Global Imbalances and Lending Constraints in a Standard Real Business Cycle Model

Suparna Chakraborty* and Robert Dekle†

February 16, 2007

Abstract

Does increased international liquidity, the "savings glut" explain the recent deterioration of US current account balances? In this paper, we develop a simple, two country real business cycle model to answer this question. The salient feature of our model is that lending by one country is constrained by its wealth by a regulatory or institutional lending constraint. We allow shocks to this lending constraint to capture a country’s ability to lend as financial regulations evolve and the country’s financial markets develop. Applying our model to the test case of Japan (lender) and the US, we find that our general equilibrium model captures well, how differential productivity growth affects the flow of capital from the lending country (Japan) to the U.S., and how the lending constraint interacts with productivity growth, to impact the borrowing country, or the U.S. current account.

1 Introduction

International liquidity and global current account imbalances are major topics of concern. According to the so-called "savings glut" view of Chairman Bernanke of the Federal Reserve Board, a combination of forces created a significant increase in the global supply of saving, explaining both the relatively low level of international interest rates and the increase in the U.S. current account deficit (Bernanke, 2005). The U.S. current account deficit has risen from a modest $120 billion in 1996 to $666 billion in 2005, and correspondingly the U.S. real interest has fallen from about 4.3 percent in 2000 to about 1.8 percent in 2005. Bernanke attributes this expansion of the U.S. current account deficit and fall in real yields to an expansion of saving in Japan, Europe, and especially in emerging Asia. In Japan and Europe, lower productivity growth relative to that in...

*Dept. of Economics and Finance, Baruch College, CUNY. Please send correspondences to suparna_chakraborty@baruch.cuny.edu
†Dept. of Economics, University of South California and NY Fed

the U.S. stimulated the outflow of capital to the U.S. Although in emerging Asia, productivity growth is higher than in the U.S., in emerging markets, local financial markets are much shallower than U.S. financial markets, leading to capital outflows to the U.S., and the deterioration of the U.S. current account.

In this paper, we develop a simple model of international liquidity and current account imbalances. We develop a two country real business cycle model, in which lending by one country is constrained by that country’s wealth by a regulatory or institutional lending constraint. We define wealth as the sum of the lending country’s capital stock and land. With this lending constraint, we try to capture the role of financial market imperfections in the lending country. We allow shocks to this lending constraint, to capture a country’s ability to lend, as financial regulations evolve, and the country’s financial markets develop. We find that our general equilibrium model captures well, how differential productivity growth affects the flow of capital from the lending country to the U.S., and how this lending constraint interacts with productivity growth, to impact the borrowing country, or the U.S. current account.

In our model, because of this lending constraint, shocks to a country’s wealth impact net lending, and the current account in the borrowing country. This additional transmission mechanism through the lending channel offsets the initial impact of the productivity shock on the current account in the borrowing country. For example, suppose that a negative productivity shock hits the lending country. This shock lowers investment opportunities in the lending country, and raises capital outflows to the borrowing country, lowering global real interest rates, and increasing the current account deficit in the borrowing country. However, with binding lending constraints, there is an offsetting wealth effect. The decline in wealth in the lending country lowers capital outflows, and reduces the current account deficit in the borrowing country. Thus, whether the decline in productivity of the lender results in an expansion of the current account deficit of the borrower, depends on the parameter values. For our chosen parameter values, we find that the first effect dominates, a negative productivity shock to the lender results in a deterioration of the current account in the borrowing country.

In contrast to the effects of productivity shocks— which tend to be small because of the offsetting effects—we find large effects on the borrower country current account, when shocks emanate from the lending constraints. One interpretation of say, a relaxation of the lending constraint is an increase in the relative attractiveness of borrowing country financial markets. For example, with a relaxation of capital outflow restrictions, the financial markets of the U.S. will become more open to China and other emerging markets. We find that a relaxation of the lending constraint will lead to a sharp increase in net lending, and a widening of the current account deficit in the borrowing country. Thus, our model can explain how a widening of the U.S. current account can result from the entry of large countries into the international lending market.

Another interpretation of the relaxation of the lending constraint is a change in regulatory capital adequacy ratios, from a higher to a lower regulatory capital adequacy ratio. For
The base model in this paper is a standard two country real business cycle model (Backus, Kehoe and Kydland (BKK, 1993)). The world comprises of two countries denoted by superscript \( i \in \{1, 2\} \), the domestic country, country 1, and the borrower country, country 2. Each country is composed of \( N_{it} \) \( i \in \{1, 2\} \) infinitely lived consumers, and an infinite number of firms. Firms are classified according to their types: the intermediate goods producing firms and the final good producing firms. The countries trade in intermediate goods \( y_{ij}, j \in \{1, 2\} \) where country \( i \) produces the intermediate good \( y_i \). The final good producing firms use the intermediate goods to produce the final good \( y_{it}, t \in \{1, 2\} \) that is used for domestic consumption, and investment in capital goods by the consumers. We assume that factors of production are immobile across geographical borders. In addition to trading in intermediate goods, the countries can trade in one period international bonds. In terms of theory, our main contribution is that the amount of capital flows to the borrower country is constrained by a "capital adequacy" requirement. As mentioned, this "capital adequacy" requirement introduces another channel in which international productivity shocks are propagated.

Since our results, particularly on the effects of productivity shocks, is sensitive to parameter values, we calibrate our model to U.S. and Japanese data between 1980 and 2004. We chose Japan as the "lender" country, since among all countries, Japan had the largest cumulative current account balances between the early 1980s and early 2000, and thus was the largest lender to the global economy during this period. In addition, Japan was marred by highly fluctuating land values during this period, which, it is alleged, affected Japanese net lending (Klein, Peek and Rosengren, 2000). Japan’s story of fluctuating asset values impacting international net lending fits well the setup of our model.

In related work, Callesari (2007), Mendoza, Quadrini, and Rios-Rull (MQR, 2006), Cavallo and Tille (2006), Faruquee, Laxton, Muir and Pesenti (2005), and Caballero, Farhi, and Gourinchas (CFG, 2006) are among the few that examine current account imbalances in dynamic optimizing models. Of these papers, for example, the 2006 implementation of the Basel II accord in many countries is expected to lower on average, regulatory capital adequacy ratios for major international banks from 8 to 6 percent.

For our purposes, the main difference between Basel II and Basel I (implemented in 1988) is that in Basel II, banks will be able to set their own capital adequacy standards, based on their own assessment of credit risk. It was deemed recently by the Basel Committee that a rigid application of Basel I risk weightings to bank assets is no longer necessary, as banks have developed their own risk assessment models. For example, rather than force banks to weight industrial loans as 0.70, and uncollateralized real estate loans as 1.0 as in Basel I, Basel II would let banks use their own risk assessment models to determine the relative weightings.

Because the bank-specific internal risk assessment models tend to assign lower risk weights to some assets heavy in bank portfolios such as mortgage lending, it is believed that the implementation of Basel II will result in a lowering of the level of overall capital adequacy standards. For example, the Bank of International Settlements (BIS) estimates that after Basel II, bank capital will on average decline by between 16 and 20 percent (BIS, 2006).
only MQR (2006) and CFG (2006) emphasize the importance of financial structure for global imbalances; and embed this structure in a general equilibrium, optimizing framework. Our paper is closest to CFG (2006), in that we emphasize financial imperfections in the lending country, while MQR (2006) emphasize financial imperfections in the borrowing country.³

This paper is organized as follows. In Section 2, we present our basic real business cycle model with "capital adequacy" constraints. In Section 3, we calibrate our model to the U.S. and Japanese economies, and present impulse responses. We find that a negative productivity shock in Japan increases U.S. borrowing as does a positive productivity shock in the US. This in turn adversely affects the U.S. current account, worsening the deficits. In a similar manner, a positive shock to the capital adequacy constraint, say due to a relaxation of access to international capital markets has a very large positive impact on lending from Japan that in turn worsens the US current account. In Section 4, we perform quantitative experiments, to see how well our model matches the outflow of capital from Japan, and the evolution of the U.S. current account in recent years.

2 Theoretical Model

We describe below the economic problem facing agents in country 1 (country 2 is analogous). The economic problem of both countries is similar except for one difference—land enters only in the economic problem of country 1. We assume that land is used for consumption as well production, and the aggregate amount of land in the economy is normalized to one. Also, we abstract from any government sector, so we do not have government expenditure or taxation in our model.

2.1 Consumer’s problem

The economic problem of the representative consumer in country 1, the "lending country" can be summarized by:

\[ E_0 \sum_{t=0}^{\infty} \beta_1^t u_1(c_{1t}, l_{1t}, h_{1t}) \]

where \( \beta_1 \) denotes the rate of time preference, consumption is given by \( c_{1t} \) and leisure is denoted by \( 1 - h_{1t} \). In addition to consumption and leisure, residential land \( l_{1t} \) also adds to a consumer’s utility.

³There are many two country general equilibrium papers that impose credit constraints in a two country general equilibrium setting, but relatively few papers that impose credit constraints on agents in the lending country, as we do here.
Utility is maximized subject to the budget constraint:

\[ c_{tt+1} + k_{tt+1} - (1 - \delta_1)k_{tt} + q_t(l_{tt+1} - l_t) + s_{tt+1} \leq w_{tt}h_{tt} + r^k_{tt}k_{tt} + r^l_{tt}l_{tt} + R_t s_t \]

Note that there are four sources of income for the consumer: wage income \( w_{tt}h_{tt} \), returns to capital \( r^k_{tt}k_{tt} \), returns to land used for production \( r^l_{tt}l_{tt} \) and finally the interest earnings from international bonds \( R_t s_t \). The wage rate \( w_{tt} \), the rental rates on capital and land, \( r^k_t \) and \( r^l_t \) and the interest on lending \( R_t \) are in terms of the final consumption good \( y_{tt} \) that is used as the numeraire.

After spending on consumption, the remainder of the income is spent on investment in domestic physical assets (comprising of domestic capital and land) and in savings (or equivalently purchase of international bonds). Investment in capital is denoted by \( k_{tt+1} - (1 - \delta_1)k_{tt} \) where \( \delta_1 \) is the rate of depreciation and the investment in land is denoted by \( q_t(l_{tt+1} - l_t) \) where \( q_t \) is the price of land in terms of the numeraire. Every period, the consumer splits aggregate land \( l_t \) into its two alternative uses: \( l_{1t} \) is the amount of land allocated for consumption purposes, and \( l_{2t} \) is the amount of land that is allocated for production of the intermediate good.

In our formulation, savings are lent in the international market but are subject to some restrictions such that:

\[ s_{tt+1} \leq \phi_t(k_{tt+1} + q_t l_{tt+1}) \]

where \( \phi_t \) determines the fraction of wealth of the consumer that is invested in the international market. One interpretation of \( \phi_t \) is that it embodies investment opportunities in the international market. For example, in our model, an increase in \( \phi \) implies an increase in the relative profitability of investment in the international market, such that consumers channel an increased fraction of their wealth abroad. A possible reason for the increase in \( \phi_t \) is that financial liberalization opens up new investment opportunities outside of the domestic economy.

Another possible interpretation of the lending constraint comes from international banking regulations. One way of interpreting the lending constraint is to say that every period the lender has to keep in reserve or maintain a capital reserve equal to \( 1 - \phi_t \) fraction of its assets which implies that lending cannot exceed \( \phi_t \) fraction of its assets. In our model the asset holding of the lender is equal to the total amount of capital and land held. Hence the maximum amount that the lender can lend any period is bound by the upper limit \( \phi_t(k_{tt+1} + q_t l_{tt+1}) \). Here, \( \phi_t \) is determined by international laws (for example those mandated by Basel accords) as well as domestic government policies. An increase in \( \phi \) denotes a relaxation of the capital adequacy requirement, thus allowing agents to lend more in the international market.
2.2 Representative intermediate good producing firm’s problem

The representative firm that produces the intermediate good $y^1$ owns a Cobb-Douglas production technology. Every period the firm hires labor, land and capital to produce the intermediate good that is then sold domestically and internationally to the final good producing firms.

Every period the representative firm maximizes profit:

$$\pi^1_{1t} = p^1_{1t}y^1_{1t} - w_1 h_{1t} - r^k_{1t}k_{1t} - r^l_{1t}l_{2t}$$

subject to the production constraint:

$$y^1_{1t} \leq A_{1t} F_1(k_{1t}, l_{2t}, h_{1t})$$

where $\pi^1_{1t}$ denotes the period $t$ profits of the representative intermediate goods producing firm and $p^1_{1t}$ is the period $t$ price of the intermediate good $y^1_{1t}$ in terms of the numeraire. $A_{1t}$ denotes the time varying productivity in country 1.

In addition to the intermediate goods producing firms, the country is also populated by an infinite number of final good producing firms.

2.3 Representative final good producing firm’s problem

A final goods producing firm uses domestic and foreign intermediate goods to produce the final good $y_1$ using an aggregation technology.

The representative firm maximizes profits:

$$\pi_{1t} = y_{1t} - p^1_{1t}c^1_{1t} - p^1_{2t}c^1_{2t}$$

subject to the production constraint.

$$y^1_{1t} \leq G(c^1_{1t}, c^1_{2t})$$

where $\pi_{1t}$ denotes the period $t$ profits of the representative final goods producing firm, $c^1_{1t}$ is the amount of domestically produced intermediate good used to produce the final good and $c^1_{2t}$ is the amount of the intermediate good produced in country 2 that is used in the production of the final good. $p^1_{1t}$ and $p^1_{2t}$ is the period $t$ price in country 1 of the intermediate goods in terms of the numeraire.

$G(.)$ denotes the aggregation technology.
2.4 Resource Constraints and Equilibrium

The resource constraints on final goods in country $i$, $i \in \{1, 2\}$ is given by:

$$y_{it} = c_{it} + k_{it+1} - (1 - \delta_i)k_{it}$$

The current account of country $i$ is the sum of net exports and the interest earnings on international bonds, or $(p_{jt}^i c_{jt}^i - p_{jt}^j c_{jt}^j) + r_t s_{it}$.

Note that in equilibrium:

$$s_{it+1} - s_{it} = p_{jt}^i c_{jt}^i - p_{jt}^j c_{jt}^j + r_t s_{it}$$

or that net lending is equal to the current account. One way to interpret this result is that if the current account exhibits a surplus, then the income received by a country in exports and interest on bonds purchased last period exceeds the income spent by the country on its imports. One way to use the surplus money is to buy more international bonds. Equivalently, for the borrower, if the expenditure on imports and interest on borrowings exceed the income from exports, a country will have an incentive to borrow to meet its current obligations. Thus for the lender, an increase in outflow of funds is associated with an improvement of the current account. Analogously, an increase in borrowing deteriorates the current account balance of the borrowing nation.

We denote the terms of trade as the ratio of the price of intermediate goods in the two countries, or $\frac{p_{1t}^1}{e_t p_{2t}^2}$, where $e_t$ is the real exchange rate.

In equilibrium, the law of one price holds such that:

$$e_t = \frac{p_{1t}^1}{p_{1t}^2} = \frac{p_{2t}^1}{p_{2t}^2}$$

In addition, the resource constraint on land in country 1 is denoted by:

$$N_{1t}(l_{1t} + l_{2t}) = 1$$

which indicates that the aggregate amount of land in the economy is fixed and is normalized to one.

The world resource constraint on traded intermediate goods are denoted by:

$$N_{1t}y_{1t}^1 = N_{1t}c_{1t}^1 + N_{2t}c_{2t}^2$$

$$N_{2t}y_{2t}^2 = N_{1t}c_{2t}^1 + N_{2t}c_{2t}^2$$
Finally the constraint on international borrowing and lending is denoted by:

\[ N_{1t} s_t = N_{2t} b_t \]

An equilibrium in this economy is given by a set of allocations:

\( \{ c_{1t}, c_{2t}, y_{1t}, y_{2t}, k_{1t+1}, k_{2t+1}, l_{1t+1}, l_{2t+1}, h_{1t}, h_{2t}, s_{1t+1}, b_{1t+1}, y_{11t}, c_{11t}, y_{21t}, c_{21t}, c_{22t} \} \) and a set of prices \( \{ e_t, p_{1t}, p_{2t}, p_{23t}, w_{1t}, w_{2t}, r_{1t}, r_{2t}, R_t, q_t \} \) such that given the set of prices, the equilibrium set of allocations solve representative consumers and the firms problem in each country and the resource constraints are satisfied.

A balanced growth for this economy occurs when all allocation variables in country \( i \) except for the variables \( \{ h_{it}, l_i \} \) grow at the rate of long term technical progress denoted by \( \gamma_i \). The per capita labor supply \( h_{it} \) is constant in the steady state while the variable \( l_i \) or per capita land holdings in country 1 decreases at the rate \( \eta_i \) where \( \eta_i \) is the population growth rate that is assumed to be constant. As for the price variables along the balanced growth path all the price variables except for \( \{ w_{1t}, w_{2t}, q_t \} \) remain constant. The wage rates \( w_{it} \) increase at the rate \( \gamma_i \) and the land price \( q_t \) increases at the rate \( \gamma_1 \eta_1 \).

### 3 Quantitative Results

To derive the quantitative implications of our model, we use the technique of log linearization by King, Plosser and Rebelo (1988). To apply the log-linearization technique we first prove the sufficient condition for the lending constraint to hold with equality, which is summarized in the Proposition below. The condition for the lending constraint to bind can only be analytically established for the steady state.

**Proposition 1** The lending constraint will bind in the steady state when \( \beta_1 > \beta_2 \)

**Proof.** The formal proof is in Appendix One. The logic is as follows: \( \beta_1 > \beta_2 \) implies that country 2 is more impatient than country 1. This creates an incentive for country 2 to borrow from country 1. In the absence of any borrowing constraint, country 2 will ideally want to borrow as much as possible. However, country 1 will face an upper limit on the amount that it can lend to country 2 and the lending constraint will bind. ■
3.1 Calibration

For our quantitative analysis, we use the following specific utility and production functions:

\[ u_1(c_{1t}, l_{1t}, h_{1t}) = \frac{\left(c_{1t}^{\alpha_1} l_{1t}^{\alpha_3} (1 - h_{1t})^{1-\alpha_1-\alpha_3}\right)^{1-\sigma}}{1-\sigma}, \sigma > 1 \]

\[ = \alpha_1 \log c_{1t} + \alpha_3 \log l_{1t} + (1 - \alpha_1 - \alpha_3) \log(1 - h_{1t}), \sigma = 1 \]

\[ u_2(c_{2t}, h_{2t}) = \frac{\left(c_{2t}^{\alpha_2} (1 - h_{2t})^{1-\alpha_2}\right)^{1-\sigma}}{1-\sigma}, \sigma > 1 \]

\[ = \alpha_2 \log c_{2t} + (1 - \alpha_2) \log(1 - h_{2t}), \sigma = 1 \]

\[ F_1(k_{1t}, l_{1t}, h_{1t}) = k_{1t}^{\theta_{1k}} l_{1t}^{\theta_{1l}} h_{1t}^{1-\theta_{1k}-\theta_{1l}} \]

\[ F_2(k_{2t}, h_{2t}) = k_{2t}^{\theta_{2k}} h_{2t}^{1-\theta_{2k}} \]

\[ G(c_{1t}, c_{2t}) = \left[ \omega (c_{1t})^{\rho} + (1 - \omega)(c_{2t})^{\rho} \right]^{\frac{1}{\rho}} \]

\[ G(c_{1t}, c_{2t}) = \left[ \omega (c_{2t})^{\rho} + (1 - \omega)(c_{1t})^{\rho} \right]^{\frac{1}{\rho}} \]

We calibrate our model parameters such that the steady state moments from the model match the moments of the data. We take country 1 to be Japan and country 2 to be US. The steady state period is assumed to be 1980 to 1984. For our analysis, we assume no population growth and the long term average growth rate of U.S. and Japan is 2%.\(^4\) Further, the per capita GDP in Japan is 70% of the per capita GDP of the U.S.

For our baseline, we begin by assuming \(\sigma = 2\) and \(\rho = -0.5\) which is taken from BKK(1993). The average interest rate \(R = 1.06\) which yields \(\beta_2 = 0.9815\). Given Proposition 1, we assume the rate of time preference in country 1 \(\beta_1 = 0.99\) such that \(\beta_1 > \beta_2\). The average capital to output ratio in Japan is 1.8 and the

\(^4\) All data for Japan are from the Japan Statistical Yearbook; and all data for the U.S. are from the Bureau of Economic Analysis.

\(^5\) Business cycle literature commonly takes the long run growth rate on the balanced growth path to be 2% that is the long run growth rate of per capita GDP in the US. As for Japan, Hayashi and Prescott (2002) assumes the long run growth rate to be the same as that of US, i.e. 2%. 


average investment to output ratio is .22 during the steady-state period. This yields a rate of depreciation $\delta_1 = .1022$. The average share corporate land in output is .98; and the value of residential land in output 1.67. The net lending by Japan to the rest of the world is 1.8% of its GDP. The U.S. has been one of the major recipients of Japanese net lending, so we take the share of net lending to U.S. as a ratio of Japanese output to be 1.8% (or in our formulation, U.S. represents the rest of the world). Given the share of capital, land and net lending in output, the steady state capital adequacy ratio or $\phi = .0041$. In addition, we estimate the share of capital in output of country 1, or $\theta_{1k} = .2756$, and the share of land in output, or $\theta_{1l} = .0255$. The share of labor in output, or $\theta_{1h} = .6989$. Given that the share of residential land in Japan is 63% of total land and workers in Japan spend 33% of their time working, the elasticity of substitution between consumption and land, or $\alpha_3 = .0225$, and the elasticity of substitution between consumption and labor or $\alpha_1 = .3469$.

We further assume that import share of output is 12.8% in Japan and 8.6% in United States. The values are taken from the World Development Indicators. Given our assumption, $\omega = .9613$, which indicates a strong home bias. As for the remaining parameters $\theta_{2k} = .36$, $\theta_{2h} = .64$ and $\delta_2 = .1$ as in BKK(1993). Furthermore, assuming that in United States, workers spend one-third of their time at work yields an elasticity of substitution of consumption and leisure of $\alpha_2 = .3596$. We summarize the calibrated parameters in Table 1.

Given Proposition 1, we assume that the capital adequacy constraint binds in the neighborhood of the steady state which allows us to solve the model using log-linearization technique. For our analysis, we assume a vector autoregressive process of order one for the log deviations of productivities $A_{1t}$ and $A_{2t}$ and the deviation of capital adequacy ratio $\phi_t$ from their respective steady states.

Summarizing the VAR processes:

$$
\bar{\alpha}_{1t+1} = \rho_{\alpha_1} \bar{\alpha}_{1t} + \epsilon_{1t+1}
$$
$$
\bar{\alpha}_{2t+1} = \rho_{\alpha_2} \bar{\alpha}_{2t} + \epsilon_{2t+1}
$$
$$
\bar{\phi}_{t+1} = \rho_{\phi} \bar{\phi}_t + \epsilon_{\phi t+1}
$$

where we define:

$$
\bar{\alpha}_{1t} = \log A_{1t} - \log A_1
$$
$$
\bar{\alpha}_{2t} = \log A_{2t} - \log A_2
$$
$$
\bar{\phi}_t = \phi_t - \bar{\phi}
$$

The error terms are assumed to be i.i.d.
3.2 Impulse Responses

To analyze the properties of the model, we examine impulse responses.

Given the theoretical model we expect the following to occur:

1. A decline in productivity in Japan or the lending nation would on the one hand create an incentive for outflow of funds to be invested in the international market which would lead to a deterioration of the current account of the borrower. At the same time, reduced productivity of the lender in the presence of binding lending constraint, reduces lending (as wealth declines) that would lead to an improvement in the current account of the recipient country. The final effect on the current account depends on which effect dominates.

2. An increase in productivity of the borrower would increase the incentive for the lender to lend more by making investment opportunities in the borrowing country more lucrative. The current account of the borrower is expected to deteriorate.

3. Finally, an increase in the "capital-adequacy" or "loan to value" ratio $\phi$ will relax international lending constraints encouraging an outflow of funds and deteriorating the current account of the borrower.

Does our impulse responses predict the same?

Given the time series on capital, labor and the land used by the corporate sector in Japan, we estimate the productivity of Japan as a Solow residual. In addition, given the amount of net lending by Japan, we can estimate the time series of the loan to value ratio or $\phi$. The productivity series in U.S. is also estimated as a Solow residual, but without land as a factor of production. Given the time series thus constructed, we estimate $\rho_{a1} = .93$, $\rho_{a2} = .91$ and $\rho_{\phi} = .67$. Since we are working with annual data, and are interested in the period 1980 to 2004, we set the length of our simulation series to be 25. We are primarily interested in the effect of exogenous shocks on three variables, the current account of country 2, $(\text{current}_2)$, the interest rate, $(\text{interest})$, and the amount of borrowing, or $(\text{borrow})$. The results are plotted in Figures 1 to 3.

In Figure 1 we plot the response to a 1% negative shock to $A_1$. A decline in the productivity of country 1 has two opposing effects: a decline in productivity reduces the returns to domestic investment providing an incentive for an outflow of funds from country 1 that causes the current account of country 2 (the recipient country) to deteriorate. On the other hand, reduction in productivity reduces the wealth of country 1 that in the presence of a binding lending constraint would reduce the outflow of funds and improve the current account of country 2. In this case, the first effect dominates the second, there is a .3% increase in outflow of funds on impact that continues for a couple of periods before declining and the current account of country 2 further deteriorates. The global real interest rate for its part reduces by 10%.
When there is a 1% positive shock to $A_2$ as Figure 2 outlines, investment opportunities in country 2 become more attractive, resulting in the flow of capital from country 1 to country 2. Consequently, borrowing by country 2 increases, resulting in a worsening of the current account by .004%. The real interest rate increases by 25%.

The external shock that we are most interested in is a change in the capital adequacy ratio, or $\phi$. A 1% positive shock to $\phi$ (that denotes a relaxation of restrictions on international lending) sharply increases the lending by country 2, and worsens the current account by -3%. The interest rate sharply increases on impact, before gradually declining (Figure 3).

4 Application: The case of United States and Japan

To evaluate the performance of our model quantitatively, we compare our model predictions with data. Our period of interest is 1980 to 2004. The stylized facts from Japan and the US that we try to match are summarized in Figures 4 to 6. The exogenous shocks in our model as estimated from the data and the first order conditions of our model are plotted in Figures 7 and 8.

4.1 Stylized facts

Figure 4 depicts the fluctuations in output per worker in Japan and the US with respect to the long term trend. The long run growth rate is taken as 2%. The eighties was a period of boom both in Japan and in the U.S. However, since 1991, the growth paths of Japan and the U.S. diverged, as U.S. output recovered and grew robustly, while Japanese output growth stagnated. As for net lending by Japan to the rest of the world as a share of output (Figure 5), it is almost countercyclical to Japanese output growth and quite volatile. Since 1996, the net lending almost monotonically increases except for a brief decline during 1998. As for current account in US as a share of output (Figure 6), we find that in the early eighties, US current account deficit increased but the trend reversed in late eighties. Since 1991, the current account deficit has worsened and the rate of increase in deficit has picked up since 1996.

Comparing the trends in US current account with the net lending by Japan, we notice that the trend is almost countercyclical as expected (except for a brief period of 1992 to 1996). During the early eighties, Japanese net lending as a share of GDP increased and so did the US current account deficit. The late eighties were a period of decline in Japanese net lending which also coincides with an improvement in US current account. Since 1996, Japanese net lending
has pretty much increased (though it is quite volatile), and the US current account deficit shows a monotonic increase. We suspect that the 1990s, especially the period after 1996 saw a lot of inflow of funds in the US from the emerging Asian economies and later, China. Hence, even though the Japanese lending shows fluctuations, US current account deficit increased due to influx of the new sources of funds.

There are three possible sources of external shocks in our model: shocks to productivities in U.S. and in Japan (measured as a Solow residual); and shocks to the loan-to-value ratio (measured as the ratio of net lending to aggregate wealth). We plot the U.S. and Japanese productivities, and the loan-to-value ratios in Figures 7 and 8. We find that productivities follow the same pattern as the fluctuations in output. As for the loan-to-value ratio, it is quite volatile, and countercyclical to Japanese output growth. At the same time, loan to value ratio is also countercyclical to US current account (an increase in loan to value ratio corresponds to a deterioration of the US current account and vice-versa).

4.2 Results of the quantitative analysis

The model predictions resulting from feeding in the exogenous shocks both individually and in combination are plotted in Figures 9 to 12.

In Table 2 we summarize the real business cycle properties of our model and data. The standard deviations of output per capita in Japan and in the U.S. are 5.8 and 2.76, respectively. Feeding in productivity fluctuations in Japan as estimated from the data in our model, we get a standard deviation of output per capita of 9.75 in Japan and 6.61 in U.S. and feeding in fluctuations in US productivity, our model predicts a standard deviation of output of .1 in Japan and 1.74 in the US. If we feed in the time series of $\phi_t$ in our model, the standard deviation of output in Japan reduces to .62, and that in the U.S. reduces to .18. Feeding in all three wedges jointly, the standard deviation of output in Japan is 9.69 while it is 6.69 in US. A pictorial depiction is presented in Figures 9 and 10. In international macro literature, the correlation of output across nations has been another area of concern. According to data, the correlation of output in Japan and US between 1980 and 2004 was .058. With productivity shocks fed individually, the model predicts a correlation of -.94 (with $A_1$ alone) and -.96 (with $A_2$ only). If we feed in $\phi$ alone, we can bring down the correlation to -.28, a number much closer to the data. Feeding in the time series of all wedges jointly, the correlation predicted by the model is -.91.

We are mostly interested in the evolution of net lending by Japan and its consequent impact on the U.S. current account. In Figures 11 and 12, we depict how our model can explain Japanese net lending, or if we take the two country model literally, the U.S. current account. The standard deviation of the current account is .016 and that of net lending as a share of output is .0094. Productivity shocks individually are not very successful in generating
net lending or current account to match the data. Our model performance improves when we feed in the time series of $\phi$. Thus, when we feed in all three shocks, we find that our model explains Japanese net lending or capital outflows quite well. As Table 2 depicts, the standard deviation of current account as a share of output is .016. Feeding in all the frictions, or model predicts a standard deviation of .0042, with fluctuations in $\phi_t$ playing an important role. The model does not do a very good job explaining the actual U.S. current account, especially since 1994 (as outlined in Figure 12). This is probably because the "rest-of-world" for Japan is actually not just the U.S., and this has been especially true since the mid-1990s, with the emergence of China as a global lender as discussed in section 4.1.

5 Conclusion

The issue of global current account imbalances is a major cause of concern in the academic and policy making circles today. One possible explanation for this phenomenon might be international liquidity, or the "savings glut" as proposed by Chairman Bernanke. The intuition is that a combination of forces including lack of domestic investment opportunities in Asia in the aftermath of the Asian Crisis and an easier access to international financial markets created a significant increase in the global supply of saving, explaining both the relatively low level of international interest rates and the increase in the U.S. current account deficit.

In this paper, we develop a simple model of international liquidity and current account imbalances. We develop a two country real business cycle model, where lending by one country is constrained by it’s wealth by a regulatory or institutional lending constraint. We allow shocks to this lending constraint, to capture a country’s ability to lend, as financial regulations evolve, and the country's financial markets develop. We find that our general equilibrium model captures well, how differential productivity growth affects the flow of capital from the lending country to the U.S., and how this lending constraint interacts with productivity growth, to impact the borrowing country, or the U.S. current account. In our model, because of this lending constraint, shocks to a country’s wealth impact net lending, and the current account in the borrowing country.

We test the performance of our model by applying it to US and Japan during the period 1980 to 2004. Throughout this period, Japan has been a net lender to United States. At the same time, this period marks upheavals in Japanese domestic market which in turn affected the amount of its lending to the US. Thus it provides us an ideal test case.

We find that productivity fluctuations by themselves in our model context have a small effect on US current account. We suspect the effect is small due to
offsetting effects: for example, a reduction in productivity in Japan creates an incentive for outflow of funds which causes current account of US to deteriorate, but at the same time, a binding lending constraint implies that a reduction in wealth (as a result of reduced productivity) reduces the amount Japan can lend internationally thus improving the current account of US. The impact on current account depends on which effect dominates. In our case though the former dominates but the magnitude is much smaller (due to the opposing wealth effect on lending).

In contrast to the effects of productivity shocks, we find large effects on the borrower country current account, when shocks emanate from the lending constraints. One interpretation of say, a relaxation of the lending constraint is an increase in the relative attractiveness of borrowing country financial markets. For example, with a relaxation of capital outflow restrictions, the financial markets of the U.S. became more open to China and other emerging markets. We find that a relaxation of the lending constraint will lead to a sharp increase in net lending, and a widening of the current account deficit in the borrowing country. Thus, our model can explain how a widening of the U.S. current account can result from the entry of large countries into the international lending market.
References


<table>
<thead>
<tr>
<th>Parameters</th>
<th>Description</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \alpha_3 )</td>
<td>Elasticity of substitution between consumption and land</td>
<td>.0225 -</td>
</tr>
<tr>
<td>( \alpha_i, i \in (1, 2) )</td>
<td>Elasticity of substitution between consumption and leisure in country 1</td>
<td>.3483 .3596</td>
</tr>
<tr>
<td>( \beta_{i, i} \in (1, 2) )</td>
<td>Rate of time preference</td>
<td>.99 .9815</td>
</tr>
<tr>
<td>( \delta_i, i \in (1, 2) )</td>
<td>Rate of depreciation</td>
<td>.1022 .1</td>
</tr>
<tr>
<td>( \theta_{i, i} \in (1, 2) )</td>
<td>Share of capital in output</td>
<td>.2756 .36</td>
</tr>
<tr>
<td>( \theta_{1i} )</td>
<td>Share of land in output in country 1</td>
<td>.0297 -</td>
</tr>
<tr>
<td>( \theta_{ih, i} \in (1, 2) )</td>
<td>Share of labor in output</td>
<td>.6947 .64</td>
</tr>
<tr>
<td>( \phi )</td>
<td>Capital adequacy ratio</td>
<td>.0052 -</td>
</tr>
<tr>
<td>( \sigma )</td>
<td>Curvature of the utility function</td>
<td>2 2</td>
</tr>
<tr>
<td>( \rho )</td>
<td>Armington elasticity</td>
<td>-.5 -.5</td>
</tr>
<tr>
<td>( \omega )</td>
<td>Home-bias</td>
<td>.9613 .9613</td>
</tr>
</tbody>
</table>

Note: The parameters are calibrated such that the moments from the model match the moments from the data where the data is collected from the National Income Accounts of US and Japan.

Source of data: Japan Statistical Yearbooks and Economic Social Research Institute (ESRI) for Japan and Bureau of Economic Analysis for US. In addition, to get data on trade balances, we also look at World Development Indicators.
Table 2: Real business cycle properties of data and model

<table>
<thead>
<tr>
<th></th>
<th>Standard deviation</th>
<th>Correlation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$y_1'$</td>
<td>$y_2'$</td>
</tr>
<tr>
<td></td>
<td>(output) of Japan</td>
<td>(output) of US</td>
</tr>
<tr>
<td>Data</td>
<td>5.8</td>
<td>2.76</td>
</tr>
<tr>
<td>Model (with $A_1$ only)</td>
<td>9.64</td>
<td>6.55</td>
</tr>
<tr>
<td>Model (with $A_2$ only)</td>
<td>.1</td>
<td>1.74</td>
</tr>
<tr>
<td>Model (with $\phi$ only)</td>
<td>.4</td>
<td>.09</td>
</tr>
<tr>
<td>Model (all frictions)</td>
<td>9.61</td>
<td>6.62</td>
</tr>
</tbody>
</table>

Note: The data is taken from US and Japanese national accounts. We take the standard deviation and correlation of the data over the period 1980 to 2004. We solve our model to get the decision rules. We feed in the exogenous shocks to productivities in Japan and the US and the time series of loan to value ratio or $\phi$ individually and jointly in our model to get the model predictions.
Figure 1: Impulse response to a 1% negative shock to $A_1$

Note: This is the benchmark case when import share of United States in its GDP is 8.6% and that of Japan is 12.8% (the figures are from World Development Indicators). The persistence parameter $\rho_{A_1}$ is .93 where we measure productivity as a Solow Residual (data collected from Japan Statistical Yearbooks and the Economic and Social Research Institute). We set the simulation period to 25 to match the data and we run 1000 simulations.
Figure 2: Impulse response to a 1% positive shock to $A_2$

Note: This is the benchmark case when import share of United States in its GDP is 8.6% and that of Japan is 12.8% (the figures are from World Development Indicators). The persistence parameter $\rho_{A_k}$ is .91 where we measure productivity as a Solow Residual (data collected from National Income and Product accounts of United States). We set the simulation period to 25 to match the data and we run 1000 simulations.
Figure 3: Impulse response to a 1% positive shock to $\phi$

Note: This is the benchmark case when import share of United States in its GDP is 8.6% and that of Japan is 12.8% (the figures are from World Development Indicators). The persistence parameter $\rho_{\phi}$ is .67 as measured from data on net lending by Japan (collected from Japan Statistical Yearbooks and the Economic and Social Research Institute). We set the simulation period to 25 to match the data and we run 1000 simulations.
Figure 4: Output per working age population in United States and Japan detrended at 2%

Note: We plot the deviations in output per working population from the long term growth rate (2%) where working population is taken as population aged 15 to 64. The data of US is from the NIPA accounts and that of Japan is from the national income statistics of Japan Statistical Yearbook (also consistent with data from ESRI) converted to US dollars in chained 2000 prices. We take the output of US in 1980 and plot the index.
Figure 5: Net lending by Japan to the rest of the world as a share of Japanese output

Note: We get the net lending to rest of the world from financial accounts of Japan and express it as a share of GDP. United States is one of the largest recipients of Japanese funds.
Figure 6: Current account of US as a share of US output

Note: The current account of US is expressed as a share of US GDP. A negative number denotes a current account deficit.
Figure 7: Time series of productivity measured as a Solow residual

Note: There are three sources of exogenous shocks in our model: fluctuations in productivities in United States and Japan are two of them. We calculate productivity as the Solow residual assuming a Cobb-Douglas production function. We plot the index of productivities in Japan and United States assuming that the productivities of the respective countries in 1980 are normalized to a 100.
Note: Time series of loan to value ratios are calculated as the ratio of net lending by Japan to the aggregate wealth of the economy. The aggregate wealth is calculated as the sum of the capital stock and the value of aggregate land (comprised of Residential and Commercial land) in a given time period.
Figure 9: Output per working population in Japan - data and model predictions

Note: We plot the performance of our model vis a vis the data on output per working population in Japan. The time series is detrended at 2% (the long run growth rate). We set the output in 1980 to be 100. We feed in various combinations of the shocks and plot the model predictions. The different combinations are outlined in the legend.
Figure 10: Output per working population in United States - data and model predictions

Note: We plot the performance of our model vis a vis the data on output per working population in United States. The time series is detrended at 2% (the long run growth rate). We set the output in 1980 to be 100. We feed in various combinations of the shocks and plot the model predictions. The different combinations are outlined in the legend.
Figure 11: Net lending as a ratio of output - data and model predictions

Note: We plot the performance of our model vis a vis the data on net lending by Japan as a share of Japanese output. We feed in various combinations of the shocks and plot the model predictions. The different combinations are outlined in the legend.
Figure 12: Current a/c as a ratio of output (US)- data and model predictions

Note: We plot the performance of our model vis a vis the data on Current Account of United States as a share of US output. We feed in various combinations of the shocks and plot the model predictions. The different combinations are outlined in the legend.
APPENDIX A

To prove proposition one, we need to solve the consumer’s problem in country one and two

Lagrangian for the consumer’s problem in country 1:

$$L_1 = \left[ E_0 \sum_{t=0}^{\infty} \beta_1^t u(c_{1t}, l_{1t}, h_{1t}) + \lambda_{1t} \beta_1^t (w_{1t} h_{1t} + r_{1t}^k k_{1t} + r_{1t}^l l_{2t} + R_t s_t - c_{1t} - k_{1t+1} + (1 - \delta_1) k_{1t} - q_t (l_{1t+1} - l_{1t}) - s_{t+1} + \mu_{1t} \beta_1^t (S(t+1) - s(t+1)) \right]$$

where $\beta_1^t \lambda_{1t}$ is the lagrange multiplier on budget constraint and $\mu_{1t} \beta_1^t$ is the lagrange multiplier on the capital adequacy requirement.

To prove proposition one, we need the first order condition with respect to savings:

$$(R_{t+1} \beta_1^{t+1} \lambda_{1t+1} - \beta_1^t \lambda_{1t} - \mu_{1t} \beta_1^t) \mu_{1t} \beta_1^t = 0$$

Given $\beta > 0$, the above equation reduces to

$$(R_{t+1} \beta_1^{t+1} \lambda_{1t+1} - \beta_1^t \lambda_{1t} - \mu_{1t} \beta_1^t) \mu_{1t} = 0$$

which in the steady-state reduces to:

$$(R \beta_1^t - (1 + g_z)^{\sigma} - \mu_t) \mu_t = 0$$

where the average long term growth rate of the economy is $g_z$ and $\sigma$ is the curvature of the utility function.

Borrowing constraint binds in the steady state if $\mu > 0$.

Lagrangian for the consumer’s problem in country 2:

$$L_2 = \left[ E_0 \sum_{t=0}^{\infty} \beta_2^t u(c_{2t}, h_{2t}) + \lambda_{2t} \beta_2^t (w_{2t} h_{2t} + r_{2t}^k k_{2t} - R_t b_t - c_{2t} - k_{2t+1} + (1 - \delta_2) k_{2t} + b_{t+1}) \right]$$

The first order condition with respect to borrowing reduces to:

$$\left( \beta_2^t \lambda_{2t} - R_{t+1} \beta_2^{t+1} \lambda_{1t+1} \right) = 0$$

In the steady-state,

$$R = \frac{(1 + g_z) \sigma}{\beta_2}$$

Then
\[ \mu > 0 \]
\[ \Rightarrow (R\beta_1 - (1 + g_2)^\sigma - \mu_1) = 0 \]
\[ \Rightarrow \mu_1 = R\beta_1 - (1 + g_2)^\sigma \]

Substituting for \( R \),

\[ \mu_1 = \frac{(1 + g_2)^\sigma}{\beta_2} \beta_1 - (1 + g_2)^\sigma \]
\[ \mu_1 = (1 + g_2)^\sigma \left( \frac{\beta_1}{\beta_2} - 1 \right) \]

Then \( \mu_1 > 0 \)
\[ \Rightarrow (1 + g_2)^\sigma \left( \frac{\beta_1}{\beta_2} - 1 \right) > 0 \]
\[ \Rightarrow \left( \frac{\beta_1}{\beta_2} - 1 \right) > 0 \text{ or } \beta_1 > \beta_2 \]