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On the Desirability of Capital Controls

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Abstract

In a standard two country international macro model we ask whether shutting down the market for international non-contingent borrowing and lending is ever desirable. The answer is yes. Imposing capital controls is unilaterally desirable when initial conditions are such that ruling out bond trade generates a sufficiently favorable change in the expected path for the terms of trade. Imposing capital controls can be welfare improving for both countries for calibrations in which equilibrium terms of trade movements improve insurance against country specific shocks.

Keywords: Capital controls, terms of trade, international risk sharing Equilibria

JEL classification codes: F32, F41, F42

1 Introduction

We revisit the question of whether capital controls might be welfare improving relative to the case of international capital mobility. Our framework will be a set of workhorse two-country business cycle models. The key model ingredient is that each country produces a specific good that is imperfectly substitutable with the output of its trading partner.

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The only friction in our environments will be an absence of financial assets offering explicit insurance against country-specific shocks With free international trade in a complete set of such assets, the welfare theorems would apply and allocations would be efficient. Thus, relative to that baseline, any restrictions on international capital flows would reduce welfare. However, our focus will be on an environment in which the only asset traded internationally is a non-contingent bond. In this context, international financial markets are incomplete, the welfare theorems do not apply, and there is a potential role for policy intervention. The intervention we consider is an extreme form of capital controls, in which we rule out asset trade altogether. Thus, we will compare welfare when the two countries only trade a non-contingent non-defaultable one period bond to welfare under financial autarky.

In a one good version of our model, this welfare comparison would not be very interesting. Allowing for bond trade would expand agents budget sets, and would necessarily be welfare improving. In two good models, the asset market structure will affect the time paths for the relative supply of domestic and foreign produced goods, and also the paths for their relative demand. The time paths for relative supply and relative demand will in turn affect the relative price of domestically versus foreign-produced goods. Atomistic price-taking agents do not internalize the effects of their choices on prices, but collectively their choices impose pecuniary externalities on other agents. For example, if domestic agents work longer hours and thereby produce more of the domestic good, they will depress the relative price of this good on world markets, imposing a negative externality on other domestic agents. This argument has been used to motivate a possible role for tariffs and export taxes in the optimal tariff literature. Here we investigate the possibility that the same pecuniary externality could motivate policy interventions to prevent international borrowing and lending.

Consider the following simple example that illustrates the idea. Suppose the domestic country (country 1) is hit by a positive persistent productivity shock. It is well known that the typical response to such a shock in models with free trade in bonds is that country 1 should run a trade deficit in the near term to finance the construction of additional capital. This extra capital allows country 1 to produce more output during the transition as the shock decays. Put simply, capital flows make it easier to make more hay where the sun shines, which is in country 1. But if country 1 is producing hay and country 2 is producing corn, this extra production of hay will depress the relative price of hay, moving the terms of trade against country 1. Agents in country 1 do not

internalize the impact of their international borrowing on the terms of trade, but the government in country 1 should understand the links between domestic supply and demand on the one hand, and the terms of trade on the other. If the negative terms of trade impact on domestic welfare outweighs the advantages bond trade offers in terms of inter-temporal consumption smoothing and a more efficient global allocation of capital, the government might decide that preventing international borrowing is the best interests of its citizens.

In this example, we emphasized the role of asset trade on the relative supply of domestically and foreign produced goods. But asset trade also potentially affects relative demand. In the near term, following a positive domestic productivity shock, the extra investment that is financed by bond trade will drive up relative demand for domestic goods, but in the longer term a negative net foreign asset position for country should reduce relative domestic demand, and thus improve the terms of trade from country 1's perspective. By considering a range of alternative models we are able to disentangle the supply and demand side effects of asset market structure on the time path for the terms of trade. A clean baseline is an endowment economy, in which both countries have identical preferences. Here there are no supply side effects – the relative supply of goods is exogenous – and the relative demand of the two countries does not matter either – since both countries consume the same mix of domestic and foreign produced goods. Thus there are no pecuniary externalities, and bond trade is unambiguously welfare improving. Introducing production (but maintaining common preferences) introduces a role for the asset market structure to impact the terms of trade via the supply channel. Introducing home bias in preferences (but abstracting from production) highlight the role of the demand channel. Our baseline model, which is the workhorse Backus, Kehoe and Kydland (1994) model, features both channels.

Throughout the paper we will consider two sets of welfare calculations defining, respectively, conditional and unconditional desirability of capital controls. Capital controls are conditionally desirable at a particular point in the state space if at least one country prefer not to trade an international bond. We focus on exploring how the desirability of capital controls varies with current country-specific productivity, conditional on both countries having capital at the non-stochastic steady state value, and conditional on the foreign country having steady state productivity. Our key finding here is that having experienced a relatively modest positive productivity shock (relative to the symmetric mean of the process) is sufficient to leave a country better off under financial autarky rather than with a bond.

We next consider whether and when capital controls are unconditionally desirable. We define capital controls to be unconditionally desirable if both countries would prefer to live in financial autarky, when alternative regimes are evaluated starting from the symmetric non-stochastic steady state and prior to the realization of any shocks that generate differential productivity. A surprising finding is that there do exist parameterizations in which imposing capital controls is Pareto improving. To understand why this is possible, recall that international asset trade plays two roles in this class of models: it affects cross-country consumption risk sharing and, in an environment with production, it affects productive efficiency. Bond trade should improve productive efficiency, since it allows capital to flow across countries to equalize expected returns. So for autarky to be welfare improving, the autarky market structure must deliver superior consumption risk sharing. One source of consumption risk sharing emphasized by Cole and Obstfeld (1991) is that the terms of trade will typically move inversely to relative country productivity, providing an automatic form of insurance. We identify two cases in which financial autarky offers sufficiently superior terms of trade insurance that capital controls are unconditionally desirable. The first is when the elasticity of substitution between tradable goods is low, so that fluctuations in the terms of trade are too large from the perspective of providing insurance. In this case, restricting capital flows dampens fluctuations in relative output and thus also dampens fluctuations in the terms of trade. The second is when the elasticity is high, but the trade share exceeds 50 percent. In this case, fluctuations in the terms of trade are too small from the perspective of providing insurance, but eliminating asset trade now amplifies (rather than dampens) terms of trade movements, since the cyclicality of net exports is reversed.

1.1 Related literature

Our paper belongs to a recent theoretical literature which studies environments where capital controls can be desirable. A common theme of this literature is that, because competitive agents do not take into account that borrowing and lending in international markets can affect international prices, restricting international borrowing and lending can lead to change in prices that improve welfare. More precisely, welfare improves if capital controls induce changes in equilibrium international prices that can reduce the impact of underlying fundamental frictions. One seminal contribution to this literature is the work of Newbery and Stiglitz (1984) which shows how in environments without perfect insurance, shutting down trade in goods can lead to terms of trade movements that provide

more insurance, and hence induce Pareto superior outcomes.

Three recent papers in this area that are quite related to ours are Brunnermeier and Sannikov (2014), Costinot, Lorenzoni and Werning (2014), and De Paoli and Lipinska (2013). Brunnermeier and Sannikov (2014) show how open international financial markets lead to a terms of trade deterioration (as in our set-up). However, their main focus is on how this deterioration can lead to a fall in net worth and subsequent financial instability and financial crises. We view their channel as potentially complementary to ours.

Costinot et al. (2014) focus on intertemporal prices (i.e. interest rates) and their key rational for capital controls is that when countries are monopolists in intertemporal markets they can obtain more favorable international interest rates by restricting capital flows.

Finally, De Paoli and Lipinska (2013) consider an environment similar to ours and study how taxes on an international bond can improve allocations for a given country. The key difference between our set-up and theirs is that we consider an environment with capital accumulation. We find that the dynamics of capital accumulation are a crucial determinant of both relative demand and relative supply, and thereby of the dynamics of international prices. Because of this our findings are quite different. They find that imposing capital controls "can be beneficial for individual countries, although it would limit cross-border pooling of risk". In our set-up we find that, in some instances, capital controls can be beneficial exactly because they enable better cross-border pooling of risk.

Note that we abstract from default risk, and thus our rational for capital controls is different from Bianchi and Mendoza (2013), who argue that individual agents do not internalize the impact of individual borrowing on the government's incentives to default. Also our environment has no borrowing constraints linked to asset prices, and so our effects do not depend on capital flows relaxing or tightening borrowing constraints (as in, for example, Bianchi, 2011 and Korinek, 2009). Finally our environment features no private information, so capital controls play no role in improving on informational frictions as in Martin and Taddei (2012).

2 The Model

We focus on the familiar two country business cycle framework developed by Backus, Kehoe, and Kydland (1995) (henceforth BKK). The two countries, indexed $i = 1$ and $i = 2$, are each populated by mass one of identical, infinitely-lived households. In each period t, the economy experiences one event $s_t \in S$. We denote by s^t the history of events up to and including date t. The probability at date 0 of any particular history s^t is given by $\pi(s^t)$.

2.1 Preferences and Technologies

The representative household derives utility from consumption, $c_i(s^t)$, and disutility from labor supply, $n_i(s^t)$. Preferences are given by

$$(1-\beta)\sum_{t=0}^{\infty}\beta^t\sum_{s^t}\pi(s^t)U\left(c_i(s^t),n_i(s^t)\right), \tag{1}$$

where the parameter β captures the rate of time preference. We consider the two most widely used specifications for period utility in the macro literature: one which is seperable between consumption and hours worked, and an alternative which is Cobb-Douglas in consumption and leisure:

$$\begin{aligned} U\left(c_i,n_i\right) &= \frac{c_i^{1-\gamma}}{1-\gamma}-\phi\frac{n_i^{1+\frac{1}{\varepsilon}}}{1+\frac{1}{\varepsilon}} \\ U\left(c_i,n_i\right) &= \frac{\left[c_i^{\mu}\left(1-n_i\right)^{1-\mu}\right]^{1-\gamma}}{1-\gamma}. \end{aligned}$$

In the first specification, ε is the Frisch elasticity of labor supply. In the second, the parameter γ determines the extent to which preferences are non-separable between consumption and leisure, and the Frisch elasticity for leisure is $(1-\mu+\mu\gamma)/\gamma$. Under both utility specifications, in the limit as $\gamma \to 1$ utility becomes separable between log consumption and a term involving hours.

Capital in place $k_i(s^{t-1})$ (chosen in the previous period) and labor are combined to produce two country-specific intermediate goods. These are the only tradable goods in the economy. The intermediate good produced in country 1 is labeled a, and the good produced in country 2 is labeled b. The intermediate goods production functions are Cobb-Douglas:

$$F_i\left(z_i,k_i,n_i\right)=\exp(z_i)k_i^{\theta}n_i^{1-\theta}, \tag{2}$$

where $z_i(s^t)$ is an exogenous productivity shock that follows a symmetric autoregressive process:

$$\begin{aligned}\begin{bmatrix} z_1(s^t) \\ z_2(s^t) \end{bmatrix} &= \begin{pmatrix} \rho & \psi \\ \psi & \rho \end{pmatrix} \begin{bmatrix} z_1(s^{t-1}) \\ z_2(s^{t-1}) \end{bmatrix} + \begin{bmatrix} \varepsilon_1(s^t) \\ \varepsilon_2(s^t) \end{bmatrix} \\ \begin{bmatrix} \varepsilon_1(s^t) \\ \varepsilon_2(s^t) \end{bmatrix} &\sim N\left(\begin{pmatrix} 0 \\ 0 \end{pmatrix}, \sigma_\varepsilon^2 \begin{pmatrix} 1 & Corr_{\varepsilon_1,\varepsilon_2} \\ Corr_{\varepsilon_1,\varepsilon_2} & 1 \end{pmatrix} \right).\end{aligned}$$

Within each country, the intermediate goods a and b are combined to produce a country-specific nontradable final good that is used for both consumption and new investment. The final goods production technology is constant returns to scale:

$$G_i(a_i, b_i) = \begin{cases} \left[\omega a_i^{\frac{\sigma-1}{\sigma}} + (1-\omega) b_i^{\frac{\sigma-1}{\sigma}}\right]^{\frac{\sigma}{\sigma-1}}, & i = 1 \\ \left[(1-\omega) a_i^{\frac{\sigma-1}{\sigma}} + \omega b_i^{\frac{\sigma-1}{\sigma}}\right]^{\frac{\sigma}{\sigma-1}}, & i = 2, \end{cases} \tag{3}$$

where $a_i(s^t)$ and $b_i(s^t)$ denote the quantities of intermediate goods a and b used in country i as inputs, σ is the elasticity of substitution between domestic and foreign-produced inputs, and ω determines the extent to which there is a home or foreign bias in the composition of domestically produced final goods. We will calibrate ω to replicate empirical measures for the volume of trade relative to GDP.

Investment augments the capital stock in the standard way:

$$k_i(s^t) = (1-\delta) k_i(s^{t-1}) + x_i(s^t), \tag{4}$$

where δ is the depreciation rate and $x_i(s^t)$ is the amount of the final good devoted to investment in country i.

The resource constraints for this economy are

$$a_1(s^t) + a_2(s^t) = F\left(z_1(s^t), k_1(s^{t-1}), n_1(s^t)\right) \tag{5}$$

$$b_1(s^t) + b_2(s^t) = F\left(z_2(s^t), k_2(s^{t-1}), n_2(s^t)\right) \tag{6}$$

and

$$c_i(s^t) + x_i(s^t) = G_i\left(a_i(s^t), b_i(s^t)\right), \qquad i = 1, 2. \tag{7}$$

2.2 Firm Problems

Households rent labor to competitive intermediate goods-producing firms at wage $w_i(s^t)$ (measured in units of the final good). They also trade intermediate goods at prices $q_i^a(s^t)$, $q_i^b(s^t)$. Final goods-producing firms purchase the intermediate inputs and produce the final consumption/investment good, solving the static problems

$$\max_{a_i(s^t),b_i(s^t)} \left\{ G_i(a_i(s^t), b_i(s^t)) - q_i^a(s^t)a_i(s^t) - q_i^b(s^t)b_i(s^t) \right\}. \tag{8}$$

Intermediate goods-producing firms hold capital and make investment decisions. The intermediate goods firm's maximization problem in country i is to choose $k_i(s^t)$, $n_i(s^t)$ for all s^t and for all $t \geq 0$ to maximize

$$\sum_{t=0}^{\infty} \sum_{s^t} Q_i(s^t) d_i(s^t)$$

taking as given $k_i(s^{-1})$, where $Q_i(s^t)$ is the price the firm uses to value dividends at s^t relative to consumption at date 0, and dividends (in units of the final good) are given by

$$d_1(s^t) = q_1^a(s^t) F\left(z_1(s^t), k_1(s^{t-1}), n_1(s^t)\right) - w_1(s^t)n_1(s^t) - x_1(s^t) \tag{9}$$

$$d_2(s^t) = q_2^b(s^t) F\left(z_2(s^t), k_2(s^{t-1}), n_2(s^t)\right) - w_2(s^t)n_2(s^t) - x_2(s^t). \tag{10}$$

The state-contingent consumption prices $Q_i(s^t)$ play a role in intermediate goods firms' state-contingent decisions regarding how to divide earnings between investment and dividend payments. We assume that firms use the discount factor of the representative local household to price the marginal cost of forgoing current dividends in favor of extra investment:

$$Q_i(s^t) = \frac{\pi(s^t)\beta^t U_{ci}(s^t)}{U_{ci}\left(s^0\right)}. \tag{11}$$

2.3 International Relative Prices

Movements in international relative prices will play an important role in our analysis. We define the terms of trade $p(s^t)$ as the price of good b relative to good a :

$$p(s^t) = \frac{q_1^b(s^t)}{q_1^a(s^t)} = \frac{q_2^b(s^t)}{q_2^a(s^t)}$$

The real exchange rate $rx(s^t)$ is the price of foreign relative to domestic consumption. Because the law of one price applies to traded intermediate goods, this is equal to

$$rx(s^t) = \frac{q_1^a(s^t)}{q_2^a(s^t)} = \frac{q_1^b(s^t)}{q_2^b(s^t)}$$

The assumptions built into preferences and technologies in the BKK framework imply a tight connection between equilibrium fluctuations in the terms of trade and the real exchange rate. In particular,

$$rx(s^t) = \left(\frac{\omega^\sigma + (1-\omega)^\sigma p(s^t)^{1-\sigma}}{(1-\omega)^\sigma + \omega^\sigma p(s^t)^{1-\sigma}}\right)^{\frac{1}{\sigma-1}}$$

Note that when $\omega = 0.5$, so that the two countries share identical preferences, there will be zero volatility in the real exchange rate, independent on the asset market structure. When $\omega = 1$, so that preferences are completely specialized, the real exchange rate is equal to the terms of trade. For $\omega > 0.5$, the terms of trade and the real exchange rate co-move positively, while for $\omega < 0.5$ they co-move negatively.

2.4 Asset Market Structure

We now describe how the representative households' budget constraints differ across asset market structures. Recall that our main interest is in comparing an economy with unrestricted trade in non-contingent bonds to an economy with no international asset trade.

Bond economy

In this model, a single noncontingent bond is traded. The bond has price $P(s^t)$ (in units of country 1's consumption good) at date t following history s^t, and entitles the holder to half a unit of domestic consumption, and half a unit of foreign consumption at date $t+1$. We assume this payoff structure to preserve symmetry. Let $B_i(s^t)$ denote the quantity of bonds bought by households in country i after history s^t. The budget constraint for the representative households are

$$c_1(s^t) + P(s^t)B_1(s^t) = w_1(s^t)n_1(s^t) + d_1(s^t) + B_1(s^{t-1})\left(\frac{1}{2} + \frac{1}{2}rx(s^t)\right) \quad (12)$$

$$c_2(s^t) + \frac{P(s^t)}{rx(s^t)}B_2(s^t) = w_2(s^t)n_2(s^t) + d_2(s^t) + B_2(s^{t-1})\left(\frac{1}{2}\frac{1}{rx(s^t)} + \frac{1}{2}\right) \quad (13)$$

Note that in the bond economy model households are not allowed to default, but there are no additional limitations on borrowing.

Financial autarky

In the financial autarky model, no assets are traded internationally; hence, the budget constraint for the representative household in country i is given by

$$c_i(s^t) = w_i(s^t)n_i(s^t) + d_i(s^t) \qquad i = 1, 2. \tag{14}$$

Complete markets

Here households trade a complete set of state-contingent claims. We assume the same denomination structure as in the non-contingent bond case. Let $B_i(s^t, s_{t+1})$ be the quantity of Arrow securities purchased by households in country i after history s^t that pay half a unit of domestic and half a unit of foreign consumption in period $t+1$ if and only if the state of the economy is s_{t+1}. Let $P(s^t, s_{t+1})$ be the price of this security. The budget constraint for the representative household in country 1 is then

$$c_1(s^t) + \sum_{s_{t+1}} P(s^t, s_{t+1})B_1(s^t, s_{t+1}) = w_1(s^t)n_1(s^t) + d_1(s^t) + B_1(s^{t-1}, s_t)\left(\frac{1}{2} + \frac{1}{2}rx(s^t)\right). \tag{15}$$

2.5 Household Problems and Definition of Equilibrium

Households choose $c_i(s^t) \geq 0$, $n_i(s^t) \in [0, 1]$ and asset purchases (if assets are traded) for all s^t and for all $t \geq 0$ to maximize 1 subject to the appropriate sequence of budget constraints given by eq. 12, 14, or 15, taking as given initial productivity shocks, initial capital stocks and, if assets are traded internationally, the initial distribution of wealth.

An equilibrium is a set of prices for all s^t and for all $t \geq 0$ such that when households solve their problems taking these prices as given, all markets clear. The goods market-clearing conditions are 5 and 7. The asset market conditions for bond and complete markets economies are, respectively,

$$B_1(s^t) + B_2(s^t) = 0 \tag{16}$$

$$B_1(s^t, s_{t+1}) + B_2(s^t, s_{t+1}) = 0, \qquad \forall s_{t+1} \in S. \tag{17}$$

2.6 Key Parameters for Welfare Comparisons

We are interested in the welfare differences between market structures. Three parameters that are the key determinants of the magnitude of these welfare differences are (i) the persistence of the shocks ρ, (ii) the import share, defined by ω, and (iii) the elasticity of substitution between imported and domestically produced intermediates σ.

The reason ρ is important is two-fold. First, if country-specific shocks are relatively transitory, the gains from being better able to smooth them via international asset trade will also be small. This is related to Lucas' (1987) famous result that the welfare cost of aggregate risk is small. Lucas was implicitly thinking about smoothing transitory deviations from trend. If shocks are very persistent, the potential welfare gains from international risk sharing are potentially much larger.[1] A second reason that ρ matters is that it is well known that if shocks are not too persistent, allocations with free trade in a bond are very similar to those under complete markets (Baxter and Crucini, 1995). Thus for such a calibration, it would be very surprising if financial autarky were to deliver higher unconditional expected welfare than the bond economy model.

The reason the import share matters for welfare comparisons across market structures is that gains from trade in assets are closely tied to gains from trade in goods. In our baseline calibration, countries' demand is heavily locally-biased, which implies modest gains from trade in assets. In the limit $\omega \to 1$ in which countries are only interested in consuming locally produced goods (so that there are no gains from trade in goods) there are also no gains from trade in assets. Brandt, Cochrane and Santa-Clara (2006) make this point eloquently in an example discussing hypothetical asset trade between Earth and Mars.

The reason the elasticity of substitution σ matters is that when countries produce and trade imperfectly substitutable goods, movements in the terms of trade tend to provide automatic insurance against country specific shocks to supply. Cole and Obstfeld (1991) showed that in an endowment economy, this insurance is perfect (in the sense that financial autarky delivers the same allocations as complete markets) when $\gamma = 1$ (unitary inter-temporal elasticity of substitution)

[1] Heathcote and Perri (2014) compute welfare under complete markets, with international bond trade, and under financial autarky, in a model in which countries face long run growth rate risk – they might grow like Argentina has done since 1960, or they might grow like Korea. The differences in expected welfare across alternative international asset market structures are very large in this case.

and $\sigma = 1$ (unitary intra-temporal elasticity of substitution between traded goods). It turns out that this result will extend to our production economy under one additional parametric restriction, namely that $\omega = 0.5$, so that both countries have identical preferences and are equally keen on consuming domestic and imported intermediates.

3 Calibration

As a baseline, we take most parameter values from Heathcote and Perri (2013). All parameters for the baseline calibration are reported in Table 1.

Table 1. Baseline Parameter Values

Preferences		
	Discount factor	$\beta = 0.99$
	Weight on labor	$\phi = 7.3$
	Curvature	$\gamma = 1$
	Frisch Elasticity	$\varepsilon = 1$
Technology		
	Capital's share	$\theta = 0.36$
	Depreciation rate	$\delta = 0.015$
	Elasticity of substitution	$\sigma = 1$
	Import share	$1 - \omega = 0.15$
Productivity process		
	Persistence and spillover	$\rho = 0.995$
		$\psi = 0.0$
	Variance and correlation	$\sigma_{\varepsilon}^2 = 0.02$
		$Corr_{\varepsilon_1,\varepsilon_2} = 0.38$

The discount factor is equal to a standard value for a quarterly model: $\beta = 0.99$. Preferences take the separable form, and $\gamma = 1$, so the inter-temporal elasticity of substitution for consumption is equal to one. We also set $\sigma = 1$, so that the technology for combining domestic and foreign intermediates to produce the final consumption / investment good is Cobb-Douglas.[2]

We set the Frisch elasticity of labor supply, ε, equal to one, and the preference weight ϕ so that in the non-stochastic steady state hours worked are equal to 1/3.

[2]Heathcote and Perri (2013) show that with these choices for γ and σ, a time invariant portfolio of domestic and foreign stocks delivers perfect risk sharing. This portfolio is home biased as long as preferences are biased towards domestically-produced goods ($\omega > 0.5$).

Our productivity process is designed to roughly reflect the volatility and persistence of shocks to developing economies. We assume a symmetric process, with no spill-overs ($\psi = 0$). We set the persistence parameter to a high value, $\rho = 0.995$,consistent with the findings by Aguiar and Gopinath (2007) that emerging markets are hit by very persistent shocks.

We set the variance of innovations σ_{ε}^2 equal to 0.02^2 and the correlation of innovations $Corr_{\varepsilon_1,\varepsilon_2}$ equal to 0.38. Thus these shocks are larger that would feature in a typical calibration to developed economies (where the standard deviation of productivity shocks is usually calibrated to be around 1%), but are consistent with estimates for developing economies (see, e.g., Neumeyer and Perri, 2005).

As a baseline, we set $\omega = 0.75$, which implies that in steady state imports are 25% of GDP, which is similar, for example, to the trade shares of China, India, Mexico, and Russia. Recall, from the discussion above, that given $\gamma = \sigma = 1$, welfare would be identical across market structures given $\omega = 0.5$. Moreover, welfare is always invariant to market structure when $\omega = 1$ (in which the two economies are closed). Because our baseline choice for ω lies in between these two values, allocations and welfare will vary with market structure.

After reporting results for our baseline specification, we will focus on exploring the sensitivity of our welfare results to two of the key parameters discussed above: (i) the import share, is, which is controlled by the preference weight ω, and (ii) the elasticity of substitution between imported and domestically produced goods σ.[3]

In a secondary sensitivity analysis we will also show how results change as we vary risk aversion γ (under the Cobb-Douglas utility specification), and the persistence of shocks ρ.

3.1 Computation

Because welfare differences across market structures are generally small, it is important that we are able to accurately characterize equilibrium allocations. We take a third order local approximation to all the equilibrium conditions around the non-stochastic steady state, using the DYNARE package. By taking a third order approximation, we incorporate both the effects of uncertainty on optimal choices, and also capture how the impact of uncertainty varies with the levels of state variables. It

[3]In steady state, $\frac{\omega}{1-\omega} = \left(\frac{1-is}{is}\right)^{\frac{1}{\sigma}}$.

is well known that if a two country bond economy is approximated linearly, the resulting law of motion for the bond position is non-stationary. A subsequent literature emerged on "closing" small open economy models (Schmitt-Grohe and Uribe, 2003). Taking a second order approximation to the same economy is sufficient to capture the precautionary motive for bond holding – which manifests as a lower average equilibrium interest rate – but it is not sufficient capture how the strength of this precautionary motive varies with the net foreign asset position. As a result, the law of motion for bonds remains non-stationary. A third order approximation captures the fact that the precautionary motive is decreasing in net foreign wealth: as one country accumulates a large net position in risk-free bonds, while the other becomes more leveraged, the precautionary motive to save weakens in the first country, and strengthens in the second, and these effects tend to push the net foreign asset position back towards zero. Thus, the net foreign asset position in our third-order-approximation-based simulations is stationary, even though we have not introduced any ad hoc devices (such as wealth-varying discount factors or quadratic bond holding costs) to make it so.

Nonetheless, absent a closed form solution, it is difficult to assess the accuracy of any numerical approximation. With a local approximation, there is always the concern that while the approximation may be extremely good in the neighborhood of the steady state, the approximation quality might deteriorate if large and persistent shocks push the state variables far from their steady state values. To partially address this concern, we have also used global methods to solve for transitions to large one-off shocks. In particular, we use variants of shooting methods to solve for transitions in response to one time shocks, and compare the impulse responses to those in our model when the variance of innovations is set to zero. We find that the dynamics are virtually identical across the two solution methods.

4 Results

We start by describing how we will compare welfare across market structures. We use a standard consumption equivalent metric, and ask what constant percentage increase in consumption in all dates and states in the bond economy model leaves the representative agent in country i indifferent between living in a world with free bond trade versus living in financial autarky. Let superscripts BE and FA index allocations under the bond economy and financial autarky market structures, and

let asterisks $*$ denote steady state values. Let $V_i^{BE}(z_1, z_2, k_1, k_2, B_1)$ denote expected lifetime utility for country 1 conditional on the aggregate state being described by the current log productivity vector (z_1, z_2), the inherited cross-country distribution of capital (k_1, k_2), and the inherited bond position is $B_1 = -B_2$. We will focus on comparing welfare when $k_1 = k_2 = k^*$, when $z_2 = z^* = 0$, and when $B_1 = B_2 = 0$. Given our baseline utility function (log separable in consumption), the welfare gain for country i in moving from the bond economy model to financial autarky is

$$\omega_i(z_1) = \exp\left[V_i^{FA}(z_1, 0, k^*, k^*) - V_i^{BE}(z_1, 0, k^*, k^*, 0)\right] - 1. \tag{18}$$

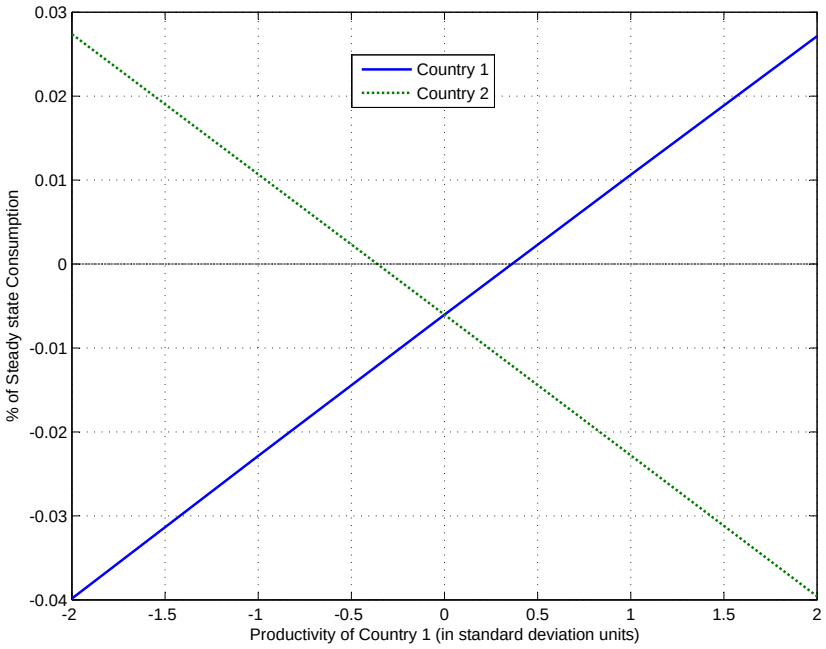
We will label $\bar{\omega} = \omega_1(0) = \omega_2(0)$ the unconditional welfare gain from moving to financial autarky: this measures the welfare difference between market structures starting from the symmetric non-stochastic steady state. We will label $\omega_i(z_1)$ for $z \neq 0$ the conditional welfare gain, which can be thought of as follows. Suppose that yesterday (at $t = -1$) the economy was in the non-stochastic steady state, and that today (at $t = 0$) country one has received a productivity innovation $\varepsilon_1 = z_1$. From this starting point, the conditional welfare gain compares expected lifetime utlity under the two market structures.

4.1 Baseline Calibration

Figure 1 plots $\omega_i(z_1)$ for our baseline calibration. Several things are apparent from this plot. First, the welfare differences between market structures are very small in this calibration: at most 0.04 percent of consumption. Second, the unconditional welfare gain $\bar{\omega}$ is negative. Thus, behind a symmetric veil of ignorance, both countries would prefer permanent access to bond trade to permanent financial autarky. Third, the conditional welfare gains from moving to financial autarky vary strongly with relative productivity. For positive productivity shocks exceeding one third of a standard deviation (i.e. $z_1 > \frac{1}{3} \times 0.02$) country 1 is better off under financial autarky, while for equally negative productivity shocks country 2 prefers financial autarky. Put differently, the range of values for relative productivity such that both countries prefer bond trade to autarky is quite narrow. This suggests that maintaining political support for free capital flows might be difficult.

We now explore the economics underlying this result. We starting by tracing out impulse responses to a one standard deviation positive innovation to productivity in country 1, assuming no further shocks. The first two panels of Figure 2 show the dynamics of net exports and the net foreign asset position in the bond economy. As shown by BKK and others, the country that is hit

Figure 1: Welfare Gains From Imposing Financial Autarky

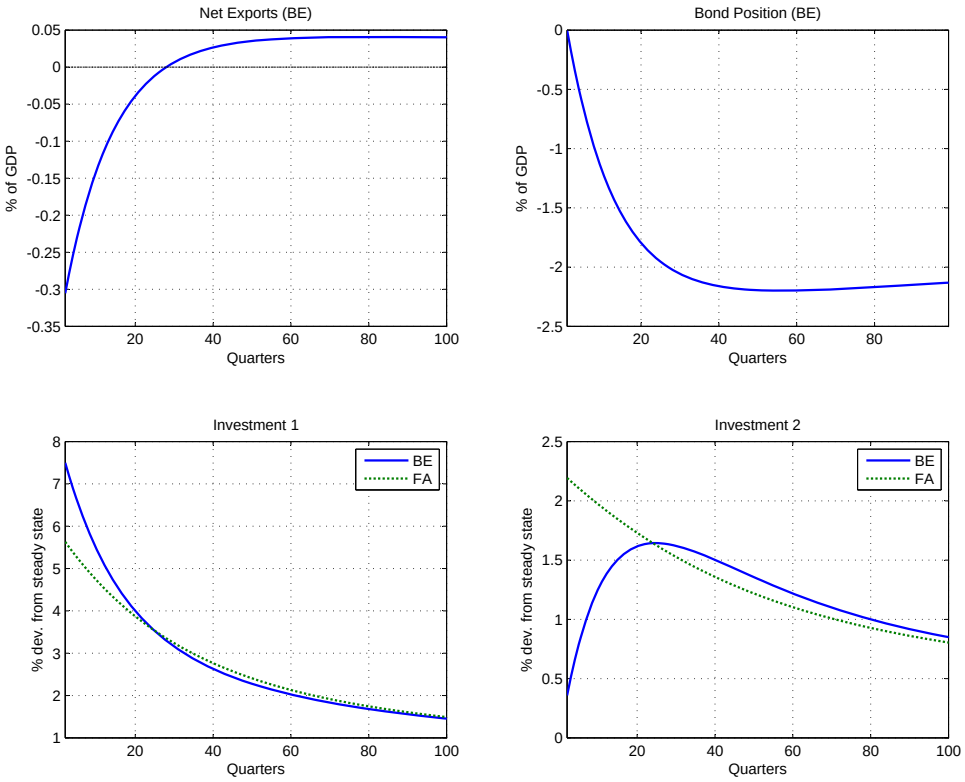


by a positive shock tends to run a current account deficit on impact, which it uses to fund a surge in investment. When international borrowing and lending is ruled out, the increase in investment in country 1, and the decline in country 2 are both muted (see the bottom two panels).

These differential investment dynamics across market structures translate into different dynamics for the relative output of the two countries. In the bond economy model, country 1 uses the extra borrowing-financed investment to produce more output over time (relative to financial autarky), while country 2 produces relatively less output (see the top two panels in Figure 3).

The combined effects of differential investment demand and different output supply combine to produce notably different dynamics for the terms of trade across market structures (see the terms of trade panel in figure 3). In the short run, the additional investment in country 1 that occurs with bond trade means additional demand for the domestic intermediate good. This partially offsets the direct effect on relative prices from greater domestic intermediate production, so that the immediate increase in the terms of trade p is smaller than under financial autarky (so in the short run terms of trade is more favorable for country 1 under the bond trading). However, once the surge in

Figure 2: Impulse Responses to a 1 sd shock in home TFP

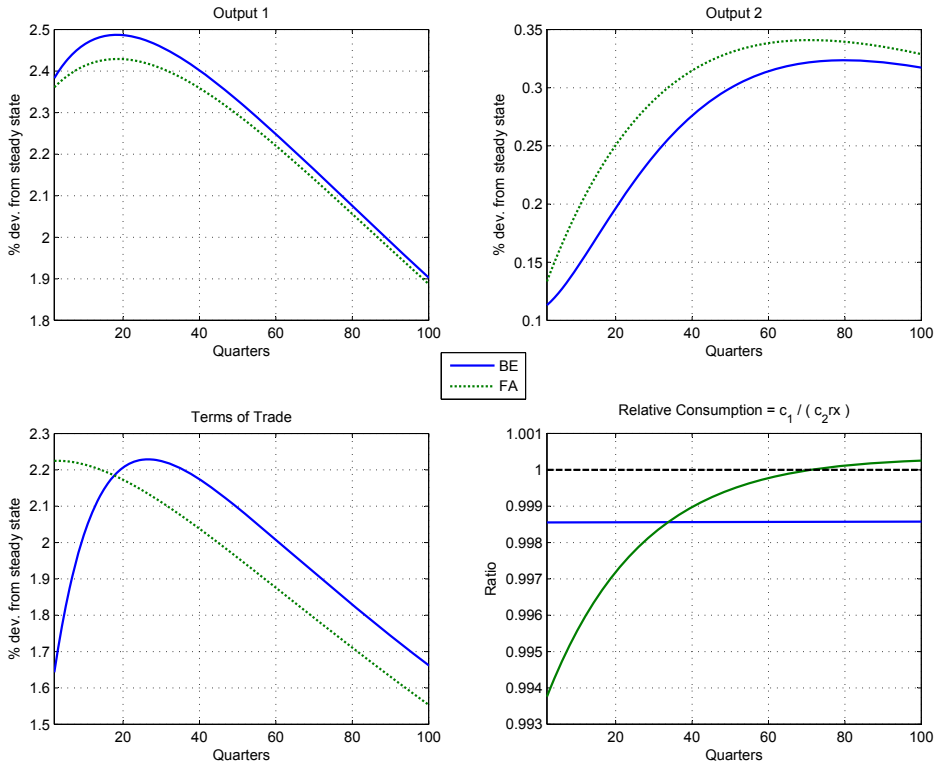


investment is over (and net exports flip from negative to positive), the fact that country one is now producing more in the bond economy than in financial autarky is the key driver of relative prices, and p is larger in the bond model than in financial autarky (and hence in the long run the terms of trade is less favorable to country 1 under bond trading). The key question is then which of the two phases dominates. To answer the question we can simply compute the (annuitized) net present value of the difference in the terms of trade under the two market structures, i.e., the quantity

$$G = (1-\beta)\sum_{t=0}^{\infty}\beta^t(p_t^{BE} - p_t^{FA})|_{z_o^1=\sigma_\varepsilon}$$

which measures the increase in the net present relative value of good a when capital markets are shut down. Under the benchmark parametrization we find that the quantity G is positive and equal

Figure 3: Impulse Responses to a 1 sd shock in home TFP



to roughly 0.11% of aggregate consumption.[4]

We are now in a position to understand our previous finding that if country 1 is relatively more productive than country 2, it is better off in financial autarky than with bond trade. The logic is that in the bond trade equilibrium, there is a lot of investment in country one, which ultimately increases the relative supply of the intermediate good produced in country 1 (good a) and therefore turns the terms of trade further against country 1. Financial autarky is preferable since it dampens the surge in investment, leading to less domestic supply, and a more favorable terms of trade from country 1's point of view. Under the baseline parameterization the gain represented by the more favourable terms of trade is large enough so that it outweighs the cost stemming from the loss of inter-temporal smoothing that comes with shutting down bond markets. It is also clear why

[4]The quantity G is of a similar magnitude if instead of discounting future values for the terms of trade at a constant rate β we instead discount using the household's marginal rate of substitution.

country 2 prefers bond trade to autarky in this scenario, since a worse terms of trade in the bond model from country 1's point of view is a better terms of trade from the perspective of country 2. Thus if country 1 were – out of self-interest – to introduce capital controls, it would impose negative spill-overs on country 2.

A closely related perspective on these dynamics can be borrowed from the optimal tariff literature. Because countries produced differentiated goods, a planner at the country level would always like to reduce output in order to raise relative prices (this is just the standard monopoly argument). For a country with relatively high initial productivity, imposing financial autarky is one way to achieve this objective, since prohibiting borrowing restrains domestic investment.

4.2 Pareto Improving Capital Controls

So far our results indicate that capital controls can be welfare improving from the perspective of one country because they imply a dynamic improvement in the terms of trade. This finding is similar in spirit to Costinot et al. (2014), and De Paoli and Lipinska (2013). Still, under our baseline parameterization, starting from a symmetric starting point, neither country would want to impose capital controls. We now move to establish a novel result, which is that for certain parameterizations, capital controls are unconditionally welfare improving, i.e. capital controls are Pareto improving when both countries are initially identical. Note that from this starting point, the usual dynamic terms of trade manipulation argument does not apply, since ex ante it is not known which country will be relatively more or less productive, and thus potentially gain or lose from restricting capital flows.

To see under what circumstances capital controls might be Pareto improving, we consider a range of alternative calibrations that vary with respect to the trade share, and the elasticity of substitution between traded goods. We consider trade shares of 50 and 75 percent, in addition to our baseline of 25 percent. Trade shares above 50% are quite common: examples include Poland, Czech Republic, Saudi Arabia, Korea, Malaysia, and Thailand. For the elasticity of substitution we consider a lower value of $\sigma = 0.5$ (similar to the value used by Corsetti, Dedola, and Leduc, 2008), as well as higher values of $\sigma = 2$ and $\sigma = 5$. For each combination of these calibrations, Table 2 reports two numbers. The first number is the expected welfare gain of moving from the bond economy to complete markets, starting from the non-stochastic steady state. This number

is necessarily positive. The second number is the expected welfare gain of moving from the bond economy to financial autarky, again starting from the non-stochastic steady state. The two cases, in bold, in which the number is positive represent cases of Pareto improving capital controls.

Table 2. Welfare Gains from Completing Markets
and Imposing Financial Autarky
(relative to Bond Economy baseline, as % of consumption)

	Elasticity of Substitution			
Import Share	$\sigma = 0.5$	$\sigma = 1$	$\sigma = 2$	$\sigma = 5$
$is = 0.25$	1.108 **0.059**	0.003 −0.006	0.153 −0.029	0.491 −0.068
$is = 0.50$	0.125 −0.045	0.000 0.000	0.111 −0.027	0.433 −0.084
$is = 0.75$	0.002 −0.024	0.005 −0.005	0.057 **0.002**	0.252 −0.028

Note: In each cell the top number is the gain from completing markets, the bottom the gain from moving to financial autarky

Consider, first, the welfare gains from completing markets – the top numbers in each cell in Table 2. These gains are always small given a unitary elasticity of substitution. The intuition is that given a unitary elasticity, fluctuations in the terms of trade provide good insurance against shocks to relative productivity. In fact, the welfare gain is precisely zero when the import share is 50 percent, and the elasticity of substitution is one. The gain of moving from the bond model to financial autarky is also zero in this case. In Subsection 4.2.3 we elaborate on the equivalence across market structures for this particular calibration. Holding fixed the import share at its baseline value of 25%, welfare gains from completing markets are larger than the unitary elasticity case for both smaller and larger elasticities of substitution.

The largest number in Table 2 corresponds to gain from completing markets when the trade share is 25% and the elasticity of substitution between traded goods is 0.5. In this case, the expected welfare gain starting from the bond economy baseline is equivalent to a permanent 1.1 percent increase in consumption. Because welfare under the bond economy is quite far from first best under this calibration, it is especially interesting to explore the welfare effects of capital controls in this case. It turns out that capital controls are welfare improving, offering a gain equivalent

to 0.06 percent permanent increase in consumption. There is one other parameter configuration in the table in which capital controls increase welfare, namely when the trade share is 75% and the elasticity of substitution between goods is $\sigma = 2$. We offer intuition for these two cases in Subsections 4.2.4 and 4.2.5 respectively.

4.2.1 Welfare Effects of Capital Controls

Trade in bonds helps agents to smooth consumption over time, while still allocating capital across countries so as to equate expected returns. The reason welfare under the bond market structure is less than under complete markets is that non-contingent bond trade does not provide insurance against shocks to relative permanent income. This lack of insurance is not very costly when productivity shocks are relatively transitory, so that relative permanent income does not fluctuate much. But it can be much more costly when shocks are permanent or near permanent.

Recall that given logarithmic utility from consumption (an assumption we maintain throughout) perfect consumption risk sharing means equating the value of consumption across countries:

$$c_1(s^t) = rx(s^t)c_2(s^t)$$

Financial autarky will offer one advantage relative to the bond economy model if the dynamics of the terms of trade under financial autarky serve to dampen fluctuations in relative permanent income, thereby generating smaller long run fluctuations in the value of relative consumption. Note, however, that the relevance of this potential argument in favor of capital controls hinges on the assumption that the goods produced by the two countries are imperfect substitutes. In a one good model, there would never be any fluctuations in relative prices, irrespective of market structure, and therefore no possibility for financial autarky to improve insurance. This is why imposing capital controls always reduces expected welfare in the high elasticity case ($\sigma = 5$) in Table 2.

As we explained above in interpreting impulse responses, in the bond model a positive productivity shock typically leads to an inflow of capital from abroad, which amplifies the impact of the shock on the relative supply of the intermediate good produced domestically (good a). This in turn amplifies the terms of trade response to the shock, in present value terms. Imposing financial autarky shuts down these capital flows and therefore tends to dampen the response of the terms of trade to shocks, relative to the bond economy model.

4.2.2 Welfare Losses in the Baseline Calibration ($\sigma = 1$, $is = 0.25$)

In the baseline model parameterization, movements in the terms of trade automatically provide very good insurance against country-specific shocks. In particular, Panel D in Figure 3 indicates that in this case, relative consumption moves very little in response to a shock. Thus, it is not surprising that imposing capital controls is welfare-reducing in this case: the usual benefits from bond trade in terms of better consumption smoothing and capital allocation are lost, and there is very little potential gain from manipulating the path for the terms of trade.

4.2.3 Cole and Obstfeld with Production ($\sigma = 1$, $is = 0.5$)

Welfare equivalence across market structures in this case reflects the fact that in each case allocations correspond to those that would be chosen by a world planner that puts equal planner weights on welfare of the two representative agents. The logic behind the result is that movements in the terms of trade provide automatic perfect insurance against country-specific shocks. Cole and Obstfeld emphasized this result in the context of an endowment economy: the novelty here is the extension to an environment with production. With production, the market structure irrelevance result only obtains with the trade share is equal to 50%. The reason is that when there is a bias towards local (or foreign) intermediate goods in final goods demand, the dynamics of relative investment affect the dynamics of the terms of trade, and thus the dynamics of relative income. When the trade share is exactly 50% relative consumption and investment demand have no impact on international relative prices, and thus the terms of trade moves exactly inversely with relative production of the two intermediate goods, delivering perfect insurance.

4.2.4 Welfare Gains with Low Elasticity ($\sigma = 0.5$, $is = 0.25$)

The first case in which capital controls increase ex ante welfare features our baseline trade share, but a low elasticity of substitution between traded goods. This calibration implies that the welfare costs of missing explicit insurance against shocks to relative permanent income are large, for two related reasons. First, because the two goods are poor substitutes, shocks to relative productivity generate large offsetting changes in the terms of trade. Thus, a positive shock in country one ends up increasing the relative permanent income of country 2. Second, these induced changes in

relative permanent income translate into a change in relative consumption that runs counter to the dictates of consumption risk sharing. In particular, when good a becomes relatively abundant (and the real exchange rate rx increases) efficiency calls for an increase in relative consumption in country 1 (whose consumption bundle is biased towards the relatively abundant good). But in the bond economy model, the fact that country 2 benefits disproportionately from the positive shock to country 1 means that relative consumption tends to move in precisely the opposite direction.

It is now easy to see why financial autarky can increase ex ante welfare in this case. When bond trade is ruled out, country 1 cannot run a trade deficit on impact, and this restrains the increase in investment in country 1, which in turn implies a more modest increase in the relative supply of good a over time, and a correspondingly more modest increase in the terms of trade (the relative price of good b). Smaller terms of trade fluctuations are exactly what is called for to deliver better insurance against shocks to relative productivity.

4.2.5 Welfare Gains with High Elasticity and High Import Share ($\sigma = 2$, $is = 0.75$)

The second case in which financial autarky is Pareto-improving relative to the bond economy is when the import share is large, and the elasticity of substitution is fairly high ($\sigma = 2$). The logic for why financial autarky is preferred in this case is somewhat different. With an import share larger than 50%, if country 1 experiences a positive productivity shock it will run a trade surplus, since with $\omega < 0.5$ it is country 2's final goods production that is relatively intensive in the now abundant good a. With a high elasticity of substitution, the terms of trade does not move much in response to a shock, and thus the relative income of country 1 increases. At the same time, the real exchange rate (the relative price of consumption in country 2) falls, because country 2's consumption is biased towards the relatively cheap good a.

From these dynamics it is clear why the potential welfare gain from completing markets is quite large in this case, and why financial autarky offers better insurance than the bond model against shocks to relative productivity. Following a positive shock in 1, risk sharing dictates an increase in consumption in country 2 relative to country 1 (rx falls) while income rises relatively more in country 1. Thus, insurance against shocks to relative productivity is relatively poor, and the welfare gains from completing markets are large. Financial autarky prevents country 1 from running a current account surplus in response to the shock. This implies less relative demand for

good a in the short run, and less country 2 investment and subsequent output of good b in the longer run. Both these forces translate into a larger increase in the present value of the terms of trade (the relative price of b). This higher path for the terms of trade makes country 2 richer, and country 1 poorer (relative to the bond model), and so ends up moving relative consumption towards country 2, which is the efficient direction.

5 Conclusion

We have explored the welfare effects of imposing capital controls within a textbook international business cycle model. We found that when countries differ with respect to initial productivity they also differ with respect to expected welfare losses from ruling out capital flows. In particular, the more productive country – which attracts inward investment in the near term under the bond trade equilibrium – would often do better under financial autarky. This finding can perhaps shed light on the long-standing puzzle that capital does not appear to flow into fast-growing countries (Gourinchas and Jeanne, 2013). In the context of the model we explored, restricting capital inflows in such countries both restrains the increase the relative supply of locally produced goods, and also supports future demand for those goods (by preventing the accumulation of a negative net foreign asset position). Both effects translate into a more favorable time path for the terms of trade.

More susprisingly, we also found that for certain parameterizations imposing capital controls is Pareto improving. We traced this result to the fact that in a two-good world with incomplete markets, movements in the terms of trade are an important form of insurance against shocks to relative income. Ruling out asset trade changes the cyclical dynamics of international relative prices, and in some cases sufficiently improves insurance that both countries prefer permannet financial autarky to permanent free bond trade.

The simple models that we have used abstract from a variety of features that may be important when considering the possible welfare effects from introducing capital controls. For example, we have not addressed the interaction of capital controls with other policies such as the choice of exchange rate regime and other dimensions of monetary policy. We have also not discussed the perceived excessive volatility of international capital flows, or the possibility of over-borrowing in environments with default risk. However, abstracting from these features has allowed us to focus on a channel that turns out to be quantitatively important for welfare: the impact of the international

asset market structure on the dynamics of international relative prices.

The asset market structures we compared were two standard benchmarks in the literature: free trade in a bond versus financial autarky. In practice it is likely that in some cases an intermediate market structure – perhaps featuring taxes on bond trade, or limits on debt positions – would offer higher expected welfare than either of these two extremes. In addition, introducing trade in additional assets would likely strengthen the case for free trade in bonds, since a sufficiently rich menu of assets should ultimately complete markets, obviating the scope for Pareto improving capital controls.

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