Key Currency Status: an Exorbitant Privilege and an Extraordinary Risk*

by

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ABSTRACT

What are the costs and benefits of the dollar's status as the key currency in the international monetary system? Here, we present a calibrated two country model in which all exports are invoiced in the key currency, and government bonds denominated in the key currency are held internationally to facilitate trade, and as official reserve assets. We show that the "exorbitant privilege" accruing to the key currency country comes from three sources: (1) a bond seigniorage that we estimate to be worth about a half a percent of consumption per period to the United States, (2) asymmetric responses to exogenous shocks that are worth an additional quarter of a percent of consumption per period, and (3) a macroeconomic hegemony in monetary and fiscal policy, reflecting the fact that the key currency's policy instruments are more potent. But, there is also an exorbitant risk to being the key currency country. We show that the costs of a potential dumping of key currency bonds are also substantial. Moreover, there appear to be no obvious monetary or fiscal policy responses that would lower the costs significantly.

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1. Introduction

The costs and benefits of the dollar's status as a key currency were hotly debated in the 1950's and 60's, both in academia and in political circles. Valery Giscard d'Estaing, while still a French finance minister, asserted that the U.S. enjoyed an "exorbitant privilege" because of the dollar's role in the international monetary system.[1] The U.S. could finance a current account deficit by issuing dollar assets at very low rates of interest. Why? Central banks held dollar assets as official reserves, and since a large fraction of international trade was invoiced in dollars, importers and exporters held dollar assets to facilitate trade.

The dollar continues to play a dominant role in the international monetary system.[2] And the dollar figures prominently in current policy discussions: the U.S. has financed most of its recent current account deficits by issuing dollar denominated debt, foreign official holdings of U.S. treasuries have grown dramatically since 2002, and there is speculation in the press about what might happen if foreign dollar holders decided to diversify into other assets.

The United States does indeed enjoy the exorbitant privilege that Giscard d'Estaing had in mind. By our model based calculations, the desire of foreigners to hold liquid, but low interest, dollar assets is worth more than half a percent of U.S. consumption each year; this estimate is in line with a literature that tries to measure this traditional source of exorbitant

[1] This phrase is sometimes attributed to Charles de Gaulle, but it is evidently due to Giscard d'Estaing, in 1965. See Gourinchas and Rey (2007), footnote 4, for an account. We will discuss the academic debate is some detail later on.

[2] Goldberg and Tille (2008; Table 1) report that large shares of various countries' imports and exports are invoiced in dollars. Lane and Milesi-Ferretti have a series of papers documenting the proclivity of foreigners to hold dollar assets; see for example Lane and Milesi-Ferretti (2007).

privilege empirically.[3] But, we will argue in what follows that the key currency country enjoys two additional types of exorbitant privilege; and to the best of our knowledge, these privileges have not been acknowledged in the literature. We will also argue that the key currency provider bears an exorbitant risk: a sudden sell off of its assets would have economic consequences that would be hard to address using obvious monetary and fiscal policies.

To do this, we develop a two country DSGE model (with Calvo price setting) in which the Home country supplies the key currency to the Foreign country. We show that the model exhibits significant asymmetries in its responses to exogenous shocks. Using the model we show that these asymmetric responses have welfare implications that result in a second source of privilege. We calculate the value of this second privilege to be smaller than the first, but still worth noting. In addition, we find that policymakers in the Home country wield macroeconomic policy hegemony: monetary and fiscal policy shocks coming from the Home country have a larger effect, both at home and abroad, than equivalent shocks emanating from the Foreign country. Calculating the value of this macroeconomic hegemony would require modeling a non-cooperative game between the Home and Foreign countries; this is well beyond the scope of the present paper.

We will also argue that the Home country faces an extraordinary risk. We will use our model to simulate a sudden dumping of key currency bonds by the Foreign central bank. We calibrate the model's sell off to match the accumulation of foreign official holdings of U.S. treasuries between 2007:4 and 2009:4, the first two years of the financial meltdown; of course,

[3] We will cite some of these empirical papers below, in our acknowledgement of previous work on key (or vehicle) currencies. Our model based estimate is not meant to contribute to the empirical literature. But, it is meant to show that our modeling is consistent with that literature.

the accumulation has continued.[4] We find that the costs to the key currency country are substantial, and we cannot find alternative monetary or fiscal policies the key currency country might implement that would reduce the costs significantly. The alternative policies we consider are: a treasury buy-back of the bonds, a central bank buy-back of the bonds, and a central bank attempt to preserve the value of the key currency.

The two countries in our model are symmetric except for two key currency assumptions: (1) exports from both countries are priced in terms of the key currency, and (2) key currency bonds are held by households in both countries to facilitate international trade, and by the Foreign central bank as official reserves. Government bonds (issued by either country) pay a low rate of interest in our model, since they yield a non-pecuniary return. The way we model the traditional notion of the "exorbitant privilege" is through asymmetric portfolios: foreign holders of key currency bonds pay a bond seigniorage to the Home treasury.[5]

The recent academic literature has shied away from key currency issues. One reason for this is that currently popular models almost invariably assume that bonds denominated in different currencies are perfect substitutes. By contrast, the two countries' bonds each provide liquidity services and are imperfect substitutes in our model. And because the marginal liquidity values of bonds depends on bond supplies, our model has much in common with portfolio balance models such as Kouri (1976), Branson and Henderson (1985), and more recently

[4] In the three subsequent years, foreign official holdings increased by a further 39%.

[5] If we modeled Foreign demand for Home currency as well as Home bonds, our estimate of the seigniorage paid by Foreign residents would be greater. One reason we do not pursue this is the lack of a reliable estimate of foreign holdings of U.S. currency.

Blanchard Giavazzi, and Sa (2005).[6]

In our model, the non-pecuniary (liquidity) services provided by government debt allow governments to borrow at low interest rates. The lower interest rate on government debt has important macroeconomic implications, especially for the effects of fiscal policy. Households discount future tax liabilities at the intertemporal marginal rate of substitution (which we refer to as the CCAPM rate) while government debt accrues interest at a lower rate that reflects its marginal liquidity value. The wealth effects that arise from this departure from Ricardian equivalence make fiscal policy powerful in our model. And these wealth effects, when combined with our key currency assumptions result in significant asymmetries in an otherwise symmetric model. Moreover, since Home and Foreign government bonds will generally have different marginal liquidity values, they are imperfect substitutes and our model generates short-run deviations from uncovered interest parity (UIP).

Our basic assumption that government bonds provide liquidity services should not be controversial. U.S. Treasuries facilitate transactions in a number of ways: they serve as collateral in many financial markets, banks hold them to manage the liquidity of their portfolios, individuals hold them in money market accounts that offer checking services and importers and exporters hold them as transaction balances.

We are of course not the first to study the transactions services of bonds. Early contributions to the literature include: Patinkin (1965), who put both money and bonds in the

[6] Models with portfolio balance effects seem more appropriate for addressing a number of issues in international finance. For example, discussions of currency crises often focus on the adequacy of the central bank's foreign reserves. But, if home and foreign bonds are perfect substitutes, there is really no need to hold foreign reserves. The central bank can simply sell home bonds.

household utility function; and Friedman (1969), who discussed the optimum quantity of money and (private) bonds. More recent theoretical contributions include: Bansal and Coleman (1996), who used the approach to study the equity premium puzzle and related issues; Holmstrom and Tirole (1998), who argued that the private sector cannot satisfy its own liquidity needs when there is aggregate uncertainty; Calvo and Vegh (1995), who studied the policy implications of liquid bonds; and Linnemann and Schabert (2010), who used a model similar to ours to study macroeconomic policy.

Empirical contributions to the this literature include: Friedman and Kuttner (1998), who studied the imperfect substitutability of commercial paper and U.S. Treasuries; Greenwood and Vayanos (2008), who find that the supply of long-term relative to short-term bonds is positively related to – and predicts – the term spread. Krishnamurthy and Vissing-Jorgensen (2008), who find that the spread between liquid treasury securities and less liquid AAA debt moves systematically with the quantity of government debt; and Pflueger and Viceira (2011), who document a liquidity premium in the spread between inflation-indexed and nominal government bonds.

And of course, there is a vast literature on key (or vehicle) currencies. This literature goes back at least fifty years. We do not have the space here to survey that literature, but we will mention a few papers that illustrate the ongoing interest in the topic. Aliber (1964) and Salant (1964) discussed the costs and benefits of being the key currency country; we will discuss their arguments later in Section V. Chrystal (1977) provided an early modeling of the demand for an international currency. Krugman (1980) provided an early modeling of the emergence of a vehicle currency. Canzoneri and Gray (1985) provided an early modeling of how vehicle

currency pricing creates an asymmetry in the effects of monetary policy. Black (1991) explored the interaction between transactions costs and vehicle currencies. Matsuyama et al (1993) provided a model of international currency competition.

More recently, Rey (2001) links trade patterns with financial exchange structures. Caballero, Farhi and Gourinchas (2008) present a model in which regions differ in their ability to generate financial assets; they use it to discuss the emergence of large U.S. current account deficits and low interest rates. Kannan (2009) discusses the welfare gains of the emergence of the Euro. Gourinchas, Rey and Govillot (2010) document a sizeable excess return of U.S. assets over liabilities, for which they argue the U.S. provides a safe asset in times of stress. Forbes (2010) finds that foreigners hold greater shares of U.S. assets in their portfolios when they have less developed financial markets at home. Kitchen and Chinn (2011) investigate the relationship between U.S. structural deficits and the rate of return on Treasuries; they question the ability of the U.S. to keep on financing its current account at these low rates. Maggiori (2011) estimates a time varying safe haven premium for U.S. Treasuries; the premium is particularly high during periods of stress. Eichengreen (2012) discusses the role of the dollar in light of the recent difficulties in the U.S. and the emergence of currencies such as the Euro and the Renminbi. There are many estimates of returns differentials, and there are issues in their measurement; see Curcuru, Dvorak, and Warnock (2013). Finally, Devereux and Shi (2013) model the emergence of vehicle currencies using a "trading post" framework. We wish to emphasize that this list of papers is far from exhaustive.

The rest of the paper proceeds as follows: In Section II, we outline our model and discuss its calibration. In Section III, we study the implications of our key currency assumptions,

using impulse response functions to illustrate the asymmetric effects of changes in various asset supplies; we also show which of these assumptions are most important for our results. In Section IV, we analyze the hegemony of the key currency country in macroeconomic policy making. In Section V, we discuss the cost and benefits of being the key currency country. And in Section VI, we conclude with a discussion of the implications of our results for future work. An appendix discusses the calibration of our model.

II. A Two Country Model with a Key Currency

Our model consists of a Home country and a Foreign country; here we obviously have in mind the United States and the rest of the world. Bonds are imperfect substitutes for money in each country,[7] and this fact alone would make Home and Foreign bonds imperfect substitutes. But, there is more: the Home country provides the key currency. All trade is priced in units of the key currency. So, Foreign households use Home bonds to facilitate trade, and the Foreign government holds Home bonds as official reserves. The two countries are symmetric apart for these two key currency asymmetries, and the key currency asymmetries drive our basic results.

In the steady state, net exports are zero, but the Home country is in debt to the Foreign country. How can this be? In our model's calibration, international portfolios are not symmetric

[7] In practice, banks use government bonds to manage the liquidity of their deposits, and households hold them indirectly through their access to money market mutual funds and other financial institutions. In Canzoneri, Cumby, Diba and Lopez-Salido (2008), we present a closed economy model with banks, bank deposits and bank loans. Here, due to the complexity of the two country model, we take a less structural approach. In Canzoneri, Cumby, Diba and Lopez-Salido (2011) we study the dynamic properties of a closed economy version of our present framework. In particular, we show that the familiar Taylor Principle is not a necessary condition for determinacy.

in the steady state: high returns on Foreign equity are balanced by the low returns on Home bonds. As a result, net income flows are zero in the steady state and Home and Foreign consumption are identical.

The rest of the model has standard NOEM features: Monopolistically competitive firms produce an aggregate consumption good in each country; household consumption reflects habit formation and a bias for the domestically produced good; labor is the only factor of production (there being no land or investment); the labor market is competitive and wages are flexible, but prices are set ala Calvo.

II. A. The Model

Home Households –

In the Home country, there is a continuum of households on the unit interval. The utility of household h is

(1) $U_t(h) = E_t\sum_{j=t}^{\infty} \beta^{j-t} [\log(c_j(h)- \xi c_{j-1}) - (1+\chi)^{-1} n_j(h)^{1+\chi}]$

where $c_t(h)$ is consumption of a composite final good (defined below), $n_t(h)$ is hours of work, c_{t-1} is aggregate consumption, the parameter ξ is a measure of habit persistence, and the parameter χ is the inverse of the Frisch elasticity of labor supply. Households are identical in this model; so, we can dispense with household indices. Moreover, the population has measure one; so in equilibrium, per capita supplies and demands will be equal to aggregate supplies and demands.

The household's budget constraint, in units of the Home consumption good, is[8]

(2) $m_t + b_{H,t} + (1+\tau_t)c_t = w_t n_t + (m_{t-1} + R_{t-1}b_{H,t-1})/\Pi_t + tr_t - x_t + div_{H,t} + s(q_t\, div^*_{F,t})$

Home households hold Home money, m_t, and Home bonds, $b_{H,t}$, to finance their purchases; $\tau_t c_t$ is a transactions cost which will be described later; w_t is the competitive market wage; R_{t-1} is the gross nominal interest rate on Home bonds; $\Pi_t = P_t/P_{t-1}$ is the gross rate of inflation of the Home CPI; tr_t is a lump sum transfer and x_t is a lump sum tax; $div_{H,t}$ is Home dividends, q_t is the real exchange rate (Home consumption goods per Foreign consumption good); $div^*_{F,t}$ is Foreign dividends; and s is the Home household's (constant) share of those dividends.[9]

Following Schmitt-Grohe and Uribe (2004), we assume that transactions costs are proportional to consumption, and the factor of proportionality is an increasing function of velocity.

(3) $$\tau_t = \begin{cases} (A/v_t)(v_t-\upsilon)^2 & \text{for } v_t > \upsilon \\ 0 & \text{for } v_t \leq \upsilon \end{cases}$$

where ν is the satiation level of velocity and A is a cost parameter. The new element here is in our definition of velocity

(4) $v_t = c_t/\tilde{m}_t$

[8] A note on notation: H and F subscripts will be used to denote Home and Foreign assets or products when those bonds or products are used in both countries; Home money, for example, is not held by Foreign entities, and therefore needs no subscript. Supercript *'s will generally denote Foreign household demands and supplies of assets or products; they will also denote Foreign interest rates, Foreign inflation rates, velocity, and relative prices in the Foreign country.

[9] We do not model the equities market. We simply assume that each household owns a proportionate share of the steady state Home country portfolio of Home and Foreign equity. The size of this portfolio will be calibrated so that Home earnings on foreign equity balance Foreign earnings on Home bonds in the steady state.

where effective transactions balances – $\tilde{m}_t$ – are a Cobb-Douglass aggregate of money and bonds

(5) $\tilde{m}_t = m_t^{\varsigma} b_{H,t}^{(1-\varsigma)}$

where $1-\varsigma \in [0, 1]$ measures the importance of bonds in facilitating trade.

The household's first order conditions include:

(6) $(c_t - \xi c_{t-1})^{-1} = \lambda_t[1 + 2A(v_t - \nu)]$

(7) $1 - A[v_t^2 - \nu^2]\varsigma(\tilde{m}_t/m_t) = \beta E_t[(\lambda_{t+1}/\lambda_t)/\Pi_{t+1}] \equiv 1/\tilde{R}_t$

(8) $1 - A[v_t^2 - \nu^2](1-\varsigma)(\tilde{m}_t/b_t) = R_t\beta E_t[(\lambda_{t+1}/\lambda_t)/\Pi_{t+1}] = R_t/\tilde{R}_t$

where λ_t is the marginal value of wealth. We can price a bond that does not provide liquidity, and call it the CCAPM bond; its gross return is $\tilde{R}_t$. $R_t/\tilde{R}_t$ is less than one, reflecting the non-pecuniary return (or liquidity premium) on Home bonds. (6) defines the marginal value of wealth. When real resources are depleted in the purchase of consumption goods, the marginal value of wealth is less than the marginal utility of consumption. (7) and (8) are the first order conditions for money and bonds.

Foreign Households –

Foreign households are modeled symmetrically, but with one major exception: Foreign households use the Home bond, in addition to their own money and bonds, to finance their purchases. The utility of a representative household, f, is

(9) $U_t^*(f) = E_t\sum_{j=t}^{\infty} \beta^{j-t} [\log(c_j^*(f) - \xi c_{j-1}^*) - (1+\chi)n_j^*(f)^{1+\chi}]$,

where c_{j-1}^* is again aggregate consumption, and the household's budget constraint is

(10) $m_t^* + b_{F,t}^* + b_{H,t}^*/q_t + (1+\tau_t^*)c_t^* = w_t^* n_t^* + (m_{t-1}^* + R_{t-1}^* b_{F,t-1}^* + R_{t-1} b_{H,t-1}^*/q_t)/\Pi_t^* + tr_t^* - x_t^* + (1-s)div_{F,t}^*$

Transactions costs are again proportional to consumption,

(11) $\tau_t = \begin{cases} (A^*/v_t^*)(v_t^* - \upsilon^*)^2 & \text{for } v_t^* > \upsilon^* \\ 0 & \text{for } v_t^* \leq \upsilon^* \end{cases}$

where

(12) $v_t^* = c_t^*/\tilde{m}_t^*$.

However, effective transactions balances – $\tilde{m}_t^*$ – are given by

(13) $\tilde{m}_t^* = m_t^{*\omega 1} b_{F,t}^{*\omega 2} (b_{H,t}^*/q_t)^{(1-\omega 1-\omega 2)}$

where $0 < \omega_1$, $0 < \omega_2$, and $\omega_1 + \omega_2 < 1$.

The Foreign household's first order conditions include:

(14) $(c_t^* - \xi c_{t-1}^*)^{-1} = \lambda_t^*[1 + 2A^*(v_t^* - \nu^*)]$

(15) $1 - A^*[(v_t^*)^2 - (\nu^*)^2]\omega_1(\tilde{m}_t^*/m_t^*) = 1/\tilde{R}_t^*$

(16) $1 - A^*[(v_t^*)^2 - (\nu^*)^2]\omega_2(\tilde{m}_t^*/b_{F,t}^*) = R_t^*/\tilde{R}_t^*$

(17) $1 - A^*[(v_t^*)^2 - (\nu^*)^2](1 - \omega_1 - \omega_2)(\tilde{m}_t^* q_t/b_{H,t}^*) = R_t \beta E_t[(\lambda_{t+1}^*/\lambda_t^*)(q_t/q_{t+1})(1/\Pi_{t+1})]$

Equations (14), (15) and (16) are analogous to the first order conditions of the Home household. But in addition, the Foreign household holds Home bonds, and (17) is the first order condition for that decision.

Interest rate spreads reflect the transactions services of money and bonds –

Home and Foreign bonds provide transactions services to households. So, bonds are imperfect substitutes for money, and imperfect substitutes for one another. The relative usefulness of the various liquid assets is reflected in a number of interest rate spreads. For example, the first order conditions (7) and (8) for the Home household imply

$$(18)\ \frac{\tilde{R}_t - R_t}{\tilde{R}_t - 1} = \left(\frac{1-\varsigma}{\varsigma}\right)\left(\frac{m_t}{b_{H,t}}\right)$$

As mentioned earlier, the Home CCAPM rate, $\tilde{R}_t$, is the return on a bond that does not provide liquidity services. The spread between this rate and the rate on liquid bonds – $\tilde{R}_t - R_t$ – is the opportunity cost of holding the liquid bond. Similarly, the spread between the CCAPM rate and the return on money – $\tilde{R}_t - 1$ – is the opportunity cost of holding money. The ratio of these spreads on the LHS of (18) is the opportunity cost of holding liquid bonds relative to the opportunity cost of holding money. If the relative cost of holding liquid bonds increases, households substitute money for bonds in their portfolios, as indicated by equation (18).[10]

A novel aspect of this model is (as mentioned earlier) that there is a departure from the usual UIP condition, because Home and Foreign bonds are no longer perfect substitutes. Home and Foreign bonds provide transactions services to the Foreign household; so, its first order conditions – (16) and (17) – describe the substitutability of Home and Foreign bonds. Linearizing around the steady state (described below) we obtain,

$$(19)\ \hat{R}_t - \left[\hat{R}_t^* + E_t(\hat{e}_{t+1} - \hat{e}_t)\right] = \frac{1-\omega_1-\omega_2}{\omega_2}\left(\frac{\tilde{\bar{R}}^* - \bar{R}^*}{\bar{R}^*}\right)\left[\hat{b}_{H,t}^* - \left(\hat{b}_{F,t}^* + \hat{q}_t\right)\right]$$

[10] The Foreign household's first order conditions, (15) and (16), imply an equation analogous to (18) for the Foreign interest rate spreads.

where e is the nominal exchange rate and variables with a bar are steady state values; a ^ denotes a percentage deviation from the steady state value. The deviation from UIP (the RHS of (19)) depends on the ratio of the stocks of Home and Foreign bonds held by the foreign household. The equilibrium spread between the expected returns has to rise if the Foreign household is going to hold more of the Home bonds (perhaps as the result of a sterilized intervention by one of the central banks).

Firms, Key Currency Pricing, Intermediate Goods, and Final Goods –

The modeling of monopolistic competition is standard; our description can be brief, focusing on aspects that are specific to our model. A continuum of monopolistically competitive firms hire labor on a competitive labor market and produce a continuum of intermediate goods using a linear technology with a common productivity shock; the log of the productivity shock follows an AR(1) process with autoregressive parameter ρ_z and innovation $\epsilon_{z,t}$. Home national product, $y_{H,t}$, is a CES aggregate of these intermediate goods, with elasticity of substitution ζ. The Home consumption good (appearing in the utility function (1)) is a CES aggregate of Home consumption of the Home product, $c_{H,t,}$ and Home consumption of the Foreign product, $c_{F,t}$:

$$(20)\quad c_t = [\mu^{1/\eta} c_{H,t}^{(\eta-1)/\eta} + (1-\mu)^{1/\eta} c_{F,t}^{(\eta-1)/\eta}]^{\eta/(1-\eta)}$$

where $\mu > ½$ reflects a bias for Home goods. Similarly, the Foreign consumption good is

$$(21)\quad c_t^* = [\mu^{1/\eta} c_{F,t}^{*(\eta-1)/\eta} + (1-\mu)^{1/\eta} c_{H,t}^{*(\eta-1)/\eta}]^{\eta/(1-\eta)}.$$

The Home and Foreign household's first order conditions imply

$$(22)\quad \frac{c_{H,t}}{c_{F,t}} = \left(\frac{\mu}{1-\mu}\right)\left(\frac{p_{F,t}}{p_{H,t}}\right)^{\eta}$$

$$(23)\quad \frac{c^{*}_{F,t}}{c^{*}_{H,t}} = \left(\frac{\mu}{1-\mu}\right)\left(\frac{p^{*}_{H,t}}{p^{*}_{F,t}}\right)^{\eta}$$

Intermediate goods firms in each country set their prices ala Calvo; the Calvo parameter is set so that the average duration of a price "contract" is four quarters in each country. Here again, however, there is an important key currency asymmetry. Home firms set prices in terms of the Home currency, for goods sold at home and abroad; the law of one price holds: $P_{H,t} = e_t P^{*}_{H,t}$, where e_t is the nominal exchange rate. Or letting lower case letters denote prices relative to CPIs,

$$(24)\quad p_{H,t} = q_t p^{*}_{H,t}$$

By contrast, Foreign firms price their exports in terms of Home currency, and the law of one price does not hold.

Benchmark Monetary and Fiscal Policy Rules –

We will consider a variety of monetary and fiscal policy rules in what follows; here, we describe the benchmark policy rules. The Home government's flow budget constraint is

$$(25)\quad m_t + d_t = (m_{t-1} + R_{t-1}d_{t-1})/\Pi_t + p_{H,t}g_t + tr_t - x_t$$

where d_t is the supply of Home government bonds. Home government spending falls entirely on the Home good. Government spending is exogenous, and $\log(g_t)$ follows an AR1 process with autoregressive parameter ρ_g and innovation $\epsilon_{g,t}$. Similarly, lump sum taxes are exogenous, and $\log(x_t)$ follows an AR1 process with autoregressive parameter ρ_x and innovation $\epsilon_{x,.}$ Lump sum transfers, tr_t, assure fiscal solvency:

(26) $tr_t = - \phi_d(d_{t-1} - \bar{d})$

where bars over variables denote steady state values, and ϕ_d is greater than the steady state real rate of interest.[11]

The Foreign government holds Home bonds as reserves, $b^{G*}_{H,t}$. The Foreign government's tax and transfer schemes are analogous to (25) and (26), but its flow budget constraint is

(27) $m^*_t + d^*_t = (m^*_{t-1} + R^*_{t-1}d^*_{t-1})/\Pi^*_t + b^{G*}_{H,t}/q_t - R_{t-1}b^{G*}_{H,t}/\Pi_t q_t + p^*_{F,t}g^*_t + tr^*_t - x^*_t$.

Once again, g^*_t and x^*_t follow AR(1) processes, and tr^*_t responds to the level of the debt.

One of the shocks we will consider is a sale of Home bonds by the Foreign government,

(28) $b^{G*}_{H,t} - \bar{b}^{G*}_H = \rho_B(b^{G*}_{H,t-1} - \bar{b}^{G*}_H) - \epsilon_{B,t}$.

For monetary policy, we will alternatively use a benchmark interest rate rule or a benchmark money growth rule. The Home policy rules are standard:

(29) $\log(R_t/\bar{R}) = \rho_R \log(R_{t-1}/\bar{R}) + (1-\rho_R)\phi_\pi \log(\Pi_t/\bar{\Pi}) + \epsilon_{R,t}$

(30) $\log(M_t/M_{t-1}) = \rho_M \log(M_{t-1}/M_{t-2}) + (1-\rho_M)\log(\bar{\Pi}) + \epsilon_{M,t}$

The Foreign policy rules are defined analogously.

The interest rate rules are of course more realistic, but the impulse response functions generated with interest rate rules conflate the direct effect of asset supply shocks with the effects of the endogenous response of monetary policy. The fixed money growth rules provide a

[11] Fiscal policy is Ricardian in the sense of Woodford (1995), but we will see that the liquidity services of bonds makes the model Non-Ricardian.

simpler conceptual framework for our analysis in the next section. For example, the shock just defined, $\epsilon_{B,t}$, would be a sterilized foreign exchange intervention with a fixed money growth rule for the Foreign government, but not with an interest rate rule.

Equilibrium Conditions and the Current Account

Most of the market equilibrium conditions are obvious. Here, we focus on those about which there may be some confusion. For Home bonds,

(31) $d_t = b_{H,t} + b^*_{H,t} + b^{G*}_{H,t}$

Government spending falls on the domestic good in each country, so

(32) $y_{H,t} = (1+\tau_t)c_{H,t} + g_t + (1+\tau^*_t)c^*_{H,t}$

(33) $y^*_{F,t} = (1+\tau^*_t)c^*_{F,t} + g^*_t + (1+\tau_t)c_{F,t}$

Combining the public and private budget constraints and imposing the market clearing conditions, we arrive at the balance of payments identity:

(34) $(1+\tau^*_t)p_{H,t}c^*_{H,t} - (1+\tau_t)p_{F,t}c_{F,t} - (R_{t-1}\Pi_t^{-1}-1)(b^*_{H,t-1} + b^{G*}_{H,t-1}) + s(q_t\, div^*_{F,t})$

$= CA_t = -[(b^*_{H,t} - b^*_{H,t-1}) + (b^{G*}_{H,t} - b^{G*}_{H,t-1})]$

Home's current account surplus is Home's exports (including Foreign's transactions costs) less Home's imports (including transactions costs) less Home's real interest payments to the Foreign country plus Home's receipts of dividend income from the Foreign country. The balance of payments identity links the current account to the change in Home's real net foreign assets.

II.B. Steady State and Calibration of the Model

The way we solve for the steady state equilibrium is dictated by our approach to the model's calibration. We calibrate the Home country to U.S. data, but we do not attempt to calibrate the Foreign country to "rest of world" data. Instead, apart from the key currency features, we calibrate the Foreign country in a symmetric fashion to the Home country. One of the virtues of this approach is that when we find asymmetries in the results, we know that they are due to the key currency assumptions.

In the steady state, net exports are zero and the current account is balanced, but international portfolios are not symmetric: Home residents hold equity claims on Foreign firms and Foreign residents hold Home bonds. Home residents earn the CCAPM rate on their Foreign equity claims while Foreign residents earn the liquid bond rate on their Home bond holdings. And because liquid assets command liquidity premia in the steady state, and not just in the transition dynamics, Home earns a higher rate of return on its foreign assets than it pays on its foreign liabilities, as is the case in the U.S. data. Home is a net debtor, but Home equity receipts from Foreign firms are balanced by Foreign earnings on Home bonds. The difference in the rates of return is sufficient in the steady state to balance the income receipts and payments. In the steady state, Home consumption is equal to Foreign consumption.

The Appendix provides a discussion of data sources and estimation procedures for parameters that we have estimated (for the exogenous processes and policy rules reported in Table 1). A number of other parameters reported in Table 1 have standard values taken from the literature. But our model has a number of parameters (those in our specifications of transactions costs and the transactions technology) that we cannot pin down in a standard way. Moreover, we

want our model to match observed average inflation, interest rates and ratios of asset stocks to consumption. Our strategy is to choose parameters to match these variables. We set $\bar{\Pi}$, $\bar{R}$, and the ratios reported in the first panel of Table 1 (i.e., $\bar{m}/\bar{c}$, $\bar{m}/\bar{c}$, $\bar{b}_H/\bar{c}$, $\bar{b}_H^*/\bar{q}\bar{c}^*$, $\bar{b}_H^G/\bar{q}\bar{c}^*$) using the data, and we set transactions cost (τ) to 0.8 percent of consumption.[12] We then use the ratios in the steady state equations to back out the parameters reported in the second panel of Table 1, and calculate the relevant steady state values of some other variables along the way.

Specifically, we have $\bar{\tilde{R}} = \bar{\Pi}/\beta$; we set $\bar{\tilde{R}}^* = \bar{\tilde{R}}$, $\bar{\Pi}^* = \bar{\Pi}$ and $\bar{q} = 1$, by symmetry. We then solve the foreign household's optimality conditions (15), (16) and (17) to eliminate the terms involving velocity and calculate the values of ω_1 and ω_2 that are consistent with the values of asset holding ratios found in Table 1. Similarly, we use the domestic household's optimality conditions (7) and (8) to infer the value of ς. Next, we use (4), (5), (12), and (13) to calculate the steady state values of velocity terms that are consistent with our asset holding ratios and the values of ς, ω_1 and ω_2. We then solve (3), (7), (11), and (15) for the satiation levels of velocity and the parameters A and A* in our specification of transactions costs. Given these parameter values, the rest of our steady state calculations are standard – the real wage is pinned down by the firms' optimality condition, and we can calculate employment from the labor-leisure margin, etc.

Before proceeding to our model simulations, it is interesting to note that money is not neutral in the long run in our model. Liquidity premia persist in the (non-stochastic) steady state.

[12] The U.S. banking sector accounts for about 1.6 percent of employment. We assume that roughly half of this is associated with facilitating transactions.

So, permanent changes in monetary or fiscal policy that affect the real steady state values of liquid assets will also affect interest rate spreads. Monetary and fiscal policies will therefore affect the steady state equilibrium, as seen in (18).[13]

III. Asymmetric Responses to Asset Supply Shocks

The Home and Foreign countries respond asymmetrically to macroeconomic shocks because of the key currency assumptions. For the rest of this section, we will assume that monetary policy is characterized by the benchmark money growth rules; this allows a cleaner interpretation of the shocks to asset supplies. Our key currency assumptions imply asymmetries in international bond holdings. Shocks to asset supplies have immediate – and asymmetric – portfolio effects, and these effects are perpetuated through time by our sticky price assumptions. We will show which of the key currency assumptions are the most important for our results.

III. A. Bond Financed Tax Cuts

Figure 1 shows IRFs for lump sum tax cuts in the Home country and the Foreign country. In each case, the tax cut is one percent of GDP and highly persistent ($\rho_x = 0.9$). And in each case, the tax cut is initially bond financed.[14] Since monetary policy is governed by money growth rules, the tax cuts are also positive bond supply shocks. Solid lines in Figure 1 depict IRFs for the Home tax cut; dotted lines depict IRFs for the Foreign tax cut. The first box shows the effect on inflation in the country in which the cut originated; the second shows the spillover

[13] Aspects of this are discussed further in Canzoneri, Cumby, Diba and Lopez-Salido (2008).

[14] That is, the benchmark fiscal policy feedback rule – (26) – does not kick in until the next period.

of inflation to the other country. Similar boxes show "own" and "spillover" effects for consumption and output. The last column of boxes shows effects on the nominal exchange rate, the real exchange rate, and the current account – in each case, from the point of view of the country in which the shock originated.

The first thing to note in Figure 1 is that lump sum tax cuts induce large increases in consumption and output. In the standard NOEM model, Ricardian equivalence prevails and the timing of tax collections does not matter; timing does matter here because government bonds pay a non-pecuniary return. More specifically, the spread between the liquid bond rate and CCAPM rate implies that a tax cut will increase household wealth: the government issues bonds to cover the decrease in revenue, and taxpayers know that their tax burden has increased; but households discount tax liabilities at the CCAPM rate, which is higher than the government bond rate. So, their net wealth increases.[15]

In addition, the Home government collects seigniorage – from both Home and Foreign households – on the low interest bonds that it issues; the seigniorage collected from Foreign households lowers the tax burden on Home households, and increases their wealth at the expense of Foreign households. By contrast, Home households do not hold Foreign government bonds, and they pay no bond seigniorage to the Foreign country. For this reason, a Home tax cut will have a stronger effect – both at home and abroad – than a tax cut of the same size in the Foreign country. This is apparent in Figure 1: both the "own" effect and the "spillover" effect on consumption are stronger when the tax cut emanates from the Home country. Note also that the

[15] Put another way, the household could invest its tax cut in CCAPM bonds and have more than enough to pay its future tax liabilities.

"spillover" effect on output is much stronger when the shock comes from the Home country.[16] This is our first example of the key currency country's hegemony in macroeconomic policy.

An increase in the supply of Home bonds requires an adjustment of portfolios, which is accomplished by a change in asset returns. Foreign households are the only private sector agents in the model that hold both Home and Foreign bonds, and their portfolio demands play the important role here. An increase in the relative supply of Home bonds causes the Home currency to depreciate, and in equilibrium, the ratio of Home to Foreign bonds in the Foreign household's portfolio – $B^{*}_{H,t}/e_tB^{*}_{F,t}$ – falls. To make Foreign households want to hold this new portfolio, the relative expected rate of return on Home assets must fall; that is, there is a negative deviation from UIP (not shown in Figure 1). But as the Home government continues to issue more Home bonds over time, the bond ratio rises. Since shocks are persistent, and goods prices are sticky, this adjustment takes time to work itself out.

Figure 1 also shows the reaction of the current account to the tax cuts.[17] Eventually, tax cuts create the expected current account deficits (since own effects on consumption are larger than spillover effects). But initially a country cutting taxes experiences a current account improvement, especially in the case of a Home tax cut. The spike in the Home current account results from valuation effects: the depreciation and the jump in output prices lowers the real value of the Home debt to foreigners, and the real interest payments to foreigners fall in the

[16] It may also be interesting to note that the own effect on output is greater for the Foreign tax shock. This is because the Foreign country does not benefit from the seigniorage tax effect described above, and Foreign households have to work harder as a consequence.

[17] In our graphs, the current account is measured as a fraction of steady state output.

initial period; these, and not the trade balance, strongly dominate current account dynamics.[18] And sticky prices make the current account adjustment take time to unwind.

III.B. A Sterilized Foreign Exchange Intervention by the Foreign Central Bank

The Foreign central bank's stock of foreign reserves consists of Home bonds. Monetary policy is governed by constant money growth rules. So, a sale of these foreign reserves must be sterilized; the Foreign central bank must conduct an offsetting purchase of Foreign bonds. Our bond sale shock – see equations (27) and (28) – is therefore a sterilized foreign exchange intervention (SFI) by the Foreign government;[19, 20] it amounts to a shock to the relative supply of Home and Foreign bonds. The effects are shown in Figure 2; in contrast with Figure 1, there is only one shock being illustrated: solid lines show effects on the Home country, while dotted lines show effects on the Foreign country.

In the standard NOEM model, bonds are perfect substitutes, and a SFI would have no effect on anything other than the relative supplies of bonds. Here, Home and Foreign bonds pay differing non-pecuniary returns, and they are not perfect substitutes. The SFI creates an excess supply of Home bonds and an excess demand for Foreign bonds. The relative return on Home bonds must rise in equilibrium, creating a positive deviation from UIP (not pictured in Figure 2).

More fundamentally, the SFI transfers wealth from Home households to Foreign households. When the (consolidated) Foreign government holds Home bonds as reserves, it is

[18] The national income accounts do not capture these valuation effects, and models like ours suggest this is serious shortcoming.

[19] In our equations, we have consolidated the central bank and the treasury.

[20] We have estimated an AR(1) process on foreign government sales of U.S. government bonds; see the calibration section. The innovation to that estimated process is our sale shock.

paying a bond seigniorage tax to the Home government.[21] When the Foreign central bank sells reserves, it undoes this process, and this lowers the tax burden of Foreign taxpayers at the expense of Home taxpayers. Foreign consumption rises, and Home households have to work more to preserve their consumption. The Home nominal and real exchange rates depreciate, and the Home current account improves (because of both valuation effects and the trade balance).

III.C. Bond Financed Increases in Government Spending

In Figure 3, we compare the effects of Home and Foreign increases in government spending. In each case, the increase in spending is one percent of GDP. The spending increases are highly persistent – we set $\rho_g = 0.90$ to facilitate comparison with the effects of tax cuts shown in Figure 1. Since in each case the spending increases are bond financed, the supply of bonds goes up by one percent of GDP, as was the case in Figure 1. Here, however, government spending directly increases aggregate demand. As in Figure 1, we show both shocks in the same box.

Perhaps the first thing to note in Figure 3 is that own consumption rises. In the standard NOEM model, consumption falls: households curtail spending and work more in response to their increased tax burden. Here however, the increased tax burden is outweighed by the positive wealth effect induced by the increase in the supply of bonds, and consumption rises, though not as much as in Figure 1. Work effort and output have to rise much more than in Figure 1 to meet the increase in aggregate demand. Note also that the government spending multipliers are

[21] Foreign taxpayers are giving Home taxpayers a low interest loan – lower than they could get on a CCAPM bond.

greater than one.[22]

In Figure 3B, we show the effects of the government spending increases assuming an interest rate rule with parameters $\rho_R = 0.9$ and $\phi_\pi = 1.5$. Consumption rises, but not as much as with the money growth rules, and the output multipliers drop to about one. If we impose a more stringent interest rate rule – such as our benchmark rule, with $\rho_R = 0.8$ and $\phi_\pi = 2$ – consumption falls. The results are very sensitive to the monetary policy that is in place.

In any case, the overall patterns in Figure 3 look very similar to those in Figure 1. The "own effects" and the "spillover effects" of the Home country spending increase are significantly larger than those of the Foreign country spending increase. The key currency country hegemony exists in both tax and spending policy.

III.E. Which of the Key Currency Assumptions is More Important?

The asymmetries in the Home and Foreign countries' responses to asset supply shocks are considerable, and they are due to the key currency assumptions. There are two key currency assumptions: key currency pricing of products in both countries, and key currency bonds that facilitate trade in both countries. Here, we assess the importance of each of these assumptions for our results. To do this we will show how each country responds to a Home government spending shock in three separate models: a symmetric NOEM with no key currency assumptions; the same NOEM, but with key currency pricing; and finally the full key currency model.

[22] There is an ongoing debate in the empirical literature over the sign of the consumption response to an increase in government spending, and over the size of output multipliers. These old-Keynesian results have been hard to obtain in new-Keynesian models without resorting to large numbers of "rule of thumb" consumers who spend whatever income they get.

In Figure 3B, the dotted lines represent responses in the symmetric NOEM. These responses are very weak (except for the effect on Home output), and they all die out quickly. Why? When bonds do not provide liquidity services the model is Ricardian, and tax and spending shocks do not create expansionary wealth effects for the households. And in fact, Home consumption falls, crowded out by the increase in government spending. The dashed lines represent the responses when key currency pricing is added. Most of the responses are bigger, and Home consumption falls further because the appreciation in the real exchange rate is larger. Finally, the solid lines represent responses in the full key currency model; they are the same as those in Figure 3A. The addition of bonds with liquidity value creates wealth effects that magnify all of the responses, and the assumption that Foreign households hold key currency bonds adds to the asymmetric responses that were described in earlier subsections.

III.F. Summing Up

There are four fundamental results stemming from our assumption that bonds provide liquidity services: First, shocks that change bond supplies have big effects on consumption, and real economic activity generally, because they induce strong non-Ricardian wealth effects. Second, Home and Foreign bonds are not perfect substitutes and sterilized foreign exchange interventions induce deviations from uncovered interest parity, and have powerful effects on consumption. Third, shocks to asset supplies imply large valuation effects that can dwarf movements in the trade balance. These valuation effects are not captured in the conventional balance of payments measure of the current account; our analysis suggests that they are big and very important to our understanding of the international transmission of macroeconomic shocks.

And finally, our assumption that Foreign households hold key currency bonds appears to be more important than the assumption of key currency pricing in producing these results.

IV. Hegemony of the Key Currency Country

Our key currency assumptions imply hegemony in macroeconomic policy for the key currency country. Shifts in monetary and fiscal policy emanating from the Home country have a greater effect on inflation and output abroad, than equivalent policy actions coming from the Foreign country. The key currency country simply has more clout when it comes to macroeconomic policy.

This fact was documented in the last section. Figures 1 and 3A illustrate the Home country's dominance in fiscal policy: tax cuts and government spending increases initiated by the Home country have stronger spillovers to inflation and output abroad than do the same policy innovations taken in the Foreign country.

Switching from money growth rules to interest rate rules, home country interest rate shocks have a larger effect on inflation and output abroad than do Foreign country interest rate shocks. Similarly, Government spending increases are less expansionary when the central banks follow the interest rates rules, since the rise in inflation induces an automatic tightening of monetary policy.[23] But once again, Home government spending innovations have more clout abroad.

In the next section, we discuss the costs and benefits of being the key currency country.

[23] And indeed, domestic consumption falls in our model following the spending increase.

It is tempting to think that hegemony in policymaking gives the key currency country a strategic advantage. And indeed, some thought that the formation of the euro might give Europe more economic clout. We do not include a discussion of hegemony in the next section because a technical analysis of this issue is well beyond the scope of the present paper. It would presumably involve a full game specification and a discussion of international policy coordination.

V. Is It Good to be the Key Currency Country?

There are many ways to approach this question. One might think that policy hegemony would give the key currency country an advantage in the international arena. Canzoneri and Gray (1985) explored some of the key currency asymmetries in a game theoretic framework, while using an earlier generation of models. To our knowledge, no one in the recent literature has modeled policy games with key currency asymmetries. Rather than do so here, we will focus on topics that may be closer to current policy debates.

V.A. The Extraordinary Privileges

As noted in the introduction, the costs and benefits of the dollar's key currency status were hotly debated in the 1950's and 60's, both in academic and in political circles. Aliber (1964) and Salant (1964) argued that the exorbitant privilege of the key currency country comes in two forms: First, they noted that the United States can finance current account deficits with low interest paper instruments; this is the most common or traditional notion of exorbitant privilege. And second, they argued that the United States has more "flexibility": writing during the Bretton Woods period, they noted that the U.S. could (at least partially) finance a current

account deficit with dollar assets, avoiding the loss of gold reserves, and delaying the need for more fundamental reforms. Bretton Woods is a relic of the past. But, we too will argue that there are a number of privileges accruing to the key currency country.

More specifically, the Home country in our model enjoys two different kinds of exorbitant privilege. First, it enjoys the traditional exorbitant privilege: the Foreign country pays the Home country an ongoing seigniorage equal to the product of their holdings of home bonds and the liquidity value of bonds. Second, it enjoys a privilege that arises from the key currency asymmetries.

In our model, the steady state values of Home and Foreign interest rates are the same. The exorbitant privilege comes from the asymmetry in steady state portfolios: the Foreign country holds Home bonds, while the Home country does not hold Foreign bonds.[24] At the end of 2007, foreign holdings of U.S. Treasury securities amounted to about 90 percent of quarterly U.S. consumption. As we discuss in the appendix, we have computed the average liquidity premium on Treasury securities to be about 0.0065 per quarter. For the data discussed in the appendix, these numbers imply that the steady state value of the exorbitant privilege is 0.585 percent of consumption.

How much is the second form of exorbitant privilege worth? Recall that Home and Foreign households are identical except for the key currency asymmetries. To control for the

[24] Gourinchas and Rey (2007) present evidence that there is also a difference in U.S. and foreign rates of return on debt instruments; so, our estimate of the exorbitant privilege may be too low. On the other hand, Curcuru, Dvorak, and Warnock (2008) point out measurement problems in that calculation. The measurement issue does not arise in the context of our model – interest rates are the same in the two countries and the exorbitant privilege reflects only portfolio composition effects.

traditional form of exorbitant privilege, we have calibrated the model to eliminate the steady state seigniorage that the Home country enjoys,[25] and compare the welfare of Home and Foreign households, using stochastic simulations. Following Lucas (2003), we will express the welfare difference in terms of consumption equivalents.

In this exercise, we include the estimated stochastic processes for productivity, taxes and government spending, and we will assume that both central banks follow an estimated interest rate rule for monetary policy. See the appendix for a description of these estimated processes.

Stochastic simulations show that the difference between Home and Foreign household welfare is about three tenths of a percent of consumption. So, the welfare effect of the key currency asymmetries is approximately half of our estimate of the traditional notion of exorbitant privilege (a half of a percent of consumption). All told then, in our model the exorbitant privilege enjoyed by the key currency country is a little over three-fourths of a percent of consumption each period. While that exorbitant privilege is not staggering, it certainly would seem to be significant, as the statement of Valery Giscard d'Estaing might suggest.

Where does this second source of exorbitant privilege come from? While we suspect that there are complicated forces at work in these dynamic asymmetries, macroeconomic hegemony is certainly a part of the story. The standard deviation of inflation in the Foreign country is about 20% higher than that in the Key currency country. This fact appears to be at the root of the welfare difference, since the standard deviations of consumption and output are about the same

[25] We do this by making the steady state returns that the Home country receives on Foreign equity equal to the steady state interest payments that the Foreign country receives on its Home bonds holdings. In the steady state, the trade balance and the current account are both zero, and Home consumption is equal to Foreign consumption.

in the two countries. So, the question becomes, what causes the difference in inflation volatility? Variance decompositions provide one answer. Home productivity explains about three times more of the variation in Foreign inflation, than the reverse; Home interest rate shocks explain about a hundred times more of the variation in Foreign inflation than the reverse; Home government spending shocks explain about ten times more variation in Foreign inflation than the reverse; and Home tax shocks explain about four times more variation in Foreign inflation than the reverse. Destabilizing shocks emanating from the key currency country simply have a greater effect on the other country than the reverse.

V.A.1 Summing Up

We have shown that the key currency country enjoys three kinds of exorbitant privilege. The first is the traditional notion of bond seigniorage; the second is hegemony in macroeconomic policymaking; and the third flows form the key currency asymmetries in a stochastic economy. We estimate the benefit from the first and third to be about three quarters of a percent of consumption each period. It is difficult to measure the value of the second without going to a game theoretic framework.

V.B. The Extraordinary Risk: a sudden dumping of key currency bonds

So, what are the costs of key currency status? They come in the form of an extraordinary risk. The concern that foreign central banks may dump their reserves of the key currency has a long history in international finance. For example, these concerns dominated economic policy considerations of both the British government and the Bank of England at the end of World War II and in the decade or so that followed. Sterling had been the key currency prior to the war and

foreign central banks held large Sterling balances. Triffin (1961) reports, "Sterling balances made up, at the end of the war, the overwhelming bulk of official foreign exchange holdings. ... Such balances would not, of course, have been accumulated during the war, and retained after the war, without a considerable element of compulsion." To make a long story short, the United States made the U.K. a loan, and the U.K. tried to reestablish the convertibility of sterling in July of 1947; the experiment lasted all of five weeks, and the British had to reimpose capital controls. Solomon (1982) notes that, "It was not until December 1958 that the United Kingdom and a number of other European countries reestablished the convertibility of their currencies."[26]

These concerns also arise in Salant's (1964) analysis of the risks facing the United States in the 1960s. "As long as foreign monetary authorities hold large reserves in the form of dollars without any commitment to keep them in that form, withdrawal or reduction of these balances is always possible. The principal cost imposed on the United States by its position as a reserve center arises from this possibility."

Salant's (1964) description of this risk sounds like it could have been written today. Concerns that foreign central banks may sell off a significant part of their dollar reserves have been voiced frequently in recent years. As the U.S. has funded a significant fraction of its budget deficits by selling bonds to China's central bank, some have characterized the rapid growth in reserves along with expanded fiscal deficits as a game of chicken between China and the United

[26] See Triffin (1961), Solomon (1982) and Cairncross and Eichengreen (1983) for very detailed accounts of the Sterling crisis.

States.[27] Another recent example involves the Federal Reserve's quantitative easing, which was motivated by purely domestic considerations and met with considerable resistance from the others in the G-20.

In order to shed some light on the extent of this risk, we will use our model to examine the consequences of a sudden sell off of some of the Foreign country's holdings of key currency bonds. We will also consider policies that the Home country might employ to soften the blow.

The size, and permanence, of a potential sell off are of course a matter of speculation. Foreign official holdings of dollar reserves really took off around 2003. Between 2002:4 and 2009:4, foreign central banks increased dollar reserves by 155%. In our simulations, we assume the sell-off is equal to the buildup of official dollar reserves between 2007:4 and 2009:4; that is, the buildup during the worst of the financial meltdown.

The macroeconomic consequences of this sale depend on what the Foreign government does with the proceeds, and on how the central banks and treasuries in each country react. Here, we will assume that the Foreign government uses the proceeds of the sale to buy back its own debt. And, in the benchmark case, we assume that the monetary and fiscal policy authorities in both countries continue to follow the benchmark policy rules, (26) and (29).[28] We begin with this benchmark case, and then we ask what alternative, or non-standard policies the monetary and fiscal authorities in the Home country might take in response to the sell-off.

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[27] See for example the Washington Post's (March 14, 2009) article titled "China Worried About U.S. Debt: Biggest Creditor Nation Demands A Guarantee."

[28] If the foreign central bank followed the money growth rule we used in the last section, the asset sale would be a sterilized foreign exchange intervention. And of course, the sterilized intervention we studied in the last section was temporary, not permanent. The results here are consequently different from those in the last section.

V.B.1 Responding to the Sell Off with the benchmark monetary or fiscal policies

As discussed earlier, when the Foreign government holds Home bonds as reserve assets, it is paying a bond seigniorage tax to the Home government. The Foreign central bank's sale of Home bonds basically reverses this trend, and a wealth transfer from Home taxpayers to Foreign taxpayers ensues. This wealth transfer has the predictable implications of lowering Home consumption and raising Home work effort; the effects on Foreign consumption and output are of course just the reverse.

As can be seen in Figure 4A, the effects on consumption and output are sizable and long lasting (because of sticky prices). Home consumption, for example, falls by more than one percent after eight quarters, and the decline in consumption is quite persistent. Due to home bias in consumption, the transfer results in a decline in the relative price of Home's good; the real depreciation of Home's currency is about five and a half percent in our benchmark case. The increase in Home's current account surplus corresponds to more than one percent of steady state output. In addition, home inflation rises and, in response to the higher inflation, Home's central bank raises interest rates (both nominal and real rates rise). The benchmark monetary policy appears to be contributing to the contraction of Home's consumption.

Alternative responses

The benchmark monetary and fiscal policies produce bleak results. There are some non-standard policies that come to mind in a situation like this. One possibility would be for the Home treasury simply to buy back the bonds; another would be for the Home central bank to buy the bonds. Alternatively, since this is a key currency crisis, the Home central bank might intervene to keep the exchange rate from depreciating. We will consider each of these

approaches in turn.

V.B.2 Responding to the Bond Sell Off with Alternative Policies

Suppose the Home treasury immediately buys back the bonds that the Foreign central bank sells; thereafter, the benchmark fiscal policy rule goes back into effect. The Home central bank continues to follow the benchmark interest rate rule. Figure 4B shows the results for consumption and output. The increase in work effort (and therefore output) is marginally smaller, but the fall in Home consumption is dramatically larger. The increase in (lump sum) taxes to fund the buy-back creates a huge negative wealth effect. For a Home household to favor this outcome, it would need to have an extreme preference for leisure over consumption. Because the buy back and the corresponding tax increase reinforces the contraction in Home consumption.

We turn next to alternative monetary policies. This is, of course, a currency crisis; the real exchange rate depreciated almost six percent in the benchmark case. One response might be to stabilize nominal exchange rates. Here, we consider the extreme case of pegging the nominal exchange rate. Like a Treasury buy-back, pegging the exchange rate reinforces the contraction in Home consumption, in this case by delaying the real depreciation required by the transfer. Figure 4B shows the results for consumption and output. Consumption falls much more than in the benchmark case, six and a half percent instead of one percent; and work effort actually falls as well. Once again, a Home household must have an extreme preference for leisure to prefer this outcome.

It may make more sense for the Home central bank to buy the bonds, instead of the treasury. This would require a dramatic fall in the nominal interest rate. In fact, with our

calibration, the nominal interest rate falls to zero before all of the bonds are bought back. The Home central bank can only purchase about eighty percent of the bonds that the Foreign central bank sells.

Figure 4C illustrates two possible scenarios. In the first, monetary policy reverts to the benchmark interest rate rule after the initial purchase, and that rule calls for interest rate smoothing. Consequently, nominal and real interest rates stay much lower than in the benchmark case for about eight quarters (not pictured), and the policy is much more stimulative. When the initial fall in interest rates is so large, the central bank may not wish to continue smoothing interest rates as before. Figure 4B also shows the results for the opposite extreme; the central bank does not smooth interest rates at all. Here, the work effort is increased slightly, and the fall in consumption is slightly less. There may be a policy somewhere in between that would better satisfy the Home household's consumption-leisure preferences than the benchmark policy.

V.B.3 Summing Up

The risk associated with being the key currency provider does indeed seem to be significant. Assuming the benchmark monetary and fiscal policies remained unchanged, the costs implied by a sudden sell off of key currency bonds are substantial because of the implied negative wealth effect on Home households. And none of the alternative monetary or fiscal policies we have considered – a Home treasury buy back of the bonds sold by the Foreign central bank, a fixed nominal exchange rate, a Home central bank buy back – would seem to lower the costs significantly unless Home households have an extreme preference for leisure over consumption. The one possible exception to this is a Home central bank buy back combined with a suspension of interest rate smoothing.

VI. Conclusion

In this paper, we have shown that there are three forms of exorbitant privilege accruing to the key currency country, but there is also an extraordinary risk. Our basic results were summarized in the "summing up" subsections of the last two sections. We do not need to repeat them here. Instead, we will discuss implications for future work.

Larger DSGE models developed for policy analysis [e.g., Erceg, Guerrieri, and Gust (2005) and Faruqee, Laxton, Muir, and Pesenti (2005)] incorporate a number of real rigidities, adjustment costs, and departures from optimizing behavior that are potentially relevant for the questions we address in this paper. We have not incorporated these features in our model because we wanted to focus on the key currency asymmetries that we have introduced here, but adding such features could make the effects we discuss here much larger. For example, adding myopic consumers would imply larger departures from Ricardian Equivalence than what we report, and portfolio adjustment costs would lead to bigger deviations from UIP.

The key currency asymmetries imply that the key currency country enjoy a hegemony in macroeconomic policy. It would be interesting to extend our analysis to a full game theoretic framework. Also, it would be interesting to pursue the game of chicken between the key currency country and the foreign bondholders; this was discussed – in the context of the U.S. and China – at the beginning of Section IV. Both of these extensions were beyond the scope of the present paper.

More fundamentally, we should ask why there are key currency asymmetries, and how a particular country becomes the key currency country. If we could answer these questions, we could study the competition to become the key currency country. This would be quite interesting

given the emergence of the Euro, and the belief by some that it will help Europe exert economic power on the international stage. But these are much more difficult questions.

Appendix: Estimated Model Parameters

1. Fiscal Variables

a. Government purchases

Regress: $\log(g_t)$ on a time trend and save residuals as detrended series $\text{ldt}(g_t)$

$$\text{ldt}(g_t) = \gamma + \rho_g \, \text{ldt}(g_{t-1}) + \epsilon_{g,t}$$

Data: $\log(g_t)$ = log of real government consumption and investment, NIPA Table 1.1.5, deflated to real terms using the price index for GDP

Sample: 1974:1 - 2007:4

Estimates: $\rho_g = 0.98$ (in the paper, we actually use 0.95 to avoid excess volatility)

$\sigma(\epsilon_g) = 0.0086$

b. Taxes

Regress: $\log(x_t)$ on a time trend and save residuals as detrended series $\text{ldt}(x_t)$

$$\text{ldt}(x_t) = \gamma + \rho_\tau \, \text{ldt}(x_{t-1}) + \epsilon_{x,t}$$

Data: $\log(x_t)$ = log of real current government receipts, NIPA Table 3.1, line 1, deflated by price index for GDP

Sample: 1974:1 - 2007:4

Estimates: $\rho_x = 0.90$

$\sigma(\epsilon_x) = 0.02$

2. Foreign Official Demand for U.S. Treasury Securities

Regress: $\log(b_{H,t}^{G^*})$ on a time trend and save residuals as detrended series, $\text{ldt}(b_{H,t}^{G^*})$

$$ldt(b^{G*}_{H,t}) = \gamma + \rho_B\, ldt(b^{G*}_{H,t-1}) + \epsilon_{B,t}$$

Data: $b^{G*}_{H,t}$ = foreign official holdings U.S. Treasury Securities, Flow of Funds, Table L.107, line 9 converted into real terms by dividing by the price index for personal consumption expenditures.

Sample period: 1974:1 - 2007:4

Estimates: $\rho_B = 0.964$

$\sigma(\epsilon_B) = 0.0434$

3. Elasticity of substitution in home consumption: Taken from Heathcote and Perri (2002).

4. Monetary Policy Rule

a. Interest Rate Rule, equation (32),

$$\log(R_t/\bar{R}) = \rho_R \log(R_{t-1}/\bar{R}) + (1-\rho_R)\phi_\pi \log(\Pi_t/\bar{\Pi}) + (1-\rho_R)\phi_y[\log(y_{H,t}/\bar{y}_H)] + \epsilon_{R,t}\ .$$

Parameter values ($\rho_R = 0.8$, $\phi_\pi = 2.0$, $\phi_y = 0.20$, and $\sigma(\epsilon_R) = 0.009$) are taken from Canzoneri, Cumby, and Diba (2007) who estimate a rule for the Volker-Greenspan period. We set the steady-state inflation and federal funds rates at their quarterly averages for the same period used to estimate the interest rate rule. These values are 0.7 and 1.1 percent per quarter.

b. Money Supply Rule

$$\log(M_t/M_{t-1}) = (1-\rho_M)\log(\bar{\Pi}) + \rho_M \log(M_{t-1}/M_{t-2}) + \epsilon_{M,t}.$$

Parameter values ($\rho_M = 0.5$ and $\sigma(\epsilon_M) = 0.009$) are taken from Ohanian, Stockman, and Kilian (1995).

5. CCAPM rate and Spread

We use a conventional value of β =1/1.01 to set the CCAPM rate to 4 percent per annum. Over the sample period, the real rate on three-month Treasury bills averaged about 2.4 percent per annum, which implies a spread between the CCAPM rate and the rate of three-month Treasury bills of 2.6 percent per annum or 0.65 percent per quarter.

Data: Three-month constant maturity Treasury bill rate from 1982 on. Prior to 1983, the secondary market rate on three-month bill, converted from a discount basis to an investment basis. Inflation data are computed as quarterly percent changes in the CPI-U.

6. Asset ratios

a. Treasury Securities

Data: $B_{H,t}$ = Private US holdings of Treasury Securities = Total outstanding less sum of central bank holdings, ROW holdings, and Government holdings.

Source: Flow of Funds, Table L.209.

$B_{H,t}^{G*}$ = Official ROW holdings of Treasury Securities.

Source Flow of Funds, Table L.107.

$B_{H,t}^{*}$ = Private ROW holdings of Treasury Securities.

Source Flow of Funds, Table L.107.

M_t = Currency held outside of banks.

Source Flow of Funds, Table L.108

C_t = Personal Consumption Expenditures. Source NIPA Table 1.1.5.

Sample: 1974:1 - 2007:4

$\overline{B}_H/\overline{C} = \overline{b}_H/\overline{c} = 1.00$

$\overline{M}/\overline{C} = \overline{b}/\overline{c} = 0.28$ (We round to 0.25.)

$\overline{B}_H^{G*}/\overline{C}$ = 0.63 (2007:4)

$\overline{B}_F^{*}/\overline{C}$ = 0.30 (2007:4)

We use a different sample for these two ratios to take into account the recent buildup in dollar balances both by foreign central banks and by the foreign private sector.

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Table 1: Calibration

Ratios, averages in the data

$\bar{m}/\bar{c}$	$\bar{m}^*/\bar{c}^*$	$\bar{b}_H/\bar{c}$	$\bar{b}_H^*/\bar{q}\bar{c}^*$	$\bar{b}_F^*/\bar{q}\bar{c}^*$	$\bar{b}_H^{G*}/\bar{q}\bar{c}^*$	$\bar{\tau}$, $\bar{\tau}^*$
0.25	0.25	1.00	0.30	0.70	0.59	0.008

Derived Parameters

ν	ν^*	A	A*	ς	ω_1	ω_2
0.31	0.44	0.007	0.005	0.42	0.42	0.41

Estimated Parameters (standard deviations of shock innovations are reported in the Appendix)

$\bar{\Pi}$,$\bar{\Pi}^*$	ρ_B	ρ_g	ρ_x	ρ_M	ρ_R	ϕ_π
1.007	0.96	0.95	0.90	0.5	0.8	1.5

Other Parameters

β, β^*	ξ, ξ^*	μ, μ^*	χ, χ^*	$\widetilde{R}$ - R	ζ, ζ^*	η, η^*	ϕ_d
.988	.7	.8	1	.0065	7	.9	0.024

Notes:
1. See appendix for parameters that are estimated.
2. We drop the gap term from the interest rate rules.