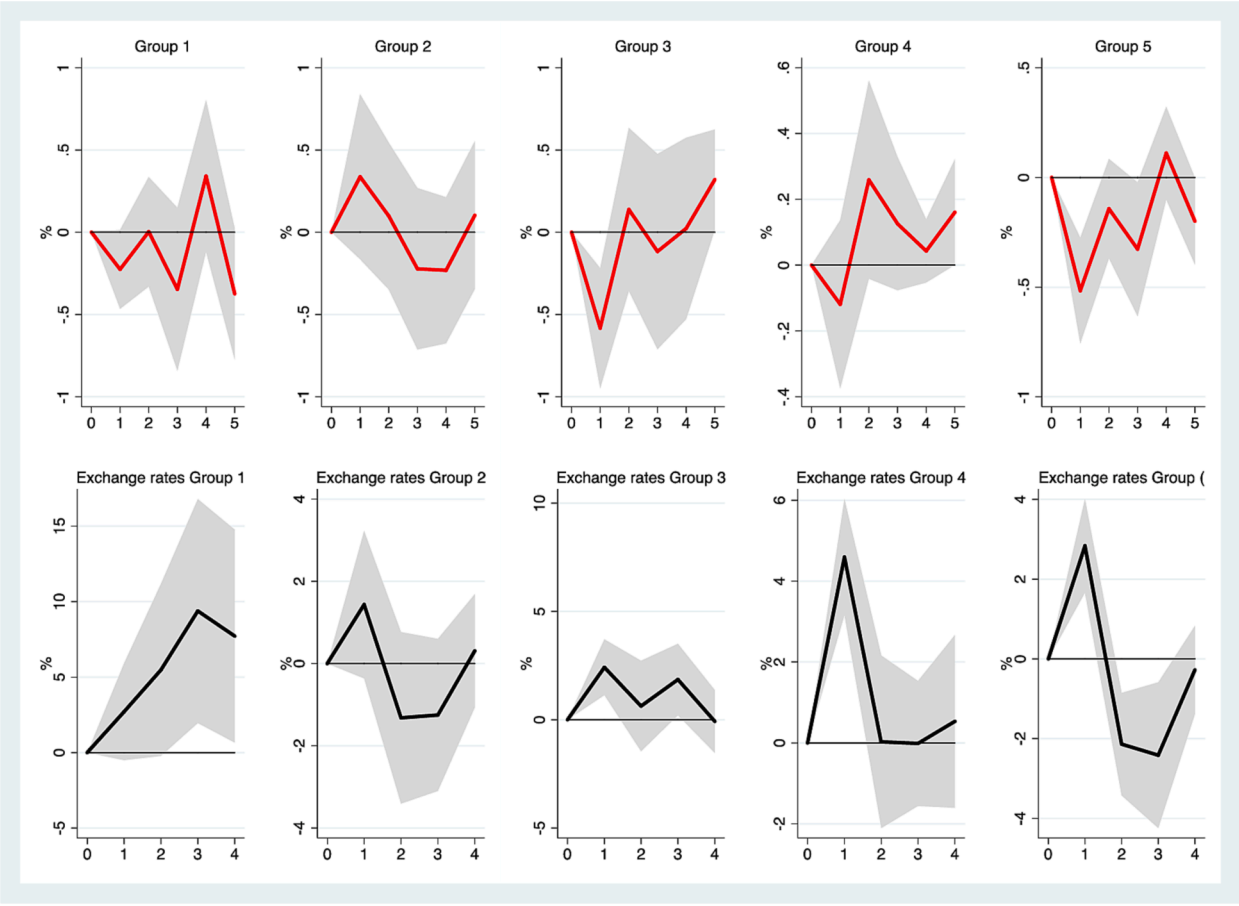

Fig. 3. Responses of foreign reserves and exchange rates, by capital control group, to a 100 basis-point shock to US monetary policy interest rate (1969–2007). Shaded areas denote 90 percent confidence bands with standard errors clustered by country. The shock occurs in t = 1. Time periods are measured in quarters. For details on Groups, see section II.C.

levels of capital controls, the effectiveness of these controls may rely on a corresponding response from foreign reserves, as in the model of Gabaix & Maggiori (2015). All else being equal, countries that partially liberalize their capital accounts without fully doing so, and cease utilizing foreign exchange reserves, tend to experience a more pronounced exchange rate reaction to U.S. monetary policy shocks. Conversely, countries with completely liberalized capital accounts allow their foreign exchange reserves to respond, thereby achieving a more tempered reaction in their exchange rates. Thus, at extreme levels of capital account openness, the use of FX reserves and capital controls do no longer seem to reinforce each other.

4. Robustness checks

To check the robustness of our results presented in the previous section, we perform a series of additional estimates.

4.1. Adding interest rates as a control variable

For our first robustness check, we add to our baseline regression the leading interest rate of the central bank as a control variable (Equation (2)). This variable is standard in models of response to external shocks since it is one of the main monetary policy tools to handle with such shocks (Miranda-Agrippino & Rey, 2020). We did not include it in our baseline regression since it is difficult to obtain comprehensive policy interest rate data for all central banks over the long run. The reason is that, in the few decades that followed World War II, many central banks often relied on credit rationing rather than interest rates to act on money, credit and prices (Eric, 2018). Including central policy rates to the dataset reduces our sample size by 27%.

Results (on the reduced sample) adding interest rates are presented in Fig. 4. Changes are marginal – compared to our benchmark case – and confirm the main findings of our previous analysis. The group of closed economies did not respond to the external shock nor by exchange rate interventions nor by their exchange rate; while foreign reserves of the other two groups declined and their exchange rates depreciated following the same shocks.

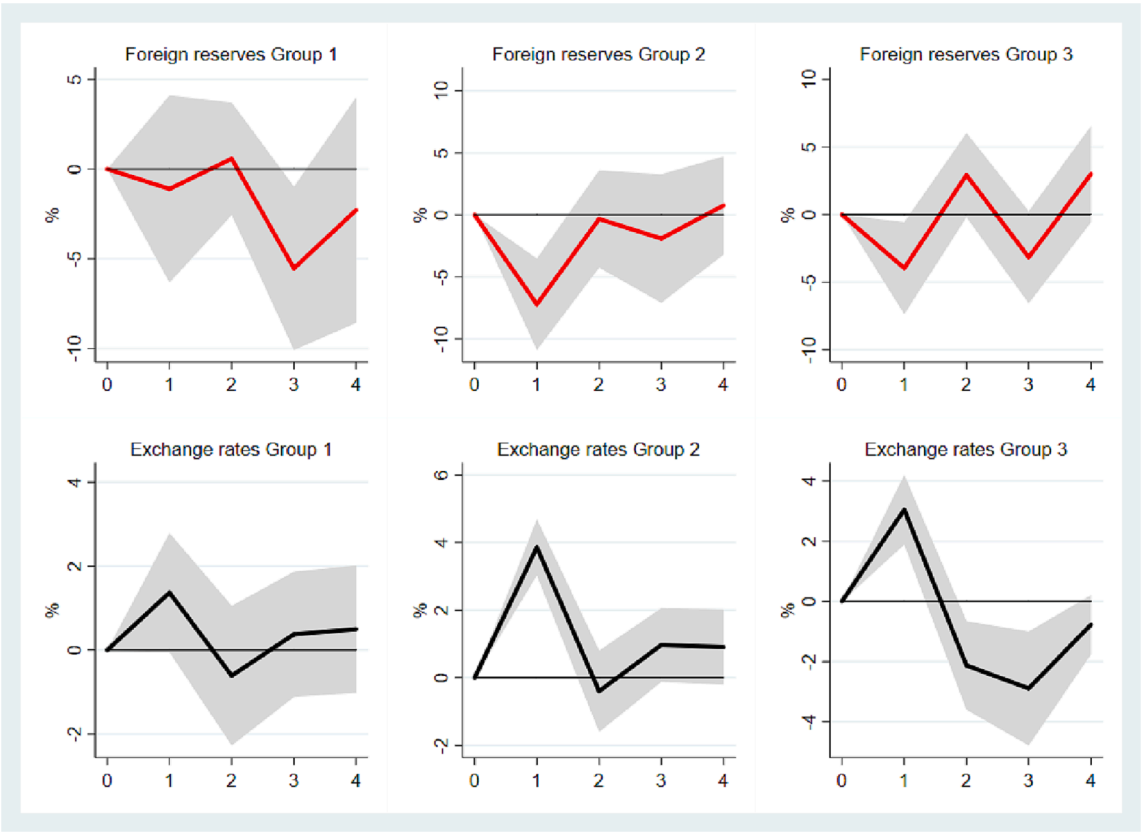

Fig. 4. Responses of foreign reserves and exchange rates, by capital control group, to a 100 basis-point shock to US monetary policy interest rate (1969–2007). These estimations control for central bank interest rates. Shaded areas denote 90 percent confidence bands with standard errors clustered by country. The shock occurs in t = 1. Time periods are measured in quarters. For details on Groups, see section II.C.

4.2. Changes in group definitions

Thereafter, we verify that results are not driven by the choice of groups according to the level of capital controls, and hence by the choice of the financial opening indicator. We change the perimeters of groups 2 and 3 by adding to the latter the countries classified in the fourth quintile distribution of the financial openness indicator. These same countries are removed from Group 2. More precisely, new Group 2 was reduced by 1090 observations, which were added to Group 3. The latter thus becomes the group with the highest number of observations (3140), just ahead of Group 1 (2752).

Results are presented in Fig. 5. Changes are marginal and our main conclusions hold, particularly on the use of foreign exchange reserves in response to the exogenous change in the U.S. rates as capital controls are lifted.

4.3. Extensions of the sample

Thirdly, in order to extend our sample by almost 50%, we added to our analysis the nineteen years between 1950 and 1968. These years are nonetheless not covered by our exogenous U.S. monetary shock (Romer and Romer 2004). In order to be able to estimate our model, we calculated our own exogenous external shock for the U.S. monetary policy during this same period. Our indicator equals the residual of the Fed funds rate estimated over expected inflation and the U.S. output gap. This residual of the forward looking monetary policy reaction is not as exogenous as the one of Romer and Romer that is calculated using published forecasts of the Fed, but is still a monetary surprise, akin to the one that would be estimated in a standard VAR with recursive (Cholesky) identification. Moreover, the period considered was the one of the Bretton Woods monetary system, when unexpected U.S. monetary shock were more likely to be

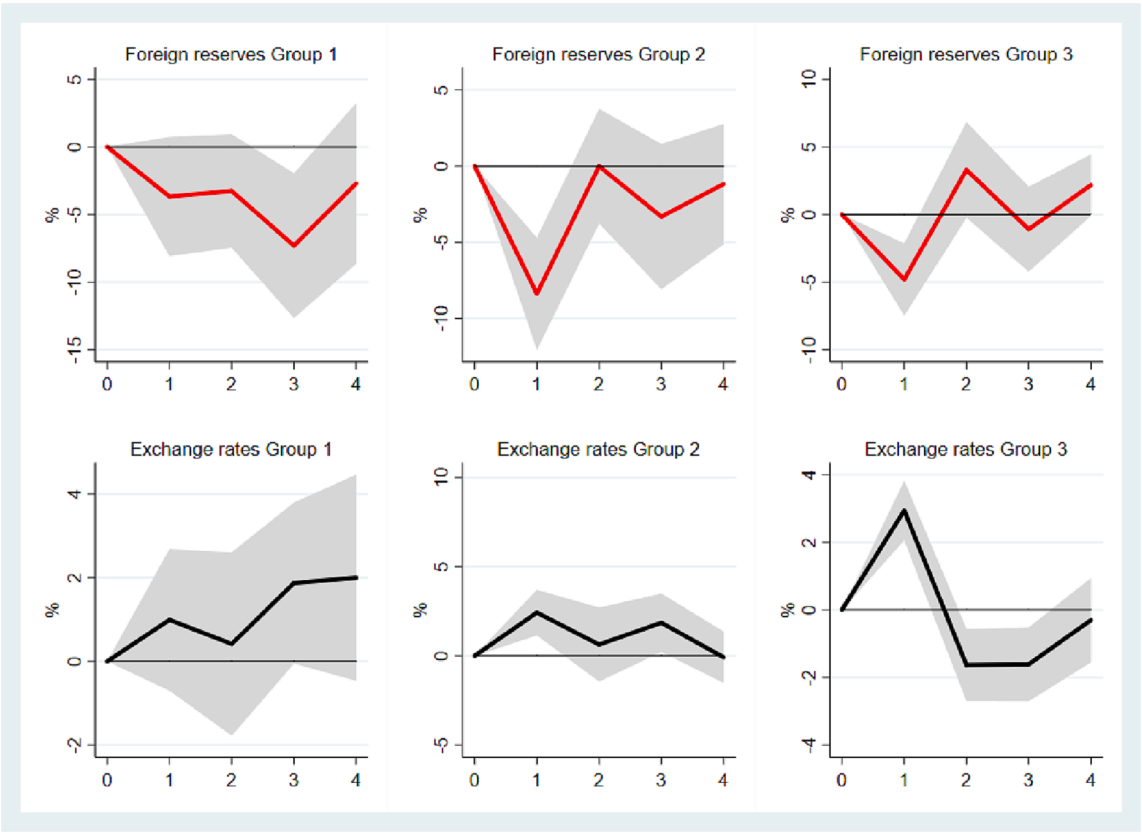

Fig. 5. Responses of foreign reserves and exchange rates, by capital control group, to a 100 basis-point shock to US monetary policy interest rate (1969–2007). Shaded areas denote 90 percent confidence bands with standard errors clustered by country. The shock occurs in t = 1. Time periods are measured in quarters. Groups 2 and 3 are changed compared to the section section II.C: New-Group 2 now covers only the third quintile of the distribution of the financial openness indicator. New-Group 3 covers the top two quintiles.

exogenous given the hegemonic position of the U.S. and the Bretton Woods system. For this reason, it is customary in the historical macroeconomic literature on the trilemma to use the U.S. monetary policy rate (Fed Fund) as exogenous to the rest of the world during the Bretton Woods period (Obstfeld et al., 2005; Jordà et al., 2019).

Results for the new sample are presented in Fig. 6. Our main results and conclusions on the different reaction of foreign reserves across groups hold with this new sample. The reaction of the exchange rate is nevertheless more muted in groups 2 and 3, which is unsurprising given that all countries adhered to a fixed exchange rate regime under Bretton Woods and nominal exchange rates were then much less volatile (Mussa 1986).

We then use the alternative measure of US monetary policy shocks of Bauer & Swanson (2023), available from 1988 to 2018, in order to cover the post-2007 years. This series is different from the one built using Romer & Romer methodology. Thus it cannot be used together with our previous measure that stops before 2007. The zero lower bound era that followed the 2008 crisis prevents researcher from building an equivalent to the Romer & Romer series post 2007. Thus, as Miranda-Agrippino and Ricco (2021) and Jorda et al. (2019), we use the Romer and Romer series to work on a longer sample. In our case, we give priority to working on a longer sample (rather than on a more recent but shorter one) because we want to exploit as much heterogeneity as possible in capital controls. The results using the Bauer & Swanson (2023) shock are presented in Fig. 7.

Our main conclusions regarding the combination between capital controls and the use of FX reserves hold; There are nevertheless some differences, as the sample changes considerably. Specifically, we lose many observations with a very closed capital account when focusing on the post-1990 period. As before, we observe that foreign exchange reserves exhibit a significant negative response only in Groups 2 and 3, that is, in countries with intermediate levels of capital controls or without any capital controls. Our investigations yield similar conclusions: as soon as countries begin to liberalize their capital accounts, they rely more on FX reserves to mitigate the impact

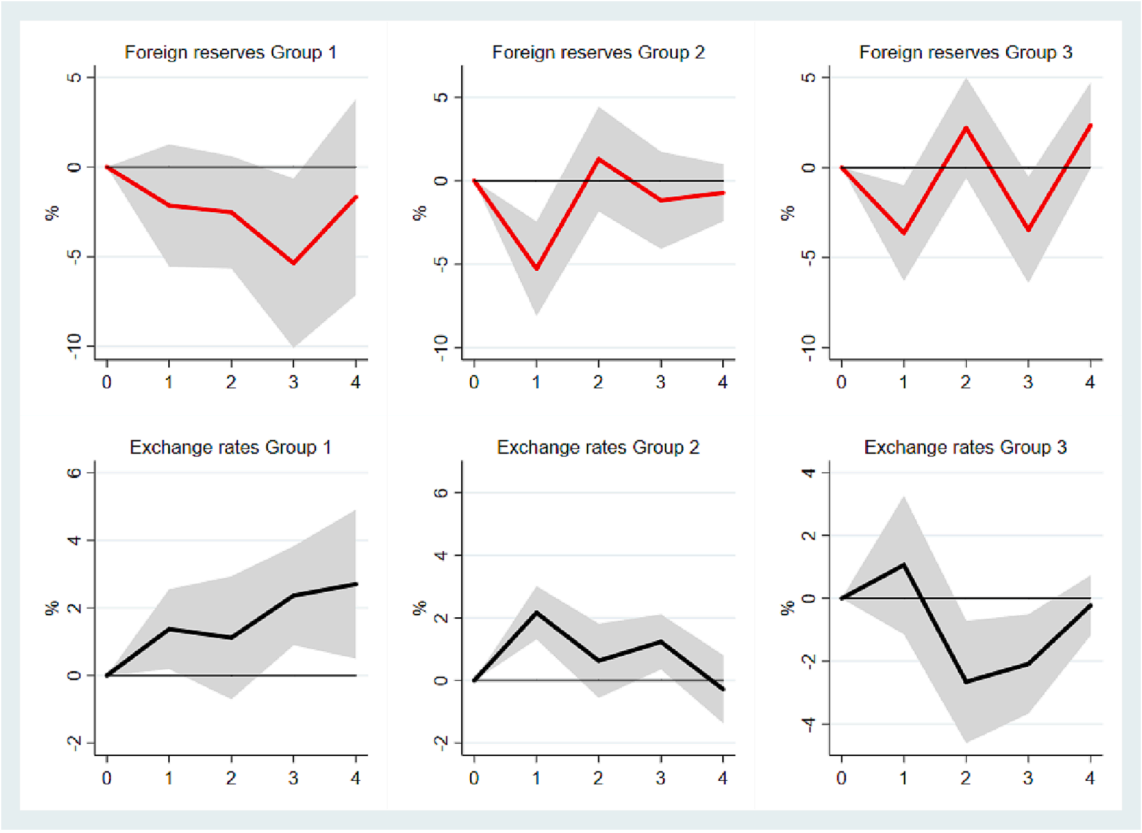

Fig. 6. Responses of foreign reserves and exchange rates, by capital control group, to a 100 basis-point shock to US monetary policy interest rate (1950–2007). Shaded areas denote 90 percent confidence bands with standard errors clustered by country. The shock occurs in t = 1. Time periods are measured in quarters. U.S. monetary shock for the period 1950–1968 was constructed by the authors and equals the residual of the Fed funds rate estimated over expected inflation and the US output gap.

of international shocks on the exchange rate, and they continue to do so even when their capital accounts are fully liberalized. The main difference concerns the response of the exchange rates in Groups 2 and 3. According to these results, the group 2 (that combines capital controls and a response of FX reserves) experiences no depreciation of the exchange rate. This finding will also be observed in the last robustness check (see below, sub-section d) that also focuses on more recent data. While this might be interpreted as an evidence that the combination of FX reserves and capital controls has become more effective, we refrain from deriving strong conclusions from these results as they might be due to a shorter estimation sample.

4.4. Valuation effect and alternative data on FX interventions

Finally, we also perform a robustness check on our foreign exchange intervention variable. Our variable in the baseline model equals the percent change in foreign reserves, which is widely used in the literature (i.g. Ilzetzki et al., 2019). However, some transactions can affect the value of such reserves other than FX interventions. This is particularly the case for some transactions in foreign currency between residents and nonresidents (for instance exchange of local and foreign currency assets). Although it has been shown by Adler et al. (2021) that FX interventions and the change in FX reserves can differ significantly, we do not expect that the bias would be systematically correlated with a U.S. monetary policy shock.

Furthermore, in our database reserves are measured in U.S. dollars. Valuation effects between two periods can thus be at play and change the value of reserves and these valuation changes are also not explained by foreign exchange intervention. Two distinct issues may be relevant. First, the nominal value of assets composing foreign reserves can change, especially during an exogenous variation in American rates. Secondly, the value in US dollars of non-dollars denominated assets are affected by changes in the exchange rate against the dollar. More specifically, an appreciation of the dollar decreases the price of the asset and vice versa for a depreciation.

To account for this valuation effect, our baseline specification controls (in all our estimations) for the long-term interest rate on U.S. government securities. This controls for the first effect but the second potential effect is more difficult to consider empirically. Our results however suggest that this second effect might not create a systematic bias. First, our results hold when including the full Bretton Woods period (1950–1971) when dollar reserves largely dominated official reserves and other key currencies were pegged to the dollar (section IV.C). Second, such bias should be present in all countries that hold foreign reserves. Thus, the fact that FX reserves do not

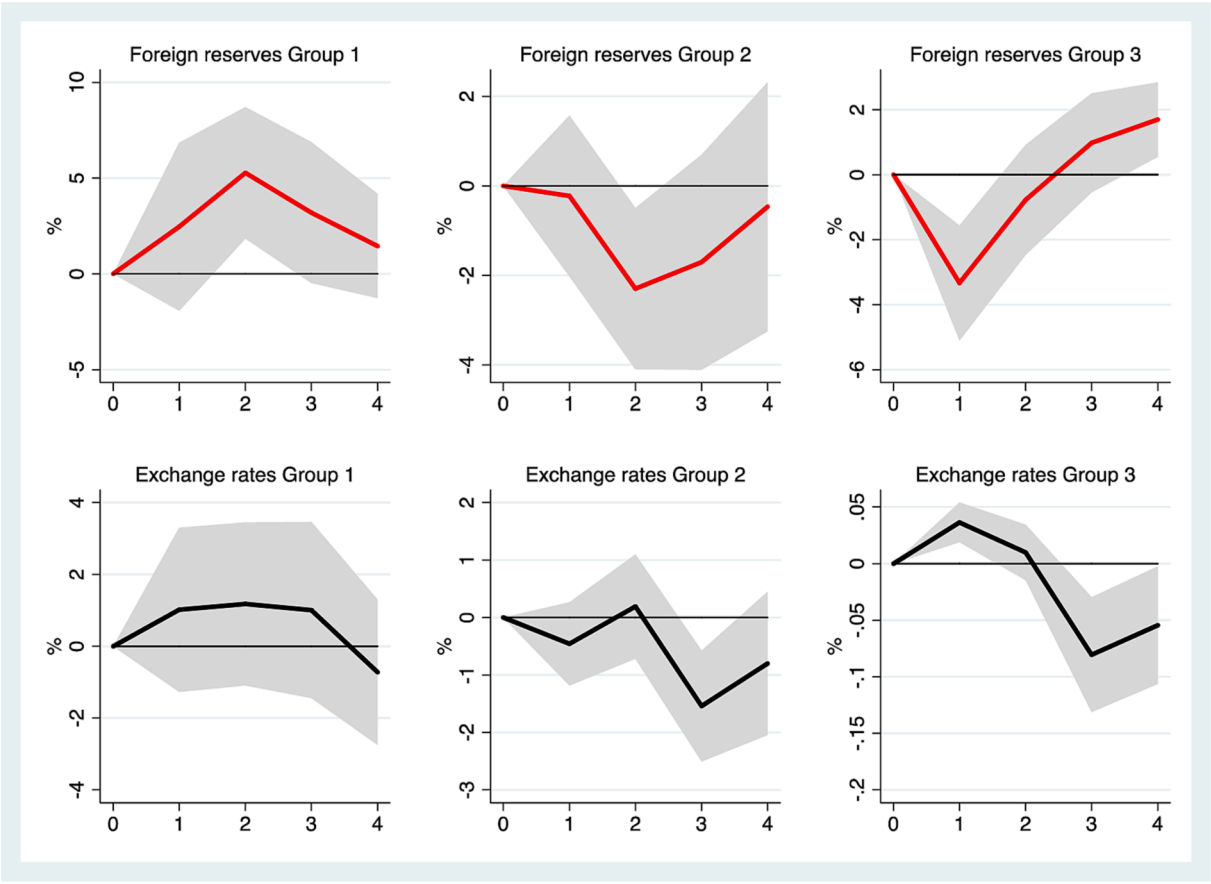

Fig. 7. Responses of foreign reserves and exchange rates, by capital control group, to a 100 basis-point shock to US monetary policy interest rate (1988-2018). Shaded areas denote 90 percent confidence bands with standard errors clustered by country. The shock occurs in t = 1. Time periods are measured in quarters. U.S. monetary shock used in this analysis is based on Bauer and Swanson (2023).

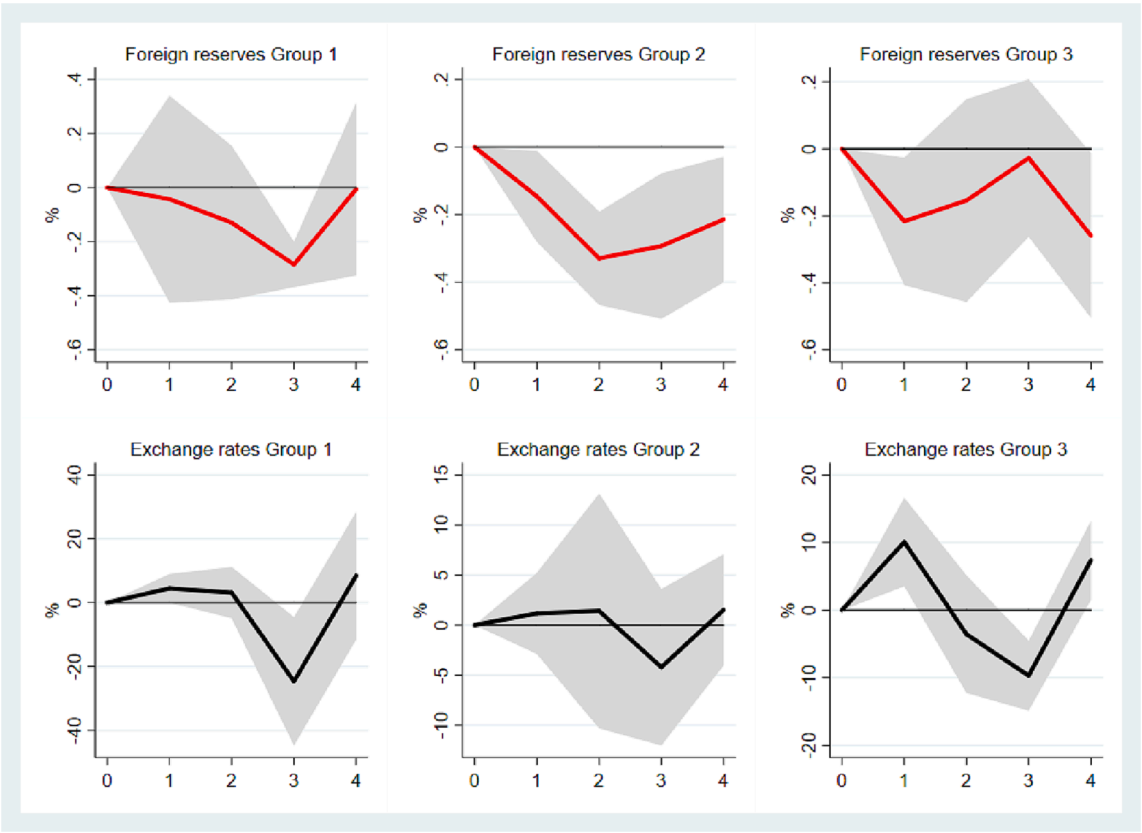

Fig. 8. Responses of foreign reserves due to FX interventions (Adler et al. 2021) and exchange rates, by capital control group, to a 100 basis-point shock to US monetary policy interest rate (2000–2007). Shaded areas denote 90 percent confidence bands with standard errors clustered by country. The shock occurs in t = 1. Time periods are measured in quarters. For details on Groups, see section II.C.

react in Group 1 is evidence that there is not a systematic bias due to a valuation effect.

Using a more precise – but limited – dataset on foreign exchange interventions is a way to address all these concerns at the same time. This database is produced by the IMF (Adler et al., 2021) and provides proxies for foreign exchange intervention for 122 countries at a quarterly frequency between 2000 and 2020. The authors have purged changes in official reserves from valuation effects and other autonomous changes in foreign exchange reserves. Note that the use of this database increases the coverage of our sample in terms of countries but drastically reduces it in terms of years and total observations. We use Eq. (2) with the new FX intervention variable as endogenous variable and including the interest rates in the explanatory variables. All other specifications remain unchanged, including the Romar & Romer shock variable. As a result, our sample is limited from 2000 to 2007.

Fig. 8 summarizes results with this new specification. They show the same pattern as previous findings; that the use of exchange rate intervention and capital controls are rather substitutable between the most closed and the most open countries, while countries in the intermediate stage use both policy tools. We interpret these results on a much smaller sample as consistent with our previous findings although they also show that a small sample with less heterogeneity of capital controls is not enough to produce robust and statistically significant estimates for the exchange rate in Group 2. Although this new result might suggests that combining both tools was more effective in the recent period, it is also possible that a shorter sample (and less capital controls heterogeneity) mechanically reduces the significance of the results.

4.5. Endogeneity of capital control

We have studied how FX reserves respond differently to a US shock, depending on the level of *de jure* capital controls. It might be possible however that, in some cases, capital controls also react to a US monetary policy shock. Although there are examples of tightening of reserve requirements on FX assets after a rise in international rates, such cases seem rare and minor events in the long road to financial openness. The evolution towards financial openness usually follows a slow path driven by policy considerations rather than the frequency of foreign shocks. Our hypothesis can be tested easily. Fig. 9 bellows presents evidence that *de jure* capital controls do not react significantly to an exogenous US monetary policy shock. This finding rules out concerns that previous results would be significantly driven by countries shifting from one capital control group to another in response to a US shock.

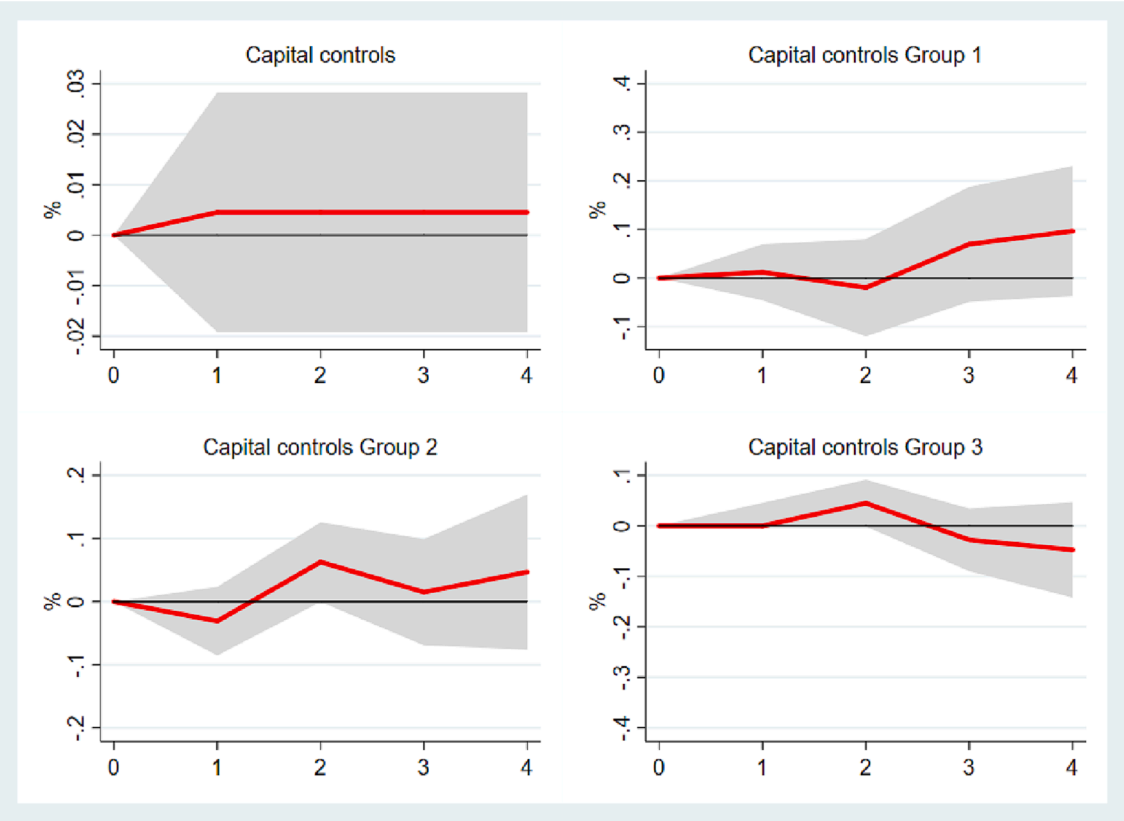

Fig. 9. Responses of the de jure measure of capital control to a 100 basis- point shock to US monetary policy interest rate (1969–2007). Shaded areas denote 90 percent confidence bands with standard errors clustered by country. The shock occurs in t = 1. Time periods are measured in quarters. For details on Groups, see section II.C.

5. Conclusion

Whether capital controls and FX reserves are used in combination remains an open question of key interest for macroeconomic theory and current policymaking. In this paper, we have presented evidence that a significant number of countries do combine them to tame the effect of international capital flows on the domestic economy. Yet, we also observe that other countries use only one of these two tools. Such conclusions could not have been reached without a long historical dataset and an identification strategy that allows us to show that foreign exchange reserves are indeed used in reaction to an international financial shock. They qualify substantially previous analyses that emphasized a linear positive relationship between capital account openness and a higher level of reserve holding (Bussière et al. (2015) and Arce et al. (2019)) Our results support the recent pragmatic approach of the IMF's Institutional policy framework (2020) regarding the choice and combination of FX interventions and capital controls against international financial shocks. They show the various context-specific strategies countries have at their disposal to mitigate the effect of an international financial shock on their exchange rate.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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