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**Why Do So Many Oil Exporters Peg Their
Currency? Foreign Reserves As A De-facto
Sovereign Wealth Fund**

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WHY DO SO MANY OIL EXPORTERS PEG THEIR CURRENCY?

Foreign reserves as a de-facto sovereign wealth fund[Ⓟ]

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PRELIMINARY AND INCOMPLETE DRAFT

Abstract

In developing countries, committing to a stable real exchange rate during a resource boom allows the central bank to build a de-facto sovereign wealth fund if the government fails to do so. Governments should optimally save resource revenues in a sovereign wealth fund, though this often fails due to corruption, political expediency or fear of raiding. If private agents have limited access to international capital markets, then the central bank controls net saving in the economy. During the boom the central bank will stabilize the real exchange rate below the equilibrium level by accumulating foreign reserves, which can support permanently higher consumption. Doing so replaces a sharp, temporary appreciation with a modest, permanent one; improves welfare relative to no intervention or an open capital account; and prevents raiding which would involve abandoning a very visible peg. This may explain why seventy-five per cent of resource-dependent economies peg their currency, despite the obvious short-run advantages of floating exchange rates for stabilizing commodity shocks.

Keywords: foreign reserves, international capital markets, floating exchange rate, currency peg, natural resources, Dutch disease, sovereign wealth fund

JEL codes: E12, E13, E42, E52, F30, F41, H30, H63, Q00

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1. Introduction

Many developing countries now enjoy the receipt of substantial revenue from commodity exports, with 55% of resource-dependent economies being low- or middle-income (Baunsgaard et al., 2012). These resource windfalls are both temporary and volatile, posing a challenge for fiscal and monetary policymakers. In practice 74% of developing resource-dependent economies peg their exchange rate, compared to 66% of others; see table 1. At first glance this seems undesirable, because it removes the possibility of independent monetary policy stabilizing shocks from commodity prices (Wills, 2013).

This paper considers why exchange rate pegs are so prevalent amongst commodity exporters. In particular, we propose that committing to a stable real exchange rate is a way of the central bank accumulating a de-facto sovereign wealth fund, if governments fail to do so for fear of raiding. In developing countries there is limited public and private financial development. Governments will ideally save resource revenues in a sovereign wealth fund,¹ but may spend them instead because of fears the fund will be raided by political rivals. The private sector is unlikely to address this because of limited access to international capital markets, so capital accounts are effectively closed.² The central bank will typically have much better access to international capital markets, and so by targeting a depreciated real exchange rate during the commodity boom they will accumulate foreign reserves.³ ⁴ These reserves can be drawn down to maintain a permanently higher level of consumption after the boom has ended. This has the added advantage of stabilizing the sharp and temporary real appreciations associated with Dutch disease (Corden and Neary, 1982). It also addresses the problem of raiding, as political parties will find it more difficult to raid central bank reserves than a SWF, as doing so would involve abandoning a very visible exchange rate peg.

At first glance, commodity exporters should let their exchange rate float, allowing independent monetary policy to respond to commodity shocks. Devaluations of the exchange rate are often seen as an

¹ This is in line with Friedman's (1957) permanent income hypothesis as has been developed in a resource context by van der Ploeg and Venables (2012) amongst others.

² The average score of resource-dependent economies on the Chinn Ito (2006) index of capital account openness is 0.38, compared to a global average of 0.56.

³ Similar arguments have been made by Bacchetta and Benhima (2013) to explain why during growth acceleration episode it is optimal to have an initial appreciation of the real exchange rate combined with an accumulation of foreign reserves, which is consistent with the Chinese experience. This study also shows that the initial depreciations are followed by an appreciation of the real exchange rate in the long run and that these policies yields a path for the optimal exchange rate which is not that different from the one that would result in an economy with full capital mobility and no central bank intervention.

⁴ Evidence on Latin-American countries provided by Aizenman et al. (2011) suggests that the active management of international reserves and exchange rates lowers the short-run impact of commodity terms of trade shocks in significantly but also affects the long-run adjustment of the real exchange rate, effectively lowering its volatility. This study also finds that relatively small increases in holdings of reserves is an almost as effective a tool as a fixed exchange rate regime in insulating the economy from commodity terms of trade shocks.

appropriate response to macroeconomic shocks that impair a country's competitiveness when nominal prices and wage are rigid, providing a case for floating exchange rates (Friedman, 1953). Floating exchange rates have been shown to benefit commodity exporters, because the real appreciation during a commodity boom (Dutch disease) can be achieved through the nominal exchange rate, rather than domestic inflation and the output gap; they also allow a sharp monetary loosening ahead of the windfall to avoid unemployment caused by forward-looking inflation (Eastwood and Venables, 1982; Wills, 2013). In many of modern new Keynesian DSGE models the degree of fluctuation in output will be optimized if the central bank keeps inflation stable which has been coined "divine coincidence" (Blanchard and Galí, 2007), but more generally this property does not hold in which case it may be appropriate to add a real exchange rate to the Taylor rule for the nominal interest rate.⁵ These results assume that capital accounts are open, which may not be relevant for developing countries.⁶

Table 1: Monetary regimes in resource-dependent economies

Monetary regimes in resource dependent economies

	USD Peg	Other Peg	Monetary Target	Inflation Target	Other	
	Iraq Angola Guyana Kazakhstan Mongolia Saudi Arabia Bolivia Mauritania Timor-Leste Suriname Trinidad & Tobago Turkmenistan Venezuela Vietnam Yemen	Ecuador Bahrain Oman UAE Qatar	Cameroon Chad Rep. of Congo Equatorial Guinea Gabon Mali Kuwait Libya Russia Syria Botswana Iran Azerbaijan Algeria Brunei	Guinea Nigeria PNG Sudan Zambia	Indonesia Peru Chile Mexico Norway	Malaysia Dem. Rep. of Congo
Number	20	15	5	5	2	
% RDEs	43%	32%	11%	11%	4%	
% Total	34%	26%	11%	23%	6%	

Source: IMF, 2008

⁵ Empirical evidence suggests that, in fact, only the Bank of Canada includes the nominal exchange rate in its policy rule whereas the central banks of Australia, New Zealand and the UK do not (Lubik and Schorfheide, 2007).

⁶ A possible alternative which is often commented upon in policy circles is to have fiscal devaluations (de Mooij and Keen, 2012). Indeed, Keynes (1931) has argued that devaluation can be mimicked by uniform ad valorem tariff on all imports in combination with a uniform subsidy on all exports. It is also possible to mimic devaluation with uniform hike in value added taxes and a cut in payroll taxes in dynamic settings with complete and incomplete asset markets and varying degrees of price rigidity (e.g., Farhi et al., 2011). With producer currency pricing such fiscal policies can yield the worsening of the terms of trade (i.e., making home goods less expensive compared with foreign goods), which would otherwise be obtained with a devaluation of the nominal exchange rate. Farhi et al. (2011) show that, with incomplete markets and debt being dominated in the home currency, one also needs a partial default which can be achieved with a uniform reduction in consumption taxes and an increase in income taxes.

However, empirical evidence suggests that floating exchange rates may be less effective at stabilizing real fluctuations than previously thought. Towbin and Weber (2013) show that floating exchange rates are less effective than pegs at stabilizing GDP through expenditure switching, if exchange rate pass-through is low or foreign-currency debt is high. Chinn and Wei (2013) use a dataset of 170 countries for the period 1971-2005 to show there is no strong, robust or monotonic relationship between exchange rate flexibility and the rate of current account reversion, even correcting for economic development and trade and capital account openness. Furthermore, empirical evidence suggests that many countries which are classified as having a floating exchange regime in fact do not and appear to have a fear of floating (Calvo and Reinhart, 2002).

Other work has identified advantages of exchange rate pegs, particularly in developing countries, though alone they cannot explain the prevalence of pegs amongst commodity exporters. The first is central bank credibility, which can be improved by anchoring the exchange rate to a strong currency. Indeed, the majority of the electorate would prefer a central banker that is more conservative than the median voter (Rogoff, 1985) or alternatively prefer a fairly rigid peg of the nominal exchange rate. The second is trade costs, which can be lowered by reducing hedging and transaction costs when trading within a monetary union. The European Union and the upcoming East African Monetary Union (from 2015) are examples of this. The case for a peg or a monetary union is better if the disadvantages of not being able to adjust the exchange rate smaller which occurs in international labor mobility and wage and price flexibility are bigger. The third is political reasons, either as a precursor to deeper union or to improve diplomatic influence, which has also characterized these unions. For these reasons to explain the prevalence of pegs amongst commodity exporters one must argue that commodities reduce the credibility of the central bank, or increase transaction and hedging costs.

This paper proposes an additional advantage for developing commodity exporters to peg their exchange rate: accumulating foreign reserves as a de-facto sovereign wealth fund. Committing to a stable real exchange rate requires the central bank to accumulate foreign reserves during the boom, which act as a de-facto sovereign wealth fund afterwards. This has the additional benefit of avoiding the welfare costs of a volatile real exchange rate, when the government spends commodity revenues as they are received. It also avoids the political challenges of sovereign wealth funds being raided. Crucially it requires the capital account to be at least partially closed, so central bank reserve policy is not reversed by the private sector. More generally, there is no market exchange rate solution for an immature credit country in which the exchange rate risks for private banks and financial institutions are too great to be financial intermediaries (McKinnon, 2010).

The policy works as follows. We assume the government spends all income from a temporary, anticipated oil boom as it is received, and the central bank has the country's only access to international capital. On discovering oil the central bank commits to a slight but permanent appreciation of the real exchange rate. Before the windfall this involves selling foreign assets to lend to the private sector, allowing aggregate consumption to rise. During the windfall the central bank will need to accumulate reserves, borrowing from households to constrain consumption and prevent the exchange rate appreciating. After the windfall the interest on reserves should be transferred to households, permanently lifting consumption and supporting the real exchange rate above its equilibrium level.

The policy has three major benefits. The first is that accumulating a sovereign wealth fund to finance permanent consumption is the first-best policy for managing a temporary windfall.⁷ A currency peg allows the central bank to do this if the government does not, due to corruption (e.g. Nigeria), political expediency (e.g. Ghana's 2008 and 2012 elections), or raiding (e.g. Nauru's Phosphate Royalties Trust). The second is that it stabilizes the real exchange rate, removing the need for disruptive changes to the terms of trade. The third is that politicians are less likely to raid central bank reserves, and abandon highly visible exchange rate pegs.

The policy also benefits all elements of society, and is particularly attractive when many households are financially constrained. We separate society into households with access to capital markets (Ricardians), and those without (hand-to-mouth). The accumulation of central bank reserves essentially encourages more saving by Ricardians during the oil boom, which can sustain a higher level of consumption in perpetuity. Hand-to-mouth consumers also benefit, because the expenditure smoothing by other households with access to capital markets provides a source of income after the boom ends. If there are relatively fewer Ricardian consumers, then they must do relatively more smoothing and in turn will have more permanent income – so the policy works best in developing countries.

The success of this policy depends crucially on the openness of the capital account, according to the Mundellian trilemma. If the capital account is perfectly open, so home and foreign financial assets are perfect substitutes, any accumulation of foreign reserves by the central bank will be offset by domestic assets purchased by foreigners. The nominal exchange rate peg could only be achieved by setting the nominal rate of interest equal to the world rate of interest (e.g., Wills, 2013). If the capital account is partially open, with domestic and foreign financial assets held as imperfect substitutes in a portfolio of assets, this will require very large flows on behalf of the central bank. If the central bank holds foreign

⁷ This is based on Friedman's permanent income rule, when capital is abundant. However, many developing countries have imperfect access to international capital markets and their optimal policy should be to invest in the domestic economy to overcome capital scarcity (e.g., van der Ploeg and Venables, 2012). To focus on the role of central banks in accumulating foreign assets, we abstract from investment and capital accumulation.

assets, other investors will need to hold more domestic assets. To do this the central bank would need to a significant intervention on the global scale, to see a substantive change in the relative return of home and foreign assets. However, if the capital account is closed then the central bank can perfectly control net saving in the economy, as accumulated reserves will not be offset by private flows.

The use of a currency peg as a de-facto sovereign wealth fund is also consistent with observed practice. In practice, resource-dependent economies (RDEs) that peg have very closed capital accounts. The average Chinn-Ito openness score for RDEs that peg (0.2) is much lower than both RREs that don't peg (0.89) and non-RREs that do peg (0.48). RDEs that peg also tend to accumulate large central bank reserves.⁸ The average central bank reserves to GDP ratio is 27% for RDEs that peg, but only 16% for non-RDEs that peg and 14% for countries that do not peg.

However, interestingly, RDEs that peg are both more likely to have a sovereign wealth fund, and have larger funds on average. 63% of RDEs that peg have a fund, compared to 50% that do not peg. The average size of the fund is 50% of GDP for peggers (excluding Timor Leste), but only 28% for countries that do not peg their currency.

This final observation can still be reconciled with currency pegs creating de-facto sovereign wealth funds, as they tie the hands of future governments. If a government chooses to establish a fund then raiding by opponents will be a concern. Under a floating currency regime, if the fund is raided and spent, then there will not be any offsetting net saving by households because of poor financial access. Under a fixed currency regime, the central bank will need to accumulate foreign reserves, so the net effect is wealth being moved from the fund to the central bank. Governments that are ultimately interested in welfare thus benefit from a peg, even if they establish a SWF.

We proceed as follows. Section 2 begins by illustrating the stabilizing effect of floating exchange rates during commodity booms, revisiting the work by Wills (2013). This uses a short-run DSGE model of a small open economy following Galí and Monacelli (2005), where capital markets are frictionless and the government does not, or cannot, use a sovereign wealth fund to smooth its oil expenditure. In this setting a nominal exchange rate peg, achieved by setting the nominal interest rate equal to the world interest rate,

⁸ Empirical evidence that attempts to explain the surge in foreign reserves points to the size of domestic liabilities that could potentially be converted into foreign currency, financial openness and the ability to access foreign currency through debt markets as well as exchange rate policy as significant predictors of foreign reserve holdings (Obstfeld, et al., 2010). Earlier empirical evidence also pinpointed to sovereign risk and costly tax collection to cover higher funded and unfunded fiscal liabilities as important determinants of precautionary foreign reserve holdings but less so for countries with substantial corruption, high discount rates and political instability (Aizenman and Marion, 2003).

performs worse than a float. For example, a float is better able to offset the unemployment caused in the announcement phase when the real exchange rate appreciates ahead of the windfall.⁹

Section 3 then introduces a real model of a developing country. This allows for diversity in the population, with Ricardian households who have access to domestic capital, and hand-to-mouth households who do not (as in Galí et al. 2007). The model allows for both open and closed capital accounts, with the latter giving a role for central bank reserve policy.

Section 4 illustrates how a developing country would respond to an oil boom when capital markets are open, showing that hand-to-mouth consumers piggyback on Ricardian households. The ability of Ricardian households to borrow internationally allows them to increase consumption before and after an oil boom. This increases demand for home goods, increasing employment, and in turn consumption, of hand-to-mouth consumers.

Section 5 then shows how an exchange rate peg can accumulate a de-facto commodity sovereign wealth fund, when the capital account is closed. We illustrate the mechanism and show that it improves welfare relative to an open capital account for all members of society.

Section 6 concludes and qualifies some of our policy messages.

2. Short-run considerations: the stabilizing effects of floating nominal exchange rates

This section illustrates the stabilizing effects that floating nominal exchange rates can have on domestic inflation and output during commodity booms (based on Wills, 2013). It is based on a DSGE model of a small-open economy with home and foreign goods and all households having access to international capital markets (cf., Galí and Monacelli, 2005), which is applicable to developed resource-exporters such as Australia, Norway, and the UAE. We assume that the government spends all revenues from an anticipated, temporary oil windfall as they are received on domestic goods. This requires the real exchange rate (also the terms of trade) to appreciate twice: when households learn of the oil wealth, and again when government spending begins. If the nominal exchange rate is fixed, then this appreciation must happen entirely through domestic inflation, which is costly. If the exchange rate is floating, then the appreciation can happen through the nominal exchange rate, through a sharp monetary loosening just before government spending begins.

The model can be summarized by the dynamic IS curve and a Phillips curve in (1), respectively,

⁹ We abstract from learning by doing and Dutch disease in which case stabilization of the nominal exchange rate might be highly distorting because it leads to misallocation of resources in other sectors of the economy (e.g., Lama and Medina, 2012).

$$(1) \quad \begin{aligned} \hat{y}_t &= E_t[\hat{y}_{t+1}] - (i_t - E_t[\pi_{H,t+1}] - \rho) - (1 + \varphi)E_t[\Delta\hat{y}_{t+1}^n] \\ \pi_{H,t} &= \beta E_t[\pi_{H,t+1}] + \lambda(1 + \varphi)(\hat{y}_t - \hat{y}_t^n) \end{aligned}$$

where \hat{y}_t is the output gap, $\pi_{H,t}$ is home good inflation, i_t is the nominal interest rate, $\beta=1/(1+\rho)$ the discount factor, φ the elasticity of labor supply and \hat{y}_t^n the natural level of output. This differs from the standard New Keynesian IS and Phillips curves by the change in the natural level of output, $\hat{y}_t^n = \phi_1 r b_t + \phi_2 \hat{g}_t$, which depends on the amount of resource revenues released by the government each period, $r b_t$, and the relative wealth of home vs foreign households, \hat{g}_t . The openness of the capital account means that households can readily borrowing from abroad if their lifetime wealth increases, even if they have not started to receive income. This allows oil revenues to change the natural level of output in the economy, and inflation and output to respond in anticipation.

Optimal monetary policy is found by minimizing a micro-founded central bank loss function, and is closely approximated by the Taylor rule in (2). Again, this differs from a standard rule by the way it responds to the expected change in the natural level of output. The intuition is that forward-looking firms and households will respond in advance to news of an oil discovery, so the central bank should do so as well. This is compared to a monetary rule that stabilizes the nominal exchange rate, by setting the nominal interest rate equal to the rest of the world.

$$(2) \quad (i_t - \rho) = \theta_1 \hat{y}_t + \theta_2 \pi_{H,t} + \theta_3 E_t[\Delta\hat{y}_{t+1}^n]$$

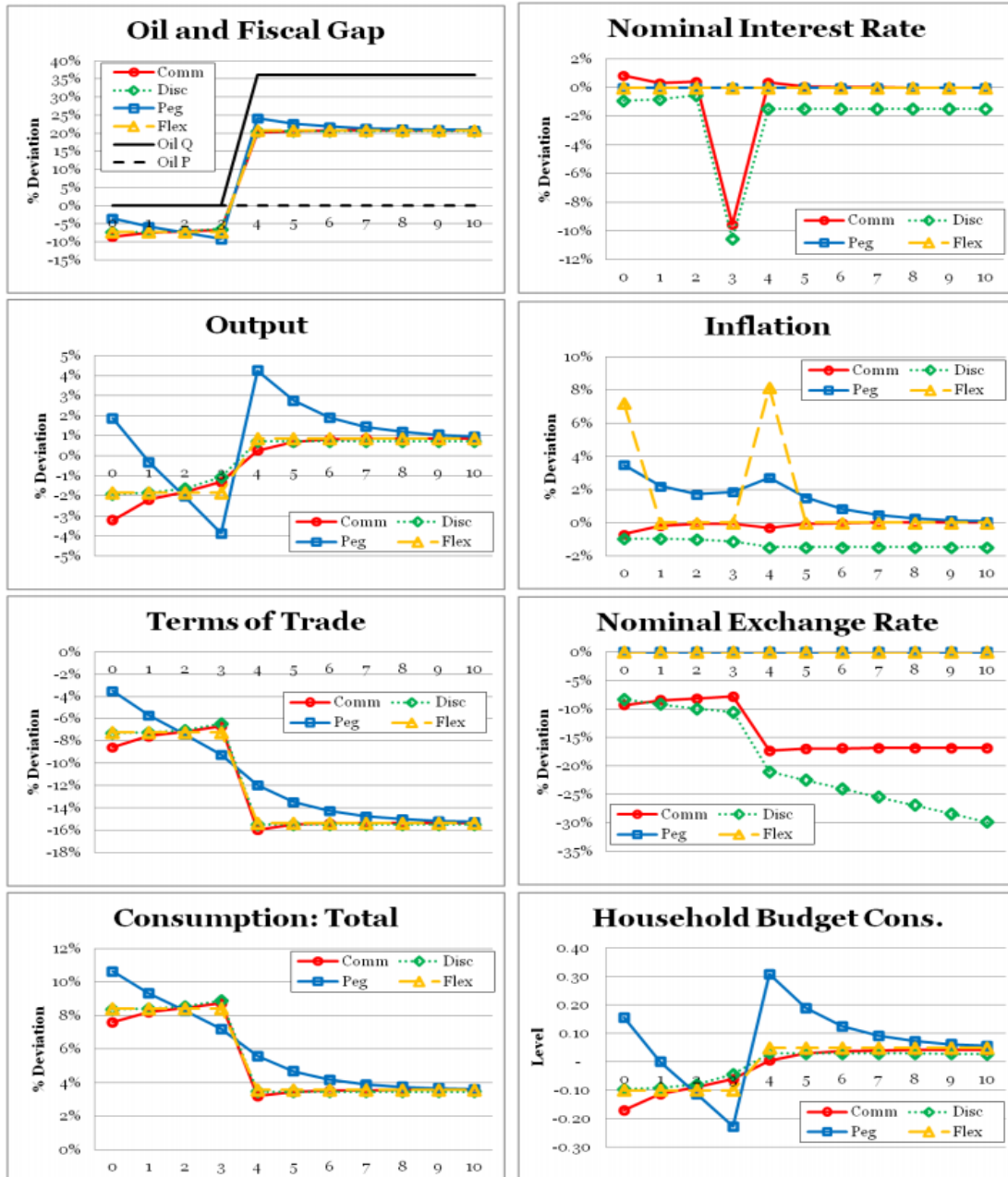
Figure 1 illustrates the effects of an anticipated oil windfall under flexible prices (yellow), and three monetary regimes: a nominal exchange rate peg (blue), optimal policy under commitment (red) and under discretion (green).¹⁰ Focusing on the flexible price case, when oil is discovered oil the real exchange rate will need to appreciate twice. The first is at discovery, when households learn they are wealthier and so smooth their lifetime consumption by borrowing on international capital markets. The second is when government spending begins, which increases demand for non-traded goods – driving up their price and squeezing out private consumption.

This figure illustrates the poor response of a nominal exchange rate peg to an oil windfall, when the capital account is open. When capital is frictionless the exchange rate must be pegged by fixing the nominal interest rate. The two real appreciations (increases in the price of home versus foreign goods) can then only occur slowly through domestic inflation, which extends throughout the anticipation period, $t = [0:4]$. The inflation is both backward-looking, as firms respond to the initial demand from households,

¹⁰ Based on calibration taken from Galí and Monacelli (2005) and Galí et al. (2007).

and forward-looking, as they anticipate future demand from the government. The latter causes output to fall below its natural (flexible-price) level, resulting in a recession. Welfare in this example is 8% lower under a pegged currency than that under optimal monetary policy with commitment.

Figure 1: Optimal response to an announced, known oil discovery (Wills, 2013).



Optimal policy involves forcing the entire real appreciation through the nominal exchange rate, by sharply loosening policy immediately before the windfall. This is true under both commitment and discretion, and results from households and firms anticipating an optimal response from the central bank.

A sharp, temporary loosening allows the central bank to appreciate the nominal exchange rate when government spending begins. This means relative prices adjust through a single, flexible price rather than many, sticky ones. Discretion is similar to commitment, but suffers a deflationary bias from trying to appreciate the currency and exploit the buying power of offshore oil wealth, resulting in welfare 1% lower than optimal policy under commitment. The Taylor rule in (2) only has a welfare loss of 0.25% relative to commitment. This confirms the message of Friedman (1953) and others that economies facing demand shocks that affect their terms of trade should not relinquish their monetary policy and have a floating exchange rate.

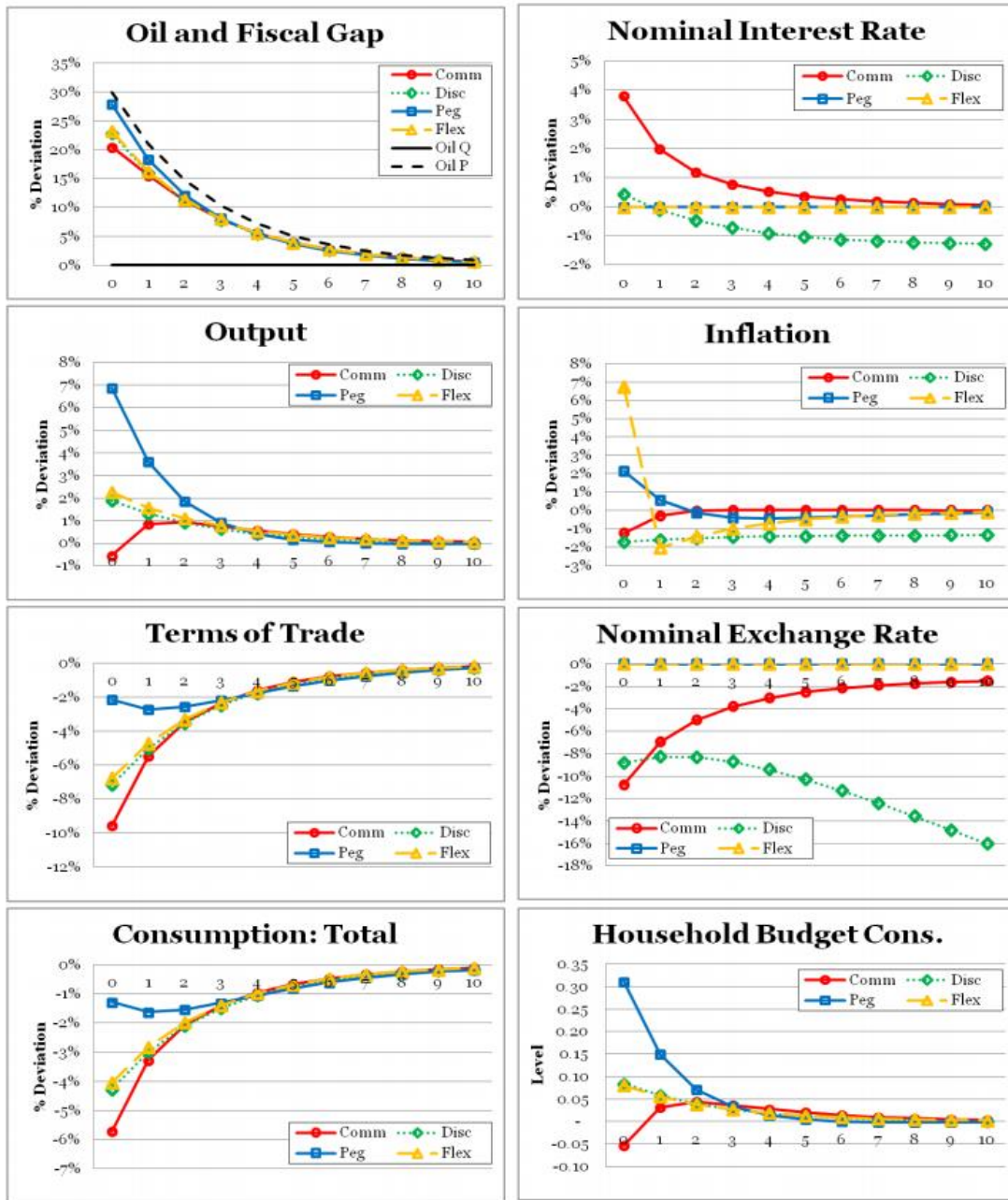
Figure 2 illustrates that output and inflation also respond much less to oil price shocks under floating exchange rates. A one standard deviation shock to the change in the oil price leads to a standard deviation in output ($s.d.(\hat{y}_t)$) of 0.23 under a peg, 0.06 under a discretionary float and only 0.05 under a float with commitment, as reported in table 2. The volatility of inflation ($s.d.(\hat{\pi}_{H,t})$) is 7 times higher under a peg than a float. Of course, the nominal currency peg leads to no volatility in the nominal exchange rate ($s.d.(\hat{e}_t)$) and to much less volatility in the real exchange rate ($s.d.(\hat{s}_t)$). Interestingly, the volatility of consumption ($s.d.(\hat{c}_t)$) is less under a peg than a float. We conclude in line with Friedman (1953) that fixed exchange rates are less effective at absorbing commodity shocks than floating, when the capital account is open.

Table 2: Volatility of various regimes

Standard Deviation of Key Variables

Variable	Comm	Disc	Peg	TR	TR*
$\hat{p}_{O,t}$	1.00	1.00	1.00	1.00	1.00
\hat{g}_t	0.75	0.76	0.92	0.81	0.78
$\pi_{H,t}$	0.01	0.01	0.07	0.04	0.01
\hat{y}_t	0.05	0.06	0.23	0.11	0.08
\hat{s}_t	0.25	0.24	0.07	0.19	0.22
\hat{e}_t	0.26	0.25	0	0.14	0.21
\hat{c}_t	0.15	0.14	0.04	0.11	0.13

Figure 2: Impulse responses to oil price shocks in the presence of price rigidities



3. The model

Let us now consider a real version of the model discussed in section 2, but extended to the case of a developing country by allowing for a proportion of hand-to-mouth consumers (cf., Galí, López-Salido and Vallés, 2007).

Households, firms and fiscal authority

There is a continuum of infinitely-lived households, $i \in [0, 1]$. A proportion $1 - \lambda$ are Ricardian households (R) with the remainder being hand-to-mouth households (M). Aggregate welfare, consumption and labor supply are given by $U_0 = (1 - \lambda)U_0^R + \lambda U_0^M$, $C_t = (1 - \lambda)C_t^R + \lambda C_t^M$ and $N_t = (1 - \lambda)N_t^R + \lambda N_t^M$, respectively. Let us define public consumption, G_t , the consumer price index, P_t , the price of home final goods, $P_{H,t}$, the wage rate, W_t , lump-sum taxes, T_t^R and T_t^M , and private domestic assets at time t as D_t which earn real interest rate r_t . Both sets of households maximize utility subject to their budget constraint:

$$\begin{aligned} \max_{C_t, N_t, D_t} U_0 = E_0 \left[\sum_{t=0}^{\infty} \beta^t \left\{ (1 - \chi) \ln(C_t^i) + \chi \ln(G_t) - \frac{N_t^{1+\varphi}}{1+\varphi} \right\} \right] \\ \text{s.t. } P_t C_t^i \leq W_t N_t^i - P_{H,t} T_t^i - E_t \left[\frac{1}{1+r_t} D_{t+1}^i \right] + D_t^i, \quad \text{for } i = [R, M] \end{aligned}$$

where $0 < \beta < 1$ is the discount factor, $0 < \chi < 1$ is the relative weight given to private rather than to public goods, and $\varphi > 0$ is the inverse of the wage elasticity of labor supply.

Assuming the labor market is competitive, labor supply for both households is given by

$N_t^i = \left[(1 - \chi) (W_t / (P_t C_t^i)) \right]^{\frac{1}{\varphi}}$ for $i = [R, M]$. This is an increasing function of the real consumption wage and a decreasing function of total wealth or consumption.

Ricardian households are the only ones with access to domestic financial assets, $D_t^R = D_t$. Using these assets they allocate consumption between periods according to the following Euler equation:

$$(1) \quad C_{t+1}^R / C_t^R = \beta(1 + r_t) P_t / P_{t+1}$$

The growth rate in consumption thus depends on the discount factor, the real interest rate, and changes in relative prices over time. Hand-to-mouth households do not have access to domestic financial assets, $D_t^M = 0 \forall t$. Each period they must therefore consume their labor income net of taxes, $S_t^{\alpha} C_t^M = (W_t / P_{H,t}) N_t^M - T_t^M$.

Both households allocate consumption across a Cobb-Douglas bundle of home goods $C_{H,t}^i = (1 - \alpha) P_t C_t^i / P_{H,t}$, and a bundle of foreign goods $C_{F,t}^i = (1 - \alpha) P_t C_t^i / P_{F,t}$, where the budget share of home goods is given by $0 < \alpha < 1$, the prices of home and foreign goods are given by $P_{H,t}$ and $P_{F,t}$,

respectively, and the (ideal) consumer price index is given by $P_t = P_{H,t}^{1-\alpha} P_{F,t}^\alpha$. The real exchange rate is the relative price of foreign goods, $S_t = P_{H,t} / P_{F,t}$.

Firms produce a differentiated good according to a linear production function, $Y_t(i) = A_t N_t(i)$. Prices are flexible. The fiscal authority does not smooth consumption. It thus spends all oil revenues on home goods so that $G_t = S_t P_{O,t} O_t + (1-\lambda)T_t^R + \lambda T_t^M$, where $P_{O,t}$ is the world price of natural resources (“oil”) and O_t the production/exports of oil.

Household assets and capital account openness

If the capital account is open, then consumption by Ricardian households will be linked to the rest of the world by a single internationally traded asset, paying a constant real interest rate $r_t = r^*$. We suppose that the economies of the rest of the world are advanced and do not have hand-to-mouth consumers. Combining the Euler equations of Ricardian home and foreign consumers then gives

$$(2) \quad \beta \left(\frac{C_t^R}{C_{t+1}^R} \right) \left(\frac{P_t}{P_{t+1}} \right) = \frac{1}{1+r_t} = \beta \left(\frac{C_t^*}{C_{t+1}^*} \right) \left(\frac{P_t^*}{P_{t+1}^*} \right) \left(\frac{\varepsilon_t^*}{\varepsilon_{t+1}^*} \right),$$

where ε_t^* is the nominal exchange rate, which we can set without loss of generality to one as the model is real. Using the present value private sector budget constraints, we get the condition for risk sharing across Ricardian home and foreign consumers: $C_t^R = \Theta_t C_t^* S_t^{1-\alpha}$, where C_t^* is aggregate foreign consumption

and $\Theta_t \equiv E_t \left[\sum_{s=0}^{\infty} \beta^s (W_{t+s}^R N_{t+s}^R - P_{H,t+s} T_{t+s}^R) / \sum_{s=0}^{\infty} \beta^s (W_{t+s}^* N_{t+s}^* - P_{H,t+s}^* T_{t+s}^*) \right]$ is a correction for asymmetric

lifetime wealth following Wills (2013). If all foreign countries are identical, then $\Theta_t^f = \Theta_t^R, \forall f$.

If the capital account is closed then consumption by Ricardian households will be unlinked from the rest of the world, and affected by central bank policy. The rate of return on domestic assets will differ from foreign assets, $r_t \neq r^*$. In this case we assume that households cannot access international capital markets, but the central bank can. Therefore central bank policy will affect the domestic real interest rate, and in turn consumption.

Central Bank reserves

The central bank’s balance sheet holds assets, in the form of foreign currency reserves F_t , and liabilities, in the form of household’s domestic assets, D_t . This financial sector is a reduced-form way of describing households holding deposits with commercial banks, who in turn hold a net position at the central bank. Domestic assets are thus net savings by the private sector. The central bank’s budget constraint is

$D_{t+1} - (1 + r_t)D_t = S_{t+1}F_{t+1} - (1 + r^*)S_tF_t + \pi_t$, where $\pi_t = r^*S_tF_t - r_tD_t$ are the profits generated by the central bank receiving a different rate of return on domestic assets (see Bachetta and Benhima, 2012; Bachetta et al., 2013).

If the capital account is open, then $r_t = r^*$ and any change in central bank reserves will immediately be countered by a change in private financial assets. The central bank's reserve policy will have no effect on real interest rates or consumption.

If the capital account is closed, then the central bank can manipulate the real interest rate by changing how many foreign reserves it holds. We transfer central bank profits directly to households, so that if $D_0 = S_0F_0$ then any change in domestic assets must be accompanied by a change in foreign assets, $D_{t+1} = S_{t+1}F_{t+1}$. Buying foreign reserves will involve issuing more private debt to households, and in turn reduce demand in the economy.

4. Open capital account: Hand-to-mouth households piggyback on Ricardian households

This section illustrates how a developing country would respond to an oil discovery if the capital account was open, such as in Botswana, Guyana, Indonesia and Yemen (Chinn and Ito, 2006). If the government does not smooth consumption then Ricardian households will do so instead, as in section 2. The presence of Ricardians benefits hand-to-mouth consumers by providing income when they wish to borrow from abroad but cannot, as illustrated in figure 3.

The effect of an oil discovery is as follows. On discovering oil Ricardians consume more, to smooth their greater lifetime wealth. This leads to upward pressure on home prices and thus to an appreciation of the real exchange rate. Hand-to-mouth consumers cannot borrow against the future windfall. However, Ricardian consumption boosts the price of home goods, and in turn the wage of hand-to-mouth households. This can be spent on relatively cheaper foreign goods. At the point that the windfall kicks in, government spending increases and hand-to-mouth consumers benefit again from the real appreciation and ensuing boost in real wages. At discovery the real appreciation and jump in consumption of goods and leisure will be smaller if there are fewer Ricardian consumers. In the case where all households are hand-to-mouth (purple lines) the real appreciation during the boom is sharpest, while it is smoothed when all households are Ricardian (blue lines).

Figure 3: Temporary inequality with an open capital account¹¹

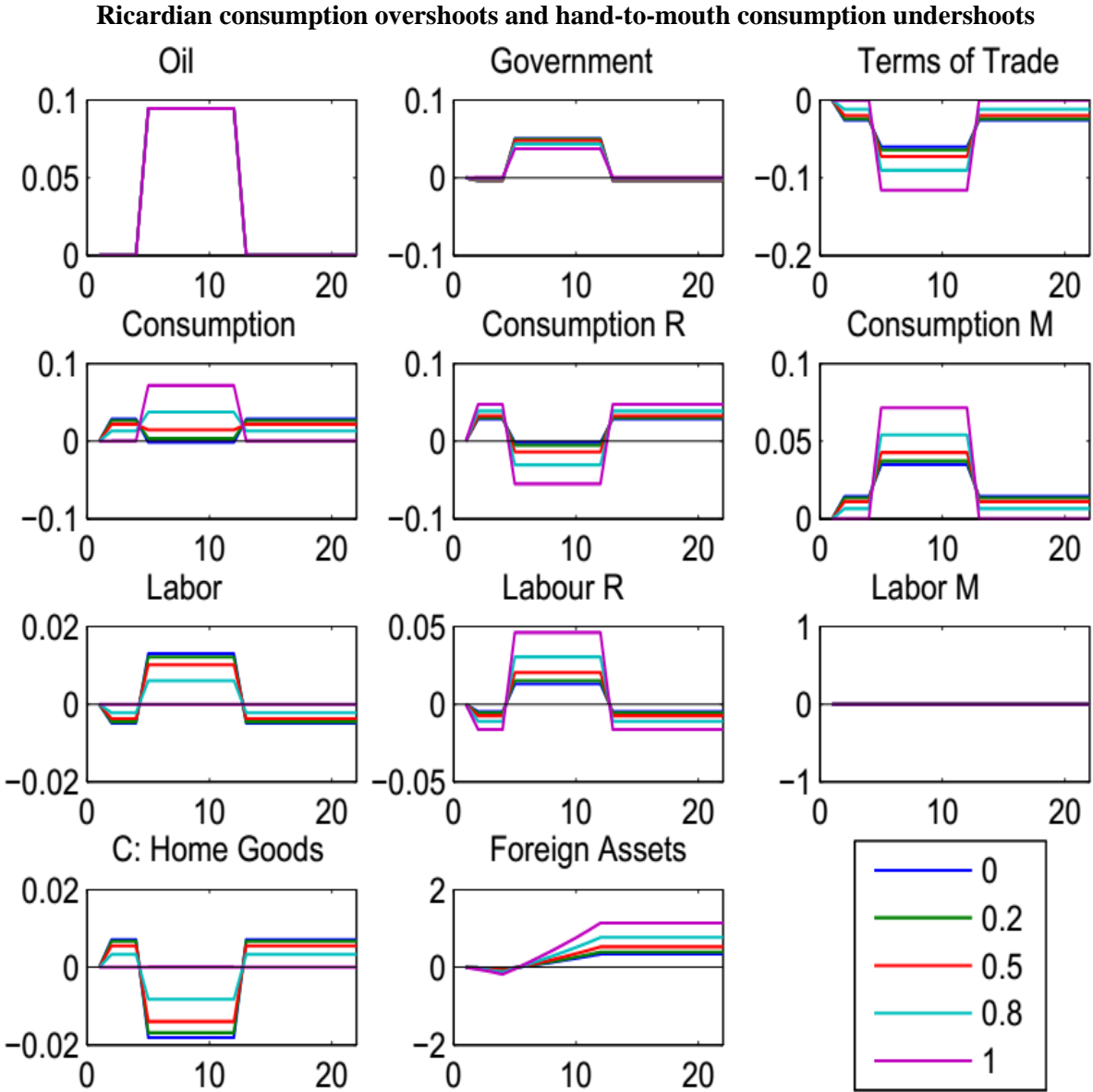
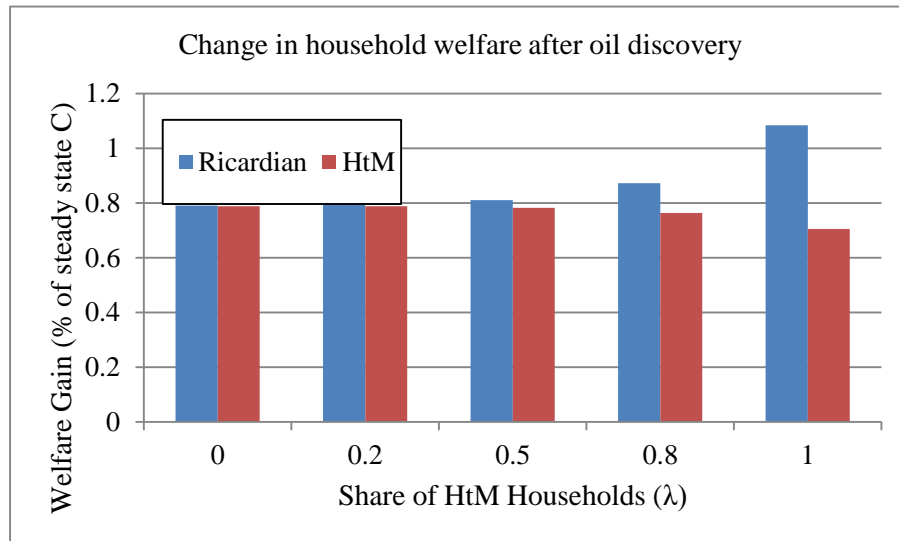


Figure 4 below indicates that the welfare of Ricardian consumers is higher with fewer other Ricardians, whilst that of hand-to-mouth consumers is lower. Each Ricardian suffers from having other Ricardians, as they provide competition for non-traded goods, driving up their relative price before and after the windfall. In contrast, hand-to-mouth consumers benefit from having more Ricardians, as the smoothing by the latter provides a source of income for the former, when they would like to spend it.

¹¹ Based on the calibration $\alpha=0.04, \rho=0.01, \varphi=3, \chi=0.2, i=0.05, T_R=T_M=0.2$ for various $\lambda=[0,0.2,0.5,0.8,1]$.

Figure 4: Welfare effects of an anticipated windfall on Ricardian and hand-to-mouth consumers

5. Closed capital account: Using an exchange rate peg as a de-facto sovereign wealth fund

We now illustrate how a central bank can use an exchange rate peg to build a de-facto commodity sovereign wealth fund – if the government is failing to do so. Once again we assume that the government spends all oil revenues as they are received. On discovering oil the central bank lets the real exchange rate appreciate slightly and permanently. This can significantly improve welfare, both relative to a case with a closed capital account and no central bank intervention and, perhaps more surprisingly, relative to an open capital account. The improvement in welfare is spread throughout society. While we focus on stabilizing the real exchange rate, this will also underpin a stable nominal currency peg. We begin with a government that is not behaving optimally and building a sovereign wealth fund (e.g., van der Ploeg and Venables, 2012). Instead, it spends resource revenues as they are received. This lack of saving has been witnessed repeatedly in practice, from Norway during the 1980s, to Nigeria, and Ghana during its elections.

On discovering oil we allow the central bank to permanently appreciate the exchange rate, as illustrated in figure 5. This is achieved by manipulating the consumption of Ricardian households via the real interest rate. Prior to the windfall the central bank sells foreign assets, to lend to domestic households and lower the real interest rate. This allows the Ricardians to increase consumption, and in turn the hand-to-mouth consumers to piggyback as before. During the resource bonanza foreign reserves will be accumulated by raising the real interest rate and borrowing from Ricardian households. This involves a significant reduction in consumption by Ricardians to accommodate the large fiscal expansion. Hand-to-mouth consumers are unaffected, because their income from Ricardian consumption is just replaced by

government consumption. After the boom the interest on foreign assets is paid back to domestic households, which enables the economy to sustain a permanent increase in consumption by both Ricardian and hand-to-mouth households.

Choosing the appropriate level for the real exchange rate is crucial, and will depend on expectations of future oil revenues. Leaving the real exchange rate at its pre-oil-discovery level will not allow households to consume any of the oil wealth that has been discovered. Instead, they will all be saved abroad in the form of central bank foreign exchange reserves, as seen in red in figure 5. Allowing the exchange rate to appreciate above its permanent income level may be sustainable during the boom, but will eventually require accumulating debt in the interests of sustaining the peg, in green.

Stabilizing the real exchange rate improves welfare relative to the case without central bank intervention. If a country's capital account is closed, then the only way that there can be net savings is via the central bank accumulating foreign assets. Failing to accumulate foreign reserves constrains the economy's Ricardian households to behave like hand-to-mouth consumers, because they will all wish to save at the same time. Therefore, without central bank intervention all the resource revenues will be consumed during the windfall, leading to a sharp, temporary appreciation of the real exchange rate. This reduces welfare relative to the pegged real exchange rate, as seen in table 3.

Table 3: Comparing welfare under different interventions

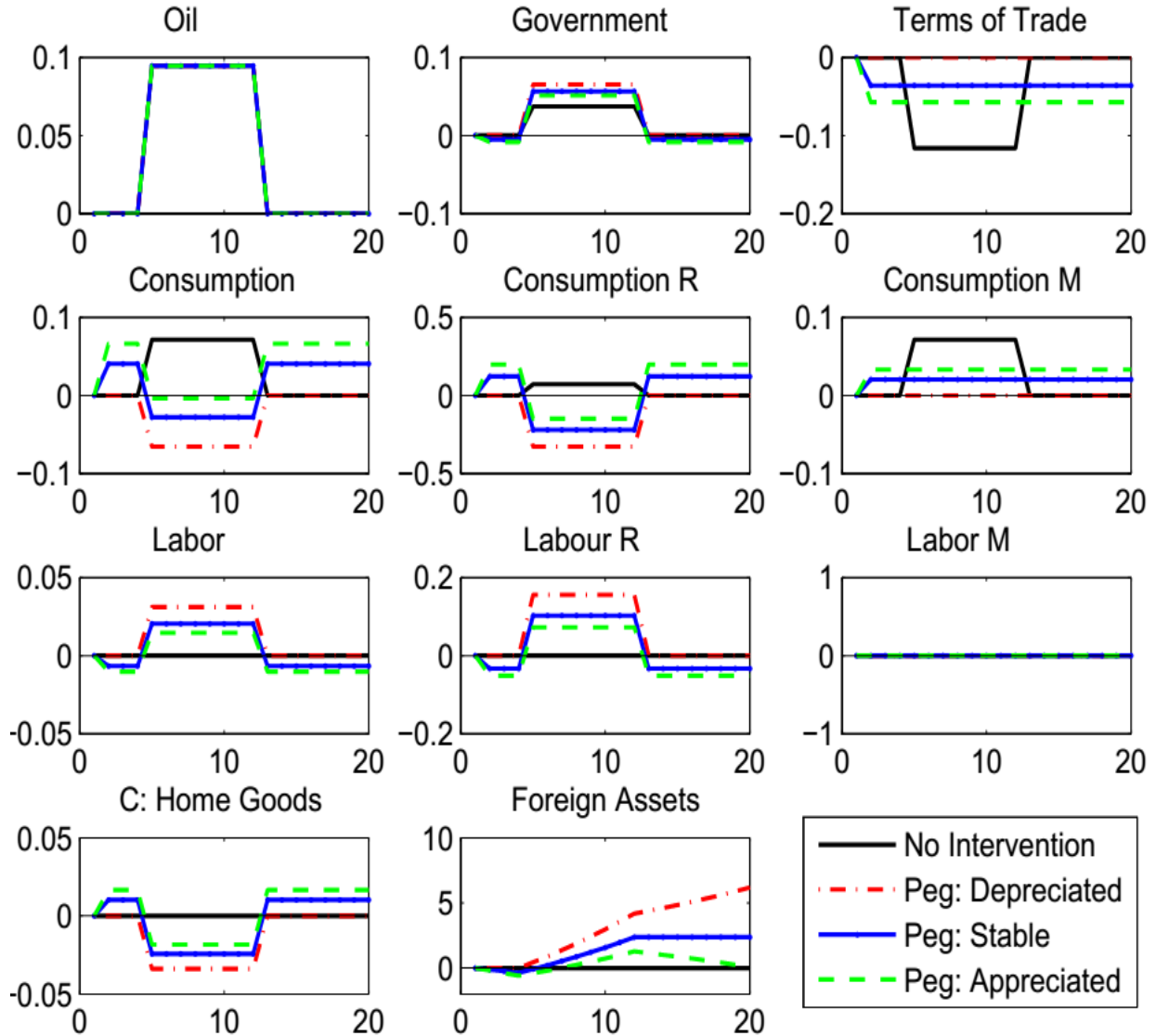
Policy	Mostly Ricardian ($\lambda=0.2$)		Mostly Hand to Mouth ($\lambda=0.8$)	
	Ricardian	Hand to Mouth	Ricardian	Hand to Mouth
No Intervention	100.0%	100.0%	100.0%	100.0%
Peg: Depreciated	98.5%	99.6%	94.7%	99.6%
Peg: Stable	104.5%	101.3%	111.6%	101.3%
Peg: Appreciation	107.4%	102.4%	122.4%	102.4%
Open Capital Acct	102.7%	100.9%	103.9%	100.4%

**Welfare expressed as consumption-equivalent in perpetuity, relative to steady-state consumption under no intervention.*

A stable real exchange rate also improves welfare relative to an open capital account during a temporary oil boom. This might seem at first blush be somewhat surprising, given that a closed capital account is a distortion. However, we also have two other distortions in the economy: a government that is spending sub-optimally and a proportion of households who have no access to capital whatsoever. As these hand-to-mouth households benefit from the consumption smoothing of Ricardian consumers, the decision to save or spend by the latter yields an externality. Net saving in the economy will therefore be too low.

Closing the capital account creates an additional friction in the economy - that the central bank controls net saving - which can then be used to correct the economy's other distortions.

Figure 5: Pegging real exchange rate and accumulating a de-facto sovereign wealth fund¹²



Welfare under the regime with a stable real exchange rate is not just higher for the economy as a whole, but also for all households within it. Ricardian households benefit from the central bank's ability to change the real interest rate, which would be fixed under an open capital account. By effectively raising the real interest rate during the boom, the central bank encourages Ricardian households to save much more than they would otherwise. The large foreign reserves that result can support a higher level of consumption in perpetuity. Hand-to-mouth households benefit from the greater saving that is being done

¹² Based on the calibration in Figure 3 with $\lambda=0.8$.

by the Ricardian households. Left to their own devices, Ricardian households will save less than is socially optimal as they do not internalize the benefits to non-Ricardian households from their smoothing. As the central bank can force Ricardians to save more through the currency peg, they indirectly improve the welfare of non-Ricardians households.

The currency peg also performs better when there are more financially constrained households as is often the case in developing countries. This is because all the saving that must be done to stabilize the real exchange rate must be done by a smaller proportion of the economy. Each Ricardian household will therefore have to save significantly more during the boom, and so can support a much higher level of consumption afterwards.

Our analysis has focused on stabilizing the real exchange rate, while in practice currency pegs stabilize the nominal exchange rate. However, a stable real exchange rate underpins a stable nominal exchange rate. If the real exchange rate is constantly changing, then a nominal peg requires relative prices to adjust through domestic inflation. This is costly if prices are sticky, illustrating the importance of a stable real exchange rate.

6. Concluding remarks

Following Friedman (1953) a regime of floating exchange rates has often been often advocated for economies to be able to adjust more efficiently to demand shocks which necessitate changes in the terms of trade. However, a float is not effective in dealing with shocks when pass-through is low and foreign-currency debt is high. In any case, many countries prefer to have a currency peg or join a monetary union for this enables them to anchor inflation in a credible fashion and reduce transactions, hedging and other costs associated with international trade. We have focused on the consequences of an anticipated windfall of foreign exchange resulting from the sale of commodities when the fiscal authorities spend all revenues. We have shown that from a short-run perspective indeed a float is better than a peg and yields higher welfare. However, from a longer run perspective this is no longer necessarily the case if Ricardian and hand-to-mouth consumers do not have access to international capital markets while the central bank does. In that case, we show that it may be beneficial for the central bank of a resource-rich country to target the real exchange rate in such a way that it accumulates a de-facto sovereign wealth fund and thereby contributes to smoothing consumption and improving welfare.

Our take on monetary and macro policy in resource-rich countries should be qualified in the following respects. First, we have examined the extreme cases of zero and perfect capital mobility and future work would benefit from considering the intermediate case of imperfect substitution between home and foreign

assets. There may then be a case for two policy instruments, namely the interest rate and sterilized foreign exchange market intervention (e.g., Ostry et al., 2012). Second, we have not looked at a combination of short-run and long-run aspects. Pegging the nominal exchange rate creates in economies with downward nominal wage rigidity a negative pecuniary externality which causes unemployment, over-borrowing and depressed consumption in which case prudential capital control are called for (e.g., Schmitt-Grohe and Uribe, 2012). Capital controls are particularly effective to address risk-premium shocks that affect the interest rate differential foreign investors require in a particular country and may even be optimal if the exchange rate is not fixed in response to risk premium shocks or if wages as well as prices are rigid (Farhi and Werning, 2013). It is interesting to see how this plays out during a resource windfall. Third, we have abstracted from the notion that resource-rich developing countries with limited financial development and capital scarcity should not build a sovereign wealth fund but use the windfall to alleviate capital scarcity and boost investment in the domestic economy (e.g., van der Ploeg and Venables, 2013). Furthermore, many emerging economies such as China and resource-rich economies suffer from the anomaly that they cannot use their own currencies to finance foreign investment (McKinnon, 2010). The resulting consequences for monetary and macro policy is left for further research. Fourth, when the windfall revenues ceases to flow it may well lead to a sudden stop in international credit flows and consequently to financial and balance of payments crises (e.g., Calvo, 1998). It is important in future work to examine how sudden stops will affect the management of resource bonanzas.

Finally, while our work is preliminary, it does raise the important division between the short- and long-run that currently characterizes core macroeconomics. The standard DSGE framework currently used to evaluate macroeconomic policy focuses on short-term fluctuations around steady states, as described by models such as that in section 2. It typically pays little attention to the important role of asset balances, financial frictions and long-term wealth considerations that we have discussed in sections 3-5. Ignoring these considerations can have quite dramatic implications when evaluating policy, in the present case meaning the difference between advocating floating exchange rates or fixed. This is particularly important for developing countries, where frictions are many and long-term dynamics key. To borrow from Tolstoy, while developed countries are all alike, each developing country is developing in its own way. Encouragingly, the work on financial frictions that is now at the core of the macroeconomic research agenda is likely to yield insights that will be particularly useful for policymakers in low-income-countries.

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