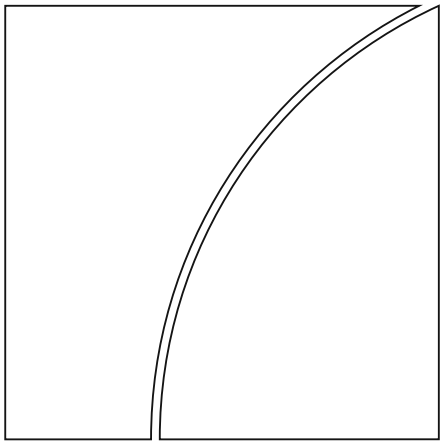
BANK FOR INTERNATIONAL SETTLEMENTS



BIS Papers

No 96

The price, real and financial effects of exchange rates

BIS-HKMA Conference on "The price, real and financial effects of exchange rates", 28–29 August 2017, Hong Kong

Monetary and Economic Department

March 2018

The views expressed are those of the authors and not necessarily the views of the BIS.

This publication is available on the BIS website (www.bis.org).

ISSN 1609-0381 (print)
ISBN 978-92-9259-147-2 (print)

ISSN 1682-7651 (online)
ISBN 978-92-9259-148-9 (online)

Contents

Policy panel

Policy panel remarks

Foreword

A research conference on "The price, real and financial effects of exchange rates" was co-hosted in Hong Kong, on 28–29 August 2017, by the Hong Kong Monetary Authority (HKMA) and the Bank for International Settlements (BIS). This conference was the culmination of the BIS Asian Office's two-year research programme on exchange rates, as endorsed by the Asian Consultative Council of the BIS in February 2016. The conference brought together senior officials and researchers from central banks, international organisations and academia.

Opening remarks at the conference were provided by HKMA Deputy Chief Executive Arthur Yuen. Sebastian Edwards (University of California, Los Angeles (UCLA)) delivered a keynote address. Six papers were presented, covering exchange rate puzzles; deviations from covered interest parity; devaluations and intraregional trade; exchange rates and corporate risk-taking; FX hedging and creditors' rights; and a risk-taking channel of FX reserves accumulation.

Four main lessons emerged from the discussions. First, nominal exchange rate fluctuations drive the real exchange rate, although the policy implications of this are not clear-cut. Second, weaker bankruptcy laws are associated with reduced hedging of FX exposures by firms. Third, the appropriate policy response to exchange rate changes depends on the source of the exchange rate change. Finally, definitive estimates of equilibrium exchange rates continue to elude researchers, in part because exchange rates depend on so many factors and their complex interaction.

This volume is a collection of the speeches, papers and prepared discussant remarks from the conference. This foreword summarises the contents of the conference and provides a synopsis of the discussions for time-constrained readers.

In "Exchange rate puzzles: evidence from rigidly fixed nominal exchange rate systems", Charles Engel (University of Wisconsin) and Feng Zhu (BIS) focus on six established exchange rate puzzles. They find that four of these (real exchange rates are too volatile and too responsive to real interest rate differentials, violate uncovered interest parity and are disconnected from fundamentals) are less puzzling under fixed nominal exchange rates, indicating the importance of nominal exchange rates in driving these puzzles. Some participants questioned whether the results indicated that fixed exchange rates are preferable over flexible ones, which most agreed to be a deeper question, going beyond the analysis of exchange rate puzzles.

The paper by Suresh Sunderasan (Columbia University) and Madhusudan Mohanty (BIS), "FX hedging and creditor rights", explores firms' incentives to hedge exchange rate exposures. Their empirical findings suggest that aggregate corporate credit spreads provide significant information on firms' FX exposures and that such exposures are negatively related to the strength of creditor rights of the countries where the firms are domiciled. Using loan-level data, they find that the introduction of a new bankruptcy code in India in 2016 increased firms' incentives to hedge FX exposures.

Rasmus Fatum (University of Alberta) and James Yetman (BIS) answer the question: "Does the accumulation of foreign currency reserves affect risk-taking?" against the backdrop of the large-scale FX reserve accumulation in EM Asia since the Asian crisis. Their empirical results suggest that there has been no clear link between reserve accumulation and risk-taking, measured using a range of financial market proxies, in the region.

Alfred Wong and Jiayue Zhang (both HKMA) explore the question "Breakdown of covered interest rate parity: mystery or myth?" Their analysis suggests that the breakdown of CIP is no mystery as it reflects the new trading environment in which uncollateralised and collateralised transactions have ceased to be treated as equivalent (so that unsecured rates are no longer used to price secured transactions). Therefore, it is a myth that the breakdown of CIP reflects an unexploited arbitrage opportunity and market failure. Moreover, their analysis suggests that the breakdown of CIP was not purely a US dollar phenomenon but also appears in currency pairs without a US dollar leg, challenging the notion that it primarily reflects a dollar funding shortage or dollar strength.

The paper by David Cook (Hong Kong University of Science and Technology) and Nikhil Patel (BIS), "Dollar invoicing, exchange rates and international trade", shows how the impact of monetary shocks on bilateral trade flows is mitigated if the two countries are involved in global value chains. The follow-up discussions focused on the need to understand the implications of these results for optimal monetary policy frameworks.

The final paper, by Sebnem Kalemli-Ozcan (University of Maryland), Xiaoxi Liu (Chinese University of Hong Kong) and Ilhyock Shim (BIS), focuses on "Exchange rate appreciations and corporate risk taking".[1] The authors use ORBIS firm-level accounting data and the estimated firm-level FX debt for a sample of 10 Asian EMEs over 2002–15 to show that exchange rate appreciations induce firms with higher FX debt to take on more risk in the form of higher leverage. They also find that such effects are stronger for firms in the non-tradable sector than those in the tradable sector.

In his keynote address entitled "Finding equilibrium: the urgency of an old question", Sebastian Edwards (UCLA) asserted that, despite a long history of exploration and the continued relevance of the topic, the current state of models of equilibrium exchange rate determination is less than satisfactory. He identified several avenues for future research and expressed his preference for approaches to equilibrium exchange rate models that give a high weight to net international investment positions (NIIP) and the sustainability of current account balances.

The conference concluded with a panel discussion on "Exchange rate challenges: how should policymakers respond?" chaired by Grant Spencer (Reserve Bank of New Zealand). One issue related to the role of the flexible exchange rate as a shock absorber. While a flexible exchange rate, combined with inflation targeting, seemed to help economies to absorb external shocks, the impact depended crucially on the operation of the "financial channel" of the exchange rate, which can not only offset the traditional expansionary impacts of depreciation but also amplify them in the presence of large unhedged foreign currency debt. The development of local currency bond markets was not a panacea for insulating domestic monetary policy from external shocks in the context of currency and maturity mismatches in many EMEs.

A second issue was the extent to which central banks should respond to exchange rates, and whether the nature and the sources of shock should play a role in designing the response. There was a view that changes in exchange rates caused

[1] The paper is not included in this volume, but has been published as BIS Working Paper no 710. The discussant's remarks, containing a short summary of the paper, are contained herein.

by fundamentals (eg terms of trade shocks) call for a different response from those induced by short-term capital flows (eg due to changed attractiveness as a carry trade destination). In addition, there may be a case for augmenting monetary policy with other tools such as macroprudential or capital flow management measures and balance sheet policies, including FX reserve management, to mitigate the destabilising effects of exchange rate volatility.

Programme

Monday 28 August

09:00–09:15	*Opening remarks* by **Arthur Yuen** (Deputy Chief Executive, Hong Kong Monetary Authority)
09:15–09:30	Photo session
09:30–10:50	*Paper 1: Exchange rate puzzles: evidence from rigidly fixed nominal exchange rate systems* Chair: **Lillian Cheung** (Hong Kong Monetary Authority) Authors: **Charles Engel** (University of Wisconsin) and **Feng Zhu** (BIS) Discussant: **Michael Devereux** (University of British Columbia)
10:50–11:10	Coffee break
11:10–12:30	*Paper 2: FX hedging and creditor rights* Chair: **Cheol Ho Choi** (Bank of Korea) Authors: **Suresh Sundaresan** (Columbia University) and **Madhusudan Mohanty** (BIS) Discussant: **Vidhan Goyal** (Hong Kong University of Science and Technology)
12:30–13:50	Lunch
13:50–15:10	*Paper 3: Accumulation of foreign currency reserves and risk taking* Chair: **Vachira Arromdee** (Bank of Thailand) Authors: **Rasmus Fatum** (University of Alberta School of Business) and **James Yetman** (BIS) Discussant: **Hans Genberg** (The South East Asian Central Banks (SEACEN) Research and Training Centre)
15:10–16:30	*Paper 4: Breakdown of covered interest parity: mystery or myth?* Chair: **Eli Remolona** (BIS) Authors: **Alfred Wong** and **Jiayue Zhang** (Hong Kong Monetary Authority) Discussant: **Yiping Huang** (Peking University)
16:30–17:00	Coffee break
17:00–18:00	*Keynote address: Finding equilibrium: the urgency of an old question* Chair: **Hyun Song Shin** (BIS) Speaker: **Sebastian Edwards** (University of California, Los Angeles)

Tuesday 29 August

08:30–09:50	*Paper 5: International price system, intermediate inputs and regional trade* Chair: **Shinobu Nakagawa** (Bank of Japan) Authors: **David Cook** (Hong Kong University of Science and Technology) and **Nikhil Patel** (BIS) Discussant: **Jian Wang** (Chinese University of Hong Kong - Shenzhen)
09:50–11:10	*Paper 6: Exchange rate appreciations and corporate risk taking* Chair: **Yoga Affandi** (Bank Indonesia) Authors: **Sebnem Kalemli-Ozcan** (University of Maryland), **Xiaoxi Liu** (Chinese University of Hong Kong) and **Ilhyock Shim** (BIS) Discussant: **Filippo di Mauro** (National University of Singapore)
11:10–11:30	Coffee break
11:30–12:50	*Policy panel: Exchange rate challenges: how should policymakers respond?* Chair: **Grant Spencer** (Reserve Bank of New Zealand) Panelists: **Diwa Guinigundo** (Bangko Sentral ng Pilipinas) **Sebastian Edwards** (University of California, Los Angeles) **Yiping Huang** (Peking University) **Hyun Song Shin** (BIS)
12:50–13:00	*Closing remarks* by **Hyun Song Shin** (BIS)

List of Participants

Central Banks

Australia	Reserve Bank of Australia **Michael Plumb** Deputy Head of Economic Analysis
Hong Kong SAR	Hong Kong Monetary Authority **Arthur Yuen** Deputy Chief Executive **Lillian Cheung** Executive Director **Alfred Wong** Senior Manager **Jiayue Zhang** Assistant Manager Hong Kong Institute for Monetary Research **Hongyi Chen** Senior Manager
Indonesia	Bank Indonesia **Yoga Affandi** Director
Japan	Bank of Japan **Shinobu Nakagawa** Deputy Director-General **Ryota Kojima** Chief Representative, Hong Kong Representative Office
Korea	Bank of Korea **Cheol Ho Choi** Director
Malaysia	Central Bank of Malaysia **Abdul Rahman Hussein** Director **Azizul Sabri Abdullah** Manager
New Zealand	Reserve Bank of New Zealand **Grant Spencer** Deputy Governor
Philippines	Bangko Sentral ng Pilipinas **Diwa Guinigundo** Deputy Governor

Thailand	Bank of Thailand **Vachira Arromdee** Assistant Governor, Financial Markets Operations Group

Academic and Other Institutions

Canada	University of Alberta School of Business **Rasmus Fatum** Department Chair and Foote Professor in International Business
	University of British Columbia **Michael Devereux** Professor
China	Chinese University of Hong Kong (Shenzhen) **Jian Wang** Assistant Dean and Associate Professor
	Peking University **Yiping Huang** Professor, National School of Development
Hong Kong SAR	Hong Kong University of Science and Technology **David Cook** Professor, Department of Ecomomics
	Vidhan Goyal Professor of Finance
Malaysia	The South East Asian Central Banks (SEACEN) Research & Training Centre **Hans Genberg** Executive Director
Singapore	National University of Singapore **Filippo di Mauro** Visiting Professor
United States	Columbia University **Suresh Sundaresan** Chase Manhattan Bank Professor
	University of California, Los Angeles **Sebastian Edwards** Henry Ford II Distinguished Professor of International Economics
	University of Wisconsin **Charles Engel** Professor of Economics

Bank for International Settlements

Hyun Song Shin
Economic Adviser and Head of Research

Boris Hofmann
Principal Economist

Nikhil Patel
Economist

BIS Representative Office for Asia and the Pacific

Eli Remolona
Chief Representative

Madhusudan Mohanty
Head of Economics and Financial Markets for Asia and the Pacific

James Yetman
Principal Economist

Ilhyock Shim
Principal Economist

Feng Zhu
Senior Economist

Opening remarks

Arthur Yuen[1]

Good morning ladies and gentlemen. It is my great pleasure to welcome you to this one-and-a-half-day conference, jointly organised by the Bank for International Settlements (BIS) and the Hong Kong Monetary Authority (HKMA). I would especially like to thank our international guests, who have travelled a long way to be with us today.

The annual research conference of the BIS's Asian Office showcases high-quality papers resulting from the collaborative efforts of leading academics and BIS economists. The HKMA is honoured to host this important and interesting event and we would also like to take the opportunity to present our own work and to participate in the discussion.

The theme of today's conference is "The price, real and financial effects of exchange rates". Since the collapse of the Bretton Woods System of fixed exchange rates in the early 1970s, the importance of understanding exchange rate movements and their international spillovers has increased enormously. Cross-border trade and capital flows have surged in recent decades, driven by globalisation and capital account liberalisation.

In line with these trends, our understanding of the role and nature of exchange rates has evolved substantially since the 1970s. Exchange rates were initially thought of as reflecting and responding to changes in macroeconomic fundamentals, such that they act as a buffer when external shocks hit the economy. Through this lens, the exchange rate was initially perceived to be like an automatic stabiliser, responding and adjusting to external shocks and imbalances, rather than itself being a source of instability. Unfortunately, we have since repeatedly seen wild swings, herding behaviour and persistent misalignments of exchange rates. These experiences, together with numerous currency crises, ranging from speculative attacks against Asian currencies in 1997 to the collapse of the Icelandic krona in 2008, have led to a re-think of the nature and role of exchange rates, away from being just a shock absorber.

The idea that the exchange rate itself can be a source of exogenous and destabilising effects on the economy means that it is also important to understand how exchange rate movements are transmitted to the real economy, and with what results. In the rapidly changing global macro-financial environment, our thinking on the transmission channel and effects of exchange rates has indeed evolved from the relatively simplified perspectives of impact through trade, capital flows and uncovered interest parity (reflecting interest rate differentials) to the recent more sophisticated view of transmission through financial channels, for example, through balance sheet effects and risk-taking behaviour.

Today, the increasingly integrated global financial markets, abundant global liquidity since the Great Financial Crisis (GFC), and large and volatile international capital flows mean that our understanding of such financial transmission channels is particularly important for thinking about the macro-financial vulnerabilities that have

[1] Deputy Chief Executive, Hong Kong Monetary Authority.

built up in recent years. We should also try to better understand the benefits of using prudential measures to address at least some of those vulnerabilities, particularly in emerging Asian economies.

Following the GFC, Asian emerging market economies (EMEs) have seen large capital inflows and currency appreciation as well as a rapid build-up in leverage and credit. To what extent do these financial imbalances have the effect of loosening domestic financial conditions, for example, through the balance sheets of borrowers with foreign currency liabilities? This would have implications for how far the eventual capital outflows and the associated currency depreciation might amplify the unwinding of leverage and credits in the region.

If large capital outflows eventually lead to volatile exchange rate movements, then is there a role for some form of policy action, be it prudential measures, capital controls or foreign exchange market interventions that could mitigate both the build-up and the unwinding of imbalances? Answers to these questions would carry significant economic and policy implications in the face of current global economic challenges. At this 10th anniversary of the GFC, and with global financial conditions beginning to normalise, this conference provides a timely opportunity for policymakers to think about our understanding of the role of exchange rates as well as the potential policy challenges.

Ladies and gentlemen, I believe we all agree that there are many important and challenging issues to be discussed at this conference. I am sure everyone is looking forward to the presentations and the dialogue during the policy panel session tomorrow. I hope that this conference will contribute useful insights, and wish you all very fruitful discussions in these two days. Thank you.

Revisiting exchange rate puzzles

Charles Engel and Feng Zhu[1]

Abstract

Engel and Zhu (2017) revisit a number of major exchange rate puzzles and conduct empirical tests to compare the behaviour of real exchange rates among pairs of economies that have rigidly fixed nominal exchange rates with their behaviour among pairs of economies under floating rates. They find that some of these puzzles become less puzzling for countries within the euro area, and regions in China and Canada, than for the non-euro-area OECD economies. Their results may have implications for exchange rate modelling.

Keywords: consumption correlation puzzle; excess volatility, exchange rate disconnect, exchange rate regime, real exchange rate, purchasing power parity, uncovered interest rate parity.

JEL classification: E43, F31.

[1] Charles Engel: Department of Economics, University of Wisconsin at Madison. E-mail: cengel@ssc.wisc.edu. Feng Zhu: BIS Representative Office for Asia and the Pacific, Hong Kong SAR. Email: feng.zhu@bis.org. We thank Luca Dedola and Michael Devereux for thoughtful comments and suggestions, and Jimmy Shek and Steve Pak Yeung Wu for excellent research assistance. The views expressed here belong to the authors alone and do not represent those of the Bank for International Settlements (BIS).

1. Introduction

The literature has named several exchange rate puzzles and has offered many potential explanations for these puzzles.[2] This paper summarises our recent work (Engel and Zhu (2017)), which focuses on six major exchange rate puzzles and investigates whether the nature of these puzzles differs under fixed and under free-floating exchange rate regimes. These puzzles include the excess volatility of real exchange rates; their excess reaction to the real interest rate differentials; the uncovered interest rate parity (UIP) puzzle; the excess persistence of real exchange rates; the exchange rate disconnect puzzle; and the consumption correlation puzzle.

We study which of the puzzles may be significantly different under rigidly fixed exchange rates versus floating exchange rates. We compare the degree to which the puzzles hold among pairs of economies with floating exchange rates (eg among the pairs of OECD member countries that are not in the euro area) with pairs of economies which have rigidly fixed exchange rates (such as Hong Kong SAR vis-à-vis the United States and country pairs within the euro area). We also extend the analysis to intra-national data, such as for US states and Canadian and Chinese provinces, and examine at least some of these propositions, depending on data availability. Within the national borders, nominal exchange rates are irrevocably fixed, providing the best example of fixed exchange rates.

Engel and Zhu (2017) suggest that, under a rigidly fixed nominal exchange rate regime, the excess volatility puzzle of real exchange rates practically disappears or becomes minor for the vast majority of the fixed-rate economies; there is less evidence for an excess reaction of the real exchange rate to the real interest rate differential; there is less disconnect between the real exchange rate and the economic fundamentals; and uncovered interest rate parity appears to hold more frequently in these economies. However, real exchange rates are as persistent in these economies as in the floating-rate economies, and the evidence for risk-sharing shows little difference among countries with fixed versus floating nominal exchange rates. This evidence may provide clues to the types of model that are useful for resolving the puzzles – and therefore, the types of model that are most useful for open-economy macroeconomic analysis.

The rest of this summary is organised as follows. Section II describes the six major exchange rate puzzles and our tests. In Section III, we present the empirical results. Section IV concludes.

2. Six exchange rate puzzles

A vast literature exists on each of the six exchange rate puzzles we examine. A key focus of Engel and Zhu (2017) is the behaviour of such puzzles under a rigidly fixed nominal exchange rate regime. There are many open-economy macroeconomic models in which there is stickiness in nominal prices or wages of varying degrees. In these models, the behaviour of the nominal exchange rate does matter for the real

[2] Obstfeld and Rogoff (2001) list six challenging puzzles in international macroeconomics, namely the home-bias-in-trade puzzle, the Feldstein-Horioka (1980) puzzle, the home-bias portfolio puzzle, the consumption correlations puzzle, the purchasing-power-parity puzzle, and the exchange-rate disconnect puzzle. They suggest that trade costs could help resolve the core quantity puzzles.

exchange rates, and the real exchange rate behaves very differently under fixed than it does under floating nominal exchange rates.

Engel and Zhu (2017) study six major exchange rate puzzles under different nominal exchange rate regimes. Define the real exchange rate Q_t as

$$Q_t \equiv \frac{S_t P_t^*}{P_t}$$

where S_t is the nominal exchange rate (the price of the foreign currency in home currency or the amount of the home currency that can be bought with one unit of foreign currency), P_t is the consumer price level in the home country, and P_t^* is the consumer price level in the foreign country. The real exchange rate is the price of the consumer basket in the foreign country relative to the price in the home country. Using lower case letters to denote the logs of variables written in upper case letters, we have

$$q_t = s_t + p_t^* - p_t \tag{1}$$

A rise in q_t then indicates a real depreciation of the home currency. Note that under a rigidly fixed nominal exchange rate regime, the real exchange rate becomes the relative foreign-to-home price, ie $q_t = p_t^* - p_t$.

One of the main puzzles of real exchange rate behaviour is the "excess volatility" of real exchange rates (see, for example, Rogoff (1996) and Evans (2011)). We define real exchange rate volatility as $\mathrm{var}(q_t)$ or $\mathrm{var}(q_t - q_{t-1})$, ie the variance of the log of the real exchange rate and the variance of the change in the log of the real exchange rate, respectively. Write:

$$p_t = \alpha_N p_{N,t} + (1 - \alpha_N) p_{T,t}$$

where $p_{N,t}$ and $p_{T,t}$ are the log of the prices of non-traded and traded goods in the home country, respectively, and α_N is the weight of traded goods in the consumption basket. Then,

$$q_t = s_{T,t} + p_{T,t}^* - p_{T,t} + \alpha_N \left(p_{N,t}^* - p_{T,t}^* - \left(p_{N,t} - p_{T,t} \right) \right) \tag{2}$$

Under the assumption of no home bias in consumption and no pricing-to-market for traded goods, since $\alpha_N < 1$, we must have

$$\mathrm{var}(q_t) < \mathrm{var}\left(p_{N,t}^* - p_{T,t}^* - \left(p_{N,t} - p_{T,t} \right) \right), \text{ and}$$

$$\mathrm{var}(\Delta q_t) < \mathrm{var}\,\Delta\left[\left(p_{N,t}^* - p_{T,t}^* - \left(p_{N,t} - p_{T,t} \right) \right) \right] \tag{3}$$

Besides (3), Engel and Zhu (2017) propose three alternative tests of excess volatility, one of which is derived based on a simple version of the Harrod-Balassa-Samuelson model.

The second puzzle that Engel and Zhu (2017) examine is the excess reaction of the real exchange rate to the real interest rate differential. Engel (2016) notes that,

under uncovered interest parity (UIP), the covariance of the real interest rate differential with the real exchange rate should be equal to that with the real exchange rate consistent with the UIP assumption. Yet for many floating-rate economies, there tends to be excess co-movement between the real exchange rate and the real interest rate differential. We compare these two covariances by estimating the UIP-consistent real exchange rates from VAR models, in terms of both levels and first differences.

The third, uncovered interest rate parity puzzle can be illustrated in the well known Fama (1984) regression:

$$s_{t+1} - s_t = \alpha_0 + \beta_0 \left(i_t - i_t^* \right) + u_{0,t+1} \tag{4}$$

where i_t and i_t^* are nominal interest rates in the home and foreign countries. The UIP relationship postulates that

$$i_t^* + E_t s_{t+1} - s_t = i_t \tag{5}$$

Under UIP, the null hypothesis is that $\alpha_0 = 0$ and $\beta_0 = 1$. Yet, in practice, for many pairs of economies under a floating exchange rate regime, the empirics actually suggest that $\beta_0 < 1$ and frequently $\beta_0 < 0$, hence the UIP puzzle.

Engel (2014, 2016) points out that most models offered as explanations for the UIP puzzle, particularly those based on foreign exchange risk premiums, actually account for the co-movement of the excess return with the real interest rate differential. In practice, the existing models present theories constructed on real exchange rates in order to explain the UIP puzzle based on returns expressed in nominal terms. But under a fixed nominal exchange rate, the only source of variation in the real exchange rate resides in inflation movements.

Recognising that the countries that have fixed nominal exchange rates do not fit the paradigm of the literature which assumes that each bond pays off a riskless return in units of the bond-issuing country's consumption basket, we modify the UIP regression. Given the fixed nominal exchange rates, the change in the real exchange rate is simply the different between foreign and home inflation rates, that is

$$\pi_{t+1}^* - \pi_{t+1} = \alpha_1 + \beta_1 \left(i_t - E_t \pi_{t+1} - \left(i_t^* - E_t \pi_{t+1}^* \right) \right) + u_{1,t+1} \tag{6}$$

For country pairs with rigidly fixed nominal exchange rates, the risk characteristics of the two bonds should be identical. Even for risk-averse investors, the two bonds should have equal expected real rates of return. This implies that UIP should hold ex ante. That is, we should find $\alpha_1 = 0$ and $\beta_1 = 1$. We test the null hypothesis of $\beta_1 = 1$.

The fourth puzzle we study relates to the excess persistence of real exchange rates, or the purchasing power parity (PPP) puzzle. Rogoff (1996) defines the puzzle as "how can one reconcile the enormous short-term volatility of real exchange rates with the extremely slow rate at which shocks appear to damp out?" He argues that the high volatility of real exchange rates might be explained in a monetary model with sticky prices, implying that the real exchange rate's persistence is determined by the speed of adjustment of nominal prices. Rogoff (1996) notes that consensus estimates suggest half-lives for shocks to real exchange rates to be of approximately

three to five years for floating-rate countries, "seemingly far too long to be explained by nominal rigidities". Indeed, measures of price stickiness suggest that the half-life of nominal price levels is closer to nine months.

For economies under a rigidly fixed nominal exchange rate regime, one direct test of excess persistence is to examine whether the half-life of real exchange rates is closer to nine months. Alternatively, we compare the half-life of real exchange rates to that of the difference between foreign and domestic relative prices of non-tradable to tradable goods.

The fifth, the exchange rate disconnect puzzle relates to the seemingly rather weak relationship between the exchange rate and any economic fundamentals. Engel and Zhu (2017) consider two different expressions for the fundamentals. The first approach, based on a simple Harrod-Balassa-Samuelson model, is to study the short-run and long-run relationship between real exchange rates and relative non-traded-to-traded productivity, by estimating an error correction model.

Alternatively, we examine the correlation between the real exchange rate q_t and q_t^{IP}, the rate that is consistent with UIP, which captures the effect of measurable economic fundamentals on the real exchange rate. That is, factors such as monetary policy, fiscal policy, productivity changes, or indeed anything that affects the real exchange rate through the real interest rate channel rather than through the deviations from UIP.

The sixth, the consumption correlation puzzle relates to the earlier literature on whether financial markets deliver risk-sharing across countries. In the presence of financial integration and some capital mobility, one would expect some degree of consumption-smoothing across countries, implying higher correlation in the growth in real consumption than that in output growth. Yet Backus et al (1992) find lower consumption growth correlation relative to output growth correlation. Engel and Zhu (2017) instead examine the correlation of the income available for consumption, ie total income minus investment and government spending in the home country, with that in the foreign country. These variables represent income made available for private consumption in the home and foreign countries, if they were closed.

But even with complete financial markets, we might not see high consumption correlation across countries, because financial assets are denominated in currencies, not in units of aggregate consumption. Assuming a constant relative risk-aversion utility function, if PPP does not hold, then relative consumption growth rates should be perfectly positively correlated with the growth rate of the real exchange rate. However, a fairly large empirical literature, including Backus and Smith (1993), has found that, among pairs of countries with floating nominal exchange rates, the correlation is actually low and negative, hence the consumption correlation puzzle or consumption-real-exchange-rate anomaly.

In reality, PPP does not hold. Assuming a logarithmic utility function, then growth rates of nominal consumption that are expressed in a common currency should be perfectly correlated if markets are incomplete. The traditional test of the consumption correlation puzzle becomes one of comparing the correlation of nominal domestic and foreign consumption with that of nominal and foreign domestic income available for consumption.

3. Empirical results

We summarise our results on the exchange rate volatility puzzle in Table 1, based on the variance bound tests (3). For the economies under a fixed nominal exchange rate arrangement, including 19 euro area countries, the variance bound (3) in levels are satisfied in 154 out of 172 cases, but only 42 out of 423 cases for the non-euro area OECD economies with floating rates.[3] The difference in terms of the changes in the real exchange rate is even more striking. Clearly, excess real exchange rate volatility is much less an issue for the economies under a rigidly fixed nominal exchange rate regime, but it remains a puzzle in those economies with floating exchange rates. The same analysis on intra-national data for 10 provinces in Canada, 31 provinces in China and 27 metropolitan areas in the United States further strengthen the outcome we obtained from the international comparisons.

The results for the alternative variance bounds are similarly striking and suggest a broadly similar picture to the patterns we observe in Table 1. The excess volatility puzzle of real exchange rates practically disappears or becomes minor for the vast majority of the economies which have adopted a rigidly fixed nominal exchange rate arrangement. The puzzle remains for most of the countries with floating nominal exchange rates such as the non-euro area OECD economies.

Excess volatility of real exchange rates: variance bounds (3)[1] Table 1

	Pairs of economies with rigidly fixed exchange rates					
	In levels			In changes		
	Both fixed[2]	Both floating[3]	Fixed vs floating[4]	Both fixed[2]	Both floating[3]	Fixed vs floating[4]
Within the bound	154	3	39	172	0	31
Above the bound	18	116	265	0	119	273
Total of pairs	172	119	304	172	119	304
	Regions in Canada, China and the United States[5]					
	In levels			In changes		
	Canada[6]	China[7]	US[8]	Canada[6]	China[7]	US[8]
Within the bound	41	411	293	45	454	351
Above the bound	4	54	58	0	11	0
Total of pairs	45	465	351	45	465	351

[1] Variance of real exchange rates relative to the variance of relative prices. [2] For the 19 euro area countries, there are a total of (19 * 19 – 19)/2 = 171 pairs. In addition, we have the US-HK pair. [3] Four of the 19 non-euro area OECD countries (Australia, Israel, Korea and New Zealand) have incomplete data. Hence, we have (15 * 15 – 15)/2 = 105 pairs. Plus 14 pairs with HK. [4] With data for 19 euro area countries and 14 non-euro area OECD countries, there are a total of 19 * 15 = 285 pairs. Plus 19 pairs with HK. [5] Based on regional data for Canada, China and the United States. [6] For the 10 Canadian provinces, there are a total of (10 * 10 – 10)/2 = 45 pairs. [7] For the 31 Chinese provinces, there are a total of (31 * 31 – 31)/2 = 465 pairs. [8] For the 27 Metropolitan area pairs, there are a total of (27 * 27 – 27)/2 = 351 pairs.

Sources: Eurostat; OECD; authors' calculations.

Empirical results are similar for the puzzle of excess reaction to the real interest rate differential. Both in levels and changes, our covariance bound is satisfied for the

[3] In the latter calculation, we group together the "both floating" and the "fixed vs floating" countries, since in fact the exchange rate floats between all country pairs in both groups.

vast majority of country pairs within the euro area for which we have data, but for only a small fraction of floating exchange rate pairs. This implies that there is an excess reaction of the real exchange rate for most floating-rate pairs, while the puzzle largely dissipates for the economies with rigidly fixed nominal exchange rates.

To analyse the UIP puzzle, Engel and Zhu (2017) estimate the coefficients α_1 and β_1 in regression (6). Table 2 summarises the test results for the null hypothesis of $\beta_1 = 1$. For the 12 euro area economies with fixed exchange rates, the null can be rejected in 27 out of 66 cases at the 1% significance level and in 31 cases at the 10% significance level. Even though the estimated coefficients are close to one, the standard errors of the coefficient estimates tend to be very small for the countries with fixed exchange rates, leading to rejection of the null at the 10% level in nearly half the country pairs. The null can be rejected in 186 out 312 country pairs at a 1% significance level and in 267 cases at the 10% significance level among the floating rate pairs.

Uncovered interest rate parity puzzle, null H_0: $\beta_1 = 1$ Table 2

	Both fixed[1]			Both floating[1]			Fixed vs floating[3]		
	10%	5%	1%	10%	5%	1%	10%	5%	1%
Do not reject H_0: $\beta_1 = 1$	35	37	39	18	31	55	27	39	71
Reject H_0: $\beta_1 = 1$	31	29	27	102	89	65	165	153	121
Total	66			120			192		

Note: the numbers indicate the counts of observations for which the *p*-values are greater than 0.10, 0.05 and 0.01, respectively.

[1] For the 12 euro area countries, there are a total of (12 * 12 – 12)/2 = 66 pairs. [2] Three of the 19 non-euro zone OECD countries (Iceland, Israel and Korea) have incomplete data. Therefore, we have (16 * 16 – 16)/2 = 120 pairs. [3] With data for the 12 euro area countries and 16 non-euro zone OECD countries, there are a total of 12 * 16 = 192 pairs.

Sources: Eurostat; OECD; authors' calculations.

Because the estimated slope coefficients are much smaller than for the fixed nominal exchange rate country pairs, and the rejection of the null is much more frequent, we can conclude that there must be something else driving the rejections of UIP among country pairs that have floating nominal exchange rates.

To examine the PPP puzzle or excess persistence of real exchange rates, Engel and Zhu (2017) follow Rogoff (1996) and compute the half-life of real exchange rates based on the estimates of the AR(1) coefficients for the rates. Their results suggest that the real exchange rate is quite persistent under both fixed and floating nominal exchange rates, but it is not any more persistent than the relative foreign-to-home and non-tradable-to-tradable prices.

We study the exchange rate disconnect puzzle by estimating the cointegrating relationship between the real exchange rate and the relative productivity variables, focusing on pairs of countries for which we have at least 15 years of data. We find that, proportionally, far more pairs of euro area countries have the correct positive sign than those country pairs with floating exchange rates. In addition, for those country pairs that have the correct positive sign, estimated error correction models suggest that the speed of adjustment is actually lower in the euro area countries on average.

We find that q_t and q_t^{IP} are very highly correlated in the country pairs with rigidly fixed nominal exchange rates, both in levels and first differences, but much less for the floating-rate countries. With both measures of fundamentals, there appears to be less disconnect between the real exchange rate and the economic variables under rigidly fixed nominal exchange rates than under floating rates.

In terms of the consumption correlation puzzle, a key result is that the primary difference does not involve the nominal exchange rate system, but rather country borders. While there appears to be evidence of some risk-sharing for about half of the euro area pairs and OECD country pairs, consumption correlation is higher than income correlation for all 45 Canadian provinces, whether we look at total income or income available for consumption.

In addition, we compare the correlation between relative consumption growth rates and the growth rate of the real exchange rate for pairs of countries with fixed exchange rates, to that of floating-rate pairs. Across countries, whether within the euro area, or among floating-rate pairs, the average and median correlation is close to zero. In contrast, the real exchange rates among Canadian provinces are mostly positively correlated with the relative consumption growth.

Comparing the correlation of nominal domestic and foreign consumption with the correlation of nominal and foreign domestic available consumption, we find strong evidence of risk-sharing by consumers among different countries and regions, whether or not exchange rates are floating.

4. Conclusion

Engel and Zhu (2017) examine six exchange rate puzzles focusing on countries within the euro area, regions in China and Canada, and Hong Kong SAR vis-à-vis the United States. Their empirical tests yield results which suggest that some of these puzzles are less "puzzling", ie less severe, under a rigidly fixed exchange rate regime, while other puzzles remain. This evidence may provide clues to the types of model that would be useful for resolving the puzzles – and therefore, the types of model that are most useful for open-economy macroeconomic analysis.

References

Backus, D, P Kehoe and F Kydland (1992): "International real business cycles", *Journal of Political Economy*, vol 100, no 4, pp 745–75.

Backus, D and G Smith (1993): "Consumption and real exchange rates in dynamic economies with non-traded goods", *Journal of International Economics*, vol 35, no 3, pp 297–316.

Engel, C (2014): "Exchange rate stabilization and welfare", *Annual Review of Economics*, vol 6, pp 155–77.

——— (2016): "Exchange rates, interest rates, and the risk premium", *American Economic Review*, vol 106, pp 436–74.

Engel, C and F Zhu (2017): "Exchange rate puzzles: evidence from rigidly fixed nominal exchange rate systems", *BIS Working Papers*, forthcoming.

Evans, M (2011): *Exchange-rate dynamics*, Princeton Series in International Economics, Princeton University Press.

Fama, E (1984): "Forward and spot exchange rates", *Journal of Monetary Economics*, vol 14:3, pp 319-338.

Feldstein, M and C Horioka (1980): "Domestic saving and international capital flows", *Economic Journal*, vol 90, no 358, pp 314–29.

Obstfeld, M and K Rogoff (2001): "The six major puzzles in international macroeconomics: is there a common cause?", *NBER Macroeconomics Annual 2000*, vol 15, pp 339–412.

Rogoff, K (1996): "The purchasing power parity puzzle", *Journal of Economic Literature*, vol 34, pp 647–68.

Discussion of Charles Engel and Feng Zhu's paper

Michael B Devereux[1]

1. Introduction

This is a creative and thought-provoking paper. In many ways, it covers familiar ground for students of open economy macroeconomics, but the contribution of the paper is to uncover some surprising and novel empirical findings within this terrain. What the paper does is to explore a series of exchange rate "puzzles" that have been widely recognised and studied in the literature, but it then asks whether these puzzles appear equally perplexing when there is no nominal exchange rate movement; ie under pegged exchange rate regimes. After all, if money was completely neutral and monetary policy irrelevant, we should see no difference in the behaviour of goods and assets prices between fixed and flexible regimes.

Of course, at least since Mussa's celebrated article (1986), it is well known that real exchange rates are much more volatile under a flexible relative to a fixed exchange rate regime. This suggests the presence of price stickiness in domestic currencies. There has been a huge follow-up literature on this question. Baxter and Stockman (1989) were the first to point out that sticky prices alone may not solve the puzzle, since when we compare fixed relative to floating regimes along other dimensions, such as output or consumption volatility, we find little difference between the two policy regimes. Flood and Rose (1995) and Jeanne and Rose (2003) pursue the mystery further by noting that excess volatility of real exchange rates seems to simply appear under floating exchange rates, without any clear fundamental drivers. A parallel literature, originated by Engel and Rogers (1996), and Engel (1999), noted that real exchange rate changes do not lead to large changes in internal relative prices. Much or most real exchange rate movement is associated with deviations in prices of the same goods across borders. The more recent literature has assembled these ideas into a "meta-puzzle" under the term "exchange rate disconnect", an expression first used in Obstfeld and Rogo (2001) (for a recent treatment, see Itskhoki and Mukhin (2016)).

What does this paper do? Essentially, it looks at the Mussa puzzle (or more generally, the exchange rate disconnect puzzle) in reverse. It asks whether real exchange rates without nominal exchange rates display a series of puzzles that have been outlined in the recent literature. The answer is ambiguous. In some cases, we can clearly establish that the anomalies in the data are due to flexible exchange rates, and do not appear under exchange rate pegs. In other cases, the results do not differ greatly between fixed and flexible exchange rates.

Aside from the details of the results for different cases, I see this paper as asking a really important question, and one that is often overlooked in the international macro literature. That is, do exchange rate economics need to be more cognisant of the nominal exchange rate? The clear answer from the paper is yes.

My comments below are organised roughly along the same lines as the paper. But one general comment I have concerns the interpretation. What do the authors want to emphasise as the main "takeaway"? One perspective is the question of

[1] Professor, Vancouver School of Economics.

whether exchange rate puzzles endure under fixed exchange rates. In this vein, one would take the message of the paper to say that, for many of the key anomalies found in the data, we should be looking more closely at the determinants of nominal exchange rates. But along different lines, one could see the paper as an attempt at a more insightful structural modelling of real exchange rates, untainted by volatility in nominal exchange rates. Both perspectives are interesting and potentially fruitful lines of inquiry. But they take us in different directions.[2]

The paper is long and comprehensive. It explores the whole range of anomalies that have been found in the exchange rate literature –the excess volatility of exchange rates, the uncovered interest parity puzzle, the exchange rate disconnect puzzle, the PPP puzzle, and the consumption correlation puzzle. My comments will mostly concern the excess volatility, exchange rate disconnect, and the PPP puzzle.

2. Detailed comments

2.1 Excess volatility

The first main result of the paper is that excess volatility in real exchange rates is particularly an attribute of floating exchange rate regimes. Of course this idea in itself is not new, but the paper provides a fresh perspective by deriving a various bound test of real exchange rate determination, based on the assumption that real exchange rates should be driven by the relative price of non-traded goods to traded goods. I am quite convinced by these results. They mirror previous work by Engel and others, although the particular test performed is different. Here I wish to give a theoretical interpretation of the results, and ask whether conventional open economy models can explain the different results under fixed and flexible exchange rates.

First, note that, following the decomposition in the paper, we can define the real exchange rate in logs as the sum of the nominal exchange rate and relative CPIs

$$q = s + p^* - p$$

which in turn, following the decomposition of Engel (1999) gives

$$q = p_T^* + s - p_T + \alpha_N \left(p_N^* - p_T^* - \left(p_N - p_T \right) \right)$$

This says that the real exchange rate is the sum of the relative price of traded goods and the relative price of non-traded to traded goods across countries, weighted by the (assumed equal) share of non-traded goods in the CPI.

But tradable goods usually contain a non-traded component, (for instance distribution services may require non-traded goods as inputs). Assume the share of the fully traded good (which designated with a hat) is κ. Then we can write the traded good decomposition as

$$\begin{aligned} p_T^* &= \kappa \hat{p}_T^* + (1-\kappa)\, p_N^* \\ &= \hat{p}_T^* + (1-\kappa)\left(p_N^* - \hat{p}_T^* \right) \\ &= \hat{p}_T^* + \frac{(1-\kappa)}{\kappa}\left(p_N^* - \hat{p}_T^* \right) \end{aligned}$$

[2] The second approach motivates the paper by Berka, Devereux and Engel (2017).

Putting all this together, for the home and foreign countries, gives the real exchange rate

$$q = \hat{p}_T^* + s - \hat{p}_T + \left[\frac{(1-\kappa)}{\kappa} + \alpha_N\right]\left(p_N^* - p_T^* - (p_N - p_T)\right)$$
$$= \Delta + \left[\frac{(1-\kappa)}{\kappa} + \alpha_N\right]\Gamma$$

where Δ and Γ are implicitly defined.

The real exchange rate is decomposed into two components; the first due to the deviation from the law of one price in traded goods, the other due to movements in the internal relative price of traded to non-traded goods across countries. The question is how do the two terms behave under alternative exchange rate regimes? The various bounds tests in the paper focus exclusively on Γ. But in order to understand the difference between flexible and fixed exchange rate regimes from the viewpoint of a theoretical model, we also need a theory for Δ.

We can break down Δ into "pricing to market" and local currency pricing (LCP). Pricing to market is defined as a situation where firms deliberately set prices in order to exploit different conditions in different markets, for instances differences in demand elasticities in different countries could lead to markup differences. We can interpret these as differences in *expected* Δ.[3] In this case we would have $E(\Delta) \neq 0$. An alternative perspective is that Δ may fluctuate because of local currency pricing (LCP) and unexpected movements in exchange rates. Then variations in exchange rates would be coming from the term $\Delta - E(\Delta)$. Many recent New Keynesian open economy models exhibit variations in real exchange rates arising from LCP. The paper finds that volatility of Γ is systematically greater than volatility of q for fixed exchange rate countries, but significantly less than the volatility of q for flexible exchange rate countries. According to our above decomposition, this should imply that much of q in flexible regimes is driven by Δ – either by pricing to market or LCP. This is quite consistent with Engel (1999) – where in fact all of q is driven by Δ.

Now take a two-country model with productivity shocks, Calvo pricing, non-traded goods, and endogenous terms of trade, allowing for productivity shocks to traded goods. Then, I ask whether in this model we can we reproduce the variance bounds results in the data. In the model, all variation in Δ is due to LCP. I calibrate so that $\left[\frac{(1-\kappa)}{\kappa} + \alpha_N\right] = 1.5$.

Figures 1 and 2 illustrate the response to a productivity shock in the traded goods sector, under fixed and flexible exchange rates, while Table 1 reproduces the theoretical variances implied by the model. Figure 1 shows that the full response of q is attributed to Γ under the fixed exchange rate regime. By definition of the model, $\Delta = 0$ in this case. The real exchange rate appreciates in response to the productivity shock. Figure 2 shows that under a flexible exchange rate regime, the response of Γ

[3] Many papers have developed models of pricing to market. See Dornbusch (1987), and Atkeson and Burstein (2008), for instance.

is approximately the same, but now Δ falls, so we do get an "excess volatility" in the real exchange rate.

Figure 1

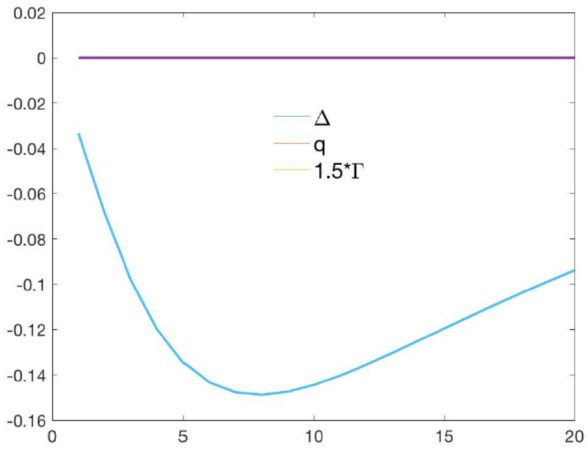


Figure 2

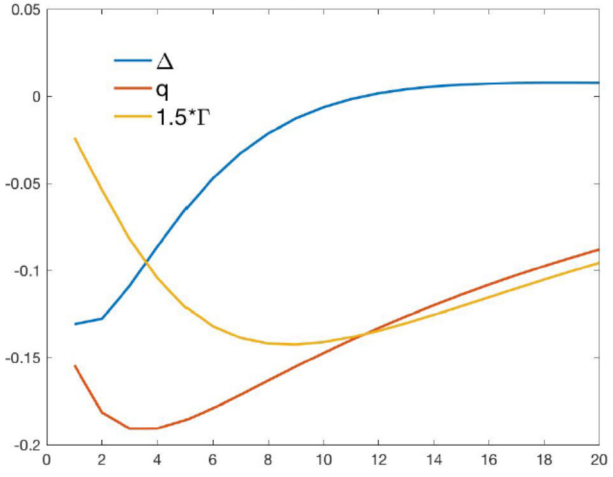
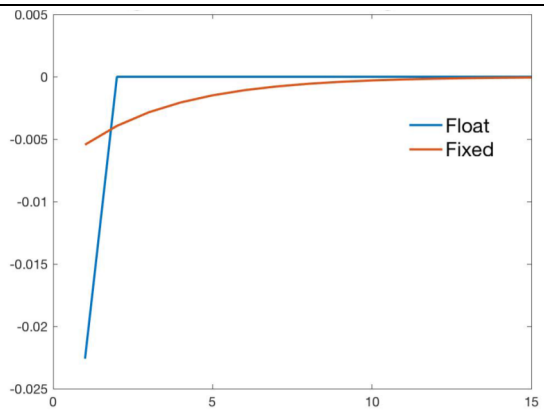


Figure 3. Real Exchange Rate



Can the model explain the variance bounds findings of the Engel and Zhu paper? Table 1 shows that the fixed exchange rate regime satisfies exactly the condition $\sigma_q = 1.5 * \sigma_\Gamma$.[4] Under flexible exchange rates, the volatility of Γ is almost the same, while now the volatility of Δ increases to about the same size as Γ. We now find that $\sigma_q = 2.9$ and $1.5\sigma_\Gamma = 2.2$, so that $\sigma_q > 1.5 * \sigma_\Gamma$. So we obtain "excess volatility", in the sense that we get the same ranking of volatilities as in the paper. But the magnitude is not large. The reason is that, while Δ is volatile, Δ, and Γ are negatively correlated (as can be seen from Figure 2). So while the results do accord with the paper's variance bounds results, they do not nearly explain the data. To see this more clearly, Table 2 reports the same objects in European data (taken from Berka et al (2017)), where we compare the within-euro zone exchange rates to the floating exchange rate European countries, using Eurostat data for prices. We see that the European data do accord with the findings of the Engel-Zhu paper, notably that the variance bounds test is

[4] I use standard deviations rather than variances for ease of interpretation.

satisfied (just) for the euro zone, but not for the floating countries. But the difference between these data and the model is that the increase in volatility of q, and Δ in comparing the euro zone with the floating regimes is much greater in the data than in the model. Thus, we are left with a puzzle in explaining excess volatility under flexible exchange rates.

Model				Table 1	Data				Table 2
Case	q	Δ	1.5Γ		Case	q	Δ	1.5Γ	
Fixed	2.3	0	2.3		Fixed (EZ)	3.3	2.8	3.2	
Flexible	2. 9	1.4	2.2		Flexible (EU)	7.0	6.0	4.3	

2.2 Real exchange rate modelling and exchange rate disconnect

One implication one could draw from the results of the paper is that understanding and modelling real exchange rates is likely to be more successful when we focus on real exchange rates among fixed exchange rate countries. As we saw above, the theoretical variance bounds tests are generally satisfied for countries that have bilaterally fixed exchange rates. This is an intriguing hypothesis, and deserves to be followed up. The obvious framework to test is the Balassa-Samuelson model. The paper finds evidence for the real exchange rate-productivity link within a variance bounds limit test. But it is worth a deeper investigation, using structural models of the real exchange rate. Some evidence for the usefulness of the Balassa-Samuelson model for the euro zone is presented in Berka and Devereux (2013), who find a tight link between real exchange rates and real GDP per capita, both in cross section and time series, for the euro zone countries, and Berka, Devereux and Engel (2017), who find strong support for an amended version of the Balassa-Samuelson model among euro zone countries using measures of sectoral productivity (again both in time series and cross section). With the expanded availability of sectoral and micro price data for many countries, this approach is likely to be further developed over time.

2.3 The PPP puzzle

An interesting finding of the paper is that real exchange rate persistence is no less under fixed rates than under flexible exchange rates. At first glance, this seems surprising. Most reading of the literature would suggest that the driving force of both excess volatility and persistence in real exchange rates comes from movements in nominal exchange rates. But it is important to note that persistence in relative prices is quite different from excess volatility. One could make the case that, in a theoretical sense, persistence in real exchange rates should be greater under fixed exchange rates. This is because real exchange rate adjustment in fixed exchange rate areas can take place only via slow movement in relative prices across regions, while the same adjustment can in principle be achieved much more quickly within a flexible exchange rate arrangement. Figure 3 shows an example of this, comparing adjustment under fixed and flexible exchange rates with a temporary government spending shock within the model described in the previous section. We see indeed that, while the amplitude of the real exchange rate response to a government spending shock is substantially greater in a flexible exchange rate regime, the persistence is greater under a fixed exchange regime. Fixed exchange rates embody intrinsic persistence that is not necessarily a characteristic of a flexible regime.

Persistence in relative prices can also be driven by large heterogeneity in speeds of price adjustment. This point is extensively explored in Carvalho and Nechio (2011).

To see this, take two sectors 1 and 2, with two regions E and W. Say that the real exchange rates are among E and W are driven by AR(1) processes as follows.

$$q_1 = \lambda_1 q_{1,-1} + u$$
$$q_2 = \lambda_2 q_{2,-1} + u$$

Then the overall real exchange rate is defined as:

$$q = \frac{q_1 + q_2}{2}$$

Carvalho and Nechio (2011) show that the aggregate real exchange rate will be an ARMA(2,1) process, as follows

$$q = \left(\lambda_q + \lambda_2\right) q_{-1} - \lambda_1 \lambda_2 q_{-2} + u - \frac{\lambda_1 + \lambda_2}{2} u_{-1}$$

Then, persistence in the real exchange rate will be driven by the largest root (most persistent sector) of the underlying sectoral real exchange rates. Again however, this will not depend on the nominal exchange rate. Persistence within countries could be just as great as that across countries.

2.4 Consumption risk-sharing

An interesting finding of the paper is that consumption risk-sharing does not seem to be linked to the nominal exchange rate. For the most part, risk-sharing seems to be similar across countries within fixed exchange rate systems as across flexible exchange rate systems, even when one explicitly accounts for the role of real exchange rate movements in risk-sharing (ie the Backus-Smith condition). This is a surprising finding, and seems to be at variance with the results of Hadzi-Vaskov (2008), Hess and Shin (2008), and Devereux and Hnatkovska (2013). It is not clear to me what is driving the difference in results. It will be interesting to explore further the different specifications.

3. Conclusions

This paper has set out a series of interesting results on the properties of real exchange rates under fixed exchange rate regimes. One the one hand, it suggests an agenda for exploring and testing models of real exchange rates without being "contaminated" by nominal exchange rates. On the other hand, it underscores the importance of nominal exchange rates in any theoretical approach to understanding real exchange rate anomalies. In this respect it seems to accord well with an idea often associated with the BIS. That is, that monetary economies are very different from standard theoretical general equilibrium models.

References

Atkeson, A and A Burstein (2008): "Trade costs, pricing-to-market, and international relative prices", *American Economic Review*, vol 98, no 5, pp 1998–2031.

Baxter, M and A Stockman (1989): "Business cycles and the exchange rate regime: some international evidence", *Journal of Monetary Economics*, vol 23, pp 377–400.

Berka, M and M Devereux (2013): "Trends in European real exchange rates", *Economic Policy*, vol 28, pp 195–242.

Berka, M, M Devereux and C Engel (2012): "Real exchange rate adjustment in and out of the euro area?", *American Economic Review: Papers and Proceedings*, vol 102, pp 179–85.

——— (2016): "Real exchange rates and sectoral productivity in the euro area?", Working Paper, University of Wisconsin.

Carlos, C and F Nechio (2011): "Aggregation and the PPP puzzle in a sticky-price model", *American Economic Review*, vol 101, pp 2391–424.

Devereux, M and V Hnatkovska (2014): "Borders and nominal exchange rates in risk sharing", Working Paper, Department of Economics, University of British Columbia.

Dornbusch, R (1987): "Exchange rates and prices", *American Economic Review*" vol 77, pp 93–106.

Engel, C (1999): "Accounting for US real exchange rate changes", *Journal of Political Economy*, vol 130, no 3, pp 507–38.

Engel, C and J Rogers (1996): "How wide is the border?", *American Economic Review*, vol 86, pp 1112–25.

Hadzi-Vaskov, M (2008): "Does the nominal exchange rate explain the Backus-Smith puzzle? Evidence from the euro area?", Utrecht School of Economics, Tjalling C Koopmans Research Institute, *Discussion Paper Series*, no 07-32.

Hess, G and K Shin (2010): "Understanding the Backus-Smith puzzle: It's the (nominal) exchange rate, stupid?", *Journal of International Money and Finance*, vol 29, pp 169–180.

Itskhoki, O and D Mukhin (2016): "Exchange rate disconnect in general equilibrium", Working Paper, Princeton University.

Jeanne, O and A Rose (2002 "Noise trading and exchange rate regimes", *Quarterly Journal of Economics*, vol 117, pp 537–69.

Flood, R and A Andrew (1995): "Fixing exchange rates: a virtual quest for fundamentals", *Journal of Monetary Economics*, vol 35, pp 3–37.

Mussa, M (1986): Nominal exchange rate regimes and the behavior of real exchange rates: Evidence and implications", Carnegie-Rochester Conference Series on Public Policy, vol 25, pp 117–214.

Obstfeld, M and K Rogoff (2001): "The six major puzzles in international macroeconomics: is there a common cause?", *NBER Macroeconomics Annual 2000*, vol 15, pp 339–412.

FX hedging and creditor rights

M S Mohanty and Suresh Sundaresan[1]

Abstract

The paper draws on Mohanty and Sundaresan (2018) to explore the effects of bankruptcy laws on the ex ante incentive for firms to hedge FX exposures. We use a simple model in which the bankruptcy code may result in deadweight losses, and may allow equity holders a share of residual value of the firm's assets in the bankruptcy proceedings. The paper predicts that, while value-maximising firms promise to hedge a higher fraction of the value of their FX exposure when the debt is issued, they may renege subsequently and take on some FX exposures at the expense of foreign creditors. To preclude this, strong and enforceable loan/bond covenants must be in place. Furthermore, the model predicts that FX exposure affects credit spreads, and that thin FX hedging markets lead to greater FX exposure, and a higher probability of default. The paper tests these theoretical predictions and shows that unhedged corporate FX exposures at the country level are indeed negatively associated with the strength of creditor rights and the depth of hedging markets. Using loan-specific data from the Reserve Bank of India, and exploiting recent changes in the bankruptcy law, the paper uncovers a clear connection between the creditor rights and the hedging behaviour of non-financial firms.

Keywords: foreign currency exposure; corporate hedging; creditor rights.

JEL classification: F31, G13, G28.

[1] Mohanty is with the Bank for International Settlements, Representative Office for Asia and the Pacific, 78th Floor, Two IFC, 8 Finance Street, Central, Hong Kong; e-mail: madhusudan.mohanty@bis.org. Sundaresan is Chase Manhattan Bank Foundation Professor of Financial Institutions at Columbia University; e-mail: ms122@gsb.columbia.edu. The views expressed in this paper are those of the authors and do not necessarily reflect those of the institutions they belong to. We are grateful to the Reserve Bank of India for sharing with us the loan-level data on external commercial borrowing (ECB) by Indian firms, and to Sneharthi Gayan, Vishal Maurya, Ranjeev Choudhury and Kamal Gupta for generous help in preparing the data set for the paper. We thank, without implication, our discussant, Vidhan Goyal, and the participants at the HKMA-BIS conference on "The price, real and financial effects of exchange rates" and the Reserve Bank of India seminar for very helpful comments. Anamaria Illes, Jimmy Shek and Ran Li provided excellent research assistance. Any remaining errors are solely our own.

1. Introduction

"Original sin" refers to the practice of a country borrowing in foreign currency (Eichengreen and Hausmann (1999)). The most recent evidence points to a global tendency to engage in currency and maturity mismatches due to central bank policies. For instance, BIS (2017) reports that between 2009 and 2016, US dollar credit to non-bank borrowers outside the United States expanded by 50% to USD 10.5 trillion, and that to emerging market non-bank borrowers more than doubled to USD 3.6 trillion. Rajan (2014) argues that large-scale asset purchases by the Federal Reserve precipitated a worldwide "competitive easing" of monetary conditions, causing excessive build-up of leverage in emerging market economies (EMEs): this is the central bank channel through which dollarisation occurs for non-dollar-domiciled borrowers. Similarly, Bruno and Shin (2017) show that very low US interest rates have encouraged emerging market firms to engage in financial exposures that have attributes of a US dollar carry trade.

In this paper, we explore how far firms might wish to take on FX exposure: we consider a firm with dollar debt, generating domestic currency cash flows. An important motive for FX hedging, or more generally hedging, is that firms face bankruptcy costs, and to avoid costly bankruptcies due to increased volatility of unhedged revenues and costs, firms may hedge even though shareholders may be fully diversified, and may not care whether the firms are hedged or not. This motive is strong at the time the firm issues dollar debt. Subsequent to the issuance, however, equity holders have an incentive to take on some FX exposure at the expense of foreign creditors. To preclude this, strong and enforceable loan/bond covenants must be in place. This presumes that contract enforcement mechanisms such as the bankruptcy laws are efficient. In countries with a weak bankruptcy code and creditor protection, this argument is much less persuasive. In such countries, dollar debt may be priced to reflect such enforcement problems, and we may see firms taking on greater FX exposure.

We develop a simple theoretical framework in which a firm with domestic currency cash flows issues FX (USD) debt. This stark setting, without any natural currency hedge, helps us to focus on FX exposure and the circumstances under which the firms may hedge that exposure. The firm operates under a bankruptcy legal framework in which default can result in deadweight losses. The equity holders choose the optimal default boundary to maximise their value, and will internalise any inefficiencies in the bankruptcy code, by adjusting their default decision. We use this setting to develop propositions that link (a) the firm's credit spreads to its FX exposure; (b) the cost of hedging to FX exposure and the probability of default; (c) the value-maximisation objective to the optimal hedge; and (d) the conflicts of interest between equity holders and creditors in hedging exposure after the issuance of debt.

We empirically test these theoretical propositions by pursuing two distinct but complementary lines of investigation. First, we explore whether a country's aggregate corporate credit spread is informative of the unhedged currency exposure of its firms, after controlling for systematic risks. To the extent that such a relationship exists, it will help us to understand the nature of the link between fluctuations in the external value of a country's currency and the probability of firms domiciled in that country facing the threats of bankruptcy. Having estimated FX exposure at the individual country level, we then proceed to investigate the role of macroeconomic and institutional factors in explaining cross-country variations in such exposures. Second,

we supplement our cross-country analysis through a quasi-natural experiment by focusing on India's recent introduction of a new bankruptcy code in May 2016. Using granular loan-level information from the Reserve Bank of India (RBI) and combining this with the firm-level data, we attempt to identify the unique effect of this new law on the hedging behaviour of firms.

Consistent with the predictions of our model, we present evidence supporting a strong association between the credit spreads of firms and FX rates, after controlling for the sovereign spreads. This evidence is based on country-level data, wherein the corporate spreads are calculated at a portfolio level. Nearly three fifths of economies in our sample have a negative exposure to a dollar appreciation, and these dollar short positions tend to be concentrated in countries with sizeable current account deficits.

Our cross-country evidence supports the main intuition behind the theoretical model that there exists a negative relationship between the corporate sector's exposure to the exchange rate and the legal rights enjoyed by the creditors in the country where the firms are domiciled. We find that countries that score high on World Bank's strength of creditors' legal rights tend to benefit from lower degrees of currency mismatches on their corporate balance sheets. Among other factors, we also find strong evidence in favour of the incomplete market hypothesis that FX exposures are negatively associated with the degree of depth of the hedging markets (lower depth implying higher costs of hedging), implying that deeper FX markets may encourage firms to hedge a larger fraction of their FX exposures.

Our quasi-natural experiment based on India confirms most of the findings obtained in the context of the cross-country analysis. Employing a probit model and dividing firms according to their ratio of foreign currency debt in total debt, we find a robust positive association between the new bankruptcy code and the probability of currency hedging by firms with a high share of foreign currency debt. Relative to the pre-new bankruptcy regime, the probability of these firms issuing loans on a currency-hedged basis rises by about 13%. Having said that, our results also point to significant differences in the behaviour of state-owned firms that are relatively insulated by the implicit government support and widely held public listed companies that are likely to face the full brunt of the new bankruptcy code.

Stepping outside our theory, we find that among the fundamental factors playing a role in hedging decisions is the availability of a natural hedge through export revenues. We find that firms that have a larger fraction of their sales in foreign currencies are more likely to issue unhedged loans. We also find that firms' growth opportunities have a significant effect on their hedging decisions, suggesting that firms that are higher in market value do tend to capitalise on that strength by hedging more of their currency and interest rate exposures, as suggested by the underinvestment theory of hedging.

The rest of the paper is organised as follows. Section 2 briefly surveys the relevant literature. In Section 3, we develop our main theoretical intuitions, which provides us with some testable implications. Section 4 contains our empirical analysis. Section 5 concludes.

2. Literature

A number of reasons have been advanced to explain why firms borrow in foreign currency, leading to currency mismatches. The depth of capital markets, credibility of

monetary and fiscal policies and supporting institutions are obvious drivers (Claessens et al (2007), Tirole (2003) and Jeanne (2002)). The rights of creditors and the efficient enforcement of contractual obligations also determine whether or not there will be a thriving domestic bond market. Aghion et al (2001) and Chamon (2001) emphasise this driver.

A second strand of literature focuses on the consequences of dollarised liabilities for firm balance sheets and borrowing costs in a dynamic equilibrium setting. This literature extends the original closed economy financial accelerator models of Bernanke and Gertler (1989) and Bernanke et al (1999) to an open economy setting where a firm is exposed to an unanticipated large devaluation of the exchange rate. Notable examples are Aghion et al (2000), Gertler et al (2007), and Cespedes et al (2004). A key aspect is that the lenders are exposed to an agency problem (the high costs of verifying bankruptcy of the borrowers), which they internalise by charging the firm an "external finance premium". In this setting, a surprise devaluation leads to a sharp deterioration in the firm's net worth, amplifying the negative effects of the shock on credit spreads and the costs of borrowing.

A third strand of research highlights the importance of the rule of law and legal institutional histories of countries for the development of credit markets. This includes the classic papers of La Porta et al (1997) and Djankov et al (2007), which establish a strong cross-country association between property rights and the degree of development of credit markets, as well as Goyal and Packer (2016) and Bae and Goyal (2009), who demonstrate the crucial role of contract enforcement in loan decisions. A related branch of the literature investigates the use of FX-denominated debt and hedging motives. Examples include Lei (2012) who examines the impact of the strength of external governance on firms' use of currency derivatives, and Kedia and Mozumdar (2003), who focus on firms' use of foreign currency-denominated debt to hedge FX exposure.

Our work focuses on the link between the provisions of the bankruptcy law, deadweight losses, and contract enforcement on the one hand, and the incentives to hedge on the other. Our paper complements others by examining yet another aspect of the bankruptcy law, that is, its implications for firms' decisions to take on unhedged currency exposures. We discuss a transmission mechanism where the deadweight costs of bankruptcy, the costs of hedging and the conflicts of interests between equity holders and creditors all influence the firm's optimal hedging strategy.

3. Theoretical intuitions

The theoretical model behind the analysis is developed in Mohanty and Sundaresan (2018). The model assumes that a typical emerging market firm has dollarised debt outstanding and must decide what fraction of its FX exposure should be hedged. The firm may need to import capital equipment to generate domestic currency revenues, for example, as would be the case in industries such as infrastructure. The firm may face some costs associated with hedging. This is related to the opportunities that the borrower has to hedge its exposure. If hedging markets are incomplete, the costs can be high. The firm also realises that hedging can reduce the upside potential to equity holders, while making its creditors better off. This will limit their incentives to hedge. On the other hand, by hedging, the firm can lower its probability of default, and this can improve the ability of the firm to realise upside potential, conditional on its survival.

Consider a firm whose unhedged asset value in domestic currency units evolves as follows:

$$dA = r_d A dt + \sigma_1 A d\omega_1 \tag{1}$$

In equation (1), $\{\omega_1\}$, is the driving process that causes A_t to evolve over time as a Geometric Brownian Motion. We assume that r_d is the domestic currency risk-free rate.

We will formalise this idea as follows. Let C be the coupon rate of the debt issued by the firm. These liabilities are in US dollars, which we assume is the foreign currency throughout the paper. The interest payments are tax deductible so that the effective cost of servicing debt for the firm is $C(1-\tau)$ where τ is the tax rate.

The risk-neutral process for the foreign currency spot exchange rate [in units of domestic currency per unit of USD] is specified below:

$$dS = (r_d - r_f) S dt + S \sigma_2 d\omega_2 \tag{2}$$

The firm is therefore exposed to both shocks in the domestic currency asset values, which arise from domestic currency revenue fluctuations, as well as the possibility of a significant depreciation in domestic currency, which can hurt its ability to service its dollar liabilities. This is the tension that we capture in our model.

In its hedging decisions, the firm really cares about the FX-denominated value of its domestic assets as its liabilities are in foreign currency. So, we define $\alpha \equiv \frac{A}{S}$ as the asset value in FX. Its dynamics is the relevant variable in the firm's optimal hedging and default decision.

The firm takes into account both the potential for domestic currency depreciation as well as a depreciation in its own domestic revenues in designing its value-maximising hedge. The interest payments on debt generate a tax shield and the continuation value of the firm is the present value of the tax shield generated by the firm in good states, net of hedging costs that must be paid for in good states to avoid losses in bad states. The costs are the deadweight losses imposed by the bankruptcy code.

Let $a^* > a$ be a fixed boundary where default occurs. The characterisation of default is central to our theory. This is where the effectiveness of the bankruptcy code comes in. If the bankruptcy causes the equity holders to be completely wiped out, they get nothing upon bankruptcy: this is consistent with the absolute priority rule. This may incentivise equity holders to default sooner, ex ante. To capture the variations in the code, we define the payoffs to the equity holders and creditors at the default boundary, a^*.

When the value of the hedged firm's assets reach the default boundary, the following payoffs are earmarked for the claim holders.

$$E(a^*) = \psi_1 a^* \tag{3}$$

and

$$D(a^*) = \psi_2 a^* \tag{4}$$

Note that $\psi_i\,(i = 1,2) \in [0,1]$ is a crucial parameter: it is the fraction of the residual value that accrues to equity holders when the firm defaults. This is a leakage from the

creditors to the equity holders. In addition, we assume that $\psi_1 + \psi_2 > 1$ so that there are deadweight losses associated with bankruptcy. We assume that the equity holders can hedge a fraction $\theta \in [0,1]$ of their FX-adjusted domestic asset value a. It costs the firm c per unit time per unit fraction of the FX-adjusted asset value that the firm hedges. The hedged asset value will have the risk-neutral dynamics, shown below.

$$da = ar_f dt + a(1-\theta)[\sigma_1 d\omega_1 - \sigma_2 d\omega_2]$$

We can think of hedging costs as capturing the extent of incompleteness in hedging opportunities, as well as the basis risk in hedging. In this setting, the equity is a down-and-out call option, and reducing the volatility will generally lower the equity value. But, if there is default risk, and the equity holders are wiped out upon default, they may have an incentive to hedge, ex ante. Since hedging reduces the overall volatility, the debt claims issued by the firm will become more valuable. Hence the total value of the firm, which is the sum of the values of equity and debt claims, may well increase when the firm pursues a value-maximising strategy. For a rational equity holder, hedging at the time of issuance of debt will reduce the cost of issuing debt, and hence will increase the overall equity value, by increasing the continuation value of the firm, and reducing the odds of an expensive bankruptcy.

Using this framework, we develop several testable propositions:

1. After the firm issues debt, a subsequent depreciation of domestic currency increases the credit spreads. Corporate credit spreads thus have a strong FX exposure;
2. An increase in the cost of hedging (implicit, such as agency costs, or explicit, such as thin FX hedging markets) increases the optimal default boundary;
3. Value-maximising firms find it optimal to hedge their FX exposure when they issue FX debt. This increases the overall value of the firm;
4. Firms hedge more if (a) the value of tax shields is high and (b) if the deadweight losses arising from bankruptcy are high. If the bankruptcy code is efficient in avoiding deadweight losses, firms hedge less. Firms hedge more if the FX volatility is high, and if the correlation between domestic currency revenues and spot currency exchange rates is negative.

The last proposition connects the bankruptcy code with incentives to hedge. If the continuation value is high enough, the firm would like to hedge. If the bankruptcy code is effective in the sense that the deadweight losses are low, the firms need to hedge less.

4. Cross-country evidence

In this section, we test our optimal hedging hypotheses by first estimating country-level FX exposures from corporate spreads and then exploring the extent to which bankruptcy regimes can explain the cross-country variations in such exposures. Drawing on the capital-asset-pricing models (eg Jorion (1990), and Dominguez and Tesar (2001)), we hypothesise that a part of the risk premium on corporate bonds represents the risk exposure of firms due to the fluctuations in the exchange rate. Our empirical model therefore takes the following form:

$$CS_t^i = \alpha_0 + \alpha_1 ss_t^i + \alpha_2 \Delta e_t^i + \varepsilon_t^i \qquad (5)$$

Where cs is corporate credit spread, ss is a market benchmark, which in our case is represented by the sovereign spread, e is the log exchange rate (a depreciation of the home currency vis-a-vis foreign currency representing a negative change in e) and i is the country subscript.

Corporate debt theory, such as Merton (1974), would suggest that the credit spreads are influenced by firm-specific factors such as (a) leverage; (b) volatility of assets; and (c) debt term to maturity. Since we work with country-level data, in our specification, we are unable to directly control for these important variables.

The coefficients α_1 and α_2 measure the market risk and the residual default risk associated with the exchange rate, respectively. In this setting, the exposure to market risk could arise from two sources: (a) macroeconomic factors that are likely to be correlated with the exchange rate and (b) exogenous changes in the exchange rate that are priced into sovereign spreads. A zero value of α_2 means that the corporate sector has the same exchange rate exposure as the sovereign. Conversely, a rejection of $\alpha_2 = 0$ implies that the corporate sector is exposed to additional exchange rate risk over and above that of the sovereign – a negative sign indicates that the firm has a short FX position so that a depreciation of the exchange rate is associated with an increase in its credit spread.

In the next stage, we explore the extent to which firms' FX exposures are determined by the legal settings of countries in which they are domiciled. Our cross-country regression therefore takes the following form.

$$\hat{a}_{2i} = \eta_0 + \eta_1 cr_i + \eta_2 z_i + \gamma_i \tag{6}$$

Where η_1 measures the response of the estimated exposure to the creditors' rights (cr) while (z) is a set of controls. Our controls include several country-level structural and macroeconomic factors that are likely to be correlated with firms' incentive and ability to hedge, ie the degree of external imbalances (measured by a country's current account deficit as percent of GDP), corporate currency mismatches (FX debt of the non-financial corporate sector as a share of GDP), the depth of hedging markets (bid-ask spreads in FX markets), and the degree of openness (share of exports and imports in GDP), and the growth rate of GDP.

Given that our measure of currency exposure is based on the aggregate corporate spreads rather than firm-level spreads, an important concern is potential bias to the estimate arising from possible reverse causation from spreads to the exchange rate. To the extent that an industry-level shock affects credit quality and exchange rates, our model will not correctly identify exposures. To correct for this endogeneity bias, we employ a 2SLS estimator. Our benchmark model is estimated using 365-day rolling exchange rate returns and spreads based on daily data. We instrument the exchange rate by gold prices and lagged exchange rates.

We estimate exchange rate exposures for 31 EMEs and two advanced Asia-Pacific economies ie Australia and Japan. The corporate bond spread series refer to the JP Morgan corporate emerging market broad bond index (CEMBI), which is a US dollar-based bond index for EM firms. For Japan and Australia, the corresponding series are the iTraxx Japan and iTraxx Australia five-year theoretical indices. Given the focus on dollar debt, we first estimate the model with the bilateral dollar exchange rate and then compare the results with a trade-weighted exchange rate and a debt-weighted exchange rate.

4.1 First-stage results

Several findings stand out from the estimates of FX exposures presented in Tables 1–3. First, as shown in Table 1, the coefficient on the exchange rate is statistically significant in many countries, irrespective of the exchange rate indicators used. In roughly three fifths of the countries in our sample (19 out of 33), the exposure coefficient is negative (first column). This means that, in these countries, a depreciation of the exchange rate against the dollar is associated with a higher probability of corporate default and therefore higher credit spreads. Conversely, in the remaining two fifths of the countries, the coefficient is positive, suggesting that currency depreciation is associated with improved corporate credit quality and lower spreads.

Second, the results appear consistent with our initial hypothesis that the dollar plays a more prominent role than other international currencies in determining the FX exposure of non-financial firms. The middle panel of Table 1 reports the estimates of exposure coefficients using the nominal effective exchange rates (NEER).[2] Of the 26 countries for which the NEER series is available, fewer than half (12 countries) have negative exposures to the dollar, which is considerably lower than the estimate using the bilateral dollar exchange rate. At the same time, replacing the bilateral dollar exchange rate with the NEER weakened the explanatory power of the regression. This is particularly true for China where the R^2 fell from 0.77 to 0.61. In contrast, in the case of Japan, Israel and the Czech Republic, the NEER seems to outperform the bilateral dollar exchange rate in explaining corporate FX exposures.

We also tested the sensitivity of the exposure coefficients using a debt-weighted exchange rate (DWER).[3] As pointed out by Kearns and Patel (2016), the purpose of constructing the DWER is to explore the possibility that there may exist a "financial channel" of the exchange rate, which can act as a potential offset to the trade channel in the sense that a depreciation of the exchange rate reduces GDP growth through tighter financial conditions. Assuming that investors price such risks into bond prices, we can expect to see a tighter link between the DWER and spreads. The main finding is that the introduction of the DWER does not substantially alter the direction of exposure estimated using the bilateral dollar exchange rate. In some cases, however, the introduction of DWER weakened the model's statistical significance.

[2] To the extent that firms hedge their net short dollar positions by running long positions on other international currencies, the bilateral dollar exchange rate can overstate exposures. Moreover, a trade-weighted exchange rate is more appropriate indicator if firms hedge their FX exposure by issuing debt in the currencies in which their exports are invoiced (Kedia and Mozumdar (2003)). On the other hand, as pointed out by Dominguez and Tesar (2001), a trade-weighted exchange rate may lack power if the weights assigned to the currencies in the basket do not correspond to the nature of firms' exposures.

[3] The methodology for computing the DWER is discussed in BIS (2016) and Kearns and Patel (2016). It is constructed as the geometric average of the bilateral exchange rate of a country against each of the five major global currencies (US dollar, euro, Japanese yen, pound sterling and Swiss franc), weighted by the shares of these global funding currencies in that country's foreign currency debt.

Estimated FX exposures

Table 1

	USD		NEER		DWER	
	β_2 coeff.	R^2	β_2 coeff.	R^2	β_2 coeff.	R^2
Australia	–0.64***	0.78	–1.22***	0.79	–0.37	0.77
China	40.13***	0.77	13.32**	0.61	37.41***	0.72
Hong Kong SAR	33.71***	0.85	2.79***	0.85	5.43	0.86
Indonesia	43.49***	0.63	45.20***	0.61	20.65	0.60
India	–4.14***	0.48	–3.37***	0.47	–5.75	0.47
Japan	2.74***	0.34	4.32***	0.45	4.09***	0.36
Korea	–2.01***	0.86	–3.33***	0.88	–1.77	0.90
Malaysia	2.36***	0.72	2.86***	0.71	2.78**	0.75
Philippines	–10.27***	0.59	–8.93***	0.51	–12.25***	0.59
Singapore	–5.53***	0.44	1.39*	0.36	–4.57	0.35
Thailand	4.48***	0.43	–1.20***	0.40	2.83	0.40
Argentina	–10.83***	0.63	–8.97***	0.59	–7.07***	0.80
Brazil	–4.79***	0.91	–5.06***	0.89	–4.37***	0.88
Chile	–2.43***	0.75	–2.72***	0.74	–2.98***	0.77
Colombia	–5.09***	0.47	–5.77***	0.44	–5.51***	0.42
Mexico	1.01***	0.72	–1.60***	0.72	–4.01	0.74
Peru	–2.06***	0.77	3.24***	0.77	–2.94**	0.82
Czech Republic	1.38***	0.16	6.87***	0.45	10.97***	0.56
Hungary	–1.11***	0.91	–0.60**	0.91	–4.00	0.94
Poland	–1.50***	0.78	8.56***	0.79	0.86	0.84
Russia	–0.16	0.86	1.35***	0.87	1.68	0.88
Turkey	0.73***	0.61	1.54***	0.62	3.56	0.72
South Africa	2.90***	0.09	3.73***	0.12	4.00*	0.05
Croatia	1.58***	0.09	6.58***	0.11		
Israel	0.17	0.59	2.79***	0.62	1.02	0.65
Saudi Arabia	–39.13**	0.35	–4.16***	0.38	–0.73	0.35
Dominican Republic	–26.78***	0.05				
Egypt	17.97***	0.13				
Ghana	41.62***	0.65				
Guatemala	–17.61***	0.68				
Jamaica	–7.14***	0.21				
Kazakhstan	–3.11***	0.75				
Ukraine	–35.98***	0.57				

Note: */**/*** indicate the significance at 10%, 5% and 1% level. The table provides estimates of foreign exchange exposures based on the bilateral exchange rate against the US dollar (USD), the nominal effective exchange rate (NEER), and the debt-weighted exchange rate (DWER), using 365-day rolling exchange rate returns. The underlying specification is the 2SLS equation: $CS_t^i = \alpha_0 + \alpha_1 ss_t^i + \alpha_2 * \Delta e_t^i + \varepsilon_t^i$. Business daily data are used for the USD and NEER and quarterly data for the DWER estimation.

Third, the results also illustrate a clear regional pattern in the distribution of FX exposures. To shed further light on this issue, we summarise the direction of exposure of countries in Table 2. The countries are grouped according to whether they have a negative or positive exposure to dollar. Interestingly, most negative coefficients and therefore short dollar positions in EMEs tend to be associated with the non-Asian region. This group includes most countries from Latin America, Africa and the Middle East that tend to run sizeable current account deficits. On the other hand, most positive exposure coefficients and hence long positions on the dollar seem to be

concentrated in Asia (China, Hong Kong SAR, Japan, Indonesia, and Thailand) that have traditionally run current account surpluses. In terms of the magnitude of impact, a 1% depreciation of the RMB against the dollar is associated with a reduction in China's corporate dollar bond index by 40 basis points. The corresponding numbers are 33 basis points for Hong Kong, 43 basis points for Indonesia, and 2–6 basis points for Japan, Malaysia and Thailand.[4]

Direction of corporate FX exposure

Table 2

Bilateral dollar exchange rate	
Negative exposure to depreciation	Positive exposure to depreciation
(1)	(2)
Australia, India, Korea, the Philippines, Singapore, Argentina, Brazil, Chile, Colombia, Peru, Hungary, Poland, Russia, Saudi Arabia, Dominican Republic, Guatemala, Jamaica, Kazakhstan, Ukraine.	China, Hong Kong SAR, Indonesia, Japan, Malaysia, Mexico, Czech Republic, Thailand, Turkey, South Africa, Croatia, Israel, Egypt, Ghana.

Finally, in terms of hedging behaviour, the results suggest that firms are likely to be more sensitive to exchange rate changes at longer horizons than at shorter horizons, as suggested by several previous studies (eg Allayannis (1997) and Bodnar and Wong (2003)). To get at the time-sensitivity issue, we estimated exposure coefficients using exchange rate returns over weekly, monthly, quarterly and half-yearly horizons.[5] The results are summarised in Table 3. Our results are consistent with previous studies that exposures are an increasing function of the horizon of exchange rate returns. This is evident from the fact that the number of significant coefficients at 5% or below increased considerably between seven-day and 90-day returns and somewhat modestly between 90-day and 180-day returns. However, lengthening the exchange rate horizon beyond 180 days does not seem to yield statistically better results. This finding remains unchanged if we judged the model sensitivity by the number of positive and negative significant coefficients rather than by the total number of significant coefficients.

However, expanding the horizon of exchange rate return does seem to change the magnitude of the exposure coefficients, and moreover this effect appears to be asymmetrical for the groups of countries with negative and positive exposures. As can be seen from the bottom rows of Table 3, a lengthening of the return horizon appears to reduce the average value of the exposure for the group of countries that have a positive exposure to the dollar. This reduction seems to be quite substantial, moving from the 180-day return horizon to the 365-day horizon. In contrast, in the group of countries that have negative exposures to the dollar, the average magnitude of exposure is roughly similar for horizon of returns above three months. Such an asymmetry does seem to suggest the possibility that firms with long and short dollar positions may respond differently to exchange rate shocks. While firms with long

[4] At the same time, there are cross-country variations in exposures that cannot be explained by macroeconomic variables alone. For instance, in Mexico, South Africa and Turkey, positive dollar exposure coefficients have been correlated with large current account deficits. On the other hand, in the Philippines and Korea, negative dollar exposures are associated with current account surpluses and a modest corporate FX debt-to-GDP ratio.

[5] As pointed out by Dominguez and Tesar (2006), the time-sensitivity of currency exposures arises because firms may adapt their operational and financial strategies to offset some of the impact of the exchange rate.

dollar positions seem more averse to an appreciation of their home currency at longer horizons, those with short dollar positions do not seem to adjust their positions substantially in response to a sustained depreciation of the exchange rate.

Estimate of FX exposure with different return horizons

Table 3

Number of countries with significant coefficient[3] (<5%)					
	Seven-day	30-day	90-day	180-day	365-day
Number of coefficients:					
USD[1]	21	27	29	32	31
NEER[2]	14	21	21	23	25
Of which have positive coefficients:					
USD[1]	13	15	14	12	13
NEER[2]	8	11	12	14	13
Of which have negative coefficients:					
USD[1]	8	12	15	20	18
NEER[2]	6	10	9	9	12
Simple average of positive coefficients:					
USD[1]	45.44	26.9	22.74	21.3	14.93
NEER[2]	24.06	15.47	13.51	8.84	7.86
Simple average of negative coefficients:					
USD[1]	–25.89	–16.06	–10.17	–9.85	–10.11
NEER[2]	–7.24	–4.61	–4.64	–4.88	–3.91

Notes: [1] 33 countries in total. [2] 26 countries in total. [3]The underlying specification is the 2SLS equation: $cs_t^i = \alpha_0 + \alpha_1 * ss_t^i + \alpha_2 * \Delta e_t^i + \varepsilon_t^i$. Business daily data are used for e_t^i, which changes depending on the return horizon

4.2 Second-stage results

Thus far we have focused on the extent to which corporate spreads provide information on FX exposures. Next we explore the potential determinants of such exposures. Several recent studies provide evidence in favour of the link between creditors' rights and corporate risk-taking. For instance, using country-level data, Acharya et al (2011) show that stronger creditor rights not only incentivise firms to diversify risks through acquisition of other firms but also strengthen their incentive to reduce leverage. On the other hand, using firm-level data for Asian economies, Goyal and Packer (2016) report a positive association between creditors' rights and firm leverage. The authors argue that the positive effects of stronger creditors' rights on credit supply more than compensate for the negative credit demand effects that stem from managers' actions to reduce cash-flow risks to avoid costly bankruptcies.

Among the previous studies that have directly explored the role of bankruptcy laws in firms' decisions to hedge currency risks are Huston and Stevenson (2010) and Lei (2012). Huston and Stevenson (2010) report a strong negative association of creditors rights with country-level FX exposures, which they attribute to creditors being to able to impose ex ante bankruptcy costs on the shareholders, preventing them from undertaking high-risk investment policies. Similarly, Lei (2012) shows that firms' use of derivatives is correlated with property rights and the efficiency in law enforcement, but also suggests that weakly and strongly governed firms may use

derivatives for different reasons. While the former use derivatives for managerial reasons (to reduce mangers' own exposures to losses) the latter may use them for financial reasons, ie having better access to external financing.

Determinants of FX exposure

Table 4

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
RGDP growth rate	1.5	1.35	1.05	1.01	1.15	1.51	1.53	1.27	1.11	0.74	0.79	0.93	1.28	1.32
Degree of openness	0.04	0.05	0.06	0.06	0.07*	0.05	0.04	0.07**	0.09***	0.08**	0.08**	0.09***	0.07*	0.07**
Depth of FX market ('000 units)	2.97***	3.14***	2.25***	2.72***	2.84***	2.86***	2.84***							
Current account balance								–1.04	–1.38*	–0.59	–0.68	–0.86	–0.95	–1
Strength of creditors' legal rights		–1.39*							–1.62**					
Resolving insolvency			–0.25**							–0.33***				
Enforcing contracts				–0.29							–0.27			
Political risk					–0.58**							–0.55**		
Investment profile						–1.02							–0.99	
Corruption							–1.65							–2.52
Constant	0.1	6.97	14.15*	18.16	37.53**	8.27	4.08	2.74	10.36*	21.14**	20.32	38.44*	10.81	8.7
Observations	33	33	32	33	33	33	33	32	32	31	32	32	32	32
Adjusted R-squared	0.17	0.21	0.31	0.21	0.25	0.15	0.15	0.03	0.08	0.23	0.04	0.09	0	0.02

Note: */**/*** indicate the significance at 10%, 5% and 1% level. The dependant variables are the absolute values of the α_2 coefficients obtained from the first stage regression using 365-day rolling exchange rate returns. The specification is: $\alpha_{2,i}=\beta_0+\beta_1 cr_i+\beta_2 z_i+\gamma_i$, where cr_i are different definitions for the creditors' rights explanatory variable; a higher score indicating a greater degree of protection of creditors.

Source: Authors' estimation.

Table 4 presents our cross-country results using estimates of exposures. As suggested by Domingeuz and Tesar (2006), we use absolute exposure coefficients to estimate equation (6) to eliminate the truncation bias that could arise from having positive and negative coefficients in the regression. Our results are consistent with previous studies about the existence of a cross-country negative relationship between the bankruptcy code and the corporate sector currency exposure. The coefficient on the strength of creditors' legal rights is significant in most models. Another factor that seems to matter for FX exposure is the depth of the hedging markets, which enters with a significant positive sign. This suggests that deeper FX markets (lower bid-ask spreads) help to reduce hedging costs, encouraging firms to hedge a larger fraction of their currency exposures. This result is consistent with the proposition developed in our model. The results also confirm that currency exposure is negatively associated with the external current account position but positively associated with the degree of openness, although the relevant coefficients are not consistently significant across all specifications.

We tested the sensitivity of our results by including additional legal institutional variables. In one specification we replaced the strength of the creditors' rights variable with the World Bank's resolving insolvency index and enforcing contract index. In a second specification, we replaced the same variable with the ICRG's political risk indicator, as a proxy for creditor rights, as suggested by Bae and Goyal (2009). In

separate regressions, we also included the subcomponents of political risk, ie the investment profile (contract viability and expropriation risks) and corruption index (the degree of political corruption), to evaluate their distinct role in firms' hedging decisions.

As can be seen from Table 4, the inclusion of new variables did not change our main findings about the importance of the bankruptcy regime. The resolving insolvency variable enters with a significant negative sign, suggesting that the time and costs required to resolve insolvency play an important role in firms' hedging decisions, as suggested by theory. This finding is also validated by the political risk indicators. On the other hand, none of the subcomponents of the political risk index is significant in the model.

5. A quasi-natural experiment

In this section, drawing on the empirical framework developed in Mohanty and Sundaresan (2018), we present the results of an event study analysis based on India's experience with a new bankruptcy law. In May 2016, the Indian Parliament passed the new Insolvency and Bankruptcy Code, 2016, creating for the first time in India a uniform and comprehensive insolvency code for companies and individuals (but excluding the financial firms). An important feature of the new code is that it transfers the right to initiate insolvency resolution from the debtors to the creditors by mandating the establishment of a creditors committee, which must decide the revival or liquidation of a defaulting firm within a period of 180 days, with a maximum grace period of 90 days. This represents a major improvement for the rights of creditors, given the fact that under the earlier regime it took almost 10 years for creditors to receive court judgement on insolvency litigation and about five years to wind up companies or recover debt (Ravi (2015)).

A seemingly related issue in India has been the persistence of a high degree of currency mismatches in the Indian corporate sector. The recent Committee to Review the Access to Domestic and Overseas Capital Markets (2015)[6] by Indian companies attributed the unhedged corporate borrowing problem to the lack of a well developed onshore derivative market and a managed exchange rate regime that provides an implicit guarantee to firms against future fluctuations in the exchange rate. Analysing firm-level data, Patnaik et al (2015) note that, while Indian firms undertaking external commercial borrowing (ECB) were generally large in size and had adequate debt-servicing capacity, they ran the risk of losing a substantial part of their equity in the event of a large depreciation of the exchange rate. A question that has not been explored is the extent to which unhedged foreign currency borrowings in the corporate sector also reflected a deeper, structural problem related to the subordination of creditors' rights in India.

Our analysis is facilitated by a loan-level ECB data base made available to us by the Reserve bank of India, providing information on the terms of each ECB (type of borrowing, maturity, currency, and spread) and whether the borrower intended to hedge the underlying currency and interest rate exposures as well as the instruments

[6] Under the restricted capital account regime of India, external commercial borrowing (ECB) by Indian firms is governed by the Foreign Exchange Management Act of 1999, which is administered by the Reserve Bank of India. The act provides the terms and conditions under which firms can access ECB financing, as well as the maximum spreads to be paid on such borrowing.

used for hedging (whether currency or interest rate swaps). In other words, for each of these loans, the data set refers to the intention of the borrower to hedge but not the actual hedging. We combine a probit model with the differences-in-differences (DID) identification strategy to investigate the effect of the new bankruptcy code on the hedging behaviour of Indian firms. To do this, we divide our sample of firms into terciles according to the share of foreign currency debt in total debt. We define firms in the top tercile with the highest shares of foreign currency debt as the treated group and those in the bottom tercile with the lowest shares of foreign currency debt as the control group. The impact is then studied by comparing the differences in the behaviour of the treated group before and after the introduction of law with differences in the behaviour of the control group.

Our results are summarised in Table 5. We find that, relative to the years before the law change, the probability of the treated group of firms hedging currency exposures increased, particularly when we exclude the state-owned enterprises from the sample, which are likely to be less sensitive to changes in the bankruptcy regime. The likelihood of firms with a high degree of currency mismatch issuing ECB loans on a fully hedged basis went up by 13.7% following the introduction of the new bankruptcy law.

The positive effect of the bankruptcy code on currency hedging decisions is interesting in the context Vig's (2013) paper, which finds a negative impact of the SARFAESI Act[7] on the flow of secured credit. Vig shows that a strengthening of creditors' rights produces an income effect and a substitution effect that can go in opposite directions. The positive income effect arises from the fact that stronger creditors' rights increase the liquidation value of the firm, reducing the costs of borrowing. On the other hand, stronger creditor rights increase the threat of bankruptcy and the probability of premature liquidation, encouraging firms to reduce collateral, with negative effects on the supply of secured credit.

Using the same analogy, our results seem to suggest the operation of a stronger demand channel in the hedging decisions, to the extent that stronger creditors' rights incentivise firms to reduce cash flow risks by hedging a larger fraction of their currency and interest rate exposures. This, in turn, helps them to access cheaper external funding. It is consistent with our theoretical results that value-maximising firms internalise costly bankruptcies (when the law is enforced efficiently) and make a credible commitment to bondholders to preserve the liquidation value in the case of default.

Among other factors, the availability of a natural hedge through export revenue plays a crucial role in the hedging decision. The results suggest that firms that have a larger fraction of their sales in foreign currencies are more likely to issue unhedged loans than those with a lower fraction of FX revenues in total sales. A 1% increase in the exports-to-sales ratio reduces the marginal probability of an ECB loan being issued on currency-hedged basis by 19%. We also find a strong and significant effect of market-to-book value on hedging decisions. Firms that are higher in value do capitalise on that strength by hedging more of their currency and interest rate exposures, which helps them to have better access to the international capital markets. This is consistent with the underinvestment theory of hedging.

[7] The Securitisation and Reconstruction of Financial Assets and Enforcement of Securities Interest Act, passed by the Indian Parliament in 2002, empowered secured creditors (particularly banks) to seize assets in the case of default.

Results of probit model on the effect of bankruptcy law on hedging behaviour of Indian firms (excluding state-owned firms) Table 5

	(1) Curr swap	(2) Int swap	(3) Both swaps	(4) Any swaps
LAW × TREAT	1.914***	0.541	1.728***	1.007*
	(3.38)	(1.06)	(3.20)	(1.83)
	[0.137]	[0.182]	[0.070]	[0.294]
ForCurr2Tot	–1.868	0.846	–2.123	0.647
	(–1.12)	(0.58)	(–1.07)	(0.42)
ExportSales	–0.923***	–0.830***	–1.365***	–0.733**
	(–2.76)	(–2.66)	(–3.88)	(–2.45)
Size	0.040	0.009	0.018	0.039
	(0.84)	(0.20)	(0.34)	(0.85)
Mkt2book	0.974**	1.315***	1.786***	0.739**
	(2.54)	(3.59)	(3.74)	(2.04)
Dividend yield	0.096	0.054	0.143**	0.032
	(1.62)	(0.95)	(2.20)	(0.55)
Leverage	–0.148	0.981	1.267	–0.258
	(–0.19)	(1.34)	(1.50)	(–0.35)
Roa	2.701	3.925**	–0.018	6.097***
	(1.35)	(2.12)	(–0.01)	(3.19)
Const.	4.718***	3.955***	4.594***	3.887***
	(7.16)	(6.31)	(6.82)	(6.15)
Obs	464	464	464	464
Pseudo R-sq	0.159	0.130	0.197	0.136

This model estimates the marginal effect of the new bankruptcy code on hedging intentions, excluding state-owned firms, using a probit model of the following form: $P\left(y_{ijt}=1\right)=\beta_0+\beta_1\tau_t+\beta_2\delta_j+\beta_3 LAW+\beta_4 TREAT+\beta_5\left(LAW\times TREAT\right)+\beta_6 X_{ijt}+\eta_{ijt}$. where y is a binary variable, which takes on the value of one for hedged loans and zero for unhedged loans; y i represents firm-loan observation, j represents industry, t represents time. τ and δ are time and industry fixed effects; LAW is a dummy variable that takes on the value of one for all ECB loans issued after May 2016, that is, when the new bankruptcy law was passed by the Parliament, and zero for loans issued prior to May 2016; $TREAT$ is a dummy that takes on the value of one if the loan belongs to the treated group (issued by firms with a high FX debt to total debt ratio) and zero if it belongs to the control group (firms with a low FX debt ratio); and X is a vector of control variables: *ForCurr2Tot*: FX debt to total liabilities; *ExportSales*: Exports to total sales; *Size*: Total assets; *Mkt2book*: Market capitalisation to enterprise book value; *Dividend yield*; *Leverage*: non current liabilities to total assets; *Roa*: After tax profit to total assets. t-statistics using robust standard errors in parentheses; ***/**/* denotes statistical significance at the 1/5/10% level. Marginal effects of D-I-D are given in the square brackets. State-owned firms have been dropped.

Source: Authors' estimation.

6. Conclusion

Various hypotheses have been proposed to explain the recent large increase in unhedged dollar borrowings by emerging market firms. In this paper, we developed a simple model of a firm with dollarised debt, which produces its revenue in domestic currency. The firm operates under a certain bankruptcy code, which can lead to deadweight losses, and creditor losses upon financial distress. The model developed

several testable propositions, linking the provisions of bankruptcy law, deadweight losses and contract enforcement on the one hand, and the incentive to hedge on the other.

Our empirical results are consistent with the theoretical prediction that corporate credit spreads in emerging markets are informative of the unhedged exposure of the firms domiciled in these economies. This result is robust to different measures of the exchange rate and alternative horizons of exchange rate returns. We also find that the bilateral exchange rates of EMEs against the dollar play a more important role than the trade or debt-weighted exchange rates in determining corporate FX exposures. Our cross-country results confirm the hypothesis that FX exposures are negatively associated with the strength of creditors' rights and the depth of hedging markets.

Our quasi-natural experiment confirms most of the findings of the cross-country investigation. Using a unique loan-level data base from the RBI, we find significant evidence of the positive effects of the new bankruptcy law on Indian firms' incentive to hedge currency and interest rate exposures on their external commercial borrowing. Having said that, we also find evidence that the ownership structure of firms may play a role. To the extent that the state-owned firms dominate the corporate sector, this can undermine the beneficial effects of the new bankruptcy regime on hedging decisions and on resource allocation, more generally, in the economy. In addition, we also find that natural hedging from export revenues plays a clear part in the decision of firms to hedge their FX exposures. Our results are broadly consistent with previous research on the link between legal institutions and the hedging behaviour of non-financial firms (eg Huston and Stevenson (2010) and Lei (2012)).

References

Acharya, V, Y Amihud and L Litov (2011): "Creditors' rights and corporate risk-taking", *Journal of Financial Economics*, vol 102, pp 150-66.

Aghion P, P Bacchetta and A Banerjee (2000): "A simple model of monetary policy and currency crises", *European Economic Review*, vol 44, pp 728–38.

——— (2001): "Currency crises and monetary policy in a credit-constrained economy", *European Economic Review*, vol 45, no 7, pp 1121–50.

Allayannis, G (1997): "The time-variation of the exchange rate exposure: an industry analysis", DSWP 97-20, December.

Bae, K and V Goyal (2009): "Creditor rights, enforcement, and bank loans", *Journal of Finance*, vol 54, no 2, pp 823–59.

Bank for International Settlements (2016): *86th Annual Report*.

——— (2017): *87th Annual Report*.

Bernanke, B and M Gertler (1989): "Agency costs, net worth, and business cycle fluctuations", *American Economic Review*, vol 79, pp 14–31.

Bernanke, B, M Gertler and S Gilchrist (1999): "The financial accelerator in a quantitative business cycle framework", in J Taylor and M Woodford (eds), *Handbook of Macroeconomics*, pp 1341–93.

Bodnar, G and M Wong (2003): "Estimating exchange rate exposures: issues in model structure", *Financial Management*, vol 32, no 1, pp 35–67.

Bruno, V and H S Shin (2017): "Global dollar credit and carry trades: a firm-level analysis", *Review of Financial Studies*, vol 30, no 3.

Chamon, M (2001): "Why can't developing countries borrow from abroad in their own currency?", Harvard University, unpublished manuscript.

Cespedes, L, R Chang and A Velasco (2004): "Balance sheets and exchange rate policy", *American Economic Review*, vol 94, pp 1183–93.

Claessens, S, D Klingebiel and S Schmukler (2007): "Government bonds in domestic and foreign currency: the role of institutional and macroeconomic factors", *Review of International Economics*, vol 15, no 2, pp 370–413.

Djankov, S, C McLiesh and A Shleifer (2007): "Private credit in 129 countries", *Journal of Financial Economics*, vol 84, pp 299–329.

Dominguez, K and L Tesar (2001): "A re-examination of exchange rate exposure", *American Economic Review Papers and Proceedings*, vol 91, pp 2396–99.

——— (2006): "Exchange rate exposure", *Journal of International Economics*, vol 68, no 1, pp 188–218.

Eichengreen, B and R Hausmann (1999): "Exchange rate and financial fragility", *NBER Working Papers*, no 7418.

Goyal, V and F Packer (2016): "Capital structure in Emerging Asia", conference draft, BIS Asian Office Annual Research Conference.

Gertler, M, S Gilchrist and F Natalucci (2007): "External constraints on monetary policy and the financial accelerator", *Journal of Money, Credit and Banking*, vol 39, no 2-3, pp 295–330.

Huston, E and S Stevenson (2010): "Openness, hedging incentives and foreign exchange exposure: a firm-level multi-country study", *Journal of International Business Studies*, vol 41, no 1, pp 105–22.

Jeanne, O (2002): "Monetary policy and liability dollarization", International Monetary Fund, unpublished manuscript.

Jorion, P (1990): "The exchange rate exposure of US multinationals", *Journal of Business*, vol 63, no 3, pp 305–60.

Kearns, J and N Patel (2016): "Does the financial channel of exchange rates offset the trade channel?", *BIS Quarterly Review*, December.

Kedia, S and A Mozumdar (2003): "Foreign currency-denominated debt: an empirical examination", *Journal of Business*, vol 76, no 4, pp 521–46.

La Porta, R, F Lopez-de-Silanes, A Shleifer and R Vishny (1997): Legal determinants of external finance, *Journal of Finance*, vol 52, no 3, pp 1131–50.

Lei, U (2012): "Currency hedging and corporate governance: a cross-country analysis", *Journal of Corporate Finance*, vol 18, no 2, pp 221–37.

Merton, R (1974): "On the pricing of corporate debt: the risk structure of interest rates", *Journal of Finance*, vol 29, no 2, pp 449–70.

Mohanty, M and S Sundaresan (2018): "FX hedging and creditor rights: evidence from an exogenous change in bankruptcy law", *BIS Working Papers*, forthcoming.

Patnaik, I, A Shah and N Singh (2015): "Foreign currency borrowing by Indian firms, towards a new policy framework", Working Paper, International Growth Centre, September.

Rajan, R (2014): "Competitive easing- is it yesterday once more", remarks at the Brookings Institution, Washington DC, 10 April.

Ravi, A (2015): "The Indian insolvency regime in practice – an analysis of insolvency and debt recovery proceedings", Working Paper, Indira Gandhi Institute of Development Research, WP-2015-027, November.

Report of the Committee to Review the Framework of Access to Domestic and Overseas Capital Markets (Phase II, Part II, Foreign Currency Borrowing) (2015): Report III, Ministry of Finance, Government of India, February.

Tirole, J (2003): "Inefficient foreign borrowing: a dual and common-agency perspective", *American Economic Review*, vol 93, no 5, pp 1678–702.

Vig, V (2013): "Access to collateral and corporate debt structure: evidence from a natural experiment", *Journal of Finance*, vol 58, no 3, pp 881–927.

Discussion of M S Mohanty and Suresh Sundaresan's paper

Vidhan K Goyal[1]

Summary

Madhusudan Mohanty and Suresh Sundaresan examine the importance of the legal rights of creditors on a firm's decision to hedge its foreign currency debt. They observe that firms sometimes hedge their foreign currency exposures and sometimes leave them unhedged. While there are a number of potential drivers of a firm's hedging decision, an important driver that has previously not been explored is the strength of the bankruptcy code and the rights of creditors in default. Mohanty and Sundaresan make an important contribution by highlighting the importance of bankruptcy laws to a firm's decision to hedge foreign currency exposures. They present a theoretical model of this choice with clear testable implications and then test the model in two very different empirical settings to show that bankruptcy laws matter for hedging decisions.

Theory tells us that firms should hedge foreign currency debt when bankruptcy is costly. While the motive to hedge foreign currency debt is strong at the time of debt issuance, the subsequent incentives would be to leave it unhedged because once debt is hedged, the default risk of debt goes down and this results in wealth transfers from shareholders to debtholders. Creditors, of course, understand these incentives. They would require higher spreads, shorter loan maturities and more covenants, and they would increase collateral requirements to compensate for the risks that come with unhedged exposures. Thus, not hedging FX debt avoids a wealth transfer from shareholders to creditors, while it also increases the risk of default.

The theoretical model in the paper suggests that, when creditor rights are strong, agency conflicts are smaller and the benefits of hedging will exceed the costs. By contrast, when creditor rights are weak, firms will leave their debt unhedged and offer higher spreads on foreign currency loans. The key testable predictions of the theory are (a) FX exposure will drive credit spreads; (b) FX exposures will be high when the cost of hedging is large; and (c) FX exposures will also be large when incentive conflicts between shareholders and creditors are large. The prediction is that borrowers are more likely to hedge FX debt when creditor rights are strong.

The paper tests the theory in two ways. First, it examines whether aggregate corporate spreads in a country contain information about the unhedged currency exposures of its firms. It shows that that credit spreads respond to exchange rate movements (after controlling for sovereign spread). It then regresses the estimated country-level FX exposures to creditor rights in a country. The results show that unhedged exposures are smaller in countries with strong creditor rights. In other words, firms hedge currency risks when creditor rights are strong. In addition, the depth of foreign exchange markets and the presence of natural hedges (as would be the case for exporting countries) also matter for currency hedging decisions. These are important results as they show that hedging decisions respond to both the costs and the benefits of hedging, with costs including not only the out-of-pocket costs of hedging but also incentive conflicts between shareholders and debtholders.

[1] Professor of Finance, Hong Kong University of Science and Technology.

These cross-country results are supplemented with a quasi-natural experiment around the enactment of the new insolvency and bankruptcy code in India in May 2016, which strengthened creditor rights. This shock to creditor rights is examined in a differences-in-differences setting to test if hedging incentives increased for high foreign currency debt firms (treatment) relative to firms with a low foreign currency debt ratio.

The paper finds a positive relationship between the new bankruptcy code and the probability of currency hedging by firms with a high share of foreign currency debt. The probability that firms with high foreign currency debt will hedge increased significantly after the new bankruptcy law came into effect in India. Among the factors playing a role in hedging decisions, the most important is the availability of a natural hedge through export revenues. Firms with a larger fraction of their sales in foreign currencies are more likely to issue unhedged debt. By contrast, growth opportunities significantly increase the likelihood of hedging currency and interest rate risk.

Comments

Mohanty and Sundaresan present a structural model of a firm with dollarised debt and with revenues produced in the domestic currency. The model yields several testable hypotheses relating a firm's hedging decisions to the legal provisions for bankruptcy, deadweight losses, and contract enforcement. I like the fact that the model, while simple, provides a rich setting to generate several testable predictions on how FX exposures drive credit spreads and how incentives to hedge depend on agency costs between creditors and shareholders and the lack of liquidity in hedging markets. The model yields the key testable prediction that a lack of enforcement of creditor rights can lead to greater FX exposure.

Empirical analysis: cross-country evidence

The rest of my comments focus on the empirical sections. I will start with a discussion of the cross-country evidence and then discuss the quasi-natural setting. As mentioned before, the first stage of the cross-country evidence is to estimate country-by-country regressions of the aggregate corporate spread over the sovereign spread and change in log exchange rates (where negative values imply depreciation of local currency against the foreign currency). The coefficient of interest is the coefficient on the change in exchange rates (FX exposures). If the local currency depreciates, foreign liabilities increase. This reduces a firm's net worth, thereby increasing corporate spreads. Thus, we would expect FX exposures to be negative if the foreign currency liabilities exceed foreign currency assets on corporate balance sheets.

To address the concern that reverse causality or omitted factors may be driving the correlation between corporate spread and exchange rate movements, the paper instruments exchange rate changes by gold prices and lagged exchange rates. The exclusion restriction is that these instruments affect corporate spreads only through contemporaneous exchange rate movements and not directly. However, one could think of gold prices directly correlating with macroeconomic variables that could directly affect spreads. Lagged exchange rates may also be driven by the same omitted factors that drive current exchange rate changes. It is unclear if the lagged value of exchange rates actually helps in isolating the causal effect of exchange rate changes on corporate spreads.

In the first stage results, we notice that about 60% of the countries have negative FX exposure coefficients. This is consistent with a depreciation of local currency increasing the probability of default and hence higher spreads. For the other 40% of cases, the exposure coefficients are positive. In these cases, local currency depreciation improves credit quality and leads to lower spreads. While we would expect this for countries with current account surpluses, the evidence is not so clear, as the exposure coefficients do not seem to be systematically related to the current account-to-GDP ratios. One possible explanation is that the specification is missing some variables that affect both exchange rate movements and corporate spreads. A possibility is that, in some countries, local currency depreciation results in stronger cash flows from export sales but also greater liabilities. The question is whether the effect on liabilities exceeds those on the assets. Thus, it may be appropriate to include additional variables such as the foreign-liabilities-to-GDP ratio and the export-to-sales ratio in the first stage regression.

The second stage is to regress the estimated absolute value of exposure coefficients (which measure the extent to which liabilities and assets remain unhedged) on creditor rights and other variables that affect hedging incentives of firms in a country. The key testable prediction is that hedging should increase with the strength of creditor rights. These results are consistent with the predictions of the model. However, the cross-country evidence presents interpretation challenges because of the omitted variables problem. For example, other country variables (GDP growth rate, for example) could be driving both creditor rights and the benefits and costs of hedging FX exposures.

Empirical analysis: quasi-natural experiment

The second experiment in the paper is to examine the effect of the new insolvency and bankruptcy code introduced in India in May 2016. How does the enactment of the new bankruptcy law, which strengthened creditor rights, change the incentives of affected firms to hedge foreign currency debt? This is an interesting empirical setting in which to examine the effect of creditor rights on such incentives. The paper explores whether the new bankruptcy had a meaningful impact on the propensity to hedge currency and interest rate risk on foreign currency debt. The analysis allows the authors to go deeper into firm-specific factors that affect hedging decisions. It also presents a clear identification strategy to isolate the impact of the change in the law from other institutional and industry-specific factors.

The law could be considered exogenous from the perspective of a firm and one could examine the effect of a shock to creditor rights on hedging decisions in a difference-in-differences setting. Mohanty and Sundaresan also have access to a unique data set from the Reserve Bank of India (RBI) taken from the reports that Indian firms are required to submit to the RBI when seeking approval to issue foreign currency debt. This is loan-level data with details about loans. Importantly, the data include the intention to hedge along with details of the hedging instrument that the firm plans to use.

The challenge with this empirical setting is that the law affected all firms. So, how do we factor out the effect of macroeconomic changes in driving hedging intentions? The strategy adopted in the paper is to classify firms with more foreign currency debt as treatment firms (these firms are expected to increase their hedging of foreign currency debt) and use the low foreign currency debt firms as controls. The difficulty here is that creditor rights became strong for both sets of firms. If intention to hedge

increases due to changes in other macroeconomic variables contemporaneous with the enactment of the new law, and if these macroeconomic factors affected high foreign-currency debt firms more than control firms, then we would naturally expect high foreign currency debt firms to hedge more than low foreign currency debt firms do. While these caveats should be kept in mind in interpreting results, the findings are nevertheless very interesting. We see that the intention to hedge significantly increased for high foreign currency debt firms after the enactment of the law relative to low foreign currency debt firms.

The paper could also examine loan spreads in more detail. The question is whether loan spreads decline when firms decide to hedge their foreign currency debt, all else equal. Once we have a model that determines which firms hedge, then we can use econometric techniques to figure out what the spreads would have been if the firms that actually hedged their foreign currency debt had decided not to hedge. The summary statistics show that yield spreads are higher for debt that is likely to be hedged compared to debt that is not to be hedged. However, this is not a meaningful comparison because of self-selection. It is quite likely that riskier firms are more likely to hedge and that they also have to pay higher spreads. We don't have a counterfactual here since we don't know what the spreads would have been if these firms had decided not to hedge. But, it would be possible to use selection models to make headway on this question.

Conclusion

The paper raises the important research question of why firms keep their foreign currency borrowing unhedged. Many emerging market economy firms do not hedge their dollar borrowing. Is this connected with bankruptcy law provisions, illiquid FX hedging markets, or natural hedges that firms have through their operations? How important are creditors' rights in a firm's decision to hedge? It is important for both academics and policymakers to understand hedging incentives and why currency mismatches exist.

The paper shows how bankruptcy law affects the incentives of firms to hedge currency exposures on their foreign debt. The unhedged exposures affect default risk and hence credit spreads. A contribution of the paper is to show that an important channel through which creditors' rights affect spreads is by affecting the incentives of firms to hedge their foreign currency exposures. This is an important result.

The paper also contributes to the literature on why firms hedge. It provides new results on the importance of FX derivative markets, natural hedges, and growth opportunities on incentives to hedge FX risks. The paper provides an important link between bankruptcy law, incentive conflicts between different claimants, and firms' hedging decisions.

Does the accumulation of foreign currency reserves affect risk-taking? An event study approach

Rasmus Fatum and James Yetman[1]

Abstract

Fatum and Yetman (2017) assess whether foreign currency reserves accumulation in the Asia-Pacific region is systematically associated with risk-taking, using an event study approach to examine the responses of various proxies of risk-taking to official announcements of reserves stocks. Across a wide range of specifications and robustness checks, we find little evidence that reserves accumulation has a significant influence on risk-taking.

Keywords: foreign exchange reserves, risk-taking, implied volatility, credit default swaps.

JEL classifications: F31, G15.

[1] Fatum: School of Business, University of Alberta, Edmonton, Alberta, Canada T6G 2R6, rasmus.fatum@ualberta.ca; Yetman: Bank for International Settlements, Representative Office for Asia and the Pacific, 78th Floor, Two IFC, 8 Finance Street, Central, Hong Kong, james.yetman@bis.org. Fatum is also Research Associate at the Federal Reserve Bank of Dallas, and gratefully acknowledges financial support from a Foote Professorship in International Business. The views expressed in this paper are those of the authors and do not necessarily reflect those of the Bank for International Settlements. We thank, without implication, participants at the HKMA-BIS conference on "The price, real and financial effects of exchange rates", a BIS workshop and Bank of Thailand-PIER seminar, as well as Hans Genberg, Christian Upper and Giorgio Valente for helpful comments. Anamaria Illes provided excellent research assistance. Any remaining errors are solely attributable to the authors.

1. Introduction

The massive accumulation of foreign currency reserves across economies in the Asia-Pacific region is now well known, and the cost of holding large stocks of foreign exchange reserves has been extensively discussed.[2] In this paper, we summarise our work (Fatum and Yetman (2017)), which seeks to add to the discussion by assessing whether reserves accumulation in the Asia-Pacific region is systematically associated with changes in private sector risk-taking within the economy where the accumulation is taking place.[3]

To motivate the importance of this research, suppose that a central bank were to accumulate foreign exchange reserves for the purpose of being able to provide emergency foreign currency funding in the event of significant financial stress. If the act of accumulating, or holding, a large stock of reserves had the effect of encouraging greater risk-taking, then this would work against the intended purpose of the accumulation: the very act of holding those reserves would increase the likelihood that they would need to be deployed at some point. The alternative scenario – where reserves accumulation does not have such undesirable side effects – would support the view that reserves stocks can be used to provide meaningful insurance against shocks. In either case, the results would have important implications for central bank policies, to be considered along with all the existing discussion surrounding the trade-offs of holding foreign currency reserves.[4]

To address this research question, Fatum and Yetman (2017) carry out a country-specific daily data event study analysis of whether official announcements of reserves stocks influence risk-taking. We focus on 10 Asia-Pacific economies (Australia, China, Hong Kong SAR, Indonesia, Japan, Korea, Malaysia, the Philippines, Singapore and Thailand) over a sample period beginning in the early-mid 2000s (depending on data availability for each economy) until approximately the end of 2016.

Our primary proxy for risk-taking is the implied volatility of out-of-the-money currency options, both calls and puts, at two different horizons (one month and 12 months). We also consider other, less direct, proxies (CDS spreads on sovereign US dollar-denominated bonds and equity price indices).

Events are defined as the announcement relative to some alternative, which would ideally represent market expectations of the announcement. Where expectations are available, we utilise these. But generally they are not available. Therefore we consider both the prior announcement and projected reserves (from a simple projection model) as alternatives to compare reserves announcements against.

Our baseline results, as well those from a large set of robustness analyses, suggest that reserves accumulation does not exert a significant influence on risk-taking. We therefore conclude that, while excessive reserves accumulation might be

[2] See, for example, Filardo and Yetman (2012) and Park and Estrada (2009).

[3] We use the term "risk-taking" to mean the willingness to take on currency risk. We do not attempt to distinguish between whether a change in risk-taking is because of changed expectations about the direction of the exchange rate, the expected volatility of the exchange rate or the associated risk premium.

[4] See ECB (2006) for an excellent overview of the more traditional costs associated with large foreign currency reserves holdings.

costly for reasons already acknowledged in the literature, any additional indirect costs via a risk-taking channel are likely to be small.

The rest of this summary is organised as follows. Section 2 outlines the macroeconomic context of the study and summarises previous studies of particular relevance. Section 3 details the empirical methodology and describes the data. Section 4 presents the results. Section 5 concludes.

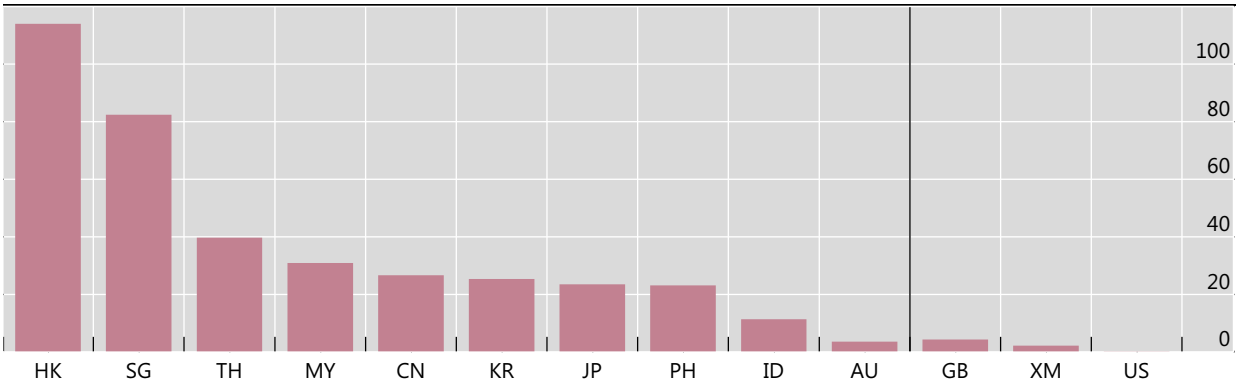
2. Context and previous results

2.1 Macroeconomic context

Underlying this research question about the possible effects of a build-up of foreign exchange reserves on risk-taking is the massive stocks of reserves across economies in the Asia-Pacific region. Graph 1 displays total foreign exchange reserves as a share of GDP for 10 major Asia-Pacific economies that Fatum and Yetman (2017) study and, for comparison, for three major economies from outside the region, as of the end of 2016. What is clear from the graph is that reserves in the region are large, in both absolute and relative terms. They exceed 20% of GDP for eight regional economies, and are more than 80% of GDP for Singapore and Hong Kong.

Foreign exchange reserves

2016 Q4, as a percentage of nominal annualised GDP — Graph 1



AU= Australia; CN = China; GB = United Kingdom; HK = Hong Kong SAR; ID = Indonesia; JP = Japan; KR = Korea; MY = Malaysia; PH = Philippines; SG = Singapore; TH = Thailand; US = United States; XM = euro area.

Sources: CEIC; Datastream; IMF, *International Financial Statistics*; national data.

Another remarkable feature of the Asian reserves data is the importance of foreign exchange reserves' growth in accounting for changes in the overall size of central bank balance sheets. For many regional economies, foreign exchange reserves growth is responsible for virtually all of the increase in balance sheet size in the region over the past decade, but very little of it for those same economies from other regions displayed above (Graph 2).

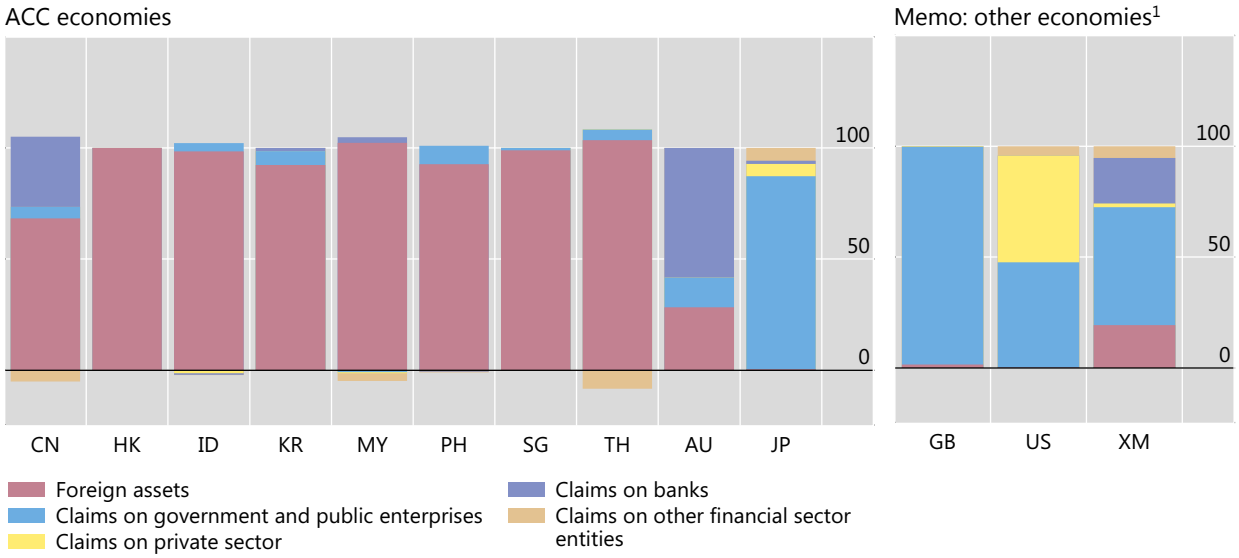
Our research question is whether this accumulation of reserves might have had unintended consequences on private sector risk-taking. High levels of reserves may be perceived to reduce the cost of currency mismatches, for example if market participants view reserves as providing a form of insurance, since the central bank can use them to stabilise exchange rates in the event of sharp depreciation pressures. This

could increase the willingness by market participants to take on unhedged foreign currency liabilities on their balance sheets.

A circumstance where reserves may seem particularly likely to encourage such risk-taking is where the central bank has used reserves to act as a provider-of-foreign-currency-liquidity-of-last-resort in the past, and may therefore be expected to do so again in future. For example, many central banks used either their own reserves or the proceeds of swaps with the US Federal Reserve or other central banks during the 2007–09 crisis to alleviate dislocations in FX markets (Jara et al (2009); Baba and Shim (2014)).[5]

Change in the composition of central bank assets in ACC economies, 2006–16

As a percentage of change in total assets — Graph 2



AU = Australia; CN = China; GB = United Kingdom; HK = Hong Kong SAR; ID = Indonesia; JP = Japan; KR = Korea; MY = Malaysia; PH = Philippines; SG = Singapore; TH = Thailand; US = United States; XM = euro area.

[1] For United Kingdom, *net* claims on central government instead of claims on government and public enterprises.

Source: IMF, *International Financial Statistics*.

2.2 Existing evidence

Fatum and Yetman (2017) build on existing literature modelling and documenting possible links between reserves accumulation and risk-taking. For example, Chutasripanich and Yetman (2015) use simulations of a simple model to illustrate how intervention intended to limit exchange rate volatility can increase the level of speculative activity of risk-averse speculators, and may hence be counterproductive. Caballero and Krishnamurthy (2000) show that reserves accumulation, and associated sterilisation operations, can have important (and perhaps counterproductive) effects on capital flows and risks. Caballero and Krishnamurthy (2004) argue that foreign

[5] Baba and Shim (2010, 2014) find that, in the case of Korea, auctioning off the proceeds of swaps with the US Federal Reserve was more effective than the use of own reserves in alleviating currency market dislocations, and postulate that this may be because the former did not result in a reduction in the level of reserves, and hence did not reduce market confidence.

exchange intervention policies limit the development of domestic financial markets and so contribute to the underinsurance of foreign currency risks. Burnside et al (2004) illustrate how implicit guarantees to banks' foreign creditors (which reserves can be used to provide) can be a root cause of self-fulfilling twin banking-currency crises. The existence of the guarantees encourages banks to take unhedged foreign currency exposures, and to then renege on these in the event of an exchange rate devaluation.

In terms of empirical evidence, Cook and Yetman (2012) report that higher foreign exchange reserves appear to provide banks with insurance against exchange rate shocks, in that their equity prices become less sensitive to exchange rate movements. Sengupta (2010) finds that reserves accumulation appears to lead to greater currency risk-taking (in terms of a higher level of dollar-denominated debt) in the corporate sector in Latin America based on data for 1,500 firms in six Latin American economies. In contrast, Berkman and Cavallo (2009) report mixed evidence of the direction of causality: while economies with high levels of liability dollarisation tend to have more active exchange rate stabilisation operations, floating exchange rates do not result in de-dollarisation in their sample. Meanwhile Ismailescu and Phillips (2015) find that high levels of foreign exchange reserves are associated with less trading of sovereign CDS in a sample of 41 countries, which could reflect less efforts being taken to insure against currency risks. Relatedly, Amstad and Packer (2015) report a positive relationship between the stock of foreign exchange reserves in Asian economies and credit ratings on foreign currency debt, which may be expected to translate into a lower cost of taking on foreign currency exposures for many borrowers.

The increase in risk-taking could, in principle, lie in the countries who are the recipients of the reserves flows rather than in the source, especially if reserves accumulation influences asset prices. The reserves are held in terms of foreign currency-denominated assets and this could depress interest rates elsewhere, encouraging increased risk-taking. Along this line, Gerlach-Kristen et al (2016) report that, during the 2003–04 period, official Japanese purchases of foreign exchange appear to have lowered long-term interest rates in the United States and, to a lesser extent, in other major advanced economies (including Japan) as well. However, the question of any effects outside of the accumulating economy is beyond the scope of Fatum and Yetman (2017).

3. Empirical methodology

The research question could be addressed in different ways. One possibility would be to include the stock of reserves in an otherwise well specified empirical model, and test to see if the reserves stocks have any significant effect on macroeconomic variables of interest (GDP, inflation, investment etc) at some horizon based on typical macroeconomic frequencies (quarterly or annual). We first examined this possibility, but found that the results were inconclusive. This was not completely surprising, given that reserves stocks are a slow-moving series and any effect is likely to be buried within all the other shocks and propagation processes affecting the economy.

An event study involves taking a complementary approach. It entails asking about a very short-term effect of a very specific event. Because of the high frequency, evidence of an effect is typically sought from financial market variables that might be directly affected. These may be proxies for the effect one is seeking to identify. A

change in the market price that coincides with the event is assumed to be driven primarily by the event, rather than other factors. The narrower the event window within which the effect is measured, the more likely this is to be the case. Given a sufficiently large number of events, event studies can have very high power to test hypotheses about the effects of the events.

In order to perform an event study, it is important to ensure that the timing of the event variable and response variable are correctly aligned, especially when financial market data are being drawn from different markets with varying opening and closing times, and some markets may be affected by daylight-saving time. In some cases, using daily frequency data (as in Fatum and Yetman (2017)) data for either the announcements or the response variables may need to be lagged by one day to ensure that the data are correctly synchronised.

In the context of the effects of reserves on risk-taking, one concern is that any correlation might reflect reverse causality: central banks increasing reserves in response to growing risk-taking activity. An event study is an effective way to address this concern, for three related reasons. First, it looks at the effects around the time of the announcement of reserves, rather than when any associated intervention in foreign exchange markets takes place, so any direct effects of central bank actions on proxies of risk-taking are likely to have occurred outside of the event windows. Second, if there was some common factor that was fuelling a change in our risk-taking measure and the change in reserves, this is unlikely to occur just at the time of the announcement. Third, for most tests it is possible to compare the behaviour of a variable in a pre-event window with a post-event window, which reduces the effect of any conflating factors that affect both windows – which is analogous to the use of fixed effects in panel regression contexts.

One important channel through which foreign exchange reserves may influence risk-taking is by reducing the perceived risks associated with exchange rate exposures. In that case, we would expect the cost of insuring against exchange rate changes to vary systematically with changes in the known level of foreign exchange reserves. Fatum and Yetman (2017) thus use the cost of insuring against exchange rate changes vis-à-vis the US dollar as a measure of risk-taking. We consider four measures of this: the implied volatility of each of calls and puts, at one-month and 12-month horizons. The precise measures used are based on 25-delta options which are out-of-the-money, to the extent that a given change in the exchange rate results in approximately 25% of that change in the value of the options. The implied volatility of currency options have previously been used to consider the effects of central bank foreign exchange intervention, including in Bonser-Neil and Tanner (1996) and Disyatat and Galati (2007).

One feature of the analysis is the examination of the implied volatility of calls and puts separately since, depending on the mechanism at work, one could expect to see a different link between either and risk-taking. Calls may be used to insure against exchange rate appreciation, and puts to insure against exchange rate depreciation. The implied volatility is a measure of the cost of taking out such insurance. On the one hand, if an increase in the level of reserves is perceived to reduce the risk of a large exchange rate depreciation more than appreciation, since the central bank can use those reserves to counter depreciation pressures, we might expect to find a stronger link between reserves and the implied volatility of puts than calls. On the other hand, if an increase in the level of reserves is thought to reflect active intervention to prevent exchange rate appreciation, and this pattern of intervention

is expected to persist into the future, then this may act as a bound on expected appreciation risks and so reduce the cost of insuring against appreciations more than it does the cost of depreciations. In that case, the link between reserves and the implied volatility of calls may be stronger than that of puts.

Fatum and Yetman (2017) consider four different tests of the effects of reserves on risk-taking, following the approach taken in Fatum (2000) and Fatum and Hutchison (2003). The first is the direction criterion test, which assesses if the response variable (the proxy for risk-taking) moves in the direction consistent with the reserves announcement during the post-event window. The null hypothesis for this test is that reserves have no influence on risk-taking. Thus the probability of observing an event consistent with the direction criterion is the same as observing an event that is not consistent with the direction criterion. That is, under the null hypothesis, the probability of either outcome is 0.5. The test essentially counts up the number of events that go the "right" way and compares that with the number that would be expected if the probability for each one was 50%. The probability density function and cumulative density function for this test are based on the binomial distribution.

The second test is the reversal criterion test, which focuses on the subset of events where the announcement goes in the direction opposite to what might have been expected, based on the direction of the response variable in the pre-event window. The number of successes in this test is the number of such events where the direction changes in the post-event window. For example, if risk-taking declines in the pre-event window and the reserves announcement indicates an increase in reserves, we would record a success if risk-taking rises in the post-event window. In this case, the number of successes is compared with the proportion of changes in direction between pre- and post-windows around non-events.

The third test is the smoothing criterion test, which is a less stringent version of the second test. Here, an event is recorded as a success if, in the post-event window, the response variable moves in the direction predicted by the reserves announcement, without it necessarily changing direction. So, if the measure of risk-taking in the pre-event window increased, and then the reserves announcement was positive, did risk-taking increase by less or decline in the post-event window (a success) or increase by more (a failure)? Again, this is compared with the analogue constructed from windows around periods when there are no events.

Finally, a fourth test, the information criterion, assesses whether reserves announcements have any information content at all. If they do, then the absolute size of the change in the measure of risk-taking in the post-event window should be larger than in the pre-event window. But, if they do not, then an increase in the absolute size of the change should be no more likely than a decrease. As with all the other tests, the evidence can be assessed against the binomial distribution.

4. Results

Table 1 contains the baseline results from Fatum and Yetman (2017), based on two-day windows where the event (the announcement of reserves) falls in the first day of the post-event window (except for one-day windows for Thailand, due to the very high frequency of announcements) and the announcement is measured relative to the previous announcement. We conduct the tests outlined in the above section for each economy, one at a time. As is conventional, asterisks indicate statistical significance at the 5% (**) or 1% (***) level.

The key thing to note is the lack of statistically significant results. Indeed, across 160 tests in all, there are a total of only five rejections of the null hypothesis based on 5% critical values, which is below the level of rejections that one would expect by chance in the event that there is no relationship at all, simply due to Type I errors.

Fatum and Yetman (2017) then go on to try many variations on the event study, and report essentially the same results in each case. We vary the window length (one, two or three days), whether the event falls in the first day of the post-event window or between the two windows, examine CDS spreads and equity prices, measure the announcement relative to either market expectations or projected reserves, test the opposite results (that reserves reduce rather than increase risk-taking), focus on the post-crisis period, split the sample based on the direction of change of either the exchange rate or reserves, or the size of the change in reserves, and run event regressions.

The greatest evidence for a positive effect of reserves accumulation on risk-taking comes from sovereign CDS spreads: the overall rejection rate at the 5% level is around 13%. However, CDS spreads are a very indirect measure of currency risk-taking, and may be affected by other factors, such as fiscal solvency. Across all the other robustness checks we examine, we get the same essential results as reported above for the base results.

One particularly intriguing set of results comes from reversing the hypotheses, and testing whether reserves accumulation reduces risk-taking. Here we actually find more evidence in favour of the opposite hypotheses than for the original ones.

Baseline results from Fatum and Yetman (2017): implied volatility, two-day windows Table 1

		Implied vol 1-month call		Implied vol 1-month put		Implied vol 12-month call		Implied vol 12-month put		Implied vol 1-month call		Implied vol 1-month put		Implied vol 12-month call		Implied vol 12-month put	
		Events	Non	Events	Non	Events	Non	Events	Non	Events	Non	Events	Non	Events	Non	Events	Non
Test		**Australia**								**China**							
1	Yes	67		69		67		67		24		26		28		26	
	No	51		48		50		50		35		33		30		32	
	p-val	0.08		0.03 **		0.07		0.07		0.94		0.85		0.65		0.82	
2	Yes	33	1462	32	1374	30	1292	26	1259	14	1467	16	1469	16	1432	13	1459
	No	21	1255	21	1566	21	1425	26	1458	14	1541	14	1539	16	1576	20	1549
	p-val	0.17		0.19		0.07		0.35		0.52		0.38		0.46		0.89	
3	Yes	43	2084	42	2073	43	1979	37	1969	22	2222	24	2237	26	2196	22	2203
	No	11	614	11	623	8	651	15	672	6	693	6	671	6	678	11	666
	p-val	0.41		0.42		0.09		0.77		0.49		0.44		0.34		0.94	
4	Yes	58		56		55		60		26		28		25		31	
	No	62		64		64		60		33		31		33		26	
	p-val	0.68		0.79		0.82		0.54		0.85		0.70		0.88		0.30	
Test		**Hong Kong**								**Indonesia**							
1	Yes	73		73		68		76		78		82		79		81	
	No	62		62		68		60		75		71		73		71	
	p-val	0.20		0.20		0.53		0.10		0.44		0.21		0.34		0.23	
2	Yes	37	1199	37	1202	31	1160	33	1169	27	986	33	1058	31	1012	38	1062
	No	30	1358	34	1355	43	1397	38	1388	29	1227	28	1155	32	1202	34	1152
	p-val	0.11		0.23		0.76		0.49		0.34		0.20		0.33		0.24	
3	Yes	56	1808	52	1801	59	1784	56	1795	43	1538	48	1589	45	1559	59	1567
	No	11	449	19	464	15	470	15	463	13	522	13	467	18	488	13	480
	p-val	0.30		0.92		0.52		0.62		0.43		0.47		0.85		0.17	
4	Yes	76		72		67		75		80		79		82		72	
	No	67		72		80		71		65		66		63		72	
	p-val	0.25		0.53		0.88		0.40		0.12		0.16		0.07		0.53	
Test		**Japan**								**Korea**							
1	Yes	78		79		72		71		76		73		75		75	
	No	70		68		78		78		68		72		69		72	
	p-val	0.28		0.21		0.72		0.74		0.28		0.50		0.34		0.43	
2	Yes	29	1367	32	1332	25	1228	25	1194	27	1177	33	1216	37	1116	42	1142
	No	35	1187	37	1222	35	1326	40	1360	41	1380	43	1341	29	1442	32	1416
	p-val	0.93		0.99		0.87		0.93		0.88		0.80		0.03 **		0.02 **	
3	Yes	46	1940	41	1928	45	1866	41	1856	46	1860	50	1884	51	1809	58	1830
	No	18	594	18	600	15	614	24	624	22	629	26	610	15	635	16	612
	p-val	0.85		0.91		0.59		0.99		0.93		0.98		0.33		0.30	
4	Yes	81		75		73		80		77		82		76		86	
	No	70		77		75		71		72		67		67		59	
	p-val	0.21		0.60		0.60		0.26		0.37		0.13		0.25		0.02 **	

Notes: Day of event included in post-event window. Columns labelled "Non" display the number of non-events used in tests 2 and 3. Only non-overlapping events/non-events are included. Results for Thailand are based on one-day windows due to the small number of non-overlapping two-day events. **/*** denote rejection of null hypothesis of no increase in risk-taking at 95/99% levels of significance.

Baseline results from Fatum and Yetman (2017): implied volatility, two-day windows (cont)

Table 1

		Implied vol 1-month call		Implied vol 1-month put		Implied vol 12-month call		Implied vol 12-month put		Implied vol 1-month call		Implied vol 1-month put		Implied vol 12-month call		Implied vol 12-month put	
		Events	Non	Events	Non	Events	Non	Events	Non	Events	Non	Events	Non	Events	Non	Events	Non
Test		**Malaysia**								**Philippines**							
1	Yes	97		105		99		98		53		52		51		51	
	No	113		105		111		113		63		64		62		61	
	p-val	0.88		0.53		0.82		0.87		0.85		0.89		0.87		0.85	
2	Yes	44	643	50	649	38	631	44	650	23	1012	21	1036	20	970	22	1014
	No	54	805	51	799	63	818	58	799	32	1492	31	1468	35	1534	32	1490
	p-val	0.50		0.20		0.90		0.67		0.47		0.61		0.69		0.54	
3	Yes	69	1020	73	1024	64	1024	69	1033	35	1614	33	1617	38	1606	36	1642
	No	29	349	28	345	37	332	33	323	20	501	19	497	17	457	18	417
	p-val	0.85		0.76		1.00		0.98		0.99		0.99		0.95		0.99	
4	Yes	122		127		124		127		69		64		64		67	
	No	115		110		115		112		54		59		57		54	
	p-val	0.35		0.15		0.30		0.18		0.10		0.36		0.29		0.14	
Test		**Singapore**								**Thailand**							
1	Yes	78		76		75		72		313		309		315		314	
	No	62		64		68		68		298		302		286		284	
	p-val	0.10		0.18		0.31		0.40		0.29		0.40		0.13		0.12	
2	Yes	27	1226	30	1229	32	1174	27	1152	152	689	150	681	162	694	160	723
	No	34	1343	33	1340	40	1395	40	1417	151	641	150	649	116	637	120	608
	p-val	0.75		0.56		0.63		0.81		0.74		0.68		0.02 **		0.19	
3	Yes	46	1865	51	1881	53	1843	46	1862	227	1003	221	987	231	973	228	999
	No	15	607	12	591	19	568	21	540	76	223	79	242	47	229	52	200
	p-val	0.57		0.23		0.76		0.97		1.00		1.00		0.20		0.82	
4	Yes	78		78		77		79		306		311		284		288	
	No	70		71		69		66		307		304		325		322	
	p-val	0.28		0.31		0.28		0.16		0.53		0.40		0.96		0.92	

Notes: Day of event included in post-event window. Columns labelled "Non" display the number of non-events used in tests 2 and 3. Only non-overlapping events/non-events are included. Results for Thailand are based on one-day windows due to the small number of non-overlapping two-day events. **/*** denote rejection of null hypothesis of no increase in risk-taking at 95/99% levels of significance.

5. Conclusion

In this paper, we have summarised our work in Fatum and Yetman (2017), where we carried out a country-specific daily data event study analysis of whether official announcements of reserves stocks influence risk-taking in the Asia-Pacific region. Our main risk-taking proxy measure was the implied volatility of currency options. Our results suggest that there is no large effect of reserves accumulation on risk-taking.

There are a number of takeaways for central banks from this work. First, conventional assessments of the costs and benefits of reserves holdings are not missing an important link between reserves and risk-taking that would have the effect of reducing the benefits from holding reserves. Second, if the accumulation of reserves did not materially increase risk-taking, then a reduction in the rate of accumulation – as has been seen in many economies in recent years – may be expected to have relatively benign effects too. Third, but more speculatively, even a substantial decline in reserves in future might be expected to have limited effects on risk-taking as well.

Although the findings are based on negative results, in the sense that there was insufficient evidence to reject the absence of any relationship between reserves

accumulation and risk-taking, they are based on numerous tests across multiple specifications and many robustness checks, as well as several different risk-taking measures.

But any such empirical study has limitations. For example, Fatum and Yetman (2017) focused on windows defined in terms of a one- to three-day span, due to data availability. Perhaps that is too long, and misses an immediate market response that dissipates over the trading day. Or perhaps it is too short, and the effects take longer to register in implied volatilities, in which case an event study may be a less-than-ideal tool to identify an effect.

Another possibility is that there are sectoral effects that are masked by looking at implied volatility, which is a market price. For example, Cook and Yetman (2012) found that bank equities are less affected by exchange rate changes the larger is the stock of foreign currency reserves. Suppose increased reserves increased risk-taking by banks, but that this was either offset by decreased risk-taking elsewhere or masked by a lack of change in other sectors of the economy. Given the crucial role of the banking sector in the economy, such a change in the sectoral composition of overall risk-taking would be of first-order importance for policymakers, even if there were no effect on the market price of risk.

References

Amstad, M and F Packer (2015): "Sovereign ratings of advanced and emerging economies after the crisis", *BIS Quarterly Review*, December, pp 77–91.

Baba, N and I Shim (2010): "Policy responses to dislocations in the FX swap market: the experience of Korea", *BIS Quarterly Review*, June, pp 29–39.

——— (2014): "Dislocations in the won-dollar swap markets during the crisis of 2007–2009", *International Journal of Finance and Economics*, vol 19, no 4, pp 279–302.

Berkman, A and E Cavallo (2009): "Exchange rate policy and liability dollarization: what do the data reveal about causality?", *IMF Working Paper*, no 07/33.

Bonser-Neil, C and G Tanner (1996): "Central bank intervention and the volatility of foreign exchange rates: evidence from the options market", *Journal of International Money and Finance*, vol 15, no 6, pp 853–78.

Burnside, C, M Eichenbaum and S Rebelo (2004): "Government guarantees and self-fulfilling speculative attacks", *Journal of Economic Theory*, vol 119, no 1, pp 31–63.

Caballero, R and A Krishnamurthy (2000): "International liquidity management: sterilization policy in illiquid financial markets", *NBER Working Paper*, no 7740.

——— (2004): "Smoothing sudden stops", *Journal of Economic Theory*, vol 119, no 1, pp 104–27.

Chutasripanich, N and J Yetman (2015): "Foreign exchange intervention: strategies and effectiveness", *BIS Working Papers*, no 499.

Cook, D and J Yetman (2012): "Expanding central bank balance sheets in emerging Asia: a compendium of risks and some evidence", in "Are central bank balance sheets in Asia too large?", *BIS Papers*, no 66, pp 30–75.

Disyatat, P and G Galati (2007): "The effectiveness of foreign exchange intervention in emerging market countries: evidence from the Czech koruna", *Journal of International Money and Finance*, vol 26, no 3, pp 383–402.

ECB (2006): "The accumulation of foreign reserves", *Occasional Paper Series*, no 43.

Fatum, R (2000): "On the effectiveness of sterilized foreign exchange intervention", *European Central Bank Working Paper* no 10.

Fatum, R, and M Hutchison (2003): "Is sterilized foreign exchange intervention effective after all? An event study approach", *Economic Journal*, vol 113, no 487, pp 390–411.

Fatum, R and J Yetman (2017): "Accumulation of foreign currency reserves and risk-taking", *BIS Working Papers*, forthcoming.

Filardo, A and J Yetman (2012): "The expansion of central bank balance sheets in emerging Asia: what are the risks?" *BIS Quarterly Review*, June, pp 47–63.

Gerlach-Kristen, P, R McCauley and K Ueda (2016): "Currency intervention and the global portfolio balance effect: Japanese lessons", *Journal of the Japanese and International Economies*, vol 39, pp 1–16.

Ismailescu, I and B Phillips (2015): "Credit default swaps and the market for sovereign debt", *Journal of Banking and Finance*, vol 52, pp 43–61.

Jara, A, R Moreno and C Tovar (2009): "The global crisis and Latin America: financial impact and policy responses", *BIS Quarterly Review*, June, pp 53–68.

Park, D and G Estrada (2009): "Are developing Asia's foreign exchange reserves excessive? An empirical investigation", *ADB Economics Working Paper*, no 170.

Sengupta, R (2010): "Does reserve accumulation lead to higher currency-risk taking in the corporate sector? Firm-level evidence for Latin America", *Santa Cruz Institute for International Economics Working Paper*, no 11-08.

Discussion of Rasmus Fatum and James Yetman's paper

Hans Genberg[1]

The objective of the paper by Fatum and Yetman (F-Y hereafter) is to provide empirical evidence on whether the accumulation of international reserves by the central bank will lead to increased risk-taking by the private sector.

Why might such risk-taking come about? To the extent that international reserves provide free insurance to domestic economic agents against the risk of not being able to secure foreign exchange in the market during a crisis, the resulting moral hazard environment may lead these agents to accumulate more risk.

Such an outcome was debated in Sweden during the Great Financial Crisis. At one point the Riksbank borrowed international US dollar reserves to provide dollar liquidity to Swedish commercial banks, which had accumulated foreign currency exposures that they could not cover in the interbank market when this market froze during the early stages of the crisis. The then Deputy Governor Lars Nyberg pointed out that this amounted to a subsidy to the banks: "This cost is essentially an insurance premium, in which the banks are the insured party and in which the general public has so far paid the premium."[2] Note that in this episode it seems that commercial banks' foreign exchange exposures were build up in anticipation of bailouts by the Riksbank. In other words, risk-taking took place before the accumulation of reserves, but it nevertheless hints at a possible link between official international reserve holdings and risk-taking in the private sector. Hence the importance of the undertaking by F-Y in this paper.

To study the possible links between reserve accumulation and risk-taking, the authors adopt an event-study methodology whereby "events" are defined as days when changes in official international reserves are announced, and the empirical tests are based on comparing the value of indicators of risk-taking immediately before the event with their value immediately after the event. A systematic increase in the indicator of risk-taking after an announcement of an increase in international would suggest a causal relationship.

After a very thorough search using various proxies for risk-taking and conducting numerous robustness checks F-Y fail to find a robust and systematic relationship between reserve accumulation and their proxies for risk-taking. What can explain their results?

One possible explanation would be: because there is no relationship.

Could there, however, be another explanation for the inability of the empirical tests to discover a relationship between official international reserves and private sector risk-taking? I will propose six possibilities that could be the basis for further empirical exploration, five of which relate to the measurement of reserve accumulation, and one which suggests a slight modification of the indicator of risk-taking.

[1] The SEACEN Centre.

[2] Speech given on 17 May 2011 and accessed from http://www.riksbank.se/Upload/Dokument_riksbank/Kat_publicerat/Tal/2011/110517e.pdf.

Possible reasons for a lack of relationship, and some suggestions for extending the empirical tests

1. Does adding to "excessive" reserves provide additional insurance. Are there diminishing marginal effects?

Consider a central bank that has already accumulated a stock of reserves large enough to provide insurance against considerable risk-taking in the private sector. Would the accumulation of additional reserves lead to additional risk-taking of the same marginal magnitude, or might there be diminishing (or, alternatively, increasing) marginal impact? To test for this possibility, one could interact the variable indication that reserve accumulation has taken place with the size of the existing stock of reserves.

2. Dealing with traditional reasons for accumulating reserves

Traditionally authorities are thought to accumulate reserves to cover risks associated with exposure to fluctuations in trade or the access to international capital markets. This has led to defining reserve adequacy in terms of import cover (conventionally expressed as a minimum of three months) or in relation to the size of short-term external debt (the Greenspan-Guidotti rule of 100% cover). The effect on risk-taking of reserve accumulation by a central bank that has inadequate reserves based on these criteria would surely be different from the effect of reserve accumulation by a central bank that already has adequate reserves, which is thus accumulating "excessive" reserves that could more easily be used to bail out risk-taking by the private sector.

As in the previous case, there would a non-linear effect of reserve accumulation on risk-taking, and it could be captured by a threshold measure whereby the effect would only be present once the reserve level has exceeded the measure of adequate reserves according to the traditional reasons for holding international reserves.

3. Does the way reserves are accumulated matter?

Some authorities may accumulate reserves as a conscious policy to reach a level of reserves they consider adequate to deal with possible drains resulting from sudden export shortfalls or capital outflows. Others, however, build up (or draw down) reserves as a by-product of the pursuit of other policies. A clear example of an institution that falls into the second category is the Hong Kong Monetary Authority, which operates a currency board system in which changes in international reserves are completely endogenous to the evolution of the current and capital account balances of the economy and to valuation effects on the existing stock of reserves. To a first approximation, this does not depend on the HKMA's assessment of what constitutes an adequate level of reserves.

In other cases, reserve accumulation may also be the consequences of the pursuit of other objectives. Central banks that manage their exchange rate may on occasion accumulate reserves in the process of countering what they perceive to be disruptive capital flows, even if they consider their reserve level to be adequate.

It is possible that reserve accumulation that is a by-product of other policies has a different impact on risk-taking in the private sector than accumulation that is the result of a deliberate move on the part of the central bank. If so, it would be useful to try to separate the two in the empirical analysis, possibly, as a first step, by conducting

the tests separately for countries that are classified as having fixed, or heavily managed, exchange rates on the one hand, and those that have freely floating exchange rate regimes on the other.

4. Is it reserve accumulation that matters, or is it the stock of international reserves?

Consider a central bank that has a large stock of international reserves, a stock that is considerably higher than a level based on "needs". Suppose this central bank is running down its reserves in a particular period. Would this be a sign for the private sector to scale back on risk-taking because the central bank is walking away from providing insurance? I would argue not, if the level of reserves is still large enough to be used for assisting the private sector should the central bank so decide.

According to this argument, it is the level of reserves held by the central bank and not the act of accumulating or drawing down reserves that matters for private sector risk-taking, and it is much more difficult to deal with empirically than the case where it is accumulation that matters. The event-study methodology used by F-Y would probably have to be replaced by an empirical model of risk pricing where the level of reserves can have a potential role. This would have to be left for a separate paper.

5. Do banks assume that the central bank will come to the rescue irrespective of the current level of reserves since the central bank may be able to borrow reserves?

Recall the example from Sweden in the beginning of these comments. The Swedish central bank apparently believed it was necessary to help Swedish commercial banks by borrowing USD funds in the international capital markets that the banks could no longer access during the Great Financial Crisis. This appears to be a situation where the increase in international reserves comes after and not before the risk-taking of the private sector. In other words, it is the perceived willingness of the central bank to engage in a bailout that matters, and the level of reserves it holds on its balance sheet does not appear to be the determining factor. As in the previous case, investigating this possibility empirically is beyond what F-Y set themselves as a task.

6. Measuring the change in the variable that serves as a proxy for risk-taking

The methodology used by F-Y relies on indicators of risk-taking that are measured as a zero-one variable: zero if there is no change in the indicator from immediately before the announcement of a change in international reserves, and one if the change in the indicator suggests an increase in risk-taking. This way of measuring the presence of risk-taking gives no weight to the size of the change in the indicator.

It would seem to be a simple matter to weight the change in the observations so that larger positive changes in the indicator would get more influence in the statistical tests.

Final remarks

The paper by Fatum and Yetman deals with an important issue for the evaluation of the costs and benefits of official reserve accumulation. They have carried out a very

careful empirical investigation designed to determine whether such reserve accumulation leads to increased risk-taking in the private sector.

After conducting numerous robustness checks, they conclude that there is little systematic evidence that such a link exists. This is an important finding, but one that could be further investigated to ensure that it is warranted. In these comments, I have made some suggestions for additional robustness tests that could be tried in follow-up research. In the meantime, the conclusion of the Fatum and Yetman is worth repeating: "Our results suggest that there is no large effect of reserves accumulation on risk-taking."

Breakdown of covered interest parity: mystery or myth?[1]

Alfred Wong, Jiayue Zhang[2]

Abstract

The emergence and persistence of basis spreads in cross-currency basis swaps (CCBS) since the global financial crisis have become a mystery in international finance, as they violate the long-standing principle of covered interest parity (CIP). We argue that the phenomenon is no mystery but merely a reflection of the different risks involved between money market and CCBS transactions in the post-crisis era. Empirical results based on seven major currency pairs support our hypothesis that swap dealers behave as if they seek to align the risks of the transactions in pricing CCBS, which causes CIP to break down. We also find that the basis spreads are well arbitraged among the currency pairs, which suggests they are fairly priced. Hence, it is a myth that CCBS basis spreads or CIP deviations are evidence of the market not functioning properly.

Keywords: covered interest parity, FX swap, cross-currency basis swap, basis spread, CIP deviation, Libor-OIS spread, counterparty credit risk, funding liquidity risk.

JEL classification: F31, F32, G15.

[1] The authors thank Michelle Chan, Sebastian Edwards, Charles Engel, Tom Fong, Cho-hoi Hui, Michael Kiley, Catherine Koch, Max Kwong, David Leung, Qi Li, Eli Remolona, Ole Rummel, Asani Sarkar, Hyun Song Shin, Suresh Sundaresan, Vladyslav Sushko, Giorgio Valente and participants of the SEACEN Third Research Week, the Banco Central do Brasil XII Annual Seminar on Risk, Financial Stability and Banking, the HKMA-BIS Conference on the Price, Real and Financial Effects of Exchange Rates, and the FIW-Research Conference on International Economics for valuable comments, suggestions and discussions.

[2] Research Department, Hong Kong Monetary Authority. Email: alfred_yt_wong@hkma.gov.hk, jjzhang@hkma.gov.hk.

1. Introduction

The phenomenon that a basis spread (hereafter referred to as basis for short) has emerged and continues to persist in cross-currency basis swaps (CCBS) for practically all currency pairs is fast becoming a mystery in international finance. The persistence of the basis suggests that covered interest parity (CIP), a long-standing economic principle, no longer holds, which puzzles many economists.[3] However, we think this is not as perplexing as it seems.

Since the onset of the global financial crisis (GFC), there has been a major reappraisal of counterparty credit risk and funding liquidity risk in global financial markets. This is evident in the sustained spread of the London interbank offered rate (Libor) over the overnight indexed swap (OIS) rate in the interbank funding market across most major currencies (Figure 1). The presence of counterparty risk is extremely important for unsecured lending/borrowing, as the lending party can end up getting nothing back if the other party defaults on the loan. However, swaps are different. They are secured transactions; neither party to the swap takes any counterparty risk. As principals are exchanged at inception, counterparty risk is largely eliminated since the parties effectively hold each other's loan as collateral.[4] To understand why basis emerges in the CCBS, or why CIP no longer holds in a market where participants are cautious about counterparty risk, it is useful to understand how swap dealers price FX swaps since a CCBS can be viewed as a series of shorter-term FX swaps.[5]

From the perspective of the swap dealer, quoting the price of an FX swap when approached by a client is essentially quoting the forward premium or discount.[6] It was a simple task before the GFC, as there was little concern for counterparty risk. All the dealer had to do was to multiply the spot exchange rate of the two currencies by their interest differential based on benchmark money market rates such as the Libors. In doing so, he is applying CIP, which basically says the ratio of the forward to spot exchange rates between the foreign and domestic currencies is equal to their interest differential. Today's money market is different as participants are acutely aware of counterparty and liquidity risks. If the dealer continues to quote the forward premium as he did in the past, then CIP would continue to hold. But this makes no sense, as CIP would then imply that the dealer ignores the fact that the FX swap effectively converts the two unsecured money market loans into secured ones.

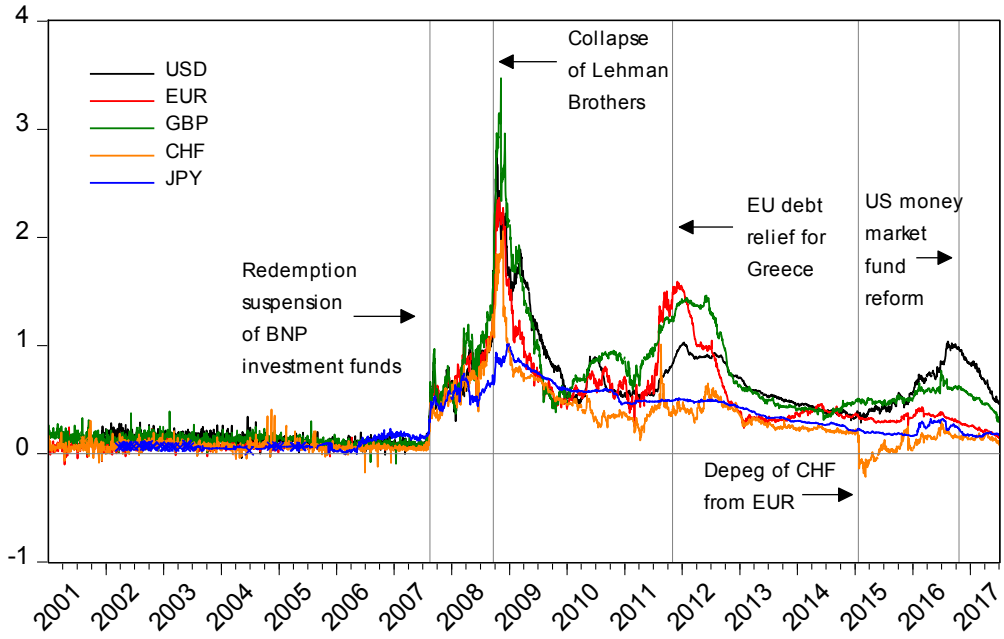
[3] A recent study even likens CIP to a physical law in international finance (Borio et al (2016)).

[4] Counterparty risk refers to the risk of default on each other's loan in this paper. Both parties, however, still take the counterparty risk of the swap itself, which is negligible compared to that of the loan.

[5] A swap dealer is a market dealer of swaps who takes positions, and hence also risks, in matching opposite sides of a swap. Textbooks often describe swaps as two parties engaging in transactions directly. However, as one can imagine, it is difficult for a company or financial institution to find another party that can offer exactly what it needs and, at the same time, needs exactly what it can offer. In reality, most of the transactions in the swap market are conducted indirectly through a dealer.

[6] The forward premium or discount refers to the difference between the spot and forward exchange rates, depending on whether the difference is positive or negative. In the FX swap market, the forward premium or discount is most commonly quoted in terms of forward or swap points, the number of pips added to or subtracted from the spot rate. We shall hereafter call it the forward premium for brevity, bearing in mind that it can indeed be a discount if it is negative.

12-month Libor-OIS spreads of major currencies Figure 1



Source: Bloomberg

Among financial institutions, there has been a huge difference between borrowing on an unsecured basis and borrowing by placing an equivalent amount of foreign cash as collateral since the GFC. Theoretically, in the latter case, the dealer would, all else equal, be willing to lend at an interest rate that is lower than the benchmark money market rate. But in an FX swap, the dealer also simultaneously borrows from his client in foreign currency. Therefore, he should equally enjoy a lower foreign interest rate than the benchmark foreign money market rate for the same reason. Therefore, in calculating the forward premium, it is only rational for the dealer to adjust the old benchmark interest differential by an amount equivalent to what he judges to be the difference between the two counterparty risk premiums. In this case, the forward premium he quotes for his client differs from what he would quote in the past (unless the two counterparty risk premiums happen to be the same). As a result, CIP does not hold. But this makes sense!

The same is also true with CCBS. As a CCBS is, in effect, a series of shorter-term FX swaps joined together, pricing a CCBS or quoting the basis of a CCBS is basically comparing the forward premium with the difference between the swap rates of the two currencies concerned.[7] Therefore, when CIP holds (ie, there is no CIP deviation) the basis is equal to zero. This was the situation before the GFC. If the swap dealer continues to quote a zero or practically zero basis in the CCBS market, CIP would of course continue to hold. However, the question again arises, why would the swap dealer price secured loans using interest rates taken from unsecured markets?

[7] The market convention is to quote the basis over the non-USD leg. For example, the five-year USD/GBP CCBS with a basis of minus (plus) α basis points means the quarterly exchange of the three-month GBP Libor minus (plus) α basis points *versus* the three-month USD Libor flat for a period of five years.

Therefore, it is reasonable to postulate that, in the post-GFC trading environment, the swap dealer behaves as if he seeks to take into account the (absence of) counterparty risks involved when quoting for his client the forward premium in the case of an FX swap or the basis in the case of a CCBS (Wong et al (2016)). This is consistent with the multi-curve modelling approach to interest rate swap (IRS) pricing in finance literature. The classic single-curve model, which worked fine in the pre-crisis era, no longer works post crisis, as the Libor curve is no longer risk-free.[8] This causes basis to occur even in the single-currency swap market (Figure 2).[9] The multi-curve model tackles the issue by using risk-embedded curves (eg, Libor-based curves) to calculate the expected future cash flows and a risk-free curve to discount them (Bianchetti (2010), Mercurio (2010), Grbac et al (2015)). This pricing methodology dates back to Tuckman & Porfirio (2003) but has gained popularity in practice only after the GFC as counterparty and liquidity risks have surged in the interbank money market (Bianchetti (2010)).[10] However, it is imperative to note that the cross-currency swap (ie, FX swap and CCBS) market differs from the single-currency swap (ie, IRS) market in that principals are exchanged in the former but not in the latter.

The collateralised nature of the FX swap or CCBS transaction eliminates only the counterparty risks that are priced into the Libors but not the liquidity risks. The fact that both parties to the transaction swap their principals at inception means they still take a liquidity risk for the funds they lend but receive a liquidity premium for the funds they borrow. Hence, as the counterparty risk premiums in the domestic and foreign money market rates are removed, the difference between the liquidity risk premiums and the difference between the risk-free rates are left in the dealer's equation in pricing the swap. The presence of the liquidity risk premiums in the price reflects the fact that the liquidity risks of the two parties are swapped in the FX swap or CCBS transaction. This explains why there is still a basis or deviation when one replaces the Libor-differential in the CIP condition with risk-free or near risk-free interest differentials such as OIS spreads, repo spreads or government bond yield spreads(Bottazzi et al (2013), Fukuda (2016), Du et al (2017)). The reason is that these interest rates contain not only minimal counterparty risk premium but also negligible liquidity risk premium.[11] However, in the swap market the forward premium must

[8] Before the GFC, IRSs were valued using the single-curve model, in which the estimation and discounting of future cash flows are based on the same interest rate curve, usually a Libor curve. The emergence of counterparty and liquidity risks since the GFC has given rise to bases as the reference interest rates, which are risk-embedded, are no longer consistent with the risk-free nature of the transaction.

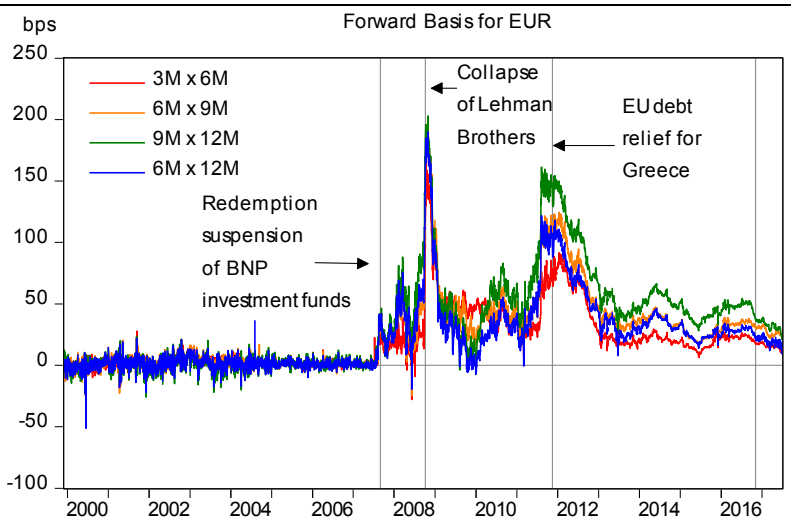
[9] Single-currency bases can be broadly classified into three types: (i) forward basis, the difference between the Libor-curve-implied forward rate and the traded forward rate agreement rate; (ii) fix-float basis, the deviation of the Libor-curve-implied fixed rate from the swap rate; and (iii) tenor basis, which occurs between two legs of a basis swap indexed to Libors of different tenors.

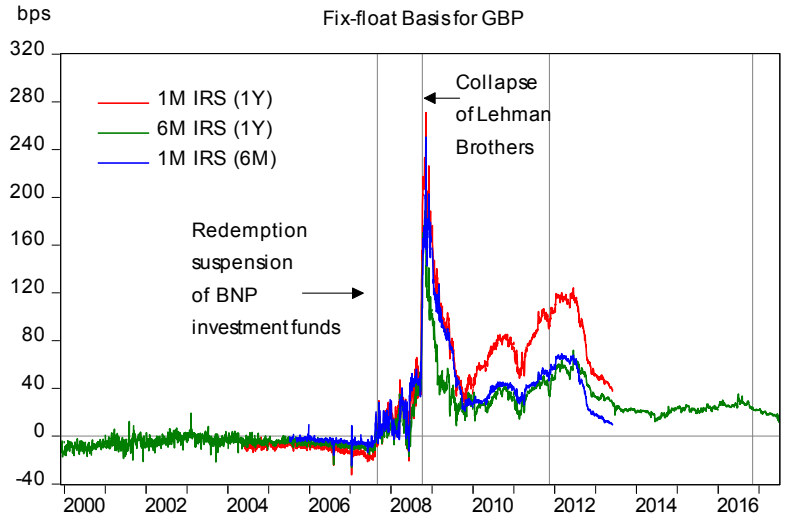
[10] The use of the multi-curve model has essentially become the standard market practice after LCH.Clearnet, which operates SwapClear, announced on June 17, 2010 that it would replace the Libor curve with the OIS curve to discount its entire IRS portfolio after extensive consultation with market participants. See press release by LCH.Clearnet.

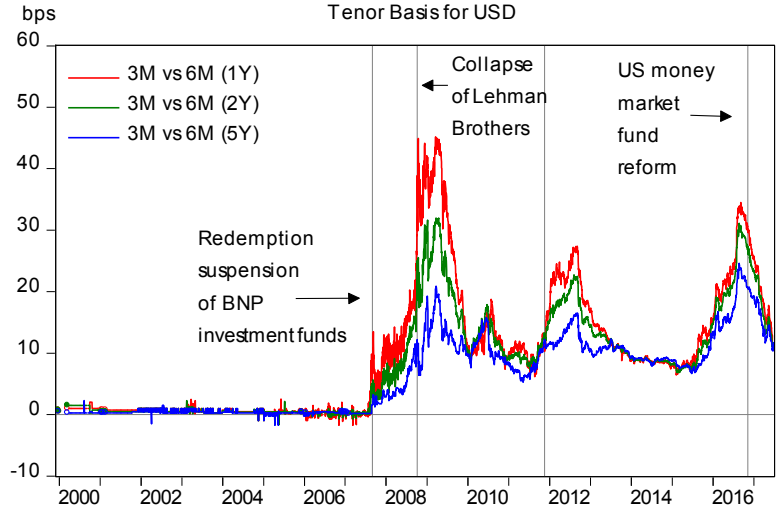
[11] Theoretically, the liquidity risk premium contained in a repo rate or bond yield depends on the market liquidity of the collateral asset or debt security concerned. The more liquid the asset or security market is, the smaller the funding liquidity risk embedded in the repo rate or bond yield. See Brunnermeier & Pedersen (2009) for a more detailed discussion about the relationship between market liquidity and funding liquidity. Needless to say, the problem will also be compounded by factors that affect the supply of, and demand for, the underlying security other than the opportunity cost of borrowing/lending, eg, the convenience yield.

Single currency basis spreads

Figure 2







Source: Bloomberg

reflect, in addition to the risk-free interest differential, the difference between the liquidity risks that are present in the two money markets. This is supported by the important finding by Rime et al (2017) that CIP deviations based on OIS rates tend to co-move strongly with measures of liquidity premium differentials.

Our explanation, therefore, differs distinctly from previous studies in recent CIP literature, which attribute the phenomenon to a global shortage of US dollars. Earlier ones argue that, during the GFC and in its aftermath, many foreign financial institutions needed US dollars to fund their US conduits but found themselves shut off from the Libor market because US financial institutions were concerned about their counterparty risk (Baba & Packer (2009), Coffey et al (2009), Genberg et al (2009), Fong et al (2010), Hui et al (2011)). As a result, they had to resort to the FX swap and CCBS markets to obtain dollar funding, and paid a premium for it. In these studies, the CIP deviation or CCBS basis essentially reflects this dollar premium. More recent studies relate the shortage of US dollars to regulatory reforms introduced following the GFC, growing demand for dollar hedging, capital and balance sheet constraints, and even global imbalances, which have singly or jointly resulted in limits to arbitrage as reflected by the persistence of the non-zero basis (Ivashina et al (2015), Borio et al (2016), Du et al (2017), Sushko et al (2017)). The phenomenon arguably reflects the special role of the dollar as the global funding currency (Avdjiev et al (2016), Shin (2016)).

Nonetheless, many of these explanations are not necessarily inconsistent with ours. We concur that the basis is a consequence of certain factors or considerations that did not exist before the GFC. The difference, however, is authors of previous studies believe these factors or considerations are external to the reference interest rates used in the pricing of the swap, while we argue that, if any such factors or considerations exist, they would be translated into counterparty or liquidity risk in money market transactions and hence the reference interest rates. For instance, Baba & Packer (2009) try to explain CIP deviation by credit default swap spreads, while Avdjiev et al (2016), Borio et al (2016), Du et al (2017) and Sushko et al (2017) attempt to relate the basis to dollar strength or dollar hedging demand. In our view, all these are already priced in by the Libor-OIS spreads. Indeed, the quarter-end spikes in the basis as observed by Borio et al (2016) and Du et al (2017) are totally consistent with the quarter-end jumps we find in the Libor-OIS spread (Table 1). To them, the greater importance accorded to quarter-end reporting and regulatory ratios following regulatory reforms makes it harder to take arbitrage at those times, which is reflected in the basis. For us, these pressures are detectable in the Libor-OIS spread as they translate into higher funding liquidity risk at quarter ends.

In this paper, we examine the CCBS market for seven currency pairs in the post-GFC era: four involving a dollar leg (USD/EUR, USD/GBP, USD/CHF and USD/JPY) and the other three a euro leg (EUR/GBP, EUR/CHF and EUR/JPY). We find consistent evidence across the currency pairs that the CCBS basis essentially reflects the difference in the counterparty risk premiums embedded in the domestic and foreign money markets. Our results also contribute to the heated debate in literature about the proportions of the counterparty and liquidity risk premiums embedded in the Libor-OIS spread (Michaud & Upper (2008), Sarkar (2009), Acharya & Skeie (2011), Garleanu & Pedersen (2011), Gefang et al (2011), McAndrews et al (2017)). Since the swap market, as we postulate, works as a risk filter that separates the two risk premiums, our model allows us to estimate econometrically the shares of the counterparty and liquidity risk premiums in the spread. For USD/EUR, for example, we find that, in this period, the counterparty risk premium, on average, accounts for

about 22.3% of the total risk premium embedded in the USD Libor, and the liquidity risk premium about 76.1%. The counterparty risk premium contributes 75.8% to the total risk premium embedded in the EUR Libor and the liquidity risk premium only 23.6%. This means the swap dealer subtracts 22.3% of the USD Libor-OIS spread from the USD Libor and 75.8% of the EUR Libor-OIS spread from the EUR Libor in pricing the CCBS.

Quarter-end spikes in the one-week Libor-OIS spreads Table 1

	USD	EUR	GBP	CHF	JPY	Panel
			Whole period			
Constant	0.1257***	0.0460*	0.0917***	-0.0758***	0.0366***	0.0522***
	(0.0184)	(0.0250)	(0.0146)	(0.0208)	(0.0072)	(0.0017)
Quarter	0.0528***	0.0275**	0.0182**	0.0092	0.0100**	0.0247***
	(0.0085)	(0.0135)	(0.0071)	(0.0167)	(0.0047)	(0.0063)
Obs.	2501	2535	2501	1815	2255	11607
R-squared	0.0023	0.0041	0.0011	0.0002	0.0010	0.1217
			Positive interest rate period			
Constant		0.0735**		0.0250***	0.0417***	
		(0.0291)		(0.0060)	(0.0105)	
Quarter		0.0398**		0.0230***	0.0170***	
		(0.0201)		(0.0065)	(0.0053)	
Obs.		1,751		1,244	1,896	
R-squared		0.0069		0.0023	0.0027	
			Negative interest rate period			
Constant		-0.0156		-0.2951***	0.0092	
		(0.0070)		(0.0055)	(0.0609)	
Quarter		0.0056**		-0.0242***	-0.0259*	
		(0.0024)		(0.0084)	(0.0141)	
Obs.		784		571	359	
R-squared		0.0047		0.0109	0.0322	

1. Quarter is a dummy variable that equals one when the observation is within the last five trading days of a quarter, and equals zero otherwise.

2. Regressions for individual currencies are estimated using Newey-West standard errors with 65 lags (average number of trading days in a quarter) and pre-whitening with 22 lags (average number of trading days in a month). The panel regression includes currency fixed effects.

3. The whole sample period spans from August 9, 2007, to June 30, 2017, which is divided into positive and negative interest rate periods depending on the currency (if applicable). The negative interest rate period for EUR, CHF and JPY starts from June 14, 2014; January 15, 2015; and January 29, 2016, respectively.

The implication of our hypothesis that CCBS are fairly priced is also evident in the behaviour of the CCBS market itself. As one can imagine, if market forces are hampered by some constraints or limits, the prices may be arbitrarily determined. However, we find that the CCBS bases relate to each other in a triangular relationship explicable by a matrix with special properties. The relationship suggests that the CCBS market is well arbitraged, although not in the sense of eliminating the basis, and that

the bases are not arbitrarily determined but fairly priced.[12] We argue that the well-arbitraged non-zero bases are driven by the difference between the counterparty risks of the two money markets concerned but acknowledge the possibility that they are determined by the limits to arbitrage caused by plausible constraints such as capital charges resulting from recent regulatory reforms. Nonetheless, the persistence of the bases (especially those between two non-USD currencies) and the considerable differences among them (even between the currency pairs with a USD leg) challenge the notion that CIP deviation or CCBS basis is essentially a dollar phenomenon.[13]

This paper is organised as follows. In the next section, we set out the model and discuss the data. Section 3 shows that the CCBS market is a well-arbitraged market and that our empirical results support the risk-adjusted version of CIP. Section 4 concludes.

2. Model and data

2.1 Model

We employ an approach similar to that adopted by Wong et al (2017) using forward point as the dependent variable to estimate the average share of counterparty risks and liquidity risks associated with different currencies in the Libor market. Since the dependent variable, forward premium, and independent variables, Libor and OIS of domestic and foreign currencies each have a unit root, we take the first difference of all variables to build the unrestricted model:

$$\Delta FP_t = C_0 + C_1 \Delta r_{f_t} + C_2 \Delta q_{f_t} + C_3 \Delta r_t + C_4 \Delta q_t + \epsilon_t$$

where the dependent variable, FP_t, is the annualised forward premium defined as the annualised log difference between the n-year forward and spot exchange rates, ie, $(ln\, F_{0,n} - ln\, S)/n$; The independent variables, r_f and q_f, refer to the OIS rates of foreign and domestic currencies respectively; r and q refer to the IRS rates of foreign and domestic currencies respectively; ϵ is the error term; Δ is the first difference operator.

In the unrestricted model, the absolute values of the coefficients of the risk-free rates, C_1 and C_2, represent the shares of counterparty risk premium in the total risk premium for foreign and domestic currencies respectively, and the absolute values of the coefficients of the interbank borrowing rates, C_3 and C_4, represent the shares of liquidity risk in the total risk premium. According to our proposed theory of decomposing the CCBS basis, the constant C_0 is expected to be zero, and the coefficients of IRS and OIS of the foreign (domestic) currency should sum to unity. Therefore, we develop our hypotheses below.

Hypothesis 1: $C_0 = 0$

Hypothesis 2a: $C_1 + C_3 = 1$

[12] The triangular relationship does not imply that CIP holds, as the triangular arbitrage is different from the conventional CIP arbitrage.

[13] The fact that bases have also emerged and persisted in the single-currency swap market for practically all currencies provides further evidence that the phenomenon is no privilege of the dollar (Figure 2). Basis is principally an outcome of swapping two interest rates whose underlying risks are not aligned with the nature of the transaction.

Hypothesis 2b: $C_2 + C_4 = -1$

Imposing the restrictions in hypotheses 2a and 2b on the unrestricted model, we derive the restricted model as below:

$$\Delta Fp_t = C_0 + C_1 \Delta r_{f_t} + C_2 \Delta q_{f_t} + (1 - C_1)\Delta r_t + (-1 - C_2)\Delta q_t + \epsilon_t$$

where the coefficients of IRS and OIS of the same currency sum to unity.

Descriptive statistics of key variables

Table 2

	USD	EUR	GBP	CHF	JPY
		5-year forward premium (annualised, %) vis-à-vis USD			
Mean		–0.93	–0.15	–1.77	–2.01
Median		–0.75	–0.04	–1.51	–2.06
Maximum		0.69	0.62	–0.57	–1.10
Minimum		–2.58	–1.59	–3.19	–2.93
Std. Dev.		0.82	0.47	0.66	0.40
Obs.		2,029	2,029	2,029	2,029
			5-year forward premium (annualised, %) vis–à–vis EUR		
Mean			0.78	–0.84	–1.08
Median			0.65	–0.80	–0.94
Maximum			2.02	–0.26	0.01
Minimum			–0.36	–1.57	–3.11
Std. Dev.			0.51	0.28	0.69
Obs.			2,029	2,029	2,029
			5-year IRS rate (%)		
Mean	1.60	1.01	1.55	0.27	0.26
Median	1.60	0.83	1.45	0.25	0.25
Maximum	2.94	3.10	3.34	1.73	0.78
Minimum	0.72	–0.34	0.30	–1.00	–0.24
Std. Dev.	0.50	0.93	0.69	0.72	0.19
Obs.	2,012	2,029	1,978	2,015	2,029
			5-year OIS rate (%)		
Mean	1.34	0.78	1.30	0.14	0.14
Median	1.37	0.63	1.18	0.13	0.15
Maximum	2.79	2.82	3.11	1.60	0.57
Minimum	0.47	–0.47	0.13	–0.95	–0.37
Std. Dev.	0.53	0.85	0.68	0.61	0.17
Obs.	2,029	2,029	2,029	1,899	2,029
			5-year IRS–OIS spread (bps)		
Mean	26.3	22.7	25.6	5.2	11.2
Median	25.1	19.6	22.7	9.2	10.5
Maximum	55.7	57.6	66.4	32.3	21.6
Minimum	13.0	7.3	12.1	–18.1	2.6
Std. Dev.	7.1	9.6	8.4	9.3	4.0
Obs.	2,012	2,029	1,978	1,887	2,029

1. This table reports the summary statistics for forward premiums, IRS, OIS and IRS-OIS spreads of five major currencies, namely US dollar, euro, British pound, Swiss franc and Japanese yen.

2. The forward premium is calculated as the annualised premium or discount between the spot and forward exchange rate, which is continuously compounded.

3. The sample period is from September 22, 2009, to June 30, 2017, subject to data availability.

Source: Bloomberg

2.2 Data

Data employed in this study are all collected from Bloomberg as at the London market close with daily frequency.[14] This paper focuses on the world's most actively traded currencies, namely USD, EUR, GBP, JPY and CHF.[15] Among these five currencies, there are a total of 10 possible currency pairs, but only seven of them are actively traded in the CCBS market: four involving a USD leg (namely, USD/EUR, USD/GBP, USD/CHF and USD/JPY) and three a EUR leg (namely, EUR/GBP, EUR/CHF and EUR/JPY). The remaining three pairs of currencies (namely, GBP/CHF, GBP/JPY and CHF/JPY) do not have an active market, and there are no data reported by Bloomberg. Table 2 summarises the descriptive statistics of key variables.

2.2.1 Choice of variables

The spot and forward exchange rates vis-à-vis USD are collected directly from Bloomberg, whereas those vis-à-vis EUR are calculated using the respective exchange rates vis-à-vis USD to keep inconsistency to a minimum.[16] The OIS rates for USD, EUR, GBP, CHF and JPY are the effective Fed funds rate, Euro overnight index average, sterling overnight index average, tom/next indexed swap and Tokyo overnight average rate, respectively. Details of each reference rate are summarised in Table 3.

Descriptive statistics of key variables — Table 3

	USD	EUR	GBP	CHF	JPY
			IRS rates		
Reference rate	3M Libor	3M Euribor	3M Libor	3M Libor	3M Libor
Payment frequency	Quarterly	Annually	Quarterly	Annually	Semi-annually
			OIS rates		
Reference rate	Effective Fed funds rate	Euro overnight index average	Sterling overnight index average	Tom/next indexed swap in CHF fixing	Tokyo overnight average rate
Description	A weighted average of rates on trades arranged by major brokers	A weighted average of overnight unsecured lending rates in the interbank market, initiated within the euro area by contributing banks	A weighted average rate of unsecured sterling overnight cash transactions brokered in London by WMBA member firms	Based on quotations from approximately 30 reference banks for its Tom/next unsecured lending rate to prime banks, supplied to Cosmorex AG	Based on uncollateralised overnight average call rates for lending among financial institutions, published by Bank of Japan
Published by	Federal Reserve Bank New York	European Central Bank	Wholesale Markets Brokers' Association	Cosmorex AG	Bank of Japan

Source: Bloomberg and FTSE Russel

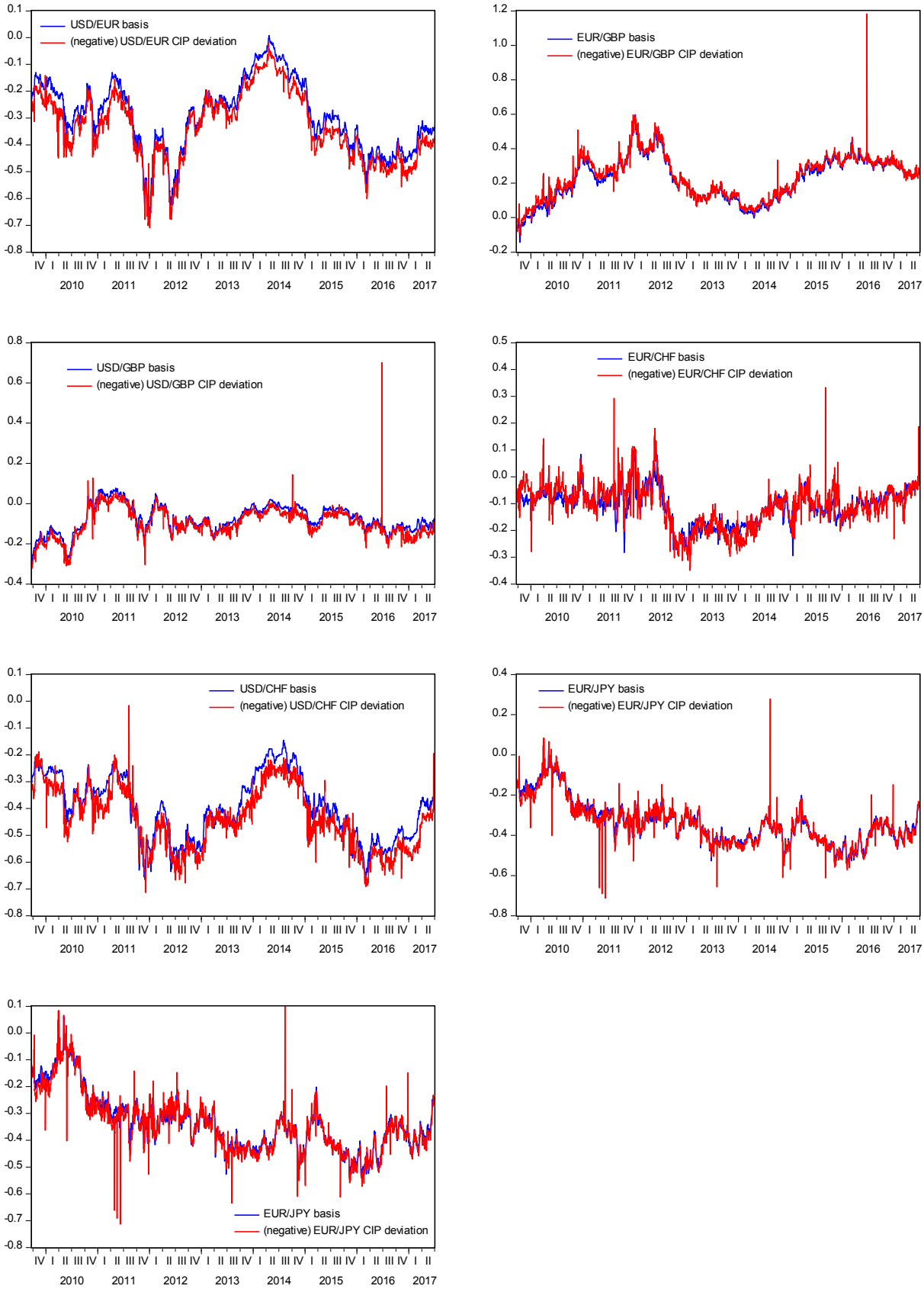
[14] Global financial markets are probably most active in London at 6pm out of the three time choices available from Bloomberg, with the other two being Tokyo, 8pm and New York, 5pm.

[15] According to BIS (2014, 2016), the average daily turnover of CCBS involving these currencies accounted for 79.16% of the total in April 2016, and 78.90% in April 2013.

[16] While direct quotes of cross exchange rates (ie, non-USD exchange rates) are also available from Bloomberg, data quality for USD exchange rates is much better due to larger trading volumes.

Five-year CCBS basis and CIP deviation

Figure 3



Source: Bloomberg

For all currency pairs, the conventional CCBS contracts are based on their three-month interbank offered rates.[17] Correspondingly, we use the fixed rates of IRS, which are indexed to three-month Libors and are of five-year tenor as r and q.[18] As can be seen in Figure 3, the CIP deviations closely track the corresponding CCBS bases for all currency pairs.

2.2.2 Choice of sample

Like most previous studies, this paper focuses on the popular five-year tenor. The sample periods are defined by data availability, ranging from 1887 to 2029 observations in each regression. For USD/CHF and EUR/CHF, the sample period is from January 13, 2010 to June 30, 2017, as the CHF OIS rate is only available from January 13, 2010. For the rest of the currency pairs, the sample period covers September 22, 2009 to June 30, 2017, as the five-year USD IRS rate is only available starting from September 21, 2009. To reduce the potential bias caused by data errors, data points lying five or more standard deviations away from the mean are deleted (Charles & Darné (2005)).[19]

3. Empirical findings

3.1 Basis matrix

The seven currency pairs under study can be divided into two groups: the first group includes four currency pairs with a USD leg (USD/EUR, USD/GBP, USD/CHF and USD/JPY), and the other includes three with a EUR leg (EUR/GBP, EUR/CHF and EUR/JPY). Figure 4 plots the bases of the four currencies vis-à-vis USD and Figure 5 those of the three vis-à-vis EUR. As can be seen, they stayed around zero before the GFC but have since consistently deviated from it. This shows that like the CCBS bases with a USD leg, those with a EUR leg bear the same characteristic in the sense that CIP also holds for them before the GFC but not after.

The bases among all currencies can be summarised by a matrix defined as

$$B = \left(\alpha_{i,j}\right)_{i,j=1}^{n}$$

where $\alpha_{i,j}$ is the basis to be added to the currency i leg of a CCBS vis-à-vis currency j. Market data suggest that the matrix satisfies the fundamental relationship:

[17] A CCBS vis-à-vis USD is referenced to Libors for both legs whenever available. A CCBS vis-à-vis EUR is referenced to Euribor for the EUR leg. In this paper, we use interest rates that refer to Euribor for the EUR leg whenever applicable.

[18] JPY is the only exception, as data for the three-month IRS are not available due to a lack of an active three-month market. We construct a proxy for the three-month IRS by subtracting the three-for-six-month basis swap spread from the six-month IRS which has a much more active market. This approximation is totally acceptable as the investor can swap his three-month JPY Libor interests into six-month ones by entering into a three-for-six-month basis swap at almost zero cost.

[19] As with most financial market data, our data set consists of some extreme outliers that possibly result from a variety of problems including typos by contributing banks to Bloomberg (Chen & Liu (1993), Brownlees & Gallo (2006)). Using the five-standard-deviation cutoff, our sample still captures 99.0-99.7% of the full sample across all data series used in the study. We have also applied cutoffs of three and four standard deviations to the data. The results, which can be available upon request, change little.

$$\alpha_{i,j} + \alpha_{j,k} + \alpha_{k,i} = 0$$

for $i, j, k = 1,2, \ldots, n$. This relationship suggests that for any three currencies the difference between the bases of any two of them vis-à-vis the third one is equal to the basis involving these two currencies. Figure 5 shows that the difference between the USD/EUR and USD/GBP bases, as depicted by the red dotted line, is always almost the same as the EUR/GBP basis traded in the market. The same is also true for the difference between the USD/EUR and USD/CHF bases, and the EUR/CHF basis; and the difference between the USD/EUR and USD/JPY bases, and the EUR/JPY basis. In our view, this is no coincidence. There must be players actively taking arbitrage in the market, which is reminiscent of what occurs in the FX market, where the exchange rates of any two non-USD currencies vis-à-vis USD can be used to derive the cross exchange rate between them.

To show how large (or small) the arbitrage opportunity is on a usual trading day, we calculate and compare two basis matrices using the data collected at the London market close on June 30, 2017.[20] Based on the properties of the basis matrix, we obtain the first matrix B_{USD} using only the CCBS bases with a dollar leg and the second one B_{EUR} using only the CCBS bases with a euro leg as follows,

$$B_{USD} = \begin{pmatrix} 0 & -33.1 & -7.4 & -35.5 & -57.8 \\ 33.1 & 0 & 25.8 & -1.9 & -24.7 \\ 7.4 & -25.8 & 0 & -27.6 & -50.4 \\ 35.5 & 1.9 & 27.6 & 0 & -22.8 \\ 57.8 & 24.7 & 50.4 & 22.8 & 0 \end{pmatrix}$$

$$B_{EUR} = \begin{pmatrix} 0 & -33.1 & -6.9 & -35.6 & -58.5 \\ 33.1 & 0 & 26.3 & -2.5 & -25.4 \\ 6.9 & -26.3 & 0 & -28.8 & -51.6 \\ 35.6 & 2.5 & 28.8 & 0 & -22.9 \\ 58.5 & 25.4 & 51.6 & 22.9 & 0 \end{pmatrix}$$

where currency $1, 2, 3, 4, 5$ represents USD, EUR, GBP, CHF and JPY respectively. As can be seen, the two matrices derived from the first (USD leg) and the second (EUR leg) rows are almost identical, with the largest difference between the corresponding bases being 1.2 basis points for GBP/JPY. However, since there is no active market for GBP/JPY, the largest difference among the seven pairs of currencies traded in the CCBS market actually lies with EUR/JPY, 0.7 basis points.

As discussed earlier, Bloomberg has CCBS basis data only for currency pairs that are actively traded. According to BIS (2016), of the seven pairs, the four pairs with a USD leg have by far considerably larger trading volumes.[21] The trading of USD/EUR and USD/JPY is most intense, while that of USD/GBP and USD/CHF is thinner. The transactions for the currency pairs without a USD leg are even smaller. Hence, the currency pairs with a USD leg, especially USD/EUR and USD/JPY, probably dominate the price discovery process whereas those without a USD leg are likely to be price followers. However, the relative small size of a market or its limited price setting power does not *a priori* impede arbitrage activity. As long as there is a reasonably

[20] June 30, 2017, the last day of our sample period, is arbitrarily chosen for illustrative purposes. One could pick any other day.

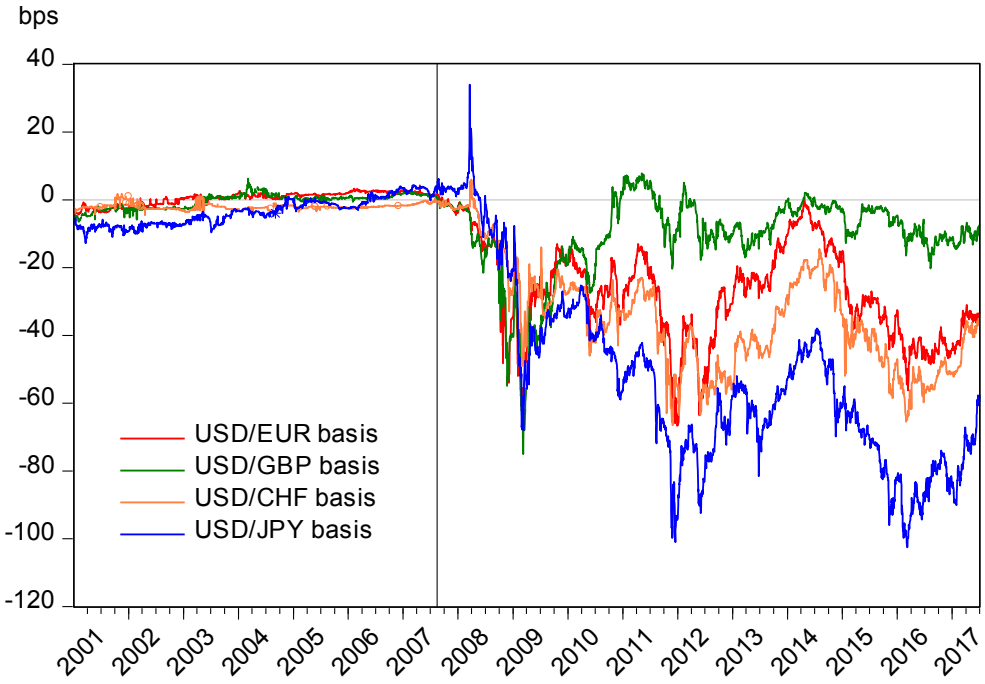
[21] The following table summarises the average daily turnover of CCBS in April 2016 for the seven currency pairs covered in this study (BIS (2016)).

(in millions of US dollar)	EUR	GBP	CHF	JPY
USD	17,834	8,157	1,326	17,247
EUR		1,490	235	432

active market, arbitrage can still take place when the price deviates enough from where it should be as implied by other markets. For the CCBS bases of the seven currency pairs, the largest price deviation on a normal trading day is only 0.7 basis points. In other words, the small differences between the two basis matrices suggest that the CCBS market is well arbitraged.

CCBS basis with a USD leg

Figure 4

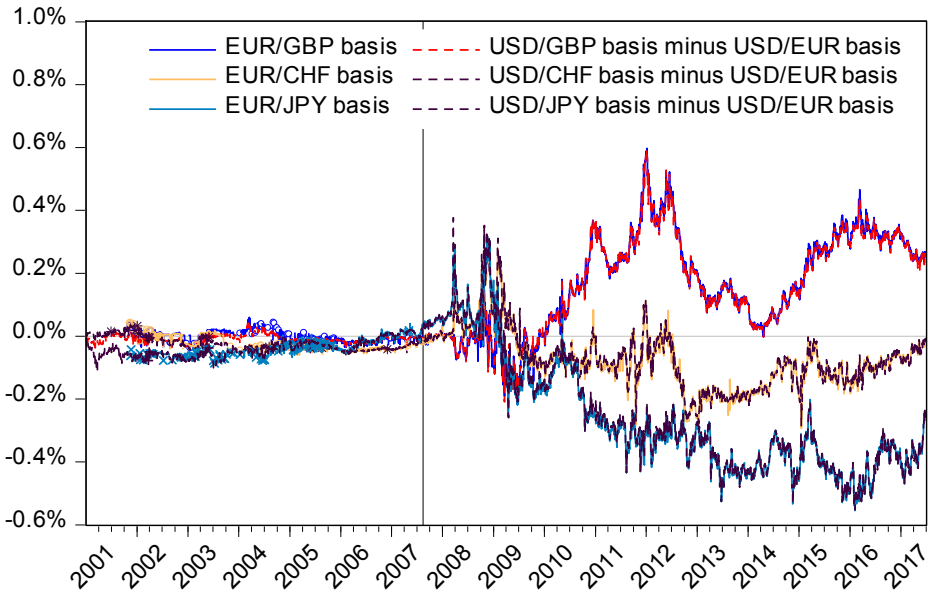


The vertical line represents August 9, 2007 (when BNP Paribas suspended redemption for three of its investment funds).

Source: Bloomberg

CCBS basis with a EUR leg

Figure 5



The vertical line represents August 9, 2007 (when BNP Paribas suspended redemption for three of its investment funds).

Source: Bloomberg

However, it is important to differentiate between this triangular arbitrage and the conventional CIP arbitrage under the new bank regulatory regime. In recent literature, there has been an increasing voice arguing that the persistent non-zero bases must be the result of some quantity constraints (Bottazzi et al (2013), Gabaix & Maggiori (2015), Borio et al (2016), Duffie (2016), Du et al (2017)). One such key constraint arises from bank regulatory reforms, in particular in relation to the risk-weighted and non-risk-weighted capital requirements.[22] For the risk-weighted capital requirement the charge, which to a large extent depends on the Value-at-Risk of the net position of the trade, is much smaller for the triangular arbitrage than for the conventional CIP arbitrage. For the non-risk-weighted capital requirement, while the triangular arbitrage involves only the swap positions, the conventional CIP arbitrage also requires the arbitrageur to go long (short) in one money market and short (long) in the other, which increases the size of the balance sheet by the notional of the trade due to these cash market positions. Hence, higher capital charges under the current regulatory regime possibly underscore why the triangular arbitrage works but the conventional CIP arbitrage does not.

Nonetheless, the fact that the no-arbitrage condition of the basis matrix holds does have two important implications. First, it shows that the CCBS bases are not arbitrarily determined, as it may be the case given all plausible constraints. From a microeconomic point of view, they are fairly priced, reflecting the difference between the counterparty risks of the two money markets in the context of the risk-adjusted CIP, or the limits to arbitrage from the perspectives of those in favour of the constraint story. Second, the well-arbitraged CCBS bases are different across currency pairs, even between those with a USD leg. This seems to suggest that the persistence of bases in CCBS is unlikely to reflect a dollar shortage. At best one may argue that the phenomenon is attributable to a relative dollar shortage, eg, a dollar shortage relative to a euro or yen shortage. The same applies for those who try to link the bases to the role of the dollar as a global funding currency. In this connection, the particular challenge to the notion of the breakdown of CIP as a dollar phenomenon is how one accounts for the different bases across currency pairs, eg, why some are more negative than the others.

3.2 Estimation results

A major objective of this study is to find out how the swap dealer sets the forward premium using the domestic and foreign risk-free and risk-embedded interest rates. However, econometrically, unless the interest rates are exogenous, estimating the models by means of ordinary least squares (OLS) potentially invites the problem of endogeneity which, if exists, can cause the estimators to be biased. In particular, the concern about endogeneity arises from simultaneous causality between the forward premium and the four interest rates, as the forward premium may arguably also affect the interest rates.

While the (spot) exchange rate and the interest rates of the two countries concerned are likely to be co-determined, it is hard to imagine the same applies to the relationship between the forward premium (the difference between the spot and forward exchange rates) and the interest rates. Nonetheless, to address the concern,

[22] In their example of a five-year CIP trade using CCBS, Du et al (2017) estimate that capital charges attributable to the risk-weighted capital requirement surge from 0.4% to more than 4% of the notional principal under Basel III, while those due to the non-risk-weighted capital requirement (ie, the leverage ratio) increase by 3%.

we first estimate a model by means of the generalised method of moments (GMM) assuming that endogeneity exists, and then test the validity of this specification. In the GMM model, the endogenous variables are the four interest rates and the exogenous instruments are the one-day to five-day lags of domestic and foreign government bond yields, domestic and foreign bank CDS spreads and the VIX index, all in first difference form. These instruments are hardly affected by the forward premium, but are correlated with the interest rates of the two countries through the risk-free opportunity cost of borrowing, counterparty risk and liquidity risk channels. Based on the GMM estimation, we conduct the Durbin-Wu-Hausman test to examine if the four endogenous variables are exogenous. The results show we cannot reject the null hypothesis that these variables are exogenous at the 10% or higher significance level for the seven currency pairs.[23] This means the estimators in the OLS models are unbiased. Since the OLS estimators are more efficient than those in the GMM, we stick with OLS in our final estimation.

The estimation results are shown in Table 4.[24] As can be seen from the first rows in the unrestricted and restricted models, the constant C_0 in all regressions are extremely close to zero and statistically insignificant. The estimation results from the unrestricted model support hypotheses 2a and 2b. First, most coefficients are highly significant in the unrestricted models with signs consistent with our expectation. Secondly, all four coefficients (C_1 to C_4) in each regression fall between zero and one. Thirdly, the sum of the coefficients of IRS and OIS in the same currency is very close to unity. They are plotted in Figure 6 for ease of inspection. For the four currency pairs with a USD leg, ie, USD/EUR, USD/GBP, USD/CHF and USD/JPY, the sum of the shares of counterparty and liquidity risk premiums for USD is 99.2%, 96.1%, 100.2% and 98.0% respectively. For the three currency pairs with a EUR leg, ie, EUR/GBP, EUR/CHF and EUR/JPY, the sum for EUR is 100.3%, 100.1% and 98.5% respectively. To formally examine the validity of hypotheses 2a and 2b, we further apply Wald tests, $C_1 + C_3 = 1$ and $C_2 + C_4 = 1$, on each regression separately. As can be seen from Table 5, eight out of the 14 tests show that we cannot reject hypotheses 2a or 2b at the 10% or higher significant levels. For the other six tests, while we can reject the hypothesis, it is worth noting that the rejection is mainly caused by the small size of the standard errors.

It is also interesting to see that the share of counterparty risk premium associated with any currency is relatively stable regardless of which currency is in the other leg. For example, the share of counterparty risk premiums for USD is 17.5%, 18.9% and 16.1% when the other leg is the EUR, CHF and JPY respectively; that for EUR is 76.2%, 79.9%, 71.0% and 76.1% when the other leg is USD, GBP, CHF and JPY respectively. This indicates that, on average, counterparty risk premium accounts for a consistently smaller share in the total risk premium in the USD Libor market when compared to Libor markets of the other currencies, while counterparty risk premium takes up a much larger share in the EUR Libor market. Perhaps, the only exception is GBP, as the share of counterparty risk premium for USD vis-à-vis GBP is 36.8%, which is still small

[23] The Durbin-Wu-Hausman test statistics for each currency pair are listed below. The null hypothesis is that the first differences of domestic and foreign currency IRS and OIS are exogenous.

Curr pairs	**USD/EUR**	**USD/GBP**	**USD/CHF**	**USD/JPY**	**EUR/GBP**	**EUR/CHF**	**EUR/CHF**
Diff. in J-stat	3.9757	5.8490	2.7510	5.8828	2.8020	2.3178	4.5259
Probability	0.4093	0.2107	0.6003	0.2081	0.5915	0.6775	0.3395

[24] As a robustness check, we conducted the same estimation using winsorised data between 0.5% and 99.5% percentiles. The results are broadly consistent with those using the five-standard-deviation outlier-detection method.

but somewhat larger when compared to the other currencies. Hence, overall, the evidence seems to suggest that the share of counterparty risk premium is perceived to be fairly consistent across the non-USD currencies.

Estimation results of unrestricted and restricted models

Table 4

Foreign currency	EUR	GBP	CHF	JPY	GBP	CHF	JPY
				Unrestricted model			
		USD as domestic currency			*EUR as domestic currency*		
Constant	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
C1 (FC OIS)	0.7616 ***	0.4480 ***	0.1175 ***	0.1882 ***	0.4262 ***	0.0936 **	0.2143 ***
	(0.0382)	(0.0446)	(0.0346)	(0.0643)	(0.0505)	(0.0365)	(0.0694)
C2 (DC OIS)	-0.1747 ***	-0.3682 ***	-0.1893 ***	-0.1606 ***	-0.7986 ***	-0.7096 ***	-0.7609 ***
	(0.0333)	(0.0386)	(0.0556)	(0.0495)	(0.0486)	(0.0723)	(0.0629)
C3 (FC IRS)	0.2246 ***	0.4979 ***	0.7899 ***	0.7243 ***	0.5343 ***	0.7506 ***	0.6860 ***
	(0.0368)	(0.0445)	(0.0453)	(0.0703)	(0.0514)	(0.0483)	(0.0742)
C4 (DC IRS)	-0.8176 ***	-0.5927 ***	-0.8128 ***	-0.8196 ***	-0.2042 ***	-0.2913 ***	-0.2239 ***
	(0.0329)	(0.0376)	(0.0548)	(0.0495)	(0.0468)	(0.0699)	(0.0616)
R-squared	0.7986	0.7104	0.6278	0.6873	0.6398	0.3742	0.5183
Adjusted R-squared	0.7982	0.7098	0.6270	0.6866	0.6390	0.3729	0.5173
DW Statistics	2.3565	2.7895	2.5773	2.5067	2.5514	2.6928	2.6482
Log Likelihood	14317	13587	12275	13400	13477	12328	13460
				Restricted model			
		USD as domestic currency			*EUR as domestic currency*		
Constant	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
C1	0.7717 ***	0.4763 ***	0.1295 ***	0.2129 ***	0.4425 ***	0.1175 ***	0.2499 ***
	(0.0365)	(0.0440)	(0.0345)	(0.0607)	(0.0503)	(0.0364)	(0.0655)
C2	-0.1796 ***	-0.3998 ***	-0.1997 ***	-0.1703 ***	-0.7993 ***	-0.7238 ***	-0.7738 ***
	(0.0326)	(0.0373)	(0.0544)	(0.0490)	(0.0465)	(0.0698)	(0.0612)
R-squared	0.7985	0.7086	0.6254	0.6868	0.6377	0.3643	0.5175
Adjusted R-squared	0.7983	0.7083	0.6250	0.6864	0.6374	0.3636	0.5170
DW Statistics	2.3618	2.8025	2.5797	2.5117	2.5587	2.6781	2.6547
Log Likelihood	14317	13581	12269	13398	13471	12313	13458

1. This table reports the coefficients estimated from the unrestricted and restricted models. Standard errors are included in parentheses.

2. The equations are estimated at daily frequency over the sample period from September 22, 2009, to June 30, 2017, subject to data availability.

3. *, ** and *** denote statistical significance at the 10%, 5% and 1% levels.

Wald test results of unrestricted models

Table 5

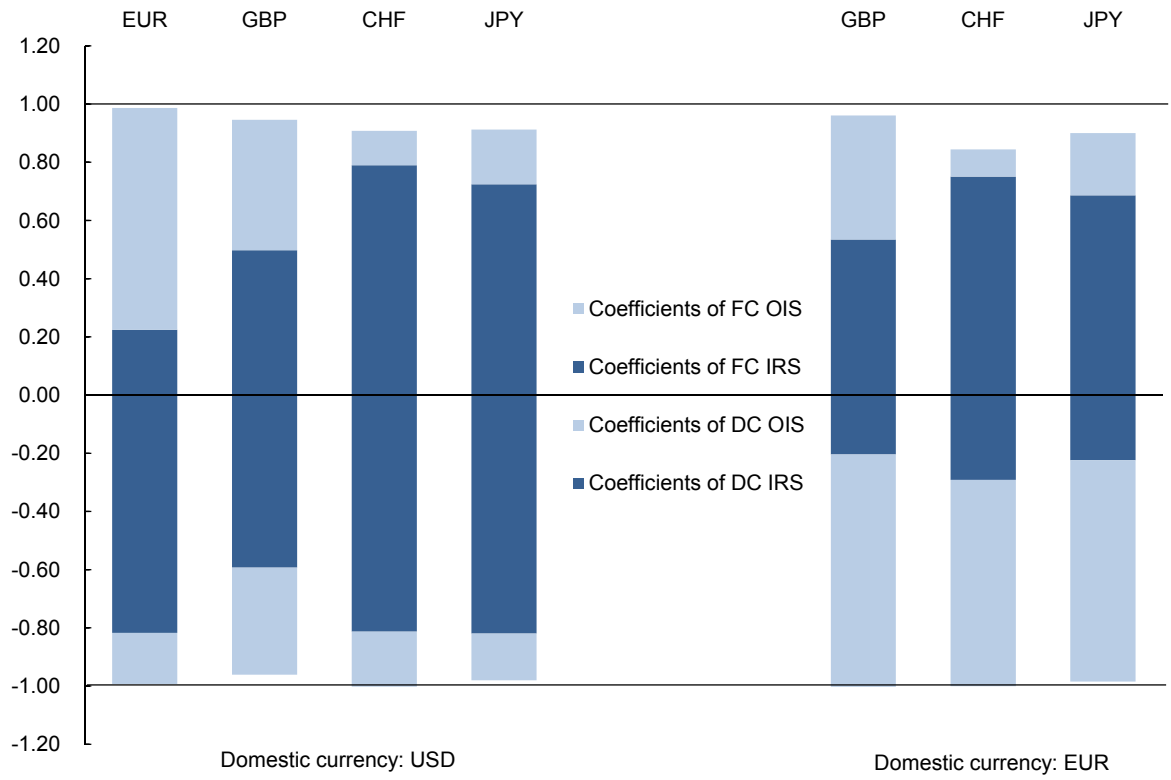
Foreign currency	EUR	GBP	CHF	JPY	GBP	CHF	JPY
		Domestic currency is USD			*Domestic currency is EUR*		
C1 + C3 = 1 (FC)		***	***		**	***	*
t-statistic	-0.9015	-3.4070	-2.8285	-1.6158	-2.3411	-4.1489	-1.8361
F-statistic	0.8126	11.6076	8.0005	2.6107	5.4808	17.2132	3.3711
p-value	0.3675	0.0007	0.0047	0.1063	0.0193	0.0000	0.0665
C2 + C4 = 1 (DC)		***					
t-statistic	-0.6708	-2.6604	0.1149	-1.3169	0.1343	0.0307	-0.7126
F-statistic	0.4499	7.0778	0.0132	1.7343	0.0180	0.0009	0.5078
p-value	0.5025	0.0079	0.9086	0.1880	0.8932	0.9755	0.4762

1. This table reports the Wald test t-statistics, F-statistics and p-values of the unrestricted models. For foreign currency and domestic currency, we separately test whether the sum of the coefficients of IRS and OIS is equal to one.

2. *, ** and *** denote statistical significance at 10%, 5% and 1% levels.

Sum of unrestricted coefficients of IRS and OIS

Figure 6



Source: Table 4

In light of the above results, we estimate the restricted model to improve the precision of the estimates. As can be seen, the results are consistent with those of the unrestricted one, where the coefficient representing the share of counterparty risk premium falls strictly between zero and one, and remains broadly consistent across currency pairs. The average shares of counterparty risk premiums for USD and EUR in the restricted model are 23.7% and 76.7% respectively, which are close to their unrestricted counterparts of 22.3% and 75.8%. In both restricted and unrestricted models, the fitness of regression is surprisingly good, considering that the variables are in the form of first differences. Adjusted R-squared, for both restricted and unrestricted estimations, lies between 0.62 and 0.80 for most regressions except for EUR/CHF (0.36) and EUR/JPY (0.52). Since the adjusted R-squared reduces only marginally, the restrictions are reasonable and sound.

However, an important caveat to the estimates of the shares of these risk premiums is how well the Libor-OIS spread can represent the risks involved for CCBS pricing or, in other words, how applicable Libors are for CCBS participants to borrow on an unsecured basis. Admittedly, the Libor-OIS spread is not a perfect measure of the risks for the CCBS market. First, the Libor scandal is well known and therefore its reliability as a measure of the cost of funding accessible by banks in general seems questionable (Hou & Skeie (2014)). Second, there is a considerable difference in the composition between the Libor and CCBS markets. The Libor market mainly consists of banks, while the CCBS market comprises of a wide range of financial and non-financial institutions, including banks, insurers, investment managers, hedge funds and large corporations. It is clear, therefore, that most of the CCBS market participants are unable to access funds at Libors on an uncollateralised basis. As a result, the risks

are likely to be underestimated. Nonetheless, the spread is still arguably the best available measure that can serve as a reasonably good approximation of the risks for our estimation, especially since first difference data are employed.

4. Conclusions

The breakdown of CIP is more of a myth in the sense that the returns on investing in different currencies are no longer the same even after exchange rate risk is covered. True, exchange-rate-risk-covered returns, taken at face value, are no longer the same because the uncovered returns, as commonly represented by Libors in testing CIP, consist of considerable counterparty and liquidity risk premiums in today's money market. Hence, CIP breaks down as Libors, which are interest rates for unsecured borrowing/lending, are no longer fit for use in pricing CCBS, which are secured transactions. Therefore, the uncovered returns must be adjusted for the counterparty risks involved in the transaction. This is precisely what the swap dealer is trying to do in the CCBS market.

In short, therefore, the CCBS basis is no mystery. It merely reflects the price adjustment the swap dealer has to undertake in order to make the transaction fair to both sides. This adjustment is absolutely necessary due to one important fact: the counterparty risk in the domestic currency money market differs from that in the foreign currency money market. Therefore, the invalidity or inobservance of CIP as manifested by the non-equivalence between the Libors of two currencies does not mean that the market has failed. Quite the contrary, the change in the behaviour of market participants reflects that the market has functioned particularly well as it prices in the associated risks in CCBS transactions. Expecting CCBS bases to be zero in today's financial markets is failing to recognise that market participants, in pricing or trading a financial product, must consider the risks that are factored into the prices of its reference financial products instead of taking them at face value. CIP asks the swap dealer to take money market rates at face value. Obviously he would not be obliged to do so.

In this paper, we have argued that the swap dealer behaves as if he seeks to remove the counterparty risk premium in the money market rates when pricing the CCBS. Given that the CCBS basis is the same as the CIP deviation, we have estimated the forward premium using the domestic and foreign OIS rates and IRS rates for seven currency pairs using the risk-adjusted CIP model. The empirical results support our thesis that the forward premium is largely determined by the difference between the weighted averages of OIS and IRS rates for both the domestic and foreign currencies as predicted by the model. Because the swap market, as we argue, functions effectively as a device to separate counterparty risk and liquidity risk, the model also allows us to estimate the shares of the two risk premiums that make up the Libor-OIS spread. Generally speaking, liquidity risk premium, on average, accounts for a much greater proportion relative to counterparty risk premium for USD, while the reverse is true for the other currencies. Hence, the USD lender (*cum* foreign currency borrower) tends to receive a greater discount from the foreign currency loan, causing the CCBS bases to be negative.

We have also shown that the so-called market anomaly exists not only in the CCBS with a dollar leg but also in those without one. This finding poses a challenge to the economists who argue that CIP deviation or CCBS basis is attributable to a global shortage of US dollars or reflects the role of the US dollar as a global funding

currency, for if it were purely a dollar phenomenon there is no reason why the CCBS bases vis-à-vis USD are considerably different from each other or why cross CCBS bases (ie, those CCBS without a dollar leg) are non-zero. We have further demonstrated how to arbitrage in the CCBS market. Interestingly, we have found that the CCBS bases satisfy a no-arbitrage condition, which means they are not arbitrarily determined but rigorously priced.

References

Acharya, V and D Skeie (2011): "A model of liquidity hoarding and term premia in inter-bank markets", *Journal of Monetary Economics*, vol 58, no 5, pp 436–47.

Avdjiev, S, W Du, C Koch and H S Shin (2017): "The dollar, bank leverage and the deviation from covered interest parity", *BIS Working Paper*, no 592, July.

Baba, N and F Packer (2009): "Interpreting deviations from covered interest parity during the financial market turmoil of 2007–08", *Journal of Banking and Finance*, vol 33, no 11, pp 1953–962.

Bank for International Settlements (2014): *Global foreign exchange market turnover in 2013*, BIS Triennial Central Bank Survey, February.

——— (2016): *Global foreign exchange market turnover in 2016*, BIS Triennial Central Bank Survey, September.

Bianchetti, M (2010): "Two curves, one price", *Risk*, vol 23, no 8, p 66.

Borio, C, R McCauley, P McGuire and V Sushko (2016): "Covered interest parity lost: understanding the cross-currency basis", *BIS Quarterly Review,* September.

Bottazzi, J, J Luque, M Pascoa and S Sundaresan (2013): "Dollar shortage, central bank actions, and the cross currency basis", paper presented at the 2013 European Meeting of the Econometric Society.

Brownlees, C and G Gallo (2006): "Financial econometric analysis at ultra-high frequency: data handling concerns", *Computational Statistics and Data Analysis*, vol 51, no 4, pp 2232–45.

Brunnermeier, M and L Pedersen (2009): "Market liquidity and funding liquidity", *Review of Financial Studies*, vol 22, no 6, pp 2201–38.

Charles, A and O Darné (2005): "Outliers and GARCH models in financial data", *Economics Letters*, vol 86, no 3, pp 347–52.

Chen, C and L Liu (1993): "Joint estimation of model parameters and outlier effects in time series", *Journal of the American Statistical Association*, vol 88, no 421, pp 284–97.

Coffey, N, W Hrung and A Sarkar (2009): "Capital constraints, counterparty risk, and deviations from covered interest rate parity", *Federal Reserve Bank of New York Staff Report*, no 393, September.

Du, W, A Tepper and A Verdelhan (2017): "Deviations from covered interest rate parity", *Journal of Finance*, forthcoming.

Duffie, D (2016): "Why are big banks offering less liquidity to bond markets?", *Forbes*, March.

Fong, W, G Valente and J Fung (2010): "Covered interest arbitrage profits: the role of liquidity and credit risk", *Journal of Banking and Finance*, vol 34, no 5, pp 1098–107.

Fukuda, S (2016): "Strong sterling pound and weak European currencies in the crises: evidence from covered interest parity of secured rates", *Journal of the Japanese and International Economies*, vol 42, pp 109–22.

Gabaix, X and M Maggiori (2015): "International liquidity and exchange rate dynamics", *The Quarterly Journal of Economics*, vol 130, no 3, pp 1369–420.

Garleanu, N and L Pedersen (2011): "Margin-based asset pricing and deviations from the law of one price", *Review of Financial Studies*, vol 24, no 6, pp 1980–2022.

Gefang, D, G Koop and S Potter (2011): "Understanding liquidity and credit risks in the financial crisis", *Journal of Empirical Finance*, vol 18, no 5, pp 903–14.

Genberg, H, C Hui, A Wong and T Chung (2009): "The link between FX swaps and currency strength during the credit crisis of 2007-2008", *Hong Kong Monetary Authority Research Notes*, no 01/2009, February.

Grbac, Z, A Papapantoleon, J Schoenmakers and D Skovmand (2015): "Affine LIBOR models with multiple curves: theory, examples and calibration", *SIAM Journal on Financial Mathematics*, vol 6, no 1, pp 984–1025.

Hou, D and D Skeie (2014): "Libor: origins, economics, crisis, scandal, and reform", *Federal Reserve Bank of New York Staff Report*, no 667, March.

Hui, C, H Genberg and T Chung (2011): "Funding liquidity risk and deviations from interest-rate parity during the financial crisis of 2007–2009", *International Journal of Finance and Economics*, vol 16, no 4, pp 307–23.

Ivashina, V, D Scharfstein and J Stein (2015): "Dollar funding and the lending behavior of global banks", *Quarterly Journal of Economics*, vol 130, no 3, pp 1241–81.

McAndrews, J, A Sarkar and Z Wang (2017): "The effect of the term auction facility on the London interbank offered rate", *Journal of Banking and Finance*, vol 83, pp 135–52.

Mercurio, F (2010): "Libor market models with stochastic basis", *Bloomberg Education and Quantitative Research Paper,* no 2010-05-FRONTIERS.

Michaud, F and C Upper (2008): "What drives interbank rates? Evidence from the Libor panel", *International Banking and Financial Market Developments*, vol 3, p 47.

Parker, F (1965): "Matrices in the market place", *Mathematics Magazine*, vol 38, no 3, pp 125–28.

Rime, D, A Schrimpf and O Syrstad (2017): "Segmented money markets and covered interest parity arbitrage", *BIS Working Paper*, no 651, July.

Sarkar, A (2009): "Liquidity risk, credit risk, and the Federal Reserve's responses to the crisis", *Financial Markets and Portfolio Management*, vol 23, no 4, pp 335–48.

Shin, H S (2016): "Global liquidity and procyclicality", presentation at the World Bank Conference on the State of Economics, the State of the World. Washington DC, 8 June.

Sushko, V, C Borio, R McCauley and P McGuire (2017): "The failure of covered interest parity: FX hedging demand and costly balance sheets", *BIS Working Papers*, no 590, August.

Tuckman, B and P Porfirio (2003): "Interest rate parity, money market basis swaps, and cross-currency basis swaps", *Fixed Income Liquid Markets Research*, Lehman Brothers.

Wong, A, D Leung and C Ng (2016): "Risk-adjusted covered interest parity: theory and evidence", *Hong Kong Institute for Monetary Research Working Paper*, no 16/2016, https://ssrn.com/abstract=2834798.

Discussion of Alfred Wong and Jiayue Zhang's paper

Yiping Huang[1]

Paper summary

This is a good paper. By using empirical evidence and estimated model results, the paper solves, in a simple way, the mystery of the violation of covered interest parity (CIP) in international finance. It suggests that the long-standing covered interest parity puzzle does not take into account country risk (in the paper, this is part of the counterparty risk premium) and liquidity risk, both of which have become prominent in the period since the global financial crisis. By calculating the risk-adjusted covered interest parity, the paper shows that the cross-currency basis swap (CCBS) market functions well: deviations from this version of CIP are small, indicating that there is little scope for arbitrage.

By estimating seven pairs of CCBS, the paper finds that the counterparty risk premium accounts for a consistently smaller share in the total risk premium in the USD Libor market (around 16–19%) while the counterparty risk premium takes up a much larger share in the total risk premium in the EUR Libor market (around 75%).

This paper contributes to the current literature in two important ways. First, it recognises the behaviour of swap dealers in correctly pricing the risks after the global financial crisis (to be exact, the swap dealers priced risks before the GFC but the risks were quite small in comparison, so that it may have looked as if they were not pricing risks) and proves that the CCBS market functions well. Second, it offers new insights on the current debate on the relative importance of country risks (measured by the default possibilities of the foreign loans) and liquidity risks in domestic money markets for both USD and EUR that are different from the "shortage of dollar supply" and "increased global demand for dollar liquidity" stories that are often mentioned.

Questions and comments on the paper

1. How should we understand or interpret the counterparty risk premium in the USD Libor market being relatively very small compared with that in the EUR Libor market, given that the global financial crisis was initially ignited within the United States? When asking this question in conjunction with the global shortage of US dollars, is it because of the relatively low risk of the country premium that leads to excess demand for the dollar, or is it because of the excess demand for the dollar that leads to a lower premium?
2. A related question is: the CCBS with a USD leg stays almost constant after the onset of the global financial crisis while the CCBS with a EUR leg diverges among different pairs of currencies. Based on the hypothesis of the paper, the CCBS is a measurement of the counterparty risk premium, ie the country risk premium on defaulting on each other's loans. Is this an indicator of the strong persistence of the country risk in the post-crisis period? If so, there seems to be no evidence that unconventional policy actions helped to stabilise the economy and reducing the country risks, especially for the US Libor market.

[1] Peking University

3. Conditional on accepting the authors' theory, as stated in footnote 16, Libor can be decomposed into three components: a risk-free rate, the counterparty risk premium, and the liquidity premium. Assuming that the risk-free rate is unchanged after the crisis, the relative shares of the counterparty risk premium and the liquidity premium in the total risk premium are interdependent. If the liquidity premium is overestimated, then the counterparty risk premium could be underestimated, while the liquidity premium is dependent on the market condition of the liquidity supply. Therefore, if there is an undersupply of market liquidity, the liquidity premium could appear larger than it actually is (as footnote 7 says). This issue could potentially apply to the US Libor market. Then the market liquidity premium of the dollar could be larger because of the supply shortage, and that could lead to an overestimate of the share of the liquidity premium, and an underestimate of the counterparty risk premium. I think the paper needs to be more careful in addressing this potential issue.

4. In proving the equivalence between FX swaps and CCBS, the paper says the equivalence holds under certain assumptions. If I understand it correctly, these implicit assumptions include:

    a. "there is a basis for any currency pair in the CCBS market so that one can arbitrage by entering as many CCBS contracts at the same time if the sum of the bases does not equal zero, as shown by equation (3)". But is it really realistic to assume that one can arbitrage by entering many CCBS contracts at the same time? Consider, in particular in relation to the dollar shortage story, that there is a limited availability of CCBS contracts with a US leg due to the shortage of the dollar currency. Swap dealers may then have to accept a lower basis to attract the contract, which may lead to lower estimates of the country risk premium.

    b. "Cash flows from a CCBS can be synthetically converted into those of an FX swap with the same maturity at zero cost, using a series of FX swaps and forward rate agreements". Is it a realistic assumption that the cost of converting CCBS into FX swap is zero? What if there is a transaction cost for making the conversion?

    c. I assume that "the foreign currency cash flow at maturity should be equal to that of the FX swap in an efficient market" is the same assumption of the zero cost as stated in b. Is this correct? If so, the same concern applies.

5. This comment is on the robustness check. In footnote 22, the authors state that the results using three or four standard deviations to the data for estimation are available upon request. I suggest that these be included in the appendix, as a proper robustness check of the results.

6. My final question is more fundamental, and relates to the behaviour of the swap dealers. According to the paper, the swap dealers have actually been well able to price the risks associated with country risk and liquidity risk into their CCBS bases since the crisis. Given the unobserved nature of these risks, what is the rationale behind this seemingly well informed pricing mechanism or pricing equation that the swap dealers have in mind in their daily operations? If the swap dealers are indeed well informed about the risks, why were there no rising risk premia before the crisis, at the very time when the country default risks were rapidly accumulating?

Finding equilibrium: on the relation between exchange rates and monetary policy

Sebastian Edwards[1]

Abstract

This paper deals with the relationship between exchange rates and monetary policy in small open economies. I also discuss the connection between policy rates in small countries and in major advanced economies. A main point is that central bankers need to know whether the currency is (approximately) close to its long-run equilibrium value. However, in the last 25 years there has been very little progress on finding the long-run exchange rate equilibrium. I argue that the economics profession needs to make a major effort to improve the relevant models. The historical situations discussed include the US abandonment of the gold standard in 1933, the East Asian crisis of 1997, and the recent fluctuations of the Mexican peso.

JEL classification: E52, E58, F30, F32.

[1] University of California, Los Angeles and National Bureau for Economic Research.

This is an expanded version of the keynote speech given at the BIS–Hong Kong Monetary Authority conference "The price, real and financial effects of exchange rates" held in Hong Kong on 28–29 August 2017. I thank conference participants for very helpful comments. As always, I have benefited from extensive discussions with Ed Leamer. The paper draws on some of my research in recent years. The title is taken from Till Düppe's and Roy Weintraub's wonderful book *Finding Equilibrium: Arrow, Debreu, McKenzie and the Problem of Scientific Credit*, where the authors discuss the process that led to the proof of the existence of a competitive equilibrium in a theoretical abstract economy.

1. Introduction

In this paper, I deal with exchange rates and monetary policy in small open economies. More specifically, I discuss the transmission mechanism under flexible exchange rates, and the relationship between the policy rate in small countries and in major advanced economies. A main point of the paper is that central bankers need to know whether the currency is (approximately) close to its long-run equilibrium value. This is a fundamental piece of information for making efficient monetary policy decisions. I review the methods currently used by central banks, the multilateral institutions and investment banks to assess the appropriateness of the real exchange rate – whether it is misaligned or close to equilibrium. I argue that these methods are rather crude, and that the profession should make a concerted effort to improve them. In that regard, this talk/paper is more a "call for action" than a catalogue of proposed solutions. Throughout the discussion, I discuss a number of historical situations, including the US abandonment of the gold standard in 1933, the East Asian crisis of 1997 and the recent fluctuations of the Mexican peso.

For a long time, it has been recognised that monetary policy affects exchange rates. Traditionally, different models have emphasised different mechanisms: the monetary approach to floating exchange rates, developed in the 1970s by Harry Johnson and Jacob Frankel, among others, emphasised the role of broadly defined money supplies – at home and abroad – as key determinants of bilateral nominal exchange rates. In these simple monetary models, it is assumed that a version of purchasing power parity (PPP) holds at all times. Monetary models in the rational expectations tradition, such as Edwards (1983), expanded this view, and tested whether money "surprises" drove most exchange rate changes. The portfolio approach, associated with authors such as William Branson and Penti Kouri, focused on portfolio equilibrium. In this setup, the exchange rate plays a fundamental role in allowing changes in the stocks of assets denominated in different currencies. In Dornbusch's celebrated model of exchange rate overshooting, monetary policy operates in a Keynesian way: an expansion of liquidity lowers short-term nominal and real interest rates, and through the uncovered interest parity condition (and under the assumption of sticky prices in the short run) generates a jump in the nominal exchange rate. Models that emphasise capital movements have focused on the "carry trade" as one of the main determinants of exchange rates in the short run. In these models, a lower policy rate generates net capital outflows, and consequently it will tend to depreciate the currency.[2] Recently, a number of authors have combined the most salient features of earlier models and have emphasised the fact that there are a number of exchange rate-related puzzles. Itskhoki and Mukhin (2017), for example, have proposed a "unified" theory of exchange rates that emphasises the role of financial shocks, including monetary policy changes, and considers new transmission mechanisms.

The works discussed above, and related literature, ask how changes in monetary policy affect exchange rates. In this paper I deal with this traditional causal relationship, as well as with causality in the opposite direction. That is, I inquire how changes in exchange rates impact, or provide a feedback, on central bankers' policy

[2] See, for example, Johnson and Frenkel (1978), Branson (1981), Kouri and Porter (1974), Dornbusch (1976), Frankel (1982), Rogoff (1996), Engel and West (2005). For early empirical tests of these models see, for example, Meese and Rogoff (1983). For recent attempts at synthesis see, for example, Itskhoki and Mukhin (2016).

decisions. I argue that in this "reverse causality" process it is fundamentally important to understand whether the (real) exchange rate is close to its long-run equilibrium value.

The rest of the paper is organised as follows. In Section 2, I provide a brief discussion of the transmission mechanism of monetary policy in small open economies. In Section 3, I deal with the feedback from the policy rate in a foreign country into domestic policy decisions. I argue that there is recent evidence of "policy spillover" from advanced to emerging countries. In Section 4, I discuss the devaluation of the dollar in 1933, one of the most important and well known devaluations in the history of monetary economics. I ask whether at the time the dollar was overvalued, or if, on the contrary, its devaluation may be seen as some sort of "currency manipulation". In Section 5, I discuss and review the alternative methods used by the economics profession to assess whether the (real) exchange rate is close to its long-run equilibrium. I argue that these methods have changed very little in the last 25 years or so, and that they provide only imprecise measures of possible real exchange rate misalignment. I point out that it is important that the profession develops better models to deal with this particular problem. In this section, I also discuss recent (2015–17) developments in Mexico, including the way in which the rapid depreciation of the peso affected the central bank's policy decisions. Finally, Section 6 concludes.

2. The transmission mechanism and exchange rates

The traditional transmission mechanism of monetary policy under flexible exchange rates and inflation targeting is the yield curve – see any model in the Mundell-Fleming tradition. The central bank changes the policy rate – usually a very short-term interbank rate – with the expectation that this change will be transmitted along the yield curve, and will affect longer-term interest rates, which, in turn, will impact consumption decisions by households and investment decisions by firms. In the case of the United States, the expectation is that changes in the federal funds rate will be reflected in the 10-year Treasury note yield. It is this longer-term benchmark rate that affects economic agents' expenditure decisions, including households' expenditure on big ticket items. In discussing the transmission mechanisms of monetary policy, Leamer (2007) has recently argued that the most important effect of changes in the long interest rate is on the housing sector.

For some time now – approximately since the first decade of the 21st century – there has been concern among experts that monetary policy in the United States – and in other advanced countries or monetary unions, for that matter – has lost effectiveness and power. Long-term interest rates seem to be much less responsive to changes in the policy rate. Perhaps the clearest manifestation of this phenomenon happened after July 2004 in the United States. Starting in that month, the Federal Reserve hiked its policy rate by 425 basis points. However, the longer-term rate (10-year Treasuries) did not change, or changed very little. This is what the then Fed Chairman Alan Greenspan referred to as the "conundrum". The most common explanation for this phenomenon is that in a globalised economy with interconnected financial markets, longer-term interest rates are determined by the global interaction between savings and investment, and are not susceptible to being influenced by local monetary policy, not even by large countries' central banks. This view came to be known as the "saving glut" perspective, as proposed and defended strongly by Ben Bernanke.

This point has been acknowledged by a number of central bankers. For example, in a 2016 presentation made at a conference in Singapore, the Governor of the Central Bank of Iceland Már Gudmundsson argued, persuasively, that the traditional interest rate transmission mechanism is weakened (or broken) in open economies in the 21st century. This is particularly so if the country in question is very small, as in the case of Iceland, New Zealand, Thailand, Chile and similar nations. Governor Gudmundsson argues that, under these open economy circumstances, the main mechanism of transmission ceases to be the yield curve, and is replaced by the nominal exchange rate.

This "exchange rate" transmission mechanism works as follows: a hike in the central bank policy rate will generate, through the "carry trade", an exchange rate appreciation. The stronger currency, in turn, will generate downward pressure on prices – through some version of the law of one price for tradable goods – and in this way will reduce the inflationary pressure in the domestic economy. Likewise, a reduction in the policy rate will prompt currency depreciation, and through this mechanism, will generate upward pressure on prices. In addition, currency depreciation will result in export expansion and an increase in domestic activity. Changes in foreign central bank policy rates will also have an impact on the value of the domestic currency: a hike in international interest rates generated by a federal funds rate increase will tend to depreciate the currency of small countries, and through this channel affect domestic prices.

In order to understand fully the transmission mechanism through exchange rate channels, it is important that models can answer two questions: (i) what is the impact of changes in domestic (and foreign) policy interest rates on the exchange rate (both bilateral and multilateral), and (ii) what is the "pass-through" coefficient that translates changes in the exchange rate into changes in domestic inflation. I address these two issues from Iceland's perspective in the second part of this report.

To the extent that monetary policy is, indeed, transmitted through exchange rate changes, it is natural that the central bank in a small open economy will take the exchange rate into account – either directly or indirectly – when formulating policy. In particular, central bankers should be concerned whether the real exchange rate is close to equilibrium, or if it is misaligned. If a country is facing misalignment, monetary policy actions triggered by inflation considerations may exacerbate this disequilibrium. This means, that there are reasons other than "fear of floating" for central bankers to worry about exchange rates – see Calvo and Reinhart (2000) on fear to float. I address some of these issues in the second part of this report, as well as in the annex devoted to real exchange rate overvaluation.

3. Monetary "policy "spillovers"

An important policy issue for small open economies with inflation targeting and flexible exchange rates is how their central banks should react when advanced countries' central banks (and, in particular, the Federal Reserve and/or the European Central Bank) change their monetary policy stance. According to traditional models of international macroeconomics (ie the Mundell-Fleming model, in many of its versions), under flexible exchange rates countries are able to undertake independent monetary policies, and don't face the "trilemma".

That is, according to these traditional models, central banks in small open economies do not have to follow (or even take into account) the policy position of

the advanced nations, such as the United States and the euro area. More recently, however, some authors, including, in particular, Taylor (2007, 2013, 2015), and Edwards (2012, 2015a, b) have argued that, even under flexible exchange rates, there is significant policy interconnectedness across countries. In a highly globalised setting, even when there are no obvious traditional reasons for raising interest rates, some central banks will follow the Fed. This phenomenon may be called "policy spillover", and could be the result of a number of factors, including the desire by central banks to protect domestic currencies from "excessive" volatility. If this is indeed the case, then even under flexible exchange rates there is no such a thing as true "monetary independence".

The late Ron McKinnon from Stanford University captured this idea, when in May 2014 he stated at a conference held at the Hoover Institution that "there's only one country that's truly independent and can set its monetary policy. That's the United States."

Of course, not every co-movement of policy rates should be labelled as a "spillover". It is possible that two countries (the United States and, say, Colombia) are reacting to a common shock – a large change in the international oil price, for example. A "spillover" would happen if, after controlling by those variables that usually enter into a central bank policy reaction function – the traditional Taylor rule variables, say – there is still evidence that the smaller central bank has followed the Fed.

As Clarida (2014), Edwards (2017a), Taylor (2015) and others have recently argued, there are at least two reasons why it may be optimal for central banks in small economies to include the interest rate of advanced countries central banks in their policy reaction function.[3] The first has to do with what Calvo and Reinhart (2000) called "fear to float". This phenomenon is usually present in countries where there is significant currency mismatch in the banking sector. There is plenty of evidence from Latin America – Chile in 1982, Mexico in 1994, Argentina in the 2000s, for example – that indicates that, due to currency mismatch, large devaluations create havoc in the financial sector. If interest rate hikes by foreign central banks result in a (large) depreciation of the domestic currency, it may be optimal for the domestic central bank to react by hiking its own policy rate, as a way of avoiding the balance sheet effects of the depreciation in the context of significant currency mismatches.

The second reason for "policy spillover" has to do with potential real exchange rate misalignment. If currency "overvaluation" is costly – and there are many reasons why this is, indeed, the case – then it may be optimal for the central bank to take misalignment into consideration when undertaking monetary policy. For instance, it is possible that an increased degree of overvaluation will undercut exports, resulting in a large future output gap. This was the case of Mexico during 2015–17.

3.1 A simple framework

In a world with two countries, this situation is captured by the following two policy equations, where r_p is the policy rate in the domestic country, r_p^* is the policy rate in the foreign country, and x and x^* are vectors with the traditional determinants of policy rates (the elements in standard Taylor rules, for example), such as deviations of

[3] It should be noted that I am referring here to the direct inclusion of the foreign policy rate in the reaction function. From early on it was understood that the exchange rate was part of any country's Taylor rule, as long as there is not a zero "passed through" coefficient.

inflation from their targets and the deviation of the rate of unemployment from the "natural" rate:

$$r_p = \alpha + \beta r_p^* + \gamma x \quad (1)$$

$$r_p^* = \alpha^* + \beta^* r_p + \gamma^* x^*. \quad (2)$$

In equilibrium, the monetary policy rate in each country will depend on the other country's rate.[4] For the domestic country the equilibrium policy rate is (there is an equivalent expression for the foreign country):

$$r_p = \frac{\alpha + \beta\alpha^*}{1 - \beta\beta^*} + \left(\frac{\gamma}{1 - \beta\beta^*}\right) x + \left(\frac{\beta\gamma^*}{1 - \beta\beta^*}\right) x^*. \quad (3)$$

Changes in the drivers of the foreign country's policy interest rate, such as α^*, β^*, γ^*, or x^*, will have an effect on the domestic policy rate. This interdependence is illustrated in Graph 2, which includes both reaction functions (1) and (2). PP is the policy function for the domestic country, and P*P* for the foreign nation. The initial equilibrium is at point A. As may be seen, a higher x^* (say the gap between the actual and target inflation rate in the foreign country), will result in a shift to the right of P*P* and in higher equilibrium policy rates in both countries; the new equilibrium is given by B.[5] Notice that in this case the final increase in the foreign policy rate gets amplified: it is larger than what was originally planned by the foreign central bank. The extent of the effect of the foreign country's policy move on the domestic country policy rate will depend on the slopes of the two curves; these, in turn, depend on the parameters of equations (1) and (2).

Given the concerns that have emerged in central banks from around the world in the last few years, it is possible to think that in some countries the actual policy rate would include other global variables, including the long rate in the world economy (r^{*L}) and the extent of uncertainty in global financial markets (μ). In this case, equation (2) would become:

$$r_p = \alpha + \beta r_p^* + \gamma x + \delta r^{*L} + \theta\mu \quad (4)$$

In a number of papers, Edwards (2012, 2015a, 2016) estimated this type of equation for a group of small open economies in Latin America and Asia. His findings suggest that, indeed, there have been "policy spillovers" in most of these countries. However, it is in the Latin American nations – Chile, Colombia, and Mexico – where this phenomenon has been stronger during the period under study, 2000–09. Similar results were obtained by Han and Wei (2018).

For a small nation's central bank, a key question is whether it should take into account explicitly policy decisions by large banks, such as the Federal Reserve or the European Central Bank. Interestingly, when asked about this issue, most central bankers state that their institution has a well defined process, or monetary rule, which takes into account the development of domestic and international variables, but that they do not follow the lead of other central banks. If pressed on the subject, many

[4] The stability condition is $\beta\beta^* < 1$. This means that in Graph 2 the P*P* schedule has to be steeper than the PP schedule.

[5] The new equilibrium will be achieved through successive approximations, as in any model with reaction functions of this type, where the stability condition is met.

central bankers become agitated and offended. For them, following a major central bank is a mistake, something that "serious" central bankers do not do.

3.2 Empirical assessment

In a series of papers, I estimated a number of error correction models of the following type for a group of East Asian and Latin American countries.

$$\Delta r_t^p = \alpha_0 + \alpha_1 FF_t + \alpha_2 \Delta r_{t-1}^p + \alpha_3 r_{t-1}^p + \Sigma \rho_j x_{jt} + \varepsilon_t . \quad (5)$$

r_t^p is the policy rate in each of the three countries in period t, FF_t is the federal funds (target) interest rate, the x_{jt} are other variables that affect the central bank policy actions, including, in particular, the long rate in the foreign country (the United States), inflationary pressures, global perceptions of country risk, and expectations of global inflation: that is, these variables capture what we would normally expect to be included in an expanded Taylor rule type of equation. If there is policy "spillover" the estimated α_1 would be significantly positive, even after controlling for other variables that affect central bankers' decisions. The extent of long-term policy spillover is given by $-\left(\frac{\alpha_1}{\alpha_3}\right)$. If, for example, $-\left(\frac{\alpha_1}{\alpha_3}\right) = 1$, then, there will be full importation of Fed policies into domestic policy rates. Parameter γ allows for the adjustment to a new equilibrium policy rate to be cyclical; this, however, is unlikely. In equation (6), the timing of the variables is contemporaneous. The purpose of these analyses is to determine whether historically central banks have taken into account the evolution of the Federal Reserve policy rate when changing their own policy rates (the period of analysis was restricted to 2000–08, in order to avoid the "zero pound" problem, and to exclude the QE period).

From a methodological perspective, the plan is to start with a bivariate specification that regresses the domestic policy rate on the foreign policy rate, and then to add additional covariates suggested by the theory, in an attempt to "knock down" the coefficient for the federal funds rate. The question is whether co-movement between the two policy rates disappears once the "true" determinants of policy decisions in the small country are included in the regression. If, after including a series of "monetary policy rule" covariates, the coefficient of the foreign policy rate continues to be significantly positive, we can state that there is some evidence suggesting the existence of "policy spillovers". In order to simplify the discussion, in this paper I only present the multivariate results.

In Table 1, I present the results from the estimation of equations of the form of (5), using instrumental variables, for a group of three East Asian countries for the period 2000–08 (I use weekly data): Korea, Malaysia and the Philippines. These three nations provide an interesting and varied sample: Korea and the Philippines had (some degree of) currency flexibility during 2000–08, while during most of the period under study Malaysia had fixed exchange rates (relative to the USD). Moreover, these three East Asia nations' central banks were de facto (but not necessarily de jure) quite independent from political pressure; and Korea and the Philippines followed inflation targeting.[6] In Table 2, I present the results for a sample of three Latin American countries (Chile, Colombia, and Mexico). All three of these countries had flexible exchange rates, followed an inflation targeting policy, and had independent central

[6] For indices of central bank transparency and independence, see Dincer and Eichengreen (2013).

banks during the period under analysis. The definition of the covariates is clear from the two tables.[7]

The most important findings may be summarised as follows. (1) For East Asia, the coefficients of the traditional Taylor rule components (inflationary pressures and domestic growth) are not significant, suggesting that during this period these countries implemented monetary policy following a criterion that differed from traditional Taylor rules. (2) There is, however, evidence that changes in the policy stance in the United States were transmitted, to some extent, to these East Asian nations. (3) The magnitude of the monetary policy "spillover" coefficients is much smaller in East Asia than in Latin America (compare tables 1 and 2). As may be seen, the coefficients for the impact effect are smaller in the East Asian case. But, more importantly, the long-term pass-through coefficient is significantly smaller in East Asia than in Latin America. Compare, for instance, equations (1.1) and (2.1), which have the same specification. According to (2.1) the long-run pass-through in the Latin American nations is a relatively high 0.68, while it is only 0.29 in the East Asian nations. Interestingly, this historical difference in response is consistent with central banks behaviour in the period December 2015 through November 2017 (the time of writing): the Latin American countries tended to follow the Fed – and in some cases, they even tried to pre-empt the Fed – and raised their policy rates, while the East Asian nations stayed "on hold".

All in all, then, the evidence summarised in these two tables provides some support to the view that under floating exchange rates there is a "policy spillover" from the large countries to the small ones. Taylor (2013) has argued that this calls for enhanced policy coordination across central banks.

4. Some history: the devaluation of the dollar in 1933 and monetary policy

In this section, I discuss one of the most important historical episodes where exchange rate and monetary policy interacted with each other. In late January 1934, President Franklin Delano Roosevelt devalued the dollar with respect to gold. The century-old parity of $20.87 per ounce of fine gold was altered, and a new price, which lasted until August 1971, was established at $35 per ounce of gold. The accepted view among economic historians – from Friedman and Schwartz to Bernanke – is that the abandonment of the gold standard and the devaluation of the dollar were at the heart of the US economic recovery from the Great Depression.[8]

4.1 The abandonment of the gold standard and the devaluation of the dollar

From today's perspective, it is difficult to imagine the depth of the Great Depression. Between 1929 and 1932, gross domestic product (GDP) measured in current dollars almost halved, production of durable goods, including automobiles, dropped by 81%, and the value of agricultural production fell by an astonishing 63%. During the same period, employment declined by almost 50%, and the number of unemployed

[7] For details and sources, see Edwards (2016).

[8] Parts of this section draw on Edwards (2017b) and Edwards (2018). For a complete and detailed analysis of the process that led to the devaluation of the dollar and its repercussion on monetary policy, see Edwards (2018).

surpassed 15 million. Those that still had jobs were earning much less than during 1929: according to the Federal Reserve, average wages declined by 67%, and cash income in the rural sector fell by more than 70%.

One of the most destructive aspects of the crisis was the generalised decline in prices. Between mid-1929 and mid-1932, the index of wholesale prices went down by approximately 70%, while the cost of living declined by 40%. Things were particularly bad in the agricultural sector, where the prices of some crops were so low that it was not worth harvesting them. Between 1919 and 1932, the average value of an acre of land for farming declined by almost 60%; the average price of cattle dropped by 63%, and that of hogs by almost 80%. The price of a dozen eggs went from 41.3 cents in 1919 to only 14.2 cents in 1933 – a decline of 66%. A bushel of wheat that in 1919 had commanded $1.53 was sold at 13.5 cents in 1932. And the price of cotton, the commodity that Roosevelt would monitor throughout his first presidency, experienced a decline from 35.34 cents per pound in 1919, to 6.52 cents in 1932 – a reduction of 82%.

As soon as he was sworn in as President, Roosevelt said that he wanted to see a price of cotton above 10 cents a pound by the end of 1933. In May, however, his goal became more ambitious, and he announced that the objective of his economic policy was to return agricultural prices to their 1926 level.

The dollar was devalued in stages: on 19 April 1933 the President announced that the country had abandoned the gold standard. Gold exports were forbidden. Not only that, individuals and institutions had to sell all of their gold holdings to the Federal Reserve at the old parity of $20.87 per ounce. On 5 June, Congress passed a Joint Resolution abrogating the gold clause in contracts. In mid-October a "gold buying program" was implemented in an effort to generate an increase in agricultural prices. On 15 January 1934, the president announced that he was asking Congress to pass a new Gold Act. On 30 January, the new legislation was passed. The next day, the president devalued the dollar officially to $35 per ounce of gold. At this point, the United States committed itself to buying and selling gold in the international market at that particular price.

Graph 2 contains monthly data from 1915 through 1940 for the quantity of money (M2), the monetary base (or high powered money), the stock of monetary gold, and the multiplier. The April 1933–January 1934 period, which corresponds to the months that elapsed between the abandonment of the gold standard and the official devaluation of the dollar, is shaded. The story that emerges from these graphs is well known and forms part of the "received wisdom" on the Great Depression mentioned above. Although the monetary base increased by 18.3% between September 1929 and April 1933, the stock of M2 money declined by 34.7% during the same period. The reason for this drop was the collapse of the multiplier. Although the stock of monetary gold remained flat, at approximately $4.1 billion, it experienced significant month-to-month variations in 1931, 1932 and early 1933. Graph 2 also shows the relaxation in monetary conditions after the January 1934 (official) devaluation of the dollar. As may be seen, this was the result of the increase in base money, which, in turn, was the consequence of large gold inflows: the multiplier remained essentially flat (more on this below). Finally, this graph also captures the change in monetary policy stance in 1937, when the Federal Reserve began to sterilise monetary inflows.

In Graph 3, I present weekly data on the USD/sterling and USD/French franc spot exchange rates between 1921 and 1936. Both rates are in the form of "dollars per unit

of foreign currency". As before, the transition period between April 1933 and January 1934 is shaded. This graph captures much of the history of global currencies during these years, including: (a) the return of Britain to gold in May 1925; (b) the re-pegging of the franc to gold (at a much depreciated level) in late 1926; (c) the devaluation of the USD in April 1933; (d) the period of a "managed" currency between April 1933 and January 1934; (e) the adoption of the new dollar gold parity in January 1934; and (f) devaluation of the French franc in October 1936.

4.2 1934: Gold and monetary policy

The first full year of recovery, with a new (more depreciated) currency, was 1934. Output was up in almost every sector, unemployment declined, and prices began to recuperate. Of course, the Depression was not completely over, but the freefall had been arrested and there was hope.

As Milton Friedman, Ben Bernanke and Allan Meltzer, among others, have emphasised, the most important factor behind these developments was a profound change in monetary policy. For the first time since 1927, the broadly defined quantity of money increased throughout the year (see Graph 2). At the heart of this policy change was the decision by the Federal Reserve to allow large inflows of gold triggered by the devaluation of the dollar to be translated into higher liquidity and credit. That is, the central bank made no attempt to "sterilise" gold inflows by selling securities to the public, and in that way mopping up liquidity from the system. With an expansion in money and credit came a jump in confidence, higher investment, enhanced sales and a reduction in unemployment. The New Deal policies, including the more controversial ones such as the National Recovery Administration (NRA) and the Agricultural Adjustment Act (AAA), also contributed to the change in mood and renewed optimism, by making clear that the government was willing to try anything in order to bring the Depression to an end.[9]

Between January and December 1934, the stock of monetary gold more than doubled in the United States, going from $3.9 billion to $8.1 billion. Part of this increase – a little over $2.5 billion – was the result of the devaluation of the dollar, which allowed the Treasury to reprice its stock of bullion (received from the Federal Reserve) at $35 an ounce. But more important than repricing were the large amounts of gold that came into the country immediately after the Gold Reserve Act was passed in late January 1934. More than $750 million flew in during February alone – $239 million from London, $124 million from Paris – another $262 million in March, and $155 million in April.[10]

Several factors were behind these very large shipments. First, as required by the newly passed Gold Reserve Act, after the devaluation the Treasury was willing to buy unlimited amounts of gold in foreign markets at $35 an ounce. This was a significant difference with respect to the second half of 1933. Second, although the devaluation was smaller than what was permitted under the Thomas amendment, it was large enough to give investors' confidence that there would be no additional adjustments in the medium term. Third, most people believed that the United States was on the

[9] Most economic historians, however, have concluded that neither the AA nor the NRA contributed to the recovery itself. In fact, a number of analysts have argued that both these programmes introduced significant distortions into the economy, and resulted in lower investment. See, for example, the essays collected in Bordo, Goldin and White (1998).

[10] Crabbe (1989).

recovery path. There was, also, an increasing feeling in financial centres that the gold bloc countries were in an untenable position and that sooner rather than later they were going to abandon the gold standard and devalue their currencies.

The decision to allow gold inflows to be reflected in higher liquidity was momentous. This change in policy, however, was not due fully to the Federal Reserve. After the Gold Reserve Act of 1934, it was the Treasury and not the central bank that controlled the policy towards gold and exchange rates. The Treasury paid for bullion by issuing gold certificates, which were deposited at the Fed. After receiving the certificates, the central bank "printed money" – fresh dollars – which were then used by the Treasury to pay foreigners for their gold.[11] It was this "printing of money" that resulted in higher liquidity. As Allan Meltzer has noted, Fed officials – including Marriner S Eccles, the new Chairman who took over from Eugene Black in late 1934 – continued to be concerned about possible bouts of inflation, and were leery about the rapid increases in liquidity. When it came to monetary policy, between 1934 and 1941 the Federal Reserve was in the back seat: its leaders "opposed devaluation, silver purchases or increases in money unless they increased consumers' purchasing power".[12]

4.3 Was the US dollar overvalued in 1933?

When analysing this historical episode in US monetary history, it is unavoidable to ask whether in 1933 the dollar was overvalued, or if, on the contrary its value was consistent with "economic fundamentals". Interestingly, in the late 1920s and early 1930s, technical analyses on these issues were mostly confined to purchasing power parity calculations. Indeed, this method had been used by Cassel and Keynes when looking at the interwar situation in Europe.[13] There are no discussions in contemporary – and by this I mean 1932 and 1933 – diaries, correspondence or memoirs on whether in the dollar was out of equilibrium (for more detail, see, for example, Edwards (2018)).

Analysing in detail whether the dollar was misaligned in the early 1930s is beyond the scope of this paper. However, and in order to have some notion about orders of magnitude, Graph 4 displays the evolution of two monthly trade-weighted real exchange rate indexes for the USD for this period – RER4 and RER5. The RER4 index includes the currencies of Canada, France and the United Kingdom: the RER5 adds Italy and Switzerland. These indexes have a base of 1913=100. The graph captures, clearly, the effects of a number of shocks and policy decisions on the US real exchange rate. In particular, it is possible to see the consequences of the suspension of the gold standard during the Great War, the return to the gold standard by the sterling area countries (Canada and the United Kingdom) and Switzerland in 1925, the return to gold by Germany in 1924, and by France and Italy in 1926. The devaluation of sterling in September 1931 is captured by the positive spike in the RER during that month; and the devaluation of the dollar in 1933–34 by a spike in the opposite direction in both indices. The devaluation of the French and Swiss francs is also clearly captured by the data.

[11] As noted by Friedman and Schwartz (1963, p 473), since the Treasury used newly created money to pay for gold, these operations did not put any pressure on the budget.

[12] Meltzer (2003, p 465).

[13] Cassel (1922), Keynes (1924).

Graph 5 presents data on the evolution of the current account balance over GDP for 1919–37. As may be seen, in every year between 1919 and 1933 the United States ran a current account surplus. These were very large in the years immediately following the Great War, reflecting the very high prices of agricultural commodities. After 1923 the surpluses hover at around 0.5% of GDP.

Graphs 4 and 5 show that (i) in late 1932 the RER indexes for the USD were between 12% and 16% higher – that is, more appreciated – than in 1913. That is, the dollar was approximately 14% stronger than it had been just before the war; and (ii) in 1931, 1932 and 1933, the United States was still experiencing a current account surplus. This was true in spite of the fact that, as pointed out by Wigmore (1987) and Temin and Wigmore (1990), foreign central banks and foreign investors withdrew significant amounts of gold during that period. However, it is important to stress that, although there were significant week-to-week fluctuations in gold flows, the overall contribution of the current account to the stock of bullion was positive in 1931 and 1932.

Taken together, these two facts suggest that the US dollar may have been slightly overvalued at the time. This would have called for a small correction in the exchanges relative to the pre-war levels. However, neither the RER data nor the current account information indicate that a massive correction of the exchanges was needed from a purely "fundamentals" point of view. It was only in the years that followed that economists embarked on detailed investigations of whether different currencies were close to their long-run "equilibrium". In early 1935, Harry Dexter White wrote a memorandum at the Treasury where he argued that at that time the dollar was 3% undervalued: according to his calculations, the pound was undervalued by 19%, while the German mark was overvalued by 27%.[14] In 1936, and after a long and detailed study, Harris (1936, p 20) concluded that "[i]t is clear from the large inflow of gold into the United States in the years 1934–1935 that the dollar is undervalued."

5. Finding equilibrium

The discussion in the previous section, on the abandonment of the gold standard and the devaluation of the dollar in 1934, brings to the fore an obvious issue: what type of method should economists use in trying to determine whether a particular currency is close to its long-run equilibrium? This is an old question in international economics.[15]

It is possible to classify the different methods used to evaluate the appropriateness of the (real) exchange rate into four groups: (1) models based on the purchasing power parity approach; (2) models based on the country's external sustainability; (3) regression-based models based on real exchange rate "fundamentals"; and (4) an approach based on DSGE models.[16] In this section, I review

[14] White (1935).

[15] There is an extensive literature on trying to determine the equilibrium value of the real exchange rate. A few examples going back to the 1980s include Edwards (1989), Williamson (1994), Wren-Lewis and Diver (1998), Montiel (1999), Edwards and Savastano (2001), Cline and Kim (2010).

[16] For a detailed discussion of this topic, see, for example, Edwards and Savastano (2001). In a comprehensive review article, Isard (2016) points out that there are six methods for assessing equilibrium real exchange rates. However, two of the methods that he describes are variants or submethods of the ones discussed here.

them briefly, and I point out that none of them provides a satisfactory way of looking at the problem. I, consequently, argue that the profession should make greater efforts to improve on these methods. I point out that this is important not only for investors or other market participants, but also for central bankers.

5.1 PPP and the equilibrium real exchange rate

As late as the 1930s there were very few economists who had thought thoroughly about the subject. The two most important were Cassel (1918, 1922) and Keynes (1924). Another active participant in this discussion was the Italian economist Bresciani-Turroni (1937), who analysed inflation and the equilibrium value of the German mark after the First World War, and who emphasised the fact that the law of one price did not hold on the aggregate if countries had different production baskets. These three authors based their analyses on variations of the purchasing power parity (PPP) doctrine. While Cassel and Keynes focused on price *levels*, Bresciani-Turroni (1937, p 139) emphasised rates of change, or the so-called "relative" version of PPP.

The PPP approach is based on the notion that, at some point in the past, the real exchange rate was in equilibrium and that the value it had during that "base year" is representative of equilibrium at the current moment. The application of the methodology implies undertaking at least two steps: first, some kind of real exchange rate index is calculated for the base and subsequent years. Second a comparison is made between the value of the index in the current moment and during the "base or equilibrium" year. If, at the present time (or at the time we are evaluating), the real exchange rate index departs significantly from its value during the "base year", it is said that the currency is misaligned. In these analyses, "significantly" is not clearly defined a priori.

Possibly one of the most lucid applications of this methodology was undertaken by Lloyd Metzler (1947), who estimated whether the currency values that the members of the International Monetary Fund had declared as initial equilibrium, in December 1946, were in line with the economically defined equilibrium. In this analysis, Metzler used the average real exchange rate between October 1936 and June 1937 as the "base year" for every country in his sample. Metzler justified the use of this benchmark year as follows (p 117):

"This period was selected because it was relatively close to the war years but at the same time reasonably free of war influences. If an earlier period had been used, difficulties would have arisen from the wave of currency devaluations which occurred in the early thirties and mid-thirties. If later period had been used, on the other hand, complication would have been introduced both by the American depression of 1937–38 and by the effects which the eminence of war had upon foreign exchange markets."

In explaining why the use of PPP was appropriate and reasonable, Metzler (p 129) said: "The virtue of the parity rate is that it preserves the earlier real exchange ratio between the goods and services of one country in the goods and services of another."

Of course, Metzler understood that there were a number of limitations associated with this approach. A particularly serious problem was that individual prices moved in different ways within each country and that these relative price movements were not captured appropriately by price composites or indexes. In his words (p 132):

"When some prices or costs rise more rapidly than others within the same country, no simple comparison between price movements in different countries can

be made. The best that can be done is to use an average or index number of price changes, and if the discrepancies in price movement between different commodities in the same countries are large, such an index number at best is only a rough indication of the changes in the value of the monetary unit. Moreover, since several types of price index number are usually available, the calculation of parity rate is not a simple procedure, but involves a considerable element of judgment as to what prices and costs are important for a country's balance of payments."

This difficulty in deciding which price level to use has led a number of analysts to suggest that it is most appropriate to focus on "unit labour costs" instead of price indices.[17] The attraction of this alternative is that, by emphasising costs in different countries, it provides an intuitive measurement of countries' degree of *international competitiveness*. However, this methodology is subject to many of the same limitations as more straightforward PPP based analyses, which are discussed below.

As noted, the main goal of Metzler's study was to undertake a comparison between the initial "equilibrium" parities actually announced by the International Monetary Fund, and the rates calculated by him using different versions of purchasing power parity. Metzler concluded that a number of nations had announced "overvalued" exchange rates to the IMF. This was not an auspicious way of launching the institution, since its mandate was to provide financial assistance to countries that run into financial difficulties because of an inadequate exchange rate level.

The PPP method for assaying the appropriateness of the real exchange has been criticised by trade theorists for a number of reasons. A central limitation is that a mechanical application of the method may lead to very misleading conclusions. This is because there is no reason for the "base period" to capture the equilibrium conditions at the present time or at the time of interest. It is possible that the terms of trade, the degree of openness and other variables – including geopolitical ones – have changed through time, rendering the old equilibrium an irrelevant historical relic. In an important paper, Rogoff (1996) showed that there are large and persistent deviations of purchasing power parity, which are corrected only very slowly over time. Indeed, this finding is considered in the literature to be one of the exchange rate-related puzzles.

Another serious limitation of simple PPP calculations is that they do not take into account the fact that productivity gains differ across countries. According to the Samuelson-Balassa effect, the equilibrium real exchange rate will appreciate – the currency will strengthen in real terms – in countries that experience faster productivity growth than their trading partners and competitors do. For details, including a survey of empirical studies, see for example Edwards and Savastano (2001). This fact has led some analysts such as Isard (2007) to argue that it is important to distinguish between the simple application of the PPP method, and a "productivity differentials-adjusted" PPP approach, where an effort is made to explicitly correct the simple PPP calculations by productivity differentials.

In spite of its problems, this methodology continues to be used around the world by central banks, investment banks, large conglomerates, consultants, journalists and even some academics. Isard (2007) reports that the simple application of the PPP methodology suggested that, in 2006, the USD was roughly in line with its long-term equilibrium. At the same time, the "productivity-adjusted" PPP approach indicated

[17] Indeed, the CBI calculates several ER indices, including one based on unit labour costs.

that that same year the dollar was 11.5% overvalued. Interestingly, Isard (2007) shows that, when alternative methods are used, including the external balance approach discussed below, extremely different results are found for the USD in 2006: according to some of these methods the dollar was overvalued by as much as 25%, while other methodologies suggested equilibrium.

5.2 Current account balance, NIIP, and the equilibrium real exchange rate

A second popular methodology for assessing if a country's RER is close to equilibrium is to analyse whether the current value of the RER is consistent with the country achieving external balance. In the simplest version of this approach, the analyst asks what is the level of the RER consistent with the country's current account balance being equal to zero. Naturally, in order to answer this question, it is necessary to have an opinion about variables that, jointly with the exchange rate, determine the current account balance. These are the so-called "real exchange rate fundamentals" and include the terms of trade, country risk premium, global interest rates, degree of openness of the economy, demand for non-tradables, and others.

A more advanced version of this method recognises that a country may have, for prolonged periods of time, current account balances that are different from zero. This approach, thus, concentrates on the "sustainable current account balance." See, for example, Milessi-Ferretti and Razin (1998) for a discussion, including for some rules of thumb on levels beyond which a current account deficit becomes dangerous. Once the *sustainable* level of the current account balance is determined – say, a deficit of 2.5 % of GDP – the analyst calculates the level of the RER that is consistent with that particular current account balance.

The simplest way to derive the "sustainable" current account balance is to undertake an analysis of the net international investment position (NIIP) of the country in question. Roughly speaking, this methodology consists of the following steps. First, and through a global portfolio analysis, the researcher determines the "equilibrium" net international demand for the country's assets. Once an equilibrium or stable ratio of the NIIP to GDP is established – this may be either a positive or negative number – it is straightforward to estimate the sustainable current account to GDP ratio. At this point, the analyst can extract, after assuming specific values of the "fundamentals", the equilibrium real exchange rate consistent with this specific sustainable NIIP to GDP ratio, and with the associated current account balance. It is important to note that this method requires – as any sophisticated version of PPP does – having a judgment about the long-term equilibrium value of these "fundamentals".

This type of analysis has been used quite extensively in effort to determine whether the USD is out of line with long-run equilibrium. For example, in an extensive paper based on this methodology, Edwards (2005) estimated that in 2004 the dollar was overvalued by around 11%. Using a similar analysis, where the NIIP analysis is based on considerations related to savings and investment, Isard (2007) estimated that in 2006 the USD was overvalued by more than 20%. Obstfeld and Rogoff (2005) use a slightly different model that emphasised the role of tradable and non-tradable goods to analyse the extent of misalignment of the dollar in 2004, and concluded that at the time it was overvalued by approximately 25%.

It is interesting to notice that, if one takes into account both the PPP and the NIIP methods, there is a wide range of estimates on the appropriateness of the value of the dollar in 2004–05. These go from equilibrium to overvaluation of the order of

25%. Having very wide range of estimated values is not particularly useful for policymakers seeking to determine how to incorporate the exchange rate into monetary policy decisions.

5.3 Regression analyses of real exchange rate "fundamentals"

A number of authors – including economists at major investment banks – have used small econometric models to assess whether a country's real exchange rate is compatible with long-run equilibrium. As a background for estimating such systems, many authors derive theoretical models of open economies that include the usual building blocks – representative consumer, optimising firms and others – and consider the existence of a number of external shocks, including terms of trade and productivity shocks.

A simplified rendition of this methodology is as follows. From the theoretical model, and as noted, a reduced form for the real exchange rate is derived and estimated. The covariates consist of the "fundamentals". Depending on the model's degree of sophistication, some monetary variables may be allowed to have a short-run effect on the real exchange rate (but not in long-run equilibrium). For mid-size countries, concerns over endogeneity emerge. In small open economies, however, assumptions of exogeneity of most (but not all) fundamentals are acceptable. Roughly speaking the RER is said to be "misaligned" if its actual value at any given moment in time deviates "significantly" from the regression fitted value. Many of the authors who have used this approach, including officials and researchers at investment banks such as Goldman Sachs and JP Morgan, use single-equation regression models.

A number of authors have argued that, to perform this type of analysis correctly, it is necessary to use "long-term equilibrium" values of the fundamentals. That is, the analyst needs to make a judgment call with respect to, say, the long-run equilibrium value of the country's terms of trade. The simplest way of doing this is by decomposing the "fundamentals" into a permanent and a transitory component. The estimated "equilibrium" real exchange rate is obtained by using the permanent components of the fundamentals in the estimated regression. Examples of work along these lines include Baffes, Elbadawi and O'Connell (1997), Ades (1996), Razin and Collins (1997), Halpern and Wyplosz (1997) and Iossifov and Loukoianova (2007).

In his 2007 paper on Iceland – the smallest of all "small open economies" with a currency of its own – Tchaidze used this regression-based methodology. He included the following fundamentals in the (logarithm of the) RER regression: net foreign assets as a fraction of import/export, a productivity differential that captures the Balassa-Samuelson effect, the logarithm of the terms of trade, and the ratio of government expenditure over GDP. When this equation was used by the CBI to assess the appropriateness of the RER in 2012, it was concluded that the króna had to depreciate by 8–10% relative to its 2006 average in order to achieve long-term equilibrium.

In spite of its popularity, this type of model has a number of shortcomings. First, by construction, these models assume that the real exchange rate has been, on average, in equilibrium during the period under study (this is the case if an intercept is included in the regression). However, from an economic point of view, there is no reason for this to be the case in every country. A second problem is that these models will tend to give very different results, depending on the sample used and on the specification considered. For example, Montiel (1997) estimated that the Thai baht

was significantly overvalued from 1981 to 1987, as well as from 1992 to 1994. On the other hand, the model of Ades (1996) indicates that the Thai currency was persistently undervalued between 1985 in 1993. Other examples include the Mexican peso: according to Broner et al (1997) the Mexican currency was already overvalued in 1990: others suggest that overvaluation started in 1987; while Warner (1997) argues that the peso was slightly undervalued until mid-1993.

5.4 Macro and DSGE models

In the last 20 years, a number of authors have developed dynamic simulation models of open economies and have used them to assess how the equilibrium exchange rate responds to different shocks, both policy-induced as well as exogenous. Some of these models have asked whether central banks should respond to changes in global interest rates that stem from policy action in large nations. See, for example, Lubik and Schorfheide (2007).

Many of these models followed the framework developed by Obstfeld and Rogoff (2005). As has become customary, these models assumed utility-maximising consumers and profit-maximising firms. They differ, however, on the assumptions with regard to the relationship between domestic and international prices. While some models consider a version of the "law of one price", others assume that there is "pricing to market." One of the challenges of this type of model is incorporating a well specified financial and banking sector. See, for example, Edwards and Vegh (1997) for an attempt along these lines.

From a practical perspective, many of these DSGE models generate results that are in line with those obtained when using the external sustainability approach discussed above. For example, Isard (2007) reports that, when these types of model were used to assess the value of the dollar in 2006, they found that the USD was overvalued in the order of 20%, a number similar to that obtained from his "external sustainability" model.

In addition to these DSGE models, a number of central banks have used mid-sized macroeconomic models with estimated equations to analyse external equilibrium conditions, and the appropriateness of the RER at given moment in time. For instance, for a number of years the Central Bank of Iceland has used a model (QMM) which is described as follows:

"QMM is used in the Central Bank of Iceland to assist in analysing the current economic situation, making economic projections, assessing the effect of policies and shocks, evaluating risks, handling uncertainty and with communication both within and outside the bank… QMM is a one-sector representation of the Icelandic economy, containing 28 empirically estimated behavioural relations and 119 other equations, such as accounting identities and definitions."

5.5 A recent episode: Mexico

In this final subsection, I discuss briefly one episode which illustrates the points made in this part of the talk/paper. Graph 6 depicts the evolution of the Mexican real effective exchange rate index between January 2010 and July 2017. As may be seen, this index was relatively stable until January 2015. At that time, and due to a number of reasons, including, in particular, presidential candidate Donald Trump's rhetoric with respect to Mexico, the peso began to rapidly lose value. During these few months, Mexico's REER lost 31%. This deep weakening of the real exchange rate was 100% due to movements in the nominal exchange rate with respect to the USD. As

the peso depreciated, inflationary pressures increased, and the Bank of Mexico was forced to react, in order to maintain macroeconomic and price stability.

Graph 7 includes data on Mexico's policy rate during this period. As may be seen, at a time when most major central banks continued to have an almost zero interest rate, Mexico hiked its policy rate by 400 basis points, to 7%. This episode illustrates two important points that have been emphasised in this paper. The first is that the exchange rate clearly affects central bankers' decisions with respect to policy. The second, which is subtler, is that in order to undertake monetary policy, it is important for the central bank to know whether the currency was initially close to its long-term equilibrium, or if it was somewhat misaligned. However, given the limitations of the current models for dealing with this question, the Bank of Mexico had to operate without having all the required information. It is important to emphasise that this is, in no way, a criticism of the Bank; on the contrary, in my opinion the Bank acted correctly. This is rather a call for the profession to improve on current methods.

6. Concluding remarks

In this paper, I have addressed a number of issues related to exchange rates and monetary policy. I have focused on several aspects of this problem, and emphasised four points. I have also discussed an important historical episode – the US abandonment of the gold standard in 1933 – where the relation between exchange rates and monetary policy was particularly salient. The most important points made in this talk/paper may be summarised as follows:

- In the last few years, there is evidence that the transmission mechanisms through the yield curve have weakened in most countries. In many nations, and in particular in small ones, the exchange rate appears to provide the most important transmission channel of monetary policy. This means that central bankers have to be particularly conscious of exchange rate movements, and of the way their policies affect the exchange rate.
- There is evidence of "policy spillover". Empirical analyses suggest that, in the last few years, many countries have taken into account policy decisions by the major central banks – principally the Federal Reserve and the European Central Bank – when deciding on policy actions. This type of spillover calls for increased monetary policy coordination across countries.
- The analysis of the 1934 USD devaluation provides a clear case of connection between exchange rates and monetary policy. In this paper, I have gone beyond most studies on the subject, and I have asked whether there was evidence that in 1933–34 the dollar was overvalued. Although I do not provide conclusive evidence – that is beyond the scope of this paper – the data that I analyse, including two newly constructed real exchange rate indexes, suggest that the dollar was not significantly out of line at that time. This indicates that the devaluation of the USD did not play a role in moving the currency back to equilibrium; it was mostly a monetary policy decision.
- A review of the methods used by economists to assess whether the exchange rate is consistent with its "fundamentals" suggests that there has been very little progress in this area in the last three decades or so. I argue that the estimates obtained from using these methods are too broad, and in most cases provide insufficient guidance to policymakers. In that regard, it is important that the

economics profession devote some additional time and effort to improving on these methods in the future.

References

Ades, A (1996): "GSDEEMER and STMPI's, new tools for forecasting exchange rates in emerging markets", Goldman Sachs Economic Research.

Baffes, J, I Elbadawi and S O'Connell (1997): "Single-equation estimation of the equilibrium real exchange rate", *World Bank Policy Research Working Paper,* no 1800.

Bordo, M, C Goldin and E White (2007): *The Defining Moment: The Great Depression and the American Economy in the Twentieth Century*, University of Chicago Press.

Branson, W (1981): "Macroeconomic determinants of real exchange rates", *NBER Working Paper*, no 801.

Bresciani-Turroni, C (1937): *The economics of inflation: a study of currency depreciation in post-war Germany 1914–1923*, Allen & Unwin.

Broner, F, N Loayza, and H Lopez (1997): "Misalignment and fundamental variables: equilibrium exchange rates in seven Latin American countries", *Coyuntura Economica*, vol 27, no 4, pp 101–24.

Calvo, G and C Reinhart (2000): "Fear of floating", *NBER Working Papers*, no 7993.

Cassel, G (1918): "Abnormal deviations in international exchanges", *Economic Journal*, vol 28, no 112, pp 413–15.

——— (1922): *Money and foreign exchange after 1914*, Macmillan.

Clarida, R (2014): "Monetary policy in open economies: Practical perspectives for pragmatic central bankers", *Journal of Economic Dynamics & Control*, December, pp 21–9.

Cline, W and J Kim (2010): "Renminbi undervaluation, China's surplus, and the US trade deficit", Peterson Institute for International Economics.

Crabbe, L (1989): "The international gold standard and US monetary policy from World War I to the New Deal", *Federal Reserve Bulletin*, no 75, p 423.

Dincer, N, and B Eichengreen (2013): "Central bank transparency and independence: updates and new measures", *International Journal of Central Banking*, vol 10, no 1, March.

Dornbusch, R (1976): "Expectations and exchange rate dynamics", *The Journal of Political Economy*, vol 84, no 6, pp 1161–76.

Edwards, S (1983): "Floating exchange rates, expectations and new information", *Journal of Monetary Economics*, vol 11, no 3, pp 321–36.

——— (1989): *Real exchange rates, devaluation, and adjustment: exchange rate policy in developing countries*, MIT Press.

——— (2006): "The relationship between exchange rates and inflation targeting revisited", *NBER Working Papers*, no 12163.

——— (2012): "The Federal Reserve, the emerging markets, and capital controls: a high-frequency empirical investigation", *Journal of Money, Credit and Banking*, vol 44, no 2, pp 151–84.

——— (2015a): "Monetary policy independence under flexible exchange rates: an illusion?", *NBER Working Papers*, no 20893.

——— (2015b): "Sovereign Default, Debt Restructuring, and Recovery Rates: Was the Argentinean "Haircut" Excessive?", *Open Economies Review*, vol 26, no 5, pp 839-867.

——— (2017a): "Monetary Policy Independence under Flexible Exchange Rates: The Federal Reserve and Monetary Policy in Latin America -- Is There Policy ``Spillover"? pp 1-54, in Bordo, M and J Taylor (Eds) (2017): Rules for International Monetary Stability: Past, Present, and Future, Hoover Press.

——— (2017b): "The London Monetary and Economic Conference of 1933 and the end of the Great Depression", *Open Economies Review*, pp 1–29.

——— (2018): *American default: The untold story of FDR, the Supreme Court, and the battle over gold*, Princeton University Press.

Edwards, S and R Rigobon (2009): "Capital controls on inflows, exchange rate volatility and external vulnerability", *Journal of International Economics*, vol 78, no 2, pp 256–67.

Edwards, S and M Savastano (2001): "Exchange rates in emerging economies: what do we know? What do we need to know?", *NBER Working Papers*, no 7228.

Edwards, S and C Vegh (1997): "Banks and macroeconomic disturbances under predetermined exchange rates", *Journal of Monetary Economics*, vol 40, no 2, pp 239–78.

Frankel, J (1982): "The mystery of the multiplying marks: A modification of the monetary model", *The Review of Economics and Statistics*, vol 64, no 3, pp 515–9.

Friedman, M and A Schwartz (1963): "A monetary history of the United States", Princeton University Press.

Gudmundsson, M (2017): "Global financial integration and central bank policies in small, open economies", *The Singapore Economic Review*, vol 62, no 1, pp 135–46.

Halpern, L and C Wyplosz (1997): "Equilibrium exchange rates in transition economies", *Staff Papers*, vol 44, no 4, pp 430-461.

Han, X and S-J Wei (2018): "International transmissions of monetary shocks: Between a trilemma and a dilemma", *Journal of International Economics*, vol 110, pp 205-219.

Harris, S (1936): *Exchange Depreciation: Its Theory and Its History, 1931-35, with Some Consideration of Related Domestic Policies*, Harvard University Press.

Iossifov, P and E Loukoianova (2007): Estimation of a behavioral equilibrium exchange rate model for Ghana, *International Monetary Fund Working Paper*, no 07/155.

Isard, P (2007): "Equilibrium exchange rates: assessment methodologies", *IMF Working Paper*, no 07/296.

Itskhoki, O and D Mukhin (2016): "Exchange rate disconnect", in *2016 Meeting Papers*, no 1589, Society for Economic Dynamics.

Johnson, H and J Frenkel (1978): *The Economics of Exchange Rates: Selected Studies*, Addison-Wesley Publishing Company.

Keynes, J (1924): *Monetary reform*, Harcourt, Brace and Company.

Kouri, P and M Porter (1974): "International capital flows and portfolio equilibrium", *Journal of Political Economy*, vol 82, no 3, pp 443–67.

Leamer, E (2007): "Housing is the business cycle", *NBER Working Paper*, no 13428.

Lubik, T and F Schorfheide (2007): "Do central banks respond to exchange rate movements? A structural investigation", *Journal of Monetary Economics*, vol 54, no 4, pp 1069–87.

Meese, R and K Rogoff (1983): "Empirical exchange rate models of the seventies: Do they fit out of sample?", *Journal of International Economics*, vol 14, no 1-2, pp 3–24.

Meltzer, A (2003): *A History of the Federal Reserve, Volume 1*, University of Chicago Press.

Metzler, L (1947): "Exchange rates and the International Monetary Fund", *International Monetary Policies,* Board of Governors of the Federal Reserve System, Washington DC, pp 30–42.

Milesi-Ferretti, G and A Razin (1998): "Current Account Reversals and Currency Crises: Empirical Regularities", vol 98, no 89, pp 1-44.

Montiel, P (1997): "Exchange Rate Policy and Macroeconomic Management in ASEAN Countries", in J Hicklin, D Robinson and A Singh (eds), Macroeconomic Issues Facing ASEAN Countries, Washington, DC: IMF.

——— (1999) Determinants of the long-run equilibrium exchange rate: an analytical model. In: Hinkle L, Montiel P (eds) Exchange rate misalignment: concepts and measurement for developing countries. Oxford University Press, Oxford, pp 264–292.

Obstfeld, M, and K Rogoff (2005): "Global current account imbalances and exchange rate adjustments", *Brookings Papers on Economic Activity*, no 2005(1), pp 67–146.

Razin, O and S Collins (1997): "Real exchange rate misalignments and growth", *NBER Working Papers*, no 6174.

Rogoff, K (1996): "The purchasing power parity puzzle", *Journal of Economic Literature*, vol 34, no 2, pp 647–68.

Taylor, J (2007): "Globalization and monetary policy: Missions impossible", in J Gali and M Gertler (eds), *International Dimensions of Monetary Policy*, pp 609–24, University of Chicago Press.

——— (2013): "International monetary coordination and the great deviation", *Journal of Policy Modeling*, vol 35, no 3, pp 463–72.

——— (2015): "Rethinking the international monetary system", remarks at the CATO Conference on Rethinking Monetary Policy.

Temin, P, and B Wigmore (1990): "The end of one big deflation", *Explorations in Economic history*, vol 27, no 4, pp 483–502.

Warner, A (1997): "Mexico's 1994 exchange rate crisis interpreted in light of the nontraded model", *NBER Working Paper*, no 6165.

White, H (1935): "Recovery program: the international monetary aspect", The Harry Dexter White papers, Princeton University, Box 3, folder 13.

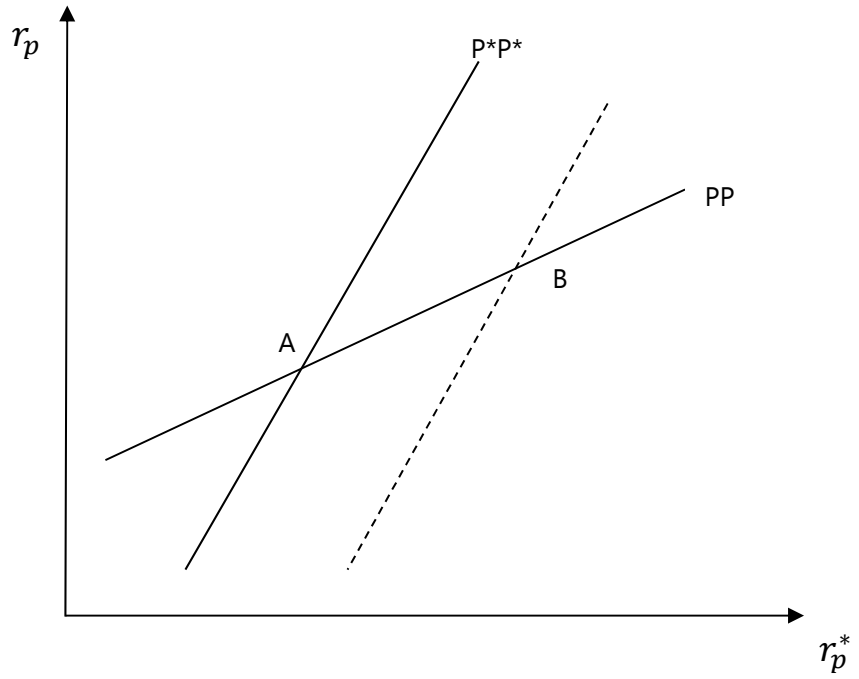
Wigmore, B (1987): "Was the Bank Holiday of 1933 Caused by a Run on the Dollar?", *The Journal of Economic History*, vol 47, no 3, pp 739–755.

Williamson, J (1994): "Estimating equilibrium exchange rates", Peterson Institute.

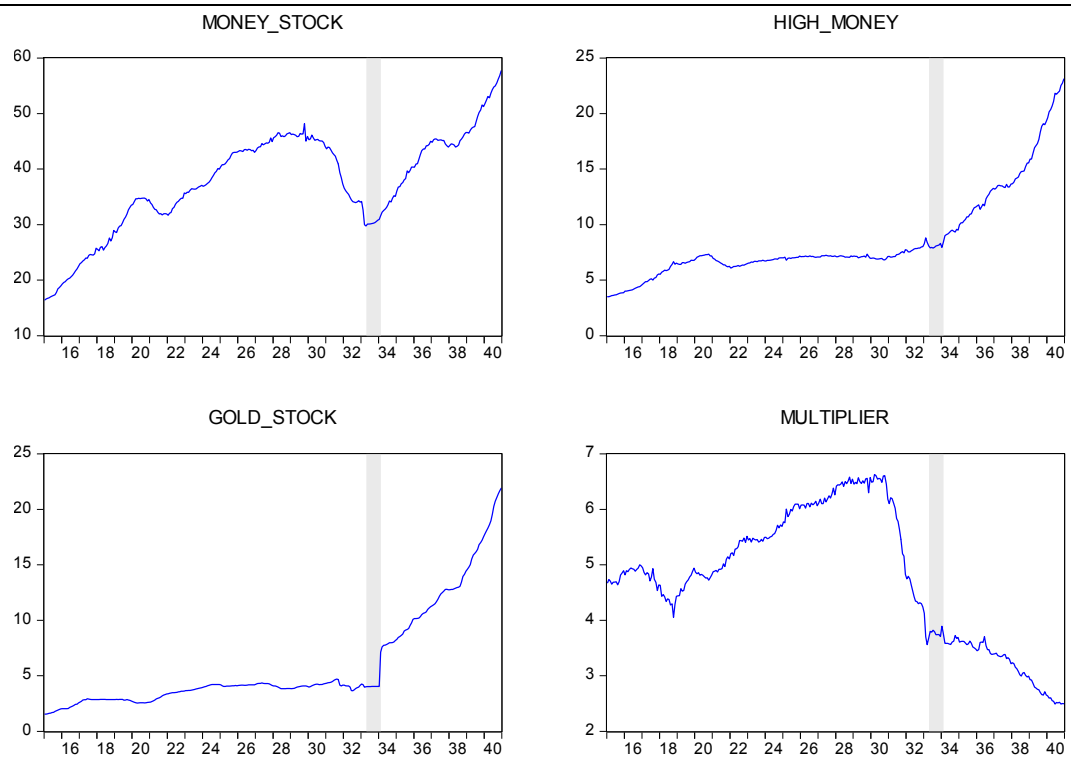
Wren-Lewis, S and R Driver (1998): "Real exchange rates for the year 2000", Peterson Institute Press: Policy Analyses in International Economics.

Graphs

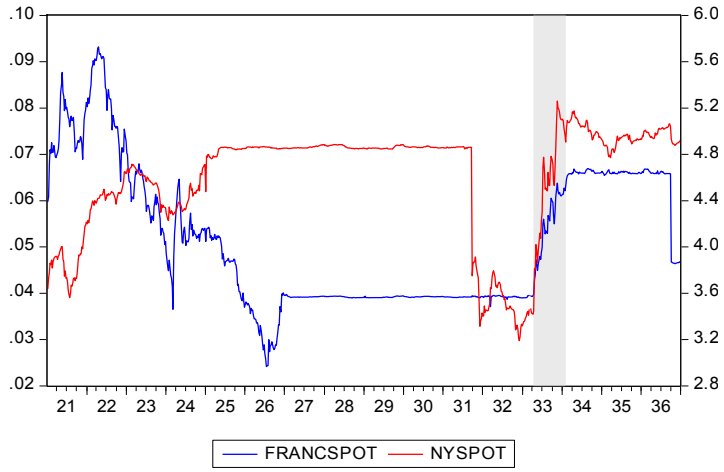
Policy rates equilibrium under "policy spillover" and large countries — Graph 1



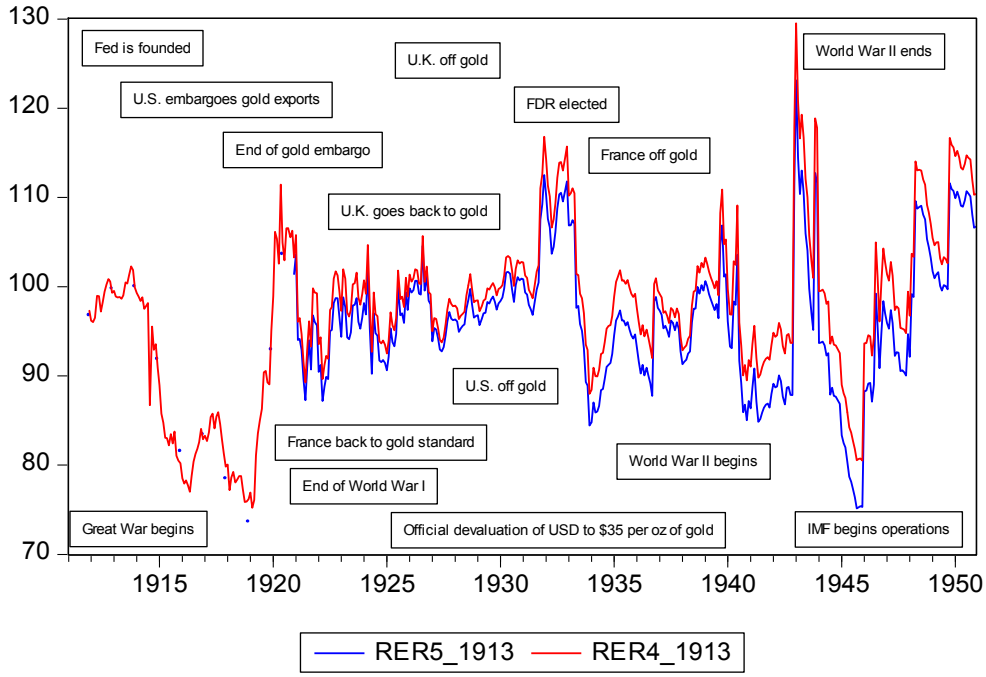
Monetary conditions, 1910–40 — Graph 2



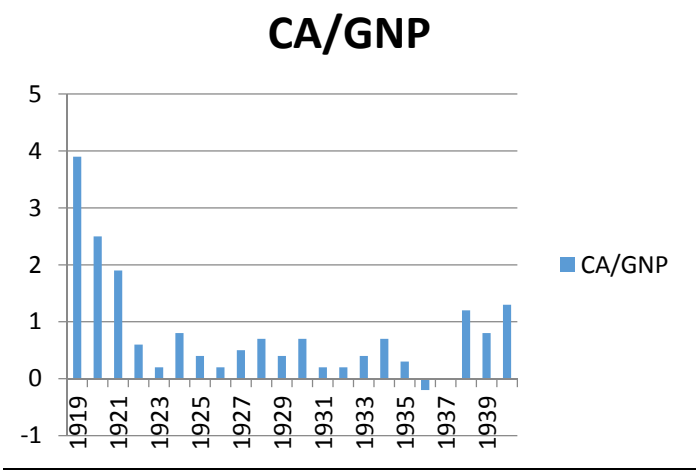
Dollar-sterling and dollar-French franc exchange rates, weekly, 1921–36 Graph 3



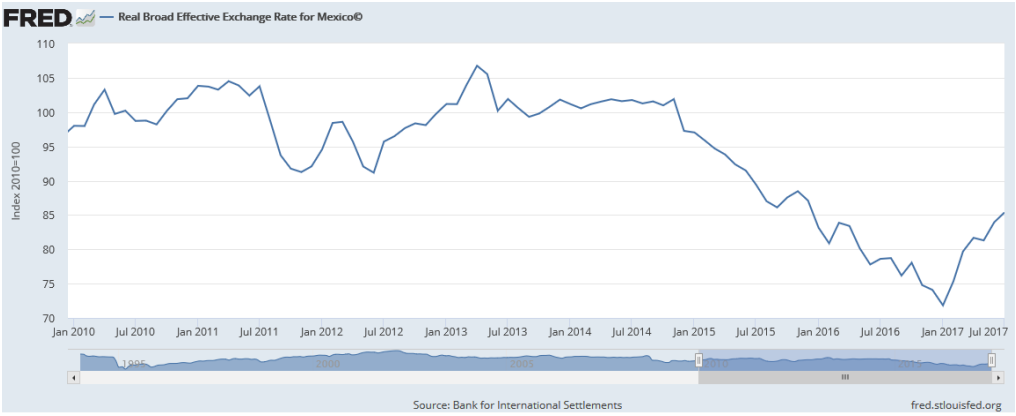
Trade-weighted real exchange rate for the US dollar, 1910–50: 1913=100 Graph 4



Current account balance as percentage of GDP, 1919–40 Graph 5



The Mexican peso RER index, January 2010–July 2017 Graph 6



Mexico's policy rate, January 2010–July 2017 Graph 7

Tables

Monetary policy rates in East Asia, dynamic panel, 2000–08

(Instrumental variables) Table 1

Eq Name:	(1.1)	(1.2)	(1.3)	(1.4)
FF_POLICY	0.0116	0.0149	0.0115	0.0114
	[4.0109]***	[2.0996]**	[3.0940]***	[3.8950]***
C	0.2523	0.2483	0.2524	0.2494
	[3.2841]***	[3.2271]***	[3.2776]***	[3.2262]***
POL_RATE(-1)	-0.0399	-0.0407	-0.0400	-0.0417
	[-4.6058]***	[-4.6363]***	[-4.5188]***	[-4.4447]***
TIPS_ INF_USA(-1)	-0.0199	-0.0175	-0.0200	-0.0212
	[-1.2329]	[-1.0432]	[-1.2150]	[-1.2906]
EMBI_ASIA	0.0003	0.0006	0.0003	-0.0002
	[0.0371]	[0.0747]	[0.0340]	[-0.0220]
D(POL_RATE(-1))	-0.0020	-0.0031	-0.0019	0.0006
	[-0.0521]	[-0.0802]	[-0.0484]	[0.0163]
INF_YOY(-4)	0.0004	0.0008	0.0004	0.0004
	[0.1587]	[0.2890]	[0.1548]	[0.1549]
GROWTH(-6)	-0.0064	-0.0045	-0.0065	-0.0079
	[-1.6088]*	[-0.8470]	[-1.3051]	[-1.5894]
UST_2YR	–	-0.0053	–	–
		[-0.5097]		
UST_5YR	–	–	0.0003	–
			[0.0305]	
UST_10YR	–	–	–	0.0054
				[0.5058]
Observations:	676	676	676	676
R-squared:	0.0244	0.0321	0.0240	0.0180
F-statistic:	3.8769	3.4716	3.4411	3.4715

*, **, and *** refer to significance at 10%, 5% and 1%, respectively.

Monetary policy rates in Latin America and the yield curve, dynamic panel (Chile, Colombia), 2000–08

(Instrumental variables) Table 2

Eq Name:	(2.1)	(2.2)	(2.3)	(2.4)
FF_POLICY	0.0141	0.0846	0.0421	0.0253
	[2.1931]**	[3.3751]***	[2.8125]***	[2.4035]**
C	-0.2987	-0.0639	-0.0976	-0.1300
	[-2.2316]**	[-0.4022]	[-0.5878]	[-0.7080]
POL_RATE(-1)	-0.0206	-0.0246	-0.0205	-0.0201
	[-2.4229]**	[-2.7927]***	[-2.3970]**	[-2.3629]**
TIPS_ INF_USA(-1)	0.0688	0.1009	0.0903	0.0811
	[1.9609]*	[2.6842]***	[2.4531]**	[2.2328]**
EMBI_LATAM	0.0083	0.0022	0.0077	0.0092
	[1.6130]*	[0.3919]	[1.4865]	[1.7716]
D(POL_RATE(-1))	-0.0338	-0.0306	-0.0306	-0.0325
	[-0.8611]	[-0.7602]	[-0.7737]	[-0.8263]
INF_YOY(-4)	0.0204	0.0101	0.0136	0.0169
	[2.6494]***	[1. 6910]*	[1.6212]*	[2.0742]**
GROWTH(-6)	0.0171	-0.0044	0.0020	0.0086
	[1.6648]*	[-0.3255]	[0.1528]	[0.6823]
UST_2YR	–	-0.0935	–	–
		[-2.9143]***		
UST_5YR(-1)	–	–	-0.0573	–
			[-2.0730]**	
UST_10YR(-1)	–	–	–	-0.0402
				[-1.3436]
Observations:	709	709	709	709
R-squared:	0.0529	0.0082	0.0424	0.0520
F-statistic:	4.1658	4.7380	4.2026	3.9069

*, **, and *** refer to significance at 10%, 5% and 1%, respectively.

Dollar invoicing, exchange rates and international trade

David Cook[1] and Nikhil Patel[2]

Abstract

This paper studies the role of exchange rates and dollar invoicing in driving the dynamics of international trade flows. It uses a granular decomposition of trade flows at the bilateral level to highlight a bifurcation, whereby in response to a rise in US interest rates, final goods trade between non-US countries, as well as trade that is more regionally oriented, declines by more than does trade that is global value chain-oriented. These results highlight an important role played by global value chains in mitigating the negative impact of external shocks.

Keywords: dollar invoicing, international trade, global value chains, monetary policy.

JEL classification: E2, E5, E6.

[1] Hong Kong University of Science and technology; e-mail: davcook@ust.org.

[2] Bank for International Settlements; e-mail: nikhil.patel@bis.org.

We would like to thank seminar participants at the Bank for International settlements and the Hong Kong Monetary Authority, and in particular our discussants Jinill Kim and Jian Wang for valuable comments and suggestions. We are grateful to Justine Pedrono and Matthias Loerch for excellent research assistance, and to Zhi Wang for sharing the data on decomposition of bilateral exports. All errors are our own. The views expressed here are those of the authors and do not necessarily represent those of the BIS.

1. Introduction

The relationship between exchange rates and international trade is one of the most intensively researched areas in economics. Going back at least to the work of Friedman (1953), Fleming (1962), and Mundell (1963), the mainstream view of exchange rate depreciations being expansionary is built on a set of frameworks in which exports are priced in the currency of the exporter. This has been labelled the producer currency pricing (PCP) paradigm. Under this setting, an exchange rate depreciation in the exporting country makes its exports more competitive in the global market, and its imports less competitive in the domestic market. Both these effects contribute to a rise in the trade balance. Subsequent studies challenged the PCP premise and considered alternate frameworks in which exports are invoiced in the currency of the importer. This gave rise to the literature on local currency pricing (LCP) or pricing to market (PCM).[3]

Recent empirical literature on export invoicing has shown that none of these pricing paradigms is an accurate description of reality (see McKinnon and Schnabl (2004); Cook and Devereux (2006); Goldberg and Tille (2006); Gopinath (2016); Boz at al (2017)). Instead, an overwhelming majority of exports around the world are priced in a handful of key "global currencies", with the US dollar being the most prominent among them. Goldberg and Tille (2008) document this outsized role of the US dollar by showing that the share of exports and imports invoiced in US dollars is consistently and substantially higher than the corresponding share of trade with the United States for most countries around the world.

Casas et al (2016) study the implications of this dollar pricing paradigm for the relationship between exchange rates and international trade flows. They show how the standard Mundell-Fleming prediction of a depreciation leading to a rise in exports becomes weaker, and most of the adjustment in the trade balance comes from the import side. They also highlight that a uniform rise in the value of the dollar can lead to a fall in global trade (including bilateral trade between non-US countries), as exports which are priced in dollars become more expensive globally.

Building on this literature, this paper contributes to the study of the implications of dollar pricing on the dynamics of international trade. Specifically, it makes two contributions. First, it takes a general equilibrium perspective on the impact of exchange rate changes brought about by interest rate shocks on the relationship between exchange rates and international trade. This addresses an important limitation in the existing literature, which typically models the exchange rate as determined outside the system and subject to random shocks. Second, recognising the increasing complexity of international trade networks and the rising importance of global value chains, the paper focuses on uncovering the differences in the impact of shocks on different types of international trade flow depending on the degree of participation in global (and regional) value chains, and the number of border crossings involved.

The main result emerging from the analysis is that, in response to an exchange rate depreciation brought about by a rise in global (US) interest rates, final goods trade between two non-US countries, as well as trade flows that are more regionally oriented, declines more than do trade flows that are global value chain-oriented and supply final demand outside the region. The reason for this difference comes from

[3] See for instance Betts and Devereux (1996).

the fact that an appreciation of the global currency gives a competitive price advantage to the imports into the global economy, which mitigates the overall decline in demand for traded goods brought about by the rise of the dollar. For example, consider a world comprising on two regional economies and a large "global" economy in which all internationally traded goods are priced in dollars. When global interest rates rise and the dollar appreciates, exports of both regional economies become more expensive (irrespective of destination) and lose competitiveness vis-à-vis domestically produced goods. This can be understood as a "price effect" which affects the demand for all traded goods. In addition, there is also a "demand effect". Since the global economy experiences a real appreciation in response to the shock, its demand for imports increases. To the extent that these imports are produced via global value chains that involve intermediate goods trade between the regional economies, the share of this global value chain-oriented trade between the regional economies rises. To summarise, while the negative price effect works for all trade flows, the positive demand effect works only for global value chain trade.

The remainder of this paper is structured as follows. Section 2 discusses a schematic representation of a framework to guide the interpretation of implications of changes in exchange rates on international trade flows in the presence of global value chains. Section 3 discusses the main empirical analysis in the paper. Section 4 concludes with a summary of the main message in the paper.

2. Model environment

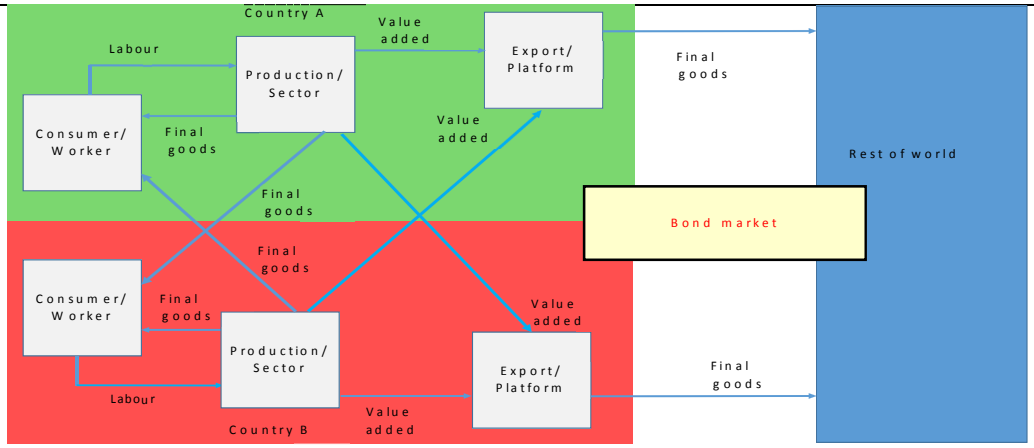
Consider a three-country world consisting of two identical regional economies (labelled A and B) and a rest-of-the-world region (Figure 1).[4] Each regional economy consists of a representative consumer/worker, a production sector, and an export platform. The consumer provides labour to the production sector, which uses it to produce output. This output can be consumed by consumers in the home country, or be exported and consumed by consumers in the regional economy as final goods, or be sold to an export platform within the economy, or be exported to an export platform in the other regional economy. The export platforms in the two regional economies in turn combine intermediate inputs from both regional economies and produce output that is exported to the global economy.

The key assumptions, which are also the key frictions in the model, are with regard to the currency of invoicing of different goods. All goods that do not cross international borders are priced in the local currency, whereas all goods that are sold across an international border are priced in the global currency. For example, goods sold by the production sector in country A to the export platform in country A are priced in the domestic currency of country A, whereas goods sold by the production sector in country B to the export platform in country A, as well as the final goods sold by the regional economies to the global economy are priced in the global currency. Prices are assumed to be sticky in the currency of invoicing, and therefore adjust only slowly in response to shocks. The two regional economies are assumed to be completely symmetrical, including their monetary policy responses, so that the exchange rate between the two regional economies is always fixed, and this combined currency is referred to as the regional currency.

[4] See Cook and Patel (2017) for a detailed mathematical description of the framework.

Model setup

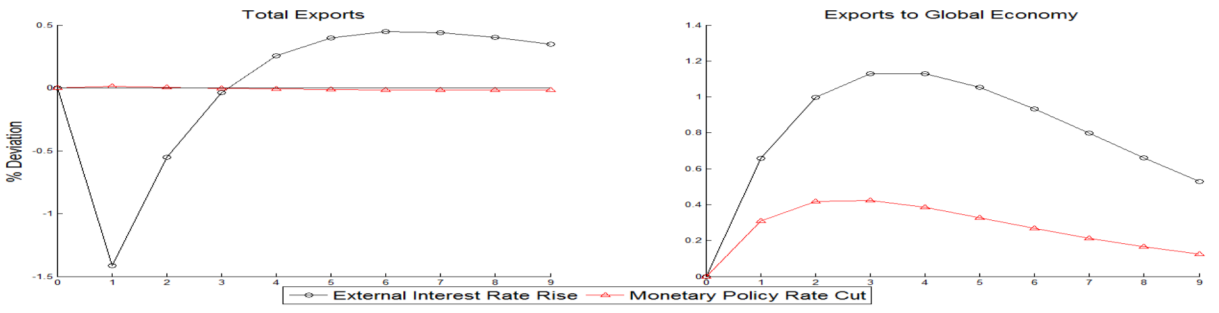
Figure 1



Under this setting, an interest rate rise in the global economy causes an appreciation of the global currency vis-à-vis the regional currency. Since all exports, irrespective of their country of origin and destination, are priced in the global currency, they become relatively more expensive than domestically produced goods for the two regional economies. Demand therefore shifts away from exports and towards domestic production in both country A and country B. The key insight of the framework is that this fall in demand for exports is not uniform across different types of export. In particular, final goods exports between the regional economies decline by more than intermediate goods exports that are subsequently used by the export platforms to produce exports for the global economy. This is due to the fact that an appreciation of the global currency leads to a rise in demand for exports from the regional economy that are produced by the export platforms, through the standard competitiveness channels. The net result is that final goods trade, and regional trade which is eventually confined to the region (such as back-and-forth trade between the two regional economies) falls in a much sharper way than final goods trade (Figure 2).

Response of exports to an interest rate shock

Figure 2



Note: The figures denote impulse responses to domestic and foreign interest rate shocks based on the benchmark framework and calibration in Cook and Patel (2017).

The opposite is true in the case of a monetary policy rate cut undertaken by the two regional economies. In this case, since the monetary expansion has a positive impact on demand for final consumption in the two regional economies, final goods

exports fall by less than regional intermediate goods exports that are eventually destined for the global economy.

3. Empirics

The preceding discussion highlights how interest rate shocks can have a markedly different impact on different forms of international trade. This section aims to analyse these implications by using data on bilateral trade flows and other macroeconomic variables in a sample of 40 major economies.

Stylised economic frameworks like the one in Figure 1 have a precise definition of intermediate and final goods trade flows. For example, as far as the regional economies are concerned, in the framework in Figure 1 there are only two kinds of trade flow, each with a clearly defined path towards the final destination. Final goods exports originate in one regional economy and are exported and consumed in the other. Intermediate goods exports originate in one regional economy, are exported to export platforms in the other regional economy, and are subsequently exported to the global economy.

International trade is much more complicated in the real world, and defining different categories, let alone measuring them precisely in the data has for the most part proved to be a forbiddingly challenging task. For example, unlike in the framework in Figure 1, not all intermediate exports are subsequently exported to other countries. In fact, as shown below, the largest part of intermediate exports is used to produce final goods that are consumed by the direct importer. In addition, some are also shipped back to the original exporting country, either in the form of final goods or intermediate goods. Standard sources on international trade data, which at best offer a two-way decomposition of international trade flows (intermediate vs final goods), are therefore not rich enough to capture these complexities, as they only track exports up to one border crossing, and do not track the subsequent journey and final destination of the exports.

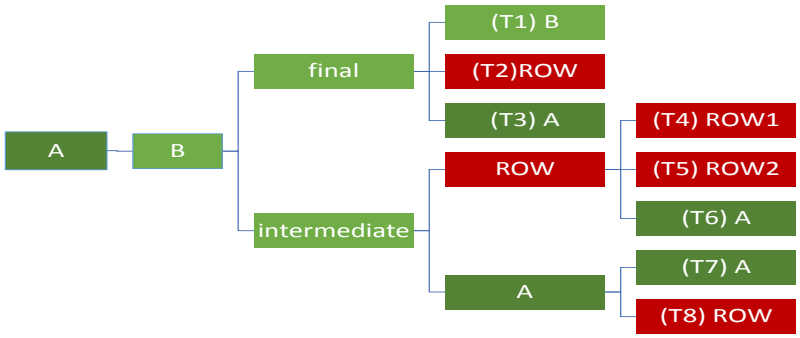
To address these challenges, we rely on recent advances in export accounting frameworks that allow for a more granular decomposition of intermediate goods trade flows. For this purpose, we use the eight-term decomposition in Wang et al (2013). Figure 3 illustrates the main idea behind the decomposition. Let A and B be the two regional economies and let "ROW" denote the rest of the world (akin to the global economy in Figure 1). The figure starts on the left with an initial shipment of intermediate exports from A to B. Standard data sources typically stop here. Once these exports reach B, they can be used either to produce intermediate goods or to produce final goods. Focusing on the latter category first, these final goods can be shipped to the rest of the world (as in the framework in Figure 1; T2), or they can be consumed in B itself (T1), or they can be shipped back to A (T3).

Likewise, the remainder of the diagram shows how the share of intermediate exports from A to B that is used to further produce intermediate exports can be traced based on the subsequent journey of these exports until they are consumed as final goods. While the framework in Figure 1 is parsimonious in comparison and does not cover all the possibilities offered by this eight-term decomposition, it nevertheless offers insights on the direction of effects of the different mechanisms that are at play. Specifically, the response of trade flows to an interest rate rise can be expected to vary depending on whether they are eventually consumed as final goods in the region constituted by A and B (identified by the green boxes in Figure 3), or consumed in

the global economy (corresponding to the red boxes in Figure 3). In response to an exchange rate depreciation of A and B brought about by an external (global economy) interest rate increase, the share of the former should fall and the share of the latter should rise (while the converse would be true in the case of an exchange rate depreciation brought about by a domestic interest rate cut in A and B).

Schematic representation of intermediate export decomposition and evolution of shares of different components in intermediate exports

Figure 3



Year	1995	2008	2009	2011
T1	69.37518	62.7517	63.79737	62.46203
T2	11.08952	12.78733	12.96956	12.90795
T3	0.05006	0.07703	0.07293	0.07328
T4	14.53779	17.17629	16.62317	17.8149
T5	2.73803	4.63388	4.05513	4.26818
T6	0.02254	0.05058	0.04182	0.04457
T7	0.08847	0.1294	0.11174	0.11649
T8	0.01824	0.03878	0.03155	0.03247

Source: Wang et al (2013).

Data and specification

We use dynamic panel regressions to study the impact of changes in US interest rates on bilateral trade between non-US countries. While the framework has implications for both domestic and external interest rate shocks, we focus on the latter as they are easy to uncover in the data, given the endogeneity concerns associated with identifying domestic monetary shocks. The empirical model is specified as follows:

$$Y_t^{i,j}(s) = \alpha^{i,j}(s) + \eta Y_{t-1}^{i,j}(s) + \beta i_{us,t} + \delta X_t + \epsilon_t^{i,j}(s)$$

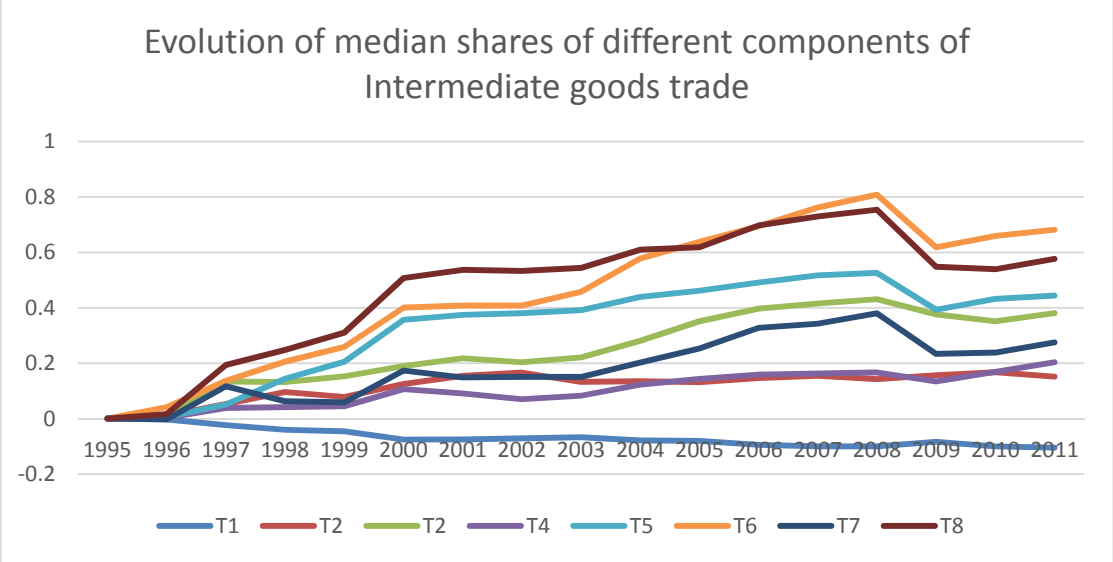
The dependent variable is a measure linked to bilateral exports from sector s in country i to country j in year t. X includes a number of control variables such as contemporaneous and lagged values of changes in the bilateral exchange rate between the importer and the exporter, change in real GDP and inflation of the importer and exporter, change in total imports by the importer, and change in total imports and exports by the importing country to the US (to control for global demand effects), contemporaneous and lagged values of US GDP growth and inflation, as well as the change in unit labour cost in the exporting country. A quadratic time trend is also included in the regressions. Dynamic responses of the dependent variable at

different horizons are computed using the local projection method in Jordà (2005). Acknowledging the issues that arise from estimating dynamic panel models with a lagged dependent variable, we use the difference GMM estimator proposed in Arellano and Bond (1991).

Across different specifications, we consider as the dependent variable different measures of bilateral trade between two (non-US) countries. In addition to gross final goods and intermediate goods exports, we also consider the dynamics of different subcomponents of intermediate goods exports in Wang et al (2013) that are summarised in Figure 3. The main data source for bilateral exports is the World Input-Output Database (WIOD). It contains bilateral trade data at the sector level for 35 sectors in 40 countries at annual frequency. The sample runs from 1995 to 2011.[5] The full list of countries and sectors is available in the appendix. The remaining data (including GDP and other macro variables) for the analysis are taken from the IMF's International Financial Statistics.

The bottom panel in Figure 4 shows the median shares of each of the eight components of intermediate goods exports across all the sectors and countries in the sample. As evident from the numbers, the largest share corresponds to intermediate inputs that are subsequently used by the direct importer to produce final goods for domestic consumption (T1). This highlights the drawback of simply using a two-term decomposition (final vs intermediate goods), as unlike in any model of global value chains, the largest part of intermediate goods in the data are actually absorbed domestically and are not re-exported. From the perspective of international shock transmission, this part is more akin to final goods trade rather than intermediate. That said, as shown in Figure 4, the share of T1 has declined, and the share of all other components that involve deeper involvement in global value chains has risen markedly between 1995 and 2011.

Response of exports to an interest rate shock — Figure 4



Notes: Percentage changes in shares of different components of intermediate exports (as a share of total intermediate exports). All shares are normalised to zero in 1995. Absolute values for benchmark years are displayed in Figure 3.

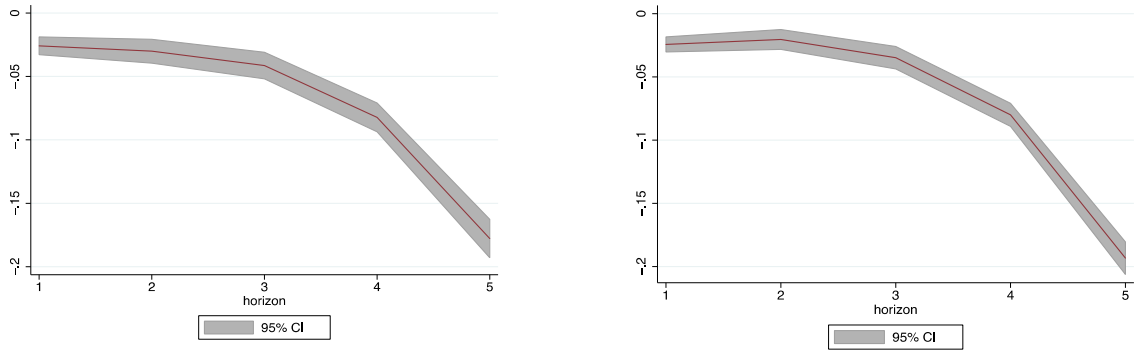
[5] See Dietzenbacher et al (2013) for a detailed description of the World Input-Output Database including information on data sources and methods used in the computations.

Results and discussion

Figure 5 shows the response of bilateral final goods and intermediate exports to a 1 percentage point rise in US interest rates. As expected, both these trade flows decline. However, there is no discernible difference between the two responses as predicted by the model. This is not surprising, since as shown in Table 1, the majority of intermediate exports are directly absorbed as final goods in the importing country. They are therefore analogous to final exports rather than the supply chain-oriented intermediate exports that we wish to study.

Response of exports to US interest rate rise — Figure 5

Final goods exports (real) | Intermediate goods exports (real)



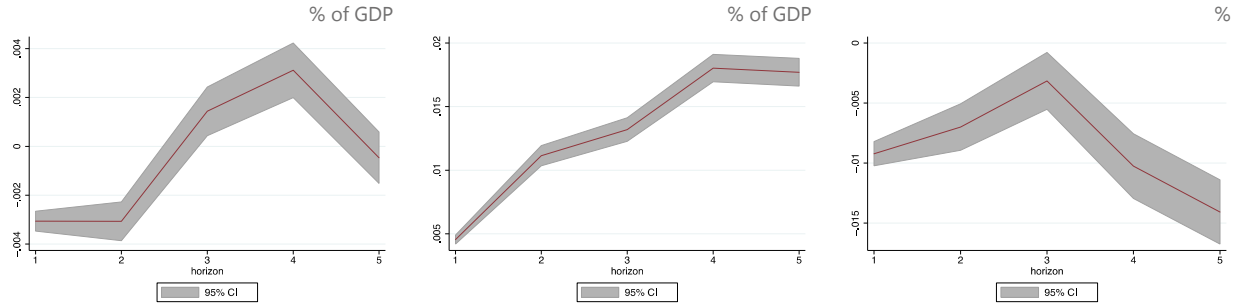
Notes: Percentage deviations from steady state. The figures display dynamic impulse responses computed using local projection methods.

Source: Authors' calculations.

To address this concern and further investigate the response of different categories of trade flows, we now consider the response of the shares of different components of bilateral intermediate goods exports in Figure 3.

Response of intermediate exports used by direct importer to produce final goods — Figure 6

Consumed domestically (ie by the direct importer) | Exported to third countries | Exported back to the source country



Notes: Percentage deviations from steady state. The figures display dynamic impulse responses computed using local projection methods.

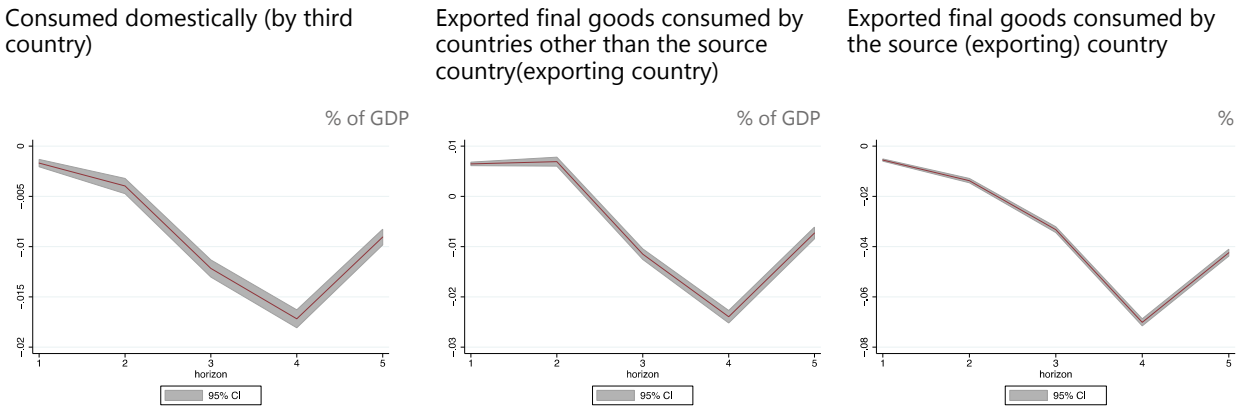
Source: Authors' calculations.

Figure 6 shows the response of the shares of the components that are used by the direct importer to produce final goods (these correspond to T1–T3 in Figure 3).

Within this category, the share that is consumed domestically declines (although it begins to rise starting in three years), as does the share that is exported back to the source country. On the other hand, the share that is exported to the global economy rises. All these responses are consistent with the predictions of the framework in Figure 1.

Response of intermediate exports first used by direct importer to produce intermediate goods exports, then used by third countries to produce final goods

Figure 7



Notes: Percentage deviations from steady state. The figures display dynamic impulse responses computed using local projection methods.

Source: Authors' calculations.

Next, we examine the response of the share of bilateral intermediate exports that are used by the direct importer to further produce intermediate goods that are exported to third countries, and are used by third countries to produce final goods (these components correspond to T4–T6 in Figure 3). Within this category, the share that is exported back to the original exporting country is found to decline persistently, as predicted by the model (Figure 7). The share that is consumed domestically by the third country also declines. Although the model does not have a direct counterpart to this component, it is likely to imply the opposite pattern in this case.

Lastly, we examine the response of the components with an even deeper global value chain structure involving back-and-forth trade (Figure 8). These include bilateral intermediate goods exports that are used by the direct importer to further produce intermediate exports that are shipped back to the source country. Within this category, the component that is consumed as final goods in the original exporting (source) country declines persistently, as would be expected based on the model. On the other hand, the response of the component that is subsequently exported to the global economy is more ambiguous. In this context, it is perhaps pertinent to note that, as the number of border crossings increases, the exchange rate effect tends to dominate the final demand effect. This may explain why the response of this component is more muted when compared with the ones above that involve fewer border crossings, especially within the region comprised by the original exporter and the original importer.

To summarise, the dynamics of regional trade uncovered here are broadly consistent with the main prediction from the framework in Figure 1. In particular, in response to an exchange rate depreciation brought about by a US interest rate rise, final goods, as well as the components of trade that are more regionally oriented,

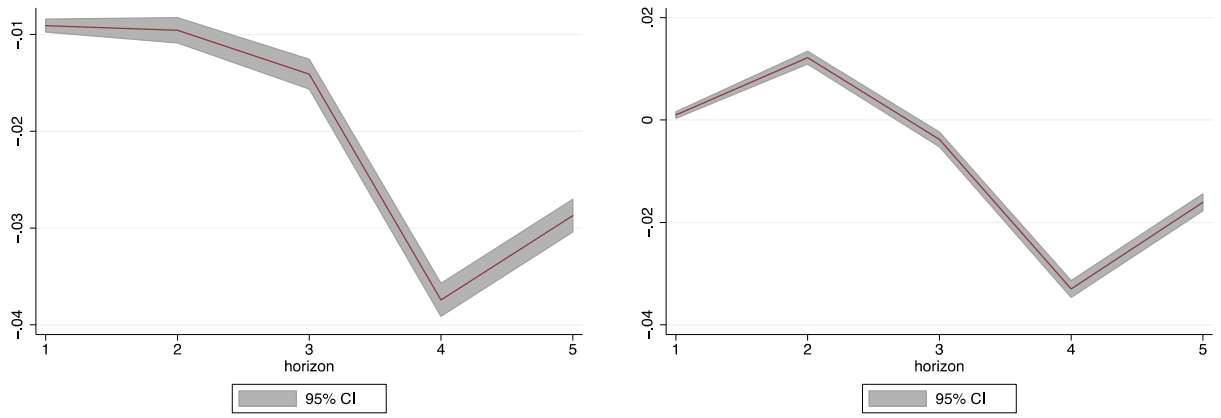
decline by more than do the components that end up being consumed as final goods in the global economy.

Response of intermediate exports first used by direct importer to produce intermediate exports shipped back to the source (exporting) country as intermediate imports to produce final goods

Figure 8

Domestic final goods consumed by the source (exporting) country

Exported final goods consumed by other countries



Notes: Percentage deviations from steady state. The figures display dynamic impulse responses computed using local projection methods.

Source: Authors' calculations.

4. Conclusion

Recent literature on export invoicing has shown overwhelming evidence for the prominence of a handful of key global currencies (in particular the US dollar) and their outsized role in trade invoicing. In particular, these studies have documented that a majority of the share of bilateral trade flows are invoiced in the US dollar, even when the United States is not one of the trading partners.

As shown by Casas et al (2016), this phenomenon of dollar invoicing has challenged the implications of the "producer currency pricing" and "pricing to market" paradigms for understanding the impact of changes in the exchange rate on trade flows. This paper builds on this literature along two dimensions. First, it takes a general equilibrium perspective to understand the role played by exchange rate movements in transmitting the impact of interest rate shocks on macroeconomics variables including international trade flows in a world in which all exports are invoiced in the global currency. Second, it analyses the impact of exchange rate changes brought about by interest rate shocks on different types of international trade flow ranging from simple final goods trade to more complicated global value chain-oriented trade flows that repeatedly cross international borders.

The main result that emerges from the analysis is that, in response to an external interest rate rise, final goods trade and trade that is more regionally oriented fall by more than trade that is global value chain-oriented and supplies final goods to the global economy. The reason for this is that an interest rate rise in the global economy and the associated appreciation of the dollar has two opposing effects on the volume

of international trade flows. On the one hand, since all exports are priced in dollars, for non-US countries imports become more expensive compared with domestic goods, leading to a decline in demand for imports. On the other hand, an appreciation of the dollar translates into a rise in the demand for imports in the United States due to standard expenditure switching effects.

Given the limitations of standard trade data, which do not provide a detailed characterisation of trade flows beyond the first border crossing, we use the granular decomposition of international trade flows at the bilateral level using the framework proposed in Wang et al (2013).The key contribution in the paper is to show how the interaction of these two effects in the data implies that final goods trade and trade that is regionally oriented decline more in response to a US interest rate rise than does trade that is more global value chain-oriented and provides final goods to consumers in the global economy.

These results illustrate an important channel though which global value chains play a role in mitigating the negative impact of shocks on small open economies. While many recent studies have emphasised the benefits of global value chains for economic development and productivity that are of a structural nature,[6] this paper highlights a complementary cyclical benefit which further reinforces the case for active policy engagement in promoting global value chain integration.

References

Arellano, M and S Bond (1991): "Some tests of specification for panel data: Monte Carlo evidence and an application to employment equations", *Review of Economic Studies*, vol 58, no 2, pp 277–97.

Betts, C and M Devereux (1996): "The exchange rate in a model of pricing-to-market", *European Economic Review*, vol 40, no 3, pp 1007–21.

Boz, E, G Gopinath and M Plagborg-Moller (2017): "Global trade and the dollar", *Working Paper*, Harvard University.

Casas, C, F Díez, G Gopinath and P Gourinchas (2016): "Dominant currency paradigm", *NBER Papers*, no w22943, National Bureau of Economic Research.

Cook, D and N Patel (2017): "International price system, intermediate inputs and regional trade", manuscript.

Cook, D and M Devereux (2006): "External currency pricing and the East Asian crisis," *Journal of International Economics*, vol 69, no 1, pp 37–63.

Del Prete, D, G Giovannetti, and E Marvasi (2017): "Global value chains participation and productivity gains for North African firms", *Review of World Economics*, vol 153, no 4, pp 675–701.

Dietzenbacher, E, B Los, R Stehrer, M Timmer and G De Vries (2013): "The construction of world input–output tables in the WIOD project", *Economic Systems Research*, vol 25, no 1, pp 71–98.

Fleming, J (1962): "Domestic financial policies under fixed and under floating exchange rates", *IMF Staff Papers*, vol 9, no 3, pp 369–80.

[6] See for instance Del Prete et al (2017) and World Bank (2017).

Friedman, M (1953): *Essays in positive economics*, University of Chicago Press.

Goldberg, L and C Tille (2006): "The international role of the dollar and trade balance adjustment", *NBER Working Paper*, no 12495.

——— (2008): "Vehicle currency use in international trade", *Journal of International Economics*, vol 76, no 2, pp 177–92.

Gopinath, G (2016): "The international price system", in Jackson Hole Symposium Proceedings, *NBER Digest*, January 2016.

Jordà, Ò (2005): "Estimation and inference of impulse responses local projections", *American Economic Review*, vol 95, no 1, pp 161–82.

McKinnon, R and G Schnabl (2004): "The East Asian dollar standard, fear of floating, and original sin", *Review of Development Economics*, vol 8, pp 331–60.

Mundell, R (1963): "Capital mobility and stabilization policy under fixed and flexible exchange rates", *Canadian Journal of Economics and Political Science/Revue canadienne de economiques et science politique*, vol 29, no 4, pp 475–85.

Wang, Z, S Wei and K Zhu (2013): "Quantifying international production sharing at the bilateral and sector levels", *NBER Papers*, no w19677, National Bureau of Economic Research.

World Bank (2017): "Measuring and analysing the impact of GVCs on economic development", *Global Value Chain Development Report 2017*.

Appendix

List of countries: Australia (non-EU), Austria, Belgium, Brazil (non-EU), Bulgaria, Canada (non-EU), China (non-EU), Chinese Taipei (non-EU), Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, India (non-EU), Indonesia (non-EU), Ireland, Italy, Japan (non-EU), Korea (non-EU), Lithuania, Luxembourg, Latvia, Mexico (non-EU), Malta, Netherlands, Poland, Portugal, Romania, Russia (non-EU), Slovak Republic, Slovenia, Spain, Sweden, Turkey (non-EU), United Kingdom, United States (non-EU).

List of sectors in the World Input-Output Database

Table A1

WIOD sector	Sector description	NACE code	(Primary, secondary and tertiary)
c01	AGRICULTURE, HUNTING, FORESTRY AND FISHING	AtB	Primary
c02	MINING AND QUARRYING	C	Primary
c03	FOOD , BEVERAGES AND TOBACCO	15t16	Primary
c04	Textiles and textile	17t18	Secondary
c05	Leather, leather and footwear	19	Secondary
c06	WOOD AND OF WOOD AND CORK	20	Secondary
c07	PULP, PAPER, PAPER , PRINTING AND PUBLISHING	21t22	Secondary
c08	Coke, refined petroleum and nuclear fuel	23	Secondary
c09	Chemicals and chemical	24	Secondary
c10	Rubber and plastics	25	Secondary
c11	OTHER NON-METALLIC MINERAL	26	Secondary
c12	BASIC METALS AND FABRICATED METAL	27t28	Secondary
c13	MACHINERY, NEC	29	Secondary
c14	ELECTRICAL AND OPTICAL EQUIPMENT	30t33	Secondary
c15	TRANSPORT EQUIPMENT	34t35	Secondary
c16	MANUFACTURING NEC; RECYCLING	36t37	Secondary
c17	ELECTRICITY, GAS AND WATER SUPPLY	E	Secondary
c18	CONSTRUCTION	F	Secondary
c19	Sale, maintenance and repair of motor vehicles and motorcycles; retail sale of fuel	50	Tertiary
c20	Wholesale trade and commission trade, except of motor vehicles and motorcycles	51	Tertiary
c21	Retail trade, except of motor vehicles and motorcycles; repair of household goods	52	Tertiary
c22	HOTELS AND RESTAURANTS	H	Tertiary
c23	Other Inland transport	60	Tertiary
c24	Other Water transport	61	Tertiary
c25	Other Air transport	62	Tertiary
c26	Other Supporting and auxiliary transport activities; activities of travel agencies	63	Tertiary
c27	POST AND TELECOMMUNICATIONS	64	Tertiary
c28	FINANCIAL INTERMEDIATION	J	Tertiary
c29	Real estate activities	70	Tertiary

c30	Renting of m&eq and other business activities	71t74	Tertiary
c31	PUBLIC ADMIN AND DEFENSE; COMPULSORY SOCIAL SECURITY	L	Tertiary
c32	EDUCATION	M	Tertiary
c33	HEALTH AND SOCIAL WORK	N	Tertiary
c34	OTHER COMMUNITY, SOCIAL AND PERSONAL SERVICES	O	Tertiary
c35	PRIVATE HOUSEHOLDS WITH EMPLOYED PERSONS	P	Tertiary

Discussion of David Cook and Nikhil Patel's paper

Jian Wang[1]

Summary

This paper proposes a theoretical model that incorporates three important features in international trade. First, most international trade is priced in a few key vehicle currencies. Second, intermediate goods account for much of the growth in international trade. Third, countries within a region trade more extensively than countries in different regions.

There are two regional small open economies (SOEs) and one large global economy in the model. Based on this model, the authors study the effect of global and regional interest rates shocks on regional SOEs. Following an increase in the global interest rate, the response of the interest rate in the regional SOEs depends on their monetary policy regimes. Under the fixed exchange rate regime, the interest rates in the regional SOEs have to increase by the same amount as the global interest rate to maintain the fixed exchange rate regime. If the regional SOEs follow CPI targeting, the interest rates in these countries also increase, but less than one to one relative to the global interest rate. In contrast, if the regional SOEs' central banks target PPI inflation, the interest rates in these countries will fall following a positive shock to the global interest rate. The dynamics and equilibrium effects on international trade and total output also vary substantially in each of the above cases.

We now consider the effect of regional interest rate shocks. Following a decrease in the interest rate in one of the two regional SOEs, the central bank of the other regional SOE has two options: CPI targeting or competitive devaluation. The exports plunge sharply due to the substitution effect if the central bank follows the CPI targeting regime.

This paper also empirically tests the model's theoretical predictions by using disaggregated sectoral data on bilateral international trade flows that are decomposed into different global value chain components.

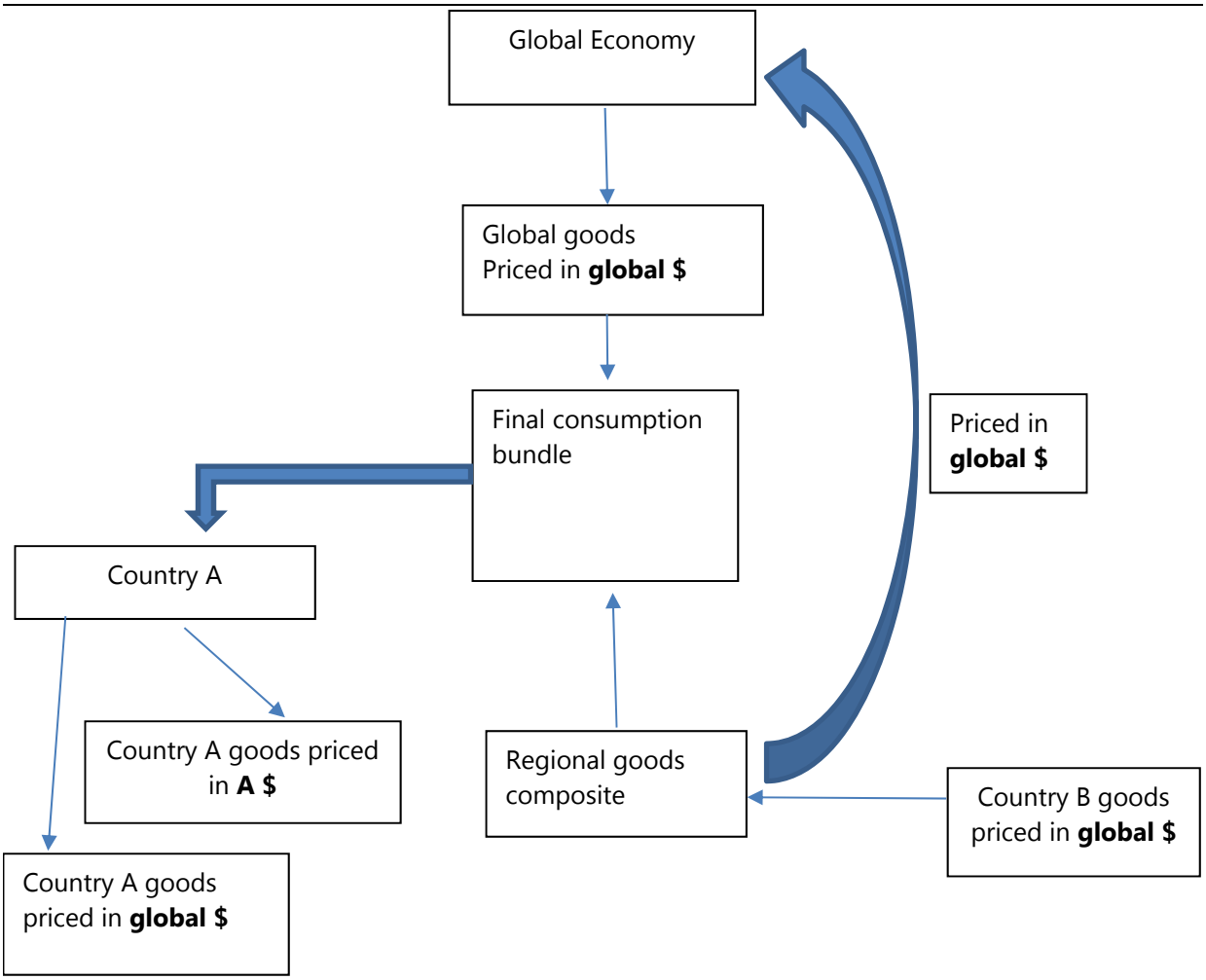
Structure of the theoretical model

My main comments are on the paper's theoretical model. Therefore, it helps to give more details about the model structure in this subsection. There are two regional SOEs and one large global economy in the model. The two SOEs are symmetrical. Figure 1 shows the structure of the model and only one of the two symmetrical regional SOEs is displayed to save space.

Goods in two regional SOEs (country A and country B) are produced from labour inputs in each country. The two types of goods are combined into regional goods composites, which are either exported to the global economy for its consumption or combined with goods from the global economy and consumed in the regional SOEs.

[1] The Chinese University of Hong Kong (Shenzhen).

Theoretical model structure Figure 1



There are two important features in this production structure. First, the final consumption goods are produced along a global value chain. For instance, the exports of country A contain the imported intermediate goods from country B. Second, exports of SOEs are priced in a vehicle currency (global dollar). This deviation from the standard invoicing currency strategy (eg local currency pricing and producer currency pricing in Devereux and Engel (2002)), plus sticky prices, implies different exchange rate pass-throughs following an interest rate shock.

Comments

I have three comments on the theoretical model of the paper and one comment on its identification strategy in the empirical section. My comments on the theoretical model focus on its policy implications and the connection between model predictions and the scenario after the 2008 financial crisis.

Comments on the theoretical model

The paper proposes a very rich DSGE model that appropriately captures the import features of regional SOEs. The authors demonstrate that such a model produces

dynamics and general equilibrium outcomes that are substantially different from those in standard models. These results are very interesting by themselves, reminding us that some simplifications in standard models may create misleading results in matching data and making policy suggestions.

The authors may want to utilise such a rich model in monetary policy evaluation in the future. The monetary policy parameters in the model are calibrated to the standard values in the literature. However, it is not clear if such a policy is optimal or not. The authors may want to find out what is the welfare-based optimal policy in the model, which is an important advantage of such a rich general equilibrium model relative to reduced-form/partial equilibrium models.

The policies in the regional SOEs are assumed to be symmetrical in the model following a global interest rate shock. It would be interesting to relax this assumption. In reality, some regional SOEs impose more restrictions on exchange rate fluctuations than others. When the United States tightens or loosens its monetary policy, how will this affect these regional SOEs with different policy regimes? What are the optimal policy for these regional SOEs in this case? And is this policy also globally optimal? The model in this paper provides a great framework for answering these important questions. I would encourage the authors to explore them further.

It would also be interesting to connect the model predictions with what happened during the global financial crisis in 2008. When the Federal Reserve loosened the monetary policy through unconventional policy tools such as quantitative easing, many emerging markets adopted similar loose policies, although their domestic economies remained relatively resilient at the time. Policymakers in emerging markets were concerned that the accommodative monetary policy in the United States would weaken the dollar, which in turn would hurt the exports of emerging economies if they did not follow a loose monetary policy.

This concern seems to be legitimate in the model of this paper because the substitution effect is very strong under the model's setup. The authors find that if country A's currency depreciates against the US dollar due to an expansionary monetary shock in country A, country B may suffer a substantial export decrease if it does not devalue its currency against the dollar. Intuitively, country B's exports are priced in the US dollar and the prices are fixed in the short run. The depreciation of country A's currency against the US dollar has two effects on country B's exports. First, it reduces the consumption of country B's goods in country A. Second, country A will also replace some intermediate inputs that it imports from country B, which are used to produce goods exported to the global economy. Following a similar logic, when the United States loosens its monetary policy, the regional SOEs may engage in competitive policy, loosening to protect their exports. The authors might want to check if that is the case if policymakers prefer to stabilise their exports. In addition, it is useful to check whether such a policy is optimal or not, either locally or globally.

Comments on empirical results

To measure the US monetary policy, the authors employ the shadow rate calculated from the dynamic factor model in Lombardi and Zhu (2014). It would be useful to check the robustness of the main findings when the shadow rate is recovered from other methods, such as the one in Wu and Xia (2015).

The authors may also consider taking the endogeneity issue more seriously in their empirical work. For instance, the monetary policy shocks identified from event studies, such as in Neely (2010).

Conclusion

Overall, this is a very promising paper with a rich structure model. The model provides a framework for policy evaluation exercises that are crucial for policymakers in emerging markets.

References

Devereux, M and C Engel (2002): "Exchange rate pass-through, exchange rate volatility, and exchange rate disconnect", *Journal of Monetary Economics,* vol 49, no 5, pp 913–40.

Lombardi, M and F Zhu (2014): "A shadow policy rate to calibrate us monetary policy at the zero lower bound", *BIS Working Papers*, no 452.

Neely, C (2010): "Unconventional monetary policy had large international effects", *Federal Reserve Bank of St Louis Working Paper*, no 2010-018G.

Wu, J and F Xia, (2015): "Measuring the macroeconomic impact of monetary policy at the zero lower bound", University of Chicago Booth School of Business*, Research Paper*, no 13-77.

Discussion of Sebnem Kalemli-Ozcan, Xiaoxi Liu and Ilhyock Shim's paper[1]

Filippo di Mauro[2]

Exchange rate appreciations can be expansionary or contractionary for an economy whose currency appreciates vis-à-vis the US dollar. The standard Mundell-Fleming model predicts a contractionary effect as a result of a decline in net exports with an appreciating currency. However, it is possible that investment responds positively to an exchange rate appreciation. This can work via two channels: the interest rate channel and the balance sheet channel. To be able to guide the policy debate, one needs to know which of these channels dominate in the aggregate. Kalemli-Ozcan et al (2018) provide evidence on this conjecture, focusing on the balance sheet channel. They ask whether firms will take on more debt if the exchange rate of their home country appreciates vis-à-vis the US dollar.

Their results show increased leverage (ie risk-taking) as a result of a positive exchange rate-related balance sheet shock to firms. When faced with a local currency appreciation against the US dollar, firms with larger FX debt before the exchange rate appreciates increase their leverage relatively more than those with smaller FX debt after the appreciation. The authors control for country- and industry-level demand and supply shocks and policy changes by using country-sector-year fixed effects.

They do not observe large appreciations: the largest is 17%. This may explain the small effects in their paper. Their benchmark estimate of 0.035 implies that a firm with more FX debt than the typical firm will increase its leverage ratio 3.5 percentage points more than the firm with FX debt lower than the typical firm after a 10% appreciation of the exchange rate. This represents a 22% increase over the sample mean of leverage. Their estimates are larger for the firms in the non-tradeable sector. The estimate for the average firm in the non-tradable sector is 0.06, representing a 6 percentage point increase in relative leverage between high- and low-FX debt firms, which corresponds to a 37% increase relative to the sample mean of leverage.

The paper's starting point is the evidence that capital inflows are expansionary, which means that the effect of lower borrowing overcomes the contractionary effect of the exchange rate appreciation. In this framework, the authors seek to test the channel of leverage behind this empirical correlation, using firm-level data. As result, they find that firms with higher foreign currency (FX) debt increase their leverage relatively more after the appreciation: with a 10% appreciation of the exchange rate, a firm with above-average FX debt will increase its leverage by 22% more than the average.

The paper makes two contributions to the literature. The first is to help solve Blanchard's puzzle: capital flows are associated with output expansion because, since they cause appreciation, they induce firms with higher FX exposure (which therefore will see their balance sheets strengthened) to take on even more debt (intermediate

[1] "Exchange rate appreciations and corporate risk taking" by Sebnem Kalemli-Ozcan, Xiaoxi Liu and Ilhyock Shim is not included in this volume but has been published as BIS Working Paper no 710.

[2] Critical help from Bernardo Mottironi (Bocconi University), CompNet analyst, is gratefully acknowledged.

result) and therefore increase output (final outcome). On the negative side, higher debt will cause potential vulnerability should a depreciation eventually occur. The paper's second contribution is the use of firm-level information, which is the only way to ascertain the micro-foundation of such mechanisms (ie the individual relative FX exposure across firms matters).

While thoroughly researched and well executed, the paper raises a number of issues, mostly related to the availability of firm-level FX debt data and to the econometric estimation. Below it is a summary of the perceived weaknesses.

First, as the FX exposures are not available at the firm level, the authors make the strong assumption that every firm's FX share of debt is in the same proportion as the country's. This is very unrealistic, since in reality a firm's FX share of debt would be dispersed. Factors that might affect it would be the firm's size and its foreign exposure (ie firms that export more have more foreign debt). Moreover, this assumption implies that a heterogeneity feature, critical to underpinning the very purpose of the paper – the importance of the FX exposure BY FIRM – is absent. The authors take into account the firm's size in the regressions and consider tradable sector and non-tradable sector firms separately. I would suggest correcting the firm's FX share of debt by retrieving the share of FX exposure by sector, drawing on a database where this info is available (for instance, in Europe), and using it to correct the data set; and, as they mention (on page 6 of the paper) that large publicly listed companies report their loans and bonds denominated in foreign currency, collecting this data and running the same regressions. They would be able then to compare the results and check the robustness of their strong assumption.

Secondly, the authors make an interesting list of stylised facts and show that the issue of FX exposure is actually high in Latin America, but not particularly worrisome in Asia, the chosen region for their application. Looking at the chart, it would seem that, for Asia, it is only in Indonesia that the share of FX exposure is relatively high – about 20% – and increasing, while for the rest of the region it is low and generally declining. Since the authors claim – in the conclusions – that their work has strong policy implications, particularly related to the reversal of the appreciation-related debt build-up, one could question the adequacy of the selected data set of countries for that purpose.

Third, the paper starts from observations that are macro: capital flows, indebtedness, growth. The micro-foundation could matter given that the samples are representative by individual countries.[3] Still, we need to know, for instance: whether they are meaningfully comparable across countries (eg CompNet) and if the data set that they used is balanced or unbalanced. Furthermore, what we gathered is that the samples contain small and very small firms, which do not hold debt. Are these the firms we want to consider? Would it not be better to go straight to Compustat, which includes only listed firms, which are more likely to engage in complex FX trading/borrowing activities (page 3 of the paper)? In this context, the authors provide separate results for the tradable and non-tradable sector, and it would be good to show separate results for large and small firms. Granularity is good to consider in general, but can be misleading when we lose the contact with the macro phenomenon.

[3] Jingting Fan and Sebnem Kalemli-Ozcan, "Emergence of Asia: reforms, corporate savings, and global imbalances", *IMF Economic Review*, June 2016, volume 64, issue 2, pp 239–267.

Fourth, regarding the estimation, in addition to the control variables of firm's size, collateral and profitability – used in the paper – the standard theory of indebtedness also uses the volatility of the operational results (dispersion/average of the EBIT in the industry), the uniqueness of the goods produced, and the median industry indebtedness.

Finally, the choice of using OLS can be criticised, because the main independent variable (high FX debt) leads to an endogeneity issue: therefore, an instrumental variable approach should be used. The authors may also want to consider a GMM estimation, because the indebtedness of a firm is a dynamic and persistent process.

To conclude, despite its good intentions, the paper seems to need some substantial reconsideration/strengthening in relation to the underlying data (especially the non-availability of firm-level FX exposure) and to the econometric procedure used. Actually, I wonder if the paper, rather than considering debt as a dependent variable, should not have considered instead as a dependent variable a more explicit final outcome, such as value added. The idea being to test directly the extent in which the exchange rate movements differentially influence the firms' outcomes – and, at the macro level, GDP, which is one of the starting points of the initial puzzle of Blanchard's puzzle – regardless of the channel of transmission (the higher debt). In this context, CompNet – the Competitiveness Research Network – has done relevant research on establishing the role of the exchange rate in explaining trade, against the background of firms' differing productivity and size.

Having said all of the above, the authors must be commended, since they are opening up an important avenue of research. Data problems will eventually be solved, and at that point we will have a framework of analysis ready to use.

Exchange rate challenges: how should policymakers respond?

Remarks on the Policy Panel

Grant Spencer[1]

The topic for our panel discussion is potential policy responses to exchange rate challenges. The main challenge from my perspective, and I would say for both Australia and New Zealand since the global financial crisis (GFC), has arisen from periods of significant upward pressure on our exchange rates. A high exchange rate puts pressure on export industries, particularly manufacturers, encourages imports and puts downward pressure on price inflation.

How we as policymakers have reacted to this has depended on how we have viewed the causes of the upward exchange rate pressure. In broad terms there have been two alternative explanations: (i) nominal shocks derived from easy monetary policies in the developed countries, particularly from quantitative easing, since the GFC; and (ii) real shocks arising from improving terms of trade as export commodity prices have outstripped the cost of imports, especially manufactured imports.

If the first explanation is most relevant, the policymaker has to assess how firm their domestic monetary policy can realistically be in the face of easy global conditions. For a large relatively closed economy, this scope for monetary policy "independence" may be significant. For a small open economy, there will be less scope for a differentiated monetary policy. This implies an easier policy than warranted by domestic conditions alone, leading to rising non-traded prices relative to traded prices, and rising property prices, potentially leading to financial stability concerns.

Policies to counter such an external nominal shock might include macroprudential policies to reduce financial system risk, restrictions on inward foreign investment (eg into housing) and potentially also FX intervention, resulting in increased holdings of (unhedged and often loss-making) foreign reserves. Essentially it is a story of domestic monetary policy being dominated by the very easy global liquidity conditions, with various other policies trying to compensate.

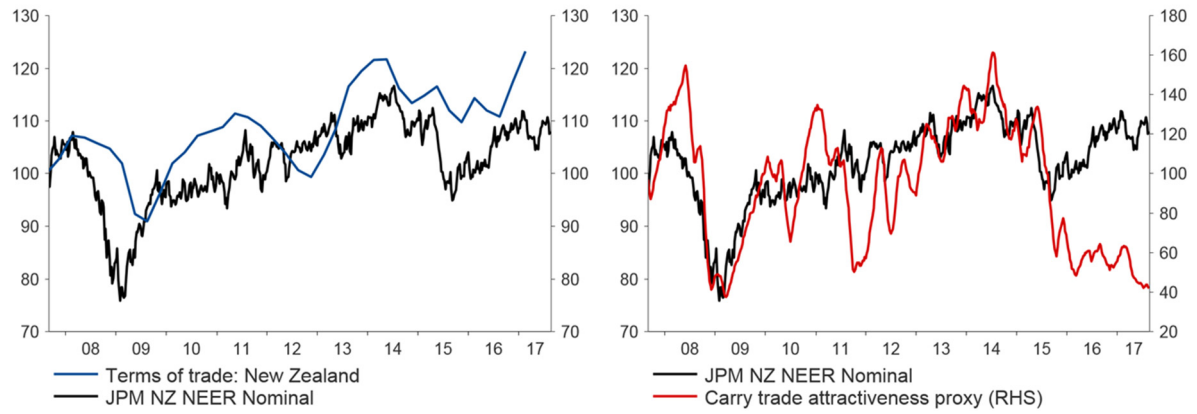
If the second explanation is more relevant, the policymaker's perspective is very different. A strong terms of trade suggests that the high exchange rate is justified and serves the purpose of distributing the real national income gain across the domestic spending sectors.

Domestic monetary policy easing will be less appropriate due to the positive terms-of-trade income effect on demand. The real appreciation and crowding out of low-return traded sectors (manufacturing) will be more acceptable as resources are diverted to the high-return export sectors. The case for using other compensating policies such as macroprudential measures, foreign investment restrictions and FX intervention will be less convincing. So assessing the drivers of the exchange rate pressure is very important in formulating the right policy response.

[1] Governor, Reserve Bank of New Zealand.

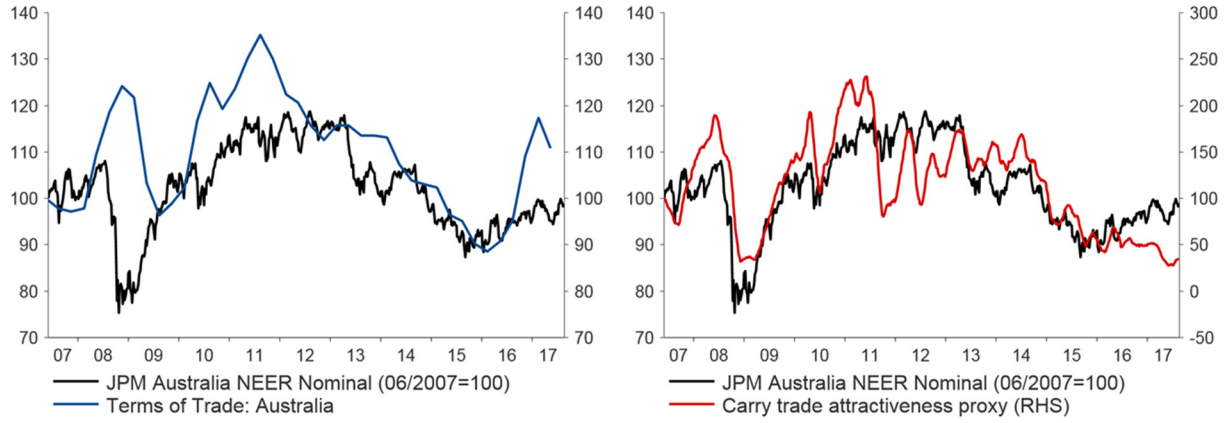
What does the evidence tell us about the relative strength of nominal vs real shocks over the past 10 years? I am not going to answer that, but I will show a few figures below. As we might expect, the figures suggest that both real and nominal shocks have been relevant, varying through time and across countries. The challenge for the policymaker is to continually reassess the drivers, and to modify policies accordingly.

Exchange rate drivers: New Zealand — Figure 1



Source: Thomson Reuters.

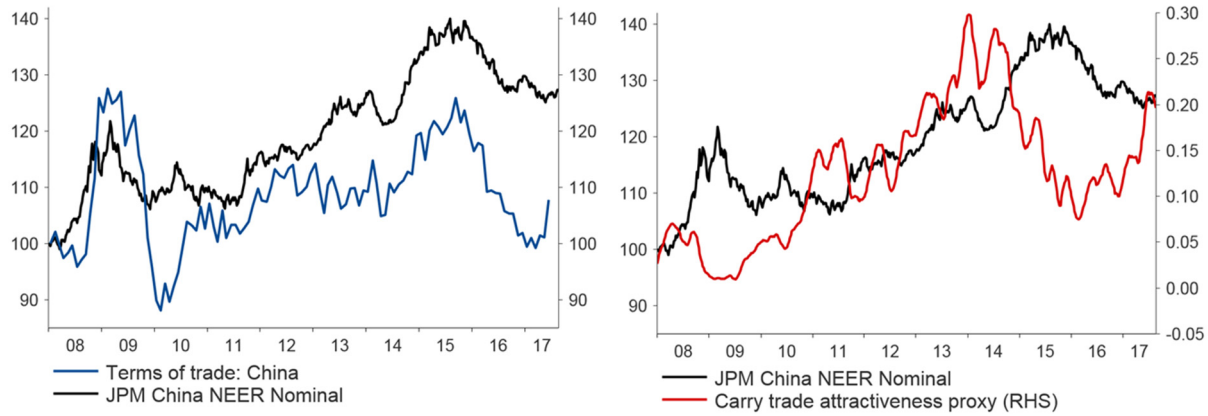
Exchange rate drivers: Australia — Figure 2



Source: Thomson Reuters.

Exchange rate drivers: China

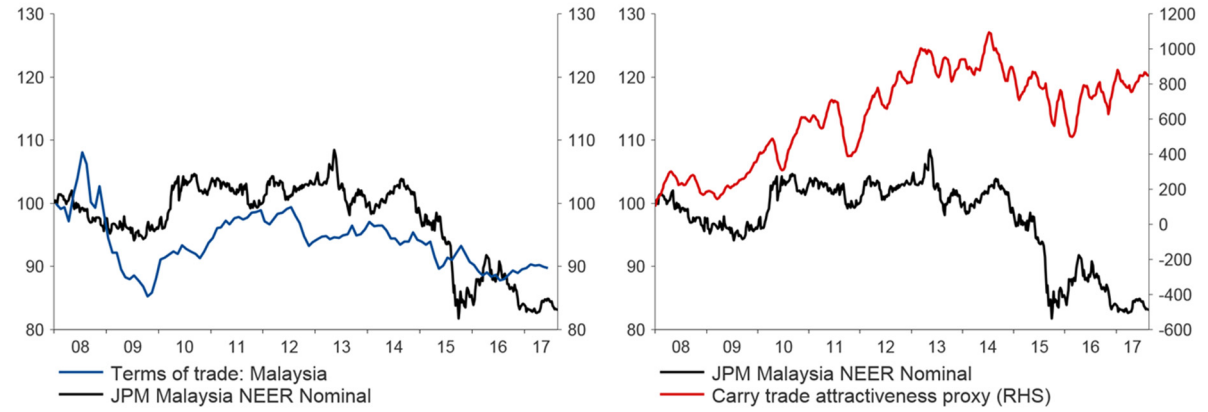
Figure 3



Source: Thomson Reuters.

Exchange rate drivers: Malaysia

Figure 4



Source: Thomson Reuters.

Note: The carry trade attractiveness proxy is constructed as the local minus the US two-year benchmark government bond rate, divided by the VIX implied volatility index: (two-year local bond rate – two-year US bond rate)/VIX index.

Exchange rate puzzles and dilemmas: how can policymakers respond?

Remarks on the Policy Panel

Diwa C Guinigundo[1]

1. Introduction: exchange rate puzzles

Since Meese and Rogoff (1983) introduced what is known as the exchange rate disconnect puzzle, which underscores the weak connection between exchange rate and virtually all macroeconomic aggregates, significant research has been devoted to the subject to improve both academics' and policymakers' understanding of exchange rates.

Notwithstanding such progress, the current rapidly evolving global economic landscape, driven in part by greater globalisation and integration, continues to challenge our conventional wisdom on exchange rates. It also continues to complicate the conduct of monetary and exchange rate management, particularly in emerging market economies (EMEs). First, EMEs have been recipients of large and volatile capital flows. While capital flows, on a net basis, have recently declined relative to their pre-global financial crisis (GFC) levels, flows have generally been increasing in gross terms. Second, the increase in international capital flows has been accompanied by a corollary increase in the volatility of financial markets, including the foreign exchange markets. Third, greater financial integration and globalisation have led to a greater incidence of financial spillovers.[2]

This paper discusses the policy implications of these challenges and the Bangko Sentral ng Pilipinas's (BSP's) experience and policy responses to cope with these challenges. In particular, the paper assesses the appropriateness of the BSP's exchange rate policy regime against these emerging global trends.

2. Emerging trends: the three inevitables of globalisation

Financial integration has taken quantum leaps amidst technological advances and massive market deregulation efforts across various jurisdictions. In the past three decades, EMEs have also become increasingly integrated in the global financial system. While this offers many benefits, this has also become associated with risks that could undermine the impact of their benefits and the effectiveness of the policy tools. In particular, greater financial integration has led to what can be considered as "three inevitables".

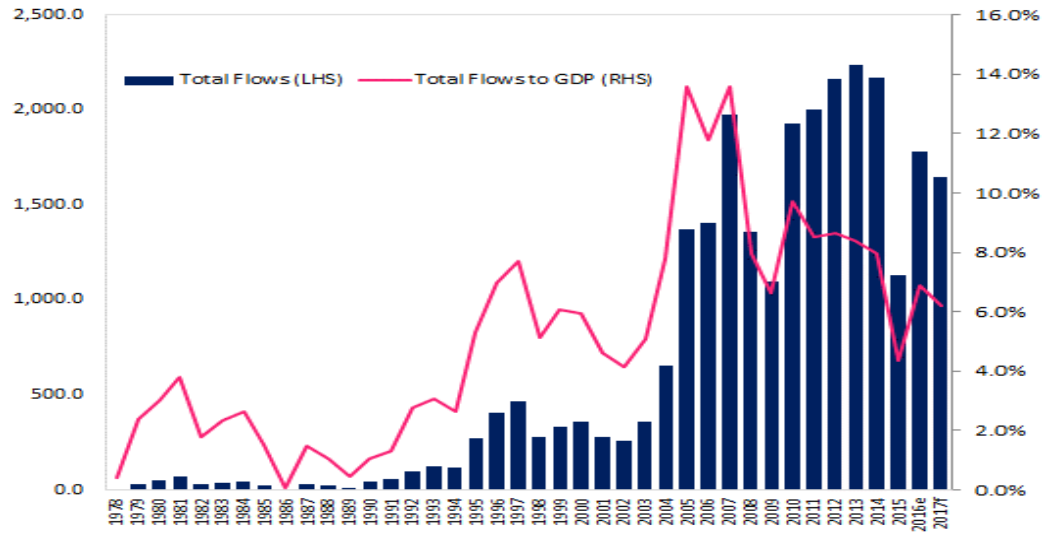
First, EMEs have been recipients of large and volatile capital flows. While capital flows, on a net basis, have recently declined relative to their pre-GFC levels, flows have generally been increasing in gross terms (Graph 1).

[1] Deputy Governor, Bangko Sentral ng Pilipinas.

[2] The IMF defines spillovers as the impact of changes in domestic asset price movements (or their volatility) on asset prices in other economies (IMF (2016)).

Total flows to EMEs

(in US$ billion, as percent of GDP) Graph 1

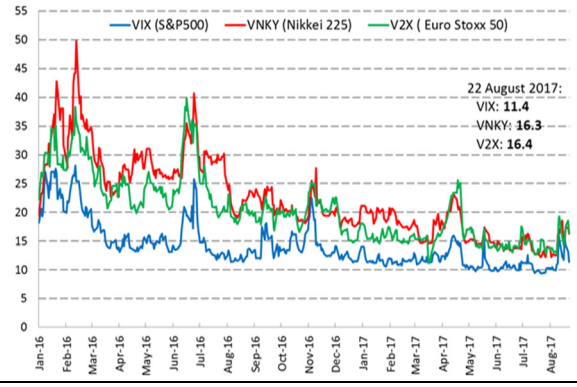


Note: Total flows is the absolute sum of private inflows and outflows to EMEs.

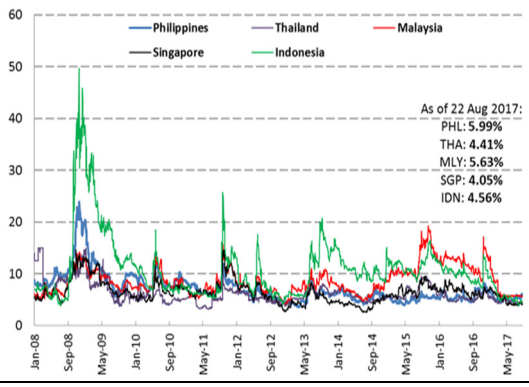
Source: Institute of International Finance (IIF).

Second, the increase in international capital flows has been accompanied by a corollary increase in volatility of financial markets. Financial markets have seen increased sensitivity to shocks. For instance, *the Chicago Board Options Exchange* Volatility Index (CBOE) or VIX, also known as the "fear index", jumped by 8.5 percentage points in a single day on 24 June 2016 in reaction to Brexit.

Implied volatility of equity indices (in percent) Graph 2



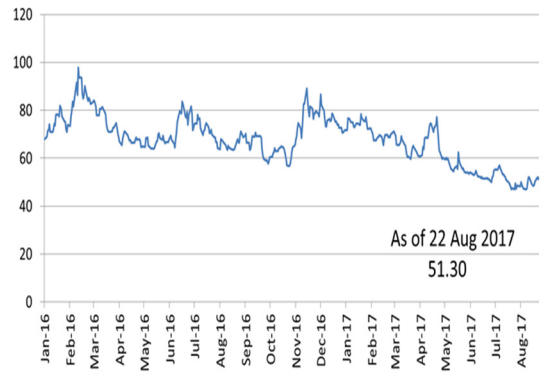
JP Morgan 1-month currency options volatility index (in percent) Graph 3



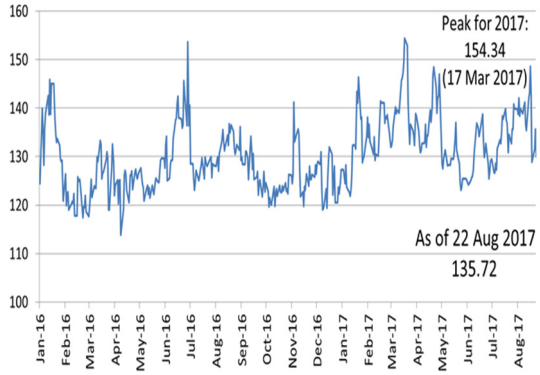
Note: VIX is a measure of market expectations of the near-term volatility by in terms of S&P 500 stock index option prices while VNKY or the Nikkei Stock Average Volatility Index indicates the expected degree of fluctuation of the Nikkei stock average in the future. V2X is based on Euro STOXX 50 Index Options traded in Eurex. The JP Morgan 1-Month Currency Options volatility index is a measure of market expected future volatility of a currency exchange rate.

Source: Bloomberg.

MOVE index
(in index points) Graph 4



Skew index
(in index points) Graph 5



Note: The Merrill Lynch Option Volatility Estimate (MOVE) Index is a yield curve-weighted index of the normalised implied volatility on a one-month treasury option. The SKEW Index is a global measure of the slope of implied volatility curve that increases as the curve tends to go steeper.

Source: Bloomberg.

As of 22 August 2017, equity markets have been relatively calm, with VIX easing to 11.4%, slightly above its historical low of 10.3% (Graph 2). Meanwhile, the FX and the bond markets have also been relatively calm, as the pricing of the one-month currency options volatility and the Merrill Lynch Option Volatility Estimate (MOVE) index[3] have both been generally on a downtrend (Graphs 3 and 4).

However, despite the observed calmness in the market, investors have been paying up to hedge against large stock price movements as shown in the general uptrend in the SKEW Index[4] (Graph 5).This could suggest that high probabilities of extreme market volatility remain a primary concern among investors.

Third, in today's highly integrated world, a problem in one jurisdiction can quickly be a problem in another jurisdiction. According to IMF (2016), spillovers have substantially risen in advanced economies (AEs) and EMEs. In fact, a third of the variation in the equities and foreign exchange markets in these economies could have been due to spillovers from shocks to EMEs.

In the BSP, spillovers in financial markets are obtained using the variance decomposition framework obtained from a generalised vector autoregressive (generalised VAR) model as suggested by Diebold and Yilmaz (2009, 2012, 2014). Under this framework, spillovers in 21 EMEs and AEs' foreign exchange and equities markets are estimated (Allon, Delloro and Fernandez (2017)).

Graph 6 shows the connectedness index for the period 3 May 2014 to 3 May 2017. The dotted line represents the average spillover for the entire sample period.

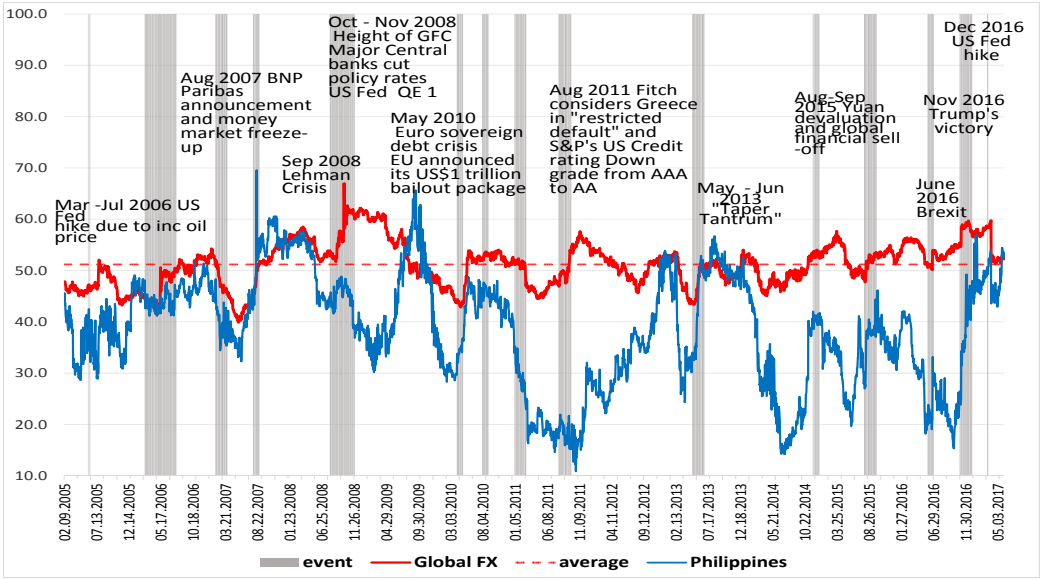
[3] The MOVE Index is a yield curve-weighted index of the normalised implied volatility on a one-month treasury option.

[4] The SKEW Index is a global measure of the slope of implied volatility curve that increases as the curve tends to steepen.

While the blue and red lines represent the evolution of spillovers on a 200-day rolling sample for the peso and the Global FX Indices, respectively.

Global FX and Peso Connectedness Indices
200-day Rolling Window (in percent)

Graph 6



Note: The indices are derived using a variance decomposition approach obtained from a Generalised VAR model. The estimation follows the Diebold-Yilmaz (2009, 2012, 2014) model which measures spillovers based on variance decompositions that are obtained from VAR models: movements in the dependent variable that are due to their own shocks; and movements in the dependent variable that are due to shocks to other variables in the system.

Source: BSP DER.

On average, the dotted line indicates that 50% of the total variation in the global FX market is due to spillovers. Moreover, the 200-day rolling indices exhibit contemporaneous spikes during periods of significant monetary policy actions and interventions in some major jurisdictions, as well as some unexpected economic and financial shocks. This suggests that spillovers in FX markets increase during periods of economic and financial stress in a particular jurisdiction.

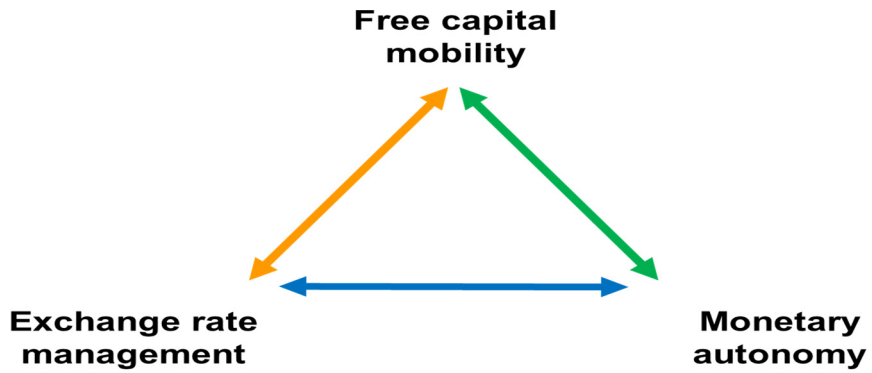
3. New puzzles: trilemma or dilemma

The foregoing emerging trends have indeed challenged and complicated the BSP's conduct of monetary and foreign exchange rate policies. The conventional wisdom has been that countries face a "trilemma", ie they must choose from (at most two out of) the following: free capital flows, a fixed exchange rate and an autonomous monetary policy (Figure 1).

However, economists and policymakers have argued that globalisation has rendered the trilemma obsolete and that governments instead face a dilemma, or an "irreconcilable duo" (Rey (2013)). Small open economies have no monetary autonomy, regardless of the exchange rate policy, due to the effect of substantial capital flows. In many cases, flows have been driven primarily by a global financial cycle that is not aligned with country-specific macroeconomic conditions.

For a small open economy such as the Philippines, which aims to expand economic development through increased financial openness, the main puzzle is how one can pursue this economic growth objective while maintaining monetary independence. This policy dilemma makes the role of the central bank as the monetary authority even more crucial.

Figure 1

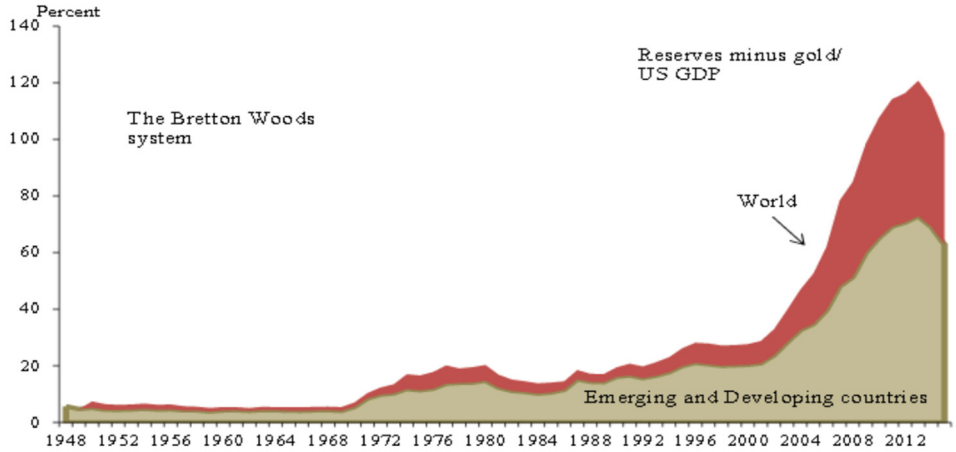


Source: Economist (2016).

Triffin dilemma. There is also the issue of what is referred to as the modern-day Triffin dilemma. The Triffin dilemma postulates that a country that issues the global reserve currency cannot maintain its value while providing adequate global liquidity at the same time. This is because increasing the amount of global liquidity makes it imperative for the global reserve-issuing country to run deficits. Hence, the value of the reserve currency declines. The ability of a currency to serve as a global reserve asset tends to be compromised if confidence in it as a global store of value is undermined.

EMEs that are exposed to capital flow volatility have resorted to the purchase of dollars to build up their reserves. Starting in 2003, we witnessed a surge in the stock of reserves held by central banks across the world (Graph 7). As is well known, this war chest of reserves was built primarily by emerging markets, notably in Asia.

Current account balance as percentage of GDP, 1919–40 Graph 7



Source: Ilzetski, Reinhart, and Rogoff (2017).

A fast-growing literature has examined the causes of that growth. Some papers have stressed the precautionary, self-insurance motive (Gourinchas and Obstfeld (2012)). Indeed, the build-up of reserves has helped economies, particularly emerging Asian economies, insulate themselves from market gyrations. However, more economists are starting to argue that this excess reserve accumulation could create modern Triffin-like dilemma pressures.

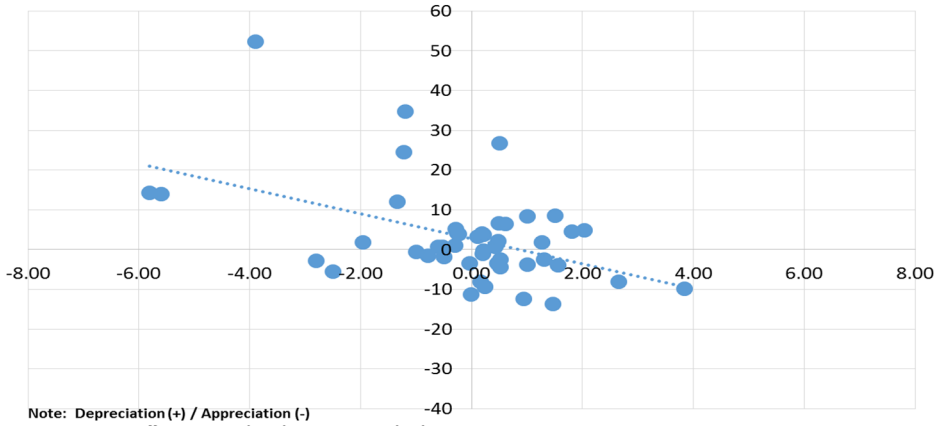
4. A flexible peso: living with the inevitables

With regard to the irreconcilable duo, the BSP's position takes a middle ground between the two extremes of the monetary policy debate spectrum. Both extremes have some validity. On global financial cycle for instance, the Philippines experienced a substantial reversal of capital flows in May 2013 (net portfolio outflow of US$640.8 million) during the taper tantrum period, despite having solid macroeconomic fundamentals in 2013 (ie gross domestic product (GDP) grew by 7.6% in the first semester). Nonetheless, the BSP is still able to enjoy monetary independence as evidenced by the successful achievement of its inflation target for six consecutive years (2009–14).

This means that maintaining a flexible exchange rate as grounded on our inflation targeting framework remains the appropriate and effective policy of choice. Flexible exchange rates act as an automatic stabiliser and contain wild swings in the financial markets.

Exchange rate flexibility (vertical axis, peso/dollar percent change) and growth forecast revisions (horizontal axis, in percentage points)
Philippines, 1994-2017

Graph 8



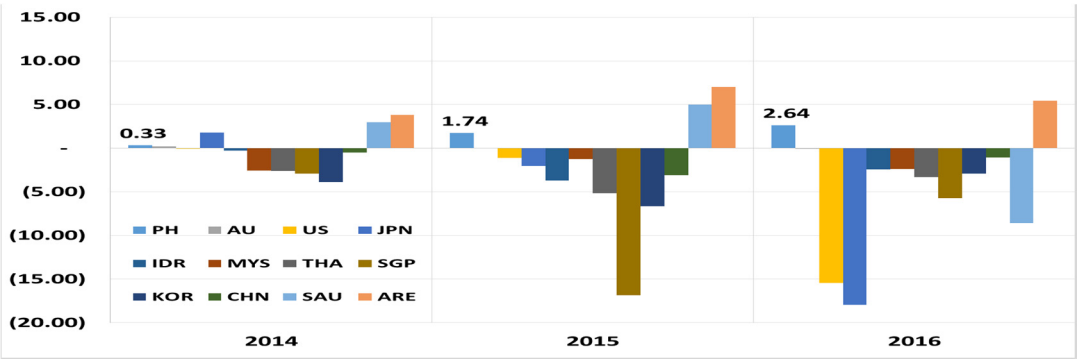
Source: BSP staff estimates, Bloomberg, IMF WEO database.

Graph 8 depicts how flexible exchange rates could perform this role. The horizontal axis refers to year-on-year changes in the World Economic Outlook (WEO) GDP forecast for the Philippines (proxy for output shocks), while the vertical axis refers to percentage changes in the nominal peso. The graph shows that, when output surprises on the upside, the peso appears to act as a buffer and tends to appreciate. Conversely, when the output shock is negative, the peso tends to depreciate. Interestingly, out of 44 instances, the peso adjusted correctly (or as expected) 27 times. Instances when peso adjustment deviated from the correct direction could

potentially be due to other factors. These suggest that, in most cases, the peso has acted as a buffer during output shocks.

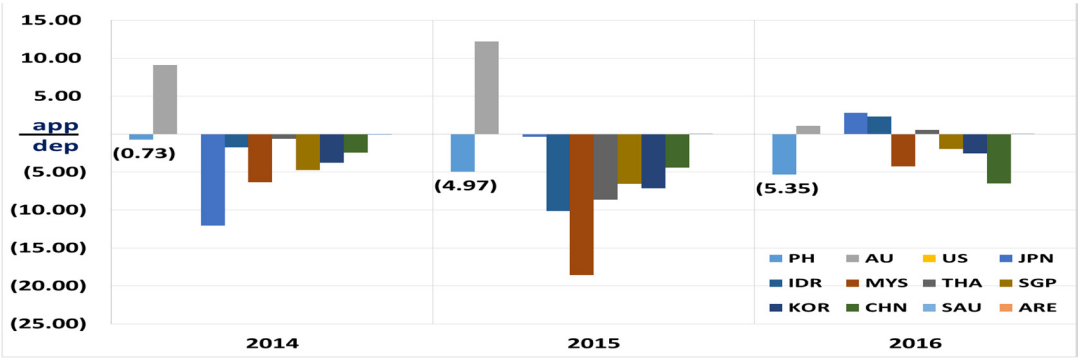
In addition, the current account adjustments needed for long-term growth are not a problem as adjustments appear to be borne by the flexible exchange rate. Graphs 9 and 10 depict recent conditions when the peso has been given the flexibility to adjust, including during periods when there has been high demand for imports.

Changes in imports (in US dollar millions)
Philippines and all major trading partners (except Hong Kong SAR) Graph 9



Source: World Bank and BSP DER Staff Estimates

Changes in exchange rates, in percent, 2012 to 2016, Philippines and trading partners
In currency per US dollar; depreciation (+); appreciation (-) Graph 10



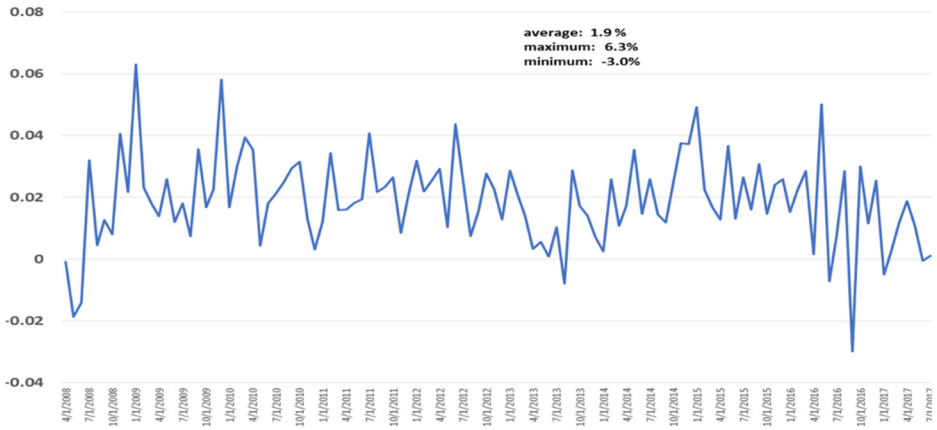
Source: Bloomberg and BSP DER Staff Estimates

Under a flexible exchange rate regime, speculative attacks on the peso have been limited as evidenced by the very small returns to carry trade for the peso. In the BSP's estimates of returns to carry trade (with the Philippine peso as investment currency), the incentive to exploit the arbitrage between peso and trading partner currencies, on average, is very small (around 1.9%). In other words, fluctuations and noise could be present from time to time, but there is no underlying profitability for shorting the domestic currency. In the end, exchange rate flexibility has allowed the market to move based on underlying market demand and supply for foreign exchange (returns could fluctuate but it moves around a steady average).

All of these support Obstfeld's (2015) findings that EMEs that adopt a flexible exchange rate are better positioned to moderate the impact of global financial and

monetary forces. Nonetheless, exchange rate adjustments do not insulate economies from external shocks and additional tools are needed.

Returns to carry trade for the peso against all trading partners
March 2008 to July 2017 Graph 11



Note: Average monthly returns to the previous months' level.

Source: BSP DER staff estimates.

5. Additional tools

The BSP also implements macroprudential and capital flow management policies to manage risks that could arise externally. Macroprudential policies are necessary to restore monetary policy independence for the EMEs. They complement the use of capital flow measures to insulate the economy from the global financial cycle. Temporary controls could be used, especially on credit flows and portfolio debt when the cycle is in a boom phase. This option has been tested in various contexts such as the Chilean encaje (1991–98) and the Brazilian taxes on equity inflows (2010–11).

The BSP has expanded its policy toolkit to include macroprudential regulations that can be focused on specific risk sources. Contingency measures such as liquidity-enhancing facilities, rediscounting windows and regional firewalls, also boost the flexibility and effectiveness of the BSP's actions. These have helped maintain the smooth functioning of markets.

Finally, the BSP focuses on improving transparency through communication, and thereby building and maintaining institutional credibility. In the era of globalisation, the expectations channel has increased its relevance as a transmission channel of monetary policy. Thus, it has been the proactive thrust of the BSP to ensure that markets clearly understand the objectives and direction of monetary policy. In the Philippines, communication is an essential pillar of the inflation targeting framework. After every policy meeting, the Monetary Board holds a press conference to explain the most recent decision on rates. This is followed by the release of the Highlights of the Meeting after six weeks, the Inflation Report and Letter to the President every quarter, and then the Annual Report during the following year.

Thus, building credibility and transparency is also important in the context of greater financial globalisation. A credible monetary policy can effectively anchor expectations and thus make monetary policy more effective.

6. Conclusion

The challenges associated with financial integration and their impact through exchange rate dynamics have complicated the conduct of monetary and exchange rate policy. Nonetheless, the flexibility of the peso has served as an effective first line of defence to dampen the impact of global financial and monetary shocks.

Moreover, the BSP is also looking for fresh approaches to further insulate the domestic economy from external shocks. To this end, the BSP has implemented a number of refinements and complementary tools to its existing monetary policy framework (inflation targeting or IT), which include the following:

- *Strengthening the transmission of monetary policy*. The period of strong capital inflows and liquidity growth following the global financial crisis has tempered the transmission of monetary policy to market interest rates. In this regard, the BSP has implemented an interest rate corridor (IRC) framework for its monetary operations. The IRC could potentially improve monetary transmission as the BSP now has greater flexibility to manage parts of the yield curve (seven days, 28 days, etc). This makes it easier to transmit policy settings to specific tenors of financial intermediation activities. Going forward, operational refinements to the IRC facilities will be critical in ensuring that liquidity conditions remain consistent with the prevailing outlook for inflation and growth.
- *Enhancing the BSP's capabilities in pursuing its objectives*. The BSP continues to pursue various amendments to its Charter that will enhance its ability to maintain price stability while promoting sustainable and inclusive growth. These amendments include, among others:
- The explicit inclusion of promoting financial stability, in addition to maintaining price stability, in its mandate;
- An increase in the BSP's capitalisation, which would enhance its credibility and capacity to ward off risks to the financial system and the broad economy and could therefore raise the integrity and authority, solid grounding and independence of the BSP; and
- Restoration of its ability to issue its own debt instruments, as a way of augmenting its monetary policy toolkit.
- Improving coordination with the government and private sector, including initiatives for data-sharing and capital market development. The BSP continues to work closely with its counterparts in other government agencies as well as with the private sector in the collection (and dissemination) of data needed to improve its forecasting and supervisory capabilities. Efforts to develop new financial services/products and to align financial regulations with international standards are also ongoing.
- Enhancing macro-financial surveillance. There is a need for an overarching framework for macro-financial surveillance that could squarely identify, measure, and manage vulnerabilities, risks and shocks with a view to effectively preventing a potential crisis. Hence, it is imperative to widen our range of tools and measures

that could cover different aspects of potential shocks to the economy. The BSP has expanded its surveillance tools to better monitor risks and vulnerabilities. Tools involve employment of a suite of quantitative models that attempt to address one or more aspects of systemic risks. These include, among others: (i) the Early Warning Systems (EWS); (ii) the Philippine Composite Index of Financial Stress (PCIFS); and (iii) the Spillover Index and other indices that measure macro-financial conditions.

In future, deeper cross-border financial integration, especially in the light of freer capital flows under the ASEAN Economic Community, could also pose challenges to the conduct of monetary policy in terms of assessing the potential impact of greater financial integration.

References

Allon, J, V Delloro and J Fernandez (2017): "Measuring Philippine financial connectedness: a variance decomposition approach", Bangko Sentral ng Pilipinas, forthcoming.

Diebold, F and K Yilmaz (2009): "Measuring financial asset return and volatility spillovers, with application to global equity markets", *Economic Journal*, vol 119, pp 158–171.

——— (2012): "Better to give than to receive: forecast-based measurement of volatility spillovers", *International Journal of Forecasting*, vol 28, no 1, pp 57–66.

——— (2014): "On the network topology of variance decompositions: measuring the connectedness of financial firms", *Journal of Econometrics*, vol 182, no 1, pp 119–34.

The Economist (2016): "The Mundell-Flemming trilemma: two out of three ain't bad", *Economics Brief*, 27 August 2016, www.economist.com/news/economics-brief/21705672-fixed-exchange-rate-monetary-autonomy-and-free-flow-capital-are-incompatible.

Gourinchas, P-O and M Obstfeld (2012): "Stories of the twentieth century for the twenty-first", *American Economic Journal: Macroeconomics*, vol 4, no 1, January, pp 226–65.

Institute of International Finance (2017): "Capital flows to emerging markets: eye of the Trumpstorm", 8 February 2017.

International Monetary Fund (2016): "The growing importance of financial spillovers from emerging market economies", *Global Financial Stability Report,* April 2016, www.imf.org/en/Publications/GFSR/Issues/2016/12/31/Potent-Policies-for-a-Successful-Normalization.

Ilzetzki, E, C Reinhart and K Rogoff (2017): "Exchange arrangements entering the 21st century: which anchor will hold?", *NBER Working Papers*, no 23134, February, www.nber.org/papers/w23134.

Meese, R and K Rogoff (1983): "Empirical exchange rate models of the seventies: do they fit out of sample?", *Journal of International Economics*, vol 14, pp 3–4.

Obstfeld, M (2015): "Trilemmas and trade-offs: living with financial globalisation", *BIS Working Papers,* no 480, January, www.bis.org/publ/work480.pdf.

Rey, H (2013): "Dilemma not trilemma: the global financial cycle and monetary policy independence", in *Global dimensions of unconventional monetary policy*, proceedings of the Federal Reserve Bank of Kansas City Jackson Hole symposium, 2013, pp 285–333.

Triffin, R (1960): Gold and the dollar crisis: the future of convertibility, Yale University Press.

Exchange rate puzzles and dilemmas: how can policymakers respond?

Remarks on the Policy Panel

Sebastian Edwards[1]

We have had two days of intense, fruitful and profound discussions. The experiences of a number of countries have been analysed, and some of the most important policy issues faced by central bankers have been highlighted. During my keynote address, I discussed some exchange rate-related issues that I believe are of importance for central bankers. Among these, perhaps the most current one relates to what central bankers in small open economies should do in the light of aggressive policy actions by the Federal Reserve and/or the European Central Bank. Should central banks in small open economies such as Thailand or Colombia follow the Fed, or should they pursue fully independent policies, based on their own policy rules?

Instead of repeating myself, what I would like to do during these closing remarks is to emphasise what I believe are the most important lessons from our discussions, and at the same time highlight where I believe we have left some loose ends. In addition, I would like to address three specific issues that, surprisingly, have been mostly absent in our deliberations.

Of course, the most important conclusion from our discussions during the last two days is that the exchange rate matters for monetary policy. Indeed, the exchange rate *matters a lot*, and in more than one way. This does not necessarily mean that the exchange rate should enter the policy rule as an additional term in the Taylor Rule. What it *does mean*, however, is that countries whose central bankers pay insufficient attention to currency developments are likely to experience heightened macroeconomic volatility.[2]

However, taking the exchange rate into account when implementing monetary policy is no easy task; it is easier said than done. A significant problem is that, in spite of major research efforts over the four decades since the abandonment of the Bretton Woods system, we still face a number of exchange rate-related puzzles. One such puzzle that has been discussed extensively at this conference is the "exchange rate disconnect," or the fact that exchange rate behaviour is not easily explained by the models that the economics profession has developed. This point was made in the 1980s by researchers such as Dick Meese and Ken Rogoff, Rudy Dornbusch and others. The truth of the matter is that, in the intervening 30 years, we have only improved our models marginally; the "disconnect" is still with us. I should notice, in parenthesis, that in the mid-1980s a number of researchers – including myself – addressed this problem by arguing that exchange rate changes were almost always the consequence of "news" and, thus, unpredictable by definition. Although this

[1] Sebastian Edwards is the Henry Ford II Distinguished Professor of International Economics at UCLA, and a Research Associate at the National Bureau of Economic Research.

[2] It should be noted that I am arguing that the exchange rate should be taken into account beyond its obvious effect on domestic inflation via the price of tradable goods.

perspective is technically solid, it is not useful for practical men and women, or for the anxious central banker.

Another important lesson that emerges from our discussions is the fact that the nominal exchange rate is not neutral in the short run. Indeed, large nominal exchange rate changes will elicit in the short run – a run that can last up to nine months, if not longer – significant real effects that will impact economic activity, including unemployment. The issue, of course, has to do with the size of the "pass-through coefficient," and with the relationship between nominal exchange rate changes and real exchange rate changes at different time horizons. This topic was researched extensively by Michael Mussa during the 1980s; his conclusion was that real exchange rate changes were overwhelmingly dominated by nominal exchange rate fluctuations. This is still true today.

As I pointed out during my keynote speech, the recent (2015–17) experience in Mexico is a clear example of the problem at hand: for political reasons – the so-called "Trump effect" – the Mexican peso depreciated at a very fast pace starting in mid-2015. In fact, the peso lost value much faster than what was justified by fundamentals. These developments introduced significant hardship into the Mexican economy, and made the job of Mexico's central bank governor, Agustín Carstens, extremely challenging. The policy rate was lifted by 425 basis points in a 20-month period!

Another important policy question raised at the conference – a point emphasised, in particular, by Charles Engel – is the extent to which capital controls should be part of the policy kit used by central bankers. Again, this is an old question. Perhaps not as old as the discussions on the "exchange rate disconnect puzzle," but dating, at least, back to the late 1980s. In a number of quarters it has become fashionable to argue that although controls on capital *outflows* do not work effectively and result in significant costs, small open economies should consider using controls on *inflows* as a way of avoiding excessive exchange rate volatility and speculation. As with many issues related to the connection between currencies and monetary policy, the empirical evidence is not 100% clear. While some researchers claim to have found that controls on inflows reduce exchange rate volatility, others have failed to unearth a significant and persistent effect.[3] Part of the problem with evaluating the effectiveness of capital controls on inflows – which often take the form of unremunerated reserve requirements, or URRs – is that they have usually been implemented at the same time as an active exchange rate intervention policy is enacted. This was indeed the case in Chile during the 1990s; what makes Chile's experience particularly important is that this was the first country to systematically adopt a URRs policy. After the controls on inflows were enacted in 1990, exchange rate volatility declined noticeably. However, the question remained of whether reduced currency volatility was the result of the controls on inflows, or a consequence of the policy of currency intervention, which at the time took the form of an exchange rate band. In order to address this issue, Roberto Rigobón and I developed a model where we calculated the "shadow" exchange rate, or currency value that would have prevailed in the absence of the bands. We concluded that the lower volatility was mostly the result of the band, and not of the controls on inflows. At the same time, we found that the unremunerated reserve requirements on short-term inflows did

[3] Much of this research has been undertaken for the case of Chile, a pioneer in the use of controls on inflows.

change the maturity of capital inflows; short-term flows were reduced, while longer term ones – including FDI – increased.[4]

Let me now turn to three topics which, surprisingly, were not addressed during our deliberations.[5] The first one is "sudden stops," a phenomenon studied in great detail by Guillermo Calvo, myself and others. Many small open economies that run relatively large and persistent current account deficits are, from time to time, subject to a sudden and very massive reduction of capital inflows. This phenomenon has been quite common in Latin America; it was widespread in Asia during the East Asian crisis in 1997–98, and more recently affected Iceland (2008). When capital inflows suddenly dry up, and countries are forced to adjust, the costs in terms of unemployment and reduced economic activity can be very significant. The key question here is how central banks should prepare themselves for the eventuality of a sudden stop episode. Indeed, incorporating this type of scenario into the analysis provides an additional rationale for an active international reserves accumulation policy on behalf of the monetary authorities. Of course, the question of the efficiency of "self-insurance" programmes is still on the table, and should be discussed and analysed in greater detail.

A second issue which was not discussed during our deliberations has to do with "current account reversals". Although this phenomenon is closely related to "sudden stops," it is not exactly the same. There is abundant evidence suggesting that there have been a number of historical episodes of sudden stops which have not been accompanied by current account reversals.[6] The explanation is that in a number of instances countries have been able to use international reserves, or official capital from the multilaterals, to cushion the effects of a sudden change in private capital flows.

The "reversals" issue is intimately connected to the question of whether there are certain thresholds for current account deficits beyond which the economic authorities should become concerned. This problem is related to what is sometimes referred to as the "Lawson Doctrine".[7] In the early 1980s, Nigel Lawson, the Chancellor of the United Kingdom's Exchequer, argued that there was no reason to be concerned about very large current account deficits, if the imbalances were the result of private sector decisions. In his view, to the extent that massive deficits – we are talking here of current account deficits in excess of 5% or 6% of GDP – were financed with private monies, there was no cause for concern. However, the empirical evidence emanating from a number of exhaustive research projects indicate that independently of the sources of financing, very large current account disequilibria are likely to be followed by very significant adjustment processes which are costly to the economy. This is particularly the case when the adjustment is accompanied by a very large devaluation – a relatively recent example of this is the Argentine peso crisis of 2001–02. In that regard, and from the perspective of the topic of this conference, a pertinent question

[4] S Edwards and R Rigobón, "Capital controls on inflows, exchange rate volatility and external vulnerability", *Journal of International Economics*, vol 78, no 2, 2009, pp 256–67.

[5] Another important topic that was absent from our discussions has to do with the "shadow" banking sector.

[6] S Edwards, "Thirty years of current account imbalances, current account reversals and sudden stops", Mundell-Fleming Lecture, *IMF Staff Papers*, 2004.

[7] O Blanchard, "Current account deficits in rich countries", *IMF Staff Papers*, vol 54, no 2, pp 191–19, 2007.

is how central bankers should react to very large external imbalances. One possibility, which was followed by the United States towards the end of the 20th century, is benign neglect. At that time, the US current account deficit moved towards 6% of GDP, a situation that led a number of economists to predict that the dollar needed to depreciate in real terms by around 15% in order for equilibrium to be re-established. And yet, the US authorities – both at the Treasury and the Federal Reserve – were rather blasé. But of course, the United States is in a unique position, having the "exorbitant privilege" of being able to "print" international reserves. A question for future gatherings of this group, then, is how central bankers in small open economies, including most Asian and Latin American nations, should face large and persistent current account imbalances.

The final topic which, in my opinion, needs to be addressed in discussions that connect monetary policy with exchange rates has to do with "fear of floating." This topic, which has been researched extensively by Guillermo Calvo and Carmen Reinhart, is of importance in many – if not most – small open economies.[8] The question is whether the economic authorities are willing to allow the currency to find its own equilibrium, independently of how large the depreciation happens to be. In the fear-of-floating literature, there are a number of reasons – currency mismatches in the banking sector, being the most important one – for the authorities, including the central bank, to be concerned about the consequences of a free-floating regime. In particular, if the corporate sector has large foreign currency-denominated debt, a major depreciation will tend to create significant financial havoc. In terms of our conference deliberations, the question is how central banks should behave in a world of currency mismatches and financial vulnerabilities. The most accepted answer is that macroprudential regulations should be put in place, in order to avoid financial distress stemming from an open capital account and a floating exchange rate. The next step in this discussion, then, is the exact nature of these macroprudential regulations. But that of course is the topic for a new conference.

[8] G Calvo and C Reinhart, "Fear of floating", *Quarterly Journal of Economics*, vol 117, no 2, 2002, pp 379-408.

Previous volumes in this series

No	Title	Issue date
BIS Papers No 95	Frontiers of macrofinancial linkages	January 2018
BIS Papers No 94	Macroprudential frameworks, implementation and relationship with other policies	December 2017
BIS Papers No 93	Building Resilience to Global Risks: Challenges for African Central Banks	August 2017
BIS Papers No 92	Long-term issues for central banks	August 2017
BIS Papers No 91	Financial systems and the real economy	March 2017
BIS Papers No 90	Foreign exchange liquidity in the Americas	March 2017
BIS Papers No 89	Inflation mechanisms, expectations and monetary policy	November 2016
BIS Papers No 88	Expanding the boundaries of monetary policy in Asia and the Pacific	October 2016
BIS Papers No 87	Challenges of low commodity prices for Africa	September 2016
BIS Papers No 86	Macroprudential policy	September 2016
BIS Papers No 85	A spare tire for capital markets: fostering corporate bond markets in Asia	June 2016
BIS Papers No 84	Towards a "new normal" in financial markets?	May 2016
BIS Papers No 83	What do new forms of finance mean for EM central banks?	November 2015
BIS Papers No 82	Cross-border financial linkages: challenges for monetary policy and financial stability	October 2015
BIS Papers No 81	Currency carry trades in Latin America	April 2015
BIS Papers No 80	Debt	January 2015
BIS Papers No 79	Re-thinking the lender of last resort	September 2014
BIS Papers No 78	The transmission of unconventional monetary policy to the emerging markets	August 2014
BIS Papers No 77	Globalisation, inflation and monetary policy in Asia and the Pacific	March 2014
BIS Papers No 76	The role of central banks in macroeconomic and financial stability	February 2014

All volumes are available on the BIS website (www.bis.org).