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Agnès Bénassy-Quéré, Yeganeh Forouheshfar

PARIS SCHOOL OF ECONOMICS
ECOLE D'ECONOMIE DE PARIS

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Agnès BENASSY-QUERE
Paris School of Economics
Université Paris 1

Yeganeh FOROUHESHFAR
University Paris-Dauphine

G-MonD

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Agnès Bénassy-Quéré[(*)] and Yeganeh Forouheshfar[(**)]

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Abstract

We study the implication of a multipolarization of the international monetary system on cross-currency volatility. More specifically, we analyze whether the internationalization of the yuan could modify the impact of asset supply and trade shocks on the euro-dollar exchange rate, within a three-country, three-currency portfolio model. Our static model shows that the internationalization of the yuan (defined as a rise in the yuan in international portfolios) would be either neutral or stabilizing for the euro-dollar rate, whatever the exchange-rate regime of China. Moving to a dynamic, stock-flow framework, we show that the internationalization of the yuan would make exchange-rate variations more efficient to stabilize net foreign asset positions after a trade shock.

Keywords: China, yuan, exchange-rate regime, euro, dollar.

JEL classification: F31, F33.

Résumé

Nous étudions les conséquences d'une multipolarisation du système monétaire international sur la volatilité des taux de change bilatéraux. Plus précisément, nous analysons comment l'internationalisation du yuan pourrait modifier l'impact des chocs d'offre d'actifs et de commerce extérieur sur le taux de change euro-dollar, dans le cadre d'un modèle de portefeuille à trois pays et trois monnaies. La version statique du modèle montre que l'internationalisation du yuan (définie comme une part plus importante de cette monnaie dans les portefeuilles internationaux) serait neutre ou stabilisante pour le taux de change euro-dollar, quelque soit le régime de change chinois. La version dynamique du modèle (ajustement stock-flux) suggère que l'internationalisation du yuan rendrait variations de change plus efficaces pour stabiliser les positions extérieures nettes après un choc commercial.

Mots-clés : Chine, yuan, régime de change, euro, dollar.

Classification JEL : F31, F33.

[(*)] Paris School of Economics, University Paris 1 and CESIfo.

[(*)] University Paris-Dauphine.

Introduction

Since World War II, the US dollar has remained the key currency of the international monetary system (IMS, hereafter). The yen never succeeded in challenging the US currency as an international means-of-payment, unit-of-account or store-of-value. As for the euro, it has emerged mostly as a diversification and as a regional currency (see ECB, 2010).

Such resilience of the dollar was benign as long as the US economy was clearly dominant in terms of GDP, trade and financial markets. Monetary pegs and reserve accumulation did not weigh much in global trade and capital flows. This is no longer the case today, and the mismatch between a unipolar IMS and a multipolar real economy has sometimes been pointed as one key ingredient of the macroeconomic environment that led to the 2007-09 financial crisis.

Against this background, China has taken significant steps towards the progressive internationalization of the yuan: it has allowed domestic exporters to invoice their cross-border sales in yuan; it has timidly opened the gate to foreign capital inflows (as a fist step, only on the off-shore market and through foreign direct investment in mainland China); it has developed bilateral swap agreements in yuan with central banks in partner countries; it has liberalized the use of deposits in yuan in Hong Kong. Although the path towards internationalization will still be long (see, e.g., Dobson and Masson, 2009; Eichengreen, 2011; Prasad, 2012; Yu, 2012), it is significant that the first steps have been carried out while the currency remained carefully managed with respect to the US dollar. According to Vallée (2011), China could go a long way in the direction of internationalization without switching to a free floating exchange-rate regime.

The implications of such developments for the IMS have generally been studied from the angle of global imbalances and the Triffin dilemma (Triffin, 1961). The debate started with Dooley et al. (2004) suggesting that the rise of China with a fixed exchange rate regime on the dollar was beneficial both to China (which could develop through exports, thanks to an undervalued currency) and to the United States (which could cheaply finance its current-account deficit through capital inflows from China). Whether this large imbalance played a role in the 2007-08 financial crisis is still debated (see Angeloni et al., 2011). As a matter of fact, the crisis triggered a renewal of the debate on the IMS. The dangers of a large mismatch between the growing role of Asia in the global economy and the persistent supremacy of the US dollar in the IMS were increasingly recognized (Bénassy-Quéré and Pisani-Ferry, 2011). In particular, Farhi et al. (2011) argued that the IMS would face a new version of the Triffin dilemma: the increasing demand for international liquidity (due to the growth of emerging economies and their appetite for reserve accumulation) would keep interest rates low for the US economy, hence encourage continuous current-account deficits in this country and, more specifically, excess government indebtedness. At some stage, international investors would lose confidence in US solvency (or equivalently, would fear massive monetization of US bonds), which would trigger a crash of the dollar. To avoid such an outcome, it would be necessary to develop alternative sources of international liquidity through the internationalization of other currencies or the development of the special drawing right (Mateos y Lago et al., 2009). However the implications of such move towards a multipolar monetary system have little been studied. On the one hand, more substitutability across key currencies would mean more frequent portfolio reallocations, hence higher exchange-rate volatility. On the other one, a given shock to a country could be adjusted

through lower exchange-rate variation, and multipolarity could act as a discipline device if investors were offered a choice between several currencies with equivalent liquidity features (Bénassy-Quéré and Pisani-Ferry, 2011).[1]

In this paper, we study the implication of a multipolarization of the IMS on cross-currency volatility. More specifically, we analyze whether the internationalization of the yuan could modify the impact of wealth and balance-of-payment shocks on the euro-dollar exchange rate. We rely on the model proposed by Blanchard, Giavazzi and Sa (2005) – a portfolio equilibrium model based on fixed portfolio allocations. Then, to the extent that domestic investors display a home bias (i.e. a preference for home-currency assets), a wealth transfer from country A to country B involves an appreciation of currency B against currency A, because the wealth transfer involves a rise in the global demand for currency A. Blanchard et al. study the implications of China pegging its currency to the dollar through foreign exchange interventions and capital controls. In this case, a wealth transfer from the United States to China (due to a bilateral trade imbalance) no longer triggers an appreciation of the yuan against the dollar because the People's Bank of China buys all the dollar released by impoverished US residents, hence the global demand for both dollar and yuan-denominated assets stays constant, and the dollar-yuan does not move. However, the global demand for euro-denominated assets falls because US residents sell euros while euro area residents do not buy them since their wealth is not directly affected by the shock: the euro depreciates against both the dollar and the yuan. Now if China switches to a free floating regime with full capital mobility, these effects are blurred: following a wealth transfer from the United States to China, the global demand for dollars falls, that for the yuan increases and that for the euro may either increase or decrease, depending on the relative preferences of the United-States and China vis-à-vis the European currency; the euro may appreciate against the dollar while depreciating against the yuan. Blanchard et al. conclude that the Chinese peg on the dollar tends to maintain the euro relatively weak against the dollar in a context of cumulated current-account deficits in the United States. However they do not consider the possibility that the Chinese currency grows international: in their setting, foreign investors are not allowed to hold Chinese assets.

Although there is considerable debate on the path of yuan internationalization (see, e.g., Dobson and Masson, 2009; Yu, 2012; Eichengreen, 2011), it is difficult to envisage a fully multipolar global economy without a considerable reshaping of the IMS in the long run (Angeloni et al., 2011). In the next decades, we consider it likely that the yuan will reap at least some international role, something like the Swiss franc or the yen today. We are interested in the implications of such move for the stability of the IMS. If European residents hold yuans in their portfolios, then a wealth transfer from the United States to China will make Europeans react to the shock. In the case where the Chinese currency floats, the Euro area investor will react to the appreciation of the yuan against the dollar by

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[1] Another strand of the literature focuses on the incentive of the hegemonic country to to assume responsibility for stabilising the system. Kindleberger (1981) argues that a hegemonic system may be more stable for this reason, whereas Eichengreen (1987) suggests that the hegemon may rather exploit its position. According to Cohen (2009), monetary power fragmentation involves economic risks (e.g. increasingly antagonistic relationships between currency blocs, possibly leading to de-globalisation) and geopolitical ones (e.g. a breakdown of fragile equilibria, such as oil and support for the US dollar in return for military protection in the Middle East).

selling yuans against dollars, which will stabilize the euro-dollar exchange rate. Hence our intuition is that, in a multipolar IMS, the Chinese currency regime may be more benign for third countries than in a dollar-centered IMS, because portfolio behaviors in third countries compensate for the distorted portfolio choices of China, following a wealth transfer.

To investigate this question, we extend Blanchard et al.'s model to allow for the internationalization of the yuan. We work on a model with three countries (US, Euro area, China) and three currencies (dollar, euro, yuan). We successively study two polar exchange-rate regimes: a fixed peg on the dollar, and a free floating exchange rate.[2] In each case, we study the impact of shocks to asset supplies and to net foreign asset positions on the euro-dollar exchange rate, depending on the international status of the Chinese currency.

We find that a simultaneous rise in the yuan's weight in US and Euro area's portfolios would make the euro-dollar exchange rate less vulnerable to bilateral imbalances between China and either the US or the Euro area. Furthermore, it would attenuate the distortions arising from China pegging its currency to the dollar, while not fundamentally modifying the reaction of the euro-dollar exchange rate to asset-supply shocks.

The remainder of the paper is organized as follows. The static model is presented in Section 2. In Section 3, it is solved under the two exchange-regimes, successively, and the impact of several shocks on the euro-dollar exchange rate is analysed. Section 4 discusses the impact of internationalizing the yuan on the results obtained in the previous section. Section 5 presents the dynamic, stock-flow model and some simulations. Section 6 concludes.

1. The model

Blanchard, Giavazzi and Sa (2005) first propose a portfolio-balance model with two countries (the United States and the Euro area) to study the impact of trade shocks and shocks to portfolio preferences on the euro-dollar exchange rate in the short run and in the long run. In their model, the residents of both areas allocate their wealth in fixed shares between domestic- and foreign-currency denominated assets. On average, they have a preference for assets denominated in their home currency (home bias). Hence, a transfer of wealth from the United States to the Euro area (deriving from US bilateral trade deficits) tends to reduce global demand for dollar-denominated assets, triggering a progressive depreciation of the dollar against the euro. In turn, a rise in the share of the dollar in investors' portfolio leads the dollar to appreciate in the short run but depreciate in the long run (in line with the fall in the net foreign asset position). In the last section of their paper, Blanchard et al. extend their model to four currencies (US dollar, euro, yen and yuan) to study the impact of US current-account and preference shocks on exchange rates, depending on China's exchange-rate regime. However they assume that only three of the four currencies are traded internationally, the yuan remaining purely national due to strict capital controls. Here we use the same framework which we limit to three countries (United States, Euro area, China) to specifically analyze the implications of the internationalization of the yuan.

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[2] We also performed an analysis under a basket peg, but the non-linearity arising in this regime did not allow us to derive clear-cut results.

The accounting framework is summarized in Table 1. Denoting by *i* the country of residence (*i*=U,E,C) and by *j* the currency of investment (*j*=$,€,¥), W^i represents the wealth of asset holders in country *i*, D^i their holdings in domestic currency and F_j^i their holdings in foreign currency *j*. Finally, the asset supply in currency *j* is denoted A_j. *All these demands and supplies are expressed in the currency of denomination, whereas wealths are expressed in the home currencies of their holders*. Using the yuan as the numeraire, $S_\$$ denotes the nominal exchange rate between the dollar and the yuan and S_ϵ the nominal exchange rate between the euro and the yuan. A rise in $S_\$$ (resp. S_ϵ) denotes and appreciation of the dollar (resp. of the euro) against the yuan.

Table 1: Accounting framework

	USD	EUR	RMB	Total (wealth)
United States (in USD)	D^U	$F_\epsilon^U S_\epsilon / S_\$$	$F_\yen^U / S_\$$	W^U
Europe (in EUR)	$S_\$/S_\epsilon F_\$^E$	D^E	$F_\yen^E / S_\epsilon$	W^E
China (in RMB)	$S_\$ F_\$^C$	$S_\epsilon F_\epsilon^C$	D^C	W^C
Total (asset supply in each currency)	$A_\$$	A_ϵ	$A_\yen$	-

Each line of Table 1 represents the budget constraint of a country, in its own currency. As for the columns, they represent the three market-clearing conditions once the demands are converted into the same currency. Specifically, the three market-clearing conditions write:

$$A_\$ = D^U + F_\$^E + F_\$^C \tag{1a}$$

$$A_\epsilon = D^E + F_\epsilon^U + F_\epsilon^C \tag{1b}$$

$$A_\yen = D^C + F_\yen^E + F_\yen^U \tag{1c}$$

We denote by f_j^i the share of currency *j* in the portfolio of country *i*'s residents, and f^i the total share of foreign currency assets in the portfolio of country *i*.[3] For instance, we have, for the United States:

$$f_\epsilon^U = \frac{S_\epsilon F_\epsilon^U / S_\$}{W^U} \qquad f_Y^U = \frac{F_\yen^U / S_\$}{W^U} \qquad \text{and} \qquad f^U = f_\epsilon^U + f_\yen^U$$

Note that, to the extent that currencies are floating, these shares are assumed exogenous: the residents of each country are assumed to keep constant the domestic currency counterpart of their foreign-currency holdings, as a share of total wealth. This means for instance that US residents will buy more euro-denominated assets whenever the euro depreciates, in order to keep the dollar-

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[3] In Blanchard et al., we have $f_\yen^U = f_\yen^E = 0$: non-Chinese investors do not hold yuan-denominated assets.

counterpart of their euro holdings constant as a share of their wealth.[4] Consistently, the three market-clearing conditions can be re-written as follows:

$$A_\$ = \left(1 - f^U\right)W^U + \frac{S_\in f_\$^E W^E}{S_\$} + \frac{f_\$^C W^C}{S_\$} \tag{2a}$$

$$A_\in = \left(1 - f^E\right)W^E + \frac{S_\$ f_\in^U W^U}{S_\in} + \frac{f_\in^C W^C}{S_\in} \tag{2b}$$

$$A_¥ = \left(1 - f^C\right)W^C + S_\$ f_¥^U W^U + S_\in f_¥^E W^E \tag{2c}$$

Due to the Walras law, having two markets in equilibrium ensures that the third one will be in equilibrium. Denoting by NFA^i the net foreign asset position of country i expressed in its own currency, we have $NFA^U = W^U - A_\$$, $NFA^E = W^E - A_\in$ and $NFA^C = W^C - A_¥ = -(S_\$ NFA^U + S_\in NFA^E)$. Equations (2a) to (2c) then re-write:

$$f^U A_\$ = \left(1 - f^U\right)NFA^U + \frac{S_\in f_\$^E W^E}{S_\$} + \frac{f_\$^C W^C}{S_\$} \tag{3a}$$

$$f^E A_\in = \left(1 - f^E\right)NFA^E + \frac{S_\$ f_\in^U W^U}{S_\in} + \frac{f_\in^C W^C}{S_\in} \tag{3b}$$

$$f^C A_¥ = -\left(1 - f^C\right)\left(S_\$ NFA^U + S_\in NFA^E\right) + S_\$ f_¥^U W^U + S_\in f_¥^E W^E \tag{3c}$$

where again the last equation is redundant due to the Walras law. As a first step, NFA^U and NFA^E are considered exogenous (we relax this assumption in Section 5). Under a flexible exchange-rate regime, Equations (3a) and (3b) jointly determine $S_\in/S_\$$ (the euro-dollar rate) and $S_\$$ (the dollar-yuan rate), for given portfolio choices. Under a fixed dollar peg in China, $S_\$$ is exogenous but the portfolio allocation of China ($f_\$^C$, $f_\in^C$) becomes endogenous. We now consider each regime, successively.

2. Resolution under each regime

2.1. A free floating regime

The most standard way of solving a portfolio-balance model is under flexible exchange rates. Consistently, we first consider all portfolio shares f as exogenous and solve Equations (2a) and (2b) for the dollar-yuan exchange rate ($S_\$$) and the euro-dollar exchange rate ($S_\in/S_\$$). We get:

$$S_\$ = \frac{\left(f^E W^E - NFA^E\right) + \varphi^C f_\$^E W^E}{\left(f^U W^U - NFA^U\right)\left(f^E W^E - NFA^E\right) - f_\$^E W^E f_\in^U W^U} f_\$^C W^C \tag{4a}$$

$$\frac{S_\in}{S_\$} = \frac{\left(f_\in^U + \varphi^C f^U\right)W^U - \varphi^C NFA^U}{\left(f^E + \varphi^C f_\$^E\right)W^E - NFA^E} \tag{4b}$$

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[4] Hence we do not account for possible bandwagon effects due to extrapolative expectations.

With $\varphi^C = f_€^C / f_\$^C$. In the following, it will be assumed that NFA^U, NFA^E <0, hence NFA^C>0, consistent with the stylized facts (see Figure 1).[5] Under this assumption, all terms under parenthesis in Equation (4a) are positive. Since f^U>$f_€^U$ and f^E>$f_\$^E$, the denominator of Equation (4a) is also positive. This means that a balanced rise in China's wealth (increase in W^C with constant NFAs) unambiguously makes the dollar appreciate relative to the yuan (except if simultaneously $f_\$^C$ falls). Strikingly, though, China's wealth has no impact on the euro-dollar exchange rate (Equation 4b): a rise in China's wealth makes both the dollar and the euro appreciate in equal proportions against the RMB, because the rise in Chinese demand for dollar and euro assets is not matched by any increase in their supply.

Figure 1: Net foreign asset positions, 1999-2007, in USD bn

Source: Lane and Milesi-Ferretti (2007, 2009 update).

However, Equation (4a) and (4b) are not reduced forms since W^C is a function of $S_\$$ and $S_€$ (remember that $W^C = A_¥ - S_\$ NFA^U - S_€ NFA^E$). The reduced form of the euro-dollar exchange rate is the following:[6]

$$\frac{S_€}{S_\$} = \frac{\left(f_€^U + \varphi^C f^U\right)A_\$ - \Phi^U NFA^U}{\left(f^E + \varphi^C f_\$^E\right)A_€ - \Phi^E NFA^E}$$

(5)

With $\Phi^U = \left(1 - f^U\right)\varphi^C - f_€^U$ and $\Phi^E = \left(1 - f^E\right) - \varphi^C f_\$^E$.

Φ^U and Φ^E represent the impact of a transfer of wealth to the United States (resp. to the Euro area) on the global demand for dollars (resp. euros). In the standard case, we assume that the home bias (captured by 1-f^i with i=U,E) is large enough so that Φ^U, Φ^E > 0. Then, given that both NFA^U and NFA^E

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[5] In Figure 1, the three NFAs do not sum to zero. To get a balanced framework, we would need to add the "rest of the world" as a fourth country, which would make the analysis much more complicated. In our framework, we will rather consider China a shortcut for large surplus emerging economies. All in all, since the internationalization of the yuan and opening up of China's financial account will be only gradual, we can consider that when our simplification applies, China's NFA will have increased considerably.

[6] Here, we concentrate on the impact of China on the euro/dollar exchange rate. Results for the dollar/yuan exchange rate are reported in Appendix A.

are negative, the numerator and the denominator of Equation (5) are both positive. Holding all NFAs constant, a rise in asset supply in dollars (resp. in euros) triggers an appreciation (resp. depreciation) of the euro against the dollar, whereas the supply of yuan-denominated assets has no impact on the euro/dollar exchange rate. In turn, a fall in the US NFA position, which means a transfer of wealth from the United States to the rest of the world, translates into a depreciation of the dollar against both the yuan and the euro. Similarly, a fall in the Euro area NFA position makes the euro depreciate against both the dollar and the yuan.

In the case of a large bias of China in favor of dollar assets, however, ϕ^C is close to zero, so that $\Phi^U < 0$. In this case, a fall in the US NFA position, holding the Euro area's NFA constant, means a rise in the global demand for dollar relative to the euro, hence an appreciation of the dollar against the euro. This is because China's NFA increases while the Chinese asset holder has a strong preference for the dollar.[7]

Table 2 depicts the sign of the various partial derivatives.

Table 2: Impact of asset supplies and NFAs on the euro/dollar exchange rate, flexible regime

x	$\partial(S_\euro/S_\$)/\partial \mathbf{x}$	x	$\partial(S_\euro/S_\$)/\partial \mathbf{x}$
$A_\$$	+	NFA^U	- if $\Phi^U > 0$
$A_\euro$	-	NFA^E	+ if $\Phi^E > 0$
$A_\yen$	0		

Source: Authors' calculations.

2.2. A peg on the dollar

We now assume that the yuan is pegged to the dollar, i.e. $S_\$$ is exogenous. The model is solved for the exchange rate of the euro against the dollar ($S_\euro/S_\$$) and for the share of the dollar in China's portfolio, $f_\$^C$. Starting again from Equations (2a) and (2b), we get:

$$\frac{S_\euro}{S_\$} = \frac{\dfrac{f^C W^C}{S_\$} - \left(f_\yen^U W^U - NFA^U\right)}{f_\yen^E W^E - NFA^E}$$ (6)

A balanced increase in China's wealth (rise in W^C with constant NFAs) now makes the euro appreciate against the dollar. The reason is given by the equation for $f_\$^C$ in Appendix A: when W^C increases, China reduces the share of the dollar in its portfolio so as to maintain its peg (otherwise the yuan would depreciate against the dollar, since the rise in W^C here is triggered by a rise in the supply of yuan-denominated assets). For a fixed share of foreign assets in the portfolio (f^C), this means raising the share of the euro.

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[7] This result is in line with Blanchard et al. (2005) ("extreme dollar preference" case).

Like in the flexible regime case, we now solve the model in terms of asset supplies and NFA positions:

$$\frac{S_\euro}{S_\$} = \frac{\dfrac{f^C A_\yen}{S_\$} + \left(1 - f_\yen^U - f^C\right)NFA^U + \left(f_\euro^U - f^U\right)A_\$}{\left(f^E - f_\$^E\right)A_\euro - \left(1 - f_\yen^E - f^C\right)NFA^E} \tag{7}$$

Due to limited internationalization of the yuan, we can assume that $f_\yen^U$ and $f_\yen^E$ are small enough so that $1 - f_\yen^U - f^C > 0$ and $1 - f_\yen^E - f^C > 0$. With $NFA^E < 0$, the denominator of the expression in Equation (7) is positive. Hence, the euro appreciates against the dollar whenever the supply of yuan-denominated assets increases (rise in $A_\yen$) or when the Chinese portfolio opens up (rise in f^C). The reason is the same as above: to maintain the peg on the dollar, Chinese authorities reduce the share of the dollar in their growing portfolio, which means that they increase the share of the euro, triggering a euro appreciation against both the dollar and the yuan.

Now, a fall in the US NFA position (holding the European NFA constant) triggers a *depreciation* of the euro against the dollar. This is because there is a wealth transfer from the United States to China, which means a fall in the global demand for dollar to the benefit of the yuan (except if f^C is very large). To avoid an appreciation of the yuan against the dollar, Chinese authorities buy more dollar-denominated assets, hence they reduce the share of the euro in their portfolio, which in turn weakens the euro against the dollar.[8] A fall in the NFA of the Euro area also leads to a depreciation of the euro through the more traditional channel (transfer of wealth from the Euro area to China, fall in the global demand for euro-denominated assets).

In a similar way, a rise in the supply of dollar-denominated assets ($A_\$$) now triggers a *depreciation* of the euro against the dollar. The reason is the increase in the US demand for yuan-denominated assets, which makes Chinese authorities increase the share of the dollar in their portfolio to oppose an appreciation of the yuan.[9]

Table 3 summarizes the impact of the various variables on the euro/dollar exchange rate.

Table 3: impact of asset supplies and NFAs on exchange rates, dollar peg

X	$\partial(S_\euro/S_\$)/\partial x$	x	$\partial(S_\euro/S_\$)/\partial x$
$A_\$$	-	NFA^U	+
$A_\euro$	-	NFA^E	+
$A_\yen$	+		

Source: Authors' calculations.

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[8] In a more sophisticated model, Mazier and Tiou-Tagba Aliti also find the dollar to appreciate vis-à-vis the euro whenever there is a negative shock on the US trade balance, if the yuan is pegged on the dollar.

[9] Note that this effect disappears if $f^U = f_\$^U$ (no internationalization of the yuan).

4. The impact of yuan internationalization on the euro-dollar exchange rate

We now study the impact of the internationalization of the yuan on the reaction of the euro/dollar exchange rate to the various variables mentioned in the previous tables. To do so we calculate how the derivatives presented in Tables 2 and 3 react to changes in the share of the yuan in US and Euro area portfolios, *holding the share the euro (resp. the dollar) in the US (resp. European) portfolios constant (hence, constant f_ϵ^U and $f_\$^E$)*. In most cases, the impact of yuan internationalization derives from the reduced forms obtained in the previous section. In a few cases, however, we have to simulate the model to get clear-cut result. We first present the calibration of the model before discussing the results obtained for the impact of yuan internationalization.

4.1. Model calibration

In four cases, we have to simulate the model to know whether yuan internationalization will increase or decrease the reaction of the euro-dollar exchange rate to shocks. To get robust results, we successively simulate the model around a symmetric and an asymmetric equilibrium.

In the symmetric equilibrium, the three countries have equal sizes: asset supplies A_j are normalized to 100. Additionally, the extent of financial openness is the same in the three countries (f^i=0.2), and symmetric across the different currencies (f^i_j=0.1). Bilateral exchange rates are normalized to unity and NFAs are all equal to zero (see Appendix B, Table B.1). This first, symmetric equilibrium allows us to highlight possible asymmetries stemming from the Chinese asymmetric exchange-rate regime (in the peg case) while eliminating any asymmetry arising from the initial equilibrium. It is however far from the real world where the United States and the Euro area display comparable sizes, but China's size is about half the US size, at current exchange rates.[10] Additionally, as illustrated in Figure 1, both the US and the Euro area's NFA positions are negative, and the former is more negative than the latter, whereas the Chinese NFA is positive. Consistently, we simulate the model around a second, asymmetric equilibrium where asset supplies are 110 in the United States, 100 in the Euro area, but only 50 in China, and the US and Euro area's NFAs are negative. To close the model, we assume asymmetric portfolio choices where the yuan represents a small share (only 2.5%) of international portfolios, whereas the dollar represents as much as 40% of the Chinese portfolio (see Appendix B, Table B.2).

These two sets of simulations are used to determine the impact of a variation in the share of the yuan in the Euro area's portfolio on the sensitivity of the euro-dollar exchange rate to some of the shocks. The results are depicted in Table 4 for both the floating and the peg regimes.

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[10] In 2011, GDP figures are USD bn 15,000, USD bn 13,100 and USD bn 7,300 for the United States, the Euro area and China, respectively (sources: World Bank and Eurostat).

4.2. The impact of yuan internationalization under a floating regime

Shocks to asset supplies

In a floating regime, the dollar depreciates against both the euro and the yuan whenever there is an increase in the supply of dollar-denominated assets ($A_\$$). Following the dollar depreciation, US investors cut their demand for foreign assets in order to keep constant shares of each type of assets (in value) in their portfolios. When the share of the yuan is higher in US portfolios, the selling of Chinese assets by US investors is greater, which makes the dollar depreciate relatively less against the yuan than against the euro. In turn, Chinese investors see the yuan appreciate less against the dollar than against the euro. Hence they buy relatively more euros. On the whole, the euro appreciates more against the dollar than in the case where the yuan plays a minor role in the US portfolio.

Conversely, when there are more yuans in the European portfolio, then an increase in the dollar supply has less impact on the euro-dollar exchange rate. In this case European investors buy more yuan assets following the euro appreciation, which puts downward pressure on the euro.

The results are symmetrical for a shock on the supply of euro-denominated assets (A_ϵ).

Finally, it can be observed from Table 4 that, whatever the share of yuan-denominated assets in US and European portfolios, the euro-dollar exchange rate is insulated to shocks on the supply of Chinese assets.

On the whole, then, a higher share of the yuan simultaneously in US and in European portfolios has benign effect on how the euro-dollar exchange rate reacts to shocks on asset supplies.

Shocks to NFAs

The results are somewhat different for shocks on NFAs. In the base case, a rise in NFA^U (holding NFA^E constant) makes the dollar appreciate against both the yuan and the euro. This is because, due to the home-bias, a transfer of wealth from China (whose NFA falls) to the United States (where it increases) raises the global demand for dollar-denominated assets. Suppose now that the share of the yuan increases in the US portfolio. Then, following the same transfer of wealth, US investors will increase by more their demand for yuan-denominated assets, which stabilizes the dollar-yuan exchange rate. If the yuan depreciates less, then Euro area's investors buy less of it, which also stabilizes the euro.

A higher share of the yuan in Euro area's portfolio also attenuates the impact of the shock on the euro-dollar exchange rate: since the euro depreciates, Euro area residents cut their demand for both dollar and yuan-denominated assets. If the yuan weighs more in their portfolio, they sell more yuan, which stabilizes the euro. Hence, the internationalization of the yuan unambiguously reduces the vulnerability of the euro-dollar exchange rate to a US NFA shock. Symmetrically, it makes the euro-dollar rate also less reactive to a Euro area NFA shock.

Summing up

It can be concluded from this sub-section that, in a free-floating regime, a simultaneous rise of the yuan's weight in both US and Euro area's portfolio would make the euro-dollar exchange rate less vulnerable to bilateral imbalances between either the US or the Euro area and China; conversely, RMB internationalization would not fundamentally change the reaction of the euro-dollar exchange rate to shocks on the supply of either dollar or euro-denominated assets, while keeping the euro-dollar rate insulated to shocks to yuan-denominated asset supply.

Table 4: impact of RMB internationalization on euro/dollar behavior

x	$\partial(S_\text{€}/S_\text{\$})/\partial \mathbf{x}$	$\partial(\partial(S_\text{€}/S_\text{\$})/\partial \mathbf{x})/\ \partial f_Y^U$	$\partial(\partial(S_\text{€}/S_\text{\$})/\partial \mathbf{x})/\ \partial f_Y^E$
Float			
$A_\text{\$}$	+	+	-
$A_\text{€}$	-	-	+[a]
A_Y	0	0	0
NFA^U	-	+	+
NFA^E	+	-	-[a]
Peg on USD			
$A_\text{\$}$	-	-	+
$A_\text{€}$	-	+	+[a]
A_Y	+	0	-
NFA^U	+	-	-
NFA^E	+	-	-[a]

Reading: in the model, a rise in the supply of USD-denominated assets (rise in $A_\text{\$}$) makes the euro appreciate against the USD (rise in $S_\text{€}/S_\text{\$}$, first column). This effect is magnified if the US residents hold more yuan-denominated assets in their portfolios (higher f_Y^U, second column) but attenuated if Euro area residents hold more yuan-denominated assets in their portfolios (higher f_Y^E, third column).

Notes: we assume $NFA^U<0$, $NFA^E<0$, $1 - f_Y^U - f^C > 0$ and $1 - f_Y^E - f^C > 0$. [a] Obtained by simulation of the linearized model around two alternative initial points – see Appendix B.

Source: Authors' calculations.

4.2 Yuan pegged on the dollar

Shocks to asset supplies

We know from Section 3 that when the yuan is pegged on the dollar, a rise in the supply of dollar-denominated assets ($A_\text{\$}$) leads the dollar to appreciate rather than depreciate against the euro. The reason is that Chinese authorities buy dollars to prevent the yuan from appreciating against the dollar. This counter-intuitive effect is magnified when there is more yuan in US portfolios,[11] because the rise in US wealth puts more pressure on the yuan (US investors want more Chinese assets), hence Chinese authorities buy more dollars to keep the bilateral exchange rate stable. Conversely, if there is more yuan in the European portfolio, then the counter-intuitive effect of $A_\text{\$}$ on the euro-dollar exchange rate is attenuated. In this case, the depreciation of the euro makes Euro area residents cut relatively more their demand for yuan-denominated assets, which alleviates the pressure on the

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[11] Here we limit ourselves to the case that the f_Y^U and f_Y^E stay small enough so that $1 - f_Y^U - f^C >0$ and $1 - f_Y^E - f^C >0$.

yuan and reduces the needs for Chinese authorities to buy dollars. On the whole, the simultaneous rise in yuan-denominated assets in US and Euro area portfolios has an ambiguous and probably limited effect on the reaction of the euro-dollar rate to shocks on the supply of dollar-denominated assets.

As for shocks on the supply of euro-denominated assets ($A_{€}$), they have the usual impact on the euro-dollar exchange rate: a rise in $A_{€}$ leads to a depreciation of the euro. The internationalization of the yuan in either US or Euro area's portfolios tends to mitigate this impact: both types of investors cut by a larger amount their demand for yuan-denominated assets, which reduces the necessity for the PBoC to buy more dollars.

Finally, we note here that more yuan in Euro area's portfolio tends to attenuate the asymmetric impact of the supply of yuan-denominated assets on the euro-dollar exchange rate: when A_{Y} rises, Chinese authorities sell dollar-denominated assets to prevent the yuan from depreciating against the USD. In doing so, they put downward pressure on the dollar against the euro. Hence the euro appreciates equally against the yuan and against the dollar. The European investor reacts by buying more foreign assets. If the weight of the yuan in the European portfolio is higher, there is relatively more demand for Chinese assets, which reduces the downward pressure on the yuan, hence also reduces the sale of dollars by China's central bank: the dollar depreciates less against the euro. Conversely, more yuan-denominated assets in US portfolios does not affect the asymmetric effect of a rise in A_{Y}. This is because any additional purchase of these assets by US investors (following a dollar appreciation) is matched by an additional sale by Chinese authorities.

On the whole, it can be concluded that a simultaneous rise in the share of yuan-denominated assets in US and European portfolios has either a neutral or a mitigating impact on the impact of asset-supply shocks on the euro-dollar exchange rate.

Shocks to NFAs

Table 4 shows that the counter-intuitive effect of a shock on NFA^{U} (a rise in US NFA triggers a dollar depreciation against the euro) is unambiguously attenuated by the internationalization of the yuan, be it in US or European portfolios. This is because the PBoC buys less dollars (to avoid a depreciation of the yuan) since both US and Euro area investors tend to buy more yuan in reaction to the increase in their wealth (US investors) or to the appreciation of their currency (Euro area's investors).

Summing up

One striking feature of the internationalization of the yuan is the attenuation of the counter-intuitive effects of US shocks on the euro-dollar exchange rate stemming from the asymmetric exchange-rate regime of China. Combining these results with those obtained under a free floating regime, it can be concluded that the internationalization of the yuan is able to (i) attenuate the reaction of the euro-dollar exchange rate following bilateral, external shocks between the US (or Euro area) and China; (ii) attenuate the distortions generated by a fixed yuan-dollar peg; and (ii) be relatively neutral vis-à-vis shocks to asset supplies. It can then be concluded that yuan internationalization would help stabilize the euro-dollar rate, whatever the exchange-rate regime of China.

3. A dynamic model

So far, we have considered net foreign asset positions (NFAs) as exogenous. Still, exchange-rate variations are deemed to impact on NFAs through trade imbalance accumulation. In this section, we consider NFA accumulation with endogenous trade balance. Like Blanchard et al. (2005), we successively describe portfolio balance, NFA accumulation and trade balances.

5.1. The portfolio balance

Indexing by t NFAs and exchange rates at the end of period t, the dollar and euro market equilibria write (see Equations (2a) and (2b) where wealths are expressed as their functions of asset supplies and NFAs)[12]:

$$A_\$ = \left(1 - f^U\right)\left(A_\$ + NFA_t^U\right) + \frac{S_{\in t} f_\$^E \left(A_\in + NFA_t^E\right)}{S_{\$,t}} + f_\$^C \left(\frac{A_Y}{S_{\$,t}} - NFA_t^U - \frac{S_{\in t}}{S_{\$,t}} NFA_t^E\right) \qquad (8a)$$

$$A_\in = \left(1 - f^E\right)\left(A_\in + NFA_t^U\right) + \frac{S_{\$,t} f_\in^U \left(A_\$ + NFA_t^U\right)}{S_{\in t}} + f_\in^C \left(\frac{A_Y}{S_{\in t}} - NFA_t^E - \frac{S_{\$,t}}{S_{\in t}} NFA_t^U\right) \qquad (8b)$$

As usual, the equilibrium of the yuan market is ensured by the Walras law.

5.2. NFA accumulation

To see how NFAs accumulate over time, it is useful to start from the following expressions:

$$NFA_t^U = f^U W_t^U - \frac{S_{\in t} f_\$^E W_t^E}{S_{\$,t}} - \frac{f_\$^C W_t^C}{S_{\$,t}} \qquad (9a)$$

$$NFA_t^E = f^E W_t^E - \frac{S_{\$,t} f^U W_t^U}{S_{\$,t}} - \frac{f^C W_t^C}{S_{\$,t}} \qquad (9b)$$

NFA accumulation then depends on valuation effects (due to exchange-rate variations), on interest rates (r^i, i=U,E,C) and on the trade balance of each country (TB^i, i=U,E). For the United States, we have:

$$NFA_t^U = f_\in^U W_{t-1}^U (1 + r^E) \frac{S_{\in t} / S_{\$,t}}{S_{\in t-1} / S_{\$,t-1}} + f_Y^U W_{t-1}^U (1 + r^C) \frac{S_{\$,t-1}}{S_{\$,t}} - \frac{f_\$^C}{S_{\$,t-1}} W_{t-1}^C (1 + r^U)$$
$$- f_\$^E W_{t-1}^E (1 + r^U) \frac{S_{\in,t-1}}{S_{\$,t-1}} + TB_t^U \qquad (10)$$

By using Equation (9a) at time t-1, we can simplify the accumulation of the US NFA as:

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[12] Asset supplies are kept exogenous and independent of time.

$$NFA_t^U = W_{t-1}^U \left[f_{\text{€}}^U \left(\frac{S_{\text{€}t} / S_{\$,t}}{S_{\text{€}t-1} / S_{\$,t-1}} (1+r^E) - (1+r^U) \right) + f_Y^U \left(\frac{S_{\$,t-1}}{S_{\$,t}} (1+r^C) - (1+r^U) \right) \right]$$
$$+ (1+r^U) NFA_{t-1}^U + TB_t^U \quad (11a)$$

Similarly, for the Euro area:

$$NFA_t^E = W_{t-1}^E \left[f_{\$}^E \left((1+r^U) \frac{S_{\text{€}t} / S_{\$,t}}{S_{\text{€}t-1} / S_{\$,t-1}} - (1+r^E) \right) + f_Y^E \left((1+r^C) \frac{S_{\text{€}t-1}}{S_{\text{€}t}} - (1+r^E) \right) \right]$$
$$+ (1+r^E) NFA_{t-1}^E + TB_t^E \quad (11b)$$

5.3. Trade balance

Finally, we assume that the trade balance of each country depends on its bilateral exchange rate vis-à-vis each partner (price competitiveness effect) and on the comparative wealth of each partner (income effect[13]). Assuming price and income elasticities are homogenous across the three countries, and starting from a symmetric and balanced equilibrium, we have:

$$TB_t^U = \theta \left(\frac{S_{\text{€}t}}{S_{\$,t}} - S_{\$,t} \right) + \gamma \left[-W_t^U + \frac{1}{2} \left(\frac{W_t^C}{S_{\$,t}} + \frac{S_{\text{€}t}}{S_{\$,t}} W_t^E \right) \right] + z^U \quad (12a)$$

$$TB_t^E = \theta \left(\frac{S_{\$,t}}{S_{\text{€}t}} - S_{\text{€}t} \right) + \gamma \left[-W_t^E + \frac{1}{2} \left(\frac{W_t^C}{S_{\text{€}t}} + \frac{S_{\$,t}}{S_{\text{€}t}} W_t^U \right) \right] + z^E \quad (12b)$$

Where $\theta, \gamma > 0$, and z^U, z^E represent exogenous shocks to the trade balances. Replacing wealths by their functions of (exogenous) asset supplies and (endogenous) NFAs, we get:

$$TB_t^U = \theta \left(\frac{S_{\text{€}t}}{S_{\$,t}} - S_{\$,t} \right) + \gamma \left(-A_{\$} + \frac{A_Y}{2S_{\$,t}} + \frac{S_{\text{€}t} A_{\text{€}}}{2S_{\$,t}} - \frac{3}{2} NFA_t^U \right) + z^U \quad (13a)$$

$$TB_t^E = \theta \left(\frac{S_{\$,t}}{S_{\text{€}t}} - S_{\text{€}t} \right) + \gamma \left(-A_{\text{€}} + \frac{A_Y}{2S_{\text{€}t}} + \frac{S_{\$,t} A_{\$}}{2S_{\text{€}t}} - \frac{3}{2} NFA_t^E \right) + z^E \quad (13b)$$

5.4. Model simulation

Equations (9a,b) (portfolio balance), (11a,b) (NFA accumulation) and (13a,b) (trade balance) jointly determine our six endogenous variables under a floating regime: NFA_t^U, NFA_t^E, $S_{\$t}$, $S_{\text{€}t}$, TB_t^U, TB_t^E. In the pegged regime, $S_{\$}$ is exogenous but $f_{\$}^C$ becomes endogenous. To further simplify the model, we assume all interest rates to be equal ($r^U=r^E=r^C=r=0.02$). We then linearize the model around the symmetric and asymmetric equilibria described in Appendix B (Tables B.1 and B.2), successively, with

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[13] Strictly speaking this is not an income effect since it depends on wealth rather than income. However, since interest rates are assumed exogenous in our framework, there is no difference between income and wealth effect. Note that Blanchard et al. (2005) only consider the exchange-rate effect.

θ=1 and γ=0.1. This allows us to study the impact of a permanent, asymmetric trade shock: a negative shock on the US trade balance (z^U= -2) and a positive, albeit smaller shock on the Euro area's trade balance (z^E=+1).[14] This means a positive shock of +1 on China's trade balance. Hence the shock is symmetric between the Euro area and China but asymmetric between these two and the United States. Here we present the results of the simulations around the symmetric equilibrium. Those obtained around the asymmetric equilibrium are qualitatively similar (see the graphs in Appendix B).

a. *Floating regime*

The results under a floating exchange-rate regime are depicted in Figure 2. As expected, the dollar progressively depreciates against both the yuan and the euro (the euro stays stable against the yuan). The decline of the US' NFA, combined with a weaker dollar, progressively pushes the trade balance back to balance, and the NFA stabilizes. In the Euro area, the NFA rises but the appreciation of the euro against the dollar, combined with the income effect, pushes the trade account back to balance, so the NFA stabilizes.

Figure 2: impact of the trade shock, floating regime
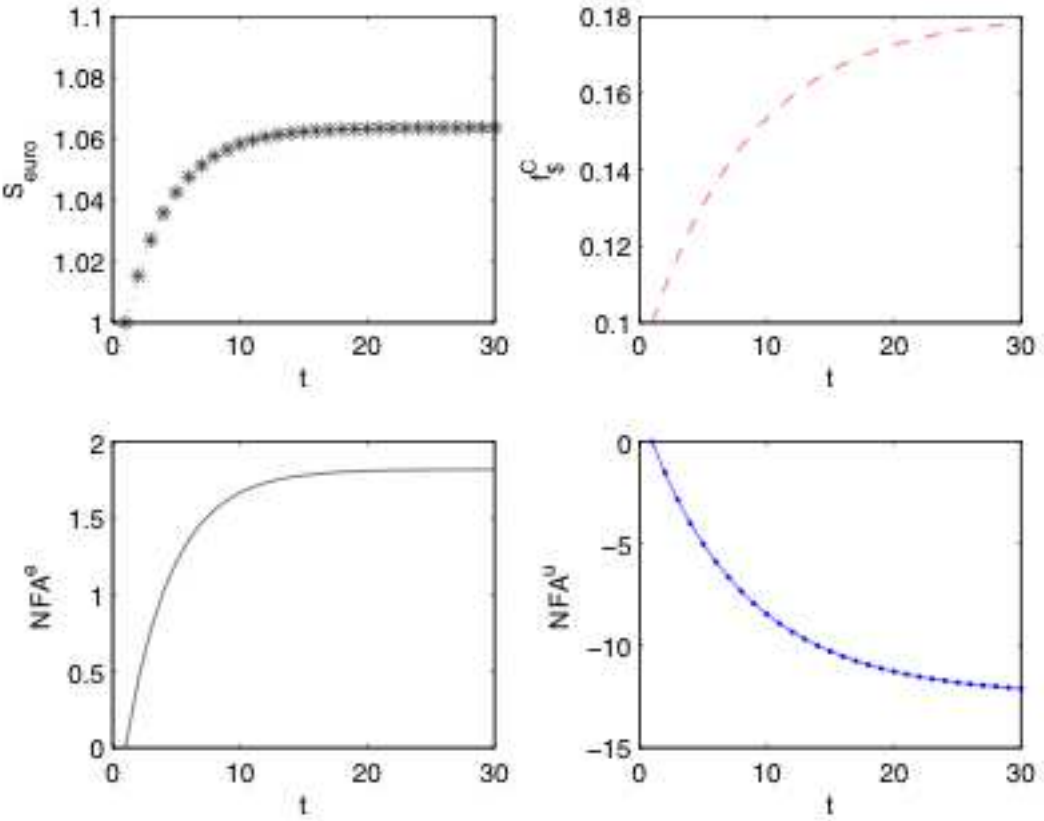**(Deviations from initial, symmetric equilibrium)**
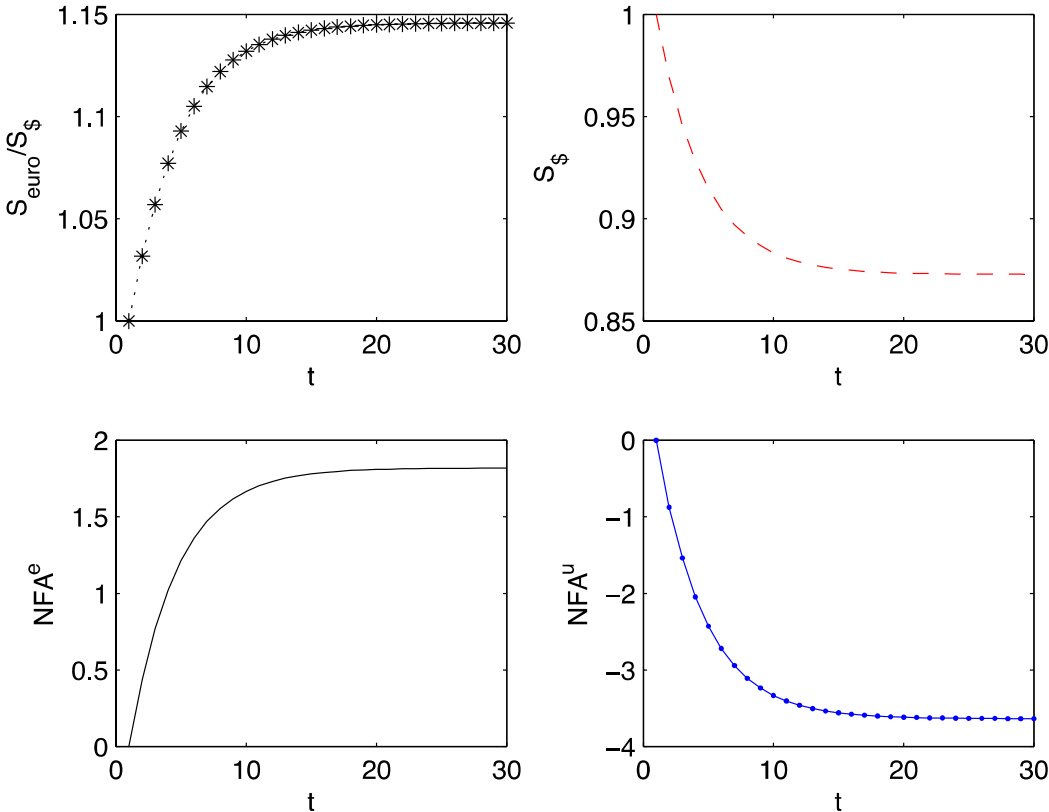
Notes: Seuro=exchange rate of the euro against the yuan; S$=exchange rate of the dollar against the yuan; NFAe=NFA of the euro area: NFAu=NFA of the United States.
Source: Author's calculations.

b. *Yuan pegged to the dollar*

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[14] These shocks represent -2 and +1 percent of US and Euro area's wealth, respectively.

The results for a pegged regime are reported in Figure 3. In this case, the euro appreciates against the yuan despite the fact that the shock is symmetric between the Euro area and China. What happens is that the share of dollar-denominated assets increases in China's (official) portfolio in order to oppose any depreciation of the dollar against the yuan. Then, the euro can no longer appreciate against the dollar without appreciating against the yuan. In this regime, the US NFA falls much more than in the floating regime because the dollar only depreciates against the euro.

Figure 3: impact of the trade shock, pegged regime
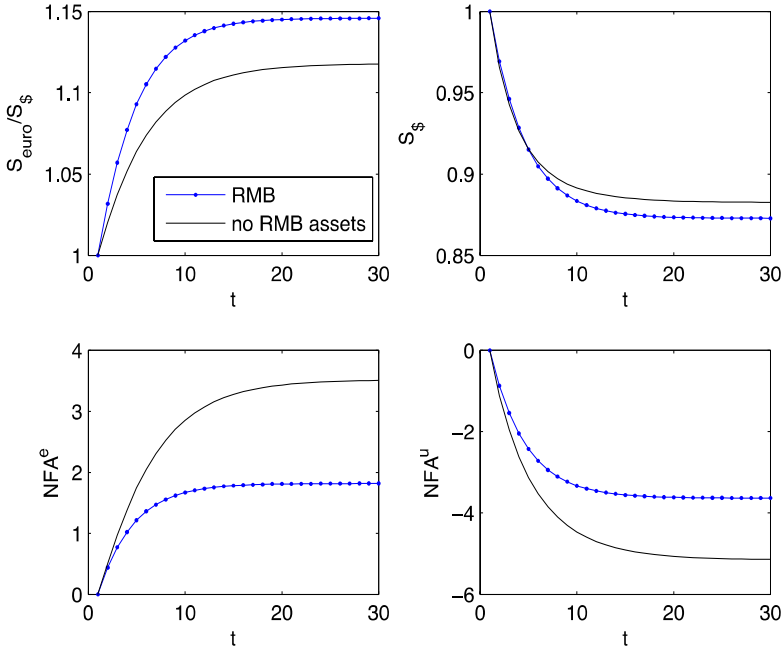**(Deviations from initial, symmetric equilibrium)**

Notes: Seuro=exchange rate of the euro against the yuan; fc$=share of the dollar in China's portfolio; NFAe=NFA of the euro area: NFAu=NFA of the United States.
Source: Author's calculations.

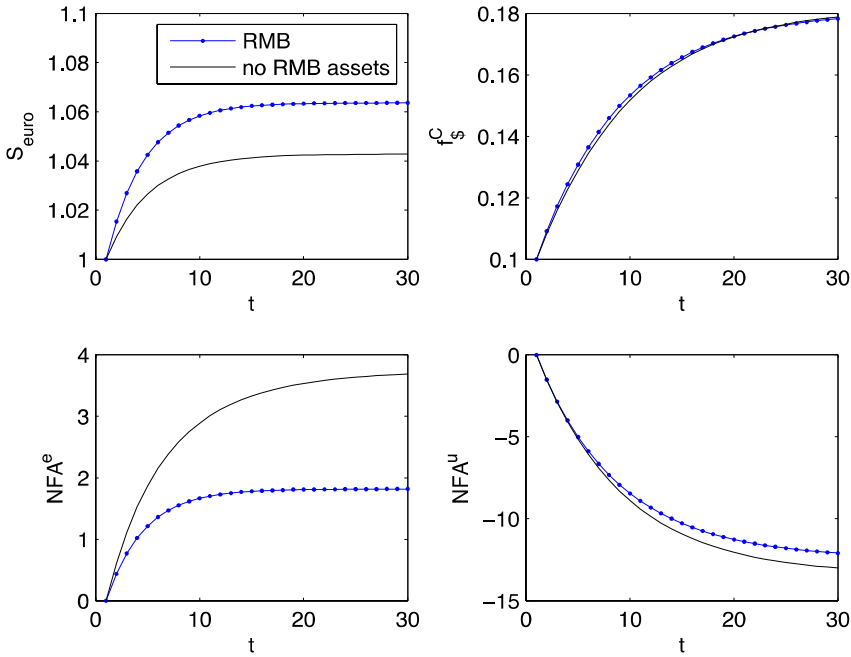*c. Internationalization of the yuan*

To study the impact of the internationalization of the yuan on the dynamics of the model, we simulate the same shock as above under a floating and a pegged regime, successively, while setting the share of the yuan in both Euro area and US portfolio at zero (scenarios with no internationalization of the yuan, see Appendix B, Table B.3). The results are reported on Figures 4 and 5. In both regimes, the internationalization of the yuan magnifies the impact of the trade shock on the euro-dollar exchange rate, but it reduces considerabily the impact of the shock on Euro area's net foreign asset positions. Hence the exchange rate plays better its role as a stabilizing device when the yuan is internationalized. The reason for this is the fact that, when the yuan is internationalized, its depreciation against the euro impacts negatively on the Euro area's NFA position, which compensates for the positive trade shock. The US NFA is also stabilized by the internationalization of

the yuan, but only in the floating regime (where the dollar depreciates against the yuan, with positive valuation effects on the US NFA).

Figure 4: Impact of the trade balance shock, floating regime
(Deviations from symmetric equilibrium)

Figure 5: Impact of the trade balance shock, pegged regime
(Deviations from symmetric equilibrium)

4. Conclusion

Based on a three-country, three-currency portfolio model, we have studied the impact of an internationalization of the yuan on the sensitivity of the euro-dollar exchange rate to various shocks, in two different exchange-rate regimes. We have shown that the counter-intuitive effects arising due to a fixed exchange rate in China (e.g. a transfer of wealth from China to the United States makes the dollar depreciate against the euro) are more limited when the yuan internationalizes, and that yuan internationalization also stabilizes the euro-dollar exchange rate in a floating regime. The dynamic version of the model further shows that yuan internationalization helps euro-dollar variations to stabilize net foreign asset positions following a trade shock, through enhanced valuation effects.

We believe these results to be encouraging for a multipolar international monetary system: even if it does not come immediately with a free floating regime, the internationalization of the yuan yields some stabilizing properties.

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Appendix A

Analytical resolution of the static model

A.1. Flexible regime

Resolution for the dollar-yuan exchange rate:

$$S_\$ = \frac{\left(f_\$^C f^E + f^C f_\$^E\right)A + \left(f_\$^E f^C - f_\$^C\left(1-f^E\right)\right)NFA^E}{\left(f^U f^E - f_\$^E f^U\right)A_\$ A - \Gamma^U A_\$ NFA^E - \Gamma^E A\, NFA^U + \Gamma NFA^U NFA^E} A_Y$$

With $\Gamma^U = f^U\left(1 - f^E - f_\epsilon^C\right) + f_\epsilon^U\left(f_\$^E - f_\$^C\right)$

   $\Gamma^E = f^E\left(1 - f^U - f_\$^C\right) + f_\$^E\left(f_\epsilon^U - f_\epsilon^C\right)$

   $\Gamma = \left(1 - f^U - f_\$^C\right)\left(1 - f^E - f_\epsilon^C\right) - \left(f_\epsilon^U - f_\epsilon^C\right)\left(f_\$^E - f_\$^C\right)$

In normal circumstances, the Γs are positive, so the denominator of the expression for $S_\$$ is also positive (given the negative signs of NFA^U and NFA^E). However, if China's portfolio choices differ greatly from those of the US or the Euro area, the Γs can turn negative.

A.2. Fixed peg of the yuan against the dollar

Resolution for the share of the dollar in China's portfolio:

$$f_\$^C = \frac{S_\$}{W^C}\left(\left(A_\$ - (1-f_Y^U)W^U\right) + f_\epsilon^U W^U + f_\$^E W^E \frac{A_\$ - (1-f_Y^U)W^U}{A_\epsilon - (1-f_Y^E)W^E}\right) - \frac{f_\$^E W^E f^C}{A_\epsilon - (1-f_Y^E)W^E}$$

Replacing W^C by its function of NFA^U and NFA^E, we get:

$$f_\$^C = \frac{\left(f^E f^U - f_\$^E f^U\right)A_\$ A_\epsilon - \Psi_1 A_\$ NFA^E - f^C f_\$^E \dfrac{A_Y}{S_\$}NFA^E + \Psi_2 NFA^U NFA^E - f^E\left(1-f^U\right)A_\epsilon NFA^U - f^C f_\$^E A_\epsilon \dfrac{A_Y}{S_\$} + f_\$^E(f^U - f^C)A_\epsilon NFA^U}{\dfrac{f_Y^E A_Y A_\epsilon - f_Y^E A_Y NFA^E}{S_\$} - f_Y^E A_\epsilon NFA^U\left(1 + NFA^E\right) + f_Y^U A_\$ NFA^E}$$

with $\Psi_1 = f^U\left(1 - f^E - f^C\right) + f_\$^E f^U$ and $\Psi_2 = \left(1 - f^U\right)\left(1 - f^E - f^C\right) + f_\$^E\left(f^C - f^U\right)$

Appendix B

Linearization and simulation around a symmetric equilibrium

Table B.1: Symmetric equilibrium

	United States	**Euro area**	**China**
Exogenous variables			
A_j	100	100	100
f^i	0.2	0.2	0.2
f^i_j	$f^U_\epsilon = f^U_Y = 0.1$	$f^E_\$ = f^E_Y = 0.1$	$f^C_\$ = f^C_\epsilon = 0.1$
Endogenous variables: baseline values			
NFA^i	0	0	-
S_j	1	1	-

Source: Authors.

Table B.2: Asymmetric equilibrium

	United States	**Euro area**	**China**
Exogenous variables			
A_j	110	100	50
f^i	0.2	0.2	0.5
f^i_j	$f^U_\epsilon = 0.175$, $f^U_Y = 0.025$	$f^E_\$ = 0.175$, $f^E_Y = 0.025$	$f^C_\$ = 0.4$, $f^C_\epsilon = 0.1$
Endogenous variables: baseline values			
NFA^i	-24.6307	-7.614	-
S_j	1.2756	1.0738	-

Table B.3: Symmetric equilibrium with no internationalization of the yuan

	United States	**Euro area**	**China**
Exogenous variables			
A_j	100	100	100
f^i	0.2	0.2	0.2
f^i_j	$f^U_\epsilon = 0.2$, $f^U_Y = 0$	$f^E_\$ = 0.2$, $f^E_Y = 0$	$f^C_\$ = f^C_\epsilon = 0.1$
Endogenous variables: baseline values			
NFA^i	0	0	-
S_j	1	1	-

Figure B.1: Impact of the trade balance shock, floating regime (Deviations from initial, asymmetric equilibrium – Table B.2)
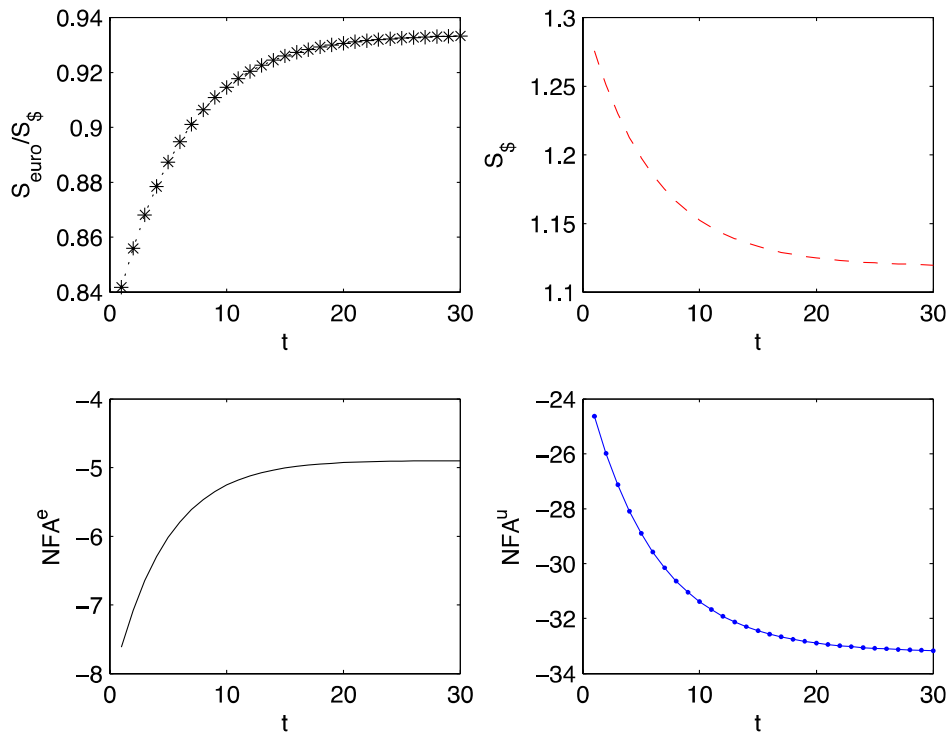
Figure B.2: Impact of the trade balance shock, pegged regime (Deviations from initial, asymmetric equilibrium – Table B.2)