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# Foreign Reserves, Crises and Growth

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*Thèse dirigée par*

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*A Keyou, à mes parents et à mes compagnons de route*

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# Abstract

This thesis includes three essays on foreign reserves, crises and growth. The first one proposes a theoretical model to look at foreign reserve accumulation in a fast-growing developing economy. The second chapter is a joint empirical work with Matthieu Bussière, Menzie Chinn and Noëmie Lisack on the role of foreign reserves during the global financial crisis. Based on a stylized model, the final chapter takes a political economy stance and shows how reserves can be used to stabilize the domestic economy when the private sector faces credit constraint and currency mismatch.

Based on a dynamic open-economy macroeconomic model, chapter 1 analyzes the motive for foreign reserve accumulation in fast-growing emerging economies. The demand for foreign reserves stems from the interaction between productivity growth and underdevelopment of the domestic financial market. As domestic firms are credit-constrained, domestic saving instruments are necessary to increase their retained earnings so as to invest in capital. The central bank plays the role of financial intermediary and provides liquid public bonds while investing the bond proceeds abroad in the form of foreign reserves. Foreign reserve accumulation is thus part of a catching-up strategy in an economy facing financial frictions. During economic transition, foreign reserve accumulation is proved to be welfare improving as long as private capital flows are controlled. This joint strategy enables the central bank to channel sufficient external funding to the domestic economy while keeping domestic interest rates under control to cope with positive shocks on productivity growth.

Based on a dataset of 112 emerging economies and developing countries, chapter 2 addresses two key questions regarding the accumulation of international reserves: first, has the accumulation of reserves effectively protected countries

during the 2008-09 financial crisis? And second, what explains the patterns of reserve accumulation observed during and after the crisis? More specifically, this chapter investigates the relation between international reserves and the existence of capital controls. It is found that the level of reserves matters: countries with high reserves relative to short-term debt suffered less from the crisis, particularly if associated with a less open capital account. In the immediate aftermath of the crisis, countries that depleted foreign reserves during the crisis quickly rebuilt their stocks. This rapid rebuilding has, however, been followed by a deceleration in the pace of accumulation. The timing of this deceleration roughly coincides with the point when reserves reached their pre-crisis level and may be related to the fact that short-term debt accumulation has also decelerated in most countries over this period.

Using a simple theoretical framework of the 'third-generation' crisis models with multiple equilibria, chapter 3 studies how foreign reserves, accumulated before the onset of the crisis, were useful to enhance countries' resilience to balance sheet effects during the recent economic turbulence. It is argued that both a targeted lending in foreign currency or a fiscal spending financed by foreign reserves help remove the bad equilibrium represented by a largely depreciated domestic currency and a very low level of domestic investment. Nevertheless, these two policy tools differ in the mechanism through which they stabilize the domestic economy and in terms of the amount of foreign reserves needed. A targeted lending is at work by altering investors' expectation on firms' net worth, thus exerts an influence on domestic investment and exchange rate. As long as foreign reserves are sufficient to cover the economy's external debt, the bad equilibrium is removed even without an actual depletion of reserves. On the contrary, a fiscal spending increases the demand for domestic goods and thus virtually appreciates the domestic exchange rate. An appreciated currency increases firms' net worth and facilitates investment.

# Contents

# Introduction

Cette thèse de doctorat comporte trois chapitres traitant de la question de l'accumulation de réserves de change dans les pays émergents, un phénomène qui tend à s'amplifier depuis la fin des années 1990. Sous différents angles, théorique comme empirique, les trois travaux présentés dans cette thèse analysent les motivations d'accumulation de réserves de change et testent l'utilité de ces avoirs en devises étrangères pendant la crise financière mondiale de 2009.

Avant d'introduire les nouveautés de chacun des trois chapitres (partie 3), je présente tout d'abord les faits stylisés (partie 1) et les principaux problématiques à l'égard de l'accumulation de réserves de change (partie 2) afin d'illustrer l'importance du sujet, tant pour la recherche académique que pour la décision des politiques économiques.

## 1 Faits stylisés

**Les réserves de change dans le monde se sont considérablement accrues à un rythme rapide depuis la fin des années 1990**. De 2049 milliards de dollars américains en 2001, les réserves de change mondiales ont atteint 11 138 milliards de dollars à la fin du deuxième trimestre 2013 et ont ainsi quintuplé en 12 ans (c.f. graphique 1). Dans une ère souvent considérée comme « dominée par le monde de la finance », il est en effet étonnant de constater que c'est le secteur public des pays qui détienne le plus d'actifs financiers. Selon un article du *Financial Times* du 15 octobre 2013, la valeur des réserves de change détenues par les autorités monétaires est quatre fois supérieure à celle des actifs détenus par tous les fonds de couverture (*hedge funds*) confondus dans le monde.

Le graphique 1 montre également que le niveau de réserves dans la monde (no-

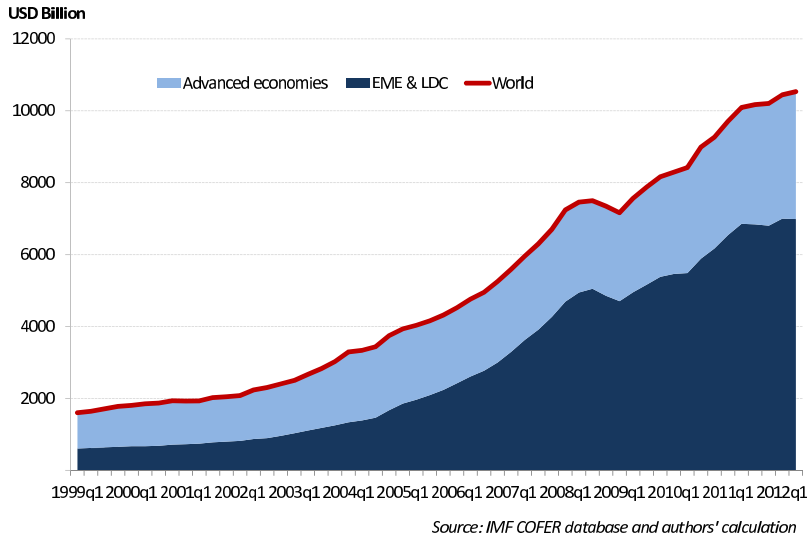


FIGURE 1 – Évolution des réserves de change dans le monde

tamment dans les pays en voie de développement) s'est infléchi pendant la crise financière mondiale de 2009. En effet, comme le soulignent Bianchi et collab. (2013) et Broner et collab. (2013), l'achat des actifs étrangers par des résidents nationaux ou par les autorités publiques d'un pays présente une tendance procyclique et s'effondre ainsi pendant les crises.

Par ailleurs, il est à noter que **l'évolution des réserves de change dans le monde depuis une décennie a été notamment induite par une accélération dans la constitution d'un stock de réserves dans les pays émergents**. Le graphique 2 montre que plus de 50% du taux d'accroissement des réserves mondiales provient des pays émergents et en voie de développement à partir de 2001. A la fin juin 2013, les réserves de change dans ces pays représentent plus des deux tiers des réserves mondiales, soit 7 469 milliards sur 11 138 milliards de dollars. On peut également constater d'après le graphique 3 que 9 des 10 plus grands détenteurs de réserves de change sont des pays émergents [1]. La Chine, à titre individuel, détient un peu moins d'un tiers des réserves de change mondiales (graphique 4).

1. Les pays émergents sont définis dans cette thèse selon le critère du Fonds monétaire international et celui du magazine économique *The Economist*. Hongkong, la Corée et Singapour sont considérés comme des pays émergents.

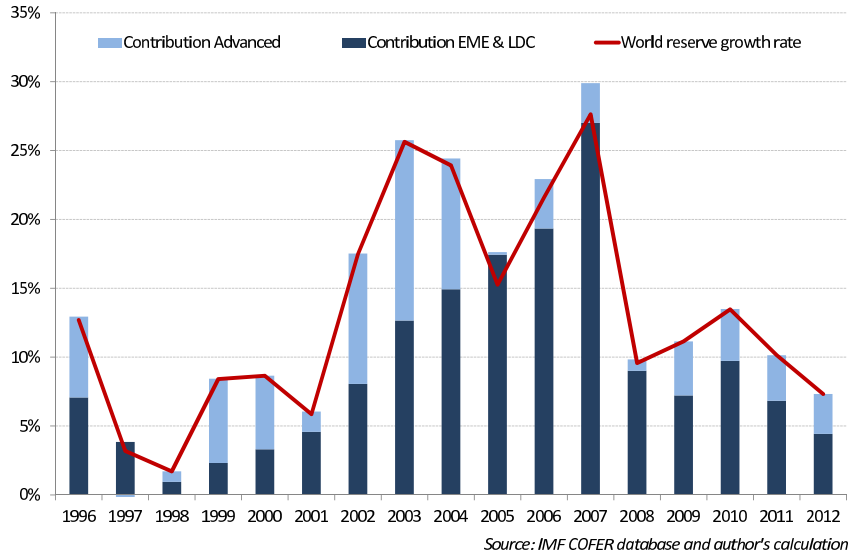


FIGURE 2 – Contribution à l'accroissement des réserves de change

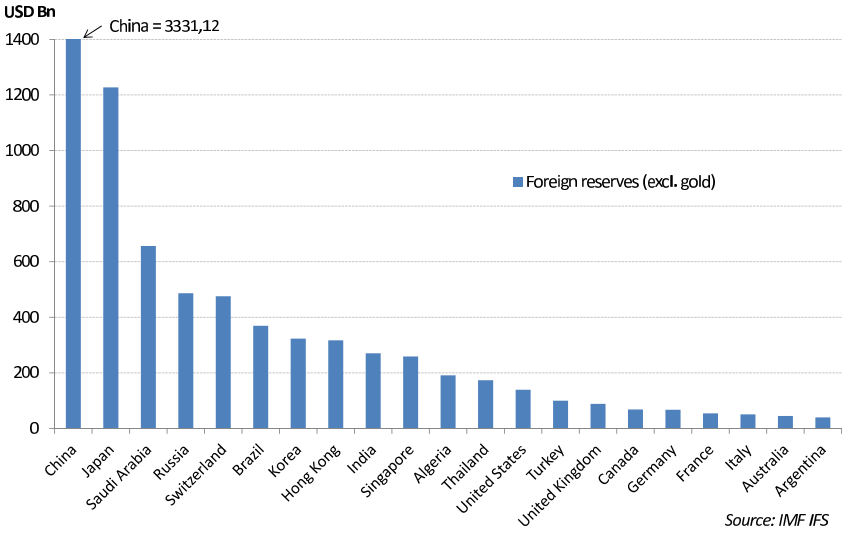


FIGURE 3 – Les grands détendeurs de réserves (fin déc. 2012)

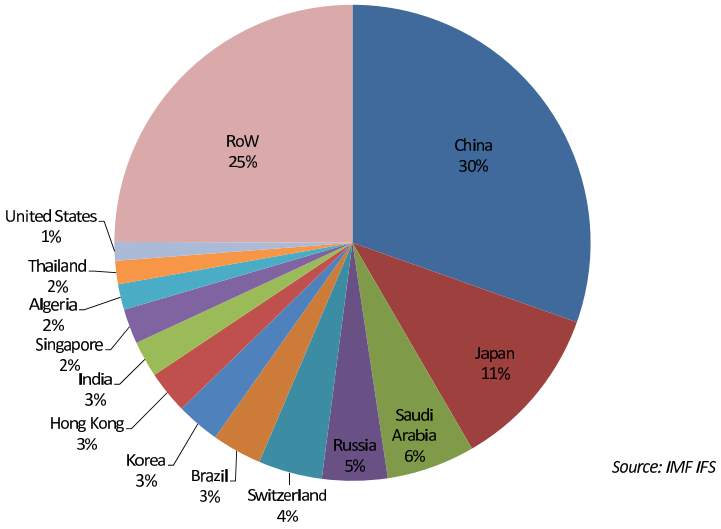


FIGURE 4 – Répartition des réserves (% des réserves mondiales, fin déc. 2012)

Concernant la composition monétaire des actifs de réserves, **le dollar reste la monnaie de réserves internationale par excellence** ; plus de 60% des réserves de change « allouées » [2] sont libellées en dollar américain (c.f. graphique 5). Or, depuis sa création, l'euro est devenu la deuxième monnaie de réserve la plus utilisée dans le monde. On constate d'ailleurs une diminution continue de la part du dollar au profit de l'euro dans graphique 6 [3]. Un phénomène récent mais important qui mérite d'être mentionné ici est que la monnaie chinoise, *renminbi* (RMB), a entamé une course vers l'internationalisation depuis juillet 2009. Selon des économistes, le RMB a le potentiel pour se hisser dans le rang des monnaies de réserve internationales dans les décennies à venir [Eichengreen (2010), Gao et Yu (2011) et Chinn (2012)]. Quelques faits économiques récents semblent étayer cette possibilité : 22 accords bilatéraux de swap en RMB ont été signés depuis 2008 entre la Banque populaire de Chine et d'autres banques centrales, dans des pays développés (Zone euro et Angleterre, etc.) comme des pays émergents (Argentine

2. Selon la base de données COFER du FMI, les réserves de change dont on connaît la composition monétaire sont appelée « allouées (allocated) ». Elles représentent 56% des réserves de change mondiales. Les 44% restantes sont appelées « réserves non-allouées (unallocated) » comme on peut observer dans graphique 5.

3. Cette tendance s'est ralentie depuis 2011, ce qui est probablement dû à la crise des dettes souveraines dans la zone euro.

et Thaïlande, etc.). Par ailleurs, le rapport triennal sur les banques centrales de la Banque des règlements internationaux datant de septembre 2013 montre qu'en passant du 17e rang mondial en 2010 au 9e en termes de volume de transactions, le RMB est dorénavant parmi les dix monnaies les plus échangées au monde [BIS (2013)].

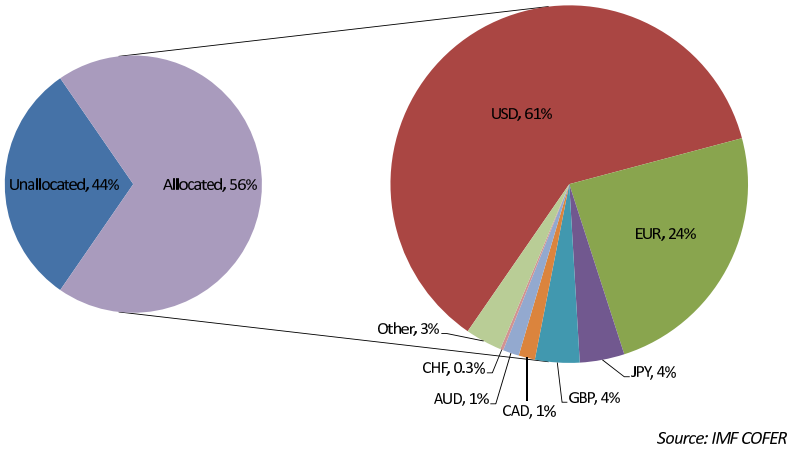


FIGURE 5 – Composition des réserves par monnaies : Les pourcentages sont calculées par rapport aux réserves allouées. USD = dollar américain, EUR = euro, JPY = yen japonais, GBP = livre sterling, CAD = dollar canadien, AUD = dollar australien, CHF = franc suisse

Enfin, il convient à souligner que malgré des symptômes communs en termes de volume et de vitesse d'accumulation des avoirs étrangers, **les sources financières des réserves peuvent être différentes dans différents pays**. Comme l'illustre l'identité de la balance des paiements ci-dessous, une augmentation des réserves de change peut provenir d'un excédent commercial ($CA$) ou d'un surplus du compte de capital ($KA$) ou des deux.

$$\Delta \text{CA} + \Delta \text{KA} = \Delta \text{Réserves}$$

Les pays producteurs et exportateurs de pétrole ont pu accumuler des avoirs extérieurs en devises étrangères grâce aux cours favorables des matières premières dans la décennie précédant la crise financière mondiale de 2009. L'accumulation

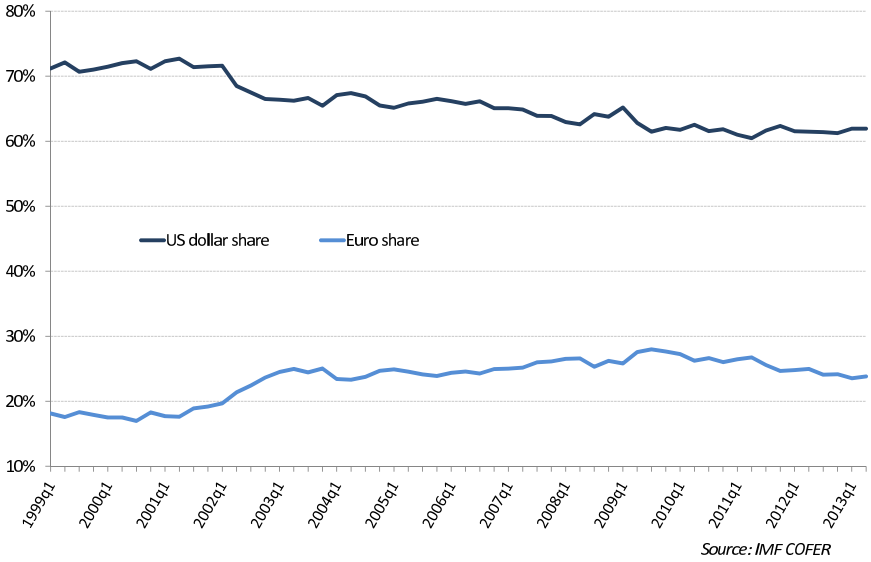


FIGURE 6 – évolution du dollar américain et de l'euro : Les pourcentages sont calculées par rapport aux réserves allouées.

des réserves provient largement d'un excédent commercial important, à l'image de la situation en Arabie saoudite (graphique 7).

Dans d'autres pays, l'accroissement des réserves de change est lié aux entrées de capitaux sous forme d'emprunts privés ou publics. Dans ce cas-là, les réserves de change sont plutôt « empruntées » qu'achetées. Ceci est souvent le cas dans des pays qui s'appuient fortement sur le financement extérieur pour le développement économique, par exemple en Amérique latine. La balance des paiements du Brésil en est le parfait exemple (graphique 8).

Le cas de la Chine (graphique 9) est particulier, car le pays a maintenu pendant longtemps un double excédent : un excédent commercial couplé à des entrées de flux de capitaux. Ce double surplus résulte d'un mode de croissance tiré par les exportations et d'un environnement d'investissement favorable pour les capitaux étrangers.

## 2 Problématiques et enjeux du sujet

L'accumulation de réserves de change n'est cependant pas une question récente. La question des réserves a depuis longtemps animé les débats politiques et

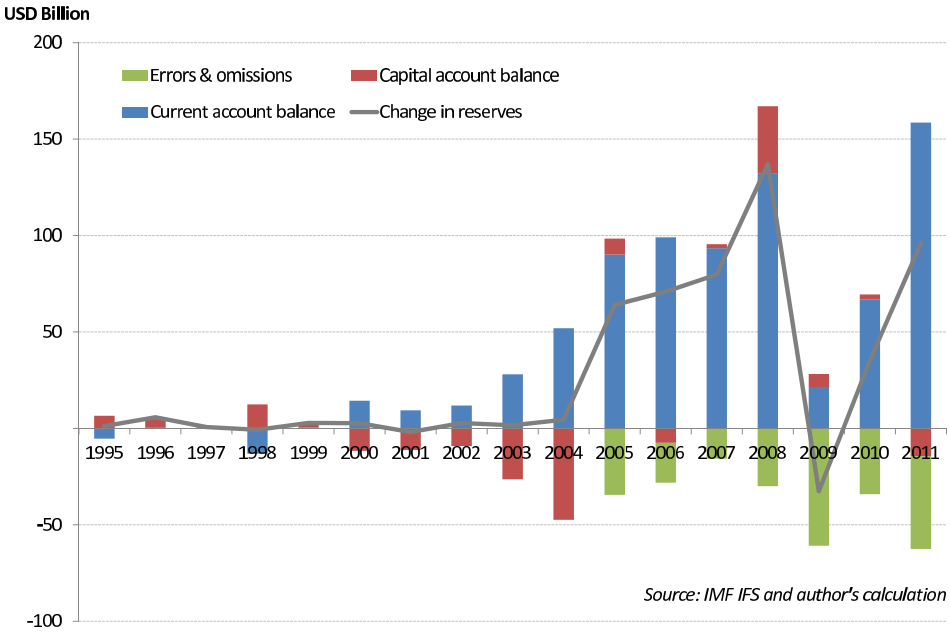


FIGURE 7 – Arabie saoudite

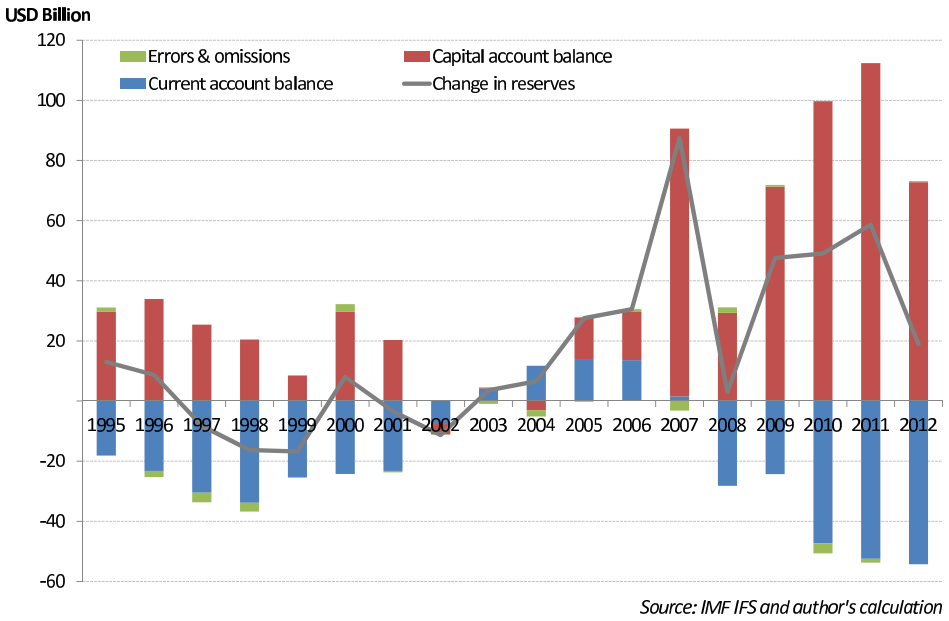


FIGURE 8 – Brésil

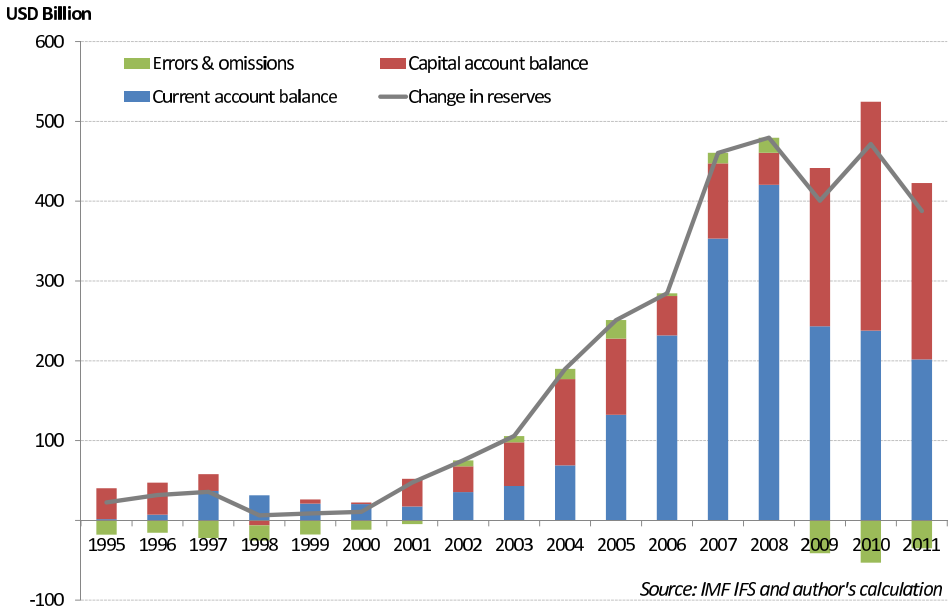


FIGURE 9 – Chine

économiques. Le bullionisme du XVI$^{e}$ siècle n'a-t-il pas prôné l'idée que les métaux précieux constituent la richesse d'une nation et préconisé le protectionnisme commercial contre la sortie de ces métaux ? Les réserves de change ont également longtemps joué un rôle de stabilisateur des taux de change dans des systèmes monétaires internationaux de changes fixes, à l'image de l'étalon-or au XIX$^{e}$ siècle et de l'étalon de change-or durant l'entre-deux-guerres, ou encore dans le système de Bretton Woods après la Seconde guerre mondiale. Au lendemain de l'effondrement du système de Bretton Woods, on ne verra cependant pas une diminution de réserves de change contrairement à ce que certains économistes prévoyaient alors.

Depuis une décennie, l'accumulation de réserves de change a ressuscité un débat virulent tant dans le milieu académique que dans la sphère politique. Celui-ci s'inscrit notamment dans un contexte de déséquilibres mondiaux et de crises économiques. Il convient dès lors de discerner trois grandes problématiques qui attestent de la valeur de ce sujet de recherche.

## Pour quelles raisons les réserves de change sont-elles nécessaires dans un monde qui est de plus en plus intégré financièrement ?

L'accumulation de réserves de change est un phénomène aux multiples facettes dont les motivations peuvent être multiples. Le Fonds monétaire international (FMI) définit cinq grands objectifs dans le management des réserves de change [IMF (2013)] :

- « Susciter et maintenir la confiance dans la politique monétaire et la politique de change en assurant la capacité à effectuer des interventions sur le marché des changes » ;
- « Limiter la vulnérabilité externe par le maintien des liquidités en devises étrangères afin d'absorber les chocs en temps de crise ou lorsque l'accès au financement extérieur est restreint » ;
- « Donner aux marchés l'assurance que le pays est en mesure de remplir ses obligations extérieures » ;
- « Démontrer le soutien à la monnaie nationale par des avoirs extérieurs de réserve ; et aider le gouvernement à satisfaire à son besoin de financement en devises étrangères et à s'acquitter de ses dettes extérieure » ;
- « Maintenir des réserves en cas de catastrophes ou d'urgences nationales ».

En fonction de ces objectifs, la motivation première pour avoir suffisamment d'actifs liquides en devises étrangères dans un pays est d'assurer la liquidité en cas de crise de balance des paiements ou de revirement des capitaux étrangers. Il s'agit de la **motivation de précaution**. Un stock de réserves suffisant pourrait garantir le paiement des importations ou le financement du secteur privé dans le cas où aucun financement extérieur n'est possible. Les pays asiatiques, comme Thaïlande et Indonésie, ont ainsi fortement augmenté leurs réserves de change dans le sillage de la crise asiatique de 1997-1998. Cette « auto-assurance » permet également aux pays de ne pas recourir à un renflouement par le FMI, souvent considéré comme très contraignant. Le rôle d'assurance des réserves pourrait aussi être envisagé comme un élément de dissuasion contre les attaques spéculatives. Un niveau de réserves suffisant réduit la probabilité d'un revirement des flux

de capitaux étrangers [Jeanne et Rancière (2011)] ou d'une attaque spéculative contre la monnaie locale [Krugman (1999)]. Le deuxième et troisième chapitres de cette thèse abordent en effet ce pouvoir dissuasif des réserves de change sous deux différents angles.

Selon d'autres économistes [Dooley et collab. (2003)], l'achat des réserves pourrait également être incité par une stratégie de croissance liée à un commerce extérieur excédentaire. Dans cette perspective, les réserves de change sont accumulées pour déprécier la monnaie locale afin de soutenir les exportations. La détention des réserves de change pourrait être ainsi considérée comme une forme déguisée de subvention au secteur exportateur [Jeanne (2012)]. Cette motivation d'accumulation de réserves est souvent appelée **motivation néo-mercantiliste**. Si accumuler des réserves de change génère un coût financier à court terme, le pays pourra bénéficier des gains de productivité à travers les exportations (« learning by exporting ») à long terme [Korinek et Serven (2010)].

Enfin, outre les objectifs définis par le FMI, **l'accumulation de réserves pourrait aussi provenir d'un écart entre l'épargne et l'investissement au sein d'une économie**. Comme l'équation ci-dessous le montre, dans une économie où les flux de capitaux privés sont contrôlés (c'est-à-dire les résidents ne peuvent pas investir facilement à l'étranger ou vice versa pour les non-résidents), l'écart entre l'épargne ($S$) et l'investissement ($I$) se traduit par une augmentation du niveau de réserves de change. Autrement dit, l'excédent de l'épargne nationale est exporté à l'étranger. Dans cette perspective, l'accumulation de réserves de change est liée aux motifs qui sont à l'origine d'une abondante épargne dans certains pays émergents et au mécanisme selon lequel l'épargne privée se retrouve dans les bilans des banques centrales. Ce mécanisme a été exploré dans la littérature par Caballero et collab. (2008), Dominguez (2010), Bénassy-Quéré et collab. (2011), Song et collab. (2011), Wen (2011) and Bacchetta et collab. (2013) etc. Le premier chapitre de cette thèse propose une nouvelle lecture de ce mécanisme en mettant en avant l'interaction entre un marché financier national sous-développé et un taux de croissance économique élevé basé sur l'investissement du capital.

$$\begin{aligned}\Delta\text{Réserves} &= \Delta\text{CA} + \Delta\text{KA} \\ &= \Delta\text{CA} \\ &= \Delta\text{S} - \Delta\text{I}\end{aligned}$$

De récentes études empiriques [Delatte et Fouquau (2012) et Ghosh et collab. (2012)] montrent clairement la multiplicité des motifs derrière l'accumulation de réserves de change et l'évolution de leur poids relatif dans le temps. Delatte et Fouquau (2012) trouvent que la motivation néo-mercantiliste devient plus importante après 2000 tandis que Ghosh et collab. (2012) mettent en avant une évolution en faveur des déterminants de la demande des réserves liés au compte de capital (risques de revirement de capitaux et ouverture financière etc.).

## Les réserves de change sont-elles « excédentaires » ?

Une seconde problématique est de savoir si le niveau de réserves observé dans un bon nombre de pays émergents est excessif.

Pour répondre à cette question, il faut définir le niveau optimal de réserves selon différentes approches. Issus d'une littérature qui date des années 1970 [4], plusieurs ratios d'adéquation de réserves de change ont été développés et par ailleurs souvent utilisés dans la prise de décision politique en matière de réserves de change. Dans une perspective d'équilibre de la balance des paiements, le niveau des réserves de change doit couvrir trois mois d'importation. Avec l'intégration financière des pays en voie de développement, notamment suite à des événements de tarissement de flux de capitaux étrangers [« sudden Stops », terme défini par Calvo (1998)], la règle « Greenspan-Guidotti » recommande que les réserves de change couvrent l'intégralité de la dette extérieure à court terme afin d'assurer la capacité de remboursement à court-terme des pays en crises. Plus récemment, s'inscrivant dans une idée de crise de change déclenchée par une ruée vers les devises étrangères fortes, Obstfeld et collab. (2010) recommandent de calculer le ratio de réserves de change sur l'agrégat monétaire M2 comme un facteur

4. c.f. Heller (1966), Clark (1970b) and Clark (1970a), etc. Bahmani-Oskooee et Brown (2002) présentent une synthèse de cette littérature historique.

TABLE 1 – Ratios d'adéquation des réserves de change

| Country | $\frac{Rserves}{PIB}$, % | | $\frac{Rserves}{imports}$, months | | $\frac{Rserves}{m2}$, % | | $\frac{Rserves}{\text{dette ext. à c.t.}}$, % | |
|---|---|---|---|---|---|---|---|---|
| | 2000 | 2007 | 2000 | 2007 | 2000 | 2007 | 2000 | 2007 |
| Argentine | 8.84 | 17.02 | 9.11 | 10.04 | 27.77 | 55.92 | 64.97 | 406.38 |
| Brésil | 5.03 | 13.13 | 5.37 | 13.65 | 11.38 | 19.25 | 96.66 | 343.58 |
| Chine | 14.04 | 45.24 | 8.06 | 17.75 | 10.24 | 27.74 | 872.04 | 1270.63 |
| Inde | 8.21 | 24.25 | 6.22 | 11.47 | 15.14 | 29.73 | 423.01 | 344.19 |
| Indonésie | 17.22 | 12.72 | 6.11 | 6.02 | 36.51 | 31.38 | 141.84 | 192.61 |
| Corée | 18.02 | 24.98 | 5.98 | 7.19 | 29.43 | 41.31 | 293.39 | 206.73 |
| Mexique | 5.65 | 8.49 | 2.22 | 3.42 | 22.66 | 31.66 | 159.17 | 344.36 |
| Russie | 9.34 | 36.07 | 4.77 | 19.89 | 43.52 | 80.68 | 229.17 | 507.16 |
| Arabie saoudite | 10.38 | 79.3 | 4.44 | 25.23 | 23.32 | 144.08 | 191.36 | 1072.94 |
| Afrique du sud | 4.57 | 10.35 | 2.21 | 3.62 | 9.23 | 12.07 | 54.81 | 195.82 |
| Thaïlande | 26.09 | 34.49 | 5.36 | 6.28 | 24.56 | 31.68 | 310.90 | 1012.25 |
| Turquie | 8.44 | 11.31 | 4.42 | 4.95 | 26.33 | 23.22 | 85.34 | 132.91 |

important, bien qu'ils ne donnent pas un « chiffre magique » pour le seuil.

Toutefois, les réserves de change dans un bon nombre de pays émergents ont largement dépassé les recommandations de ces ratios classiques. Le tableau 3.1 nous donne une idée sur l'évolution des ratios d'adéquation dans des pays émergents entre 2000 et 2007.

De récentes études fondées sur des modèles plus complexes ont essayé de trouver une réponse à cet écart entre le niveau de réserves observé et les prédictions des ratios classiques. Jeanne et Rancière (2011) partent d'un modèle d'assurance et préconisent un ratio de réserves de change sur le PIB équivalent à 9.1%, ainsi capable d'absorber un choc du compte de capital de 10%. En se basant sur un modèle Probit, Calvo et collab. (2013) trouvent que les réserves de change réellement observées ne sont pas loin de la prédiction de leur modèle avant la crise. Ils concluent qu'il n'y a pas d'éléments probants pour justifier une accumulation excessive de réserves avant la crise de 2009.

Plusieurs pistes de recherche future pourraient être exploitées afin de réduire l'écart entre la réalité et la prévision. D'une part, comme Jeanne et Rancière (2011) le mentionne, l'aversion au risque pourrait être un élément important qui expliquerait l'engouement des pays émergents, notamment en Asie, envers les réserves de change. Les implications macroéconomiques désastreuses de la crise asiatique ont laissé une empreinte si forte que les pays qui avaient été touchés par la crise comme ceux qui en avaient constaté l'ampleur voudraient évier à tout prix des crises futures similaires. Par ailleurs, les « stigmates » laissés par les programmes de crédit du FMI pourraient aussi avoir joué un rôle. Enfin, il pourrait y avoir une concurrence importante entre des pays géographiquement proches en

termes d'accumulation de réserves. Cette émulation pourrait être incitée par un grand besoin de financement extérieur [5] [le cas dans des pays de l'Amérique latine ; c.f. Cheung et Sengupta (2011)] ou par un besoin de maintenir un taux de change faible [6] (le cas des pays asiatiques).

Enfin, si l'excédent des réserves de change est confirmé, il faut trouver des moyens pour réduire le niveau de réserves de change dans des pays émergents. Une réponse possible serait de déterminer des alternatives aux réserves de change. Sous l'angle dit « de précaution », par exemple, est-il possible de remplacer une auto-assurance par un filet de sécurité global (« global safety net » à l'image des lignes de crédit du FMI) ou/et par les filets de sécurité régionaux (« regional safety net », tels que l'Initiative de Chiang Mai (CMI) ou le Fonds de stabilité européen (ESM)). Pour réduire la partie de réserves liées à la motivation mercantiliste, il faut que les pays en excédent commercial réorientent leur mode de croissance vers la consommation interne plutôt que la demande extérieure.

## L'accumulation des réserves de change alimente-t-elle les déséquilibres mondiaux ?

L'accumulation de réserves de change n'est pas un phénomène qui se confine uniquement à l'intérieur des frontières d'un pays. Elle constitue une question d'envergure internationale en raison de ses retombées sur le niveau des taux d'intérêt, la croissance économique et la stabilité économique et financière à l'échelle mondiale.

Tout d'abord, selon la théorie de l'« excès d'épargne mondiale » [« global saving glut », théorie développée par Bernanke (2005)], la capacité des États-Unis à financer le déficit de leur balance des paiements courants a été favorisée par les achats massifs d'obligations du Trésor américain et de titres d'agences américaines par des banques centrales des pays émergents sous forme de réserves de change. Autrement dit, une accumulation de réserves de change dans des pays émergents

5. Les réserves de change pourraient être considérées comme une assurance sur la capacité de remboursement vis-à-vis des investisseurs étrangers. Pour arbitrer entre deux destinations de perspective économique similaire, les investisseurs pourraient préférer celle qui s'avère plus robuste financièrement avec un niveau de réserves élevé.

6. Cette émulation est justifiée par la volonté de déprécier la monnaie locale afin de favoriser une croissance tirée par exportations.

ont comme conséquence (volontaire ou involontaire) de déprécier la monnaie locale et d'engendrer ainsi un excédent commercial persistent. En contrepartie, le surplus de la balance commerciale dans les pays émergents et en voie de développement est compensé par le déficit commercial des pays industrialisés.

Par ailleurs, l'achat massif des titres gouvernementaux américains par des pays émergents fait baisser le rendement de ces titres publics, c'est-à-dire le taux d'intérêt mondial à long-terme [7]. Autrement dit, la politique monétaire accommodante aux États-Unis avant la crise des subprimes aurait été financée par des pays émergents. En effet, selon Bernanke (2005), « [c]ette offre grandissante d'épargne [internationale] a fait prospéré les valeurs des actions américaines pendant l'euphorie du marché boursier et a aidé à accroître la valeur des immobiliers dans une plus récente période. Ainsi, l'épargne nationale aux États-Unis diminue et le déficit commercial du pays se creuse. » Sous cet angle, l'accumulation de réserves de change contribue directement à l'éclatement de la crise financière mondiale de 2009 car cette dernière partagent « des causes communes » avec les déséquilibres mondiaux avant la crise [Obstfeld et Rogoff (2009)].

Enfin, dans une perspective de croissance incertaine dans des pays avancés et de ralentissement économique dans des pays émergents, une émulation en termes d'accumulation des réserves entre pays, notamment incitée par des intérêts dans le commerce international, pourrait entrainer une guerre des monnaies et une spirale protectionniste dans le monde. Dès 2008, Aizenman (2008) a mis en exergue ce risque : « dans un monde où des économies émergentes symétriques se font concurrence sur des secteurs d'activité comparables, l'accumulation compétitive [de réserves] tend à annuler l'essentiel des gains de compétitivité, entraînant l'appauvrissement de ces économies ».

7. Les taux de rendement des bons du Trésor américains servent souvent de taux directeur sans risque à long-terme.

# 3 Contribution de la thèse

## Chapitre 1

Le premier chapitre de cette thèse [8] est une véritable contribution à la littérature traitant de la relation entre les réserves de change et l'écart entre l'épargne et l'investissement dans une économie en forte croissance. En comparaison avec des articles considérant que les réserves sont un résidu de la politique de change dans une économie où le coût de stérilisation reste faible, cette étude soutient la thèse que la banque centrale dans un pays en voie de développement peut avoir une politique de réserves optimale dans le but d'accélérer le rattrapage économique. En effet, l'accumulation de réserves résulte de l'interaction entre une forte croissance de la productivité et des frictions sur le marché financier qui restreignent le financement des investissements dans le capital physique. En effet, lorsqu'un pays connaît des chocs positifs sur le taux de croissance des productivités, les entreprises sont incitées à investir dans le capital dont le produit marginal augmente avec les gains des productivités. En revanche, la capacité des firmes à financer de nouveaux investissements est limitée par leur capacité d'endettement à cause des frictions sur le marché financier national. Face à ces frictions financières, les autorités publiques, en l'occurrence la banque centrale, peuvent fournir des titres publics avec lesquels les entreprises peuvent épargner davantage. Ce qui a comme conséquence de réduire les frictions du marché financier liées aux contraintes de crédit. Dans une économie où il y a un réel manque d'actifs financiers nationaux, la banque centrale ne peux compenser l'émission des titres publiques nationaux par une augmentation des ses avoirs en devises étrangères.

Par ailleurs, ce chapitre de thèse entend définir les conditions dans lesquelles une accumulation de réserves de change issue du mécanisme décrit au-dessus peut être une politique optimale en termes de bien-être social. A l'aide d'un problème de Ramsey, il est prouvé que l'accumulation de réserves de change est d'autant plus efficace que les flux de capitaux privés sont contrôlés, c'est-à-dire, une économie avec des contrôles de capitaux est plus efficace qu'une économie financièrement ouverte pour atteindre l'état stationnaire de long terme. Deux raisons

8. L'article de recherche sur lequel est basé ce premier chapitre de thèse a été accepté pour publication dans *Macroeconomic Dynamics*, numéro de juillet 2014.

justifient ce résultat. Premièrement, la banque centrale, en tant que représentant de l'économie nationale, peut obtenir autant de financements étrangers qu'une économie financièrement ouverte. En second lieu, le compte de capital étant fermé pour le secteur privé, la banque centrale garde la mainmise sur les taux d'intérêt nationaux car les agents privés ne peuvent se contenter que des titres publics nationaux dont les taux d'intérêt sont fixés par l'état. En conséquence, la banque centrale pourrait ajuster les taux d'intérêt nationaux à la hausse face à un choc de productivité temporaire afin d'inciter les agents privés à épargner davantage et à investir plus dans le stock de capital par la suite.

Ce chapitre met en avant trois résultats dont la portée politique est particulièrement intéressante. Tout d'abord, selon cette approche que j'analyse, l'accumulation de réserves de change est un phénomène propre aux pays en phase de rattrapage économique. Même sans tenir compte des préoccupations de change ou d'assurance, les autorités monétaires de ces pays peuvent être amenés à acheter des réserves pour répondre aux chocs de productivité positifs et à la capacité insuffisante du secteur privé à s'endetter. De surcroît, pendant la phase de transition, l'accumulation de réserves de change, combinée à des contrôles de capitaux sur les flux privés constitue une politique optimale en termes de bien-être social. Cette politique conjointe permet en effet non seulement à l'économie tout entière d'avoir suffisamment de ressources financières par rapport à une économie financièrement ouverte, mais aussi d'ajuster les taux d'intérêt nationaux si besoin. Enfin, l'utilisation de contrôles de capitaux et de réserves n'a de réelles conséquences que temporaires ; les gains du bien-être issus d'une utilisation combinée de réserves et de contrôles de capitaux diminuent avec le développement des marchés financiers. Dès lors qu'il n'y a plus de contraintes financières, il suffit d'ouvrir complètement le compte de capital afin que l'économie atteigne l'équilibre du « first-best ». Ainsi, l'accumulation de réserves de change et l'utilisation des contrôles sur les flux de capitaux ne doivent pas empêcher les réformes structurelles nécessaires sur le marché financier national.

## Chapitre 2

De nature empirique, ce chapitre[9] propose une analyse du rôle d'assurance des réserves de change pendant la crise financière mondiale de 2009. Malgré une riche littérature théorique soulignant la motivation de précaution, la littérature empirique n'a pas trouvé de résultats univoques à l'égard du rôle des réserves pendant la dernière crise financière mondiale.

A l'aide d'une base de données comprenant 112 pays émergents et en voie de développement, ce travail examine d'abord la relation entre l'accumulation de réserves avant la crise et la performance économique pendant la crise, à savoir si les pays qui avaient accumulé plus de réserves de change se sont mieux sortis de la crise. La performance économique d'un pays se mesure par la perte de niveau de Produit Intérieur Brut (PIB) par rapport à une moyenne historique ou à un niveau de PIB contrefactuel (si la crise n'avait pas eu lieu). Un aspect particulier qui est analysé dans cette étude est l'interaction entre le niveau de réserves de change et les contrôles de capitaux. Dans la littérature en macroéconomie et finance internationales, les réserves de change et les contrôles de capitaux sont considérés tantôt comme des substituts, tantôt comme des compléments. En effet, un pays dont le compte de capital est ouvert s'expose plus à la volatilité des flux de capitaux étrangers et est ainsi incité à accumuler plus de réserves pour se prémunir contre des revirements des capitaux étrangers. Dans cette perspective, les contrôles de capitaux et les réserves de change peuvent être considérés comme des substituts ces deux politiques réduisant le risque lié à la volatilité des capitaux étrangers. Or, ces deux instruments peuvent aussi être complémentaires, comme le souligne ce chapitre de thèse. Autrement dit, leur effet marginal sur la croissance se renforce mutuellement : les réserves de change sont d'autant plus efficaces comme moyen d'assurance que le compte de capital est fermé. Enfin, par rapport à la littérature empirique sur les réserves de change, notre étude instrument les réserves de changes, car ces dernières pourraient avoir un effet sur la croissance via des variables omises (« biais de variables omises »). Il est possible qu'un pays qui est structurellement vulnérable (par exemple, à cause d'institu-

9. Ce chapitre fait partie d'un travail de recherche en collaboration avec Matthieu Bussière (Banque de France), Menzie Chinn (Université de Wisconsin, Madison) et Noëmie Lisack (Institut universitaire européen). Il est publié en tant que document de travail du NBER WP19791.

tions inadéquates) accumule plus de réserves de change par anticipation. Dans ce cas-là, des régressions estimées par la méthode des moindres carrés génèrent des résultats biaisés. Pour corriger ce problème, ce chapitre propose plusieurs variables instrumentales potentielles.

Trois résultats sur le rôle des réserves pendant la crise peuvent être dégagés de cette étude. Tout d'abord, lorsque le ratio d'adéquation de réserves de change est calculé en point de pourcentage par rapport à la dette extérieure à court-terme, la performance économique d'un pays pendant la crise est positivement corrélée avec les réserves de change d'avant la crise. Ce résultat reste robuste même si on change la définition de la performance économique, utilise différents sous-échantillons ou rajoute d'autres variables de contrôle. Il suggère également que la dette extérieure à court terme pourrait être un objectif sous-jacent qu'un État peut avoir à l'esprit lors d'une prise de décision sur la politique de réserves. On observe également que le coefficient de régression illustrant l'interaction entre les réserves de change et les contrôles de capitaux est significatif. Autrement dit, l'effet de réserves de change sur la performance économique d'un pays dépend de l'ouverture financière de celui-ci : un pays ayant un compte de capital moins ouvert voit l'effet marginal des réserves augmenter. Il est à noter que l'effet marginal des réserves (pondérées par la dette extérieure à court terme) se renforce lorsque l'on élimine les observations « aberrantes » [10] et les petits pays. Enfin, cette étude essaie d'apporter une réponse à un débat récent : les réserves de change doivent-elles être réellement déployées pour jouer le rôle d'assurance ? En effet, il se peut que l'utilisation des réserves pendant la crise (pour défendre la monnaie locale) atténue le détresse économique ou que l'existence même d'un stock régulateur décourage les attaques spéculative. Ce chapitre est en faveur du pouvoir dissuasif des réserves. Il montre que si une variable indicatrice de l'utilisation de réserves est ajoutée à la régression le ratio de réserves sur la dette extérieure à court terme d'avant la crise reste statistiquement significative tandis que la variable indicatrice ne l'est pas.

En outre, grâce à des données récentes après la crise, ce chapitre met en avant les nouvelles tendances dans le comportement d'accumulation des réserves de change que l'on peut observer dans un bon nombre de pays. D'une part,

10. Définies en détails dans le chapitre en question.

les pays qui avaient largement utilisé des réserves de change pendant la crise financière de 2009 en ont reconstitué un stock dès leur sortie de crise. D'autre part, la vitesse d'accumulation des réserves s'est ralentie depuis deux ans. Plusieurs facteurs pourraient être à l'origine de cette évolution. Basé sur un modèle à correction d'erreur (VECM), cette étude montre que cette récente décélération dans l'accumulation des réserves est corrélée avec la stabilisation du niveau de la dette extérieure à court terme. Cette dernière étant une variable d'objectif que les réserves doivent entièrement couvrir afin d'éviter des risques liés à la volatilité des flux de capitaux étrangers.

## Chapitre 3

Le troisième chapitre revient sur un facteur déstabilisateur qui a lourdement affecté les pays émergents pendant les crises de la fin des années 1990 et qui est beaucoup moins étudié dans le contexte de la crise financière de 2009 : l'asymétrie de devises dans le passif et l'actif du bilan (« currency mismatch ») et l'effet d'une dépréciation sur les bilans du secteur privé (« balance sheet effect ») qui en résulte. En effet, si le secteur privé s'expose à la dette extérieure libellée en devises étrangères, une dépréciation de la monnaie locale, anticipée ou réalisée, accroîtra le passif du bilan du secteur privé et entraînera une insolvabilité de ce secteur, ce qui déclenchera par la suite une sortie de capitaux étrangers qui confirmera une fois de plus la pression baissière sur le cours de change. Ainsi, comme le montre Krugman (1999), deux équilibres de marché peuvent exister : un équilibre défavorable caractérisé par une dépréciation importante de la monnaie locale et un niveau d'investissement faible ; un équilibre favorable avec un taux de change apprécié et un niveau d'investissement élevé.

Le travail effectué dans ce chapitre de thèse montre qu'en accumulant des réserves de change, le gouvernement est en mesure d'améliorer les anticipations des investisseurs et d'éliminer l'équilibre défavorable. D'une part, le gouvernement peut promettre une recapitalisation du secteur privé en réduisant la dette extérieure de ce dernier ou s'endetter auprès des investisseurs étrangers pour le secteur privé national. Pour ce faire, le gouvernement doit avoir un stock suffisant d'actifs libellés en devises étrangères. Hormis pour des raisons dites de « précau-

tion », la valeur en monnaie locale des réserves de change augmente dans le cas où la monnaie locale subit une pression de dépréciation. Ainsi, une perte de richesse du secteur privé en cas de choc négatif sera compensée par une augmentation de la valeur des actifs étrangers détenus par le gouvernement. L'équilibre défavorable est ainsi écarté du fait que la richesse du secteur privé est garantie par le gouvernement en cas de choc. Les réserves de change peuvent ainsi être considérées comme une forme d'assurance contingente dépendant du taux de change.

D'autre part, le gouvernement peut également mener une politique de relance fiscale afin d'accroître la demande des biens produits à l'intérieur du pays, ce qui apprécie le taux de change, réduit la charge financière des entreprises et garantit leur richesse qui sert de collatéral pour le financement des entreprises.

En termes de ressources utilisées, ce travail montre que la politique de recapitalisation demande moins de réserves que la politique de relance budgétaire. En effet, la politique de recapitalisation change les anticipations des investisseurs tandis que la politique de relance budgétaire doit réellement changer le taux de change afin d'assurer la capacité de financement des entreprises.

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# Chapter 1

# A Growth Perspective on Foreign Reserve Accumulation

The work presented in this chapter is accepted for publication in *Macroeconommic Dynamics* (Cambridge University Press), forthcoming in July 2014.

## 1.1 Introduction

Since the beginning of the 21st century, the fast accumulation of international reserves in emerging market economies and developing countries has driven the world total international reserves to an unprecedented high level. This recent phenomenon has reignited the debate on the reasons motivating the demand for reserve assets among academics and policymakers.

Inspired by the situation in China, I propose in this paper a theory of foreign reserve accumulation in fast-growing emerging economies. The focal point of the theory resides in the interaction between productivity growth and financial frictions, two features commonly observed in emerging market economies. Positive shocks on productivity growth induce the private sector to invest in capital while financial frictions constrain the private sector's borrowing ability. In this context, domestic capital formation needs to rely on firms' retained earnings. In order to push capital formation to its first-best level - defined as the steady state level without financial frictions - the central bank intervenes by providing the pri-

vate sector with domestic assets which are in turn financed by the central bank's investment in foreign reserves. Foreign reserve accumulation is thus motivated by a strong demand for domestic liquid assets, especially when the domestic financial market lacks alternative investment opportunities to absorb the central bank's bond proceeds. By comparing with a situation of financial autarky, it is shown that the central bank's intervention by channeling external funding to the domestic economy relaxes the credit constraint and raises the domestic interest rate. Altogether, this generates higher retained earnings for the private sector and accelerates domestic capital formation to reach the first-best level.

Using a Ramsey problem, this paper goes one step further to examine conditions under which the central bank's reserve policy is optimal in terms of social welfare. In comparison with a financially open economy, an economy where only the central bank can get access to international financial markets while private capital flows are controlled is proved to raise social welfare provided binding financial constraints. The reason is that with foreign reserve accumulation and capital controls the central bank can not only channel as much external funding as in a financially open economy - the central bank is merely a financial intermediary between the domestic economy and the rest of the world - it has also the domestic interest rate under control. As a result, it can increase it to encourage domestic firms to save more facing positive productivity shocks.

This paper contributes to a long line of literature on motives for international reserve accumulation. Several different motives have been identified [11]. Often, reserves and the resultant sterilization are considered means of keeping a country's currency undervalued while avoiding inflation risks [See Bénassy-Quéré et al. (2011)]. I provides here an account of a reserved causality: a central bank's sterilization bonds are additional saving instruments for the private sector while

11. For a detail account of the precautionary motive for reserve accumulation, see Aizenman and Lee (2007), Alfaro and Kanczuk (2009), Aizenman and Hutchison (2010), Jeanne and Rancière (2011), Bianchi et al. (2013), Benigno and Fornaro (2012), Bussière et al. (2014) and Calvo et al. (2013). For the mercantilist approach, see Dooley et al. (2003), Korinek and Serven (2010) and Jeanne (2012). For an account of the relationship between reserve accumulation and domestic financial conditions, see Caballero et al. (2008), Dominguez (2010), Obstfeld et al. (2010), Song et al. (2011), Wen (2011) and Bacchetta et al. (2013). Recent empirical papers, such as Delatte and Fouquau (2012), Ghosh et al. (2012) and IEO (2012) shed light on the country-group specific and time-varying aspects of foreign reserve accumulation.

reserves are the counterpart used to finance these domestic bonds. My paper complements the strand of the literature arguing that foreign reserves can be accumulated because of domestic financial frictions. Song et al. (2011), Wen (2011), Coeurdacier et al. (2012) and Bacchetta and Benhima (2012) have studied this relationship in a standard open economy setting. They all document that in an open economy domestic credit frictions generate a wedge between domestic savings and investment, thus lead to a structural surplus of the balance of payments and capital outflows. As these models study the open economy, they only focus on the overall position of net foreign assets of a country; official foreign reserves held by the country's monetary authorities and private foreign assets cannot be discriminated. By introducing capital controls [12], my model focuses on the central bank's reserve assets [13] and allows a scrutiny of its optimal reserve policy. Moreover, my paper argues that it is through domestic public bond provision that the central bank, as a financial intermediary, reduces the wedge between domestic savings and investment and transfers external financing into the domestic economy. This is also a missing aspect in the existing literature.

With respect to a joint analysis of foreign reserve accumulation and capital controls, this paper is directly comparable with Bacchetta et al. (2013) but differs in several aspects. First, I nest foreign reserve accumulation in a growth model so as to examine the relationship between reserve holding and economic growth. Second, whereas Bacchetta et al. (2013) present an endowment economy, I focus on the contribution of reserves to domestic capital formation, driver of economic catch-up in emerging market economies. The introduction of capital is crucial for three main reasons. It introduces a feedback loop [14] in the credit constraint

12. Benigno and Fornaro (2012) also look at the imperfect substitutability between public and private flows. Instead of imposing capital controls as this current article does, they choose to impose an external borrowing constraint on private firms. Also, they study different motives of reserve accumulation.

13. In this paper, international reserves comprise foreign exchange reserves ['official claims on nonresidents in the form of foreign banknotes, bank deposits, treasury bills, short- and long-term government securities and other claims usable in the event of balance of payments need' (IFS Yearbook 2012)], reserve position in the Fund, the U.S. dollar value of SDR holdings and gold holdings. As foreign exchange reserves are the major component, I will use 'international reserves' and 'foreign (exchange) reserves' interchangeably.

14. Future output produced with the capital invested today serves as a collateral. Thus, the more capital invested, the less binding the constraint and more capital can be further invested.

and allows a better understanding of how the public intervention relaxes the constraint facing domestic firms. It also enables me to examine gains from capital formation instead of redistributive effects and consumption smoothing gains in the welfare analysis. Ultimately, this makes the model more relevant to fast-growing economies, such as China. The economic growth in these countries is largely driven by strong productivity growth and resultant capital accumulation [see Nelson and Pack (1999), Bond et al. (2010) and Ahuja and Nabar (2012)] [15].

The theory that I develop is also related to the seminal contribution of Woodford (1990) who argues that issuing public bonds promotes domestic capital investment and is welfare improving when the private sector faces borrowing constraints. My paper can be regarded as an extension to Woodford's framework in an open economy context with possibilities of imposing capital controls; it explains how official foreign reserves can be complementary to domestic bonds so as to ease domestic financial frictions.

This article yields three sets of interesting policy implications. First, foreign reserve accumulation is a 'transition' phenomenon; it is driven by the constrained demand for domestic borrowing due to financial frictions in the context of strong productivity growth. Second, the model argues in favor of a temporary and timely use of capital controls jointly with the reserve policy. The combined use of these two instruments generates higher welfare during economic transition in comparison with a financially open economy, despite the same long-run steady state which is reached in both policy regimes. Third, the welfare gains from the joint use of reserve accumulation and capital controls diminish with financial development, namely when the credit constraints become less binding. Therefore, capital controls need to be used in a temporary manner, and its use should not hinder any structural reforms in the financial market.

This paper is organized as follows. Section 1.2 describes the model setting. Section 1.3 analyzes reserve accumulation and capital formation in a decentralized economy. Section 1.4 introduces the optimal policy of the central bank and presents numerical results. Section 1.5 concludes.

15. Notice that this view challenges somehow the widespread view on Chinese export-led growth. However, one can easily calculate the contribution to the Chinese GDP growth. Investment is by far the most important contributor (more than 40% since 2000).

## 1.2 Model setting

The model that I develop is inspired by Bacchetta and Benhima (2012) to which I explicitly add a central bank [16].

The benchmark economy is however different from a standard small open economy setting, because capital controls can be imposed by the central bank. Indeed, the central bank can set the economy in one of the three policy regimes: financial autarky when no capital flows are allowed; a fully open economy where both the public and private sectors get access to international financial markets; a semi-open economy à la Bacchetta et al. (2013) where only the central bank has access to external financing while private capital flows are controlled. The central bank can choose the appropriate policy regime through two key variables: foreign assets $B^*$ and domestic interest rate $r$ as table 1.1 illustrates.

Table 1.1: Policy regimes

| | | Policy Instruments | |
|---|---|---|---|
| Policy regime | Characteristics | Foreign assets | Interest rate |
| Financial autarky | No external financing | $B^* = 0$ | $r \in \Re^+$ |
| Open economy | Financial liberalization | $B^* \in \Re^+$ | $r = r^*$ |
| Semi-open economy | Controls on private flows | $B^* \in \Re^+$ | $r \in \Re^+$ |

### 1.2.1 The private sector

The private sector in this paper is composed of two symmetrical family businesses [17]. Each of them is made up of a continuum of individuals of measure one. Family members in each family business are either a worker or an entrepreneur. Within the family business, the worker provides the labor force to the entrepreneur who in turn pays the worker at the marginal product of labor.

16. More standard models with a representative agent can be found in Korinek (2011), Jeanne (2012) etc.

17. Symmetrical in the sense that the two families are identical but in two different stages at each time point as I will explain below.

Importantly, I assume that the family business pools together the incomes of both family members and optimally makes consumption and investment decisions at the family level [18]. This is a parsimonious way to model households and firms all combined. The advantage of doing so is twofold: it simplifies the program of the private sector and renders the Ramsey problem neater; it also allows both the worker and the entrepreneur to save and to contribute to physical capital investment, in contrast with Bacchetta and Benhima (2012) where only the corporate sector is allowed to save (as the worker in their model is 'hand-to-month' and consumes all the labor income every period).

I assume that each family business is infinitely lived and capital is invested every two periods. As a result, any family produces in one period and invests in the other and so on so forth; that is, each of the two families changes its status every two periods, alternating between a 'producing-saving' period (denoted $S$) and an 'investing-borrowing' period (denoted $I$). The assumption of two symmetrical family businesses is to guarantee that in each period there is always one family in the 'producing-saving' stage and the other in the 'investing-borrowing' stage, so that there is always a family ('investing-borrowing') which faces the borrowing constraint.

### Family businesses' program

As the family businesses are symmetrical, it is sufficient to look at the program of one of them. Let's consider the family who starts at time $t$ in the 'producing-saving' period. It faces a standard intertemporal utility function with a discount factor $\beta$:

$$\sum_{t=0}^{\infty} \beta^t \Big[ U(c_t^S) + \beta U(c_{t+1}^I) \Big] \tag{1.1}$$

18. There are other papers which adopt this strategy of modeling a family business (or 'representative family') composed of two types of members, such as Merz (1995) or Ljungqvist and Sargent (2007).

It has the following alternating budget constraints every two periods:

$$\text{At } t\text{: } F(A_t, K_t, N_t) - r_t L_t = c_t^S + S_{t+1} + \frac{T_t}{2} \tag{1.2}$$

$$\text{At } t{+}1\text{: } r_{t+1} S_{t+1} + L_{t+2} = c_{t+1}^I + K_{t+2} + \frac{T_{t+1}}{2} \tag{1.3}$$

The family business which starts with the 'investing-producing' period at time $t$ has similar budget constraints: at time $t$, $r_t S_t + L_{t+1} = c_t^I + K_{t+1} + \frac{T_t}{2}$; at time $t+1$, $F(A_{t+1}, K_{t+1}, N_{t+1}) - r_{t+1} L_{t+1} = c_{t+1}^S + S_{t+2} + \frac{T_{t+1}}{2}$.

From (1.2) and (1.3), a typical family business in its 'producing-saving' period harvests an output $F(A_t, K_t, N_t)$ (produced with inputs $K_t$ and $N_t$ chosen a period earlier), and makes the decision between current consumption $c_t^S$ and savings $S_{t+1}$. The willingness to save is explained by the fact that the output is only harvested every two periods. Namely, at $t+1$ the family will be in its 'investing-borrowing' period and will rely on retained earnings $r_{t+1} S_{t+1}$ as well as domestic borrowing $L_{t+2}$ to invest in physical capital $K_{t+2}$ and to consume $c_{t+1}^I$. If the 'producing-saving' family is able to save, it is because the other symmetrical family is in the 'investing-borrowing' period and demands for loans (or because additional saving instruments, such as central bank bonds or foreign assets, are available)[19]. $r_t$ denotes the sequence of the domestic *gross* interest rate ($r_t > 1$, for all $t$). $T_t$ denotes lump-sum taxes (transfers) to (from) an implicit government.

The production function $F(A_t, K_t, N_t)$ is a standard neoclassical production function: increasing in all arguments, concave and homogeneous of degree one. $F_{K,t}$ and $F_{N,t}$ denote the marginal product of capital and that of labor respectively. $A_t$ stands for a production technology which is the only source of shocks in the model. The wage payment does not appear in the above budget constraints. This is because the wage payment between the worker and the entrepreneur is carried out internally with $w_t = F_{N,t}$ while consumption and investment decisions are made by the head of the family at the family level. It is further assumed that the labor supply is inelastic with $N_t = 1$.

19. In the current setting, families lend to each other directly and the banking sector is absent. However, the results that I derive in the subsequent sections will not change even if a competitive banking sector is introduced. Therefore, to keep the model tractable, I decide to leave the financial sector aside.

### Credit constraint and demand for liquid assets

Most importantly, there is a credit constraint facing the family in its 'investing-borrowing' period:

$$L_{t+1} \leq \frac{\psi F(A_{t+1}, K_{t+1})}{r_{t+1}} \tag{1.4}$$

The maximum amount of loans that an investing family can get is conditional on the discounted value of its next period output, thus negatively correlated with the domestic interest rate and positively related to the production technology and to the contemporaneous capital investment. $\psi$ denotes the tightness of the credit constraint with $\psi \in [0, 1]$. The smaller the value of $\psi$, the tighter the constraint [20].

Whenever the credit constraint is binding, the demand for domestic borrowing is reduced, generating a wedge between savings and borrowing, namely $S_{t+1} - L_{t+1} > 0$. In equilibrium, this leads either to a lower supply of savings and a repressed domestic interest rate - as savings $S_{t+1}$ are pinned down by the constrained borrowing $L_{t+1}$ - or calls for supplementary liquid assets for saving.

The demand for supplementary liquid assets is thus motivated in this paper by the interaction between a fast productivity growth which generates strong incentives to invest and a borrowing constraint which confines both domestic savings and borrowing in a suboptimal level. The motive of the demand for liquid assets is thus different from Bacchetta and Benhima (2012) where the liquidity demand is induced by the need to pay the labor force in advance.

Finally, it is assumed that the credit constraint is institutional and cannot be removed in the short run. It is very common to observe obstacles to domestic financing in various emerging and developing countries: direct lending is costly or banks have preference biases in selecting firms to which they grant loans, etc. For example, in China, households have a large level of savings that they are willing to lend to firms in need but fail to do so short of a developed financial market [see Chamon and Prasad (2010)]. In addition, being mostly state-owned, commercial banks in China prefer (and sometimes are obliged) to lend to state-

20. The form of the credit constraint can be micro-founded based on the contract enforcement argument [e.g. Bernanke et al. (1999)].

owned enterprises; domestic private firms, notwithstanding more productive, are unable to get enough loans from commercial banks [see Song et al. (2011)]. To remove the credit frictions, many structural reforms[21] need to be implemented and this takes time.

### 1.2.2 The central bank

The central bank issues domestic saving bonds, $B_{t+1}$, which aim at filling out the gap between domestic savings and borrowing. Due to the limited scope of the domestic financial market, the central bank then invests domestic bond proceeds in foreign assets, $B^*_{t+1}$. The central bank's flow budget constraint is described as follows:

$$r^*_t B^*_t + B_{t+1} + T_t = r_t B_t + B^*_{t+1} \tag{1.5}$$

$r^*_t$ is the world interest rate; it is assumed that the world interest rate is constant and equals to the inverse of the discount factor $\beta$, namely $r^*\beta = 1$ (assuming the same time preference in the domestic economy and abroad). $T_t$ is a lump-sum transfer *from* the government which taxes households to pay this transfer (this can be a transfer *to* the government as well if $T < 0$). To focus on the central bank's policy, it is assumed that the transfer from (to) the government is exogenous, used only to balance the central bank's flow budget constraint each period; it captures the financial gains or losses from the central bank's investment, which are transfered to the government as the latter can be regarded as the central bank's stakeholder.

The supply of liquid bonds by the central bank is determined by the demand on the domestic market (difference between domestic savings and borrowing):

$$\underbrace{B_{t+1}}_{\text{supply of liquid bonds}} = \underbrace{S_{t+1} - L_{t+1}}_{\text{demand for liquid bonds}} \tag{1.6}$$

In a financially open economy, $B^*$ and $B$ are perfect substitutes; the 'producing-saving' family is indifferent between investing in domestic public

21. One may especially think of fiscal reforms (reinforcing domestic firms' financial situation) or standardization of accounting principles, etc.

bonds or foreign assets[22]. In a semi-open economy, namely with controls on private capital flows, the central bank plays the role of financial intermediary between the domestic economy and external financial markets. Public bonds and foreign assets are thus not perfect substitutes for the private sector. Figure 1.1 shows the basic model setting presented above and the two possible policy regimes to channel external funding to the domestic economy. I will show in Section 3.3 and 1.4 the similarities and differences between these regimes.

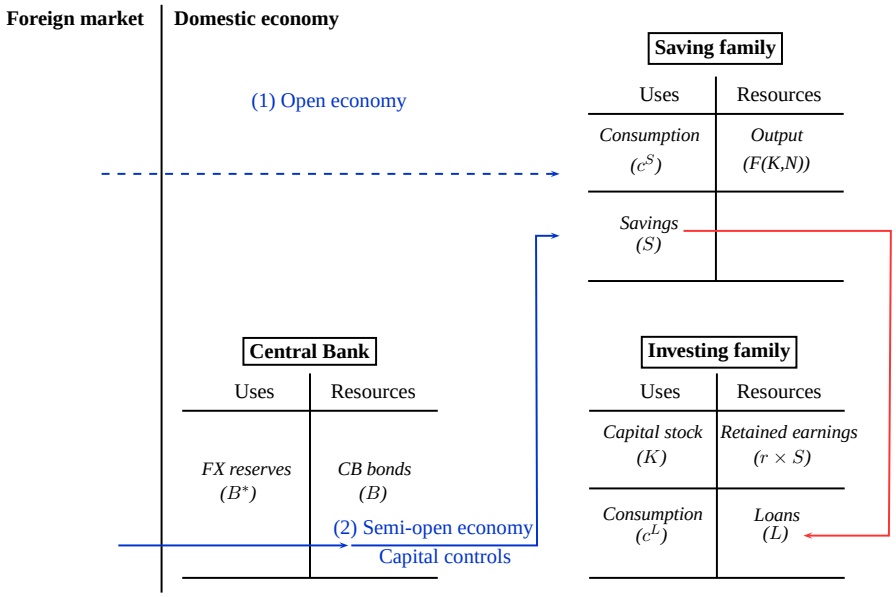


Figure 1.1: Model scheme

### Central bank's purchases of foreign reserves

The use of public debt, e.g. government or central bank bonds, has proved to be welfare improving in the presence of market frictions, as Woodford (1990) demonstrates. In this paper, I argue that in order to provide public liquid bonds the central bank needs to invest abroad. One reason is that in a financially underdeveloped economy, domestic assets which can absorb the central bank's bond proceeds are scare. This assumption is plausible if one looks at the features

22. In this case, it is theoretically equivalent to solve the model by letting families to choose their allocation in foreign assets or letting the central bank to do it for the sake of the private sector.

of the domestic financial market in China: domestic private bond and equity markets are dwarfed by the large public bond issuance(See figure 1.2). Another reason, intrinsic to the model, is that foreign assets generate higher returns than domestic assets as the credit constraint drives down the domestic equilibrium interest rate. Figure 1.3 illustrates the gap between the interest rate on Chinese central bank bills and that on US Treasury bills from 2003 (when data on the interest rates of the Chinese central bank bills started to be available) to the onset of the global financial crisis in 2008. It is observed that during this period which corresponds to a period of fast reserve accumulation, China paid lower interest rates on its central bank bills than that earned on its investment in U.S. Treasury bills. Furthermore, the job of liquidity provision cannot be undertaken by the government as government financing is usually more closely regulated by law than central bank bonds.

In sum, foreign reserve accumulation is motivated by a strong demand for domestic liquid assets in an economy facing a rapid productivity growth rate and an underdeveloped domestic financial market.

To close the model, the aggregate budget constraint is presented below. Output produced by the family in its 'producing-saving' period is consumed by both types of family, invested in capital, and used to buy foreign assets.

$$F(A_t, K_t) = c_t^S + c_t^I + K_{t+1} - r_t^* B_t^* + B_{t+1}^* \tag{1.7}$$

## 1.3 Competitive market equilibrium

In this section, I present fundamental features of the model in a competitive market equilibrium and emphasize on how the credit constraint motivates either a financial liberalization (open economy) or an active intervention of the central bank (semi-open economy). An analysis on domestic capital formation will also be given a special attention. In order to derive analytical results, log-utility and Cobb-Douglas production function are used henceforth, namely

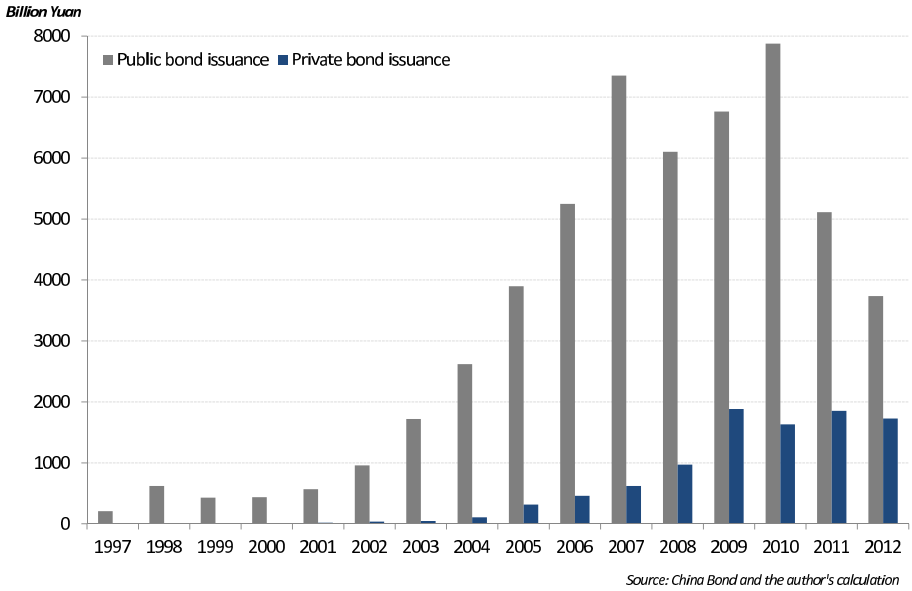


Figure 1.2: Chinese bond market

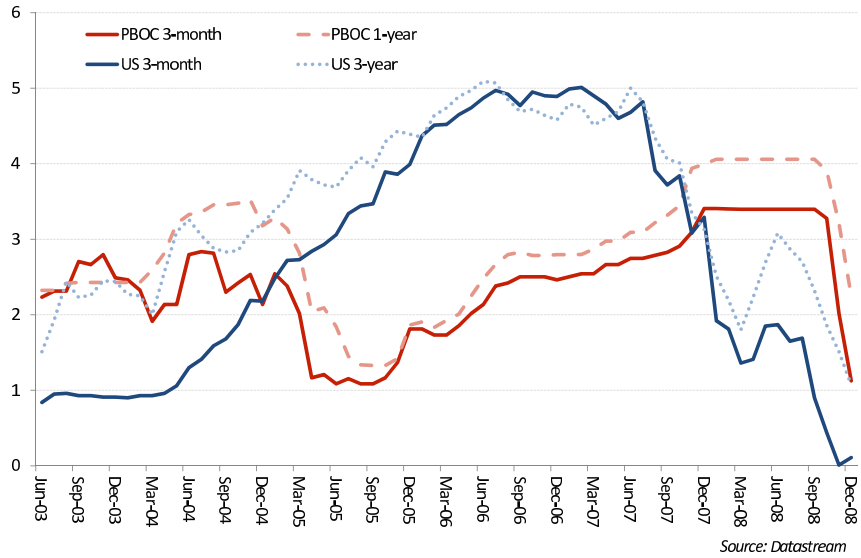


Figure 1.3: Interest rates in China and in the US

$U(c_t^i) = log(c_t^i), i \in (S, I)$ [23] and $F(K_t, A_t) = K_t^\alpha A_t^{1-\alpha}$. For simplicity, I assume $T = 0$, that is the central bank balances its balance sheet with domestic bonds and foreign assets every period.

**Definition 1** *A perfect foresight market equilibrium in a decentralized economy is a sequence of allocation* $\{c_t^S, c_t^I, K_{t+1}, S_{t+1}, L_{t+1}\}$*, for a given sequence of price* $\{r_t\}$*, policy set* $\{B_t^*, B_t, T_t\}$*, and initial conditions* $\{K_0, L_0, S_0, B_0, B_0^*, T_0\}$*, such that for all* $t > 0$*: 1) the utility function* (1.1) *is maximized subject to the family business' budget constraints* (1.2) *and* (1.3)*; 2) the borrowing constraint* (1.4) *is verified; 3) the central bank's budget constraint* (1.5)*, financial and good markets clearing conditions* (1.6) *and* (1.7) *are all respected.*

The first order conditions for the family business in its 'producing-saving' stage at time $t$ are presented below (the first order conditions of the other family can be derived by symmetry):

$$(1 + \psi\lambda_t)F_{K,t} = r_t(1 + \lambda_t) \tag{1.8}$$

$$u'(c_t^S) = \beta r_{t+1} u'(c_{t+1}^I) \tag{1.9}$$

$$u'(c_{t+1}^I) = \beta r_{t+2} u'(c_{t+2}^S)(1 + \lambda_{t+2}) \tag{1.10}$$

$\lambda_t u'(c_t^S)$ denotes the Lagrange multiplier associated with the credit constraint at time $t$. (1.8) tells us that the marginal product of capital is equal to the cost of capital $r_t$ augmented by a coefficient $\frac{1+\lambda_t}{1+\psi\lambda_t}$, which is related to the credit constraint. (1.9) and (1.10) are Euler equations. The Euler equation (1.10), which relates the marginal utility of consumption of an investing family to that of the same family in its 'producing-saving' stage a period later, depends clearly on the credit constraint, $\lambda_{t+2}$.

According to the Kuhn-Tucker theorem, the Lagrange multiplier with respect to the credit constraint verifies $\lambda_t u'(c_t^S)[r_t L_t - \psi F(A_t, K_t)] = 0$. Therefore, $r_t L_t = \psi F(A_t, K_t)$ if the credit constraint is binding or $\lambda_t = 0$ if the constraint is unbinding.

23. Log-utility is only required to derive the uniqueness of the constrained steady state. The results do not change with a more general form of the utility function (e.g. constant relative risk aversion (CRRA).

Using the log-utility and equations (1.2) and (1.3), the consumptions can be expressed as a share of the wealth: $c_t^S = (1-\beta)\Big[F(A_t, K_t) - r_t L_t\Big]$ and $c_{t+1}^I = (1-\beta) r_{t+1} S_{t+1}$.

This gives:

$$S_{t+1} = \beta\Big[F(A_t, K_t) - r_t L_t\Big] \tag{1.11}$$

$$K_{t+2} - L_{t+2} = \beta r_{t+1} S_{t+1} \tag{1.12}$$

### 1.3.1 Uniqueness in steady state

The steady state is uniquely determined when the credit constraint is binding. This result is important to analyze capital formation and other features of the model. For this purpose, I normalize all endogenous variables by the output $F(A_t, K_t)$, namely I define $b^* = \frac{B^*}{F(A,K)}$, $b = \frac{B}{F(A,K)}$ and $\tau = \frac{T}{F(A,K)}$.

The central bank's budget constraint (1.5) becomes:

$$(r^* - 1)b^* + \tau = (r-1)b \tag{1.13}$$

Given international and domestic interest rates as well as the level of government transfer, one can observe from (1.13) that if the central bank wants to provide liquid assets in the domestic economy, it can achieve this objective by purchasing foreign reserves.

**Proposition 1** *Considering the simplest case where $\tau = 0$ (central bank do not have financial gains/losses in the long run), the financially constrained steady state is uniquely determined if $0 < b < \beta(1-2\psi)$.*

**Proof.** See Appendix 1.A ■

Proposition 1 implies that the credit constraint is not binding when $b \geq \beta(1-2\psi)$; the central bank can achieve this goal by raising $b^*$. When the credit constraint is unbinding, the domestic interest rate is equal to the world interest rate $r = r^* = \frac{1}{\beta}$; when the credit constraint is binding, the domestic interest rate is repressed and lower than its international counterpart. Moreover, when the central bank provides liquid bonds which are scarce in the economy, it lowers the

price of the liquid bonds and pushes the domestic interest rate up to the world interest rate level. $r$ is indeed increasing in $b$: $r = \frac{\psi}{\beta(1-\psi)-b}$.

We can further look at the steady state in different policy regimes.

**Financial autarky** In a closed economy where $B^* = 0$, if $\psi \geq 1/2$, the credit constraint does not bind in the steady state (the critical value of $\psi$ is derived in Appendix 1.B). In this case, $\beta r = 1$, namely, the domestic interest rate is equal to the world interest rate. $K = A(\alpha\beta)^{\frac{1}{1-\alpha}}$, the capital stock achieves its first-best level (i.e. the long-run steady state with an unbinding credit constraint). Consumptions are perfectly smoothed, namely the consumption in the saving stage and that in the investing stage are equalized $c^S = c^I$.

If $\psi < 1/2$, the credit constraint binds in the steady state. The Lagrange multiplier associated with the credit constraint is thus positive, $\lambda = \frac{1}{\beta^2 r^2} - 1 > 0$. The domestic interest rate is lower than the world interest rate, namely $\beta r = \frac{\psi}{1-\psi} < 1$. The capital stock, $K = A\left\{\alpha\left[(1-\psi)\beta^2 r + \frac{\psi}{r}\right]\right\}^{\frac{1}{1-\alpha}}$, cannot achieve the first-best level. As for consumptions, that of the investing stage is always smaller than that of the saving stage, $\frac{c^I}{c^S} = \frac{\psi}{1-\psi} < 1$.

In fact, in a financial autarky, with positive productivity growth, the more capital invested the better. There is thus a strong demand for capital investment. However, the investing family is financially constrained and the aggregate economy does not have sufficient resources to finance the investment as no external financing is available. The left panel in figure 1.4 shows that in case of a decrease in $\psi$, the credit constraint becomes more binding and the demand for domestic assets increases while the supply remains fixed (due to the financial autarky). This results in a sharp decrease in the domestic interest rate. This is undesirable both for capital investment and domestic consumptions.

**Open economy** One big difference here in comparison with the financial autarky is that the economy has access to external financing. It results in the equalization between the domestic interest rate and the world interest rate, $r = r^* = \frac{1}{\beta}$. There is an unlimited supply of external financing. In this case, the credit constraint is never binding, leading to $b = b^* = \beta(1-2\psi)$. In an open economy,

both the central bank and the private sector get access to the international financial market and therefore central bank bonds and foreign assets are perfect substitutes. The saving family can choose to save with either financial assets. In aggregate, there are sufficient assets with which the 'producing-saving' family can save at the world interest rate $r^*$ (see the mid-panel in figure 1.4). Capital formation and consumptions all reach the first-best level. Clearly, in the steady state, the open economy dominates the financial autarky.

**Semi-open economy** Another possibility to amend the shortcoming of the financial autarky is to allow the central bank to provide extra liquid assets. The semi-open economy is indeed a nested situation of the financial autarky and the open economy. In the steady state, the central bank can replicate the open economy by purchasing the same amount of foreign assets as in the open economy. The only difference is that central bank bonds and foreign assets are no longer perfect substitutes as the private sector is forced to buy central bank bonds without the possibility to get access to foreign financing. A supply of central bank bonds also reduces the price of liquid assets (previously overprice), raising the domestic interest rate (see the right panel in figure 1.4). In the steady state, a semi-open economy can do as well as an open economy.

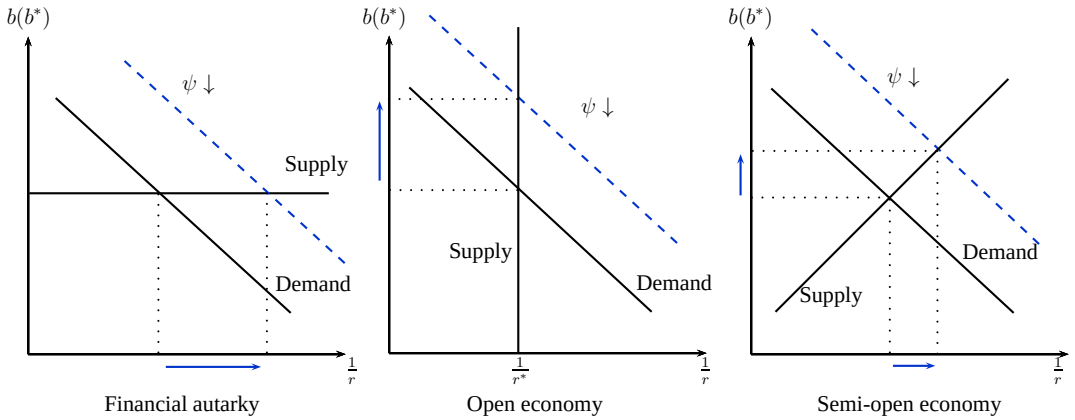


Figure 1.4: Effects of a tightening of the credit constraint

### 1.3.2 Capital formation

How does the capital stock evolve over time? From (1.11) and (1.12), capital accumulation which is consistent with optimal consumptions in a financially constrained economy satisfies:

$$\begin{aligned} K_{t+2} = & \underbrace{\beta r_{t+1} S_{t+1}}_{\text{retained earnings}} + \underbrace{L_{t+2}}_{\text{loans}} \\ & = \beta^2 r_{t+1}(1-\psi)F(A_t, K_t) + \frac{\psi F(A_{t+2}, K_{t+2})}{r_{t+2}} \end{aligned} \tag{1.14}$$

Notice that retained earnings and loans are affected by the interest rate in two opposite ways. An increase in the domestic interest rate raises the retained earnings of the saving family (revenue effect) but reduces the loans that the same family may make next period during its investing period (borrowing effect). Whether capital stock increases or decreases depends on which effect dominates.

A feedback loop effect can be observed through capital investment in (1.14). Namely, more capital invested ($K_{t+2}$) provides a stronger collateral (as the capital enters in the production function), allowing the investing family to borrow more ($L_{t+2}$) during the investing stage and relaxing the credit constraint. This further pushes up capital investment. For example, an initial positive shock on retained earnings (e.g. an increase in $r_{t+1}$, an increase in the initial capital stock $K_t$ or a productivity shock at time $t$) will lead to an increase in capital formation at $t+2$ (through the revenue effect), which in turn drives loans up (through the feedback loop). Capital formation $K_{t+2}$ further increases, generating a virtuous cycle.

To better understand the impact of the interest rate on domestic capital formation, (1.15) can be derived in the steady state using (1.8)-(1.10). Three distinct effects on capital stock can be identified: 1) opportunity cost of capital, 2) revenue effect, $(\beta r)^2 = \frac{1}{1+\lambda}$, 3) borrowing effect, $\psi[1-(\beta r)^2]$.

$$F_K = \frac{r}{(\beta r)^2 + \psi[1-(\beta r)^2]} \tag{1.15}$$

The first effect, the opportunity cost of capital, is standard: the higher $r$, the higher the cost of investing in capital stock, the less capital is demanded. The

other two effects are specific to this model.

The second term $(\beta r)^2$ is related to families' saving revenues. As families are occasionally credit-constrained, they have incentives to rely on retained earnings to invest in capital. As the retained earnings are increasing in the interest rate, the revenue effect has a positive impact on capital stock. Notice that the square appears as the capital is invested every two periods. In an extreme case, when $\psi = 0$ (i.e. no borrowing is possible), families rely entirely on retained earnings for capital investment. The revenue effect clearly dominates the opportunity cost. As a result, a higher supply of liquid bonds leads to a higher domestic interest rate and higher retained earnings. This unambiguously increases the capital stock.

The third effect stems from the fact that the loans that an investing family can ask are conditional on the discounted value of the future production. An increase in $r$ lowers the borrowing capacity of the investing family, as it reduces the discounted value of the collateral. The interest rate has thus a negative borrowing effect on capital stock.

**Proposition 2** *Capital stock represents a U-shape curve as a function of $\beta r$ in the steady state. Purchasing foreign reserves, which leads to a higher supply of domestic liquid assets and thus a higher interest rate, increase capital stock and output production in the economy.*

**Proof.** See Appendix 1.C ■

From figure 1.5, the capital stock achieves the first-best level if $\beta r = 1$ (i.e. in an open economy steady state) or $\beta r = \frac{\psi}{1-\psi}$. However, the latter case is ruled out by the uniqueness of the binding steady state (see Appendix 1.A).

When $\frac{\psi}{1-\psi} < \beta r \leq \sqrt{\frac{\psi}{1-\psi}}$, the curve is decreasing. That is, when the financial constraint is stringent, the initial domestic interest rate is very low, any increase in the interest rate decreases the value of the collateral, leading to a decrease in borrowing. The initial domestic savings are also very low short of saving instruments, an increase in retained earnings (due to a raise of interest rate) cannot offset the decrease in borrowing. Therefore, on this part of the curve, the borrowing effect of the interest rate dominates the revenue effect, leading to a decrease in capital stock. The initial steady state (before the realization of

any shock on productivity growth) can only be located on the lower part of this decreasing curve as $\beta r$ is proved to be strictly higher than $\frac{\psi}{1-\psi}$.

When $\sqrt{\frac{\psi}{1-\psi}} < \beta r \leq 1$, the curve is increasing. This is because when the central bank provides more liquid assets, families save more. The supply of central bank bonds also decreases the price of liquid assets previously overpriced and accordingly increases the interest rate. Families' retained earnings increase due to both a quantity effect (more saving instruments) and a price effect (higher interest rate). The retained earnings are used for capital investment a period later when the family faces investment opportunities. The revenue effect thus dominates the borrowing effect on this part of the curve.

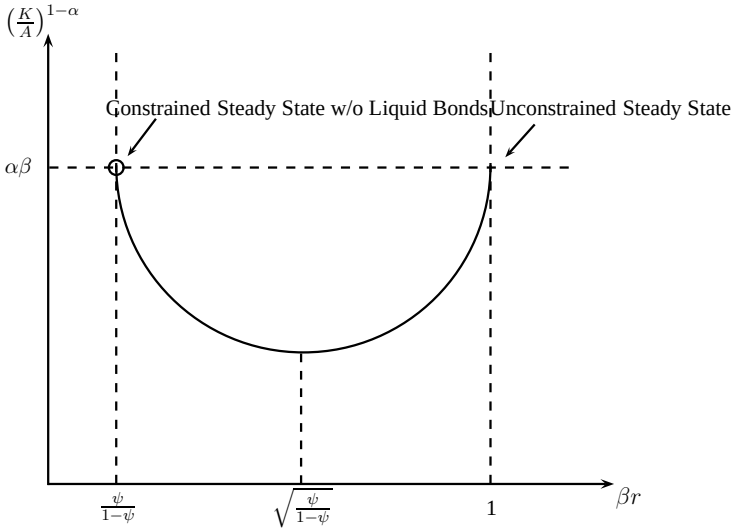


Figure 1.5: U-shape capital formation

## 1.4 The central bank's optimal policy

Section 3.3 showed that an open economy and a semi-open economy achieve the same unconstrained steady state in the long run. Based on a Ramsey problem, I demonstrate in this section how the welfare effects can be different in these two policy regimes during economic transition. This is another important result of this paper: the economy where the central bank imposes capital controls and accumulates foreign reserves (semi-open economy) dominates the financially open

economy on the convergence path [24]. This is because the incentives to invest are particularly strong during a fast-growing transition; in addition to the supply of sufficient funding to domestic firms, the central bank can effectively adjust the domestic interest rate to cope with unanticipated shocks on productivity growth should private capital flows be controlled. With higher retained earnings thanks to the interest rate policy, not only families can invest more in capital, the domestic credit constraint is also more easily relaxed.

### 1.4.1 Ramsey problem

The central bank optimizes the consumptions of the two contemporaneous symmetrical families according to the following objective function.

$$\max_{\{S_{t+1},L_{t+1},K_{t+1},c_t^S,c_t^I,B_{t+1}^*,r_{t+1}\}} \sum_{t=0}^{\infty} \beta^t \Big[u(c_t^S) + u(c_t^I)\Big] \tag{1.16}$$

**Definition 2 (Ramsey problem)** *The central bank's optimal policy consists of choosing a sequence of policy variables* $\{B_{t+1}^*, B_{t+1}, r_{t+1}\}$ *and a sequence of endogenous private sector's variables* $\{c_t^S, c_t^I, K_{t+1}, L_{t+1}, S_{t+1}\}$ *for all* $t > 0$ *such that: 1) the corresponding competitive equilibrium allocation* (1.8) *to* (1.10) *maximizes the welfare function* (1.16)*; 2) individual families' budget and credit constraints,* (1.2), (1.3) *and* (1.4)*, are verified; 3) the central bank's budget constraint* (1.5)*, bond market clearing* (1.6) *and resource constraint* (1.7) *are all respected.*

The way to solve the Ramsey problem follows the 'Primal approach' described by Erosa and Gervais (2001).

24. For an empirical account of the joint use of foreign reserves and capital controls, see Aizenman et al. (2011) and Bussière et al. (2014).

The full Ramsey problem is presented below. Details about the derivation of first order conditions can be found in Appendix 1.D.

$$\begin{aligned}\max_{\{S_{t+1},L_{t+1},K_{t+1},c_t^S,c_t^I,B_{t+1}^*,r_{t+1}\}} \sum_{t=0}^{\infty} \beta^t \Bigg\{ & u(c_t^S) + u(c_t^I) \\ & + \eta_t^S \Big[ F(A_t,K_t) - r_t L_t - c_t^S - S_{t+1} - \frac{T_t}{2} \Big] \\ & + \eta_t^I \Big[ r_t S_t + L_{t+1} - c_t^I - K_{t+1} - \frac{T_t}{2} \Big] \\ & + \eta_t^G \Big[ F(A_t,K_t) - c_t^S - c_t^I - K_{t+1} - B_{t+1}^* + r_t^* B_t^* \Big] \\ & + \theta_t^S \Big[ \frac{1}{c_t^S} - \beta r_{t+1} \frac{1}{c_{t+1}^I} \Big] \\ & + \theta_t^I \Big[ \frac{1}{c_t^I} - \beta r_{t+1}(1+\lambda_{t+1}) \frac{1}{c_{t+1}^S} \Big] \\ & + \rho_t \Big[ (1+\psi\lambda_t) F_{K,t} - r_t(1+\lambda_t) \Big] \\ & + \Lambda_t \Big[ \psi F(A_t,K_t) - r_t L_t \Big] \Bigg\}\end{aligned}$$

As it is explained in Section 3.2, the way to model capital controls in this paper is through two key variables $B_{t+1}^*$ and $r_{t+1}$. In a semi-open economy with capital controls, one needs to derive the first order conditions with respect to both $B_{t+1}^*$ and $r_{t+1}$, as they are all policy variables controlled by the central bank. In an open economy, however, only the first order condition with respect to $B_{t+1}^*$ is derived as the central bank cannot set the domestic interest rate which is always equal to the world interest rate. As I will show in the following section, the superiority of the semi-open economy over the open economy stems precisely from the central bank's ability to manipulate the domestic interest rate $r_{t+1}$.

### 1.4.2 Numerical results

This section provides a direct insight of the superiority of the semi-open economy over an open economy using numerical simulations [25].

25. The simulations are obtained using Dynare 4.3.2, see Adjemian et al. (2011).

### Calibration

The productivity growth is assumed to follow an AR(1) process: $A_t = (1 + g_t)A_{t-1}$ and the growth rate of the productivity is determined by $g_t = \mu g_{t-1} + \epsilon$. $\mu$ stands for the persistence of the productivity growth which is less than 1 and $\epsilon$ is an unanticipated shock. I simulate the model by setting a positive shock of 10% on the productivity growth rate at the beginning of the period 1. The productivity process and the shock are used to mimic the fast economic catch-up in emerging economies.

The discount factor $\beta$ is calibrated to match the average yields of the one-year US Treasury bills [26]. This gives $\beta = \frac{1}{r^*} = \frac{1}{1.05} = 0.95$. The capital share is set to $\alpha = 0.5$, consistent with Bai et al. (2006) and also used by Song et al. (2011) which is the most recent and influential quantitative work on the Chinese economic growth. I choose the value of the key parameter $\psi$, tightness of the credit constraint, so as to match the savings-to-output ratio in the initial steady state of simulations with China's average gross saving rate (as a percentage of the national income) [27]. This gives $\psi = 0.12$. A summary of parameter values can be found in table 1.2.

Notice that due to the parsimony of the model, the numerical results that I present below only aim at illustrating the qualitative results derived from the model.

Table 1.2: Calibrated parameters

| Parameter | Description | Value |
|---|---|---|
| $\alpha$ | Share of capital in the production | 0.50 |
| $\beta$ | Discount factor | 0.95 |
| $\psi$ | Credit constraint tightness | 0.12 |
| $\epsilon$ | Initial shock on productivity growth | 0.10 |
| $\mu$ | Persistence of productivity shock | 0.50 |

26. The average rate of return on one-year US Treasury bills amounts to 5% between 1998 and 2005. This rate can be regarded as a proxy to measure the world interest rate in this paper. Data source: Datastream.

27. This amounts to 42% between 1998 and 2005. Data source: World Bank WDI database.

### Superiority of the semi-open economy during economic transition

Figure 1.6 presents the impulse responses from the numerical exercise. Unless otherwise notified (i.e. for the current account balance which is expressed in absolute change), all impulse responses are expressed in terms of the percentage deviation from the initial steady state (period 0). The solid lines represent the results in a semi-open economy while the dashed lines represent that in an open economy.

It has been analytically demonstrated in Section 3.3 that a semi-open economy and an open-economy can both achieve the long-run steady state with an unbinding credit constraint (first-best situation). In fact, figure 1.6 shows that all variables achieve the same final steady state regardless of the policy regime. Recall that a semi-open economy is an economy where *only* the central bank gets access to foreign financial markets while private capital flows are strictly controlled; an open economy is on the contrary an economy with a fully liberalized capital account. In steady state, accumulating foreign reserves while keeping the capital account closed do not allow the central bank to do better than in a fully open economy. This is because the central bank in the steady state accumulates sufficient foreign assets so that the domestic interest rate catches with the world interest rate.

However, during economic transition, especially when the productivity growth becomes suddenly higher, the combined use of foreign reserves and capital controls allows a faster convergence to the final steady state than in a fully open economy (the solid lines are in general higher than the dashed lines during transition). This is precisely due to the autonomy of the central bank to set the domestic interest rate in a semi-open economy. Facing the same shock on productivity growth at the beginning of the period 1, the central bank raises immediately the domestic interest rate in a semi-open economy while the interest rate is fixed in an open economy [Panel (a)]. To achieve this, the central bank provides more saving instruments [Panel (b)] with which the 'producing-saving' family can save to overcome the credit constraint. The private sector has indeed incentives to save more in a semi-open economy [Panel (c)]. On the one hand, this is because it is financially more interesting for the private sector to save with a higher interest

rate. On the other hand, a positive shock on productivity growth triggers a strong demand for capital investment as the marginal product of capital raises; due to future binding credit constraints, the private sector can increase the investment only by saving more.

The pace of reserve accumulation accelerates accordingly [Panel (d)] as the central bank invests its bond proceeds abroad. Regarding the loans [Panel (e)], in a semi-open economy, the demand for loans first declines with the rise in the domestic interest rate, as a higher interest rate reduces the discounted value of the collateral, making the contemporaneous credit constraint more binding. However, as shown in Section 3.2 there is a positive feedback loop effect with the capital which serves as a collateral for borrowing. Thanks to a rise in capital formation triggered by an increase in retained earnings as a response to the increase in the domestic interest rate in period 1, domestic loans go up in period 2 through this positive feedback loop. Moreover, the domestic interest rate falls after the period 1, which lowers financial costs related to loans. With an overall faster increase in domestic capital formation, the domestic credit constraint is more easily relaxed and loans reach the first-best level more rapidly in a semi-open economy. From Panel [f], one can indeed observe that in a semi-open economy capital slightly decreases in the first period due to the decline of loans in response to a rise in the domestic interest rate, but increases afterwards at a more rapid pace to reach the steady state, thanks to the higher level of the private sector's saving revenues and to a relaxed credit constraint.

One can see in Panel (g) that output increases steadily to reach a 20% higher new steady state at an accelerated pace in the semi-open economy, so do consumptions in both the 'producing-saving' and the 'investing-borrowing' periods [Panel (h) and (i)]. Panel (j) presents the deviation from the initial steady state of the period welfare defined as the sum of the two families' utilities in each period. The social welfare increases faster in a semi-open economy due to an accelerated growth of production. Finally, Panel (k) shows that the economy runs a balance-of-payments surplus during economic transition as the central bank constantly purchases foreign assets to finance domestic bond issuing.

In sum, one can see that in a semi-open economy the central bank can not only provide sufficient domestic funding by investing in foreign reserves, it can

also tackle unanticipated shocks on productivity growth by adjusting the domestic interest rate. The combined policy of reserve accumulation and capital controls makes the semi-open economy better off and allows it to more rapidly reach the higher final steady state.

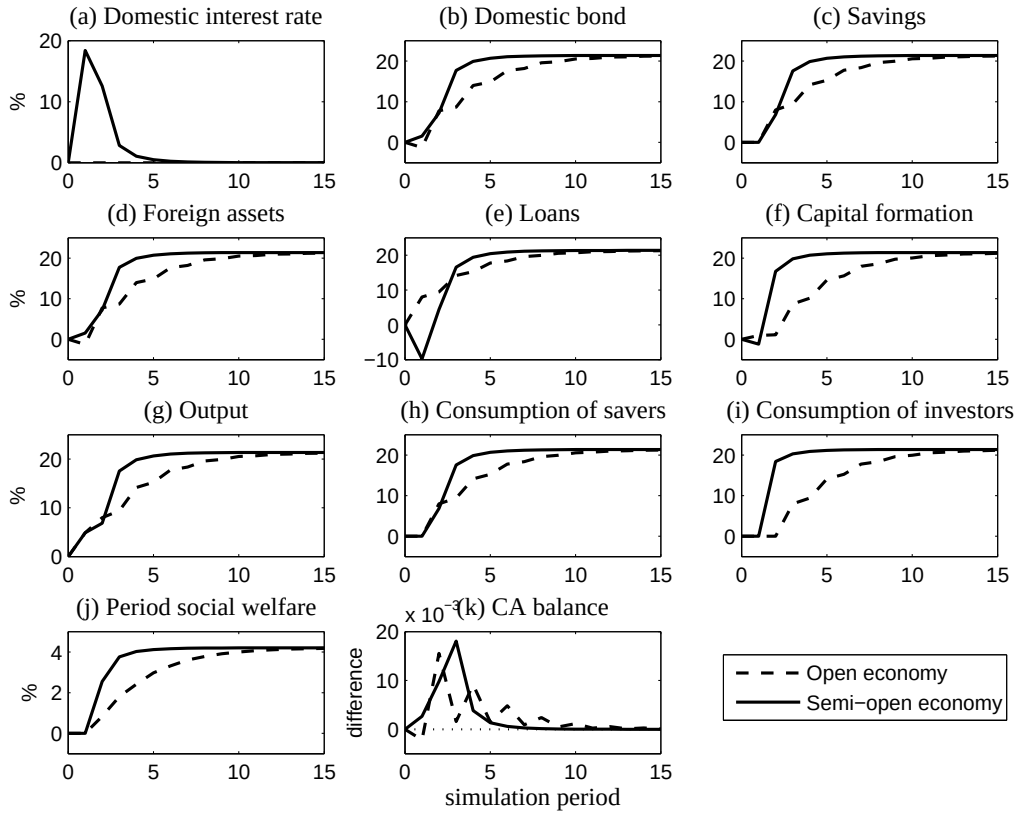


Figure 1.6: Impulse responses. The figure shows the percentage deviation from the initial steady state (except for current account balance) in a semi-open economy (solid lines) and in an open economy (dashed lines) for the impulse responses to a positive shock on productivity growth of 10% at the beginning of period 1.

### Financial frictions and capital controls

How does the welfare gains in a semi-open economy depend on the main assumption of the model, namely a binding credit constraint?

I calculate first the social welfare according to the welfare function (1.16) separately in an open economy and a semi-open economy, for different values of

the credit constraint tightness $\psi$. Then, I calculate the welfare gains in a semi-open economy compared to an open economy and present it as a function of the parameter $\psi$. The result is shown in figure 1.7.

One can observe that the bigger $\psi$ - the credit constraint less binding - the lower the welfare gains of a semi-open economy over an open economy. Moreover, the closer $\psi$ gets to the threshold value 0.5, the sharper the decline in the welfare gains. This is because when $\psi$ gets bigger and close to 0.5, the demand for loans of the 'investing-borrowing' family is close to the unbinding level and almost absorbs the maximum savings that the 'producing-saving' family is willing to provide. In the extreme case where there is no more credit constraint, a semi-open economy can do no better than an open economy; the welfare gains associated with capital controls and foreign reserve accumulation vanish. Put it in another way, in an economy with little financial frictions, liberalizing the capital account is the first-best strategy.

This result sheds light on the temporary character of the benefits from the use of capital controls. In fact, capital controls are welfare improving and need to be maintained only if there are strong imperfections on the domestic financial market. Once appropriate financial reforms eliminate financial frictions, there is no more reason for imposing capital controls.

## 1.5 Conclusion

Based on the model presented in this paper, I can partly attribute the rapid accumulation of foreign exchange reserves in fast-growing emerging economies to the joint force of fast productivity growth and domestic financial market frictions. In fact, facing a rapid economic catch-up, the private sector in these countries has a strong demand for liquid assets to support capital investment. In the absence of a sound financial market with sufficient domestic assets, the central bank has to serve as a financial intermediary to provide domestic liquid assets by investing abroad in foreign exchange reserves short of domestic investment opportunities.

This paper also proves that during economic transition characterized by positive shocks on productivity growth it is welfare improving to let the central bank accumulate foreign reserves and supply domestic liquid assets instead of letting

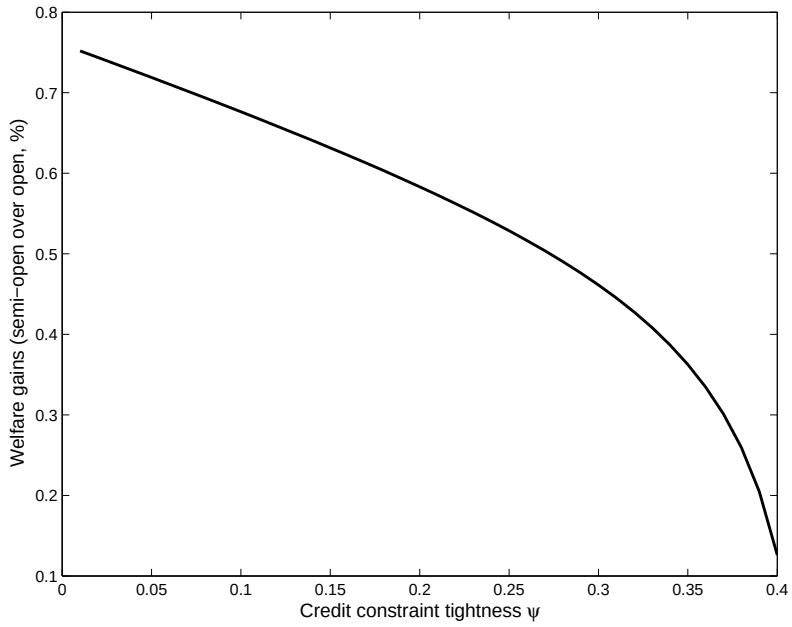


Figure 1.7: Simulation: Welfare gains

the private sector itself hold foreign assets. That is, a combined used of foreign reserves and capital controls leads to a faster economic transition than in a situation of financial liberalization. This is because when private capital flows are controlled, the central bank can adjust the domestic interest rate to cope with any positive productivity shock in addition to the supply of sufficient saving instruments. The welfare gains in a semi-open economy with capital controls diminish, however, with the development of the domestic financial market; welfare gains vanish when the domestic credit constraint hardly binds. This suggests that capital controls should only be used when the domestic financial market is underdeveloped. In the long run, a country needs to implement structural reforms and to open its capital account.

There are several possibilities to address additional interesting issues related to this paper. For one thing, one may think of making capital controls a continuous variable; Schmitt-Grohe and Uribe (2003) and Bénassy-Quéré et al. (2011) provide a framework to do so. In this regard, foreign reserve accumulation can be studied in the context of the optimal sequencing between financial reforms and capital account liberalization. Moreover, the current model finds it optimal for

the domestic economy to accumulate reserves and set capital controls, it might not be the case if cross-country spillover effects are taken into account. It would be interesting to study the same question in an international context by extending the model into a two-country framework [28].

28. There are a couple of new papers studying the impact of foreign reserves using a two-country model in the context of bilateral relations between China and the United States [e.g. Bonatti and Fracasso (2013)].

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## 1.A Proof of Proposition 1

**Proof.** The central bank has to have a balanced budget (1.5) and the financial market has to be cleared (1.6). The steady state of the model with a binding credit constraint is determined by these two conditions:

– Central Bank's budget balance

– Financial market clearing

Using the binding credit constraint (1.4), (1.6), (1.11) as well as normalized policy variable, one can derive:

$$\begin{aligned} B &= S - L \\ \Rightarrow B &= \beta[F(A,K) - rL] - L \\ \Rightarrow B &= \beta(1-\psi)F(A,K) - \frac{\psi F(A,K)}{r} \\ \Rightarrow b &= \beta(1-\psi) - \frac{\psi}{r} \end{aligned}$$

The financial market clearing shows a negative linear relationship between $b$ and $\frac{1}{r}$.

Moreover, in the simplest case without any government transfer, using (1.13) gives,

$$\begin{aligned} (r-1)b &= (r^*-1)b^* \\ \Rightarrow b &= \frac{1}{r-1}(r^*-1)b^* \\ \Rightarrow b &= \left(\frac{1}{1-\frac{1}{r}} - 1\right)(r^*-1)b^* \end{aligned}$$

The balanced central bank's budget shows a non-linear and positive relationship between $b$ and $\frac{1}{r}$.

The uniqueness of the steady state can be thus demonstrated graphically (figure 1.8).

Figure 1.8 shows that there are two solutions of $\frac{1}{r}$, corresponding respectively to $\frac{1}{r} < 1$ (equivalent to $b > 0$) and $\frac{1}{r} > 1$ (equivalent to $b < 0$). I focus here on the first case; $r$ being a *gross* interest rate should be greater than 1. This equilibrium corresponds to $b > 0$ (central bank issues bonds). The interest rate is uniquely determined, $\beta < \frac{1}{r} < \min(1, \frac{\beta(1-\psi)}{\psi})$. For $\psi < \frac{1}{2}$, $\frac{1}{\beta}\frac{\psi}{1-\psi} < r < \frac{1}{\beta}$.

Therefore, when $0 < b < \beta(1-2\psi)$, the economy has a unique binding steady state, provided that $\psi < \frac{1}{2}$ (I will show in Appendix 1.B that $\psi < \frac{1}{2}$ is the condition for the credit constraint to bind.). ■

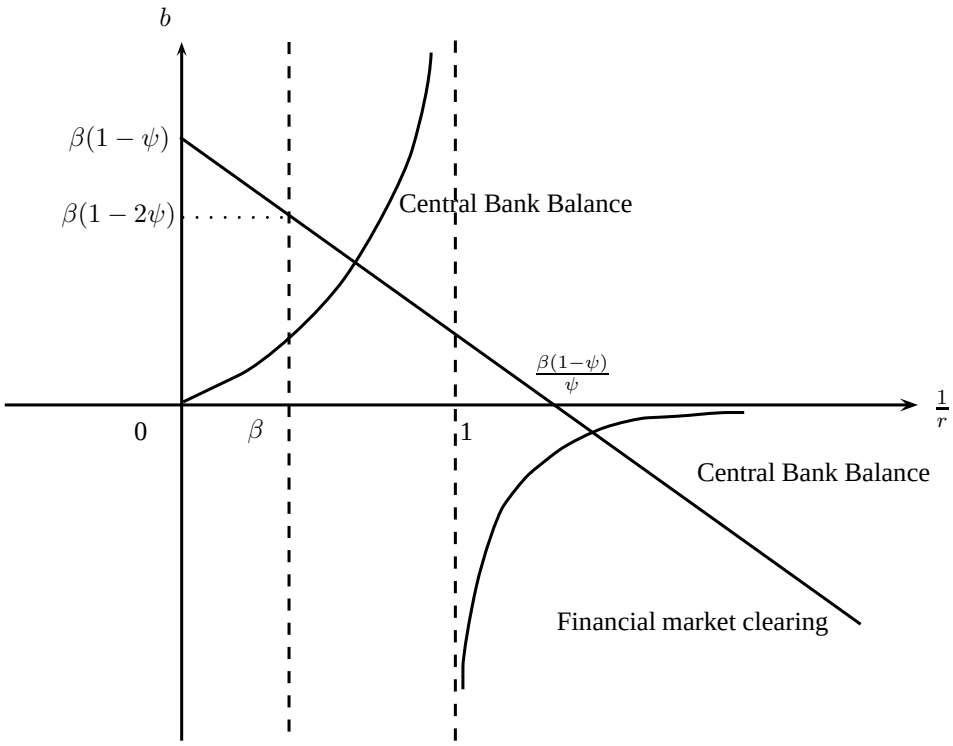



Figure 1.8: Uniqueness of binding steady state

## 1.B Deriving the threshold value of $\psi$

**Proof.** In a steady state when the credit constraint is not binding, $S = L$ and $\beta r = 1$.

From (1.11) and (1.12):

$$S = \beta[F(A,K) - rL]$$
$$\Rightarrow S = L = \frac{1}{2}\beta F(A,K)$$

When the credit constraint is not binding, $rL \leq \psi F(A,K)$, namely $\frac{1}{2}r\beta F(A,K) \leq \psi F(A,K)$.

Therefore, in a steady state with an unbinding credit constraint, I obtain:

$$\psi \geq \frac{1}{2}$$

Accordingly, the steady state is binding if $\psi < \frac{1}{2}$ ■

## 1.C Proof of Proposition 2

**Proof.** In a constrained state steady, (1.9) and (1.10) generate:

$$1 + \lambda = \frac{1}{\beta^2 r^2} \tag{1.17}$$

Using this result, along with the first order condition of capital (1.8), gives equation (1.15):

$$F_K = r\frac{1+\lambda}{1+\psi\lambda}$$
$$= \frac{r}{(\beta r)^2 + \psi[1-(\beta r)^2]}$$

Graphically, $K$ first decreases in $\beta r$ then increases to go back to the first-best level (figure 1.5). ■

## 1.D Details of the Ramsey program

I derive first order conditions with respect to all endogenous variables from the Ramsey program described in Section 1.4.1.

$$
\begin{aligned}
&FOC(S_{t+1}) : \eta_t^S = \beta r_{t+1} \eta_{t+1}^I \\
&FOC(L_{t+1}) : \eta_t^I = \beta r_{t+1} \left(\eta_{t+1}^S + \Lambda_{t+1}\right) \\
&FOC(B_{t+1}^*) : \eta_t^G = \beta r_{t+1}^* \eta_{t+1}^G \\
&FOC(K_{t+1}) : \beta \eta_{t+1}^S F_{K,t+1} - \eta_t^I - \eta_t^G + \beta \eta_{t+1}^G F_{K,t+1} + \beta \psi \Lambda_{t+1} F_{K,t+1} = 0 \\
&FOC(c_t^S) : \frac{1}{c_t^S} - \eta_t^S - \eta_t^G - \frac{\theta_t^S}{(c_t^S)^2} + \frac{\theta_{t-1}^I r_t (1+\lambda_t)}{(c_t^S)^2} = 0 \\
&FOC(c_t^I) : \frac{1}{c_t^I} - \eta_t^I - \eta_t^G - \frac{\theta_t^I}{(c_t^I)^2} + \frac{\theta_{t-1}^S r_t}{(c_t^I)^2} = 0 \\
&FOC(r_{t+1}) : \beta \eta_{t+1}^I S_{t+1} - \beta \left(\eta_{t+1}^S + \Lambda_{t+1}\right) L_{t+1} - \beta \frac{\theta_t^S}{c_{t+1}^I} - \beta \theta_t^I \frac{(1+\lambda_{t+1})}{c_{t+1}^S} \\
&- \beta \rho_{t+1} (1+\lambda_{t+1}) = 0 \\
&FOC(\lambda_{t+1}) : \frac{-\theta_t^I \beta r_{t+1}}{c_{t+1}^S} + \beta \rho_{t+1} (\psi F_{k,t+1} - r_{t+1}) = 0
\end{aligned}
$$

# Chapter 2

# For a Few Dollars More: Reserves and Growth in Times of Crises

This chapter is a paper written with Matthieu Bussière (Banque de France), Menzie Chinn (University of Wisconsin, Madison) and Noëmie Lisack (European University Institute). It is published in the NBER Working Paper Series no.19791 in January 2014.

## 2.1 Introduction

In the decade preceding the 2008 global financial crisis (GFC), emerging market economies accumulated large stocks of international reserves (figure 2.1). The unprecedented pace of reserve accumulation was, at least partly, a response to the lessons drawn from previous financial crises which predominantly affected emerging markets. Most research on emerging market crises suggests that countries with an insufficient level of reserves, measured against appropriately chosen benchmarks, suffered more from crises in the 1990s [29]. A natural question arising from this observation is to what extent the accumulation of international reserves has protected countries from the negative shock of the latest crisis: have countries with more reserves fared better, in terms of output growth performance,

29. For a detailed review of this literature, see Flood and Marion (1999), Berg and Pattillo (1999), Reinhart and Kaminsky (1999), Bussière and Mulder (1999), Gourinchas and Obstfeld (2012), Catao and Milesi-Ferretti (2013) and Obstfeld (2013).

than countries with less reserves? Are there, in addition, other policy tools that can strengthen or dampen the effects of reserves on growth performance?

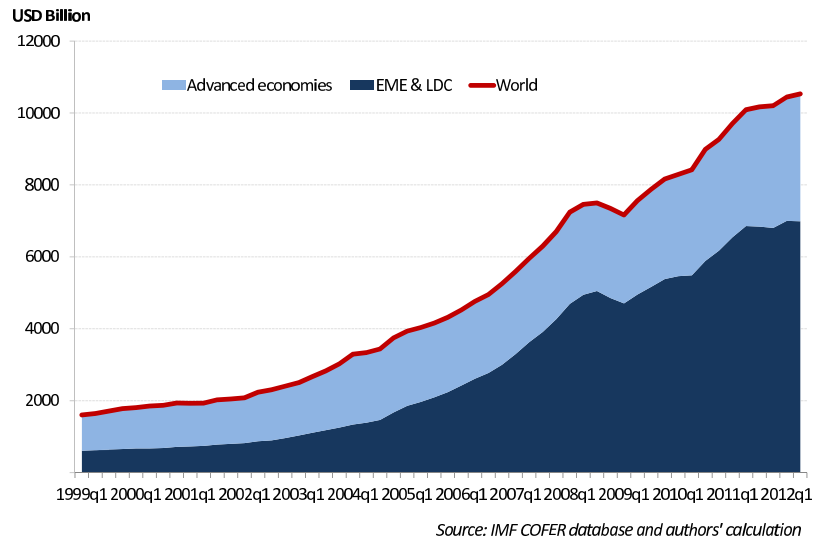



Figure 2.1: World international reserves

The first objective of this paper is therefore to identify the relationship between pre-crisis foreign reserve accumulation and economic growth during the GFC; the latter can be viewed as an ultimate test for the usefulness of reserves as an insurance mechanism. One aspect we pay particularly close attention to in this paper is the interconnection between international reserve holdings and capital controls. Indeed, one may ask whether a higher level of reserves is needed in a country with a more open capital account, to the extent that an open capital account would expose the country to volatile international capital flows. According to this view, reserve accumulation and capital account controls can be understood as substitutes in the quest to avoid financial crises. An alternative view is that these two policy tools can be complementary and reinforce each other: reserves are all the more useful when the capital account is closed. Finally, the paper also devotes attention to the endogeneity issue that may arise from this simple exercise: it is possible that the policy authorities of a highly vulnerable country decide to accumulate more reserves. In this case a simple regression may yield biased results, which we account for using an instrumental variable approach.

Aside from this first objective, which focuses on the initial stage of the crisis, the paper also investigates the patterns of reserve accumulation in the subsequent periods. Indeed, the finding that more reserves before the crisis have indeed benefited countries during the GFC may have prompted countries to accumulate even more reserves after the crisis. We therefore seek to uncover the patterns of reserve accumulation after the GFC, distinguishing between the immediate aftermath of the crisis, which recorded a strong rebound, and the following period, during which the pace of reserve accumulation decelerated.

Against this background, the paper presents three sets of findings. First, we test the hypothesis that international reserves fulfill the protective role they are often assigned to, by testing whether the extent of the crisis (proxied here by two different measures of output collapse, which control for idiosyncratic factors) are related to the level of reserves before the crisis. More specifically, given the debate on what constitutes the most appropriate metrics for international reserves, we construct a set of reserve ratios, expressing reserves as a percentage of GDP, imports, M2 and short-term debt. The results indicate that when reserves are measured as a percentage of short-term debt, there is a statistically significant relationship with the dependent variable, but not for the other reserve adequacy ratios (i.e. reserves/M2, reserves/imports and reserves/GDP). This result is robust to using alternative definitions of the crisis variable, different sub-samples (emerging market countries only or combined with developing countries) or introducing additional control variables such as trade openness, dummy variables for oil exporting countries or financial centers, and so forth. In this set of regressions we also use an instrumental variable approach to account for a potential endogeneity bias. We develop two main instruments for our reserve ratio, focusing on reserve accumulation in neighboring countries as an alternative accumulation motive.

Second, we focus on the interaction between international reserves and capital account openness by introducing an interaction term involving these two variables. We find that the coefficient of the interacted term is sometimes significantly different from zero. The magnitude of the marginal effects of reserves depends on the degree of capital controls; that is, a less open capital account

reinforces the positive marginal effect of reserves that we find in the first set of regressions [30]. This finding is especially interesting given the observation in figure 2.2 [31] – namely in comparison with advanced countries, developing and emerging market economies have accumulated more international reserves and have kept their capital account more closed. Advanced countries, by contrast, chose to open their capital account with a clear jump towards greater financial openness around 1992-1993, but typically do not hold large amounts of reserves.

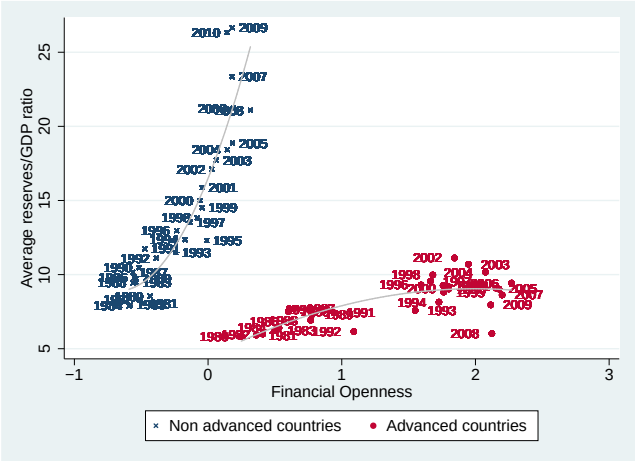



Figure 2.2: International reserves vs. capital controls

The third set of results aims at identifying changes in the behavior of foreign reserve accumulation after the GFC. To study this, we rely upon data of higher frequency (i.e. monthly and quarterly data). We examine whether countries which experienced greater foreign reserve depletion during the crisis tended to rebuild a large stock of reserve assets in the wake of the crisis. We also investigate the patterns of reserve accumulation in more recent years. We find that the countries that used more reserves during the crisis also rebuilt them more quickly in the aftermath of the crisis. However, in the subsequent period, the pace of

30. The relationship between capital controls and foreign reserve accumulation is complex. Several parallel stories can be advanced regarding why the stock of reserves is larger in an economy with capital controls (for keeping the domestic currency undervalued, or for social welfare concerns). We provide an analysis of the subject in Section 3.3. In any case, the multiple motives for reserve accumulation do not prevent us to test the usefulness of reserve holdings during the crisis, alone or with capital controls.

31. In figure 2.2, the y-axis represents the average reserves to GDP ratio and the x-axis represents the average financial openness in a given country group.

reserve accumulation slowed down. One possible explanation may stem from the fact that the level of short-term debt growth declined for most countries, perhaps because of higher risk aversion. To further investigate this hypothesis, we estimated a VECM comprising both reserves and short-term debt: the results suggest that the slowdown in reserves may be related to the slowdown of short-term debt accumulation.

Our paper follows three strands of literature: the motives of foreign reserve accumulation, the impact of foreign reserve accumulation on real economic growth during crisis times and the behavior of reserve holding during and after the GFC. Starting with the literature on the insurance motive of reserve accumulation, both the early literature in the 1970s [32] and a more recent literature based on open-economy macroeconomic models suggest that reserves constitute a buffer stock to limit the impact of negative trade and financial shocks on output should a country be hit by balance-of-payment shocks or 'sudden stops'. In fact, as Jeanne and Rancière (2011), Benigno and Fornaro (2012), Bianchi et al. (2012) demonstrate, a sufficient stock of reserves is useful to purchase foreign imports and to repay external debt coming due when no external borrowing is possible. Based on a calibration using a sample of sudden stops in 34 middle-income countries over 1975-2003, Jeanne and Rancière (2011) show that the negative impact of the financial account reversal on domestic absorption can be offset by reserves. In this perspective, an average country needs to hold a stock of reserves equivalent to 9.1% of its GDP. Our paper thus provides empirical evidence of the role of reserves as insurance against negative external shocks.

In parallel, our paper is closely related to a rich pool of recent empirical studies examining the role of international reserves on macroeconomic performance during the GFC. Rose and Spiegel (2009), Rose and Spiegel (2010), Blanchard et al. (2010), Llaudes et al. (2010) and Frankel and Saravelos (2012) are among the first papers looking at the impact of the GFC on emerging market economies by regressing a set of crisis impact variables (e.g. output losses, consumption growth changes, exchange market pressure index, etc.) on numerous pre-crisis policy variables, including foreign reserves. Blanchard et al. (2010) and Rose and

32. Bahmani-Oskooee and Brown (2002) provide a detailed review.

Spiegel (2010) advance the proposition that the pre-crisis level of foreign reserves does not play a central role in protecting countries from the global financial crisis. In contrast, Frankel and Saravelos (2012) find that the foreign reserve level (scaled by GDP, external debt and imports) in 2007, along with exchange rate movements, is a significant leading indicator of the cross-country incidence of the crisis: the higher the foreign reserve ratios, the less likely an economy would be hit by the global financial crisis. In the same vein, Llaudes et al. (2010) find a positive and statistically significant role of reserves scaled by short-term debt on output growth during the crisis. They further argue that this relationship is non-linear; namely, reserves had a more significant impact on output in countries with low levels of reserves but much less in countries with high levels of reserves.

Our paper incorporates several novel aspects. The above cited papers are all broad studies examining many different aspects of the crisis impact using a number of different policy variables. In contrast, our paper focuses on the relationship between pre-crisis reserve accumulation and real economic growth during the crisis. The most important contribution of our paper is to assess the impact of reserves alongside another policy instrument, capital controls. We provide intuition and empirical evidence on the complementarity between reserves and capital controls in terms of managing the impact of the global financial crisis. Moreover, we go beyond a mere documentation of the correlation between reserves and growth by introducing instrumental variables. In addition, the results from these early papers lead to diverging conclusions as different authors used different reserve metrics and different country observations. The samples used are smaller than in the present study. Blanchard et al. (2010) run a regression using 29 country points and Llaudes et al. (2010) have a mixed sample of emerging economies and developing countries with 40 observations. For our paper, we construct a large dataset of more than 100 emerging and developing countries and we follow a rigorous econometric procedure to establish the relationship between reserves and economic growth.

Finally, our paper is also related to several papers that examine the use of reserves during the GFC and the rebuilding afterwards. Aizenman and Sun (2009), Aizenman and Hutchison (2010), Dominguez (2012) and Dominguez et al. (2012) have all addressed the following question: if international reserves are held to cope

with potential external shocks, were they used during the GFC? Aizenman and Hutchison (2010) focus on the trade-off between exchange rate depreciation and foreign reserve losses for countries facing a high exchange market pressure during the 2008-2009 crisis. They highlight the 'fear of losing reserves' - many countries chose to let their currency depreciate rather than to risk a run on their foreign exchange reserves - and the greater vulnerability of countries with a higher ratio of foreign liabilities to GDP. These results corroborate those of Aizenman and Sun (2009) with regard to the preference for exchange rate depreciation among emerging countries.

In contrast, Dominguez (2012) and Dominguez et al. (2012) distinguish between the total stock of reserves and actively managed reserves; the latter are reserves sold or purchased by a country's authority net of any valuation effect and interests payment. Based on this new definition, they find that countries have actively used foreign reserves during the crisis period. Dominguez (2012) finds that countries whose pre-crisis reserves exceeded optimal levels predicted by standard models of reserve accumulation were the most likely to use their reserves during the crisis. In addition, Dominguez et al. (2012) advance the proposition that both pre-crisis level of reserves and an active management of foreign reserve assets during the crisis are positively correlated with the GDP growth in the wake of the global financial crisis. A limitation of using the decomposition of reserves is that the available sample is very small. One can only calculate the actively managed component of reserves for countries which have subscribed to the IMF's Special Data Dissemination Standard (SDDS) in the Reserve Template [33].

Compared to this strand of literature on the use of reserves, we defend the thesis that the pre-crisis level of reserves still matters. For us, international reserves should be viewed as being akin to 'nuclear weapon' having a deterrent effect, rather than to true 'gunpowder', to be used in intervention. In other words, having a large stock of reserves prior to any external shocks will deter speculators from attacking. This is of course consistent with the literature of the second generation crisis model [e.g. Obstfeld (1986)] that demonstrates that the occurrence of a speculative attack on a country's currency is conditional on this

33. There are currently 70 countries which have subscribed to the SDDS, where 41 are emerging and developing countries.

country's foreign reserve holdings. A sufficient level of reserves will hence obviate the need for a country to intervene massively as the risk of crises is minimized.

Finally, we also extend some results of Dominguez (2012) and Dominguez et al. (2012) with regard to the reserve accumulation behavior after the financial crisis. Dominguez (2012) argues that countries that experienced losses on their reserve stocks during the crisis tended to accumulate more afterwards. We confirm this trend using more recent data. Moreover, we further document that the pace of reserve accumulation has decelerated in many emerging economies in the last couple of years. We attribute this outcome to a plateauing of the underlying target variable, short term debt.

The rest of the paper is organized as follows. Section 2.2 describes the data and the methodology used. Section 2.3 presents our main econometric analysis of the role of international reserves on economic growth during the GFC. Section 2.4 examines countries' behavior in reserve accumulation in the wake of the financial crisis and section 2.5 concludes.

## 2.2 Data and specification

### 2.2.1 Data and key variables

Our primary data source for annual, quarterly and monthly international reserves is the database *International Financial Statistics* (IFS) of the International Monetary Fund (IMF). The macroeconomic data of different frequencies are also retrieved from the *IFS* and complemented with the *World Development Indicators* (WDI) issued by the World Bank (WB). For selected countries that are absent from the IMF and WB databases (e.g. Taiwan), national sources are used.

To preserve the homogeneity of our sample in terms of reserve accumulation and capital account policy, we decided to focus only on non-advanced countries (NAC). Our database includes 161 countries, divided into two sub-samples: 32 emerging market economies (EME) and 129 developing countries (LDC). EMEs are defined according to a combined criteria of the IMF and the economic magazine *the Economist*. For 49 countries, we did not have enough observations for the

key independent variables including control variables; therefore, 112 countries are effectively used in our main regressions. The details about our country coverage can be found in Appendix 2.A.

### International reserves

Several important features of the reserve data we use in this paper need to be highlighted.

*Which assets are included in reserves?* International reserves can be defined as the immediately available external assets denominated in foreign currencies that a country's government or monetary authority effectively holds. According to the *IFS*, total international reserves comprise foreign exchange reserves[34], reserve position in the Fund, the U.S. dollar value of SDR holdings and gold holdings[35]. Except gold holdings, all the other assets are included in the reserve data we use in the scope of this paper. The reason to exclude gold holdings is that the gold share is very small in non-advanced countries and gold holdings are less liquid than other reserve assets. As foreign reserves constitute the major component of international reserves (reserve position in the Fund and SDR holdings are also very small), we will interchangeably use the terms international reserves and foreign reserves in this paper.

Similarly, external assets held by sovereign wealth funds are not included in our reserve data. Foreign assets held by a sovereign wealth fund and that under control of a central bank are indeed managed under very different principles. While higher returns and strategic value are the objective of reserve management in a sovereign wealth fund, the liquidity and security of foreign assets are the guidelines for reserve management in a central bank. As we focus on the insurance role of foreign reserves, we only consider those foreign assets managed under the liquidity and security motives.

Moreover, the IMF credit facilities (e.g. Precautionary and liquidity line,

34. This includes 'official claims on nonresidents in the form of foreign banknotes, bank deposits, treasury bills, short- and long-term government securities and other claims usable in the event of balance of payments need' (IFS Yearbook 2012).

35. Gold holdings are expressed in millions of fine troy ounces and valued in U.S. dollar by each country.

Flexible credit line, Stand-by facility, etc.) and bilateral swap lines between countries are not included in foreign reserves defined by the *IFS* and used in this paper [36]. There are fundamental differences between the self-owned stock of foreign reserves and *ad hoc* contingent facility instruments which are short-term in nature. A few papers examine the substitutability between swap lines and foreign reserves [see Aizenman et al. (2011), Obstfeld et al. (2009)]; this is however out of the scope of this paper.

Finally, it is very important to notice that there is an issuance of 183 billion of Special Drawing Rights by the IMF in August 2009 (equivalent to 283 billion of U.S. dollars). This is in part due to the requirements of reforming the international monetary system under the G20 negotiations. This new issuance can be regarded as an exogenous increase of member countries' SDRs, thus of their stock of foreign reserves; it leads to an unexpected jump in the reserve data from 2009 and constitutes an issue when we examine the after-crisis behavior of reserve accumulation. Therefore, in order to concentrate on a given country's own decision of holding foreign reserves, we subtract this newly issued SDR in 2009 from our monthly and quarterly data on foreign reserves which is used in Section 2.4.

*How to incorporate reserve data into our analysis?* In this paper, we will use reserve adequacy ratios (in log [37]) instead of the absolute level of reserves. The reasons are two-fold. First, a reserve adequacy ratio facilitates cross-country comparison; the heterogeneity in the stock of reserves is tremendous, for example between China, which holds more than a third of the world foreign reserves, and small African countries. Second, the absolute level of reserves does not provide useful information about the robustness and resilience of a country facing shocks;

36. However, we used a dummy variable for the Fed swap lines. This only concerns Korea and Mexico in our non-advanced country sample. The introduction of this dummy does not change our results. Details are available upon request.

37. We use the log ratio in our regressions for several reasons. First, it is commonly used in the existing literature regarding the role of foreign reserves during crises in emerging market economies. Second, the evolution of international reserves, especially in non-advanced countries, is non-linear, displaying an exponential pattern. Third, based on our analysis, the effect of *ex ante* holding of reserves on economic growth is non-linear; it exhibits positive and concave patterns, meaning that the marginal contribution of the reserve adequacy ratio on growth is diminishing. The effect is more pronounced for countries with low values of reserves to short-term debt ratio. Llaudes et al. (2010) provides a more detailed account on the non-linearity of this effect.

at most it shows the country has enough financial resources to purchase reserve assets. On the contrary, reserve adequacy ratios do provide information about how reserves can be deployed to cope with some underlying target variables. Based on an extensive literature, we use the following four indicators:

- GDP based indicator : $log(\frac{\text{Reserves}}{\text{GDP}} \times 100)$ $(rsv\_gdp)$
- Trade based indicator: $log(\frac{\text{Reserves}}{\text{Imports}} \times 12)$ $(rsv\_imports)$
- Debt based indicator: $log(\frac{\text{Reserves}}{\text{Short-term debt}} \times 100)$ $(rsv\_std)$
- Money based indicator: $log(\frac{\text{Reserves}}{M_2} \times 100)$ $(rsv\_m2)$

The GDP based indicator is a way to control for country size, no further information can be inferred from it. The trade based indicator is a traditional metric of the reserve adequacy. It reflects the capacity of a country to purchase foreign goods (for production or final consumption) even in case of limited or no access to external financing. The common wisdom requires that foreign reserves cover at least three-month imports. The debt based indicator has developed with the financial integration of emerging market economies and less developed countries. When a country's economic growth is financed by external debt, it is important for that country to insure the service of its debt, at least that coming due in short-term. Sufficient foreign reserves need to cover the repayment of all the short-term debt denominated in foreign currencies. The money based indicator has gained popularity with Obstfeld et al. (2010) who emphasize the role of foreign reserves on stabilizing domestic financial market. A country needs to hold enough foreign reserves to offset the capital flight triggered by a weak confidence in the market of that economy. The amount of immediately available domestic assets which can be drained out during an episode of capital flight is proxied by the monetary aggregate $M_2$. This amount of assets needs to be covered by foreign reserves.

### Capital controls

An important control variable for our analysis regards the controls on capital flows. There are a number of measures of capital controls in the literature, either

*de jure* or *de facto*[38]. Our measure of capital controls is based on the *de jure* measure of capital openness constructed by Chinn and Ito (2006). This is not only a widely used index of the financial openness, it also captures well regulatory restrictions on capital account transactions, which is essential as we focus on policy variables.

For ease of interpretation, we invert the Chinn-Ito index such that the higher our capital control index, the more stringent the constraints on both capital inflows and outflows. Table 2.1 summarizes the basic statistic descriptions of our measure. We observe that advanced countries are much more financially open than non-advanced countries. 50% of advanced countries have a fully open capital account; their capital control index reaches the minimum $-2.50$.

Table 2.1: *capital controls*: Descriptive Statistics (2007)

| | Non-advanced countries | | | Advanced countries |
|---|---|---|---|---|
| | EME | LDC | Total | |
| mean | -0.69 | -0.04 | -0.18 | -2.20 |
| median | -0.12 | 1.14 | 0.29 | -2.50 |
| s.d. | 1.53 | 1.58 | 1.59 | 0.61 |
| min | -2.50 | -2.50 | -2.50 | -2.50 |
| max | 1.14 | 1.86 | 1.86 | -0.12 |
| obs | 31 | 117 | 148 | 30 |

### 2.2.2 Specification

The analysis of this paper is based on cross-section econometrics; this allows us to make cross-country comparisons and to homogenize the shock of the recent crisis. Our benchmark specification is described below:

$$y_{i,09} = \beta_0 + \beta_1 rsv_{i,07} + \boldsymbol{\beta X_{i,07}} + \epsilon_{i,09} \tag{2.1}$$

$rsv_{i,07}$ stands for one of the four reserve adequacy ratios mentioned above.

38. For *de jure* measures see Chinn and Ito (2006), Kose et al. (2009), etc.; for *de facto* measures see Lane and Milesi-Ferretti (2007)

$\boldsymbol{X_{i,07}}$ corresponds to additional control variables. Note that all the independent variables (except for dummies) are lagged two periods [39]. Taking lagged independent variables allows us to have a snapshot of the situation of the country before the start of the crisis, and to use this picture to explain its performance during the crisis. Using later values for reserves and other controls would be problematic, since countries may already have changed their reserve holdings by the end of 2008 due to the start of the crisis. Yet, this does not solve endogeneity issues, which we will tackle in Section 2.3.4.

### Construction of the dependent variable $y_{i,09}$

To assess the role of foreign reserves in mitigating the crisis impact on real economic growth in 2009, we need to construct appropriate measures of the GFC impact. Based on the above-cited literature on this issue, we use two measures that aim at capturing the gap between the actual real economic growth rate and a counterfactual growth rate should the crisis have not occurred.

The first method calculates the difference between the realized real economic growth rate and a linear prediction from a historical mean. We call this dependent variable 'purged real GDP growth', and denote it $rgdp\_residual$ in our equations and tables. It is obtained as follows:

$$rgdp\_residual_{i,09} = \Delta ry_{i,09} - \widehat{\Delta ry}_{i,09}$$
$$\widehat{\Delta ry}_{i,09} = \hat{\alpha}_0 + \hat{\alpha}_1 \overline{\Delta ry}_{i,03-08}$$

The coefficients $\hat{\alpha}_0$ and $\hat{\alpha}_1$ are estimated using a preliminary regression:

$$\Delta ry_{i,09} = \alpha_0 + \alpha_1 \overline{\Delta ry}_{i,03-08} + \epsilon_{i,09}$$

This preliminary regression assumes constant coefficients across countries, namely the contribution of the historical trend to real economic growth rate at a given time $t$ being identical for all countries in our sample.

39. As a robustness test, we have also used independent variables lagged three periods. The results remain very similar to that presented in the paper. Details can be provided upon request.

Our alternative dependent variable follows Blanchard et al. (2010) and Berkmen et al. (2012) and captures the change between the actual real GDP growth in 2009 and the IMF World Economic Outlook (WEO) forecast in the first quarter of 2008 (before the Lehman collapse in September of the same year). This variable measures the real output losses due to the unexpected magnitude of the financial crisis. We call it 'unexpected real GDP growth' and denote it $rgdp\_fe$. One caveat about this variable is that there might be estimation errors associated with the forecast model that the IMF adopts. We assume that these errors are not time-varying and consistent over time.

We have also tried another potential dependent variable: the difference between actual real GDP growth and a historical mean, over 2003-2008. We find consistent results using this different dependent variable [40].

In Appendix 2.B, figures 2.11 and 2.12 illustrate the ranking of a few big emerging market economies (belonging to the G20) in terms of our two dependent variables $rgdp\_residual$ or $rgdp\_fe$. In the same appendix, a list of the main variables used in our econometric analysis is also available.

## 2.3 Econometric analysis: the role of pre-crisis reserve adequacy during the GFC

### 2.3.1 Reserve adequacy ratios: which one works better?

Based on the 2008-2009 global financial crisis, we first try to examine whether *ex ante* foreign reserve accumulation has played any role in preventing output losses during the crisis. We pay a particular attention to the distinct explanatory power of each of the above-mentioned four reserve metrics.

We find that the reserves to short-term debt ratio is the most useful indicator to explain the real output growth during the crisis. The stock of foreign reserves scaled by the level of short-term debt two years prior to the crisis is positively and significantly correlated with the real GDP growth deviation from the trend. We illustrate this result using the full sample and the 'purged real GDP growth'

40. The results using this third variable as dependent variable are available upon request.

as dependent variable in table 2.2 (The different numbers of observations are due to the data availability of the scaling variables.).

Table 2.2: Results with different reserve adequacy ratios

| | (1) rgdp_residual | (2) rgdp_residual | (3) rgdp_residual | (4) rgdp_residual |
|---|---|---|---|---|
| L2.log rsv/gdp | -0.359 | | | |
| | (0.607) | | | |
| L2.log rsv/imports | | 0.704 | | |
| | | (0.627) | | |
| L2.log rsv/m2 | | | -0.0378 | |
| | | | (0.564) | |
| L2.log rsv/std | | | | 0.624** |
| | | | | (0.257) |
| Constant | 1.522 | -0.590 | 0.491 | -3.165** |
| | (1.814) | (1.058) | (2.097) | (1.588) |
| Observations | 143 | 134 | 138 | 138 |
| $R^2$ | 0.002 | 0.009 | 0.000 | 0.042 |
| Adjusted $R^2$ | -0.005 | 0.002 | -0.007 | 0.035 |

Standard errors in parentheses

Homoscedasticity not rejected according to the White test

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

This result is robust if we switch the dependent variable to the 'unexpected real GDP growth' (table 2.12 in Appendix 2.C). The coefficient associated with the reserves to short-term debt ratio is significant. We have also checked the robustness of this result by removing outliers [41] and small countries [42] from the sample. As can be seen in tables 2.13 and 2.14 in Appendix 2.C, the main

41. The outliers removed are countries whose reserve adequacy ratio or dependent variable fall below the 1st percentile or above the 99th percentile. It corresponds to Armenia, Bahamas, Botswana, Latvia, Lebanon, Liberia, Libya.

42. We use the World Bank classification to define small countries.

conclusions remain unchanged. Given that China has a very specific behavior in terms of reserve accumulation, we also removed this country from the sample, and obtained largely unchanged results [43].

### 2.3.2 Do reserves matter for economic growth during the GFC?

In order to better understand the influence of reserve holdings on output growth, we add control variables and estimate the full specification of our regression equation (2.1). The control variables $\boldsymbol{X_{i,07}}$ include capital controls, trade openness, an exchange rate regime dummy [44] and an oil exporter dummy [45].

After controlling for further specific characteristics of different countries, we still find that the accumulation of foreign reserves prior to the crisis positively and significantly contributes to the real GDP growth during the crisis. The significance and magnitude of the coefficient associated with the reserve adequacy ratio remain similar when adding controls, for both of our dependent variables (columns (1) and (2) in table 2.3).

43. As these findings are obtained with a ratio, a natural question to ask is which term in the ratio drives the results. However, this is a complex question: testing both terms separately may not be conclusive if what really matters is the ratio of the two. Bearing this caveat in mind, we ran two additional sets of regressions. First, when using $log(\frac{reserves}{STD})$ and $log(\frac{reserves}{GDP})$, both are significant with $rgdp\_residual$ as dependent variable, but only the first term is significant with $rgdp\_fe$ as dependent variable. Second, when using $log(\frac{reserves}{STD})$ and $log(\frac{STD}{GDP})$, only the second term is significant with $rgdp\_residual$ as dependent variable, and nothing is significant with $rgdp\_fe$ as dependent variable (with a collinearity issue). Third, $log(\frac{reserves}{GDP})$ and $log(\frac{STD}{GDP})$ have also been used to replace the reserve adequacy ratio. Only the second term turns out to be significant; but this result cannot validate the hypothesis that short-term debt matters more than foreign reserves, as $log(\frac{reserves}{GDP})$ is not a significant regressor even in a bivariate regression with our two dependent variables (table 2.2). These complementary results, which are available upon request, are therefore mixed, such that it is hard to conclude whether one of the two terms is predominantly driving the main result.

44. Our exchange rate regime dummy is constructed based on the classification by Reinhart and Rogoff (2004). It takes the value 1 when a country has a 'crawling peg' or more controlled exchange rate regime; it takes the value 0 when a country has a 'managed floating' or 'free floating' regime.

45. The countries classified as oil exporters/producers are the following: Algeria, Angola, Bahrain, Cameroon, Chad, Congo, Ecuador, Equatorial Guinea, Gabon, Iran, Iraq, Kazakhstan, Kuwait, Libya, Mexico, Nigeria, Oman, Qatar, Russia, Saudi Arabia, Sudan, Timor-Leste, Trinidad and Tobago, Turkmenistan, United Arab Emirates, Uzbekistan, Venezuela, Yemen.

We further test the robustness of our results by estimating the same regressions using trimmed samples. Appendix 2.D provides the results obtained after outliers [46] or/and small countries are ruled out. The coefficients have the same signs as in table 2.3 but have larger magnitude and stronger significance. One additional control variable, trade openness, turns out to be significant and has a negative sign as expected when $rgdp\_residual$ is used as dependent variable. The goodness of fit, in terms of $R^2$ and adjusted $R^2$, also becomes larger. Hence, our results can be regarded as robust and do not depend on the inclusion of outliers and small countries.

For robustness, we tested our results with additional control variables (i.e. net foreign assets and current account balance); the results are qualitatively similar. More restrictively trimmed samples have also been used throughout the paper [47]; the estimates of interest (reserves to short-term debt ratio and capital controls) become even larger and more significant. These results are available upon request.

### 2.3.3 Controlling for the interaction between reserves and capital controls

The introduction of an interacted term between foreign reserves and capital controls as a further control variable can help us check the robustness of our results, and shed light on the complementarity between foreign reserves and capital controls.

We show how the role of foreign reserves on economic growth may depend on other relevant policies, in particular capital account management, and then present the specification we adopt to estimate the interacted term.

46. Defined in the same line as in footnote 12, namely all observations which fall below the 1st percentile or above the 99th percentile of any continuous variables (i.e. dependent variable, reserve ratio and trade openness). This criteria will apply in the subsequent sections when outliers are eliminated. As a result we further drop Brazil, Hong Kong, Rwanda and Singapore from the sample (no financial centers in this case).

47. In these regressions, we have removed the top and bottom 5% observations of any continuous variables, or countries whose reserves to short-term debt ratio exceeds 1000 (75th percentile) in 2007.

Table 2.3: Full specification

| | (1) rgdp_fe | (2) rgdp_residual |
|---|---|---|
| L2.log rsv/std | 0.615** | 0.729** |
| | (0.291) | (0.317) |
| L2.capital controls | 0.498* | 0.689** |
| | (0.282) | (0.307) |
| L2.exchange regime index | -1.282 | -0.652 |
| | (1.335) | (1.457) |
| L2.trade openness | -0.0194* | -0.0184 |
| | (0.0117) | (0.0128) |
| oil dummy | -2.612** | -1.561 |
| | (1.292) | (1.410) |
| financial center | 5.374 | 5.284 |
| | (4.941) | (5.395) |
| Constant | -5.527** | -1.400 |
| | (2.358) | (2.575) |
| Observations | 112 | 112 |
| $R^2$ | 0.154 | 0.155 |
| Adjusted $R^2$ | 0.106 | 0.107 |

Standard errors in parentheses

Homoscedasticity not rejected according to the White test

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

### Intuition

Our empirical results suggest that foreign reserves and capital controls are complements with regard to their impact on economic growth during the GFC. We provide here an intuition which supports this particular relationship. In fact, if foreign reserves can be seen as munitions of liquidity that can be deployed when a country is cut off from external financial markets, a closed capital account can be interpreted as a neutralized playing field for the impact of reserves to be effective. Indeed, capital controls insure that public capital outflows (foreign reserve purchasing) are not completely offset by private capital inflows (accumulation of private foreign liabilities). As a matter of fact, foreign reserves can be used to provide an aggregate insurance to the economy, but the moral hazard associated with foreign reserve accumulation might incite the private sector, firms and banks, to take extra risks given that the government will provide foreign currency liquidity when it is necessary. Therefore, the insurance provided by foreign reserves can be offset by private capital inflows should the capital account be completely open. There are a few recent theoretical works which support our intuition and empirical finding. For example, Benigno and Fornaro (2012), Bacchetta et al. (2013) and Cheng (2013) all argue that the imperfect substitutability between public and private capital flows is crucial for foreign reserves to play a role. According to this strand of literature, foreign reserve accumulation and a closed capital account are complements rather than substitutes.

### Specification

There are several ways to introduce an interactive term. To facilitate interpretation, we use a demeaned interacted term: $(rsv\_std_i - \overline{rsv\_std_i}) \times (cc_i - \overline{cc}_i)$ as stated in equation (2.2). Using this setting, the coefficient before $rsv\_std_i$ (respectively $cc_i$) refers to the marginal effect of that variable when $cc_i$ (respectively $rsv\_std_i$) is valued at its mean. Note that $\boldsymbol{x_{i,07}}$ refers to the set of control variables we used in Section 2.3.2 except capital controls.

$$y_{i,09} = \beta_0 + \beta_1 rsv\_std_{i,07} + \beta_2 cc_{i,07} + \beta_3 \underbrace{(rsv\_std_{i,07} - \overline{rsv\_std}_{07}) \times (cc_{i,07} - \overline{cc}_{07})}_{\text{interaction}} + \boldsymbol{\beta x_{i,07}} + \epsilon_{i,09} \tag{2.2}$$

The marginal effect of foreign reserves is calculated as follows:

$$\frac{\partial y_{i,09}}{\partial rsv\_std_{i,07}} = \beta_1 + \beta_3 \times (cc_{i,07} - \overline{cc}_{07})$$

To fully validate the introduction of an interacted term, we need to make sure that a statistically significant coefficient before the interacted term does not come from a bivariate relationship between the two variables incorporated in the interacted term, namely $rsv\_std_i$ and $cc_i$ in this paper [48].

**Results**

In the following exercise, we try to identify the contribution of foreign reserves to support economic growth during the crisis time, conditional on the degree of capital account openness.

In table 2.4, columns (1) and (2), we see that foreign reserves and capital controls both contribute to reduce a country's real GDP losses during the recent financial crisis (they both have a positive and significant coefficient). The coefficient associated with the interacted term is also significant and positive, reinforcing the marginal effects of the reserve adequacy ratio and of capital controls. One can look at the joint F-test (test scores reported at the bottom of table 2.4) between reserves and the interaction term in order to infer the significance of the

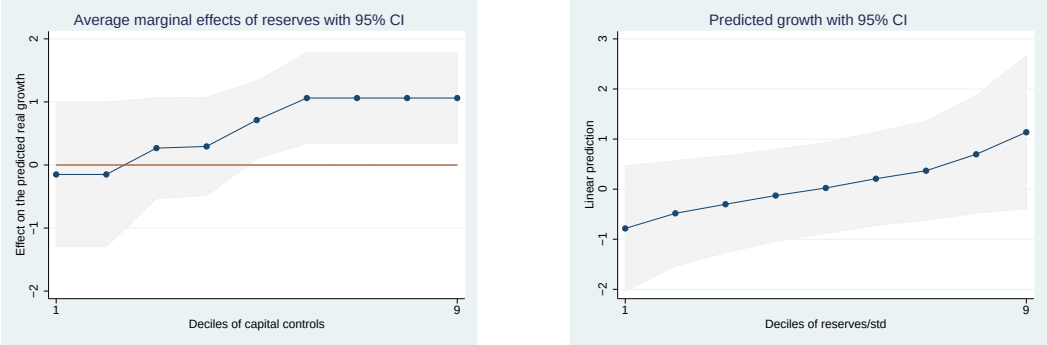
48. To avoid spurious regressions, we have controlled for the quadratic forms of $rsv\_std_i$ and $cc_i$ respectively. We have also orthogonalized these two key variables using the Frisch-Waugh theorem before constructing the interacted term. The details of these results are available upon request.

impact of foreign reserves on growth. These estimates are indeed jointly highly significant (at the 98% significance level).

Taking into account the interactive term, we can calculate the marginal effects of foreign reserves in terms of capital controls using the estimates presented in table 2.4 column (2):

$$\frac{\partial y_{i,09}}{\partial rsv\_std_{i,07}} = 0.623 + 0.333 \times (cc_{i,07} - \overline{cc}_{07})$$

The marginal effect of reserves on our purged measure of GDP growth is equal to 0.623 for a country that has average capital controls. The more stringent a country's capital account (higher value of $cc$), the more pronounced the marginal effect of the *ex ante* foreign reserve adequacy ratio on economic growth during the GFC. The left panel in figure 2.3 gives an illustrative overview of the evolution of the marginal effects of reserves as a function of the tightness of capital controls. The marginal effects of reserves is increasing and becomes positive slightly before capital controls reach their 3rd decile ($cc > -1.18$); it becomes significantly different from zero when capital controls are beyond their 5th decile ($cc > -1.12$). Moreover, the right panel in figure 2.3 shows how the predicted real detrended economic growth improves with a higher reserves to short-term debt ratio when all other variables (including capital controls) are valued at their mean value.




(a) Marginal effects of reserves (b) Predicted real economic growth

Figure 2.3: Marginal effects and predictions

Table 2.4: Foreign reserve accumulation and capital controls

| | full sample | | without outliers | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| | rgdp_fe | rgdp_residual | rgdp_fe | rgdp_residual |
| L2.log rsv/std | 0.506* | 0.623* | 0.911*** | 0.866*** |
| | (0.291) | (0.319) | (0.305) | (0.329) |
| L2.capital controls | 0.586** | 0.774** | 0.0713 | 0.281 |
| | (0.281) | (0.308) | (0.274) | (0.292) |
| L2.log rsv/std × capital controls | 0.345** | 0.333* | 0.0965 | 0.170 |
| | (0.170) | (0.187) | (0.199) | (0.216) |
| L2.exchange regime index | -1.344 | -0.711 | -0.934 | -0.260 |
| | (1.316) | (1.443) | (1.234) | (1.316) |
| L2.trade openness | -0.0191* | -0.0181 | -0.0233** | -0.0283** |
| | (0.0115) | (0.0126) | (0.0105) | (0.0113) |
| oil dummy | -2.642** | -1.590 | -3.124*** | -1.962 |
| | (1.273) | (1.396) | (1.137) | (1.214) |
| financial center | 4.718 | 4.649 | | |
| | (4.881) | (5.352) | | |
| Constant | -4.981** | -0.872 | -6.921*** | -1.477 |
| | (2.340) | (2.566) | (2.305) | (2.477) |
| Observations | 112 | 112 | 104 | 102 |
| $R^2$ | 0.186 | 0.180 | 0.215 | 0.206 |
| Adjusted $R^2$ | 0.131 | 0.125 | 0.166 | 0.156 |
| F-test capital controls | 3.656 | 4.155 | 0.127 | 0.615 |
| P-value | 0.0292 | 0.0184 | 0.881 | 0.543 |
| F-test reserves | 4.350 | 4.287 | 5.359 | 4.685 |
| P-value | 0.0153 | 0.0163 | 0.00620 | 0.0115 |

Standard errors in parentheses

Homoscedasticity not rejected according to the White test

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Here again, we check for robustness by dropping outliers [49]. Whereas the previous results (without the interaction term between reserves and capital controls) were fairly robust to this change of sample, here both the coefficients of capital controls and of the interaction term lose significance when we control for outliers, as one can see in columns (3) and (4) of table 2.4 [50]. However, the coefficient associated with the reserves to short-term debt ratio is highly significant and increases in magnitude. From this, we can conclude that the impact of the reserve adequacy ratio itself is still fairly robust, even after we drop outliers from our sample. Finally, as regards the magnitude of the coefficient associated with the reserve adequacy ratio, it seems that the estimate we obtained in our benchmark regression (table 2.3) is rather a minimal value, since the associated coefficient tends to increase when excluding outliers.

### 2.3.4 Accounting for endogeneity

As mentioned above, using foreign reserves as an explanatory variable to explain real economic growth can cause endogeneity issues. Foreign reserves might be held by a central bank as in anticipation of a future negative shock to the national economy; foreign reserves and higher GDP growth might also both be by-products of a mercantilist exchange rate policy. So far, we have been using lagged metrics of foreign reserves as our main explanatory variable without controlling for endogeneity; this is also the method adopted by most existing empirical papers on foreign reserves. This may induce a bias in our coefficient estimates, the direction of which is however ambiguous. On the one hand, if we consider that fragile countries accumulate more reserves for precautionary reasons, and are more likely to be affected in a crisis (because of the idiosyncratic fragility), we can argue that the OLS coefficient associated to reserves may be biased downwards. On the other hand, reserve accumulation can be a buy-product of an undervalued domestic currency which stimulates economic growth through

49. Results are similar when excluding both small countries and outliers. They are presented in Appendix 2.E table 2.17. Results using more restrictively trimmed samples are available upon request.

50. Note that by dropping outliers (top and bottom 1% of observations of each continuous variable), we drop all financial centers from our sample, which explains the absence of the financial center dummy in columns (3) and (4) of table 2.4.

strong exports. This mechanism implies an upward bias of our OLS coefficient. It is therefore difficult to predict the direction of the bias altogether. We go one step further to account for endogeneity and reverse causality by choosing appropriate instrumental variables for foreign reserve metrics.

### Construction of instrumental variables

Finding an instrumental variable for reserves is not an easy task. An appropriate instrumental variable needs to fulfill two conditions: first, it needs to be correlated with the instrumented variable; second, it must be uncorrelated with the error term in the original OLS regression (equation (2.1)). We have thought of various candidates, including a dummy for the occurrence of currency crises in the 1970's and 1980's, a measure of the severity of past crises, real GDP per capita expressed in purchasing power parity, or metrics of regional peer pressure for reserves accumulation. After carefully examining different possibilities, we conclude that the regional peer pressure is the best suited instrumental variable with respect to our analysis.

Regional peer pressure for reserve accumulation captures the idea of 'keeping up with the Joneses', namely a country might be motivated to hold foreign reserves as its neighbors do so. In many empirical papers[51], this idea of regional peer pressure is introduced to study the demand function of foreign reserves. Therefore, it should be highly correlated with foreign reserve accumulation *per se*. Furthermore, these instrumental variables allow us to focus on reserves accumulated for 'neighborhood' motives, and disregard those related to precautionary or mercantilist motives, which are related to the economic performance of a country and therefore endogenous.

As for our instrumental variables, we propose two proxies to measure the regional peer pressure:

- $\boldsymbol{IDW06_i}$: An inverse distance weighted mean for country $i$ measures the average of the reserves to GDP ratio of all other countries in the world ($j \neq i$) weighted by the inverse distance between country $i$ and country $j$ (so that country $i$'s neighbors matter more than remoter countries). We

51. See Bastourre et al. (2009), Cheung and Sengupta (2011), etc.

assume that country $i$ can only observe the decision made by other countries in terms of reserve accumulation in the previous year. As a result, we use the inverse distance weighted mean in 2006 as the instrument for the reserves to short-term debt ratio in 2007. The advantage of this instrument is that it is more broadly defined and comprises much more information than regional dummies. The construction of $IDW06_i$ is detailed below and the data on geographical distance is retrieved from Mayer and Zignago (2011). Note that country $i$'s own reserve ratio is not included in its distance weighted mean.

$$IDW06_i = \sum_{j \neq i} w_i^j \frac{Reserves_j}{GDP_j}$$
$$w_i^j = \frac{(dist_{ij})^{-2}}{\sum_{k \neq i}(dist_{ik}^{-2})}$$

– ***Joneses*$_i$**: The Joneses index defined by Cheung and Sengupta (2011) is calculated by the sum of the reserves to GDP ratio of country $i$'s neighboring countries $j \neq i$ in a given geographical region[52]. Here again, country $i$'s own reserve ratio is excluded from this sum.

$$Joneses_i = \sum_{j \neq i} \frac{Reserves_j}{GDP_j}$$

Given the regional patterns we observe in terms of reserves accumulation (Asian countries for instance accumulate much more reserves than others), we expect a positive correlation between our instrumental variable and our reserve adequacy ratio. Moreover, we need to insure that our instrumental variables are orthogonal to the error term in our original OLS regression. Remember that our dependent variable in equation (2.1) measures a country's economic perfor-

52. We define 8 regions: East Asia & Pacific, South Asia, Eastern Europe & Central Asia, Latin America & Caribbean, Middle East & North Africa, Sub-Saharan Africa, European Union (27) and North America. Advanced countries being dropped out, the latter two regions, European Union (27) and North America do not have observations.

mance during the global financial crisis compared to non-crisis times, namely a 'detrended' real GDP growth rate. This is thus a measure of short-term economic growth, mainly affected by circumstantial factors (i.e. temporary external shocks). The importance of reserve holdings of a country's neighbors in 2006 should not be directly related to the impact of the 2009 financial crisis on economic growth.

Hence, the reserve accumulation behavior of neighbor countries before the crisis has no clear relationship with residuals of our OLS regression (which correspond to the crisis impact that is not explained by reserves, capital controls, trade openness, exchange rate regime, and financial centers) [53].

We provide the results of the first-stage regressions using our candidate instrumental variables, in table 2.18 in Appendix 2.F. Column (1) shows the results using the distance-weighted index, column (2) uses the Joneses index, while column (3) uses both variables as joint instruments. In all three cases we find a significant correlation with the instrumented variable, reserves to short-term debt ratio, and obtain signs consistent with our expectation, namely the stronger regional pressure, the higher reserve adequacy ratio. The $R^2$ is also reasonably large, around 14% in all three cases. These findings confirm our choice of instrumental variables. The sign and goodness of fit of the distance-weighted index remain stable when we drop outliers; that of the Joneses index is slightly weaker (see table 2.19 in Appendix 2.F).

### Two-stage least square regressions

We present in table 2.5 the results of the second stage regression when the reserve adequacy ratio is instrumented. To facilitate interpretation, we repeat our OLS results in column (1). Columns (2), (3) and (4) respectively show the final results of the two-stage least square procedure (2SLS) using the distance-weighted index, the Joneses index and both.

53. One caveat: one may argue that countries in a given region have similar trade and financial flows, therefore the pattern of their reserve accumulation may have a common component related to common growth expectations in the region. This would weaken the exogeneity of our instruments.

Using instrumental variables, the coefficients of interest in our regressions are not significant any more. This result is not very surprising, since we know that the 2SLS procedure usually yields larger standard errors, driving down the significance of the 2SLS estimates. For this reason, it is hard to conclude anything in terms of bias correction and magnitude. The signs of the 2SLS estimates are consistent with the OLS estimates, although the magnitude of the 2SLS estimates are higher, but none of the coefficients estimated through 2SLS are significantly different from zero [54].

For robustness checks, table 2.20 in Appendix 2.F presents similar results when dropping outliers from the sample. We also instrumented the reserve adequacy ratio when adding the interaction term between reserves and capital controls in the regression; results are fairly similar to that presented above and are available upon request.

54. Considering that the corresponding Hausman test fails to reject the null hypothesis of exogenous right-hand-side variables, we feel more confident on relying on our OLS estimates.

Table 2.5: 2SLS: Second stage

| | (1) OLS | (2) distance weighted index | (3) Joneses | (4) both |
|---|---|---|---|---|
| L2.log rsv/std | 0.729** | 2.088 | 0.944 | 1.413 |
| | (0.317) | (1.888) | (1.485) | (1.213) |
| L2.capital controls | 0.689** | 0.506 | 0.660* | 0.597* |
| | (0.307) | (0.408) | (0.356) | (0.343) |
| L2.exchange regime index | -0.652 | -1.330 | -0.759 | -0.993 |
| | (1.457) | (1.789) | (1.589) | (1.556) |
| L2.trade openness | -0.0184 | -0.00567 | -0.0164 | -0.0120 |
| | (0.0128) | (0.0220) | (0.0184) | (0.0167) |
| oil dummy | -1.561 | -2.131 | -1.651 | -1.848 |
| | (1.410) | (1.673) | (1.498) | (1.479) |
| financial center | 5.284 | 1.700 | 4.718 | 3.479 |
| | (5.395) | (7.488) | (6.488) | (6.169) |
| Constant | -1.400 | -9.972 | -2.754 | -5.716 |
| | (2.575) | (12.03) | (9.502) | (7.821) |
| Observations | 112 | 112 | 112 | 112 |
| $R^2$ | 0.155 | 0.007 | 0.151 | 0.117 |
| Adjusted $R^2$ | 0.107 | -0.049 | 0.103 | 0.067 |
| Hausman $p - value$ | . | 0.442 | 0.886 | 0.563 |

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

### 2.3.5 Foreign reserves: gunpowder or nuclear weapons?

We have so far seen that foreign reserve adequacy (relative to short-term debt) contributes, on its own or jointly with capital controls, to real output growth during the recent global financial crisis. Other papers [e.g. Aizenman and Sun (2009) and Dominguez et al. (2012)] rather focus on reserve depletion and its impact on economic growth of the same period. These different views reflect an interesting question behind: are foreign reserves 'gunpowder', meaning that they have to be deployed during a war (crisis), or are they akin to 'nuclear weapons' - the mere existence of reserves suffices to act as a protection? We try to bring some empirical evidence to this question here.

First, we want to know whether countries that had a larger pre-crisis level of reserves compared to short-term debts depleted more reserves during the GFC. The scatter plot in figure 2.4 does not show a clear relationship between pre-crisis reserve adequacy and reserve depletion during the GFC[55]. This feature remains true even if we exclude outliers. It seems like only countries whose pre-crisis reserves to short-term debt ratio falls in the middle range depleted reserve assets during the GFC; both countries which had a very high or very low reserve adequacy ratio did not use much their reserves. Notice that in order to cover a broader range of non-advanced countries, we use the change in the *total* reserve stock as our proxy for reserve depletion during the GFC [different from Dominguez et al. (2012) who use SDDS data].

Next, we proceed to include a control variable of reserve depletion in our main specification, equation (2.2), so that we can see whether this control variable has an effect on the coefficients we estimated above. In particular, we are interested to see whether including reserve depletion changes the coefficient of pre-crisis reserve adequacy ratio.

For this exercise, we construct a dummy variable as a proxy of reserve depletion. It takes the value 1 if the growth rate of reserves is zero or negative between 2008 and 2009 and the value 0 otherwise. We find that the pre-crisis reserve adequacy ratio remains statistically significant when the variable of reserve depletion is added (reserve depletion itself not significant, see table 2.6).

55. We also tested this relationship empirically using an OLS regression. Results can be

Table 2.6: Reserve depletion as a control variable

| | (1) rgdp_residual | (2) rgdp_residual |
|---|---|---|
| L2.log rsv/std | 0.729** | 0.752** |
| | (0.317) | (0.321) |
| L2.capital controls | 0.689** | 0.719** |
| | (0.307) | (0.313) |
| L2.exchange regime index | -0.652 | -0.681 |
| | (1.457) | (1.469) |
| L2.trade openness | -0.0184 | -0.0169 |
| | (0.0128) | (0.0130) |
| oil dummy | -1.561 | -1.179 |
| | (1.410) | (1.563) |
| financial center | 5.284 | 4.844 |
| | (5.395) | (5.458) |
| reserve depletion dummy | | -0.758 |
| | | (1.422) |
| Constant | -1.400 | -1.594 |
| | (2.575) | (2.603) |
| Observations | 112 | 111 |
| $R^2$ | 0.155 | 0.157 |
| Adjusted $R^2$ | 0.107 | 0.100 |

Standard errors in parentheses

Homoscedasticity not rejected according to the White test

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

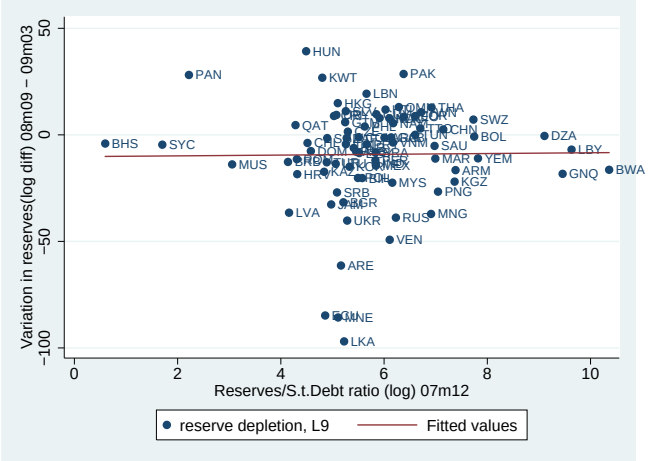



Figure 2.4: Depletion vs. Pre-crisis adequacy

## 2.4 Foreign reserve accumulation after the global financial crisis

So far, we have analyzed the role of foreign reserves on real economic growth during the GFC and have concluded that sufficient reserves with respect to a country's short-term debt level are important to limit output losses during a crisis. Did the GFC then reshape countries' perception about the necessity of hoarding foreign reserves? As noted by the IMF, '[a]uthorities in several countries, including some advanced economies, had started focusing anew on the role of reserves in crisis mitigation and management [...] and even several small advanced countries have since taken a new look at their need for reserves in relation to the international exposures of their financial systems [IEO (2012)].'

In fact, in line with existing papers [Dominguez et al. (2012)], we find that many countries see their reserves 'bounce back' immediately after a period of reserve losses during the GFC. Compared to the existing literature, this paper takes advantage of more recent data to better describe reserve rebuilding after the GFC, and more importantly, to document a recent trend of deceleration in reserve accumulation.

Figure 2.5 illustrates how the monthly growth rate in foreign reserve accumu-

provided upon request.

lation has changed from a high speed before the crisis to a relatively slow pace in more recent years. We can especially observe a spectacular depletion of reserves during the crisis period, a fast 'bounce-back' in the aftermath of the crisis followed by a 'flattening-out'. We will document these three phenomena in this section.

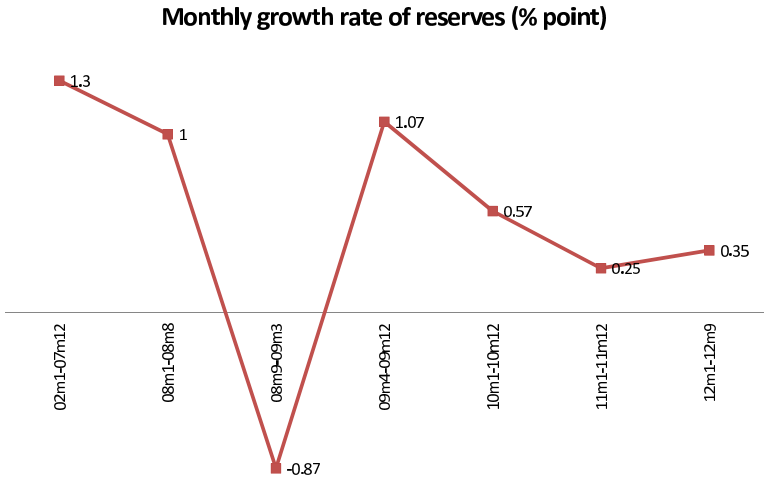



Figure 2.5: Evolution of foreign reserve accumulation

### 2.4.1 Reserve rebuilding in the immediate aftermath of the crisis

Two features draw our attention with respect to reserve rebuilding. First, a significant rebuilding is more pronounced in countries which had a relatively low pre-crisis reserve adequacy ratio. Figure 2.6 shows a scatter plot comparing pre-crisis reserves to short-term debt in December 2007 with reserve rebuilding from April to December 2009. This time span is defined as the period immediately following the peak of the GFC. We take the timing of being hit by the GFC from Dominguez et al. (2012) [56].

We can see a clear negative relationship between these two variables. Namely, the lower the pre-crisis reserve adequacy ratio, the stronger the rebuilding. This

56. Dominguez et al. (2012) report that most non-advanced countries experienced the crisis between 2008Q4 and 2009Q1 in spite of some heterogeneities.

might reflect an increasing demand for reserves in countries that were insufficiently self-insured before the GFC.

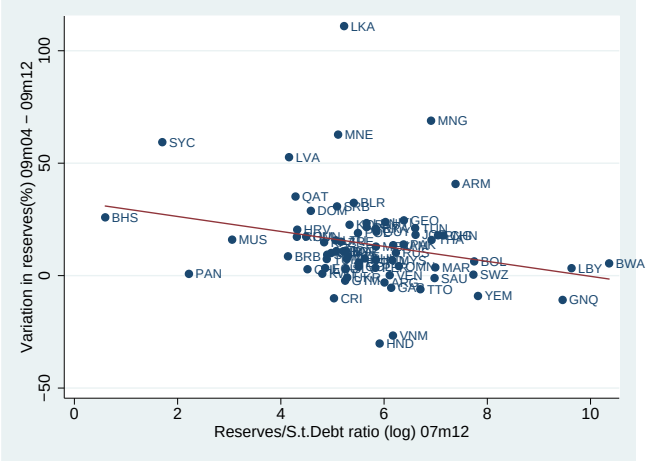



Figure 2.6: Rebuilding vs. Pre-crisis level of reserves

We further test this bivariate relationship with a simple OLS regression specified as follows:

$$\Delta rsv_{09m04-09m12,i} = \gamma_0 + \gamma_1 log(\frac{rsv}{std})_{07m12} + \boldsymbol{\gamma x} + \epsilon_i \tag{2.3}$$

$\boldsymbol{x}$ stands for control variables, including especially a dummy variable which indicates whether a country drew credit lines from the IMF before 2009Q1. We construct this dummy variable based on the IMF annual report and we conjecture that if a country resorted to an IMF program during the crisis its willingness to re-build foreign reserves after the financial crisis would be enhanced.

We observe from table 2.7 that the post-crisis reserve rebuilding rate is significantly and negatively correlated with pre-crisis reserve adequacy ratio in most cases. The coefficient of the pre-crisis adequacy ratio loses the significance once we add the oil country dummy. Oil countries did not seem to recover their reserve stock after the GFC; this however might be due to the collapse of world oil demand. This result is robust after controlling for outliers (column (4)). A more pronounced reserve rebuilding seems to be associated with a lower pre-crisis reserve adequacy ratio.

We now turn to the relationship between reserve rebuilding after the crisis and

Table 2.7: Reserve rebuilding vs. Pre-crisis adequacy ratio

| | | full sample | | w/t outliers |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| | rebuilding | rebuilding | rebuilding | rebuilding |
| log rsv/std (07m12) | -3.326** | -2.368 | -2.724* | -2.636* |
| | (1.555) | (1.565) | (1.542) | (1.478) |
| IMF credit dummy | | 10.83** | 12.24** | 10.67** |
| | | (5.269) | (5.151) | (4.340) |
| financial center | | -5.035 | -3.413 | -3.143 |
| | | (19.79) | (19.81) | (15.91) |
| oil dummy | | -7.138 | | |
| | | (5.960) | | |
| Constant | 32.95*** | 25.94*** | 26.06*** | 25.36*** |
| | (9.121) | (9.391) | (9.420) | (8.947) |
| Observations | 73 | 73 | 73 | 69 |
| $R^2$ | 0.061 | 0.151 | 0.133 | 0.152 |
| Adjusted $R^2$ | 0.047 | 0.101 | 0.096 | 0.113 |

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

reserve depletion during the crisis. From figure 2.7, we observe that a massive depletion of reserves during the crisis is associated with a stronger rebound. This seems once again to confirm countries' increasing appetite for reserve assets as a self-insurance.

We can also test this relationship using the following OLS regression:

$$\Delta rsv_{09m04-09m12,i} = \gamma_0 + \gamma_1 \Delta rsv_{08m09-09m03,i} + \boldsymbol{\gamma x} + \epsilon_i \tag{2.4}$$

Table 2.8 shows that the negative relationship between the growth rate of reserves during and after the GFC that we can see from the scatter plot in figure 2.7 is statistically significant. A higher rebuilding rate is associated with a more severe reserve depletion. This result is also robust even if we control for other variables (column (2)) or eliminate outliers (column (3)).

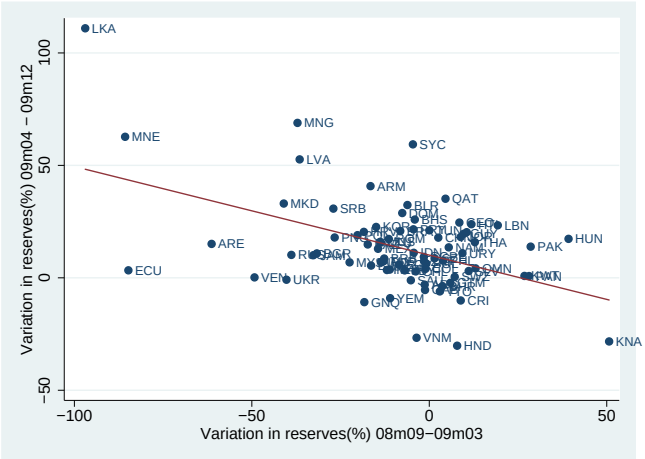



Figure 2.7: Rebuilding vs. Depletion of reserves

Table 2.8: Reserve rebuilding vs. Reserve depletion

| | full sample | | w/t outliers |
|---|---|---|---|
| | (1) | (2) | (3) |
| | rebuilding | rebuilding | rebuilding |
| reserve depletion | -0.394*** | -0.427*** | -0.232*** |
| | (0.0844) | (0.0802) | (0.0779) |
| IMF credit dummy | | 8.497* | 10.06** |
| | | (4.504) | (3.939) |
| oil dummy | | -13.25** | -11.39** |
| | | (5.118) | (4.307) |
| financial center | | -1.185 | |
| | | (17.48) | |
| Constant | 10.10*** | 9.843*** | 11.03*** |
| | (2.237) | (2.847) | (2.374) |
| Observations | 77 | 76 | 73 |
| $R^2$ | 0.225 | 0.358 | 0.266 |
| Adjusted $R^2$ | 0.215 | 0.322 | 0.234 |

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

### 2.4.2 Foreign reserve accumulation: a recent deceleration

Thanks to ampler data, we now analyze the more recent behavior in reserve accumulation. We observe a noticeable slow-down in the pace of foreign reserve accumulation in several emerging market economies, like India, Russia, and some Eastern European countries (e.g. Bulgaria, Croatia and Romania). One important exception is China.

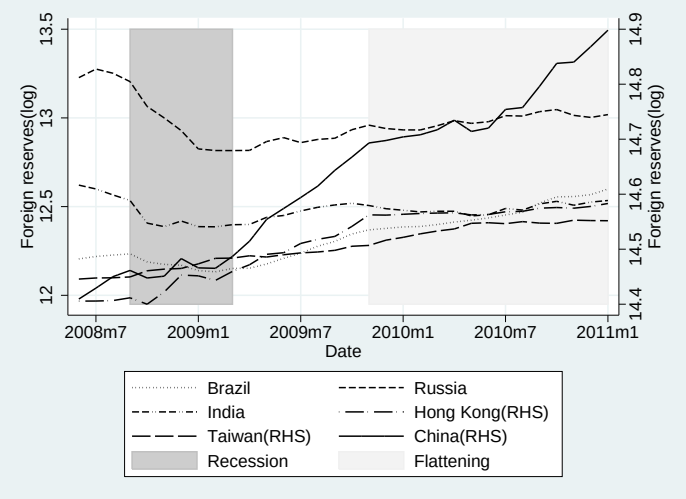



Figure 2.8: Recent foreign reserve accumulation in BRIC, Hong Kong and Taiwan

From figure 2.8, apart from China where foreign reserve accumulation has a clearly different pattern, there is a general tendency of a deceleration in the pace of foreign reserve purchasing from the end of 2009. This tendency is especially observable in India, Russia and Hong Kong; foreign reserves in Taiwan also tail off, though with a delay, from mid-2010 [57].

A 'flattening-out' of foreign reserve accumulation is also noticeable in other countries when a more recent period is considered. This is the case for Indonesia, Malaysia and Thailand (figure 2.9) and many East European countries (figure 2.10) from the end of 2010.

What drives this 'flattening' in foreign reserve accumulation? We come up with several possible explanations. First, it is possible that, once a country reached its pre-crisis level of reserves, it slows down the accumulation as for-

57. The GFC period corresponds to the finding of Dominguez et al. (2012) as noted before.

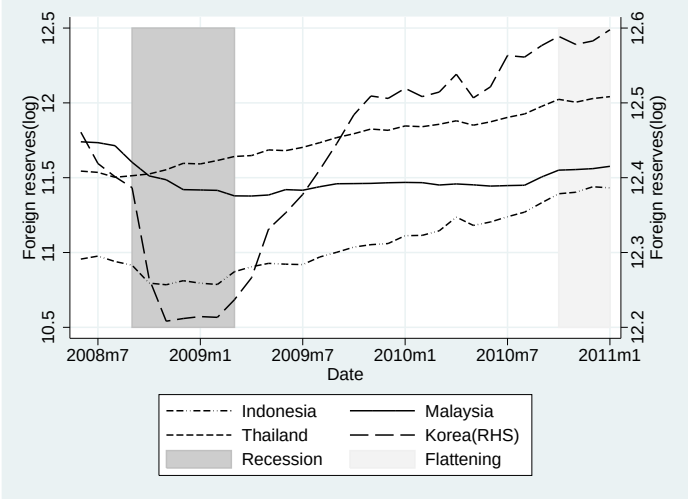



Figure 2.9: Selected Asian countries

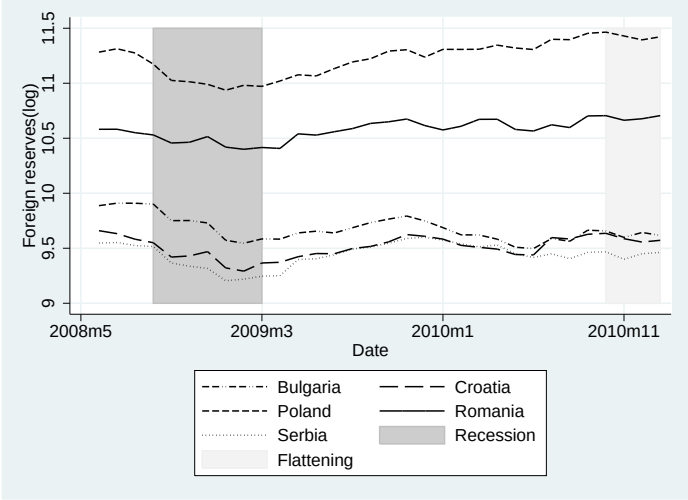



Figure 2.10: Selected East European countries

eign reserves are no free lunch and the opportunity cost and risks associated with valuation effects may be high. Second, the deceleration of foreign reserve accumulation may reflect a change of policy priority with regard to monetary autonomy, exchange rate stability and financial openness in the wake of the 2008-2009 financial crisis, as Aizenman et al. (2010) put forward. After all, reserve accumulation may be motivated by the need to reconcile the 'Impossible Trinity' (this is however an aspect of reserve accumulation that we do not consider in this paper). Last but not least, if foreign reserve accumulation tails off, it might be because of the stabilization of the underlying macroeconomic variable that foreign reserves are used to cover. In our paper, we argue that this macroeconomic variable is short-term debt. With the 'flattening-out' of short-term debt after the financial crisis (the reasons why short-term debt diminishes after the GFC are multiple, e.g. Great Retrenchment), the demand for foreign reserves must fall.

We can test the relationship between short-term debt and foreign reserves based on a Vector Error Correction Model (VECM), which can identify the long-run co-integration relation as well as short-term dynamics between these two variables. Due to the availability of data and the minimum data points needed, we use quarterly data of reserves and short-term debt, as well as other control variables for this exercise. We consider the period running from 2002Q1 to 2012Q1.

The VECM specification can be written as:

$$\begin{aligned}\Delta log(rsv_{i,t}) =& \phi_i\Big(log(rsv_{i,t-1}) - \theta_0 - \theta_1 log(std_{i,t-1})\Big) \\ &+ \delta_{1,i}\Delta log(std_{i,t}) + \boldsymbol{\delta_i'}\boldsymbol{\Delta x_{i,t}} + \epsilon_{i,t}\end{aligned} \tag{2.5}$$

$\phi_i$ is the error correcting term, namely the speed of adjustment. If it is significantly negative, one can conclude that there is convergence to the long run relationship which is described as follows:

$$log(rsv_{i,t-1}) = \theta_0 + \theta_1 log(std_{i,t-1})$$

The short run dynamics are captured by the short run coefficients $\delta_{1,i}$ and $\boldsymbol{\delta_i'}$.

To estimate equation (2.5), several methods can be used. Below we present the

estimation results using pooled mean group estimates, which assume a common long-run coefficient across countries but heterogeneous short-term adjustment.

From table 2.9, we observe that there is a clear positive long-run relationship between foreign reserves and short-term debt both expressed in logarithm. In the baseline case (column (1)), $log(rsv_{i,t}) = 0.436log(std_{i,t})$. In the short-term, the error correction coefficient (-0.0743) is significant and negative, meaning that if foreign reserves exceed the long-run equilibrium level a country reduces its foreign reserve accumulation with an adjustment rate of 7% in the baseline case.

As a robustness check, we also tried different estimation methods and used additional control variables. The main coefficients presented in table 2.9 do not change in signs nor in magnitude.

The VECM confirms our initial guess on why foreign reserve accumulation tails off in recent years. It is likely that the underlying target variable for foreign reserves, namely short-term debt, stabilizes after the financial crisis; this, in turn, may be associated with the global liquidity crunch and Great Retrenchment? [Milesi-Ferretti and Tille (2011)] in international capital flows that took place in the wake of the GFC.

## 2.5 Conclusion

In the late 1990s and early 2000s, a consensus developed that reserves were useful in averting, or at least mitigating, the occurrence of crises in emerging market and developing countries. Policy makers from these countries have apparently absorbed the lessons from this literature, as the level of international reserves dramatically increased in the 2000s (even accepting that other motives have played a role). The results presented in this paper suggest that the Great Financial Crisis has further demonstrated the usefulness of reserves: empirically, the countries that held more reserves as a percentage of short-term debt have been less negatively impacted than others, ceteris paribus. The results also suggest that this effect is especially strong when the capital account is less open.

Given that reserves seem to have played a role in offsetting the effect of the crisis, it is not surprising that the countries that depleted reserves to a greater

Table 2.9: Vector Error Correction Model (2002Q1 - 2012Q1)

| | (1) $\Delta$ log(reserves) | (2) $\Delta$ log(reserves) | (3) $\Delta$ log(reserves) |
|---|---|---|---|
| Long-run | | | |
| L.std_log | 0.436*** | 0.445*** | 0.448*** |
| | (0.0249) | (0.0243) | (0.0270) |
| Short-run | | | |
| error correction | -0.0743*** | -0.0815*** | -0.186*** |
| | (0.0107) | (0.0130) | (0.0514) |
| D.std_log | 0.138*** | 0.128*** | 0.148*** |
| | (0.0188) | (0.0173) | (0.0277) |
| LD.reserves_log | | 0.113*** | 0.0338 |
| | | (0.0296) | (0.0399) |
| L2D.reserves_log | | -0.0357* | -0.131*** |
| | | (0.0213) | (0.0436) |
| $\Delta$ log(RGDP) | | | 0.282 |
| | | | (0.485) |
| $\Delta$ log(M2) | | | 0.225 |
| | | | (0.199) |
| $\Delta$ log(REER) | | | 0.0474 |
| | | | (0.0920) |
| Constant | 0.438*** | 0.468*** | 0.950*** |
| | (0.0584) | (0.0697) | (0.230) |
| Observations | 2752 | 2750 | 1093 |

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

extent are also the ones that rebuilt them more quickly in the direct aftermath of the crisis, as shown in the paper. One possible factor is that policy makers in emerging market and developing countries have concluded from the experience of the GFC that reserves are indeed very useful in protecting countries against crises. Nonetheless, we also find that in the most recent period, the pace of reserve accumulation has slowed down, in line with the deceleration in the pace of short-term debt. This outcome suggests that countries target the level of short-term debt: if, for whatever reason, short-term debt accumulation decelerates, then reserves are likely to follow the same course.

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# 2.A Country sample

For Eastern European countries, we decided to classify countries at the periphery of Europe and not in the Eurozone as emerging market economies, whereas countries that belong to the Eurozone are considered as advanced economies and not included in our sample.

Table 2.10: Country list

| country | cncode | region | regioncode | country group |
|---|---|---|---|---|
| Afghanistan | AFG | South Asia | 1 | LDC |
| Albania | ALB | Europe & Central Asia | 8 | LDC |
| Algeria | DZA | Middle East & North Africa | 4 | LDC |
| Angola | AGO | Sub-Saharan Africa | 7 | LDC |
| Antigua and Barbuda | ATG | Latin America & Caribbean | 3 | LDC |
| Argentina | ARG | Latin America & Caribbean | 3 | EME |
| Armenia | ARM | Europe & Central Asia | 8 | LDC |
| Aruba | ABW | Latin America & Caribbean | 3 | LDC |
| Azerbaijan | AZE | Europe & Central Asia | 8 | LDC |
| Bahamas | BHS | Latin America & Caribbean | 3 | LDC |
| Bahrain | BHR | Middle East & North Africa | 4 | LDC |
| Bangladesh | BGD | South Asia | 1 | LDC |
| Barbados | BRB | Latin America & Caribbean | 3 | LDC |
| Belarus | BLR | Europe & Central Asia | 8 | LDC |
| Belize | BLZ | Latin America & Caribbean | 3 | LDC |
| Benin | BEN | Sub-Saharan Africa | 7 | LDC |
| Bhutan | BTN | South Asia | 1 | LDC |
| Bolivia | BOL | Latin America & Caribbean | 3 | LDC |
| Bosnia and Herzegovina | BIH | Europe & Central Asia | 8 | LDC |
| Botswana | BWA | Sub-Saharan Africa | 7 | LDC |
| Brazil | BRA | Latin America & Caribbean | 3 | EME |
| Brunei Darussalam | BRN | East Asia & Pacific | 6 | LDC |
| Bulgaria | BGR | Europe & Central Asia | 8 | EME |
| Burkina Faso | BFA | Sub-Saharan Africa | 7 | LDC |
| Burundi | BDI | Sub-Saharan Africa | 7 | LDC |
| Cambodia | KHM | East Asia & Pacific | 6 | LDC |
| Cameroon | CMR | Sub-Saharan Africa | 7 | LDC |
| Cape Verde | CPV | Sub-Saharan Africa | 7 | LDC |
| Central African Republic | CAF | Sub-Saharan Africa | 7 | LDC |
| Chad | TCD | Sub-Saharan Africa | 7 | LDC |
| Chile | CHL | Latin America & Caribbean | 3 | EME |
| China | CHN | East Asia & Pacific | 6 | EME |
| Colombia | COL | Latin America & Caribbean | 3 | EME |
| Comoros | COM | Sub-Saharan Africa | 7 | LDC |
| Congo | COG | Sub-Saharan Africa | 7 | LDC |
| Congo (Dem) | ZAR | Sub-Saharan Africa | 7 | LDC |
| Costa Rica | CRI | Latin America & Caribbean | 3 | LDC |
| Cote d'Ivoire | CIV | Sub-Saharan Africa | 7 | LDC |
| Croatia | HRV | Europe & Central Asia | 8 | LDC |
| Czech Republic | CZE | Europe & Central Asia | 8 | EME |
| Djibouti | DJI | Middle East & North Africa | 4 | LDC |
| Dominica | DMA | Latin America & Caribbean | 3 | LDC |
| Dominican Republic | DOM | Latin America & Caribbean | 3 | LDC |
| Ecuador | ECU | Latin America & Caribbean | 3 | LDC |
| Egypt | EGY | Middle East & North Africa | 4 | EME |
| El Salvador | SLV | Latin America & Caribbean | 3 | LDC |
| Equatorial Guinea | GNQ | Middle East & North Africa | 4 | LDC |
| Eritrea | ERI | Sub-Saharan Africa | 7 | LDC |
| Ethiopia | ETH | Sub-Saharan Africa | 7 | LDC |
| Fiji | FJI | East Asia & Pacific | 6 | LDC |
| Gabon | GAB | Sub-Saharan Africa | 7 | LDC |
| Gambia | GMB | Sub-Saharan Africa | 7 | LDC |
| Georgia | GEO | Europe & Central Asia | 8 | LDC |

| | | | | |
|---|---|---|---|---|
| Ghana | GHA | Sub-Saharan Africa | 7 | LDC |
| Grenada | GRD | Latin America & Caribbean | 3 | LDC |
| Guatemala | GTM | Latin America & Caribbean | 3 | LDC |
| Guinea | GIN | Sub-Saharan Africa | 7 | LDC |
| Guinea-Bissau | GNB | Sub-Saharan Africa | 7 | LDC |
| Guyana | GUY | Latin America & Caribbean | 3 | LDC |
| Haiti | HTI | Latin America & Caribbean | 3 | LDC |
| Honduras | HND | Latin America & Caribbean | 3 | LDC |
| Hong Kong | HKG | East Asia & Pacific | 6 | EME |
| Hungary | HUN | Europe & Central Asia | 8 | EME |
| India | IND | South Asia | 1 | EME |
| Indonesia | IDN | East Asia & Pacific | 6 | EME |
| Iran | IRN | Middle East & North Africa | 4 | LDC |
| Iraq | IRQ | Middle East & North Africa | 4 | LDC |
| Jamaica | JAM | Latin America & Caribbean | 3 | LDC |
| Jordan | JOR | Middle East & North Africa | 4 | LDC |
| Kazakhstan | KAZ | Europe & Central Asia | 8 | LDC |
| Kenya | KEN | Sub-Saharan Africa | 7 | LDC |
| Kiribati | KIR | East Asia & Pacific | 6 | LDC |
| Korea | KOR | East Asia & Pacific | 6 | EME |
| Kosovo | KSV | Europe & Central Asia | 8 | LDC |
| Kuwait | KWT | Middle East & North Africa | 4 | LDC |
| Kyrgyz Republic | KGZ | Europe & Central Asia | 8 | LDC |
| Lao | LAO | East Asia & Pacific | 6 | LDC |
| Latvia | LVA | Europe & Central Asia | 8 | EME |
| Lebanon | LBN | Middle East & North Africa | 4 | LDC |
| Lesotho | LSO | Sub-Saharan Africa | 7 | LDC |
| Liberia | LBR | Sub-Saharan Africa | 7 | LDC |
| Libya | LBY | Middle East & North Africa | 4 | LDC |
| Lithuania | LTU | Europe & Central Asia | 8 | EME |
| Macao | MAC | East Asia & Pacific | 6 | LDC |
| Macedonia | MKD | Europe & Central Asia | 8 | LDC |
| Madagascar | MDG | Sub-Saharan Africa | 7 | LDC |
| Malawi | MWI | Sub-Saharan Africa | 7 | LDC |
| Malaysia | MYS | East Asia & Pacific | 6 | EME |
| Maldives | MDV | South Asia | 1 | LDC |
| Mali | MLI | Sub-Saharan Africa | 7 | LDC |
| Marshall Islands | MHL | East Asia & Pacific | 6 | LDC |
| Mauritania | MRT | Sub-Saharan Africa | 7 | LDC |
| Mauritius | MUS | Sub-Saharan Africa | 7 | EME |
| Mexico | MEX | Latin America & Caribbean | 3 | LDC |
| Micronesia | FSM | East Asia & Pacific | 6 | LDC |
| Moldova | MDA | Europe & Central Asia | 8 | LDC |
| Mongolia | MNG | East Asia & Pacific | 6 | LDC |
| Montenegro | MNE | Europe & Central Asia | 8 | LDC |
| Montserrat | MSR | Latin America & Caribbean | 3 | LDC |
| Morocco | MAR | Middle East & North Africa | 4 | EME |
| Mozambique | MOZ | Sub-Saharan Africa | 7 | LDC |
| Myanmar | MMR | East Asia & Pacific | 6 | LDC |
| Namibia | NAM | Sub-Saharan Africa | 7 | LDC |
| Nepal | NPL | South Asia | 1 | LDC |
| Nicaragua | NIC | Latin America & Caribbean | 3 | LDC |
| Niger | NER | Sub-Saharan Africa | 7 | LDC |
| Nigeria | NGA | Sub-Saharan Africa | 7 | LDC |
| Oman | OMN | Middle East & North Africa | 4 | LDC |
| Pakistan | PAK | South Asia | 1 | EME |
| Panama | PAN | Latin America & Caribbean | 3 | LDC |
| Papua New Guinea | PNG | East Asia & Pacific | 6 | LDC |
| Paraguay | PRY | Latin America & Caribbean | 3 | LDC |
| Peru | PER | Latin America & Caribbean | 3 | EME |
| Philippines | PHL | East Asia & Pacific | 6 | EME |
| Poland | POL | Europe & Central Asia | 8 | EME |
| Qatar | QAT | Middle East & North Africa | 4 | LDC |
| Romania | ROM | Europe & Central Asia | 8 | EME |
| Russia | RUS | Europe & Central Asia | 8 | EME |
| Rwanda | RWA | Sub-Saharan Africa | 7 | LDC |

| | | | | |
|---|---|---|---|---|
| Samoa | WSM | East Asia & Pacific | 6 | LDC |
| Sao Tome and Principe | STP | Sub-Saharan Africa | 7 | LDC |
| Saudi Arabia | SAU | Middle East & North Africa | 4 | EME |
| Senegal | SEN | Sub-Saharan Africa | 7 | LDC |
| Serbia | SRB | Europe & Central Asia | 8 | LDC |
| Seychelles | SYC | Sub-Saharan Africa | 7 | LDC |
| Sierra Leone | SLE | Sub-Saharan Africa | 7 | LDC |
| Singapore | SGP | East Asia & Pacific | 6 | EME |
| Solomon Islands | SLB | East Asia & Pacific | 6 | LDC |
| Somalia | SOM | Sub-Saharan Africa | 7 | LDC |
| South Africa | ZAF | Sub-Saharan Africa | 7 | EME |
| Sri Lanka | LKA | South Asia | 1 | LDC |
| St. Kitts and Nevis | KNA | Latin America & Caribbean | 3 | LDC |
| St. Lucia | LCA | Latin America & Caribbean | 3 | LDC |
| St. Vincent and the Grenadines | VCT | Latin America & Caribbean | 3 | LDC |
| Sudan | SDN | Sub-Saharan Africa | 7 | LDC |
| Suriname | SUR | Latin America & Caribbean | 3 | LDC |
| Swaziland | SWZ | Sub-Saharan Africa | 7 | LDC |
| Syrian Arab Republic | SYR | Middle East & North Africa | 4 | LDC |
| Taiwan | TWN | East Asia & Pacific | 6 | EME |
| Tajikistan | TJK | Europe & Central Asia | 8 | LDC |
| Tanzania | TZA | Sub-Saharan Africa | 7 | LDC |
| Thailand | THA | East Asia & Pacific | 6 | EME |
| Timor-Leste | TMP | East Asia & Pacific | 6 | LDC |
| Togo | TGO | Sub-Saharan Africa | 7 | LDC |
| Tonga | TON | East Asia & Pacific | 6 | LDC |
| Trinidad and Tobago | TTO | Latin America & Caribbean | 3 | LDC |
| Tunisia | TUN | Middle East & North Africa | 4 | LDC |
| Turkey | TUR | Europe & Central Asia | 8 | EME |
| Turkmenistan | TKM | Europe & Central Asia | 8 | LDC |
| Tuvalu | TUV | East Asia & Pacific | 6 | LDC |
| Uganda | UGA | Sub-Saharan Africa | 7 | LDC |
| Ukraine | UKR | Europe & Central Asia | 8 | EME |
| United Arab Emirates | ARE | Middle East & North Africa | 4 | LDC |
| Uruguay | URY | Latin America & Caribbean | 3 | LDC |
| Uzbekistan | UZB | Europe & Central Asia | 8 | LDC |
| Vanuatu | VUT | East Asia & Pacific | 6 | LDC |
| Venezuela | VEN | Latin America & Caribbean | 3 | EME |
| Vietnam | VNM | East Asia & Pacific | 6 | LDC |
| Yemen | YEM | Middle East & North Africa | 4 | LDC |
| Zambia | ZMB | Sub-Saharan Africa | 7 | LDC |
| Zimbabwe | ZWE | Sub-Saharan Africa | 7 | LDC |

## 2.B Variables used for econometric analysis

Table 2.11: Key variable description

| Variable | Full Name | Description | Source |
|---|---|---|---|
| $rgdp\_residual$ | Purged real GDP growth | real GDP 09 - linear prediction from a mean 03-08 | IMF IFS (2012) |
| $rgdp\_fe$ | Unexpected real GDP growth | real GDP 09 - forecast in 2008Q1 | IMF WEO (2008), IFS (2012) |
| $rsv$ | Reserve adequacy ratios | One of the four ratios detailed in p.9 | IMF IFS (2012) |
| $rsv\_std$ | Reserves to short-term debt ratio in log | $log\frac{reserves}{s.t.debt} \times 100$ | IMF IFS (2012) |
| capital controls ($cc$) | Capital control index | $-kaopen$ | Chinn and Ito (2006) |
| trade openness | Trade openness index | $\frac{X+M}{GDP} \times 100$ | IMF IFS (2012) |
| exchange regime dummy | De facto exchange rate classification | dummy variable | Reinhart and Rogoff (2004) |
| oil dummy | Oil producer/exporter index | dummy variable | IMF (2012) |
| financial center | Financial center index | dummy variable | IMF (2012) |
| $\Delta rsv_{08m09-09m03}$ | Reserve depletion | log-difference of reserves between 08m09 and 09m03 | IMF (2012) |
| $\Delta rsv_{09m04-09m12}$ | Reserve rebuilding | log-difference of reserves between 09m04 and 09m12 | IMF (2012) |

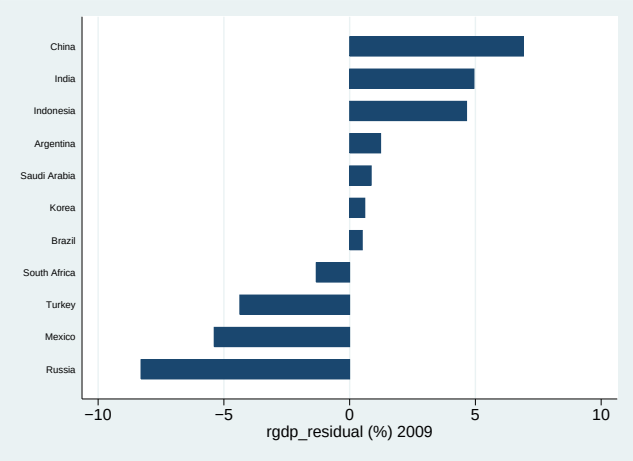



Figure 2.11: Crisis impact using $rgdp\_residual$

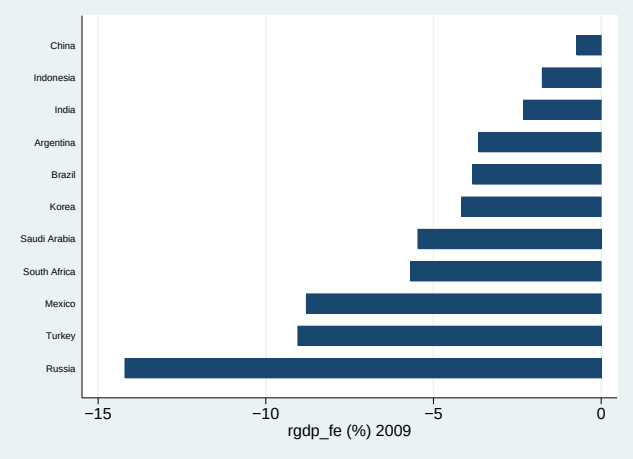



Figure 2.12: Crisis impact using $rgdp\_fe$

## 2.C Complementary results for Section 2.3.1

Table 2.12: Results with different reserve adequacy ratios, with $rgdp\_fe$ as dependent variable

| | (1) rgdp_fe | (2) rgdp_fe | (3) rgdp_fe | (4) rgdp_fe |
|---|---|---|---|---|
| L2.log rsv/gdp | -0.0670 | | | |
| | (0.566) | | | |
| L2.log rsv/imports | | 0.810 | | |
| | | (0.574) | | |
| L2.log rsv/m2 | | | -0.0315 | |
| | | | (0.524) | |
| L2.log rsv/std | | | | 0.671*** |
| | | | | (0.238) |
| Constant | -4.956*** | -6.455*** | -5.131*** | -9.090*** |
| | (1.691) | (0.970) | (1.948) | (1.473) |
| Observations | 142 | 133 | 138 | 138 |
| $R^2$ | 0.000 | 0.015 | 0.000 | 0.055 |
| Adjusted $R^2$ | -0.007 | 0.007 | -0.007 | 0.048 |

Standard errors in parentheses

Homoscedasticity not rejected according to the White test

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 2.13: Results with different reserve adequacy ratios, without outliers

| | (1) rgdp_residual | (2) rgdp_residual | (3) rgdp_residual | (4) rgdp_residual |
|---|---|---|---|---|
| L2.log rsv/gdp | -0.135 | | | |
| | (0.630) | | | |
| L2.log rsv/imports | | 0.649 | | |
| | | (0.677) | | |
| L2.log rsv/m2 | | | 0.468 | |
| | | | (0.595) | |
| L2.log rsv/std | | | | 0.857*** |
| | | | | (0.253) |
| Constant | 0.966 | -0.350 | -1.200 | -4.406*** |
| | (1.876) | (1.116) | (2.202) | (1.561) |
| Observations | 135 | 126 | 130 | 131 |
| $R^2$ | 0.000 | 0.007 | 0.005 | 0.082 |
| Adjusted $R^2$ | -0.007 | -0.001 | -0.003 | 0.075 |

Standard errors in parentheses

Homoscedasticity not rejected according to the White test

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 2.14: Results with different reserve adequacy ratios, without outliers and small countries

| | (1) rgdp_residual | (2) rgdp_residual | (3) rgdp_residual | (4) rgdp_residual |
|---|---|---|---|---|
| L2.log rsv/gdp | -0.723 | | | |
| | (0.729) | | | |
| L2.log rsv/imports | | 0.213 | | |
| | | (0.816) | | |
| L2.log rsv/m2 | | | -0.431 | |
| | | | (0.775) | |
| L2.log rsv/std | | | | 0.957*** |
| | | | | (0.355) |
| Constant | 3.006 | 0.611 | 2.336 | -4.971** |
| | (2.160) | (1.391) | (2.898) | (2.216) |
| Observations | 100 | 95 | 97 | 101 |
| $R^2$ | 0.010 | 0.001 | 0.003 | 0.068 |
| Adjusted $R^2$ | -0.000 | -0.010 | -0.007 | 0.059 |

Standard errors in parentheses

Homoscedasticity not rejected according to the White test

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

## 2.D Complementary results for Section 2.3.2

Table 2.15: Full specification without outliers

| | (1) rgdp_fe | (2) rgdp_residual |
|---|---|---|
| L2.log rsv/std | 0.951*** | 0.937*** |
| | (0.292) | (0.316) |
| L2.capital controls | 0.0352 | 0.220 |
| | (0.263) | (0.281) |
| L2.exchange regime index | -0.892 | -0.196 |
| | (1.226) | (1.311) |
| L2.trade openness | -0.0235** | -0.0286** |
| | (0.0104) | (0.0113) |
| oil dummy | -3.142*** | -1.987 |
| | (1.132) | (1.211) |
| Constant | -7.111*** | -1.830 |
| | (2.263) | (2.431) |
| Observations | 104 | 102 |
| $R^2$ | 0.213 | 0.201 |
| Adjusted $R^2$ | 0.173 | 0.159 |

Standard errors in parentheses

Homoscedasticity not rejected according to the White test

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 2.16: Full specification without outliers and small countries

| | (1) rgdp_fe | (2) rgdp_residual |
|---|---|---|
| L2.log rsv/std | 1.311*** | 1.239** |
| | (0.469) | (0.512) |
| L2.capital controls | -0.0365 | 0.315 |
| | (0.352) | (0.373) |
| L2.exchange regime index | -1.147 | -0.341 |
| | (1.323) | (1.410) |
| L2.trade openness | -0.0274** | -0.0302** |
| | (0.0127) | (0.0138) |
| oil dummy | -2.925** | -1.852 |
| | (1.260) | (1.344) |
| Constant | -8.958*** | -3.422 |
| | (3.111) | (3.357) |
| Observations | 82 | 80 |
| $R^2$ | 0.206 | 0.197 |
| Adjusted $R^2$ | 0.153 | 0.143 |

Standard errors in parentheses

Homoscedasticity not rejected according to the White test

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

## 2.E Complementary results for Section 2.3.3

Table 2.17: Foreign reserve accumulation and capital controls, without outliers and small countries

| | (1) rgdp_fe | (2) rgdp_residual |
|---|---|---|
| L2.log rsv/std | 1.355*** | 1.292** |
| | (0.472) | (0.516) |
| L2.capital controls | -0.00486 | 0.347 |
| | (0.354) | (0.375) |
| L2.log rsv/std × capital controls | 0.248 | 0.277 |
| | (0.273) | (0.299) |
| L2.exchange regime index | -1.342 | -0.540 |
| | (1.342) | (1.428) |
| L2.trade openness | -0.0269** | -0.0300** |
| | (0.0128) | (0.0139) |
| oil dummy | -2.953** | -1.900 |
| | (1.261) | (1.346) |
| Constant | -9.293*** | -3.791 |
| | (3.136) | (3.384) |
| Observations | 82 | 80 |
| $R^2$ | 0.214 | 0.207 |
| Adjusted $R^2$ | 0.151 | 0.141 |
| F-test capital controls | 0.417 | 0.786 |
| P-value | 0.660 | 0.459 |
| F-test reserves | 4.309 | 3.345 |
| P-value | 0.0169 | 0.0407 |

Standard errors in parentheses
Homoscedasticity not rejected according to the White test
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

## 2.F Complementary results for Section 2.3.4

Table 2.18: First stage regression for 2SLS

| | (1) L2.log rsv/std | (2) L2.log rsv/std | (3) L2.log rsv/std |
|---|---|---|---|
| L2.capital controls | 0.107 | 0.101 | 0.0800 |
| | (0.111) | (0.108) | (0.112) |
| L2.exchange regime index | 0.591** | 0.576** | 0.650** |
| | (0.297) | (0.268) | (0.299) |
| L2.trade openness | -0.0109** | -0.0106** | -0.0119** |
| | (0.00447) | (0.00440) | (0.00467) |
| oil dummy | 0.517 | 0.364 | 0.455 |
| | (0.394) | (0.359) | (0.395) |
| financial center | 3.095** | 2.803* | 3.194** |
| | (1.440) | (1.419) | (1.475) |
| L2.distance weighted index | 0.0325** | | 0.0287* |
| | (0.0150) | | (0.0149) |
| L2.Joneses | | 0.00228** | 0.00209* |
| | | (0.00111) | (0.00106) |
| Constant | 5.749*** | 5.037*** | 4.646*** |
| | (0.375) | (0.679) | (0.646) |
| Observations | 112 | 112 | 112 |
| $R^2$ | 0.132 | 0.143 | 0.164 |
| Adjusted $R^2$ | 0.082 | 0.094 | 0.108 |

Standard errors in parentheses
Homoscedasticity not rejected according to the White test
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 2.19: First stage regression, without outliers

| | (1) | (2) | (3) |
|---|---|---|---|
| | L2.log rsv/std | L2.log rsv/std | L2.log rsv/std |
| L2.capital controls | 0.199** | 0.196** | 0.177* |
| | (0.0909) | (0.0871) | (0.0918) |
| L2.exchange regime index | 0.423 | 0.470* | 0.491* |
| | (0.286) | (0.269) | (0.292) |
| L2.trade openness | -0.00735 | -0.00744* | -0.00815* |
| | (0.00445) | (0.00447) | (0.00461) |
| oil dummy | 0.537 | 0.421 | 0.491 |
| | (0.369) | (0.342) | (0.372) |
| L2.distance weighted index | 0.0255* | | 0.0227 |
| | (0.0149) | | (0.0151) |
| L2.Joneses | | 0.00157 | 0.00144 |
| | | (0.000989) | (0.000967) |
| Constant | 5.683*** | 5.230*** | 4.921*** |
| | (0.408) | (0.659) | (0.617) |
| Observations | 102 | 102 | 102 |
| $R^2$ | 0.149 | 0.154 | 0.169 |
| Adjusted $R^2$ | 0.105 | 0.110 | 0.116 |

Standard errors in parentheses

Homoscedasticity not rejected according to the White test

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 2.20: Second stage regression, without outliers

| | (1) OLS | (2) distance weighted index | (3) Joneses | (4) both |
|---|---|---|---|---|
| L2.log rsv/std | 0.937*** | 1.116 | 1.541 | 1.353 |
| | (0.316) | (2.070) | (1.896) | (1.467) |
| L2.capital controls | 0.220 | 0.180 | 0.0852 | 0.127 |
| | (0.281) | (0.531) | (0.501) | (0.421) |
| L2.exchange regime index | -0.196 | -0.266 | -0.434 | -0.360 |
| | (1.311) | (1.507) | (1.490) | (1.402) |
| L2.trade openness | -0.0286** | -0.0274 | -0.0247 | -0.0259* |
| | (0.0113) | (0.0172) | (0.0164) | (0.0144) |
| oil dummy | -1.987 | -2.070 | -2.267 | -2.180 |
| | (1.211) | (1.510) | (1.476) | (1.358) |
| Constant | -1.830 | -2.923 | -5.524 | -4.375 |
| | (2.431) | (12.74) | (11.68) | (9.086) |
| Observations | 102 | 102 | 102 | 102 |
| $R^2$ | 0.201 | 0.198 | 0.170 | 0.186 |
| Adjusted $R^2$ | 0.159 | 0.156 | 0.127 | 0.144 |
| Hausman $p - value$ | . | 0.932 | 0.750 | 0.776 |

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

# Chapter 3

# Balance Sheet Effects, Foreign Reserves and Public Policies

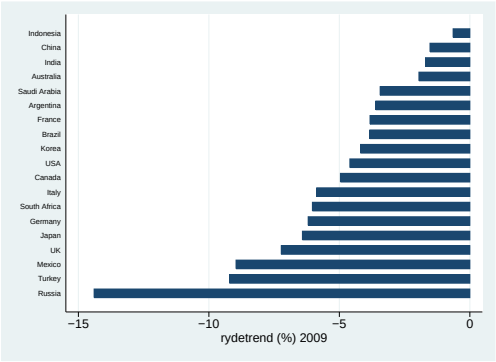
## 3.1 Introduction

The global economic turmoil which started with a local crisis in 2007 in the United States has quickly become a widespread global financial crisis (GFC) of a magnitude never seen since the Great Depression in 1929. One particular phenomenon which can be observed in recent years is that emerging market economies (EMEs), which seemed most vulnerable during the last waves of financial crises in the 1990s, fared much better than advanced economies during the GFC.

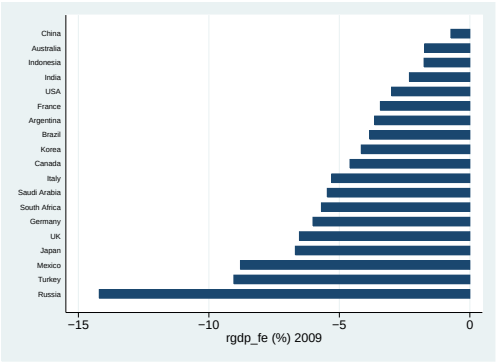
As a matter of fact, figure 3.1 presents two crisis impact indicators [58] in terms of real GDP losses in the G20 countries (excluding the European Uinon); one can see that many EMEs, such as China, Indonesia, India and Argentina, suffered less output losses than developed industrial economies. Moreover, figure 3.2 shows that some EMEs, such as Argentina, Indonesia and Thailand which had experienced large currency depreciation in previous crisis periods demonstrated

58. Both indicators are calculated by Bussière et al. (2014). The detrended real GDP growth measures the difference between the actual annual real GDP growth rate in 2009 and a six-year historical mean before the crisis. The forecast errors capture the difference between the actual real GDP growth in 2009 and the IMF World Economic Outlook (WEO) forecast in the first quarter of 2008 (before the Lehman collapse in September of the same year).

a remarkable exchange rate stability during the GFC [59].




(a) Detrended real GDP growth




(b) Forecast errors

Figure 3.1: Crisis impact indicators

Since 2009, an increasing number of papers started to look at the strengthened resilience of EMEs during the GFC and the underlying explanations [60]. Two noticeable changes in EMEs have been particularly highlighted. First, they have accumulated massive foreign reserve assets between the early 2000s and the onset of the GFC. By examining the conventional metrics [61] of foreign reserve adequacy(see table 3.1), one can easily see that many EMEs have doubled or even

59. In the case of Korea, although very volatile, the exchange rate depreciated less in the GFC than in the Asian financial crisis.

60. For a detailed review, please refer to Eichengreen (2010), Didier et al. (2012), Gourinchas and Obstfeld (2012), Ceballos et al. (2013), Catao and Milesi-Ferretti (2013), Obstfeld (2013) and Bussière et al. (2014).

61. There are four commonly used reserve adequacy metrics: reserves to GDP ratio, reserves to imports ratio, reserves to M2 ratio [see Obstfeld et al. (2010)] and reserves to short-term debt ratio (Greenspan-Guidotti's rule).

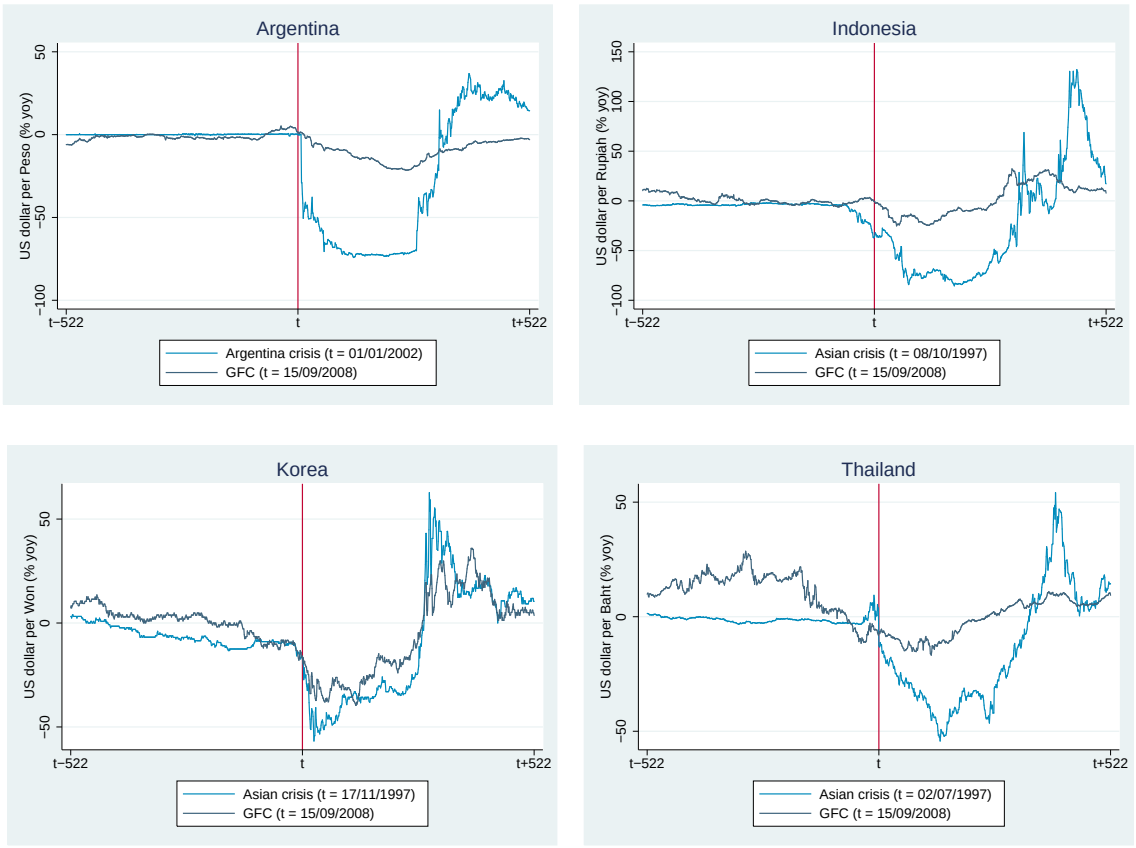



Figure 3.2: Nominal exchange rate depreciation in times of crises: Using daily data, the series are expressed in year-on-year growth rate (percentage point). A negative value indicates depreciation. Time $t$ indicates the date of crisis occurrence which is chosen according to Obstfeld (2013) and other relevant literature on emerging market crises. Data source: DataStream, GTIS - FTID/TR

Table 3.1: Reserve adequacy ratios

| Country | $\frac{Reserves}{GDP}$, % | | $\frac{Reserves}{imports}$, months | | $\frac{Reserves}{m2}$, % | | $\frac{Reserves}{st.debt}$, % | |
|---|---|---|---|---|---|---|---|---|
| | 2000 | 2007 | 2000 | 2007 | 2000 | 2007 | 2000 | 2007 |
| Argentina | 8.84 | 17.02 | 9.11 | 10.04 | 27.77 | 55.92 | 64.97 | 406.38 |
| Brazil | 5.03 | 13.13 | 5.37 | 13.65 | 11.38 | 19.25 | 96.66 | 343.58 |
| China | 14.04 | 45.24 | 8.06 | 17.75 | 10.24 | 27.74 | 872.04 | 1270.63 |
| India | 8.21 | 24.25 | 6.22 | 11.47 | 15.14 | 29.73 | 423.01 | 344.19 |
| Indonesia | 17.22 | 12.72 | 6.11 | 6.02 | 36.51 | 31.38 | 141.84 | 192.61 |
| Korea | 18.02 | 24.98 | 5.98 | 7.19 | 29.43 | 41.31 | 293.39 | 206.73 |
| Mexico | 5.65 | 8.49 | 2.22 | 3.42 | 22.66 | 31.66 | 159.17 | 344.36 |
| Russia | 9.34 | 36.07 | 4.77 | 19.89 | 43.52 | 80.68 | 229.17 | 507.16 |
| Saudi Arabia | 10.38 | 79.3 | 4.44 | 25.23 | 23.32 | 144.08 | 191.36 | 1072.94 |
| South Africa | 4.57 | 10.35 | 2.21 | 3.62 | 9.23 | 12.07 | 54.81 | 195.82 |
| Thailand | 26.09 | 34.49 | 5.36 | 6.28 | 24.56 | 31.68 | 310.90 | 1012.25 |
| Turkey | 8.44 | 11.31 | 4.42 | 4.95 | 26.33 | 23.22 | 85.34 | 132.91 |

tripled (e.g. Argentina and Thailand's reserves to short-term debt ratio) their reserve adequacy ratios from 2000 to 2007. At the same time, EMEs seem to have slowly '[graduated] from fiscal procyclicality' [Frankel et al. (2013)] and have proactively used fiscal policy to stabilize their domestic economy during the crisis period. According to Obstfeld (2013) it seems like these fast-growing economies used the tranquil time after the emerging market crises at the end of the 1990s to reform their policy framework so that they have become more resilient to external shocks of the 21st century.

Based on these recent empirical observations, my work provides a simple theoretical framework to understand the channels through which EMEs better protected themselves against the GFC. The starting point of the story that I tell is in the canonical Krugman (1999) model which identifies the balance sheet effect via investors' expectation on a country's exchange rate as the main source of fragility in EMEs, albeit their relatively sound macroeconomic fundamentals. I am in fact interested to show how holding international reserves can eliminate the bad equilibrium associated with a negative perception on a country's exchange rate. This is a relevant question in the context of the GFC, as a gloomy world economic outlook may trigger investors to downward adjust their expectation on a country's exchange rate especially when this country has a large export sector which can be affected by the 'global trade collapse' [Baldwin (2009)]. A negative perspective on a country's currency would then increase entrepreneurs' financial burden of foreign debt repayment, lower their net worth and even make them temporary insolvent. I argue in this paper that the government can use foreign reserves to

restore lenders' confidence on the country's currency. There are however several ways regarding how reserves work to eliminate the unfavorable equilibrium. One the one hand, the government can use its previously accumulated foreign reserves as a targeted lending to the private sector; namely the government writes off the private sector's foreign-currency liabilities or provides extra foreign-currency liquidities when any other external funding is cut off. This is equivalent to give lenders' a government guarantee on the loans they grant private entrepreneurs or to let the government borrow abroad for the sake of the private sector. On the other hand, the country's authorities can also choose to stabilize domestic absorption via an increase in government spending. This expansionary fiscal policy can be financed by foreign reserves (expenditure switching policy) for example.

Comparing the targeted lending with fiscal spending, it is shown in this paper that although both policies eliminate the bad equilibrium (i.e. a very depreciated exchange rate and a zero domestic investment) they stabilize the economy through two different mechanisms. In the case of targeted lending, foreign reserves can be regarded as a state-contingent insurance. Its value expressed in domestic terms increases with domestic depreciation while the latter lowers firms' net worth. Therefore, a targeted lending mainly affects lenders' expectation on domestic entrepreneurs' wealth which is used as collateral for borrowing. The bad equilibrium can be removed even without an actual depletion of reserves as long as the stock of reserves in the economy is sufficient with respect to entrepreneurs' foreign debt. However, a fiscal spending affects entrepreneurs' wealth via a virtual change in the domestic exchange rate. This is achieved by an increase in demand for domestic goods on the good market. The need for reserves depends on the magnitude of the domestic depreciation. Therefore, it is not surprising to see that the minimum amount of reserves needed for a targeted lending policy is lower than for fiscal spending. In both cases, the stock of reserves matters.

This paper is closely related to three strands of literature: foreign reserve accumulation, 'third-generation' crisis models and currency mismatch, as well as the countercyclical fiscal policies in EMEs during the GFC.

As for the motives of foreign reserve accumulation, my work fits well in the

works on the precautionary motive of reserve holding [62]. In the literature, studies on the precautionary role of reserves have been mainly focusing on how holding reserves can smooth domestic output or/and consumption when the economy is hit by 'sudden stops' [Jeanne and Rancière (2011)] [63] or when the government faces increasing costs of external financing or default risks [Bianchi et al. (2012)]. In contrast, I rather study how reserves are useful in the context of currency mismatch and of the resultant balance sheet effect. In fact, reserves can not only be used to provide foreign-currency liquidity in case of 'sudden stops' [Calvo (1998)], they can also alter investors' expectations on the net worth of a country's private sector and on the country's domestic exchange rate, thus insulating the domestic economy from balance sheet effects. This is the focal point of my current work. After all, the last wave of emerging market crises, especially in Asia, is largely explained by balance sheet effects and curiously, this aspect of the insurance role of reserves has not been thoroughly analyzed. My current work can also be regarded as a theoretical underpinning to a few recent empirical papers [64] which point out that the reserves to (short-term) external debt ratio [65] is the most relevant metric to predict countries' economic performance during the GFC. Moreover, I argue that depending on the policy tool used, foreign reserves need to be or not to be virtually depleted. This is related to the empirical finding of Bussière et al. (2014) who document that reserves are rather 'nuclear power' than real 'gunpowder'. Finally, my work does not only focus on the motives of reserve accumulation, it also analyzes and compares different ways of 'using' reserves. This is a new angle of studying foreign reserves.

My current work is also closely related to the literature on the 'third-generation' crisis. In the aftermath of the Asian financial crisis, Krugman (1999)

62. For a detailed review, see Aizenman and Lee (2007), Alfaro and Kanczuk (2009), Aizenman and Hutchison (2010), Obstfeld et al. (2010), Jeanne and Rancière (2011), Bianchi et al. (2012), Benigno and Fornaro (2012), Calvo et al. (2013) and Bussière et al. (2014).

63. Based on a calibration using a sample of sudden stops in 34 middle-income countries over 1975-2003, Jeanne and Rancière (2011) show that the negative impact of the financial account reversal on domestic absorption can be offset by a depletion of reserves; a 10% fall in capital inflows leads to less than 3% of GDP collapse if there is a buffer stock of reserves.

64. See Llaudes et al. (2010), Catao and Milesi-Ferretti (2013) and Bussière et al. (2014)

65. In the case of emerging market economies, their short-term debts are mostly denominated in foreign currency due to the 'Original sin' [Eichengreen et al. (2007)]

demonstrates that multiple equilibria exist when the private sector in a country faces credit constraint (where the net worth serves as collateral) and is exposed to large foreign-currency debt. While Krugman (1999) aims at proving the existence of multiple equilibria, I propose concrete policy choices to eliminate the bad one. Moreover, I add a government sector into Krugman (1999)'s framework. By doing so, lenders' expectation concerns not only entrepreneurs' wealth but also the strength and the willingness of the government to stabilize domestic economy whenever it is necessary. My paper is also inspired by Aghion et al. (2000) and Aghion et al. (2004) who provide a micro-founded version of Krugman's model. While these two papers focus on how a monetary policy affects the multiple equilibria, I study fiscal policies and targeted lending in foreign currency.

The currency mismatch is a key assumption for the balance sheet effect to work. In the scope of this paper, as I aim at illustrating how different public policies may be used to stabilize the domestic economy rather than at explaining why entrepreneurs want to hold foreign-currency liabilities *ex ante*, I take currency mismatch as given. There are nevertheless various well-founded motivations in the literature explaining the demand for foreign-currency liabilities. Burnside et al. (1999) and Schneider and Tornell (2004) argue that foreign-currency borrowing results from a risk-overtaking behavior of domestic firms when they know that the government will bail out domestic banks in case of default. Jeanne (2000) and Jeanne (2003) point to the signaling and commitment effect of borrowing in foreign currency. Namely, by allowing the private sector to hold foreign debt which is subject to exchange rate fluctuations, the government sends to the market a signal about its commitment not to inflate the economy or depreciate the currency. The need for foreign funding can also be explained by the fact that the domestic financial market is underdeveloped; there is no sufficient domestic savings to be channeled to firms. This is the assumption pointed out by Aghion et al. (2000) that I follow in my analysis.

Regarding how to reduce the impact of the currency mismatch, Jeanne and Zettelmeyer (2002) compare the pros and cons of the monetary policy and of the choice of exchange rate. They conclude that the monetary policy is contradictory in dealing with balance sheet effects. With perfect capital mobility, the country where the private sector is hit by negative expectations on the exchange

rate should increase the interest rate to prevent depreciation. However, a rise in interest rates is detrimental to domestic investment. I explore in this paper a policy choice that has been mentioned but not analyzed in Jeanne and Zettelmeyer (2002): how fiscal policies can play a role when the monetary policy is not effective in dealing with the multiple equilibria. Two different fiscal policy tools - targeted lending or fiscal spending - are analyzed in the subsequent sections. Jeanne and Wyplosz (2003) take a different angle to analyze how an international lender-of-last-resort can be useful in dealing with the issue of currency mismatch. The GFC has unfortunately demonstrated that an international coordination in the matter of crisis management is far from developed nowadays. Many countries might prefer to constitute a buffer stock for self-insurance instead of resort to the assistance of international financial institutions.

Finally, my paper is related to some recent empirical works on how EMEs used countercyclical fiscal policies to tackle the GFC. As Crowe et al. (2009), Eichengreen (2010) and Didier et al. (2012) point out, in the past, fiscal policy in emerging market countries used to be procyclical because EME business cycles tend to be driven by capital flows [see Kaminsky et al. (2005)]. This strand of literature has emphasized the role of countercyclical fiscal policies to smooth domestic production. I rather study to what extend these policies can help alleviate the balance sheet effect in the private sector. Prasad (2011), Didier et al. (2012) and Obstfeld (2013) argue that many EMEs have reduced the external debt denominated in foreign currency and the external financing is oriented towards equity (which have advantages of being denominated in local currency and state-contingent) and foreign direct investment. However, as Llaudes et al. (2010) points out 'large increases in reserves played a more important role than any change in the currency denomination of external debt' in reducing a country's exposure to external liabilities. The private sector might still have net foreign liabilities in its balance sheet and is thus vulnerable to valuation losses in case of domestic currency depreciation. Indeed, as Eichengreen (2010) states, '[w]hile on-balance sheet foreign currency mismatches had been reduced, corporations [...] had increased their off-balance sheet foreign currency exposure through derivative positions.'

This paper is organized as follows. Section 3.2 describes the model setting. Section 3.3 analyzes and derives conditions for the existence of multiple equilibria in absence of government intervention. Section 3.4 studies and compares two policy tools used to stabilize the domestic economy. Section 3.5 concludes.

## 3.2 The model

The aim of this paper is to provide a theoretical framework showing the ways through which foreign reserves can be useful in stabilizing the domestic economy. In the paper, I especially focus on the risks associated with the currency mismatch and the resultant balance sheet effect in the private sector. For this purpose, the analysis in this paper is based on a stylized model with multiple equilibria similar to Krugman (1999). Although very simple, it is enough to demonstrate the different ways the government can stabilize the domestic economy using foreign reserves. This is a real-economy model with three types of agents: 'hand-to-mouth' workers, entrepreneurs[66] and a government. Capital is supposed to be perfectly mobile across borders and all prices are flexible.

### 3.2.1 Workers

As in Krugman (1999), the role played by workers is completely passive. They provide the labor force to entrepreneurs and get paid at the marginal product of labor. They do not have access to financial market so that they consume all the labor income every period (so called 'hand-to-mouth' labor). The choice of passive labor force is motivated by the fact that the main mechanism of the balance sheet effect goes through entrepreneurs' investment decision to which the attention of this paper is paid. It is further assumed that the labor supply is inelastic and the total mass of labor is equal to one.

The workers consume both domestic goods, $C_t^H$, and foreign goods, $C_t^F$. The domestic goods are regarded as the numéraire with an unitary price. Therefore,

66. In this paper I focus on the balance sheet of entrepreneurs. But the analysis can also be applied to banks which are exposed to foreign liabilities, like in Jeanne and Zettelmeyer (2002). There are no fundamental differences between firms and banks with regard to the balance sheet effect.

the price of foreign goods in terms of domestic goods, $p_t$, denotes the real exchange rate in the domestic economy. An increase in $p_t$ means a depreciation of the price of the domestic goods (depreciation of the local currency, loosely speaking.). For simplicity, I assume that the elasticity of substitution between domestic goods and foreign goods is one. The workers maximize their utility subject to the budget constraint as described below:

$$\begin{aligned} \underset{C_t^H, C_t^F}{\text{Max}} \quad & U(C_t^H, C_t^F) = (C_t^H)^{1-\mu}(C_t^F)^{\mu} \\ \text{such that} \quad & C_t^H + p_t C_t^F = C_t \end{aligned}$$

$C_t$ refers to the total consumption by domestic workers, expressed in terms of domestic goods. The workers' maximization program yields the following results:

$$\begin{aligned} C_t^H &= (1-\mu)C_t \\ C_t^F &= \frac{\mu C_t}{p_t} \end{aligned}$$

The consumption of domestic goods is thus a constant share $(1-\mu)$ of the total consumption $C$.

### 3.2.2 Entrepreneurs

The economy is populated by identical entrepreneurs who face credit constraints which prevent them from borrowing and investing more than a multiple of their current real wealth ($W_t$). Entrepreneurs' wealth is therefore the fundamental variable that determines investment and output.

In fact, entrepreneurs use labor ($N_t$) and capital ($K_t$) to produce an output. The labor supply being perfectly inelastic with $N_t = 1$. The capital is chosen a period earlier through investment and fully depreciates every period, namely $K_t = I_{t-1}$. As one can see later, entrepreneurs' capacity to invest is precisely constrained, depending on their real wealth.

The production function is a standard neoclassical production function. Namely, the production is increasing in both inputs with decreasing marginal returns and is homogeneous of degree one. $Y_t = F(K_t, N_t) = K_t^{\alpha} N_t^{1-\alpha}$.

For private investment, it is assumed that entrepreneurs need both foreign and domestic goods. They spend a constant share $\mu$ of total investment on imported goods, and thus a constant share $1-\mu$ in domestic goods. Namely $I_t^H = (1-\mu)I_t$ and $I_t^F = \frac{\mu I_t}{p_t}$.

In each period, the only important decision that entrepreneurs need to make is how much to invest in capital which is financed by borrowing from both domestic lenders and foreign lenders. The timing of events can be summarized as follows: investors (those who lend to entrepreneurs) enter the period $t$ with an expectation on the exchange rate which affects the expected value of entrepreneurs' wealth and thus the collateral value for borrowing. An expectation on the investment is thus formed and it will feed back the expectation on the exchange rate through the domestic good market clearing. Everything is thus simultaneously determined. In rational expectation equilibrium, the expected values coincide with the actual values.

Two important assumptions characterize entrepreneurs' investment behavior: entrepreneurs face credit constraint on the one hand and they have foreign-good denominated liabilities on the other.

First, the assumption on the credit constraint stipulates that the maximum amount of credit that entrepreneurs may obtain in period $t$ depends on their real net worth. Namely, from lenders' viewpoint, they would only lend up to a share $\psi$ of entrepreneurs' net worth, namely $L_t^e \leq \psi W_t^e$. $L_t^e$ denotes expected credit that lenders are willing to grant entrepreneurs. $W_t^e$ refers to entrepreneurs' expected wealth. $\psi$ is a parameter of the tightness of the credit market. The higher $\psi$ [67], the higher leverage entrepreneurs have. Entrepreneurs' investment at time $t$ can be written as:

67. The value of $\psi$ depends on the stage of development in a country. $\psi = 0$ when no borrowing (especially external borrowing) is possible. This can be the case in less developed countries where the financial market is far from developed. In this extreme case, the balance sheet effect is not at work as there is no foreign borrowing at all. In an advanced economy, $\psi$ is expected to be high, the private sector mainly replies on borrowing to finance the investment. As Aghion et al. (2000) argue, the financial market is mature in advanced economies, there is sufficient domestic credit available such that the balance sheet effect may or may not apply. The emerging market economies (middle-income countries) that I focus on in this paper should have a $\psi$ in between the two former cases and have a strong demand for foreign credit.

$$I_t^e = W_t^e + L_t^e \leq (1+\psi)W_t^e \tag{3.1}$$

The functional form of the credit constraint is well-founded in the literature on financial accelerator [see Bernanke et al. (1999)], based on the idea of contract enforcement. The investment constraint (3.1) can be binding or unbinding depending on the value of the collateral. When this constraint is binding, $I_t^e = (1+\psi)W_t^e$. When the constraint is unbinding, the amount of investment is determined by the equalization between marginal product of capital and marginal cost. As the economy is fully open, the marginal cost is ultimately equal to the world *gross* interest rate $R^*$. Namely, $F_k(K_{t+1}, N_{t+1}) = R^*$, where $F_k(\cdot)$ denotes the marginal product of capital. This gives $I_t = \bar{I} = \left(\frac{\alpha}{R^*}\right)^{\frac{1}{1-\alpha}}$ when the credit constraint is not binding.

The second assumption that entrepreneurs have foreign-good denominated liabilities is crucial to trigger balance sheet effects that this paper wants to study. As entrepreneurs have foreign-good denominated liabilities, their real wealth $W_t$ is subject to the valuation effect of the exchange rate. As in Krugman (1999), I take the currency mismatch as given in order to concentrate on the link between the domestic exchange rate and entrepreneurs' wealth and investment. There are several ways to endogenize the currency mismatch as I summarized in the literature review. A nature extension of my current work is to endogenously determine entrepreneurs' portfolio choice.

Entrepreneurs' wealth function can thus be written as follows:

$$W_t^e = \alpha Y_t - D_t - p_t^e D_t^* \tag{3.2}$$

Notice that $Y_t$ is predetermined in period $t$ as both inputs of production are chosen a period earlier. $\alpha Y_t$ is the output accruing to entrepreneurs (equivalent to entrepreneurs' earnings after paying the labor force). $D_t$ and $D_t^*$ respectively denote the domestic-good denominated and foreign-good denominated net debts.

They are both exogenously given. Therefore, the expectation on entrepreneurs' wealth in period $t$ only depends on the expectation on the exchange rate $p_t^e$. Clearly, if lenders *thought* the domestic exchange rate would depreciate (namely a rise in $p_t^e$), they would *expect* an increase in entrepreneurs' burden of foreign debt repayment, thus a decrease in entrepreneurs' net worth. As a result, lenders would cut down their investment, driving down the next-period production (period $t+1$) through equation (3.1).

Combining equations (3.1) and (3.2), the demand for investment of entrepreneurs can be derived below; it is a truncated function of the expected exchange rate.

$$I_t = \begin{cases} 0 & p_t > \bar{p}_t \\ (1+\psi)(\alpha Y_t - D_t - p_t^e D_t^*) & \underline{p_t} < p_t^e < \bar{p}_t \\ \bar{I} = \left(\frac{\alpha}{R^*}\right)^{\frac{1}{1-\alpha}} & p_t < \underline{p_t} \end{cases} \tag{3.3}$$

$\bar{p}_t = \frac{\alpha Y_t - D_t}{D_t^*}$ denotes the threshold value of exchange rate beyond which entrepreneurs' wealth is reduced to zero or beneath. On the contrary, $\underline{p_t} = \frac{\alpha Y_t - D_t - \frac{\bar{I}}{1+\psi}}{D_t^*}$ denotes the threshold value of exchange rate below which entrepreneurs' wealth is high enough that the credit constraint (3.1) does not bind. In between these two threshold values, the investment is a negative function of the expected exchange rate.

In sum, as the red cycle in figure 3.3 illustrates, the mechanism of the model goes through lenders' expectation on the domestic exchange rate which affects entrepreneurs' expected wealth via foreign debt repayment. The expected investment in the economy will ultimately determine the actual level of the domestic exchange rate on the good market as I will detail in the next subsection. Therefore, the only endogenous variables in this model that are important in period $t$ are domestic investment $I_t$, domestic exchange rate $p_t$ and entrepreneurs' wealth $W_t$. As a matter of timing, all the decisions are made within the period $t$. The impact of the period $t$ decisions on the future economy only goes through domestic investment which will be entirely used for the next-period production. From

Section 3.3 and on, I will drop the time subscripts as we only need to focus on period $t$ variables.

### 3.2.3 Government and the good market clearing

I introduce a government in the model economy. Entering period $t$, the government has some resources in hands in the form of foreign reserve assets $B^*$ that have been accumulated beforehand. The following sections of the paper will focus on how the government should use its resources to stabilize the domestic economy whenever it is necessary. For purposes of analysis, the costs of accumulating reserves *ex ante* are not incorporated into the analysis.

To close the model, I present the clearing condition on the domestic good market. It is also assumed that the domestic economy exports part of domestic output abroad. I denote $X_t^*$ units of domestic goods exported abroad and expressed in terms of foreign goods. I assume that the foreign elasticity of substitution is also one [68].

The aggregate demand for the domestic goods can be written below:

$$\begin{aligned} Y_t &= (1-\mu)C_t + (1-\mu)I_t + p_t X_t^* \\ &= (1-\mu)(1-\alpha)Y_t + (1-\mu)I_t + p_t X_t^* \end{aligned} \tag{3.4}$$

This is actually the equation which determines the real exchange rate given a level of investment. Bear in mind that the production is predetermined and the foreign demand is exogenously given. Therefore, equation (3.4) gives an unambiguous negative relationship between exchange rate and investment, as described below:

$$p_t = \frac{Y_t[\mu + (1-\mu)\alpha] - (1-\mu)I_t}{X_t^*} \tag{3.5}$$

68. Allowing the elasticity of substitution to be bigger than one does not change the qualitative results of the model. It is easy to extend the current model using a CES trade framework with monopolistic competition.

An increase in domestic total investment appreciates the value of domestic goods (an appreciation of the domestic currency in a nominal model). This is because an increase in domestic investment raises the demand for domestic goods. As the supply of domestic goods is predetermined, an increase in the demand leads to a rise in the price of domestic goods.

The model economy is summarized in figure 3.3. I will show that there are multiple equilibria in a decentralized economy in Section 3.3 and how two government policies (targeted lending or fiscal spending) can help eliminate the bad equilibrium in Section 3.4.

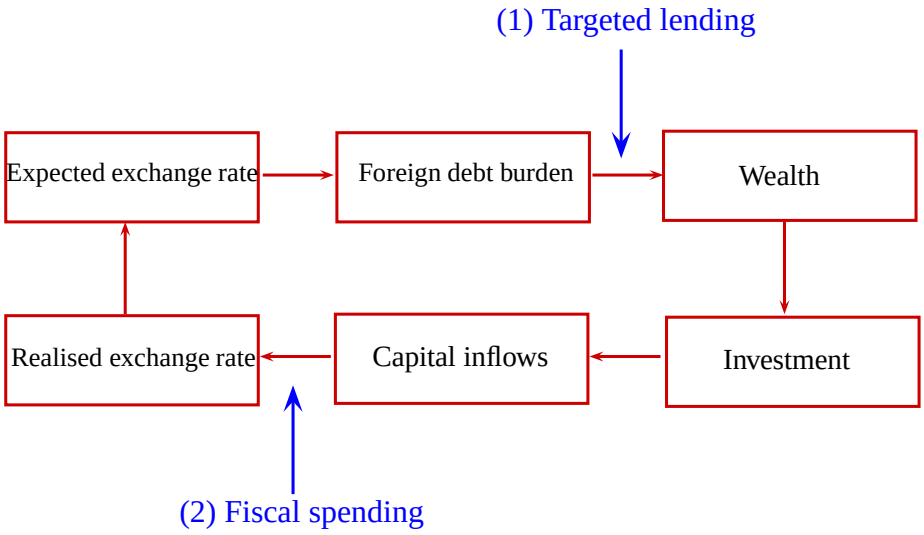



Figure 3.3: Model scheme

## 3.3 Multiple equilibria in a decentralized economy

### 3.3.1 Market equilibrium

This stylized model can be solved using a system of two equations (3.3) and (3.5) in an orthogonal plan of $p(p^e)$ and $I(I^e)$.

Equation (3.3) links the *expected* exchange rate[69] and *expected* investment

69. Here I can talk about the *expected* exchange rate, as the credit constraint is forward-

from lenders' viewpoint. This gives a truncated curve of the demand for investment (henceforth called II curve), as figure 3.4 shows:

- When lenders expect large depreciation, meaning that $p^e > \bar{p}$, the burden of foreign-good denominated debt repayment is so heavy that entrepreneurs' wealth is driven to beneath zero. In this case, no pledgeable income is available for lenders. Therefore, rational investors would never lend to the economy. Thus, $I = 0$. This scenario is represented by the red vertical segment on the y-axis
- When foreign investors expect large appreciation which increases entrepreneurs' wealth so largely that the credit constraint (3.1) never binds. Domestic investment reaches the unbinding level: $\bar{I} = \left(\frac{\alpha}{R^*}\right)^{\frac{1}{1-\alpha}}$. This situation is represented by the red vertical segment with $I = \bar{I}$ for all values of $p^e < \underline{p}$
- When $\underline{p} < p^e < \bar{p}$, the investment is determined by the binding credit constraint (3.1)

Recall that $\bar{p} = \frac{\alpha Y - D}{D^*}$ and $\underline{p} = \frac{\alpha Y - D - \frac{\bar{I}}{1+\psi}}{D^*}$.

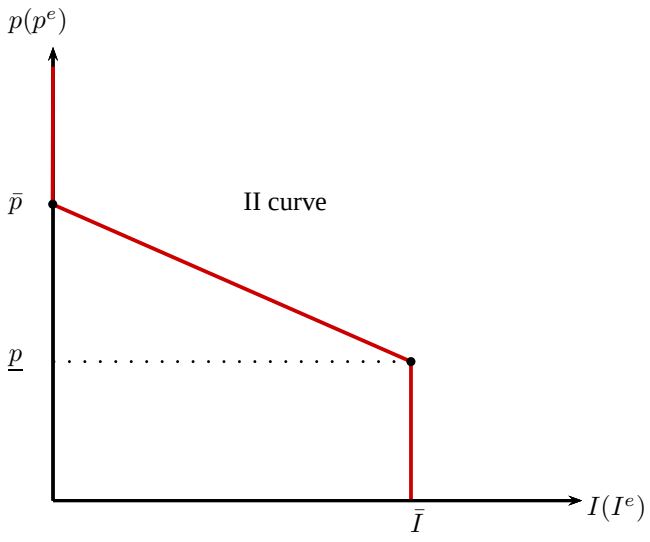



Figure 3.4: Demand for investment

looking, lenders make lending decisions before the actual realization of the exchange rate which is determined by equation (3.5).

Equation (3.5) gives an unambiguous negative relationship between $p$ and $I$; it determines the level of the domestic exchange rate given a level of investment. A downward sloping line (henceforth called the DD curve) which represents equation (3.5), along with x- and y-axes, form the feasible set of the economy (see figure 3.5).

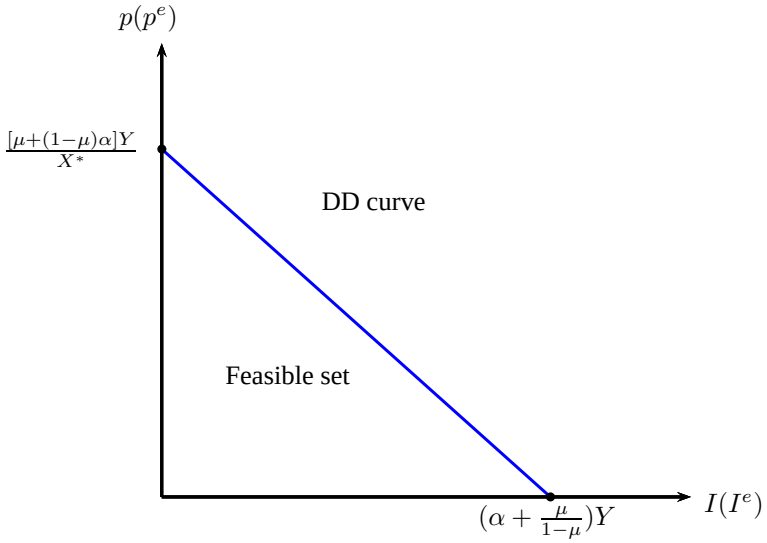



Figure 3.5: Aggregate resources

### 3.3.2 Conditions for the existence of multiple equilibria

Combining the II and DD curves gives the equilibrium points in the model economy as figure 3.6 illustrates. There can be two equilibria - a good equilibrium and a bad equilibrium (the middle intersection point is unstable, proof in Appendix 3.A), should the following conditions be fulfilled:

1. $\frac{[\mu+(1-\mu)\alpha]Y}{X^*} \geq \bar{p} = \frac{\alpha Y - D}{D^*}$
2. $|-\frac{1-\mu}{X^*}| \geq |-\frac{1}{(1+\psi)D^*}|$

The condition 1 is to insure that a bad equilibrium exists. This yields $\frac{D^*}{X^*} \geq \frac{\alpha-d}{\mu+(1-\mu)\alpha}$. $d = \frac{D}{Y}$ denotes the per GDP ratio of domestic-good denominated liabilities, which is exogenously given. As a result, to remove the bad equilibrium, it is sufficient to violate this condition.

The condition 2 is to insure that there is a good equilibrium. It requires the DD curve to have a steeper slope than the II curve when the credit constraint is binding [70]. This leads to $\frac{D^*}{X^*} \geq \frac{1}{(1-\mu)(1+\psi)}$.

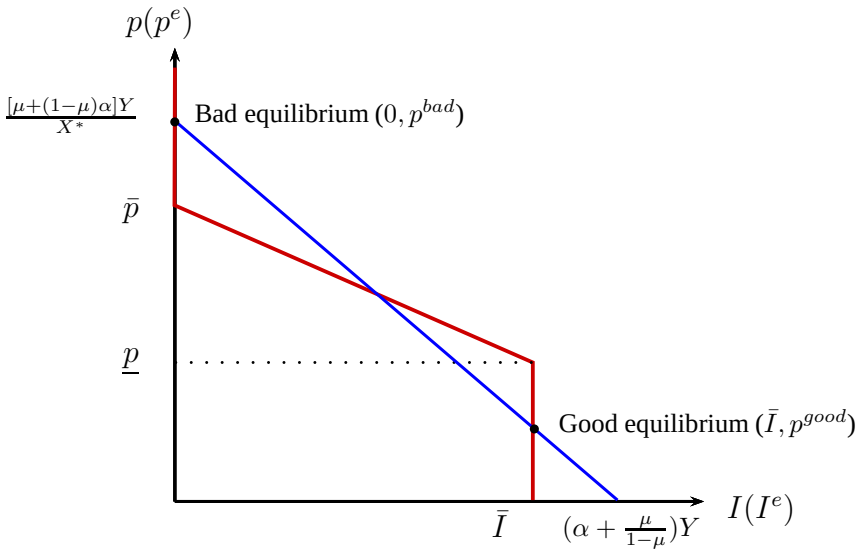



Figure 3.6: Multiple equilibria

As long as $\frac{D^*}{X^*} \geq max\left(\frac{1}{(1-\mu)(1+\psi)}, \frac{\alpha-d}{\mu+(1-\mu)\alpha}\right)$, there are multiple equilibria in the economy. This is equivalent to say that the model economy needs to be sufficiently exposed to foreign-good denominated liabilities (relative to foreign income from exports) such that multiple equilibria exist.

In sum, the existence of multiple equilibria mainly depends on four key parameters: the leverage ratio ($\psi$), the propensity to imports ($\mu$), the level of foreign-good denominated debt ($D^*$) and the level of exports ($X^*$). The story on the expectation is simple, similar to the one told by Krugman (1999). If investors expect depreciation of the domestic exchange rate, they anticipate a decrease in entrepreneurs' wealth due to a more costly repayment of foreign-good denominated debt; the resultant lower collateral value decreases lenders' incen-

70. Strictly speaking, there might be another possible equilibrium: when the DD curve is very steep, it might intersect the x-axis before reaching the vertical segment $I = \bar{I}$ (namely $p < 0$). This gives a corner solution which is the intersection point between the DD curve and the x-axis. This is however not an interesting solution (as the equilibrium exchange rate is equal to zero). For purposes of this paper, I concentrate on the interior solutions of the model.

tives to invest in the economy. A reduction in capital inflows is thus expected, driving down the price of domestic goods and further confirms investors' expectation. This unambiguously leads to the bad equilibrium $(0, p^{bad})$. On the contrary, an optimistic expectation on the price of domestic goods will lead to the good equilibrium.

I will show in the next section to what extent appropriate public policies can eliminate the bad equilibrium and stabilize the domestic economy, especially in the context of unfavorable international economic environment.

## 3.4 Public policies

To understand how the government can use foreign reserves to stabilize domestic economy, suppose we are in the context of the GFC. Lenders form a negative expectation on exporting countries' exchange rate due to a gloomy perspective on foreign demand [e.g. a decrease in foreign demand $X^*$ due to the 'global trade collapse Baldwin (2009)']. Without any government intervention, a domestic depreciation is foreseeable through the resource constraint (3.4).

The objective of the government is to eliminate the bad equilibrium associated with the scenario of depreciation and a low level of investment. This requires sustaining entrepreneurs' wealth which is the key variable linking exchange rate perspective and domestic investment. Several ways of public intervention can be considered: a targeted lending denominated in foreign goods to entrepreneurs or an increase in public spending which restores the value of the domestic exchange rate. I will show these different policy tools in the following sections.

### 3.4.1 Targeted lending to the private sector

As the government has previously accumulated foreign reserves, one policy choice is to lend directly foreign goods to the private sector so as to insulate entrepreneurs' net worth from potential exchange rate depreciation. As a consequence, the impact of the exchange rate on entrepreneurs' balance sheets would be largely minimized. Under this vision, foreign reserves can be regarded as a state-contingent insurance, as its value increases with potential depreciation of

the domestic exchange rate. One the one hand, depreciation increases the foreign debt repayment and thus lowers entrepreneurs' net wealth. On the other hand, it increases the value of reserves held by the government which are used for the targeted lending policy, all expressed in terms of domestic goods. This policy is similar to the idea of setting an 'international banking fund' which provides liquid foreign-good assets to 'truly solvent banks' [Jeanne and Wyplosz (2003)]. The difference here is that the targeted lending is provided by a national government [71]. As long as foreign reserves cover the foreign liabilities in the domestic economy, there will be a full insurance. Concretely, the promise of the government to strengthen entrepreneurs' wealth by targeted lending changes the wealth function (3.2). It alters the lenders' perspectives on entrepreneurs' wealth, thus on the value of collateral for their lending. The new wealth function is written:

$$W^e = \alpha Y - D - p^e D^* + p^e B^* \tag{3.6}$$

The aggregate resource function (3.4) which determines the actual level of exchange rate does not change, as nothing changes the demand for domestic goods. As a result, the DD curve remains the same while the II curve shifts upward (with the unbinding level of demand for investment $\bar{I}$ unchanged which only depends on the international interest rate). Figure 3.7 shows the new equilibrium and compares it with the multiple equilibria in a decentralized economy.

Figure 3.7 clearly shows that when the government lends foreign goods to the private sector, it eliminates the bad equilibrium $(0, p^{bad})$, where $p^{bad} = \frac{Y[\mu+(1-\mu)\alpha]}{X^*}$, as it is derived in Section 3.3. The good equilibrium is the same as in the decentralized market equilibrium. Put it in another way, the government's commitment to lend foreign goods to entrepreneurs whenever it is necessary is equivalent to give lenders a government guarantee on their loans. This immediately eliminate the bad equilibrium. In theory, if the government has enough foreign reserves to cover foreign-good denominated liabilities, it does even not need to actually use

71. Clearly, the 'international banking fund' has never be founded since Jeanne and Wyplosz's paper in 2003. One argument in this model in favor of holding international reserves at the national level is that the stock of reserves gives a positive signal to the market on the economy's financial capacity to conduct appropriate policies in the times of crises. Moreover, national authorities should know better their domestic private institutions and can be more easily to select 'truly solvent' banks or firms to which the lending in foreign goods should be granted.

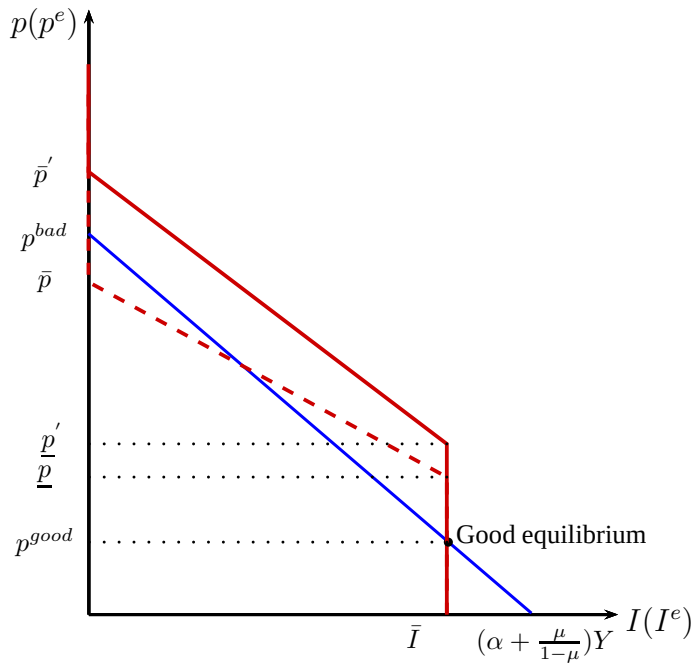



Figure 3.7: Equilibrium with targeted lending

its stock of reserves. As long as the government's commitment is credible (backed by the stock of foreign reserves), the expectation of lenders will be altered towards the good equilibrium through equation (3.6).

In fact, with the government's targeted lending $p^e B^*$, the slope of the II curve becomes steeper. The bad equilibrium is removed as long as $0 < p^{bad} \leq \bar{p}' = \frac{\alpha Y - D}{D^* - B^*}$. This gives:

$$D^* - \frac{\alpha - d}{\mu + (1-\mu)\alpha} X^* \leq B^* < D^* \tag{3.7}$$

The minimum level of reserves needed for targeted lending is equal to $B^{*bail}_{min} = D^* - \frac{\alpha - d}{\mu + (1-\mu)\alpha} X^*$. From the first condition for the existence of multiple equilibria, one can see that $B^{*bail}_{min}$ is larger than zero as long as there are multiple equilibria. Namely, when the foreign-good income cannot cover foreign liabilities, reserves are needed to make sure that entrepreneurs' wealth is above zero.

The amount of reserves needed[72] depends on the private sector's exposure to foreign-good debt ($D^*$). The higher foreign debt, the higher reserves are needed for targeted lending policy. It is negatively correlated with foreign-good income earned through exports. If at time $t$, the flow of exports exceeds that of foreign liabilities, $B^*$ might become negative, namely there is an accumulation of reserves instead of depletion. The amount of reserves for targeted lending policy also depends on the marginal propensity to imports and the share of domestic lending per GDP. The higher $\mu$, the more foreign goods are demanded, thus higher reserves are needed to pay out imported goods.

Notice that the targeted lending policy can be replicated in a situation where the government commits to borrow externally for the sake of the national economy, using its own net worth along with entrepreneurs' net worth as collateral, when private entrepreneurs are excluded from external financial markets (mainly because of their negative net worth for example). The good thing about holding reserves is that there is a valuation effect which increases the government's net worth in case of depreciation. Put it in a formal way, the government enters period $t$ with a net worth equal to $W^G = p^e B^*$, $p^e$ being the expected exchange rate in period $t$. In case of domestic deprecation, $W^G$ increases, allowing the government to borrow for the sake of the private sector whose net worth $W$ is driven to negative due to higher repayment of foreign debt (equation (3.2)). If the government uses its own net worth as collateral to borrow externally, the investment function (3.1) becomes:

$$\begin{aligned} I^e &\leq (1+\psi)(W^e + W^G) \\ &= (1+\psi)(\alpha Y - D - p^e D^* + p^e B^*) \end{aligned}$$

This is exactly the equation (3.6) in the case of a targeted lending policy.

In reality, during the GFC, some emerging economies which were seriously hit by the balance sheet effect during the last wave of emerging economy crises

72. This is a flow variable which refers to the amount of reserves required to conduct a certain public policy. This is different from the stock of reserves which is a stock variable.

experienced rather an exchange rate stability. This is the case in Thailand for example (see figure 3.2). Obstfeld (2013) attributes this exchange rate stability to the ample level of reserves in Thailand compared to its external debt. In the case of Korea, albeit a large absolute level (sixth largest reserve holder), the reserves to short-term debt ratio is less impressive there in comparison with other EMEs (see table 3.1). If reserves are scaled by total external debt of different maturities, they can only cover 70% of the entire exposure of the Korean private sector to foreign-currency debt [Cho (2012)]. According to Cho, the Korean government depleted its foreign reserves to supply foreign currency liquidity required to reduce the accumulated leverage in the private banking sector; '[i]t was not a sheer coincidence that the amount of decrease in foreign reserves during the crisis period from September to December 2008, approximately US$40 billion, was almost the same as that of short-term foreign debts [Cho (2012)].' Based on the implications of the current model, the market may think Korea do not hold enough foreign reserves to rule out the bad equilibrium. As a result one observes in figure 3.2 that the exchange rate of Korean won was still very volatile during the GFC compared to other EMEs' currencies.

### 3.4.2 Fiscal spending

The second policy choice of the government is to increase public spending. Bearing in mind that in the framework of Krugman (1999), a fiscal spending should not be understood in the Keynesian sense, as prices are fully flexible in this stylized model and the supply of domestic goods is predetermined at the beginning of each period. Therefore, an expansionary fiscal policy affects entrepreneurs' wealth as well as their investment through a pure price effect. Namely, a fiscal expansion would raise domestic demand and appreciate the domestic exchange rate given a fixed level of good supply.

Different from the targeted lending policy, a fiscal spending affects the exchange rate through the aggregate resource constraint. Suppose the fiscal spending is financed by previously accumulated foreign reserves, the aggregate resource constraint (3.4) becomes:

$$\begin{aligned} Y &= (1-\mu)(1-\alpha)Y + (1-\mu)I + G + pX^* \\ G &= pB^* \end{aligned} \tag{3.8}$$

It instantaneously affects the exchange rate as a fiscal spending raises the demand for domestic goods, thus appreciates the domestic exchange rate. Through equation (3.8), the exchange rate is determined: $p = \frac{Y[\mu+(1-\mu)\alpha]-(1-\mu)I}{X^*+B^*}$.

The DD curves is rotated downwards around the point $\left((\alpha + \frac{\mu}{1-\mu})Y, 0\right)$. The II curve remains unchanged as in the decentralized economy.

Figure 3.8 shows the new equilibrium and compares it with the multiple equilibria in the decentralized economy. It can be seen that a fiscal spending financed by previously accumulated reserves can also eliminate the bad equilibrium $(0, p^{bad})$, where $p^{bad} = \frac{Y[\mu+(1-\mu)\alpha]}{X^*}$ as before. However, the good equilibrium in this case is not the same as in the decentralized economy or in case of targeted lending. In fact, although the realized investment achieves the same unbinding level $\bar{I}$, the exchange rate is appreciated to $p^{good'}$, with $p^{good'} < p^{good}$. This is because a fiscal spending changes immediately the demand for domestic goods and determines consequently a new level of exchange rate through the new aggregate resource constraint (3.8). Foreign reserves are depleted in this case.

As for the conditions which eliminate the bad equilibrium, it can be observed in figure 3.8 that $p^{'}$ needs to be smaller than $\bar{p}$. Namely, $0 < p^{'} = \frac{Y[\mu+(1-\mu)\alpha]}{X^*+B^*} \leq \bar{p} = \frac{\alpha Y - D}{D^*}$. This gives:

$$D^* \frac{[\mu + (1-\mu)\alpha]}{\alpha - d} - X^* \leq B^{*fisc} \tag{3.9}$$

The minimum level of reserves needed to conduct an expansionary fiscal policy is: $B^{*fisc}_{min} = D^* \frac{[\mu+(1-\mu)\alpha]}{\alpha-d} - X^*$. The condition 1 for the existence of multiple equilibria also guarantees that $B^{*fisc} > 0$.

One may argue that government spending is usually financed by domestic taxes instead of foreign reserves. Suppose now that the fiscal spending is fi-

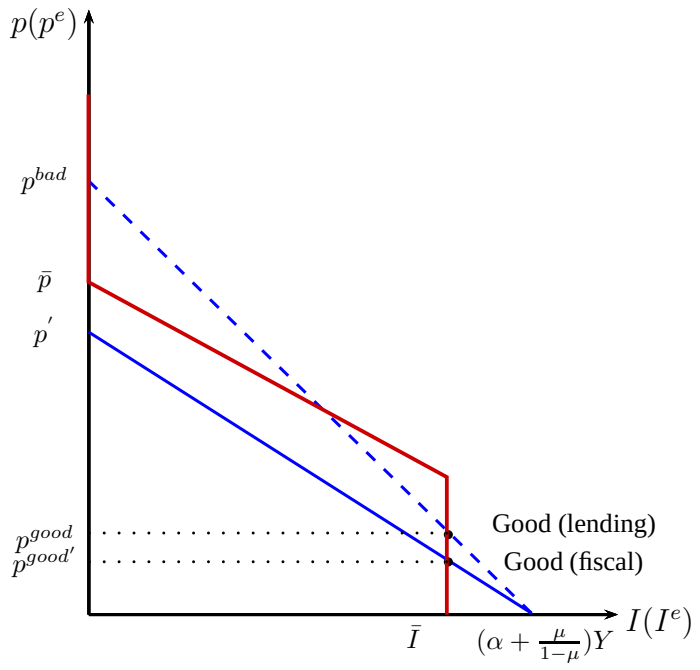



Figure 3.8: Equilibrium with fiscal spending financed by reserves

nanced by previously collected taxes [73]. In this case, the government resources are denominated in domestic goods only. The new aggregate resource constraint becomes:

$$\begin{aligned} Y &= (1-\mu)(1-\alpha)Y + (1-\mu)I + G + pX^* \\ G &= T \end{aligned} \tag{3.10}$$

The exchange rate is determined: $p = \frac{Y[\mu+(1-\mu)\alpha]-T-(1-\mu)I}{X^*}$. This time, the DD curve (black line in figure 3.9) is shifting downwards in parallel to the former DD curve (dashed blue line) in the decentralized economy. The II curve remains unchanged. As one can see from figure 3.9, the bad equilibrium can also be eliminated, but the exchange rate needs to be more largely appreciated in the good equilibrium than in the case where fiscal spending is financed by foreign reserves.

73. To compare what is comparable, I also assume taxes are collected *ex ante* as foreign reserves.

The condition for removing the bad equilibrium requires: $p^{''} = \frac{Y[\mu+(1-\mu)\alpha]-T}{X^*} < \bar{p} = \frac{\alpha Y - D}{D^*}$. This gives a criterion for the minimum taxes that the governments needs to stabilize the domestic economy:

$$T \geq Y[\mu + (1-\mu)\alpha] - \frac{(\alpha Y - D)X^*}{D^*} \tag{3.11}$$

.

Namely, the minimum amount of taxes needed to eliminate the bad equilibrium is $T_{min} = Y[\mu + (1-\mu)\alpha] - \frac{(\alpha Y - D)X^*}{D^*}$.

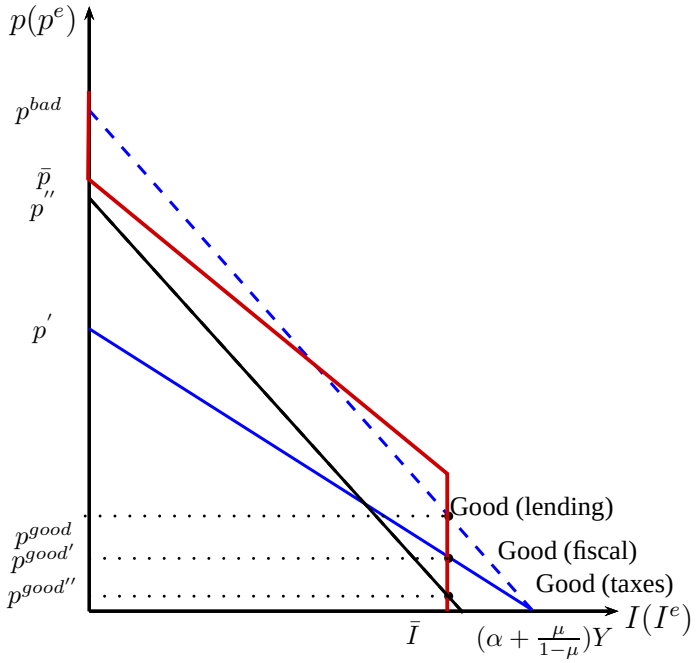



Figure 3.9: Equilibrium with fiscal spending financed by taxes

One counterfactual question which can be naturally asked is: if the public spending financed by taxes achieves the same equilibrium as in the case where fiscal spending is financed by foreign reserves, can the bad equilibrium also be removed? This situation is represented by the black line in figure 3.10. It can be proved that a fiscal spending financed by taxes cannot unambiguously remove the bad equilibrium as the minimum taxes which help the economy to achieve the same good equilibrium as in the case of a fiscal spending financed by foreign re-

serves is smaller than the minimum taxes needed to remove the bad equilibrium [74] and derived in equation (3.11).

The difference between these two ways to finance a fiscal expansion is grounded in the fact that using reserves not only raises the demand for domestic goods but also converts foreign goods into domestic goods - this also exerts an appreciation effect on the domestic exchange rate. Therefore, it is easier to remove the bad equilibrium by using foreign reserves. The underlying reason is that a fiscal spending financed by foreign reserves not only strengthens the domestic exchange rate through an increase in the demand for domestic goods, it also works through a conversion of foreign goods into domestic goods in the first place.

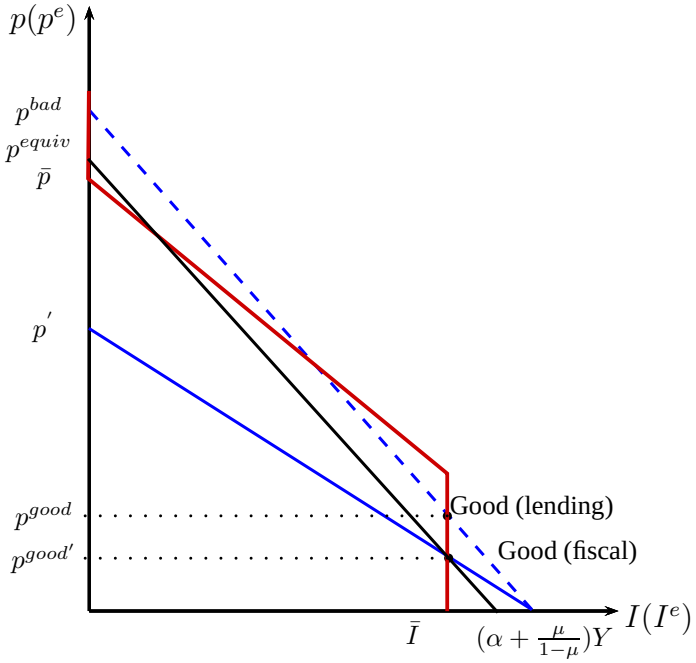



Figure 3.10: Fiscal spending: equivalence

74. It can be shown that the minimum taxes requested to achieve the same good equilibrium as in the case of a fiscal spending financed by foreign reserves are equal to $p^{good'} B^{*fisc}_{min}$ (see figure 3.10). $p^{good'}$ is determined by plugging the unbinding level of investment $\bar{I}$ into equation (3.8). One can then easily demonstrate that $p^{good'} B^{*fisc}_{min} < T_{min}$.

### 3.4.3 Differences between targeted lending and fiscal spending

A targeted lending policy and a public spending policy, although both can remove the bad equilibrium, work through two different mechanisms. They also differ in terms of the amount of reserves needed. I discuss these differences in this section.

First, a targeted lending policy can be at work through lenders' expectation while a fiscal spending virtually shifts the demand for domestic goods and raises the real exchange rate. In fact, the targeted lending policy affects entrepreneurs' wealth function. As one can see in figure 3.7, what changes with the announced targeted lending is to increase the threshold exchange rate for which entrepreneurs' wealth falls beneath zero ($\bar{p}^{'} > \bar{p}$). Similarly, this policy makes it easier for the credit constraint not to bind ($\underline{p}^{'} > \underline{p}$). As a result, lenders will believe that entrepreneurs' wealth is positive and is kept as high as possible; so is the collateral for borrowing. Therefore, lenders will be willing to provide funding to this economy. With the targeted lending, the government only needs to hold sufficient foreign reserves to cover the private sector's foreign liabilities so as to eliminate the bad equilibrium. Foreign reserves will need to be deployed only if a shock on foreign demand $X^*$ materializes.

This theoretical funding is in line with the empirical literature on the role of foreign reserves in the GFC. Bussière et al. (2014) find that the pre-crisis reserves to short term debt ratio is the most significant reserve adequacy ratio when assessing the role of reserves on the real GDP growth across different emerging and developing economies during the GFC. Moreover, their paper finds that it is rather the level of foreign reserves which matters than the active use.

As for the fiscal spending, the mechanism is different. An increase in government spending will unambiguously change the exchange rate through the aggregate demand for domestic goods. To insure the same amount of investment (when the credit constraint is unbinding), the government needs to appreciate the price of domestic goods by increasing government consumption so as to maintain entrepreneurs' wealth. If the insurance provided by a targeted lending policy

works through entrepreneurs' wealth directly, the fiscal spending affects the level of domestic exchange rate and affects entrepreneurs' wealth indirectly. I have also shown that the funding of fiscal spending matters. For the same amount of resources (denominated in domestic goods, $T = p^{good'} B^{*fisc}_{min}$), a fiscal spending financed by foreign reserves can eliminate the bad equilibrium while a fiscal spending financed by taxes cannot unambiguously remove it. More resources need to be deployed in the latter case.

I can also compare the minimum levels of reserves needed to implement the targeted lending or fiscal spending financed by reserves. In fact, accumulating foreign reserves is not costless, the less reserves needed to achieve the same policy objective the better.

Let us denote $\Gamma = B^{*bail}_{min} - B^{*fisc}_{min}$.

$$\begin{aligned}
\Gamma &= D^* - \frac{(\alpha - d)X^*}{\mu + (1-\mu)\alpha} - [D^* \frac{[\mu + (1-\mu)\alpha]}{\alpha - d} - X^*] \\
&= \Big[d + (1-\alpha)\mu\Big]\Big[\frac{X^*}{\mu + (1-\mu)\alpha} - \frac{D^*}{\alpha - d}\Big] \\
&= -\Big[d + (1-\alpha)\mu\Big] X^* \frac{1}{\alpha - d}\Big[\frac{D^*}{X^*} - \frac{\alpha - d}{\mu + (1-\mu)\alpha}\Big]
\end{aligned}$$

$\Gamma < 0$ unambiguously as long as there are multiple equilibria, namely $\frac{D^*}{X^*} \geq max\left(\frac{1}{(1-\mu)(1+\psi)}, \frac{\alpha - d}{\mu + (1-\mu)\alpha}\right)$.

As a result, $B^{*fisc}_{min} > B^{*bail}_{min}$. To increase government spending requires a higher level of reserves than a direct lending in foreign goods. The reason behind is that a lending policy can be regarded as a direct write-off of the private sector's foreign-good debt or an official government guarantee on the private sector's debt. The need in terms of foreign goods is capped by the total amount of external debt facing the economy. However, for an expansionary fiscal policy to stabilize the domestic exchange rate, the amount of foreign reserves that the government needs to sell and with which it buys domestic goods depends on the magnitude of the depreciation. The more severe the depreciation, the more reserves are needed.

Therefore, in terms of the level of reserves needed, a targeted lending uses less resources than an expansionary fiscal policy.

In sum, a lending policy or an increase in government spending can both stabilize an economy where the private sector faces balance sheet effects due to the level of foreign-good denominated debt in the economy. In terms of foreign reserves needed, a lending policy uses fewer resources than a fiscal spending.

## 3.5 Conclusion

This work provides a simple theoretical framework to study different mechanisms through which foreign reserves can be useful in an economy where the private sector faces credit constraints and currency mismatch. It is shown that foreign reserves can be considered as a state-contingent insurance when the exchange rate valuation effect is taken into account. This is an aspect which has not yet been emphasized in the literature on foreign reserves. In fact, when there is a negative shock or a negative expectation on a country's currency, the domestic value of foreign reserves increases such that they can be used to stabilize the domestic economy, either through a targeted lending to the private sector or through an expansionary fiscal policy. The former channel works through investors' expectation and requires less foreign reserves than in the second case. The underlying reason is that a targeted lending is equivalent to give investors' a governmental guarantee on the private sector's liabilities (especially foreign liabilities). Having sufficient foreign reserves alters investors' expectation and pushes the economy towards the good equilibrium as it is defined in Krugman (1999).

The current framework remains a bit too simple. A more comprehensive theoretical framework is needed to endogenize entrepreneurs' portfolio choice and different costs related to *ex ante* foreign reserve purchases.

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## 3.A Unstable middle intersection point

Based on figure 3.11, I show here that the middle intersection point (point A) between the DD and II curves is unstable. There are only two stable multiple equilibria: good equilibrium (G) and bad equilibrium (B).

**Proof.** Suppose the lenders form an expectation at time $t$ which locates at the point $A^-$ on the II curve. The expected investment at the point $A^-$ will then determine the exchange rate through the aggregate resource constraint, namely the DD curve. The economy goes from point $A^-$ to $A^{-'}$. Given the new exchange rate at point $A^{-'}$, lenders will adjust their investment. The economy goes from $A^{-'}$ to $A^{-''}$. Again, the adjusted investment determines the exchange rate using the DD curve. This pushes the stable equilibrium to the B point (bad equilibrium). The same logic chain applies when the economy starts at the point $A^+$ ■

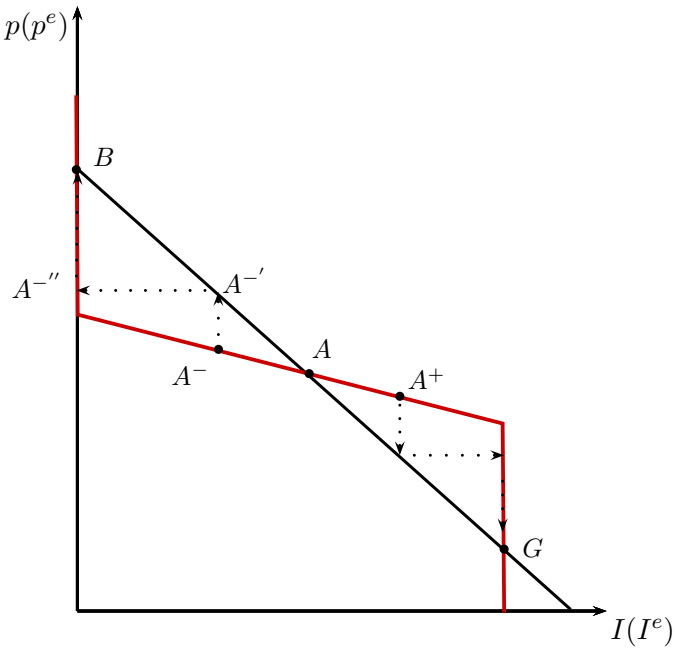


Figure 3.11: Unstable middle point

# Conclusion

At the end of the journey, I hope I have conveyed some thoughtful messages on foreign reserve accumulation in emerging market economies and have convinced the reader that there is a promising avenue for future research. In chapter 1, I have showed that foreign reserve accumulation is a 'transition' phenomenon; it is driven by the constrained demand for domestic borrowing due to financial frictions in the context of strong productivity growth. Moreover, this chapter provides some simulated results in favor of a temporary and timely use of capital controls jointly with the reserve policy. The combined use of these two instruments generates higher welfare during economic transition in comparison with a financially open economy. However, the welfare gains from the joint use of reserve accumulation and capital controls diminish with financial development, namely when the credit constraints become less binding. Therefore, capital controls need to be used in a temporary manner, and should not hinder any structural reforms in the financial market. In the future, I should incorporate more ingredients in this model so as to provide a more comprehensive cost-benefit analysis of foreign reserve accumulation, both within a growing economy and at the international level.

Chapter 2 finds a significant positive relationship between pre-crisis reserves to short-term debt ratio and economic performance during the global financial crisis. Namely, countries with high reserves relative to short-term debt suffered less from the crisis, particularly if associated with a less open capital account. Moreover, in the immediate aftermath of the crisis, countries that depleted foreign reserves during the crisis quickly rebuilt their stocks. This rapid rebuilding has, however, been followed by a deceleration in the pace of accumulation. For a future research

agenda, with my co-authors we are trying to find more relevant instruments for foreign reserves on the one hand and dig into the reasons explaining the more recent behavior of reserves accumulation in emerging economies, namely the factors behind this 'flattening-out' of reserve accumulation.

Chapter 3 analyzes the effective use of reserves to tackle balance sheet effects in an economy where the private sector is exposed to foreign liabilities and faces credit constraints. It is argued that both a targeted lending in foreign currency and a fiscal spending financed by foreign reserves help remove the bad equilibrium represented by a largely depreciated domestic currency and a very low level of domestic investment. It is also showed that the mechanisms through which these two policy tools stabilize the domestic economy are different. While targeted lending works through investors' expectation on the domestic exchange rate and on firms' net worth, fiscal spending affects the investment through a direct change of the value of domestic exchange rate. This framework needs to be enriched in the future so as to incorporate firms' portfolio choice and costs related to reserve accumulation in the analysis.

In conclusion, foreign reserve accumulation has received much attention in the past decade. The topic is closely related to many key issues in economic debates around the world, including discussions on exchange rate alignments, global imbalances and growth strategies, capital account management as well as the reforms in the international monetary and financial system. Will global or regional financial safety nets be well-functioning so as to substitute foreign reserves held by individual countries? What will be the future reserve currencies? Will China reduce its reserve holdings with the internationalization of its currency and recent financial reforms? Many questions regarding foreign reserve accumulation are already in the future agenda of academics and policymakers.