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A Contagious Malady? Open Economy Dimensions of Secular Stagnation

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Conditions of secular stagnation—low interest rates, below target inflation, and sluggish output growth—characterize much of the global economy. We consider an overlapping generations, open economy model of secular stagnation, and examine the effect of capital flows on the transmission of stagnation. In a world with a low natural rate of interest, greater capital integration transmits recessions across countries as opposed to lower interest rates. In a global secular stagnation, expansionary fiscal policy carries positive spillovers implying gains from coordination, and fiscal policy is self-financing. Expansionary monetary policy, by contrast, is beggar-thy-neighbor with output gains in one country coming at the expense of the other. Similarly, we find that competitiveness policies including structural labor market reforms or neomercantilist trade policies are also beggar-thy-neighbor in a global secular stagnation. [JEL E31, E32, E52, F33]
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Introduction

In this paper, we analyze the open-economy dimensions of secular stagnation. The concept of secular stagnation, dating back to Hansen (1939), was recently resurrected by Summers (2013).[1] The key idea, in Summers formulation, is that the natural rate of interest—the real interest rate the Federal Reserve needs to track to achieve full employment—is permanently negative. This poses a major challenge for policy due to the fact that the nominal interest rate cannot be cut below the zero lower bound (ZLB). Eggertsson and Mehrotra (2014) offer the first attempt to formally model secular stagnation using an overlapping generations model (OLG) in the spirit of Samuelson (1958) in a closed economy. However, low interest rates and lackluster growth are a global phenomenon. To understand secular stagnation in an open economy, we here consider a two-country open-economy OLG framework with varying degrees of financial market imperfection across countries.

Broadly speaking, this paper makes three central points. First, secular stagnation—which can be thought of as economies permanently facing the possibility of the ZLB without any natural force towards normalcy—may be important in modeling modern economies. Secular stagnation can be an important phenomenon in the global economy either because the world economy as a whole is in stagnation or a part of the global economy is in stagnation. In the latter case, we show how stagnation can be transmitted from one part of the global economy to another via capital flows and the associated trade dislocations.

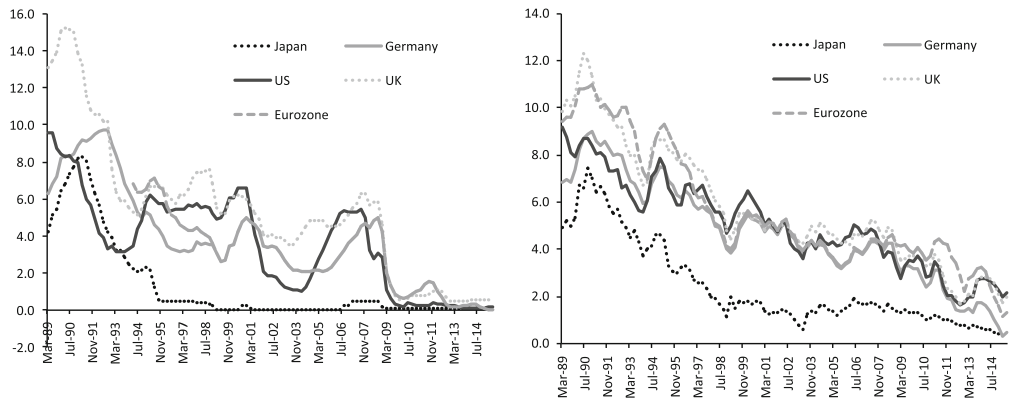
Second, in the open economy, policies that are stimulative for the home economy can have very different impacts on other economies and on the choices available to other countries in a secular stagnation. In general, monetary policies and those directed at competitiveness carry negative externalities, while fiscal policies and policies directed at stimulating domestic demand carry positive externalities. In a positive sense, the fact that fiscal policy benefits spillover across countries explains why the world has relied more on monetary policies relative to fiscal policies in the wake of the financial crisis. In a normative sense, our findings point towards the desirability of a robust fiscal response.

Third, fiscal policies in response to secular stagnation are consistent with the government's long-run budget constraint with three considerations being central. First, they may pay for themselves as in DeLong and Summers (2012), and we verify, in our model, that fiscal expansions actually lower the debt-to-GDP ratio. Second, balanced budget policies like tax financed spending or the expansion of pay as you go social security have positive fiscal impacts. Third, a one shot increase in debt will raise demand and is clearly sustainable in a secular stagnation.

At the time of writing, the United States has just raised the Federal Funds rate for the first time since 2008 based upon the hope that recovery is well underway and inflation will rise back to target. Meanwhile, much of the world remains stuck at the ZLB with some central banks seeking further stimulus. Our analysis

[1]See also Summers (2014, 2015a, b) for further exposition on the secular stagnation hypothesis.

Figure 1. Short- and Long-Term Interest Rates



suggest that, to the extent that the rise in U.S. rates increases capital flows to the United States, these flows place further downward pressure on the natural rate of interest in the United States. If these forces are strong enough, the Federal Reserve will be forced to cut rates back to zero. Capital flight to the United States due to a slowing economy and political instability from emerging markets, such as China, Brazil, and Russia, will have the same effect. Figure 2 shows the acceleration in capital outflows from China in 2015 and 2016 according to an estimate from the Institute for International Finance.

This article is organized as follows with some key results highlighted. The section on Capital Integration and the Natural Rate of Interest proposes a two-country overlapping generations endowment economy with imperfect capital integration. Here, we provide a simple framework that rationalizes the secular decline in short- and long-term interest rates, seen in Figure 1, throughout the world in the past quarter of a century. We incorporate imperfect capital integration across countries to explain persistent differences in real interest rates across countries, thus rationalizing how one part of the world may find itself in a secular stagnation, while the other is not. Indeed, Japan hit the zero bound in the mid-1990s—well before the Great Recession brought the rest of the developed world to the ZLB. While the closed economy literature on secular stagnation emphasized forces like demographic trends, inequality, the fall in relative price of investment, and debt deleveraging, our framework shows how these forces can be transmitted across regions via "global imbalances"—countries with excess savings and low real interest rates will export savings to those countries where returns are higher.

In the section on Government Debt and the Global Savings Glut, we extend the model to include government debt, taxes, and reserve accumulation. The goal is to show how the global saving glut hypothesis of Bernanke (2005) fits naturally into our framework. According to this hypothesis, current account deficits in the United States prior to the Great Recession were a consequence of heightened demand for U.S. debt, including the accumulation of U.S. Treasuries by various foreign governments. Figure 3 displays global imbalances leading up to the financial crisis. Both the global savings glut and the forces emphasized in secular stagnation theory can generate a persistent decline in the natural rate of interest in the United States.

Prices, Production and Exchange Rates extends the simple endowment economy to include production and price determination and formally defines equilibrium in the full model. Open Economy Secular Stagnation shows how the model can be reduced to a simple set of steady-state relationships that can by analyzed via basic aggregate demand and supply diagrams. This simplifies our expressions considerably and corresponds to a limiting case where the secular stagnation is permanent without any pullback to full employment. We consider secular stagnation under both imperfect and perfect capital integration. In the former case, one country is in secular stagnation while the other is not; we think of this version of the model as capturing the salient features of the global imbalances period pre-2008 and, particularly, the interaction of the United States and Japan prior to 2008. In the latter case, we think of our model as capturing features of the U.S. and Eurozone interaction from 2008 to 2015. On the endowment economy in the section on Capital Integration and the Natural Rate of Interest, current account imbalances transmitted low real rates; in the production economy with wage rigidity, capital markets may propagate output shortfalls and a binding zero lower bound rather than lower real interest rates.

The fact that capital flows can worsen stagnation allows us to formalize the idea of neomercantilism—a policy regime that encourages exports and discourages imports with the aim of increasing a country's net foreign asset position. If a country targets a positive net foreign asset position via its trading partner (e.g., by running large trade surpluses), this policy will exert a negative externality on the trading partner. A policy of this type can, in principle, generate a recovery at home, depending on the details of how the increase in net asset holdings is financed. Neomercantilism is therefore an example of a beggar-thy-neighbor policy. It is worth emphasizing that these effects are specific to a world in which the nominal interest rate is zero.

Another example of a beggar-thy-neighbor policy is structural reforms where a country increases wage flexibility. While this policy raises output in the country undertaking the reform, it comes at the expense of its trading partner. Moreover, aggregate world output declines as a consequence. This finding is suggestive that structural reforms of this type in Southern Europe may not be the magic bullet for restoring growth in Europe.

The Monetary Policy section studies monetary and exchange rate policy. We find that exchange rate depreciation, in general, is at the expense of the trading partner if both countries are in secular stagnation. It is thus yet another example of beggar-thy-neighbor policy. Increasing the inflation target in one country can be effective, but will also have similarly strong negative externalities on the trading partner if the trading partner does not inflate as well. We also identify a key difficulty with monetary policy in a secular stagnation which extends the previous result in Eggertsson and Mehrotra (2014) to an open economy. While a higher inflation target, if credible, allows for a better equilibrium, the secular stagnation equilibrium cannot be excluded.

Fiscal Policy introduces fiscal policy. In contrast to monetary policy, trade policy, or structural reforms, expansionary fiscal policy generates positive

Figure 2. Net Capital Flows from China

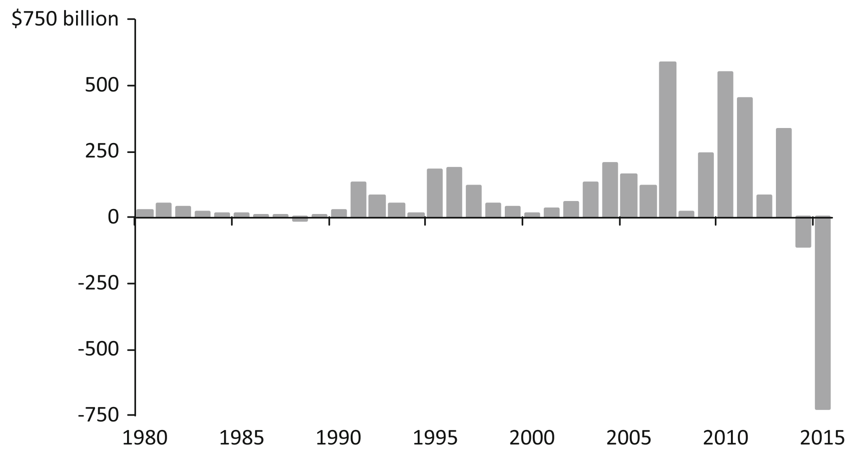
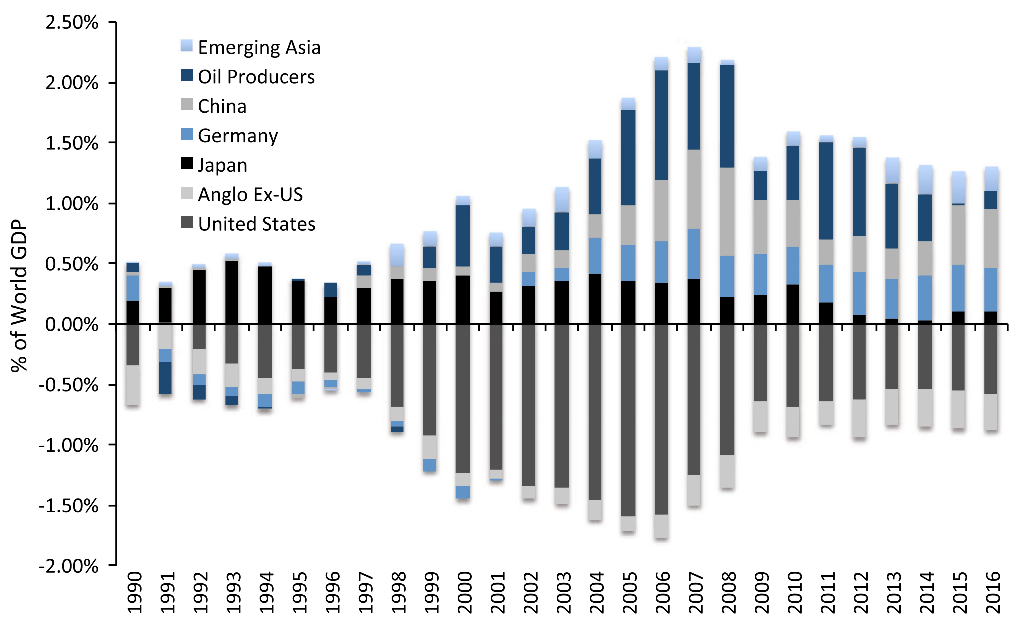


Figure 3. Global Imbalances



externalities for the trading partners in a secular stagnation. Moreover, fiscal policy does not suffer from the multiple equilibria problem that we find for monetary policy. A sufficiently robust fiscal expansion eliminates the secular stagnation equilibrium altogether. Fiscal policy "jump starts" the economy.

One reason fiscal policy is so powerful in our model is that Ricardian equivalence does not hold due to the assumption of finite lifetimes. This means that government debt is far from neutral. Higher levels of public debt raise the natural rate of interest directly and thus eliminate the need for a negative real interest rate, thereby pulling the economy out of secular stagnation. We formally establish, under mild conditions, that debt-financed fiscal expansions actually reduce the debt-to-GDP ratio in a secular stagnation as suggested in DeLong and Summers (2012). We obtain this finding without assuming any hysteresis effects.

While this policy is quite powerful, we also discuss some possible drawbacks. We consider the effect of increasing government spending with direct taxation on the working population. This balanced budget policy, as well, directly increases the natural rate of interest and pulls the economy out of secular stagnation. As with debt expansion, this policy has strong positive externalities for the trading partners. Given that fiscal policy carries positive externalities, countries will tend to undersupply fiscal expansion. We show formally how fiscal expansion absent coordination is undersupplied relative to cooperation, and show what factors influence the severity of the coordination problem.

In Quantitative Examples, we calibrate our model to quantify the two particular episodes already alluded to: the asymmetric stagnation of Japan and the United States pre 2008 and the symmetric stagnation of the United States and Eurozone from 2008 to 2015. Our calibration suggests that Japan greatly benefited from capital flows to the United States, as this allowed it to export its excess savings during this period. Our calibration also suggests that the United States in fact may have benefited from closing capital markets in the latter period, as it would have avoided the zero bound. These numerical examples are meant to highlight that the framework presented here can easily be parameterized to draw concrete quantitative conclusions on the sources of secular stagnation and possible policy responses. We expect it can be enhanced considerably to yield more detailed quantitative predictions.

Related Literature

We have already pointed out that our paper draws heavily on Summers original reformulation of the secular stagnation hypothesis, and the model proposed in Eggertsson and Mehrotra (2014). Our paper also relates to the emerging literature on models of economic stagnation, including Kocherlakota (2013), Caballero and Farhi (2014), Schmitt-Grohé and Uribe (2013), Benigno and Fornaro (2015), Bianchi and Kung (2014), and Guerron-Quintana and Jinnai (2014). With the exceptions of Kocherlakota (2013) and Caballero and Farhi (2014), these models feature a steady-state real interest rate that is always positive and determined solely by the discount factor of the representative household.

This paper is closest in spirit to recent work by Caballero and others (2015) which was developed independently and concurrently with our work. In their model, a stagnation episode in their model is driven by shortage of safe assets. In contrast, our framework highlights several alternative forces that have been more closely tied to the secular stagnation hypothesis, including demographics, debt deleveraging, a fall in the relative price of investment goods, income inequality, and global capital flows. While, we do not analyze the safe asset shortage hypothesis, we do not view it as incompatible with our framework. Despite a different theoretical setup, we find that many of our policy conclusions are broadly complementary.

At a conceptual level, another key difference in our model from Caballero and others (2015) is our focus on imperfect financial integration across countries.

Our model allows for the possibility that only part of the world is in a secular stagnation while the rest of the world is not. By contrast, in Caballero and others (2015) all countries are in a secular stagnation or none. This feature is necessary to capture the long-lasting slump in Japan, and the fact that the United States appears to exit the ZLB while Europe and Japan do not. This difference arises from the fact that we consider the case of incomplete financial integration which allows us to model violations of interest rate parity.

One key advantage of our framework, relative to others is that our model delivers a locally unique equilibria which allows for comparative statics.[2] Our model is thus easier to quantify and delivers sharper implications for policy relative to the literature that focuses on the deflation steady state in a standard representative agent model.

Our approach contrasts with the analysis of liquidity traps in New Keynesian open economy models. These models, including Fujiwara and others (2013), Cook and Devereux (2013), and Acharya and Bengui (2016), analyze monetary policy in a global liquidity trap and consider the implications of capital market integration. As in our model, Devereux and Yetman (2014) show that capital controls can potentially prevent the spread of liquidity traps. In general, like the closed economy New Keynesian model, these models cannot generate a ZLB steady state (or highly persistent ZLB episodes) and generally suffer from the forward guidance puzzle (see McKay and others 2015).

Our model is similar in structure to the model of Coeurdacier and others (2015) which examines how financial integration accounts to declining real interest rates and capital flows from emerging markets to advanced economies. We consider the implications of low natural rates with a binding zero lower bound and nominal frictions. Our model also shares features of models that examine the global demand for safe assets and the persistent US current account deficit: Caballero and others (2008), Gourinchas and Jeanne (2013), and Maggiori (2013). Interestingly, when the natural rate falls below the population growth rate, our model can generate a trade deficit in steady state for debtor countries. Finally, our results on the gains from monetary and fiscal coordination build on earlier work by Clarida and others (2002), Dixit and Lambertini (2003), and Benigno and Benigno (2006).

Finally, let us note that Eggertsson and others (2016) consider a textbook variation of this model, confirming the basic insights of what we show here and also discussing the role of real exchange rate movements.

Capital Integration and the Natural Rate of Interest

We start by showing how the real interest rate is determined in an endowment economy, allowing for varying degrees of financial integration. In the more general model we introduce later, the real interest rate we derive here maps directly into the natural rate of interest in each country. To consider intermediate

[2]Schmitt-Grohé and Uribe (2013) and Benigno and Fornaro (2015) are examples of models in which the stagnation steady state is locally indeterminate.

cases between autarky and full financial integration, we introduce a constraint on international capital flows. Our focus is to show how the domestic real interest rate is affected by the degree of financial market integration.

There are two countries, domestic and foreign. Each country trades a one-period risk-free bond with returns r_t and r_t^*, respectively. Without loss of generality, we focus here on the case in which $r_t \geq r_t^*$—a situation in which the returns on the asset in the domestic economy dominate that in the foreign country so long as capital markets are imperfectly integrated.

Consider a simple overlapping generation economy. Households live for three periods: they are born in period 1 (young), earn income in period 2 (middle-aged), and retire in period 3 (old). We assume there are no aggregate savings, but that the generations can borrow and lend to one another. We assume that only the middle-aged receive income, Y_t and Y_t^*, respectively. This will imply that the middle-aged generation in each country lend to the young in order to save for retirement. A key constraint we impose is on the borrowing of the young. The young are constrained by a borrowing limit $(1+r_t)B_t^y \leq D_t$ and $(1+r_t^*)B_t^{*y} \leq D_t^*$ as in Eggertsson and Krugman (2012). Implicitly, we think of this limit as emerging from some type of incentive constraint; however, for our purposes, we take it to be exogenous.

If the real interest rate is higher in one country than the other, savings will flow to the country with the highest yield. If there are no constraints on capital flows, then the real interest rate in equilibrium is equalized across the two countries. We impose a simple quantity constraint on international capital flows which we denote by K_t. In particular, we assume that the domestic debt held by the foreign middle generation has to be lower than some K_t. Again, implicitly, we are assuming this constraint reflects some sort of incentive constraint, perhaps due to incomplete enforcement of contracts across national borders, home bias for investors, or other limits to arbitrage. For the purpose of our analysis, we will simply treat this constraint as exogenous. One could similarly interpret this as representing some form of capital controls since it places a direct quantity limit on how much capital can move across countries. When the constraint is not binding, then real interest rates must be equalized across the two countries.[3]

Formally, consider the following overlapping generation model. A domestic household born at time t has the following utility function:

$$\max_{C_t^y, C_{t+1}^m, C_{t+2}^o} \mathbb{E}_t\left\{\log\left(C_t^y\right) + \beta \log\left(C_{t+1}^m\right) + \beta^2 \log\left(C_{t+2}^o\right)\right\}$$

subject to the following (real) budget constraints:

$$C_t^y = B_t^y \tag{1}$$

$$C_{t+1}^m = Y_{t+1} - (1+r_t)B_t^y - A_{t+1}^D - A_{t+1}^I \tag{2}$$

[3] We derive similar results when there is a credit spread function that depends on the level of the capital flow between the two countries. We adopt the quantity restriction here given that the resulting equilibrium conditions are a generalization of the closed economy case considered in Eggertsson and Mehrotra (2014) and provide a slightly simpler exposition.

$$C^o_{t+2} = (1 + r_{t+1})A^D_{t+1} + (1 + r^*_{t+1})A^I_{t+1} \tag{3}$$

$$(1 + r_t)B^i_t \leq D_t \tag{4}$$

$$0 \leq A^I_{t+1} \leq K_{t+1} . \tag{5}$$

Here C^i_t denotes consumption for each generation i, B^y_t borrowing in a one-period risk-free bond that carries an interest rate r_t. A^D_t is the asset holding of the middle-aged household of the domestic bond that carries interest rate r_t, while A^I_t is the middle generation holdings of the foreign asset. The foreign economy has the same set of preferences and faces the same set of constraints. We assume that there is no short-selling of the foreign asset. While the middle generation can accumulate a positive position in A^I_t, which earns interest r^*_t, it cannot issue its own debt at the rate r^*_t.

We consider an equilibrium in which the borrowing constraint for the young is binding:

$$C^y_t = B^y_t = \frac{D_t}{1 + r_t} . \tag{6}$$

In equilibrium, the middle generation lend to the young to save for their retirement. Their savings decision satisfies a consumption Euler equation:

$$\frac{1}{C^m_t} = \beta \mathbb{E}_t (1 + r_t) \frac{1}{C^o_{t+1}} , \tag{7}$$

while the old consume all their income—principal and interest on domestic and foreign savings.

$$C^o_t = (1 + r_{t-1})A^D_{t-1} + (1 + r^*_{t-1})A^I_{t-1} . \tag{8}$$

The residents of the foreign economy satisfy the same conditions where we denote each variable with a star. The model is closed by bond market clearing in each country. For the domestic market, it is given by

$$N_t B^y_t = N_{t-1} A^D_t + N^*_{t-1} A^{I*}_t , \tag{9}$$

while the foreign bond market-clearing condition is given below:

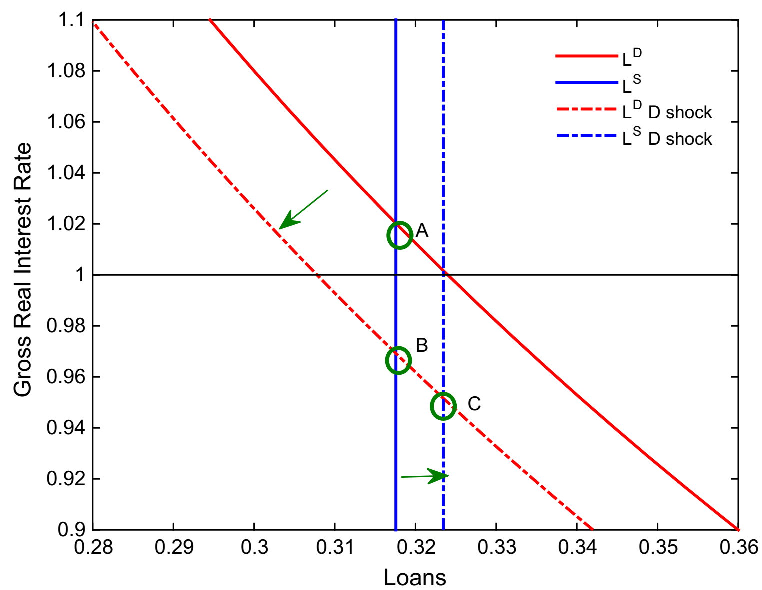
$$N^*_t B^{y*}_t = N^*_{t-1} A^{D*}_t + N_{t-1} A^I_t \tag{10}$$

which closes the model.[4]

Without loss of generality, we consider the case in which $r_t > r^*_t$. In this case, the international lending constraint is binding (5). Define $1 + g_t = \frac{N_t}{N_{t-1}}$ and $\omega_t = \frac{N_t}{N_t + N^*_t}$. Then we can express the domestic asset market-clearing constraint as

[4]For a given set of exogenous processes $\{D_t, N_t, Y_t\}$ and $\{D^*_t, N^*_t, Y^*_t\}$, an equilibrium in the global economy is now characterized by a collection of stochastic processes $\{C^y_t, C^o_t, C^m_t, r_t, B^y_t, A^I_t\}$ and $\{C^{y*}_t, C^{o*}_t, C^{m*}_t, r^*_t, B^{y*}_t, A^{I*}_t\}$ that solve (1), (2), (5), (6) , (7), and (8) for the domestic and the foreign households, respectively, along with asset market-clearing conditions (9) and (10).

Figure 4. Equilibrium in the Asset Market



$$(1+g_t)B_t^y = A_t^D + \frac{1-\omega_{t-1}}{\omega_{t-1}} K_t^* .$$

The left-hand side is the domestic demand for loans, L_t^d, and the right-hand side is the supply of loans, L_t^s from domestic and foreign sources. The domestic demand for loans can be expressed in terms of the collateral constraint (6) so that

$$L_t^d = \frac{1+g_t}{1+r_t} D_t .$$

Assuming perfect foresight, we obtain the domestic supply of loans by substituting the budget constraint of the old (8) to solve for the consumption of the middle-aged using the Euler equation (7). We then substitute the resulting expression for C_t^m into the middle-aged budget constraint (2), use (6) and solve for A_t^D to obtain

$$L_t^s = \frac{\beta}{1+\beta}\left(Y_t^m - D_{t-1}\right) + \frac{1-\omega_{t-1}}{\omega_{t-1}} K_t^* .$$

Figure 4 depicts the demand and supply for loans in the domestic economy. The demand for loans increases as the real interest rate falls. A lower interest rate increases the borrowing capacity of the young, allowing them to take on more debt. As emphasized by Eggertsson and Mehrotra (2014), both the debt deleveraging shock D_t as well as a slowdown in population growth can reduce the real interest rate. Either mechanism will shift down the demand for loans, as shown at point B in Figure 4, leading to a drop in the real interest rate.

By contrast, the supply for loans remains unchanged with deleveraging and population growth shocks.[5] This assumption implies that the middle-aged are simply saving a fixed fraction of their disposable income. As a result, the supply of savings is a vertical line in Figure 4. One interesting mechanism that shifts the supply for loans is a permanent debt deleveraging shock. This shock leads to a reduction in D_{t-1} triggering a further reduction in the real interest rate by shifting out the supply for loans in the next period as shown by point C in Figure 4, in line with Eggertsson and Mehrotra (2014) but in contrast to the earlier literature on deleveraging such as Eggertsson and Krugman (2012). The fact that the young can take on less debt after a persistent decrease in D_t means that these households have greater disposable income in middle age and thus a higher supply of savings. Thus, a permanent tightening of the collateral constraint leads to a permanent reduction in the real interest rate.

Relative to Eggertsson and Mehrotra (2014), the new element in this model that impacts interest rate determination is the presence of international lending K_t^* in the supply of loans. The inflow of foreign capital will directly shift out the supply of loans, thereby reducing the real interest rate. This provides for an additional force that can lead to secular stagnation.

Equating loan supply and loan demand, we obtain an expression for the domestic interest rate:

$$1 + r_t = \frac{1+\beta}{\beta} \frac{(1+g_t)D_t}{Y_t - D_{t-1} + \frac{1-\omega_{t-1}}{\omega_{t-1}} \frac{1+\beta}{\beta} K_t^*}. \tag{11}$$

The most important implication of our supply and demand framework for loanable funds is that there is no inherent reason to expect the equilibrium real interest rate to be positive. Whether rates are positive or negative depends on the relative size of demand and supply for loanable funds. While we show above how population dynamics and debt deleveraging may affect this relationship, the earlier literature has also emphasized other forces such as an increase in income inequality (which increases the supply of savings), a fall in the relative price of investment, or an increase in uncertainty. Importantly, liberalization of capital markets—to the extent it leads to a capital inflow—also exerts downward pressure on the domestic interest rates via increases in K_t^*.

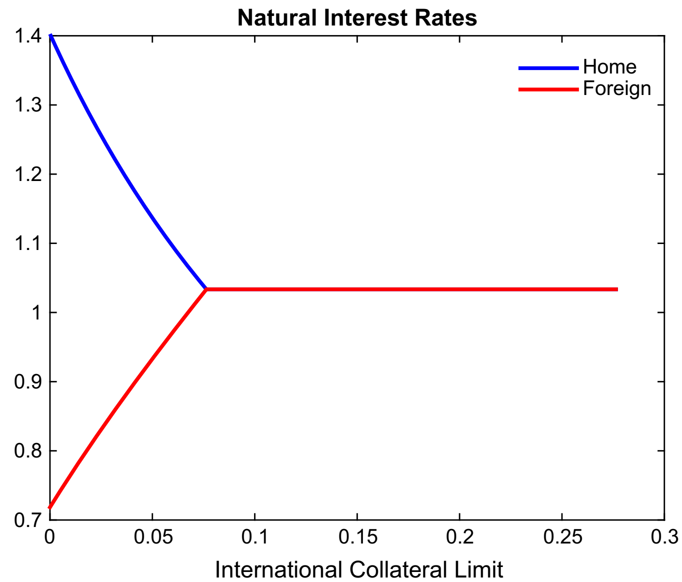
Analogously, using the foreign asset market-clearing condition (10) and combining foreign budget constraints, we can obtain an expression for the foreign real interest rate:

$$1 + r_t^* = \frac{1+\beta}{\beta} \frac{(1+g_t^*)D_t^* + \frac{1+r_t}{1+\beta} K_t^*}{Y_t^* - D_{t-1}^* - K_t^*}, \tag{12}$$

where the foreign real interest rate will be influenced by the domestic interest rate, since the foreign old collect higher interest income from the domestic

[5] This is not a general feature of the model, but is due to the assumption of log preferences and the fact that all income is accrued in middle-aged. Eggertsson and Mehrotra (2014) treat the more general cases that we omit here for simplicity.

Figure 5. Effect of an Increase in International Lending on Natural Rate



borrowers. Figure 5 shows domestic and foreign interest rate determination graphically. The x-axis reflects ranges of K_t^*, and the y-axis shows the gross real interest rate. In autarky then $K^* = 0$ so the two interest rates are determined independently of each other. In the current example, the foreign interest rate is negative while the domestic rate is positive. We see that as K_t^* increases, the two interest rates converge.

Finally, when K_t^* is high enough, the international lending constraint (5) is no longer binding and interest rates are equalized. The point of convergence may happen at either positive or negative world interest rates, depending on parameter values. Beyond this point, there is a single world interest rate given by

$$1 + r_t^W = \frac{1+\beta}{\beta} \frac{\omega_{t-1}(1+g_t)D_t + (1-\omega_{t-1})\left(1+g_t^*\right)D_t^*}{\omega_{t-1}(Y_t - D_{t-1}) + (1-\omega_{t-1})\left(Y_t^* - D_{t-1}^*\right)}. \tag{13}$$

Under full integration, the world interest rate will lie in between the two autarky rates.

Proposition 1: *If* $r_t^{\text{aut}} > r_t^{\text{aut}^*}$, *then* $r_t^{\text{aut}} > r_t^W > r_t^{\text{aut}^*}$.

Proof: Follows directly from the expression for the world interest rate under integration and the domestic/foreign interest rates under autarky. □

Observe that in this equilibrium, as long as $r_t > r_t^*$ in autarky then capital will flow into the domestic economy. The domestic economy's net foreign asset position under full integration is given by

$$NFA_t^{\text{full}} = \frac{\beta}{1+\beta}(Y_t - D_{t-1}) - (1+g_t)\frac{D_t}{1+r_t} < 0 \,.$$

The trade balance is simply the change in the net foreign asset position adjusted for interest payments and population growth. In the case of the domestic economy, the trade balance is given by the following expression:

$$TB_t = NFA_t - \frac{1+r_{t-1}}{1+g_{t-1}} NFA_{t-1} \,. \tag{14}$$

In steady state, if the real interest rate exceeds the growth rate of population, the trade balance takes the opposite sign of the net foreign asset position. Debtor countries with negative NFA positions must run a trade surplus in steady state. However, if $r < g$, the trade balance and NFA share the same sign. Debtor countries can run perpetual trade deficits.[6]

As we show in coming sections, the assumption of incomplete integration will be helpful to make sense of the fact that Japan has been experiencing conditions consistent with a secular stagnation for a far longer period than the rest of the world. Incomplete integration will also help us analyze the spillovers from reserve accumulation and rising global imbalances in the pre-2008 period.

Government Debt and the Global Savings Glut

The global saving glut hypothesis argues that the reduction in real interest rates in the United States and developed countries in recent years has been triggered by reserve accumulation by East Asian and oil-producing countries. We have shown how these forces could work via private capital flows, where interest rates fall in higher interest rate countries as the lending constraint slackens. The emphasis in the global savings glut literature, however, has usually been on government policies that put downward pressures on U.S. interest rates via purchases of U.S. Treasuries. We now extend our model to focus more squarely on reserve accumulation and fiscal policies, which will, in general, impact the determination of interest rates in an OLG economy. One interesting feature of our environment is that the effects of reserve accumulation depend both on how reserve accumulation is financed and the extent of capital market integration.

We denote the lump sum tax levied on each generation by T_t^y, T_t^m, T_t^o. The domestic government issues public debt and levies taxes on each generation to make interest payments on past government debt and finances some level of government expenditure G_t. The government's budget constraint is given by

[6]The intuition for why debtor countries can run permanent trade deficits is somewhat distinct in our model from Caballero and others (2008) and Maggiori (2013). Those models carry a well-defined risk premium, and debtor country trade deficits reflects compensation for risk (akin to the equity premium). In our case, $r < g$ implies dynamic inefficiency and the debtor country can borrow since the present value of national income is infinite. We thank Matteo Maggiori for pointing out this distinction.

$$B_t^g + \frac{1}{1+g_{t-1}} T_t^o + T_t^m + (1+g_t) T_t^y = G_t + \frac{1+r_{t-1}}{1+g_{t-1}} B_{t-1}^g \,. \tag{15}$$

Our aim here will not be to analyze fiscal policy in general (we defer that discussion until we have incorporated endogenous production), but instead clarify how foreign reserve accumulation can lead to a drop in the natural rate of interest. For now, assume that $T_t^y = 0$ and $G_t = 0$. Also, as in Eggertsson and Mehrotra (2014), we assume that both governments adopt a particular fiscal rule that eliminates any loan supply effects of taxation:

$$T_{t+1}^o = \beta(1+r_t) T_t^m \,. \tag{16}$$

The overall level of taxes will adjust to ensure the government budget constraint is satisfied. The foreign government also issues public debt and levies taxes on each generation to make interest payments on past government debt. However, the foreign government also chooses to accumulate some of the debt issued by the other country, IR_t:

$$\begin{aligned} &B_t^{g*} + \frac{1}{1+g_{t-1}^*} \left(T_t^{o*} + (1+r_t) IR_{t-1}\right) + T_t^{m*} + (1+g_t^*) T_t^{y*} \\ &\quad = G_t^* + \left(1+r_{t-1}^*\right) B_{t-1}^{g*} + IR_t \end{aligned} \,. \tag{17}$$

Here the left-hand side of the equation tallies the revenues of the government, while the right-hand side gives government expenditures. We express the variables in terms of spending/reserves per middle-aged person. In particular, a positive level of IR_t denotes foreign reserve assets accumulated by the foreign government which are in the form of the bond issued by the domestic government. Observe that we assume that the government is not constrained by K_t which only applies to private capital flows.[7]

Fiscal policy impacts interest rates through its effects on the asset market-clearing conditions:

$$N_t B_t^y + N_{t-1} B_t^g - N_{t-1}^* IR_t = N_{t-1} A_t^D + N_{t-1}^* K_t \tag{18}$$

$$N_t^* B_t^{y*} + N_{t-1}^* B_t^g = N_{t-1}^* A_t^{D*} \,. \tag{19}$$

To avoid unnecessary notation, we assume symmetric country size for now so that $\omega_t = 1/2$ and no population growth, $g_t = g_t^* = 0$. If the capital constraint is binding, then the equilibrium real interest rate in debtor and creditor countries is given by

$$1 + r_t = \frac{1+\beta}{\beta} \frac{D_t}{(Y_t - D_{t-1}) + \frac{1+\beta}{\beta}(K_t^* - B_t^g + IR_t)} \tag{20}$$

[7]The rationale for assuming that the reserve accumulation decision is not subject to the international lending constraint is that emerging market economies are, typically, quite closed to private portfolio flows despite considerable official capital flows. Further, some emerging market economies accumulate low interest U.S. Treasuries for non-pecuniary reasons (i.e., insurance against sudden stops, exchange rate manipulation to favor traded sector, etc.).

$$1 + r_t^* = \frac{1+\beta}{\beta} \frac{D_t^* + \frac{1+r_t}{1+\beta} K_t^*}{Y_t^* - D_{t-1}^* - K_t^* - \frac{1+\beta}{\beta} B_t^{g*}}, \tag{21}$$

while if capital markets are perfectly integrated, the single world interest rate given by

$$1 + r_t^W = \frac{1+\beta}{\beta} \frac{D_t + D_t^*}{Y_t + Y_t^* - D_{t-1} - D_{t-1}^* - B_t^g - B_t^{g*} + IR_t}. \tag{22}$$

The equations above offer several insights. First of all, notice that an increase in government debt will always raise the real interest rate in that country. However, fully integrated capital markets are necessary for a rise in the foreign country debt to have an effect on the interest rate in the domestic economy. Therefore, the manner in which foreign reserve accumulation is financed has different effects under complete versus incomplete integration.

Consider first incomplete integration. We see in Equation (20) that an increase in reserves will directly reduce the real interest rate in the domestic economy. However, the foreign economy only has an influence on the domestic real interest rate through IR_t and K_t^*. Hence from the perspective of the domestic economy, it does not matter whether the increase in reserves is financed by debt or taxes.

Under perfectly integrated financial markets, however, we see that the financing of foreign reserves, IR_t matters a great deal. In particular, imagine that the increase in IR_t is met by a proportional increase in the debt of the foreign country B_t^{g*}. In that case, foreign reserve accumulation has no effect on the world real interest rate as the increased supply of bonds offset the decline in debt held by the public.

The effect of reserve accumulation on global rates we have just outlined is fully consistent with the argument advanced in Bernanke (2015). Hence, a global saving glut is a natural complement to other forces that may trigger secular stagnation, like a fall in population growth or deleveraging shocks. A final point to emphasize is that IR_t reflects a policy choice of the government. While we would not expect private capital to flow from one country in our model to another unless there is a positive interest rate differential, no such interest rate differential is needed for reserve accumulation. This matters, since a large driver of current account deficits we documented in the introduction stems from countries such as China or oil-producing countries. It is not obvious that rates of return in the United States dominate the returns in these countries. The fact that those countries choose to invest in U.S. Treasuries still acts as a negative force on the U.S. natural rate of interest, which (as we will show) can have negative consequences when we take nominal frictions and the zero lower bound into account. Foreign reserve accumulation, in this way, exerts a negative externality on the United States.

Prices, Production, and Exchange Rates

That the natural rate of interest is negative need not be a problem in and of itself. It only becomes a problem once we incorporate the zero lower bound and nominal frictions. We now introduce nominal price determination, the zero lower bound, endogenize production, and introduce nominal frictions. Critically, we assume that each country runs its own monetary policy. Accordingly, each country has a currency which determines the price level in terms of that nominal unit. On the production side, we assume frictions in the adjustment of nominal wages defined in the price level of each country.

Prices

We follow the literature by introducing nominal price determination via the Woodford "cashless" economy. Each country now trades, in addition to the real bond, a nominal bond denominated in each country's price level. We assume that households in either country can hold these nominal bonds implying arbitrage equations between the real and the nominal bonds within a country, but also arbitrage equations across nominal assets denominated in different currencies.[8] Let us denote the domestic price level by P_t and the foreign price level with P_t^*. The nominal exchange rate is $S_t = \frac{P_t}{P_t^*}$.

The presence of the two nominal bonds implies two new Euler equations for the middle generation in each country:

$$\frac{1}{C_t^m} = (1 + i_t)\beta E_t \frac{1}{C_{t+1}^o} \frac{P_t}{P_{t+1}} \tag{23}$$

and an equivalent Euler equation for the foreign middle generation. Each middle generation household also must be indifferent between real and nominal debt implying the Fisher relation:

$$(1 + r_t)E_t \frac{1}{C_{t+1}^o} = (1 + i_t)E_t \frac{1}{C_{t+1}^o} \frac{P_t}{P_{t+1}}. \tag{24}$$

Monetary Policy

We assume that each country follows a strict inflation targeting regime, so that

$$\Pi_t = \bar{\Pi} \quad \text{if } \mathrm{i_t} \geq 0 \text{ otherwise } \mathrm{i_t} = 0 \text{ and } \Pi_\mathrm{t} < 1 \tag{25}$$

$$\Pi_t^* = \bar{\Pi}^* \quad \text{if } \mathrm{i_t^*} \geq 0 \text{ otherwise } \mathrm{i_t^*} = 0 \text{ and } \Pi_\mathrm{t}^* < 1\,. \tag{26}$$

Each country will set its nominal interest rate so as to achieve its inflation target. If the inflation target cannot be achieved, then the central bank sets its nominal interest rate equal to zero. The zero interest rate then closes the model instead of

[8]In equilibrium, we assume that the nominal bonds may be in zero net supply. Hence, these equations are only important for pricing, i.e., the resulting pricing equations for these nominal bonds is what pins down the nominal price level in each country—see Equations (23)–(24). This is convenient because it implies that, in equilibrium, the budget constraint will be identical to the endowment economy so that the previous derivations continue to hold.

the inflation target.[9] This assumption conveniently abstracts altogether from a particular feedback rule while focusing on the possible problems a country may face if it cannot achieve its inflation target due to the zero bound. Fiscal policy follows the same fiscal rule as outlined in the previous section on Government Debt and the Global Savings Glut.

Production

We assume that firms are price takers on product and labor markets. However, we assume that wages are downwardly rigid. This assumption is sufficient to generate a long-run trade-off between inflation and output, which is what is needed to generate a secular stagnation.[10]

Households supply labor inelastically at $\bar{L}$. We assume that only the middle-aged supply labor. There is one firm per middle-aged household. Firms hire labor to produce output using a decreasing returns to scale technology. Firms maximize profits Z_t, taking wages and prices as given

$$Z_t = \max_{L_t} P_t Y_t - W_t L_t \tag{27}$$

$$\text{s.t. } \mathrm{Y_t} = L_t^{\alpha} . \tag{28}$$

The optimality condition for firm labor demand is standard:

$$\frac{W_t}{P_t} = \alpha L_t^{\alpha-1} , \tag{29}$$

If prices and wages are flexible, the model is closed by setting aggregate labor supply equal to labor demand:

$$L_t = \bar{L} . \tag{30}$$

Under this assumption, the economy is identical to the endowment economy we have already studied, except for the determination of nominal prices and exchange rates.

What separates our model from the endowment economy is that we replace the market-clearing relationship (30) with the assumption that wages do not fully adjust. In particular, we assume that workers will never be willing to supply labor to firms if the firm offers a wage that falls below some wage norm $\tilde{W}_t$ (the classic example of this is the Keynesian idea that workers will never accept wages lower than last year's nominal wages). This constraint is asymmetric, that is, workers would happily accept higher nominal wages. Accordingly, if the wage rate implied

[9] One way in which a policy regime of this kind can be implemented is to assume that the central bank follows a Taylor rule where the response coefficient approaches infinity, but the zero bound is respected.

[10] In Eggertsson and Mehrotra (2014), we examine alternative nominal frictions that incorporate forward-looking behavior, like Calvo pricing, but find that it added much complexity with little additional insight. In that environment, the long-run trade-off between inflation and output stems from inefficient price dispersion and misallocation across identical producers.

by competitive markets is above $\tilde{W}_t$, then wages get bid up and the market clears. This implies is that if the wage norm is binding real wages can be higher than they would need to be for the market to clear. In this case, employment is rationed.

To be more specific, we assume that wages are downwardly rigid and given by

$$W_t = \max\left\{\tilde{W}_t, W_t^{\text{flex}}\right\},$$

where $\tilde{W}_t$ is a wage norm determined by

$$\tilde{W}_t = \gamma W_{t-1}\bar{\Pi} + (1-\gamma)P_t\alpha\bar{L}^{\alpha-1}.$$

When $\gamma = 1$ and $\bar{\Pi} = 1$ wages are perfectly downwardly rigid and when $\gamma = 0$, wages are flexible and real wages always attain their market-clearing level.[11]

We allow for possibility that the wage norm is binding at the inflation target of the central bank, $\bar{\Pi}$ which implies costs of inflation rates below the central bank's target.[12] With a positive inflation target, outright deflation is not needed to generate a secular stagnation. When inflation is less than target, $W_t > W_t^{flex}$, and, therefore, $L_t < \bar{L}$ because firms' labor demand does not exhaust the labor endowment and employment is rationed. Let us denote output when labor is fully employed as $Y_f \equiv \bar{L}^\alpha$.

Combining labor demand, the production function, and the wage norm, we can obtain an aggregate supply curve of the form:

$$Y_t = \begin{cases} Y^f & \text{if } \Pi_t \geq \left(\dfrac{Y^f}{Y_{t-1}}\right)^{\frac{1-\alpha}{\alpha}} \\ \left[\gamma \dfrac{Y_{t-1}^{\frac{\alpha-1}{\alpha}}}{\Pi_t} + (1-\gamma)Y_f^{\frac{\alpha-1}{\alpha}}\right]^{\frac{\alpha}{\alpha-1}} & \text{otherwise} \end{cases} \quad 0 \leq A_{t+1}^I \leq K_{t+1}. \tag{31}$$

Analogously, for the foreign economy, we have

$$Y_t^* = \begin{cases} Y^{*f} & \text{if } \Pi_t^* \geq \left(\dfrac{Y^{*f}}{Y_{t-1}^*}\right)^{\frac{1-\alpha}{\alpha}} \\ \left[\gamma^* \dfrac{Y_{t-1}^{*\frac{\alpha-1}{\alpha}}}{\Pi_t^*} + (1-\gamma^*)Y_f^{*\frac{\alpha-1}{\alpha}}\right]^{\frac{\alpha}{\alpha-1}} & \text{otherwise} \end{cases}. \tag{32}$$

With production, we now adjust the middle generation household budget constraint to take account of labor income and profits, replacing Y_t in (2) with

[11] This type of wage rigidity can be incorporated in a search and matching framework as in Hall (2005) and could be microfounded by staggered wage bargaining as in Gertler and Trigari (2009).

[12] To generate a secular stagnation, a long-run Phillips curve is needed whereby inflation below target reduces output below its full-employment level. Pricing frictions as in Calvo would also generate this type of Phillips curve, assuming either price or wage rigidities. See Appendix G in Eggertsson and Mehrotra (2014) for discussion.

$\frac{W_t}{P_t}L_t + \frac{Z_t}{P_t}$. Noting that $Y_t = \frac{W_t}{P_t}L_t + \frac{Z_t}{P_t}$, the budget constraints take on exactly the same form as before, and hence the first-order conditions for each generation's maximization problem we derived in the endowment economy still apply. Hence, following the same steps as before, we can express the interest rate in each country as in Equations (11) and (12) while under full integration, we use (22).

We now have all the pieces together to explicitly define the equilibrium in the model and, without loss of generality, we restrict our attention to the case in which $r_t \geq r_t^*$.

Definition 1: An equilibrium under incomplete capital integration is a set of quantities $\{Y_t, C_t^y, C_t^m, C_t^o, B_t^y, A_t^m, T_t^m, T_t^o\}$ and a set of prices $\{r_t, i_t, \Pi_t\}$ for the domestic economy, an analogous set of quantities and prices for the foreign economy, and a set of exogenous processes for $\{D_t, D_t^*, N_t, N_t^*, G_t, G_t^*, B_t^g, B_t^{g*}, IR_t\}$ that satisfies (1), (2), (3), (4), (7), (16), (23), (25), (31), for the domestic and foreign economies, along with government budget constraints (15), (17) and asset market-clearing conditions (18), (19) with (5) binding. If $r_t = r_t^*$, then global asset market clearing (22) replaces the domestic and foreign asset market-clearing conditions and (5) not binding.

Open Economy Secular Stagnation

While the equilibrium defined above may appear somewhat unwieldy, the model can be reduced to only a few equations and exposited by a simple AD-AS diagram, not unlike a typical textbook model. We obtain this tractability by focusing on steady states so the model can be summarized by two equations relating output and inflation in steady state. Our focus on steady states follows naturally from our interest in analyzing protracted slumps across developed countries—the steady state being a limiting case.[13] For simplicity, we assume below that both countries are of the same size, there is no population growth, and $r \geq r^*$.[14]

Monetary policy in (25) and (26) is useful to organize our thinking about global secular stagnation. It helps us reduce the equilibrium conditions to the essentials. In particular, we consider the four possible scenarios that represent possible combinations of monetary policy:

Definition 2: An inflation targeting equilibrium represents 4 scenarios at time t:

Scenario 1: Full employment: Both countries set $\Pi_t = \bar{\Pi}$ and $\Pi_t^* = \bar{\Pi}^*$ while $i_t \geq 0$ and $i_t^* \geq 0$.

[13]Our full model exhibits transition dynamics with differences in the response of output and inflation on impact and with a lag. Eggertsson and Mehrotra (2014) feature a quantitative examination of the transition dynamics of our model. Moreover, the determinacy results in this section concern the behavior of the log-linearized dynamic model.

[14]These assumptions are not critical and are in fact relaxed in our numerical examples.

Scenario 2: Global secular stagnation: Both countries miss their inflation targets with $\Pi_t < \bar{\Pi}$ and $\Pi_t^* < \bar{\Pi}^*$ and set $i_t = i_t^* = 0$.
Scenario 3: Foreign secular stagnation: Home sets $\Pi_t = \bar{\Pi}$ while $i_t \geq 0$. Foreign misses its inflation target $\Pi_t^* < \bar{\Pi}^*$ and sets $i_t^* = 0$.
Scenario 4: Domestic secular stagnation: Home misses its inflation target $\Pi_t < \bar{\Pi}$ and sets $i_t = 0$. Foreign sets $\Pi_t^* = \bar{\Pi}^*$ while $i_t^* \geq 0$.

Notable in our definition of the inflation target equilibrium is what it excludes. We do not consider the possibility that inflation is above $\bar{\Pi}$ in each country. The central bank could always eliminate this equilibrium by raising interest rates. In other words, the only reason inflation fails to meet its target according to this definition is because of the zero bound. We will explore later the effect of the central bank deliberately increasing its inflation target and the conditions under which this target can be reached.

The definition below establishes the equilibrium conditions satisfied by a steady state in our model:

Definition 3: The inflation targeting steady state consists of a vector $(Y, Y^*, \Pi, \Pi^*, i, i^*, r, r^*)$ that satisfies the following eight conditions:

$$\text{if } r > r^* \begin{cases} Y = \left(1 + \frac{1+\beta}{\beta}\frac{1+g}{1+r}\right) D - \frac{1+\beta}{\beta}\left(\frac{1-\omega}{\omega}K^* - B^g + IR\right) & (33) \\ Y^* = \left(1 + \frac{1+\beta}{\beta}\frac{1+g}{1+r^*}\right) D^* + \left(1 + \frac{1}{\beta}\frac{1+r}{1+r^*}\right) K^* + \frac{1+\beta}{\beta} B^{g*} & (34) \end{cases}$$

$$\text{if } r = r^* = r^w \begin{cases} \omega Y + (1-\omega) Y^* = \left(\frac{1+\beta}{\beta}\frac{1+g}{1+r^w} + 1\right)(\omega D + (1-\omega) D^*) \\ \qquad + (\omega(B^g - IR) + (1-\omega) B^{g*}) \end{cases} \tag{35}$$

$$Y = \begin{cases} Y_f & \text{if } \Pi \geq 1 \\ Y_f \left(\frac{1 - \frac{\gamma\bar{\Pi}}{\Pi}}{1-\gamma}\right)^{\frac{\alpha}{1-\alpha}} & \text{otherwise} \end{cases} \tag{36}$$

$$Y^* = \begin{cases} Y_f^* & \text{if } \Pi^* \geq 1 \\ Y_f^* \left(\frac{1 - \frac{\gamma^*\bar{\Pi}^*}{\Pi^*}}{1-\gamma^*}\right)^{\frac{\alpha}{1-\alpha}} & \text{otherwise} \end{cases} \tag{37}$$

$$\Pi = \bar{\Pi} \text{ or } i = 0 \tag{38}$$

$$\Pi^* = \bar{\Pi}^* \text{ or } i^* = 0 \tag{39}$$

$$1 + r = \frac{1+i}{\Pi} \tag{40}$$

$$1 + r^* = \frac{1+i^*}{\Pi^*}. \tag{41}$$

The first two equations apply under incomplete capital market integration. They are equivalent to a basic IS relationship in many macroeconomic models. A lower real interest rate raises output demanded. If the value of K^* is high enough, then interest rates are equated across the two countries and the third Equation (35) is operative. World demand depends on a world real interest rate r^w. Equations (36) and (37) describe aggregate supply under both imperfect and perfect integration. Under this specification, if inflation is above target, output is at its full-employment level and wages are equal to their market-clearing wage. If inflation falls below the inflation target then real wages rise above their market-clearing level (due to the binding wage norm) so labor demand falls below the labor endowment. Equations (38) and (39) describe the monetary policy rules, while the last two equations are the domestic and foreign Fisher relations.

For future reference, it will be useful to define the natural rate of interest. It is the real interest rate and that emerges if the central bank hits its inflation target and output is at its full-employment level. The natural rate corresponds to the interest rate we derived in the endowment economy. It is straightforward to confirm that in our general model, the natural rate of interest is given by Equations (20)–(22) where output in each equation is replaced by full-employment output Y_f.

Definition 4: The natural rate of interest r^n, r^{n*} is the real interest rate in (33) *and* (34) with output at Y_f and Y_f^*, respectively.

When full employment in both countries is not feasible, the cases defined in Definition 2 often allow for any of the three scenarios (i.e., either both countries are in stagnation or exactly one country is in stagnation) to be consistent with the equilibria in Definition 4. This holds true either under perfect integration or imperfect financial integration (albeit under stricter conditions in the latter case).

Discussing all the different cases, however, is somewhat unwieldy. Accordingly, we focus our analysis on a subset of scenarios. We first consider the case of imperfect financial integration where one country is in a secular stagnation and the other is not. This is a useful benchmark because it illustrates how secular stagnation is transmitted via capital flows—a country that is in a secular stagnation will in general attempt to export its excess savings to its trading partner, thereby possibly exporting secular stagnation. While the same forces also operate under full financial integration, differing degrees of financial integration make this transmission mechanism particularly clear. We also illustrate the case in which both countries are in secular stagnation but markets are not fully integrated. This case makes transparent the important role of reserve accumulation, and how reserve accumulation can exert negative externalities on the trading partner, a result similar to neomercantilism.[15]

While the possibility of multiple equilibria suggested in Definition 2 can arise under both perfect or imperfect financial market integration, analyzing the model under perfect integration is simpler and more transparent for that purpose. Accordingly, we highlight the multiplicity of equilibria in this simpler setting. Similarly, the study of both monetary and fiscal policy is simpler under perfect integration, which is why we will also use perfectly integrated financial markets as a benchmark when analyzing monetary and fiscal policy in the later sections. We leave the analysis of the interactions between capital market imperfection and monetary and fiscal policy to future research.[16]

Stagnation Under Imperfect Financial Integration

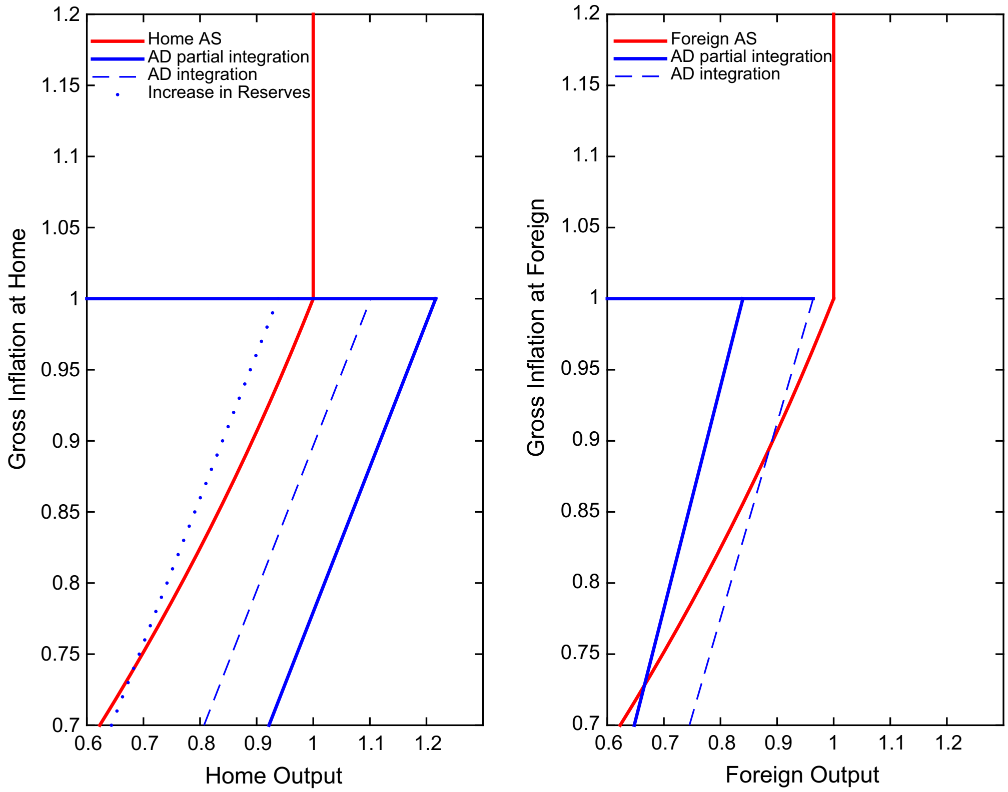
We start by considering the case when one country is in a secular stagnation while the other is not. This case shows how secular stagnation can be transmitted through greater capital market integration. In particular, this case can show how current account surpluses in Japan during the late 1990s and early 2000s reduced interest rates in US while easing the effects of stagnation in Japan. In Quantitative Examples, we analyze quantitatively the spillover from Japan to the United States in the pre-2008 global imbalances period. This section also answers a broader question: how can international capital flows coincide with a world in which one country suffers from secular stagnation while the other does not? Imperfect arbitrage on capital flows allows for this outcome. The prospect of asymmetric stagnation has once again become relevant as the United States seeks to normalize interest rates in 2016, while other developed economies remain stuck at the zero lower bound.

We can plot graphically the equilibria in Definition 3 via simple diagrams. The panels of Figure 6 plots steady-state output and inflation for the home and foreign country. Aggregate demand is determined by combining the IS equation (33) with the monetary policy rule (38) and the Fisher relation (40). The demand curve is horizontal at the inflation target of the domestic economy, which, for simplicity, is set at $\Pi = 1$. The central bank will set interest rates at whatever is needed to achieve this target. We can then back out from the IS equation (33) the required nominal interest rate to achieve the inflation target. However, at some point, keeping inflation at target may require a negative nominal interest rate. A kink appears in the aggregate demand curve as shown in the figure at the point when the nominal rate hits zero. Once interest rates hit zero, the aggregate

[15]As we have already pointed out in the section Government Debt and the Global Savings Glut, this result also obtains under perfect financial integration but, in that case, it depends on how reserve accumulation is financed.

[16]Another reason for focusing on perfectly integrated capital markets is that the way in which we introduce incompleteness is via fixed quantity constraint. A more general characterization could specify capital flows as a function of the interest rate differential between two countries. In general, the policy implications are likely to depend on the precise specification of capital market imperfections so we have opted here to focus largely on the case of complete integration. We have some discussion of this in Eggertsson and others (2016).

Figure 6. Effect of an Increase in International Lending



demand curve is increasing in inflation since higher inflation reduces real interest rates and raises demand. Below the kink, the AD curve (home country) is given by combining the IS equation (33) with the Fisher equation (40) and imposing the zero bound:

$$Y = \left(1 + \frac{1+\beta}{\beta}\Pi(1+g)\right)D - \frac{1+\beta}{\beta}\left(\frac{1-\omega}{\omega}K^{*} - B^{g} + IR\right).$$

The aggregate supply curve is given by Equation (36) and is shown as the red line in Figure 6. At positive inflation this relationship is vertical as the wage rate is equal to its flex price level and the labor endowment is fully employed. If inflation is below zero (or, more generally, below the central bank's inflation target), then the wage norm becomes binding in Equation (36). Accordingly, the AS curve is upwards sloping in inflation and output.

The left panel in Figure 6 depicts the steady state in the domestic economy when the natural rate of interest is positive at home. The aggregate demand and aggregate supply curve intersect at full employment. The right panel in Figure 6 shows the equilibrium in the foreign economy under the assumption that the foreign natural rate of interest is negative. The solid line shows the case when $K^{*} = 0$ and the dashed line the case in which $K^{*} > 0$ and capital moves from the foreign country to the domestic. Indeed, we can prove under general conditions that a unique asymmetric stagnation equilibrium exists. In this equilibrium, the foreign country in stagnation accumulates claims on the domestic economy.

Proposition 2: *If the international lending constraint, K^*, is binding so that $r > r^*$ and $r^n > 0$, $r^{n*} < 0$, $\bar{\Pi} = \bar{\Pi}^* = 1$, and $\gamma^* > 0$, there exists a unique, locally determinate secular stagnation equilibrium in the creditor country with $i^* = 0$, $\Pi^* < 1$, and $Y^* < Y_f^*$.*

Proof: See Appendix A. □

As shown in Figure 6, an increase in international lending leads to capital flows from the foreign country to the domestic economy. This has no effect on output in the domestic economy but reduces the domestic real interest rate. For the foreign economy, greater international lending allows the foreign economy to export its excess savings and thereby reduce the downward pressures on the natural rate. In a secular stagnation, this increases demand and raises output by increasing the inflation rate. There is no reason to assume that this process of exporting excess savings will not push the domestic economy all the way to the zero lower bound. The condition needed for this is simply that K^* is large enough so that the natural rate of interest is negative in the home country as well. In this scenario, it may be beneficial for the home country to close its capital markets to prevent secular stagnation from spreading, and we will investigate this possibility with some numerical examples in the section on Quantitative Examples.

The effect of increasing private foreign capital holdings on the domestic economy is exactly the same as if the foreign government directly invests in the foreign economy through reserve accumulation (as we see in Equation 33). In either case, the foreign government is exporting excess savings and putting downward pressure on the real interest rate in the domestic economy. This capital inflow, in principle, may be large enough so as to drag the domestic economy into a secular stagnation.[17] In this case, foreign capital inflows no longer transmit lower interest rates, but instead transmit a recession. We see this case in the second dotted line in Figure 6, whereby foreign official capital flows (given by IR) push the domestic economy into a secular stagnation. It is worth noting that this increase in IR need not have any effect on the foreign economy [see Equation 34)] if the fiscal rule is formulated so that there are no loan supply effects.

Proposition 3: *If the international lending constraint at $K^* = 0$, $\bar{\Pi} = 1$, and $\gamma > 0$, then, if $r^n > 0$, $i > 0$, $\frac{\partial r}{\partial IR} < 0$, and $\frac{\partial Y}{\partial IR} = 0$. If $r^n < 0$, $i = 0$, $\frac{\partial r}{\partial IR} > 0$, and $\frac{\partial Y}{\partial IR} < 0$.*

Proof: See Appendix A. □

Proposition 3 shows that while capital inflows typically lower the real interest rate, once the zero bound becomes binding, capital inflows instead

[17]Substantial reserve accumulation in the pre-2008 era may have made the United States more vulnerable to negative demand shocks by increasing the likelihood of hitting the zero lower bound.

transmit a recession and *higher real interest rate*. We have framed Proposition 3 in terms of the government policy variable IR which measures the amount of domestic assets (reserves) acquired by the foreign government. We do this for simplicity. We have seen that an increase in capital flows as measured by an increase in K^* has exactly the same effect.[18]

Our model offers a framework for thinking about neomercantilism—policies that attempt to boost a country's net foreign asset position by targeting persistent trade surpluses for some period. In our model, these policies may be expansionary for the country that implements them but comes at the expense of a trading partner in secular stagnation. Thus if successful, this policy corresponds to a classic beggar-thy-neighbor policy.

Under imperfect integration, private capital flows from the country with lower rates to the country with higher rates. Given our assumptions, however, reserve accumulation need not go in the same direction as private capital flows. Moreover, we can imagine that a country can curtail private capital inflows with capital controls. Reserve accumulation will always worsen the stagnation in the debtor country. An increase in international reserves, say by Japan or China purchasing U.S. Treasuries, reduces the stock of U.S. Treasuries held by U.S. residents. This lowers the natural rate of interest in the United States. If the United States is at the ZLB and in a secular stagnation, this has the effect of pushing inflation further below target and worsening the output shortfall.

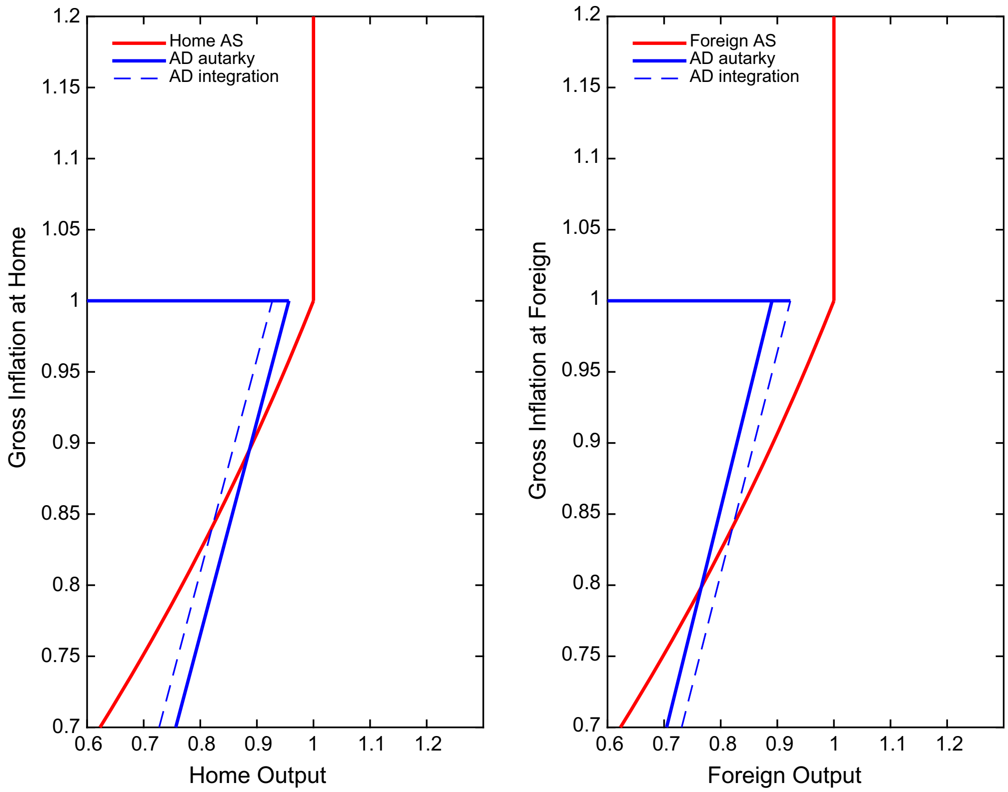
Figure 7 shows how reserve accumulation can be beggar-thy-neighbor. The figure depicts two countries in secular stagnation under imperfect integration. In this case, an increase in reserve accumulation by the foreign country (Japan) shifts inward the U.S. aggregate demand curve lowering inflation and output. Under the appropriate fiscal policy for the foreign country, this reserve accumulation alleviates a secular stagnation as shown by the dashed line in the right panel of Figure 7.

For the country building up reserves, it will in general matter how reserve accumulation is financed, while this is irrelevant from the perspective of the United States under incomplete financial integration. If reserve accumulation is financed by taxation of savers or by issuance of public debt, this policy has the effect of raising the natural rate of interest and boosting inflation/output in the creditor country. Alternatively, if both the middle-aged and old are taxed according to fiscal rule (16), then reserve accumulation has no impact on equilibrium inflation and output in the creditor country. In this particular case, reserve accumulation worsens secular stagnation in the debtor country while providing no benefit for the creditor country.

Reserve accumulation is equivalent to a net foreign asset target for the country acquiring reserves. Along the transition path, the country accumulating reserves will need to run a trade surplus. If equilibrium interest rates are negative, then these surpluses can even be permanent as we saw in Equation (14).

[18]Framing the proposition in term of K^* instead of IR, however, involves some complications. We then need to ensure that there remains a positive interest rate differential $r \geq r^*$ at all times. Otherwise, the international lending constraint may no longer be binding or private capital flows can reverse (leading to different special cases depending on parameters).

Figure 7. Effect of International Reserve Accumulation



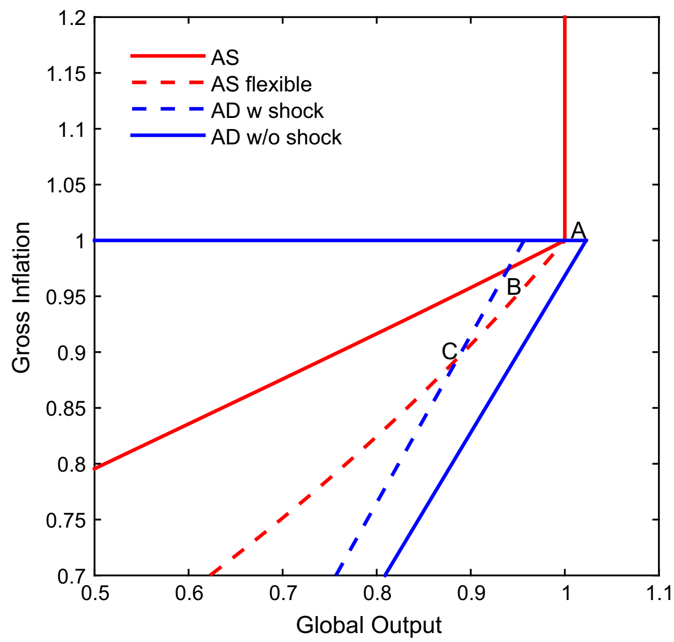
Significant trade surpluses in Japan and Germany along with continued reserve accumulation by emerging market economies are policies that may have ameliorated output gaps in those countries while exerting a significant drag on the U.S. economy.

Let us now move onto the issue of the possibility of multiple equilibria, and some policy options. Either issue is most clearly illustrated assuming perfect capital integration.

Perfect Capital Integration and Multiple Equilibria

Consider now a world in a secular stagnation with perfect financial integration. In this case, the world interest rate is determined by a single Equation (35) which then determines aggregate world demand, given by the population weighted output of the two countries. Importantly, under full capital integration, the real interest rate is always the same across the two countries. The zero lower bound and the inflation target in each country now place a lower bound on the *equilibrium* world real interest rate. Let us first consider the case in which both countries are in a secular stagnation, so that interest rates in both countries are at the ZLB. Equations (40) and (41) then imply that the inflation rate is equalized across these two countries with world gross inflation Π^w.

Figure 8. Global Stagnation



We depict this equilibrium in Figure 8 that shows aggregate world demand and supply. The intersection of these schedules at point A shows the case of a positive world natural rate of interest. If the world natural rate is negative due to, for example, a negative financial shock like the U.S. housing crisis (contraction in D), both countries find themselves in a world secular stagnation (point B). Assuming both countries share the same inflation target, we can establish the next proposition:

Proposition 4: *If* $r^{W,n} < \bar{\Pi}^{-1}$, *there exists a locally determinate secular stagnation equilibrium with* $Y < Y_f$, $Y^* < Y_f^*$, $i = i^* = 0$, and $\Pi < \bar{\Pi}$.

Proof: See Appendix A. □

Even if both countries are in a secular stagnation, this need not imply that both countries experience the same output gap. The output gap in each country is determined by the deviation of inflation below the inflation target and the degree of wage rigidity. Assuming a symmetric inflation target of $\bar{\Pi} = \bar{\Pi}^* = 1$, Definition 3 implies that the output gap in each country is given by the following equations:

$$Y = \left(\frac{1 - \frac{\gamma}{\Pi^w}}{1 - \gamma} \right)^{\frac{\alpha}{1-\alpha}} Y_f \qquad (42)$$

$$Y^* = \left(\frac{1 - \frac{\gamma^*}{\Pi^w}}{1 - \gamma^*} \right)^{\frac{\alpha}{1-\alpha}} Y_f^* \qquad (43)$$

$$1 + r = \frac{1}{\Pi^w}, \tag{44}$$

where Equations (42) and (43) are the domestic and foreign AS curves, and (44) is the Fisher equation defining the real interest rate when the zero lower bound is binding in both the home and foreign country. Equations (35), (42)–(44) jointly determine the endogenous variables r , Π^w, Y, and Y^* in a symmetric stagnation equilibrium.

The country with the higher degree of wage rigidity, as given by the higher γ or γ^*, will suffer a more severe output gap. The wage norm reacts more sluggishly in the less flexible labor market, moving the real wage further from its market-clearing level. Holding constant the world interest rate, it is unambiguously beneficial for each country to increase its wage flexibility in a secular stagnation as seen in Equations (42) and (43). The general equilibrium effect, however, is ambiguous and depends on the size of the country relative to the world economy. What is clear, however, is that this policy increases the world demand shortfall and increases global deflation, as seen by point C in Figure 8. Overall, a structural reform policy leads to a paradox of flexibility, lowering global output, and can, at best, just redistribute the output shortfall from one country to the other. In other words, structural reforms under perfect integration are also a beggar-thy-neighbor policy. This insight carries particular relevance for the Eurozone.

Our previous proposition assumed a symmetric equilibrium. Our model, however, is also consistent with one country in secular stagnation while its trading partner is at full employment. Under perfect integration, real rates could be equalized with one country at the ZLB experiencing deflation while the other country has a high nominal rate with inflation on target.

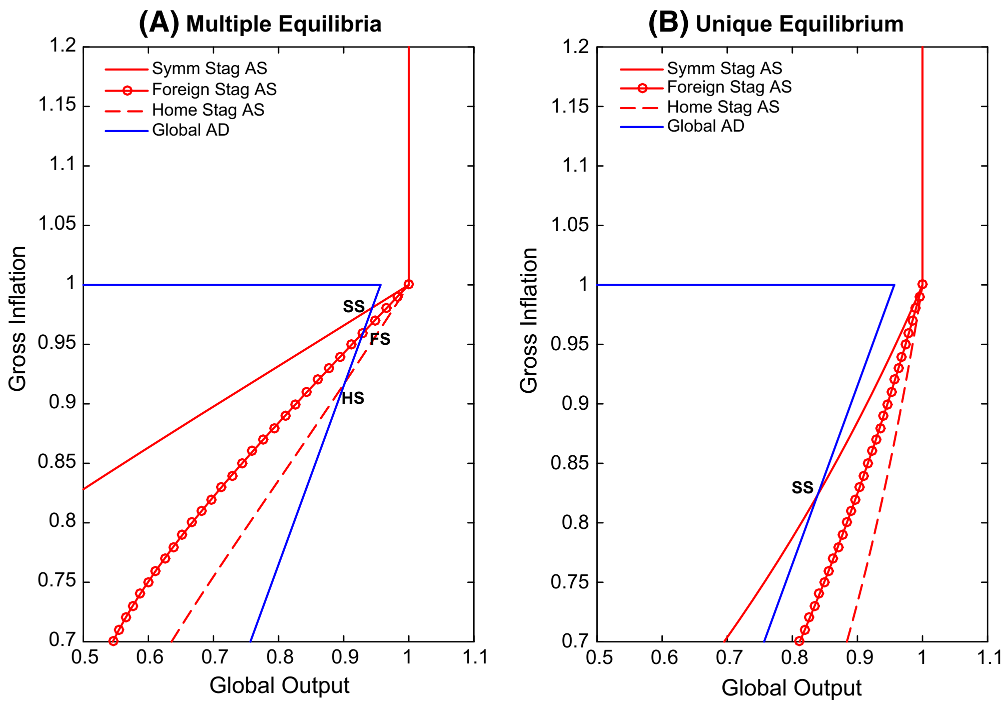
Proposition 5 establishes conditions and properties of an asymmetric stagnation equilibrium under perfect integration in the case when home is in stagnation and foreign is not. The analogous conditions establish when the mirror case occurs: home country at full employment with foreign country in stagnation. Depending on parameter values, both, one, or neither of these asymmetric stagnation equilibria may emerge.

Proposition 5: *If* $r^{W,Nat} < \bar{\Pi}^{-1}$, $D^W > (1-\omega)Y_f^*$, $\gamma > 0$, *there exists a unique, locally determinate asymmetric secular stagnation with* $r = r^*$, $Y < Y_f$, $Y^* = Y_f^*$, $i = 0$, *and* $\Pi < \bar{\Pi}$.

Proof: See Appendix A. □

The left panel of Figure 9 displays the asymmetric equilibria. Real interest rates are equalized across the two countries. Assuming for simplicity that $\bar{\Pi} = 1$ for both economies, this means that the country in secular stagnation experiences actual deflation, while the economy not in stagnation will see its inflation on target and positive interest rates. For the foreign country not in stagnation, then, $Y^* = Y_f^*$ and $\Pi^* = 1$. World output is given by the following expression:

Figure 9. Asymmetric Stagnation



$$Y^w = \omega\left(\frac{1-\frac{\gamma}{\Pi}}{1-\gamma}\right)^{\frac{\alpha}{1-\alpha}} Y_f + (1-\omega)Y_f^* + \cdot \tag{45}$$

The global AD curve remains unchanged from Equation (35). An analogous equation for world output obtains in the mirror case if the foreign economy is in secular stagnation and domestic is not, with γ replaced by γ^* and Π with Π^*. In drawing Figure 9, we have assumed that $\gamma < \gamma^*$—wages are more flexible at home than abroad.

The different possibilities are shown in Figure 9. While panel A shows that asymmetric equilibria are possible, panel B depicts a case where no asymmetric equilibria emerge.[19] A sufficient condition for multiplicity is given in Proposition 5: if the global collateral constraint exceeds the level of output of the country that is not in stagnation, then we can guarantee existence of an asymmetric stagnation steady state.

An important implication of Propositions 4 and 5 is that, if the asymmetric stagnation equilibrium exists, then a symmetric stagnation will also always be a possibility. Figure 9, panel A, shows the three possibilities: home-only stagnation (HS), foreign-only stagnation (FS), and symmetric stagnation (SS). The key

[19]In an asymmetric stagnation, one country must absorb the entire shortfall in world output. Intuitively, supply exceeds demand and if higher interest rates drive down global demand faster than global supply no equilibria exists. The failure of the AD and AS curves to cross is due to the fact that global supply in an asymmetric stagnation is bounded below by the full-employment level of output in the country not in stagnation. In a symmetric stagnation, there always exists a sufficiently high rate of deflation that drives global output to zero while demand remains bounded away from zero.

takeaway from the figure—and this is a general property of the model—is that in the event of an asymmetric stagnation, the country that is in stagnation must absorb the entire drop in output needed to balance desired investment and savings. Moreover, because of decreasing returns in labor, the total drop in world output will always be larger in an asymmetric stagnation than if both countries share the burden. Therefore, if one country escapes secular stagnation at the expense of the other, world output will fall, even if the country that escapes will obviously benefit. This is an important insight when thinking about monetary policy in the next section.

As we have shown in this section, the possibility of a natural rate of interest that falls below a central bank's inflation target leads to secular stagnation equilibria into which one or both countries may fall. While capital controls may prevent secular stagnation from spreading to countries with a sufficiently high autarky natural rate, other policy options may be preferable. We next turn to monetary and fiscal policy to investigate whether these policies can eliminate the possibility of secular stagnation.

Monetary Policy

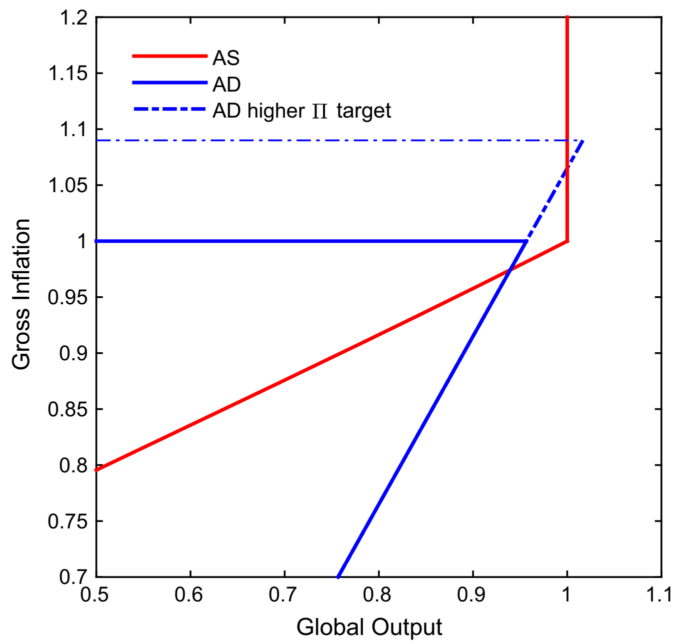
Increasing the Inflation Target

Imagine that both countries have an inflation target of $\Pi = \Pi^* = 1$ and the natural rate of interest is negative in a world with perfect capital integration. Assume that the domestic economy announces a higher inflation target while the foreign economy does not. If the domestic economy reaches this new inflation target, the only possible equilibrium is an asymmetric secular stagnation where the foreign economy remains trapped and the domestic economy is at full employment. This possibility will be important when we analyze the effects of monetary policy formulated in terms of an exchange rate rule. Crucially, there is no guarantee that the domestic economy will reach its new inflation target—one cannot exclude the possibility of the domestic economy remaining in a secular stagnation.

Consider now a symmetric secular stagnation where both countries increase their inflation target. Figure 10 displays the effect of an increase in the global inflation target. Our model does not have much new to say about this policy change. In essence, this policy is equivalent to the experiment considered in Eggertsson and Mehrotra (2014) in a closed economy. An increase in both inflation targets shifts up the kink point in the AD curve. This allows for the possibility of a new equilibrium at the intersection of the two curves at the new inflation target. While the higher inflation target allows for a full-employment equilibrium, it does not exclude the secular stagnation steady state.[20] This

[20]Our model does not feature any costs of a higher steady-state level of inflation. With Calvo pricing, deviations of inflation in steady state from zero impose misallocation costs. If these costs are sufficiently large, these misallocation costs must be weighed against the unemployment costs due to downward nominal wage rigidity.

Figure 10. Effect of Raising the Inflation Target



multiplicity provides one motivation for fiscal policy. Before getting there, however, our model does have something new to say about how relative monetary policies of the two countries can interact.

Currency Wars

So far, we have formulated the policy of each economy as a simple inflation target. Consider an alternative formulation—the central bank in the domestic economy formulates its policy target in terms of the nominal exchange rate, $S_t = \frac{P_t}{P_t^*}$. Thus, we replace the monetary policy rule (25) for the domestic economy with

$$\frac{S_t}{S_{t-1}} = \bar{S} \quad \text{if } i_t \geq 0 \text{ otherwise } i_t = 0\,. \tag{46}$$

This rule, in and of itself, does not alter the possible equilibria under perfect integration as shown in Panel A of Figure 9. However, if monetary policy has additional tools to implement an exchange rate policy at the zero lower bound, exchange rate policy may select one of the equilibria.

We note that, in our model, the real exchange rate is fixed so we cannot analyze the expenditure switching effect of a change in the real exchange rate. However, we can still think about monetary policies that affect the evolution of the nominal exchange rate. Broadly speaking, commitments about nominal exchange rates represent alternative monetary policy regimes across the two countries. A target for growth rate of nominal exchange rate for the domestic economy, as above, is simply a policy commitment that refers to the relative inflation rates in each country since $\frac{S_t}{S_{t-1}} = \frac{\Pi_t}{\Pi_t^*}$. Hence, the domestic economy is pinning down the path of the domestic price level *relative* to path of the price level abroad.

Many authors have suggested that the nominal exchange rate can act as an additional instrument of policy and that the central bank can affect the exchange rate by printing money and buying foreign currencies (see, for example, Bernanke 2000). In our model, however, the nominal exchange rate is simply pinned down by the relative price level of the two countries, and if the central bank loses control of its own price level, it loses control over the nominal exchange rate as well.

It still seems of interest, however, to explore what are the consequences for the trading partner if the domestic monetary authority can successfully formulate a policy commitment in terms of the nominal exchange rate, even if we do not explicitly model the means through which this commitment is implemented. But is this type of commitment (i.e., in terms of the exchange rate) not just the same as assuming that the government can commit to higher future domestic prices via inflation, and, therefore does away with secular stagnation altogether? The answer to that is no as a nominal exchange rate commitment only specifies the price level of home country relative to that of its trading partner. As we show, this distinction has interesting implications.

Consider first the case of an asymmetric secular stagnation. Under asymmetric stagnation, one country is producing at full capacity, while the other is not. As a result, the nominal exchange rate is continuously appreciating for the country in stagnation. If, for example, the domestic economy is in stagnation, so that $i = 0$, while the foreign economy achieves price stability (inflation target of $\bar{\Pi}^* = 1$), then

$$\Pi^D = \left(\frac{S_{t+1}}{S_t}\right)^{-1}.$$

The domestic currency is continuously appreciating at the rate of deflation of the domestic economy.

Consider a policy in which the domestic economy pegs its exchange rate to the foreign currency so that $S_{t+1} = S_t$. In this case, a straightforward proposition follows:

Proposition 6: *Suppose* $r^{W,n} < 0$, *capital markets are perfectly integrated, and the domestic and foreign inflation targets are given by* $\bar{\Pi} = \bar{\Pi}^* = 1$, *and the nominal exchange rate is pegged at* $\frac{S_{t+1}}{S_t} = 1$. *Then the global symmetric secular stagnation equilibrium is the unique solution of the model.*

The proof of this proposition follows directly from the fact that if the nominal peg is constant, inflation rates of the two countries must be equalized.

Since the inflation target of $\bar{\Pi} = \bar{\Pi}^* = 1$ cannot be achieved due to the negative world natural interest rate, the only equilibria is a symmetric secular stagnation.

Interestingly, if a given country finds itself in a secular stagnation (and the other does not) and reacts by pegging its exchange rate, it does not escape stagnation. Instead, it exports deflation to its trading partner. Like neomercantilism and structural reform, an exchange rate policy of this type is a beggar-thy-neighbor policy.

Can a country escape a secular stagnation all together via exchange rate policy? Denote the rate deflation of the foreign country if it finds itself in an asymmetric secular stagnation by $\Pi^{FS*} < 1$. Suppose now that the nominal exchange rate target of the domestic economy is such that $\frac{S_{t+1}}{S_t} = \bar{S} < \Pi^{FS*}$. We then obtain the following proposition:

Proposition 7: *Suppose* $\frac{S_{t+1}}{S_t} = \bar{S} < \Pi^{FS*}$ *and the world natural rate of interest is negative. Then there exists no equilibrium in which the domestic economy is in a secular stagnation, but, if* $\bar{\Pi}^* = 1$, *the foreign economy must always be in secular stagnation.*

The proof of this proposition follows directly from the fact that $\frac{S_{t+1}}{S_t} < \Pi^{FS*}$ implies that the inflation rate in domestic economy has to be higher than that of the foreign economy. Since the inflation target of the foreign economy is $\Pi^* = 1$, we can exclude the possibility that neither one is in a secular stagnation, and since the inflation rate of the domestic economy is higher, the only feasible equilibria is one in which the domestic economy is not in stagnation so it is achieving its inflation target $\bar{\Pi}$ (which can be any number greater than unity), while the foreign economy remains trapped.

An interesting element of the last two propositions is that a successful monetary policy commitment that is framed in terms of the nominal exchange rate when the world natural rate of interest is negative will always come at the expense of its trading partner. This is in contrast to the policy we initially considered of a higher inflation target in both countries in which both countries can benefit. This suggests the desirability of framing policy objectives in terms of nominal domestic variables, instead of framing policy relative to those of the trading partner.

We emphasize that the model, in its current form, is one in which the home and foreign good are perfect substitutes thereby fixing the real exchange rate. Therefore, secular stagnation is not transmitted via the real exchange rate. Eggertsson and others (2016) sketch out how this framework can be expanded to include variation in the real exchange rate. Real exchange rates strengthen the beggar-thy-neighbor aspect of monetary policy. In this case, currency depreciation not only operates through capital flows by redirecting excess saving overseas, but, additionally, the induced real exchange rate depreciation switches expenditure away for its trading partner further exacerbating the demand shortfall.

Our finding show that, generically, a weakness of monetary and exchange rate policies is that these solutions cannot exclude the secular stagnation equilibria. Are there policies available that eliminate these secular stagnation equilibria? The answer is yes—through the use of fiscal policy.

Fiscal Policy

Government Spending

One natural policy option, emphasized in the zero bound literature, is an increase in government spending. However, in contrast to some of the existing literature, the effects of an increase in government spending depend crucially on how expenditures are financed. For example, an increase in government spending financed via a tax on the credit-constrained young has no effect, since every dollar of increased government spending is offset by a corresponding decrease in spending by the young.[21] For now, we consider balanced budget financing and perfectly integrated capital markets. The most natural balanced budget assumption is that spending is financed via a tax on the working-age population (the middle generation).

Assuming $G_t = T_t^m$ and setting taxes on the old to zero in the government budget constraint [Equation (15)], we can write the IS equation under perfect capital integration in steady state as

$$\omega Y + (1-\omega)Y^* = \left(1 + \frac{1+\beta}{\beta}\frac{1+g}{1+r^w}\right)(\omega D + (1-\omega)D^*) + \omega G + (1-\omega)G^*. \tag{47}$$

As this expression shows, it is the weighted average of government purchases in both countries that is relevant for the world real interest rate. Higher government spending in one country raises the natural rate in both countries—a beneficial policy in a secular stagnation.

In normal times, government purchases would leave output unaffected given that labor is supplied inelastically. Therefore, an increase in either G or G^* is met with an increase in the world rate r^w leaving aggregate world output unchanged. In a symmetric secular stagnation, higher government purchases instead lower the real interest rate. Fiscal policy accomplishes this by raising inflation and crowding in consumption resulting in multipliers greater than one. The model suggests that small changes in government spending carry sizable multipliers—an insight we confirm in the section on Quantitative Examples where we find multipliers well over unity. Moreover, it does not matter for aggregate output which country increases government expenditures—the symmetric and asymmetric fiscal expansions deliver the same increase in output in each country.

[21] See Eggertsson and Mehrotra (2014) for further discussion on fiscal multipliers under different financing regimes.

As Equation (47) reveals and our numerical experiments in the section on Quantitative Examples highlights, output in a symmetric secular stagnation depends on overall global government spending. Spending in one country carries positive demand externalities—the foreign country benefits from a purely domestic increase in government spending. If government stimulus is costly, then each country may provide too little fiscal expansion if it only cares about the welfare of its own citizens and does not coordinate policy with its trading partner.

To formalize this insight, let us assume that each government has a loss function given by

$$L_t = (\Pi_t - 1)^2 + (Y_t - Y^f)^2 + (G_t - G^{\text{target}})^2$$

and the loss function for the foreign government is the same but in terms of foreign variables. While this loss function is ad hoc, a welfare criterion of the same form can be derived by assuming that government spending enters additively separately in household utility.[22] We also assume that there is some cost of inflation deviating from target [see Eggertsson (2001) which derives a welfare function of this form].[23]

Let us call a solution that selects G and G^* jointly to maximize both countries' objective function the cooperative solution. Let us call the solution if each country maximizes its own objective, taking the other country's spending as given the non-cooperative solution. We prove the following proposition:

Proposition 8: Government spending in the non-cooperative solution is less than in the cooperative solution, with coordination losses maximized when $\omega = \frac{1}{2}$.

Proof: See Appendix B. □

The logic of this proposition is straightforward. Because fiscal stimulus is costly (government is larger than its optimal size in absence of frictions), each country supplies too little stimulus to stabilize world output since the benefits are shared by foreigners. As we establish in a corollary in Appendix B, the coordination problem—the gap between government spending in the cooperative and non-cooperative solutions—is increasing in the number of countries and, in the case of two countries, is worst when these countries are the same size. This result has implications for the Eurozone where fiscal expansion by smaller periphery economies will have little impact on overall Eurozone demand. Likewise, our

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[22]At the first best, optimal government spending is then determined by equating the marginal utility of private and public consumption. The planner only wishes to deviate from target in a secular stagnation since higher government expenditures can alleviate the output gap and inflation shortfall.

[23]To obtain exactly the same welfare function in our current setting, we could assume that there is some resource cost of changing prices which does not directly alter the AS equation as these firms are perfectly competitive. It does, however, imply that social welfare can be approximated as above. Note, however, that one would want to assume that all generations receive the same welfare weights.

results suggest a substantial coordination problem between the United States and Eurozone given the similar size of their economies to the extent that capital markets are perfectly integrated.[24]

Debt Policy

As we have shown in Government Debt and the Global Savings Glut, our model can be generalized to incorporate government debt. Foreign reserve accumulation in the absence of an increase in public debt issuance puts downward pressure on the natural rate of interest, as can be seen in Equation (22).

Equation (22) has other important implications. In particular, an increase in government debt will directly increase the natural rate of interest. Thus, a straightforward solution to secular stagnation is to issue government debt. That foreign reserve accumulation puts downward pressure on the natural rate of interest is essentially the inverse of this—an increase in reserve accumulation reduces the total amount of government bonds held by the private sector.[25]

One concern about debt-financed fiscal expansions may be the risk that materializes from a higher debt-to-GDP ratio that may become a burden in the future. In a secular stagnation, our model shows that increases in government spending financed by an increase in public debt actually *lower* the debt-to-GDP ratio. As emphasized in DeLong and Summers (2012) in a setting with hysteresis effects, debt-financed fiscal expansions in our model are fiscally sustainable. Conversely, reductions in the public debt actually worsen the fiscal position of countries in secular stagnation. In Proposition 9, we show that, in autarky, a permanent increase in government spending financed by debt issuance will lower the debt-to-GDP ratio. The proposition carries over directly to the open economy (modulo notation) under the case of perfect integration.

Proposition 9: *Consider a secular stagnation in autarky with taxes levied only on the middle generation and where $r < g$. Then an increase in steady-state government spending G lowers the public debt-to-GDP ratio: B_g/Y.*

Proof: We wish to show that $dB_g/dY < 1$. When taxes are levied on the middle generation and the zero lower bound is binding, the AD curve becomes,

$$B_g + D(1+g)\Pi(Y) = \frac{\beta}{1+\beta}(Y - D - T),$$

where we have implicitly substituted the aggregate supply relation into the AD equation. Holding taxes constant, we can derive an expression for the change in output given a change in the public debt:

[24] With imperfect integration, the benefits of government spending are fully realized by the country undertaking the fiscal expansion *conditional* on the lending constraint remaining binding.

[25] A permanent increase in government debt has the same effects as a helicopter drop at the zero lower bound. A permanent increase in the money supply can eliminate a secular stagnation.

$$\frac{dY}{dB_g} = \left(\frac{\beta}{1+\beta} - D(1+g)\Pi'(Y)\right)^{-1} > \frac{1+\beta}{\beta} > 1\,.$$

It remains to show that an increase in government spending raises the level of public debt. With constant taxes, the steady-state government budget constraint becomes

$$T = \frac{r-g}{1+g} B_g + G\,.$$

Holding taxes constant, an increase in government spending raises the level of public debt when $r < g$ as required. □

The assumption that $r < g$ holds in a mild secular stagnation where inflation falls below the target and the population is growing modestly. Indeed, this appears to be the relevant empirical case in the United States and other developed countries where real rates on government debt are slightly negative and population growth is slightly positive or flat. Importantly, a pure redistribution of increasing public debt and issuing refunds to the young and/or old generations will also lower the debt-to-GDP ratio.

However, will increasing government debt always work? Japan, in confronting its extended period of stagnation, has experienced a large increase in the gross level of public debt without successfully increasing inflation or interest rates. However, it is worth noting, that debt expansion will only be effective to the extent that the expansion is regarded as permanent. As shown in Eggertsson and Mehrotra (2014), a temporary (one-period) increase in public debt is Ricardian and will be offset by a rise in private sector saving. Likewise, what matters is debt held by the private sector. To the extent that increases in public debt are held as assets by institutions like the Bank of Japan or other entities, the natural rate remains unaffected.

In the open economy, increases in public debt are also subject to the same coordination problems as government spending if governments perceive a cost of carrying excessive levels of public debt. One possibility is, given a probability that the forces that give rise to a secular stagnation ultimately reverse themselves, interest rates eventually may rise. If the government has accumulated large amounts of debt, the real cost of servicing this debt may be quite high. Higher distortionary taxation may result in welfare losses, and hence place limits on the amount of debt the government is willing to issue. Another possibility is that if debt rises above a certain level, this triggers uncertainty about if debt will get repaid again.

To the extent such constraints exist on the government's willingness to issue debt, a reasonable approximation to the planner's objective function might take a similar form as we considered earlier. The government would choose the optimal level of debt to minimize a loss function of the following form (in this case holding G_t constant for simplicity):

$$L_t = (\Pi_t - 1)^2 + \lambda_Y(Y_t - Y_t^f) + \lambda_b\left(B_t - B^{\text{safe}}\right)^2,$$

where we denote B^{safe} as the level above which agents start putting some probability on a government default.[26] If the loss function of the government of each country takes this form, then policy will be subject to exactly the same problem as we considered in previous section: each government has the incentive to free ride on the fiscal stimulus of the other country. Austerity will be over-supplied, and the coordination problem worsens with the number of countries.

Quantitative Examples

Asymmetric Stagnation: U.S. and Japan, 2000–2008

We now illustrate how this framework can be used to rationalize recent developments in the global economic environment. The first question, is whether our model is consistent with the fact that Japan appears to have been in a secular stagnation with zero interest rates since the mid to late 1990s while, in the United States, the nominal interest rate only fell to zero following the economic crisis of 2008. Here we consider, for simplicity, a world in which Japan and the United States are the only two countries. The key insight of the experiment is to confirm quantitatively one of the main conclusions we had previously reached qualitatively, that a country in a secular stagnation benefits greatly from the opening of financial markets so that it can export its excess savings. The host of these capital inflows, then, will experience a drop in the real interest rate and a credit boom in the private sector.

We calibrate the model to get a sense of the magnitudes of various parameters and the implications of capital flows for interest rates, output, and the external balance. In Table 1, we fit the model to match several targets for the United States and Japan between 2002 and 2008. Typical parameters such as the rate of time preference and labor share are set to conventional values: $\beta = 0.96$, $\alpha = 0.7$. We must choose population growth rates, inflation targets, and collateral constraints for each country. Additionally, we must choose the wage rigidity parameter γ^* for Japan. We must also set the international lending constraint K^*.

For the United States, the population growth rate is set at 1 percent, the US inflation target is set at 2 percent—the unofficial target of the Federal Reserve, and the nominal interest is set at 3 percent to match the average real interest rate from 2002 to 2007. The real interest rate determines the level of the collateral constraint D. For Japan, the population growth rate is set at 0, and the inflation target is set at 0 percent given that the Bank of Japan has only recently announced a 2 percent target. The rate of inflation is set at -0.5 percent to match the average real interest rate in Japan from 2002 to 2007. Given the OLG structure, periods last 20 years and all rates are converted accordingly.

[26]Formal microfoundations could be provided as follows. Imagine that if debt rises above a target level B^{safe}, the household incurs some monitoring cost to prevent default given by $g\left(B_t - B^{\text{safe}}\right)$. Furthermore, as before assume that the perfectly competitive firms pay a resource cost from changing prices. Then a second-order approximation of a representative utility (weighting all generations the same) can generate a loss function of this form.

Table 1. Parameterization: US and Japan, 2002–2008

Panel A: Common Parameters	Symbol	Value	
Labor share	α	0.7	
Discount rate	β	0.96^{20}	
Int'l lending constraint	K	0.14	
Panel B: Country-Specific Parameters	**Symbol**	**US**	**Japan**
Inflation target	$\bar{\Pi}, \bar{\Pi}^*$	2 percent	0 percent
Population growth	g, g^*	1 percent	0 percent
Potential output	Y_f, Y_f^*	1	0.34
Wage adjustment	γ, γ^*	N/A	0.296
Collateral constraint	D, D^*	0.237	0.071

Measuring the output gap is somewhat more difficult. We set the output gap at -10 percent based on the discussion in Hausman and Wieland (2014). US potential output is normalized to one, while potential output in Japan is set at 0.35 based on Japanese GDP (as a percentage of US GDP in 2007) at market exchange rates. The output gap and inflation rate in Japan pin down the foreign collateral constraint D^* and γ^*. The international lending constraint K is set to match the bilateral net foreign asset position. Based on TIC data from the Department of the Treasury, net Japanese holdings of debt securities in the US were approximately \$2 trillion in June 2008. The K value in Table 1 is the net foreign asset position as a percentage of 20-year GDP (\$2 trillion/\$14.5 trillion $\times$ 1/20).

These targets imply a modest degree of wage rigidity with $\gamma^* = 0.3$ (or 0.94 annualized)—when $\gamma^* = 1$, wages are fully rigid. The collateral constraint is looser for the US but comparable across both countries. Given this calibration, we can consider the implications of autarky for secular stagnation in Japan. If $K = 0$, Japan's inflation rate would fall to -1.38 percent per year and the output gap would rise drastically from -10 to -28.6 percent. Based on this numerical example, the \$2 trillion net asset position in the United States significantly ameliorated Japan's output gap. Conversely, full capital market integration between Japan and the United States would pull Japan out of a secular stagnation with the world natural rate of interest. However, equilibrium world real interest rates would be quite low in this scenario at 0.87 percent.

By contrast, the effects of this large negative NFA position were fairly modest for the United States. Setting $K = 0$, the U.S. nominal (and real) interest rate would be 7 basis points higher and the household debt-to-GDP ratio would be 1.5 percent lower relative to the baseline. However, these calculations ignore substantial capital inflows into the United States during this time from other emerging market and oil-producing countries. These patterns qualitatively fit the rise in household debt and easing of collateral constraints experienced in the United States during the credit boom between 2001 and 2008.[27]

[27]This mechanism is also at work in the quantitative lifecycle model of Favilukis and others (2015) who consider the effect of the global savings glut on U.S. house prices and asset prices.

In short, in a world with incomplete financial integration, we can construct numerical examples that match the broad patterns in the data seen in the United States and Japan. Japan gained significantly from capital market integration, as that allowed it to export some of its excess savings to the United States. In the United States, this capital flow reduced interest rates, easing lending constraints, and boosted household debt—albeit by a modest amount. One interesting implication of this is that both countries would have benefited from full financial integration, as this would have pulled Japan out of a secular stagnation, a conclusion that, however, can be overturned in a different setting as we now shall see.

Symmetric Stagnation: U.S. and Europe, 2008–2015

Under perfectly integrated financial markets, one country may benefit from closing its capital account. To illustrate this possibility, we calibrate the model to analyze the interaction of the United States and Eurozone in the post-2008 Great Recession period. In this numerical experiment, we find that U.S. interest rates would be positive in the absence of capital inflows from Europe. We also show that our calibration implies that the Eurozone suffers a greater shortfall in output due to a higher degree of wage rigidity.

To calibrate the model, we choose the wage rigidity parameters in the United States and the Eurozone to match output gaps in each region and chose the collateral constraints to match global interest rates and the net foreign asset position of the Eurozone in the United States. Standard parameters—the rate of time preference β and the labor share α are set as before. The growth rate g is set at 1 percent annually in accordance with the average population growth rate across the regions.

Both the U.S. and Eurozone nominal rates are set at zero given the zero lower bound has remained binding in each region over this period. The inflation target is set at 1.75 percent to reflect the Eurozone's somewhat lower desired inflation target. The inflation rate is set at 1 percent in both regions to equate the world real interest rate at -1 percent—approximately consistent with U.S. and Eurozone short-term real rates between 2008 and 2015. The full-employment level of output is normalized to unity in the United States and 0.96 in the Eurozone based on GDP relative to the United States, evaluated at market exchange rates in 2008.

We target an output gap in the United States and Eurozone at -10 and -15 percent, respectively, reflecting the deviation of real GDP per capita in the United States and Eurozone relative to pre-recession trend. The average output gap and global real interest rate determines the average collateral constraint. In June of 2013, Eurozone holdings of U.S. debt securities net of U.S. holding of Euro debt equaled \$2 trillion. The net foreign asset target is computed as a percentage of 20-year GDP (\$2 trillion/\$16.5 trillion $\times$ 1/20). The foreign asset position determines the difference between the US and Eurozone collateral constraints: D and D^*.

In Table 2, we show the implied parameter values that match the targets described above. Wage rigidity in the United States and Eurozone are comparable and, for the Eurozone, imply a somewhat greater degree of wage adjustment than found in Schmitt-Grohé and Uribe (2011). In particular, the United

Table 2. Parameterization: US and Eurozone, 2008–2015

Panel A: Common Parameters	Symbol	Value	
Labor share	α	0.7	
Discount rate	β	0.96	
Inflation target	$\bar{\Pi}$	1.75 percent	
Population growth	g	1 percent	
Panel B: Country-Specific Parameters	**Symbol**	**US**	**Eurozone**
Potential output	Y_f, Y_f^*	1	0.96
Wage adjustment	γ, γ^*	0.217	0.297
Collateral constraint	D, D^*	0.157	0.136
Panel C: Counterfactual under Autarky	**Symbol**	**US**	**Eurozone**
Output gap	Y, Y^*	0 percent	−21.3 percent
Nominal rate	i, i^*	0.25 percent	0 percent
Welfare (rel. to integration)	U, U^*	+7.5 percent	−4.2 percent

States displays more flexible wages than the Eurozone implying that, for a given level of inflation below target, the shortfall in output is less in the United States than the Eurozone. These wage rigidity values are also consistent with the more prominent role of unions in wage-setting in the Eurozone.

The collateral constraints are also comparable across regions and somewhat tighter in the Eurozone to reflect the fact that net capital flows toward the United States. Interestingly, in steady state, the US runs a trade deficit with the Eurozone despite the fact that the US has a negative net foreign asset position. Since the equilibrium world interest rate is negative, the United States is, in effect, paid to borrow from the Eurozone. This permanent trade deficit is, however, quite small—only 0.22 percent of GDP in steady state.

Table 2, Panel C, displays the counterfactual case of financial autarky. In the absence of capital integration, the natural rate of interest would be −1.5 percent in the United States and −2.1 percent in the Eurozone. At the assumed inflation target, the United States would be able to remain at full employment. In other words, net capital flows from the Eurozone pushed the United States into a secular stagnation. These values also suggest that only a modest increase in inflation expectations is needed to attain the world natural rate of interest. Under autarky, the output gap in the Eurozone would worsen by 6 percent points and the inflation rate would fall to 0.7 percent. As Table 2 shows, U.S. welfare increases under autarky while Eurozone welfare worsens. Here we measure welfare as given by the utility of citizens of each country. Any gains from further consumption smoothing under integration are offset by the gains from a smaller output gap in the United States.

Finally, Table 3 shows the effect of an increase in government spending in either Europe or US corresponding to 1 percent of the combined GDP of the two countries. As we discussed, it does not matter which country engages in the expansion as the effect is felt in both countries. It is worth emphasizing here that the assumption of perfect financial markets is important in this case; the effect of

Table 3. Government Spending Multipliers

Regime	US (percent)	Eurozone (percent)
Baseline output gap	−10	−15
Symmetric expansion output gap	−7.1	−10.7
Asymmetric expansion output gap	−7.1	−10.7
Welfare (rel. to symmetric)	−0.2	+0.2

fiscal spillovers is more complicated if there are limits to arbitrage between the two countries (see Eggertsson and others 2016 for some discussion of this case).

However, the welfare implications are somewhat different. Here we assume that welfare is given by the utility stream of private consumption of the citizens of each country with government spending generating no utility (and labor supply no disutility). If only the US undertakes a fiscal expansion, then U.S. working-age population bears the greater burden of taxation reducing domestic consumption. The Eurozone meanwhile enjoys the benefits of higher global inflation and higher consumption. Quantitatively, these welfare effects are not particularly large compared to the overall benefit of higher output in both countries. The inflation rate rises from 1 percent in the baseline calibration to 1.2 percent—a twenty basis point reduction in the global real interest rate.

Conclusion

In this paper, we extend secular stagnation to an open-economy setting, showing how capital markets act as a mechanism to transmit low natural rates. In the presence of the zero lower bound and nominal frictions, negative natural rates of interest can result in a secular stagnation in one or both countries characterized by a binding zero lower bound, low inflation or deflation, and a persistent output gap. Our two-country setting illuminates possible monetary and fiscal policy spillovers. Uncoordinated changes in monetary policy have beggar-thy-neighbor effects, improving conditions in one country at the expense of the other. Fiscal policy, by contrast, has positive externalities across countries. These positive externalities may give rise to a coordination problem whereby fiscal expansion is undersupplied.

While our model emphasizes the analysis of a steady state of an economy in which the natural rate of interest is permanently negative, this does not imply that the zero bound must always be binding in our framework. The steady state is locally unique and determinate. It is therefore straightforward to consider local perturbations of the model to shocks. We can therefore have "secular stagnation" business cycles, in which interest rates rise from time to time above steady state. A key prediction of the theory is that, if the steady-state natural rate is negative, then the zero bound will be hit much more frequently, and contractions will be more violent, as they cannot be offset by interest rate cuts. The failure of long-term real interest rates to rise recently, even in the wake of Fed's decision to increase the Federal Funds rate, raises the distressing possibility that the United States may find itself in this scenario in coming years.

At the end of 2015, as the United States embarks on the first interest rate increase in nearly a decade, the monetary policy stance is increasingly moving in a different direction in the United States relative to the Eurozone and Japan. Our model suggests that, at the very least, continued low interest rates in other developed economies will act as an anchor on U.S. interest rates, limiting the degree to which nominal interest rates in the United States will rise. Our model also suggests a reemergence of global imbalances as higher rates in the United States increase capital inflows and widen the U.S. current account deficit. Indeed, in recent quarters, U.S. export growth has substantially slowed and the trade deficit has increased, lowering the growth rate of U.S. GDP.

Finally, it is worth considering the implications of the slowdown in economic growth in major emerging market economies, and its implications for the global economy. Chinese economic growth is decelerating while previously robust economies like Russia and Brazil are exhibiting substantial weakness. The drop in global oil prices may have further negative implications for other emerging market economies. On one hand, slow growth in these countries may reduce demand for U.S. Treasuries and safe assets, thereby providing a force to raise U.S. and global interest rates. China is already reducing its stock of U.S. Treasuries to stabilize its exchange rate. On the other hand, slower growth will likely reduce FDI flows from developed to emerging market economies. To the extent that the fall in portfolio flows to the United States is offset by a fall in FDI flows to emerging market economies, net capital flows to the United States may be unchanged or even increasing. Such an outcome would place further downward pressure on U.S. rates in the coming years.

Appendix A: Existence, Uniqueness, and Local Determinacy

Here we provide formal proofs for various propositions presented in the body of the text.

Proposition 2: *If the international lending constraint is binding*, $r^n > 0$, $r^{n*} < 0$, $\bar{\Pi} = \bar{\Pi}^* = 1$, *and* $\gamma^* > 0$, *there exists a unique, locally determinate secular stagnation equilibrium in the creditor country with* $i^* = 0$, $\Pi^* < 1$, *and* $Y^* < Y_f^*$.

Proof: Under the assumptions of the proposition and the monetary policy rule, the zero lower bound is binding for the creditor country and the equilibrium real interest rate in steady state is given by $r^* = \frac{1}{\Pi^*}$. Equilibrium inflation and output in steady state in the creditor country solve the following equations:

$$Y^* = D^* + K^* + \psi^* \Pi^* \tag{48}$$

$$Y^* = \left(\frac{1 - \frac{\gamma^*}{\Pi^*}}{1 - \gamma^*} \right)^{\frac{\alpha}{1-\alpha}} Y_f^* \, , \tag{49}$$

where $\psi^* = \frac{1+\beta}{\beta}(1+g)\left(D^* + \frac{1+r^n}{1+\beta}K^*\right) > 0$. We may define the difference equation $\Delta(\Pi^*)$ by taking the difference between (48) and (49) . This function is continuous in Π^* with $\Delta(\gamma^*) > 0$ and $\Delta(1) < 0$. Therefore, there exists a $\gamma^* < \Pi^* < 1$ such that $\Delta(\Pi^*) = 0$. Since $\Pi^* < 1$, it follows that $Y^* < Y_f^*$.

To establish uniqueness, we first assume that their exist multiple distinct values of Π^* at which $\Delta(\Pi^*) = 0$. Graphically, in inflation-output space (output on the x-axis), the AS curve [Equation (49)] lies above the AD curve [Equation (49)] when inflation equals γ^* and the AS curve lies below the AD curve for inflation at unity. Thus, if multiple steady states exist, given that AS is a continuous function, there must exist at least three distinct points at which the AS and AD curve intersect.

At the first intersection point, the slope of AS curve crosses the AD line from above and, therefore, at the second intersection the AS curve crosses the AD curve from below. Since the AD curve is a line, the AS curve is locally convex in output in this region. Similarly, between the second and third intersection, the AS curve is locally concave in output. Thus, as output Y^* increases, the AS curve must first have a positive second derivative followed by a negative second derivative.

We compute the second derivative of inflation with respect output of the AS curve and derive the following expression (we drop the $*$ for simplicity):

$$\frac{d^2\Pi}{dY^2} = G(Y)\left((1+\phi)(1-\gamma)\left(\frac{Y}{Y^f}\right)^{\phi} + (\phi - 1)\right) \tag{50}$$

$$G(Y) = \frac{\phi\gamma(1-\gamma)\left(\frac{Y}{Y^f}\right)^{\phi}}{Y^2\left(1-(1-\gamma)\left(\frac{Y}{Y^f}\right)^{\phi}\right)} \tag{51}$$

$$\phi = \frac{1-\alpha}{\alpha}. \tag{52}$$

As can be seen, over the region considered, the function $G(Y)$ is positive and, therefore, the convexity of the AS curve is determined by the second term. This term may be negative if $\phi < 1$, but this expression is increasing in Y between 0 and Y_f. Therefore, the second derivative cannot switch signs from positive to negative. Thus, we have derived a contradiction by assuming multiple steady states. Therefore, there must exist a unique intersection point.

As established before, it must be the case that the AS curve has a lower slope than the AD curve at the point of intersection. The slope of the AS curve is

$$\frac{d\Pi^*}{dY^*} = \frac{1-\alpha}{\alpha}\frac{1}{\gamma^*}\frac{\Pi^*}{Y^*}(\Pi^* - \gamma^*) \,. \tag{53}$$

If the slope of the AS curve is less than the slope of the AD curve at the intersection point, then it must be the case that

$$\frac{1-\alpha}{\alpha}\frac{\Pi^*}{Y^*}\left(\frac{\Pi^*}{\gamma^*}-1\right)<(\psi^*)^{-1}$$
$$\frac{1-\alpha}{\alpha}\frac{\psi^*\Pi^*}{Y^*}\left(\frac{\Pi^*}{\gamma^*}-1\right)<1$$
$$\frac{1-\alpha}{\alpha}\frac{Y^*-D^*-K^*}{Y^*}\left(\frac{\Pi^*}{\gamma^*}-1\right)<1\ \cdot$$
$$s_y\frac{\alpha}{1-\alpha}+1>\frac{\Pi^*}{\gamma^*}$$
$$\frac{\gamma^*}{\Pi^*}\left(s_y\frac{\alpha}{1-\alpha}+1\right)>1$$

Linearizing the equilibrium conditions around the secular stagnation steady state, we obtain the following linearized AD and AS equations:

$$0=E_t\pi_{t+1}-s_yy_t^*+d_t^*+s_dd_{t-1}^* \quad (54)$$
$$y_t^*=\gamma_w^*y_{t-1}+\gamma_w^*\frac{\alpha}{1-\alpha}\pi_t^*, \quad (55)$$

where d_t^* is the collateral shocks and various coefficients are given in terms of their steady-state values.

$$\gamma_w^*=\frac{\gamma^*}{\bar{\Pi}^*}$$
$$s_y=\frac{\bar{Y}^*}{\bar{Y}^*-\bar{D}^*-\bar{K}^*}.$$
$$s_d=\frac{\bar{D}}{\bar{Y}^*-\bar{D}^*-\bar{K}^*}$$

Substituting (55) into (54), we obtain a forward-looking difference equation in y_t^*. The local determinacy condition requires the coefficient on $E_ty_{t+1}^*$ to be less than one. This condition is the same as the slope condition. Therefore, the unique secular stagnation steady state is always locally determinate as required. □

Proposition 3: If the international lending constraint at $K^*=0$, $\bar{\Pi}=1$, and $\gamma>0$, then, if $r^n>0$, $i>0$, $\frac{\partial r}{\partial IR}<0$, and $\frac{\partial Y}{\partial IR}=0$. If $r^n<0$, $i=0$, $\frac{\partial r}{\partial IR}>0$, and $\frac{\partial Y}{\partial IR}<0$.

Proof: Given the inflation target, if $r_n>0$, then the domestic nominal interest rate is $i=r_n>0$. Since the inflation target is attained, the wage norm does not bind and $Y=Y_f$. The expression for the real rate in steady state is given below:

$$1+r=\frac{1+\beta}{\beta}\frac{D}{(Y_f-D)+\frac{1+\beta}{\beta}(IR-B^g)}.$$

For small changes in IR, $Y=Y_f$, therefore, $\frac{\partial Y}{\partial IR}=0$ and, from the previous equation $\frac{\partial r}{\partial IR}<0$ as required.

Given the inflation target, if $r_n < 0$, then the domestic nominal interest rate is $i = 0$. As shown in Proposition 2, a unique secular stagnation steady-state exists with $\Pi < \bar{\Pi}$ and $Y < Y_f$. Observe that $\frac{d\Pi}{dY} < \left(\frac{1+\beta}{\beta} D\right)^{-1}$—the slope of the AS curve is less than the slope of the AD curve evaluated at the secular stagnation steady state.

In the stagnation steady state, output is given implicitly by the following equation where $\Pi(Y)$ is output inflation relationship from the AS curve:

$$\frac{1}{\Pi(Y)} = \frac{1+\beta}{\beta} \frac{D}{(Y-D) + \frac{1+\beta}{\beta}(IR - B^g)}$$

$$\Rightarrow \frac{1+\beta}{\beta} D\Pi(Y) = Y - D + \frac{1+\beta}{\beta}\left(IR - B_g\right) \qquad .$$

$$\Rightarrow \frac{\partial Y}{\partial IR} = -\frac{1}{\frac{\beta}{1+\beta} - \frac{d\Pi}{dY} D}$$

In a secular stagnation steady state, the denominator is positive (since the slope of the AS curve is less than the slope of the AD curve at the intersection point), so the $\frac{\partial Y}{\partial IR} = 0$. Since $\frac{d\Pi}{dY} > 0$, $\frac{\partial r}{\partial IR} > 0$ as required. □

Proposition 4: If $r^{W,Nat} < \bar{\Pi}^{-1}$, there exists a locally determinate secular stagnation equilibrium with $Y < Y_f$, $Y^* < Y_f^*$, $i = i^* = 0$, and $\Pi < \bar{\Pi}$.

Proof: Under the assumptions of the proposition, monetary policy in both countries cannot track the world natural rate of interest and $i = i^* = 0$. Perfect capital market integration requires equalization of the domestic and foreign real interest rate, hence $\Pi = \Pi^*$. Steady-state inflation, domestic output, and foreign output jointly satisfy the following equilibrium conditions:

$$\omega Y + (1+\omega) Y^* = D^W + \psi^W \Pi \tag{56}$$

$$Y = \left(\frac{1 - \frac{\gamma\bar{\Pi}}{\Pi}}{1-\gamma}\right)^{\frac{\alpha}{1-\alpha}} Y_f \tag{57}$$

$$Y^* = \left(\frac{1 - \frac{\gamma^*\bar{\Pi}}{\Pi}}{1-\gamma^*}\right)^{\frac{\alpha}{1-\alpha}} Y_f^*, \tag{58}$$

where $D^W = \omega D + (1-\omega)D^*$ and $\psi^W = \frac{1+\beta}{\beta}(1+g)D^W > 0$. We may define the difference equation $\Delta(\Pi)$ by taking the difference between (56) and the weighted sum of (57) and (58). Without loss of generality, assume that $\gamma < \gamma^*$. We assume that output is bounded below by zero—that is, if $\Pi < \gamma^*$, then $Y^* = 0$. Given this assumption, the function $\Delta(\Pi)$ is continuous (but not necessarily differentiable), with $\Delta(\gamma) > 0$ and $\Delta(\bar{\Pi}) < 0$. Therefore, there exists a global inflation rate Π_{ss} with $\Pi_{ss} < \bar{\Pi}$ implying that, in steady state, $Y_{ss} < Y_f$ and $Y_{ss}^* < Y_f^*$.

To establish that this steady state is locally determinate, we observe that, graphically, at $\Pi = \gamma$ the global AS curve [weighted sum of Equations (57) and (58)]. At $\Pi = \bar{\Pi}$, the global AD curve lies above the AS curve. Thus, there exists at least one equilibrium in which the AD curve is locally steeper than the AS curve. We first derive the condition for local determinacy. The log-linearized equilibrium conditions for a symmetric stagnation equilibrium are given below:

$$E_t\pi_{t+1} = \bar{\omega}s_y y_t + (1-\bar{\omega})y_t^* + shocks \tag{59}$$

$$y_t = \gamma_w y_{t-1} + \gamma_w \phi \pi_t \tag{60}$$

$$y_t^* = \gamma_w^* y_{t-1}^* + \gamma_w^* \phi \pi_t\,, \tag{61}$$

where $\phi = \frac{\alpha}{1-\alpha}$ and the other coefficients are defined below:

$$\begin{aligned} \gamma_w &= \frac{\gamma\bar{\Pi}}{\Pi_{ss}} \\ \gamma_w^* &= \frac{\gamma\bar{\Pi}}{\Pi_{ss}} \\ s_y &= \frac{\omega Y_{ss} + (1-\omega)Y_{ss}^*}{\omega(Y_{ss}-D) + (1-\omega)(Y_{ss}^* - D^*)} \\ \bar{\omega} &= \frac{\omega Y_{ss}}{\omega Y_{ss} + (1-\omega)Y_{ss}^*} \end{aligned}.$$

This linearized system can be expressed as

$$\begin{aligned} AE_t x_{t+1} &= Bx_t + shocks \\ E_t x_{t+1} &= A^{-1}Bx_t + A^{-1}shocks \end{aligned},$$

where $x_t = [\pi_t, y_{t-1}, y_{t-1}^*]'$ and the A, B are square matrices with suitably defined coefficients. Local determinacy requires that the matrix $A^{-1}B$ has exactly one eigenvalue outside the unit circle.

Since the matrix B has a row of zeros, one eigenvalue of the system is zero. The characteristic polynomial that determines the remaining eigenvalues is

$$\lambda^2 - \left(\phi s_y\left(\bar{\omega}\gamma_w - (1-\bar{\omega})\gamma_w^*\right) + \gamma_w + \gamma_w^*\right)\lambda + \gamma_w\gamma_w^*\left(1 + s_y\phi\right) = 0\,.$$

Since the characteristic polynomial is positive at $\lambda = 0$, the condition that ensures local determinacy is that the characteristic polynomial is negative at $\lambda = 1$. This condition requires

$$1 + \gamma_w\gamma_w^*\left(1 + s_y\phi\right) < \phi s_y\left(\bar{\omega}\gamma_w - (1-\bar{\omega})\gamma_w^*\right) + \gamma_w + \gamma_w^*\,. \tag{62}$$

It remains to show that this local determinacy condition is identical to the slope condition that must be satisfied in equilibrium. The slope of the global AS curve and global AD curve is given below:

$$\frac{dY_{AS}^W}{d\Pi} = \phi\left(\omega\gamma_w \frac{Y_{ss}}{\Pi_{ss} - \gamma\bar{\Pi}} + (1-\omega)\gamma^* \frac{Y_{ss}^*}{\Pi_{ss} - \gamma^*\bar{\Pi}}\right).$$
$$\frac{dY_{AD}^W}{d\Pi} = \psi^W$$

A steeper slope for the AD curve relative to the AS curve implies

$$\frac{dY_{AS}^W}{d\Pi} > \frac{dY_{AD}^W}{d\Pi}$$
$$\phi\left(\omega\gamma_w \frac{Y_{ss}}{\Pi_{ss} - \gamma\bar{\Pi}} + (1-\omega)\gamma_w^* \frac{Y_{ss}^*}{\Pi_{ss} - \gamma^*\bar{\Pi}}\right) > \psi^W$$
$$\phi\left(\bar{\omega}\frac{\gamma_w}{1-\gamma_w} + (1-\bar{\omega})\frac{\gamma_w^*}{1-\gamma_w^*}\right) > \psi^W \frac{\Pi_{ss}}{Y^W},$$
$$\phi s_y\left(\bar{\omega}\gamma_w(1-\gamma_w^*) + (1-\bar{\omega})\gamma_w^*(1-\gamma_w)\right) > (1-\gamma_w)(1-\gamma_w^*)$$
$$\phi s_y\left(\bar{\omega}\gamma_w + (1-\bar{\omega})\gamma_w^* - \gamma_w\gamma_w^*\right) > 1 - \gamma_w - \gamma_w^* + \gamma_w\gamma_w^*$$
$$\phi s_y\left(\bar{\omega}\gamma_w - (1-\bar{\omega})\gamma_w^*\right) + \gamma_w + \gamma_w^*$$

where the last inequality is identical to the determinacy condition derived in Equation (62). □

Proposition 5: If $r^{W,Nat} < \bar{\Pi}^{-1}$, $D^W > (1-\omega)Y_f^*$, $\gamma > 0$, there exists a unique, locally determinate asymmetric secular stagnation with $r = r^*$, $Y < Y_f$, $Y^* = Y_f^*$, $i = 0$, and $\Pi < \bar{\Pi}$.

Proof: Under the assumptions of the proposition and the monetary policy rule, the zero lower bound is binding for the home country and not binding for the foreign country. Nevertheless, real interest rates are equalized across both countries: $\frac{1}{\Pi} = r = r^* = \frac{i^*}{\Pi^*}$ where $i^* > 0$. Equilibrium inflation and output in the home country solve the following equations:

$$Y = \frac{1}{\omega}\left(D^W - (1-\omega)Y_f^* + \psi^W\Pi\right) \tag{63}$$

$$Y = \left(\frac{1 - \frac{\gamma\bar{\Pi}}{\Pi}}{1-\gamma}\right)^{\frac{\alpha}{1-\alpha}} Y_f, \tag{64}$$

where $D^W = \omega D + (1-\omega)D^*$ and $\psi^W = \frac{1+\beta}{\beta}(1+g)D^W > 0$. We may define the difference equation $\Delta(\Pi)$ by taking the difference between (63) and (64) . This function is continuous in Π with $\Delta(\gamma) > 0$ (since $D^W > (1-\omega)Y_f$) and $\Delta(\bar{\Pi}) < 0$ since $r^{W,Nat} < \bar{\Pi}^{-1}$. Therefore, there exists a $\gamma < \Pi < \bar{\Pi}$ such that $\Delta(\Pi) = 0$. Since $\Pi < \bar{\Pi}$, it follows that $Y < Y_f$.

Uniqueness of an asymmetric stagnation equilibrium under perfect integration is established identically as in Proposition 2. Graphically, the global AD curve (Equation (63) form a line in domestic inflation-output space. The domestic AS curve [Equation (64)] is identical to Equation (49) and cannot cross the AD curve more than once given that the second derivative cannot switch signs from positive to negative.

It must be the case that the AS curve has a lower slope than the AD curve at the point of intersection. The slope of the AS curve is identical to Equation (53). If the slope of the AS curve is less than the slope of the AD curve at the intersection point, then it must be the case that

$$\frac{1-\alpha}{\alpha}\frac{\Pi}{Y}\left(\frac{\Pi}{\gamma\bar{\Pi}}-1\right)<\left(\frac{\psi^W}{\omega}\right)^{-1}$$
$$\frac{1-\alpha}{\alpha}\frac{\psi^W\Pi}{\omega Y}\left(\frac{\Pi}{\gamma\bar{\Pi}}-1\right)<1$$
$$\frac{1-\alpha}{\alpha}\frac{\omega Y-D^W-(1-\omega)Y_f^*}{\omega Y}\left(\frac{\Pi}{\gamma\bar{\Pi}}-1\right)<1.$$
$$s_y\frac{\alpha}{1-\alpha}+1>\frac{\Pi}{\gamma\bar{\Pi}}$$
$$\frac{\gamma\bar{\Pi}}{\Pi}\left(s_y\frac{\alpha}{1-\alpha}+1\right)>1$$

The linearization of the global AD curve [Equation (63)] and the domestic AS curve [Equation (64)] around the asymmetric stagnation steady state imply identical expressions to the linearized equilibrium conditions in Proposition 2 where the coefficients are given by

$$\gamma_w=\frac{\gamma\bar{\Pi}}{\Pi_{ss}}$$
$$s_y=\frac{\omega Y_{ss}}{\omega Y_{ss}-D^W-(1-\omega)Y_f^*},$$

where Π_{ss} and Y_{ss} are the solution to steady-state equilibrium conditions (63) and (64). Substituting the linearized AS curve into the linearized AD curve as in Proposition 2 provides a forward-looking difference equation in y_t. Local determinacy requires the coefficient on $E_t y_{t+1}$ to be less than unity. This condition is identical to slope condition derived above implying that the asymmetric stagnation equilibrium is always locally determinate, as required. □

Appendix B: Fiscal Policy Coordination

Non-Cooperative Game

The government in each country *unilaterally* chooses its own level of government spending G to minimize the deviations of output, inflation, and level of government spending from their own respective target levels. We assume both countries have identical aggregate supply curves—same full-employment level of output, labor share, and degree of wage rigidity. The policy objective and constraints are given below:

$$\begin{aligned}
&\min_{G,Y,Y^*,\Pi} \left(Y - Y_f\right)^2 + (\Pi - 1)^2 + \left(G - G_{target}\right)^2 \\
&\text{s.t.} \;\; \omega Y + (1-\omega)Y^* = D^W + \omega G + (1-\omega)G^* + \psi^W \Pi \\
&Y = \left(\frac{1 - \frac{\gamma}{\Pi}}{1-\gamma}\right)^{\frac{\alpha}{1-\alpha}} Y_f \\
&Y^* = \left(\frac{1 - \frac{\gamma}{\Pi}}{1-\gamma}\right)^{\frac{\alpha}{1-\alpha}} Y_f
\end{aligned},$$

where $D^W = \omega D + (1-\omega)D^*$ and $\psi^W = \frac{1+\beta}{\beta}(1+g)D^W$.

By substituting the domestic and foreign aggregate supply curves into the objective function and global aggregate demand curve, we obtain the following Lagrangian:

$$\begin{aligned}
\mathcal{L} = {} & \frac{1}{2}\left(Y_{AS}(\Pi) - Y_f\right)^2 + \frac{1}{2}(\Pi - 1)^2 + \frac{1}{2}\left(G - G_{target}\right)^2 \\
& + \lambda\left(\omega Y_{AS}(\Pi) + (1-\omega)Y^*_{AS}(\Pi) - D^W - \omega G - (1-\omega)G^* - \psi^W \Pi\right)
\end{aligned}.$$

The first-order conditions are given below:

$$\begin{aligned}
0 &= \frac{dY_{AS}}{d\Pi}\left(Y_{AS}(\Pi) - Y_f\right) + \Pi - 1 + \lambda\left(\frac{dY_{AS}}{d\Pi} - \psi^W\right) \\
0 &= G - G_{target} - \lambda\omega
\end{aligned},$$

where λ is the Lagrange multiplier on the global aggregate demand curve. Given that the domestic economy is in secular stagnation: $Y < Y_f$ and $\Pi < 1$ and $\frac{dY_{AS}}{d\Pi} > \psi^W > 0$—and the slope of the AS curve exceeds the slope of the AD curve, the multiplier $\lambda > 0$ and the fiscal authority in secular stagnation always chooses a level of government spending that exceeds the target. The level of government spending above target is increasing in ω.

Cooperative Game

We now consider the optimal level of government spending when both countries jointly maximize their welfare. The loss function of the global planner is the weighted sum of each country's loss function. Given that the aggregate supply curve are identical and if we assume that the target level of government expenditures is the same, we obtain the following loss function subject to a global aggregate demand and global aggregate supply constraints:

$$\begin{aligned}
&\min_{G,Y,\Pi} \left(Y - Y_f\right)^2 + (\Pi - 1)^2 + \left(G - G_{target}\right)^2 \\
&\text{s.t.} \quad Y = D^W + G + \psi^W \Pi \\
&\qquad Y = \left(\frac{1 - \frac{\gamma}{\Pi}}{1 - \gamma}\right)^{\frac{\alpha}{1-\alpha}} Y_f
\end{aligned},$$

where $D^W = \omega D + (1 - \omega) D^*$ and $\psi^W = \frac{1+\beta}{\beta}(1 + g) D^W$. In the cooperative setup, Y is global output (instead of output of the domestic country only) and G is global government spending. Relative to the non-cooperative setup, the only difference is that the planner chooses G and G^* simultaneously.

The first-order conditions for the optimal level of global government spending are given below:

$$\begin{aligned}
0 &= \frac{dY_{AS}}{d\Pi}\left(Y_{AS}(\Pi) - Y_f\right) + \Pi - 1 + \lambda\left(\frac{dY_{AS}}{d\Pi} - \psi^W\right) \\
0 &= G - G_{target} - \lambda
\end{aligned},$$

where the multiplier is the same as in the case of the non-cooperative game. The only difference is that ω no longer appears in the second optimality condition.

Proposition 7: *Consider two countries in symmetric secular stagnation with identical aggregate supply parameters, loss functions, and target levels of government spending. Then coordinated optimal government spending exceeds uncoordinated government spending. Coordination losses are maximized when* $\omega = \frac{1}{2}$.

Proof: Global government spending under coordination and absent coordination are given below along with the Lagrange multiplier, λ:

$$\begin{aligned}
G_{coop} &= G_{target} + \lambda \\
G_{non-coop} &= G_{target} + \lambda\left(\omega^2 + (1 - \omega)^2\right) \\
\lambda &= \frac{\frac{dY_{AS}}{d\Pi}\left(Y_f - Y_{AS}(\Pi)\right) + 1 - \Pi}{\frac{dY_{AS}}{d\Pi} - \psi^W}
\end{aligned},$$

where G_{coop} is global government spending under cooperation and $G_{non-coop}$ is global government spending absent coordination. Since $\omega \leq 1$, $G_{non-coop} \leq G_{coop}$. The term $\omega^2 + (1 - \omega)^2$ is minimized at $\omega = \frac{1}{2}$ implying that losses from coordination are maximized when the two countries have the same size. $\square$

Corollary: Consider N countries in a symmetric secular stagnation with identical aggregate supply parameter, loss function, and target levels of government spending. Global government spending absent coordination goes to zero as $N \to \infty$.

Proof: Since countries are identical, $\omega = \frac{1}{N}$. The optimality condition for government spending for each country is given by the first-order condition of the non-cooperative game. Therefore, global government spending absent coordination is given by the expression below:

$$\begin{aligned} G_{non-coop} &= G_{target} + \lambda N \omega^2 \\ &= G_{target} + \lambda \frac{1}{N} \end{aligned},$$

where the second term goes to zero as $N \to \infty$. □

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