Borrowing Constraints and Asset Market Dynamics: Evidence from the Pacific Basin

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This paper estimates a linearized, stochastic version of Kiyotaki and Moore's (1997) credit cycle model, using land price data from Hong Kong, Japan, and Korea. It is shown that the welfare costs of borrowing constraints are positively related to the persistence of (detrended) land price fluctuations. When the residual demand curve for land is inelastic and the steady state share of land held by the constrained sector is less than 30 percent, welfare costs are less than 1 percent of GDP in all countries. However, the costs of borrowing constraints rise quickly as the constrained sector becomes more important and as the elasticity of unconstrained land demand increases. For example, if the efficient share of the constrained sector is 50 percent and the residual demand elasticity is 2.0, then costs range from 9 percent of GDP in Korea, where fluctuations are relatively transitory, to 11 percent of GDP in Japan, where land price fluctuations are the most persistent.

What is perhaps most surprising about recent events in Asia is not the widespread currency devaluations, but the subsequent declines in economic activity. Many observers noted that the declining yen and the devalued yuan had eroded the competitiveness of these countries. (Chinn 1998 provides some evidence that most of these currencies were overvalued based on standard PPP considerations.) In addition, given these countries' common interest in exporting similar products to the U.S. and Japan, it is not surprising that they devalued together (Huh and Kasa 1997). However, devaluation was supposed to restore their competitiveness and *stimulate* their economies. Instead, these devaluations produced recessions.

There are many reasons why a devaluation might produce a recession.[1] The thesis of this paper is that in the case of the recent Asian crisis, financial market imperfections are a particularly likely explanation. Specifically, I argue that a combination of an open-economy version of Irving Fisher's (1933) debt-deflation hypothesis, featuring foreign debt and a currency devaluation rather than a price level decline as the initial negative impulse, along with leverage-induced feedback between collateralized asset prices, borrowing constraints, and investment as the propagation mechanism, can provide a convincing account of recent events in Asia.

To substantiate this claim, I estimate a linearized version of Kiyotaki and Moore's (1997) credit cycle model. This model features two sectors. One sector is subject to borrowing constraints, i.e., investment must be fully backed by the value of collateral. The other sector is unconstrained and acts as a buffer, i.e., it provides an alternative use for the collateralized asset. Kiyotaki and Moore show that shocks emanating in either sector set into motion a dynamic feedback process between asset prices and borrowing constraints. Fundamentally, this feedback arises from the dual nature of assets in this economy. Not only are durable assets, like land, an input to production, but they also provide collateral, and hence affect borrowing constraints. A sudden decline in asset prices lowers the value of collateral, which reduces investment in the constrained sector. Since in equilibrium the marginal product of capital is

1. Krugman and Taylor (1978) outline a number of demand-side stories, while van Wijnbergen (1986) points to potentially adverse supply effects, e.g., a devaluation inceases the prices imported intermediate inputs.

higher in the constrained sector, a reallocation of investment away from the constrained sector reduces aggregate output, which further depresses asset prices.

Economists have long recognized the potential role of leverage as a cyclical propagation mechanism. For example, Veblen (1904), in his own inimitable way, described the process clearly, if not entirely persuasively:

> Funds obtained on credit are applied to extend the business; competing business men bid up the material items of industrial equipment by the use of funds so obtained; the value of the material items employed in industry advances; the aggregate of values employed in a given undertaking increases, with or without a physical increase of the industrial material engaged; but since an advance of credit rests on the collateral as expressed in terms of value an enhanced value of the property affords a basis for a further extension of credit, and so on. . . . The extension of loans on collateral has therefore in the nature of things a cumulative character. This cumulative extension of credit through the enhancement of prices goes on, if otherwise undisturbed, so long as no adverse price phenomenon obtrudes itself with sufficient force to convict this cumulative enhancement of capitalized values of imbecility. (Chapter 5, p. 55)

Of course, these days economists prefer to study economies inhabited by rational actors, not imbeciles, and the contribution of Kiyotaki and Moore (1997) is to show how such a cumulative process can arise in an explicit, quantifiable, and internally consistent model. They also characterize the (local) dynamics of this process.

In principle, any asset that is not highly specialized could play the role of collateral in a Kiyotaki and Moore-type model.[2] When implementing their model empirically, however, one must take a stand on the exact nature of this collateralizable asset. In this paper, I assume "land" plays the role of collateral (as well as being a factor of production). Land is undeniably a widely used source of collateral. Moreover, casual empiricism suggests that land values go through exactly the sort of boom and bust cycles predicted by Kiyotaki and Moore's model. Unfortunately, "land" is as heterogeneous as "capital" and presents the same sort of measurement and aggregation problems. Also, many other kinds of durable assets are used as collateral, and ignoring these could be misleading in a quantitative exercise.

The remainder of the paper is organized as follows. Section I develops an open-economy OLG version of Kiyotaki and Moore's credit cycle model. For reasons of both analytical convenience and empirical plausibility, I assume the economy is "small," and the world interest rate is given. Even with this simplification the model is nonlinear, and the first order of business is to show that under certain reasonable parameter restrictions, the deterministic steady state is characterized by a unique positive land allocation and associated level of aggregate output. I then incorporate stochastic (non-diversifiable) endowment shocks and linearize around this steady state. To a first-order approximation, land prices and aggregate output turn out to follow stationary AR(1) processes. The dynamics of the current account also are characterized. A key result of the model is the fact that the *persistence* of the model's fluctuations increases as the borrowing constraints become more "important," as measured by the steady state relative size of the constrained sector and the elasticity of the residual demand curve for land. I use this relationship later to back out estimates of the welfare cost of borrowing constraints from estimates of the persistence of land price fluctuations.

Section II provides a brief discussion of the data. I focus on three countries (on an individual, case-by-case basis): Hong Kong, Japan, and Korea. Each of these countries has experienced considerable fluctuations in land values. The exact definition of land differs somewhat from country to country. For Japan and Hong Kong I obtain actual transactions-based data on land prices according to use. I employ broad measures that encompass both residential and commercial uses of land. For Korea the data are closer to being a standard housing price index, which of course is a rather noisy indicator of land values.

Section III begins by presenting trend/cycle decompositions of land prices for each country. Cyclical fluctuations are quite persistent in all the countries, with half-lives of between three to six years. Fluctuations are most persistent in Japan and least persistent in Korea. Since the shocks are regarded as unobservable, the amplitudes of the cyclical fluctuations are harder to interpret.[3] It turns out that the standard deviations of the cyclical components range from a relatively modest 4.5 percent in Korea to a relatively volatile 16 percent in Hong Kong.

Next, using estimates of the persistence parameters, I compute the implied welfare cost of borrowing constraints under alternative assumptions about the structure of the economy. Not too surprisingly, if the steady state share of the constrained sector is small, and land demand is inelastic in the unconstrained sector (so that Harberger triangles are small), then borrowing constraints do not cost the economy very much. For example, a combination of inelastic demand and a constrained sector share of less than 30 per-

2. Shleifer and Vishuy (1992) discuss how the degree of asset specificity affects the feedback between asset prices and borrowing constraints. Their model is static, however.

3. Thus, this paper focuses more on the second half of the debt-deflation/credit-cycle account of the Asian crisis. That is, in this paper I am more interested in the duration and propagation of the crisis than in the initial impulse that started it.

cent always produces welfare cost estimates of less than 1 percent of GDP, even in Japan, where price fluctuations are the most persistent. However, costs increase rapidly as the constrained sector becomes larger and as residual land demand becomes more elastic. If the elasticity of demand is 2.0, then welfare costs rise to about 10 percent of GDP when the share of the constrained sector is 50 percent and approach 40 percent of GDP if the share of the constrained sector is as high as 70 percent.

Section IV of the paper summarizes the main results and offers a few suggestions for future research.

I. THE MODEL

Kiyotaki and Moore (1997) construct several versions of their credit cycle model, differing in complexity and in the particular dynamic mechanisms highlighted. In each version there are two sectors, a constrained sector and an unconstrained sector. Kiyotaki and Moore refer to the constrained sector as "farming" and to the unconstrained sector as "gathering." Farmers and gatherers are distinguished by the technology available to them for producing (perishable) "fruit." Both technologies use land and labor inputs at time t to produce fruit output at time $t+1$, but differ crucially in the nature of their labor inputs. The labor input of gatherers can be guaranteed ahead of time, independently of any debt they might have. In contrast, farmers cannot commit to work. Hart and Moore (1994) refer to this lack of commitment as the "inalienability of human capital." The inalienability of human capital exposes potential lenders to the risk of default, since it is assumed that no fruit is produced without the farmer's labor input. If a farmer's debt becomes sufficiently onerous, it will be in his interest to withdraw his labor and default on his loan. As a result, lenders will require loans to farmers to be backed by collateral. In general, the amount of collateral required depends on the specifics of the bargaining process that follows default. Based on the results of Hart and Moore (1994), Kiyotaki and Moore argue that farmers will capture the entire difference between their debt and the liquidation value of their land, so that lenders will require the full (expected) value of their land as collateral.[4] In other words, a farmer cannot take out a loan for more than the (expected) value of his current land holdings. This constraint makes the equilibrium sequential and is responsible for all the model's dynamics.[5]

In their "baseline" model, Kiyotaki and Moore make three unconventional assumptions that facilitate the analysis. First, they abstract from issues of risk-sharing by assuming that preferences are linear in fruit consumption. Second, to make the equilibrium interesting, they assume farmers and gatherers have different rates of time preference. In particular, farmers are assumed to be less patient than gatherers, so that in equilibrium farmers are borrowers and gatherers are lenders. Third, they impose a technological upper bound on the savings rate of farmers (by assuming that some of their output is nontradeable) and impose parameter restrictions ensuring a corner solution for their savings decisions. Thus, savings dynamics play no role in the baseline Kiyotaki-Moore model.

Even with these unconventional simplifying assumptions, the model is quite complex, and yields potentially rich dynamic interactions between asset prices and aggregate economic activity. However, the baseline model has a couple of unattractive features that Kiyotaki and Moore address in an extended version. First, there is no aggregate investment in the baseline model. The total supply of land is fixed, and dynamics take the form of reallocations of land between farmers and gatherers. Second, leverage ratios are unrealistically high, being equal to the reciprocal of the gross interest rate. Such high leverage ratios then yield implausibly large impulse responses to unanticipated shocks. In addition, the lack of aggregate investment makes these responses rather transitory.

Kiyotaki and Moore remedy these shortcomings by introducing reproducible capital into the model. This capital takes the form of "trees." Fruit is now assumed to grow on trees using land and labor as inputs, and trees are grown by planting fruit. Trees are assumed to be specific assets, and hence are uncollateralizable. This reduces leverage ratios and dampens the economy's response to shocks. By assuming that in any given period only a fraction of the farmers have the opportunity to invest in trees, Kiyotaki and Moore are also able to draw out the economy's response to shocks. Moreover, they show that this extended model can potentially have (stable) complex roots and thus produce cyclical responses to shocks.

A third version of the model is developed in the appendix to their paper, which is designed to show that none of the substantive results from their baseline model depend

4. Because farmers cannot commit to pay dividends either, introducing an equity market would not help them raise capital. However, in some versions of Kiyotaki and Moore's model, there may be an advantage to setting up a rental market in land.

5. There are of course other ways of introducing financial market imperfections. Perhaps the most common approach is to assume asymmetric information. For example, this is the route taken by Bernanke and Gertler (1989), who study similar issues. However, basing debt on the "inalienability of human capital" rather than on moral hazard or adverse selection simplifies matters considerably in dynamic settings. See Gertler (1992) for a multiperiod application of the asymmetric information approach.

on its unconventional preference and technology assumptions. It is this third version of the Kiyotaki-Moore model that I employ in studying land price dynamics in the Pacific Basin. The model features a Blanchard (1985)-style overlapping-generations structure, in which farmers and gatherers each face a constant probability of dying, $1 - \sigma$, where σ is the probability of surviving from one period to the next. Each period, new cohorts of farmers and gatherers are born, each of size $1 - \sigma$, so that by the law of large numbers the economy's total population remains constant at 2. Although the assumption of geometrically distributed lifetimes is demographically unrealistic, it does have the virtue of greatly facilitating aggregation, since marginal propensities to save are independent of age.

In contrast to the baseline model, preferences of farmers and gatherers are now assumed to be identical and concave. Specifically, both farmers and gatherers have the following logarithmic preferences:

$$(1) \qquad \max_{\{c_t\}} E_t \sum_{j=0}^{\infty} (\beta\sigma)^j \ln[c_{t+j}].$$

That is, both farmers and gatherers maximize the expected present discounted value of utility from fruit consumption, c_t, conditional on surviving each successive period. Note that leisure does not enter the utility function, so that labor is supplied inelastically.

At this point it should be noted that Kiyotaki and Moore conduct their analysis entirely within a context of perfect foresight. This is a useful abstraction when solving the model and illustrating its dynamics. To make the model econometrically implementable, however, non-degenerate shocks must be incorporated. These shocks will play the role of regression error terms. I do this by assuming that each new cohort's endowment is stochastic. In particular, I assume that at time t newborn farmers and newborn gatherers each receive a fruit endowment of e_t. The e_t process is assumed to be independent over time, with constant mean value, $\bar{e}$. I also assume that there is no way to diversify the endowment shock, even though its realization will in general have first-order aggregate effects.

Remember that farmers and gatherers are distinguished by their technologies for producing fruit. Following Kiyotaki and Moore, I assume farmers have linear technologies. Thus, if we denote the time t aggregate land holdings of farmers by $K_{f,t}$ and farmers' fruit output at time $t + 1$ by $Y_{f,t+1}$ we have

$$(2) \qquad Y_{f,t+1} = aK_{f,t} ,$$

where a is the constant marginal product of land in farming. Gatherers, on the other hand, are assumed to produce fruit subject to diminishing returns. In particular, their production function is quadratic:

$$(3) \qquad Y_{g,t+1} = G(K_{g,t}) = b_0 K_{g,t} - \frac{b_1}{2} K_{g,t}^2 ,$$

where $Y_{g,t+1}$ is the time $t + 1$ fruit output of gatherers, and $K_{g,t}$ is their time t land holdings. As in the baseline Kiyotaki-Moore model, I assume the total land supply is fixed at $\bar{K}$, so that market clearing requires $\bar{K} = K_{f,t} + K_{g,t}$ for all t. Hence, the model's dynamics take the form of reallocations of land between farmers and gatherers. Although this rules out some potentially important dynamics, these reallocations do incorporate a notion of "fire-sale" asset transactions, which seems to be an issue in the current Asian crisis.[6] To guarantee an interior steady state allocation of land I impose the following parameter restrictions:

$$(4) \qquad b_0 > a > a\sigma > b_0 - b_1\bar{K}.$$

This says that if gatherers hold all the land, the marginal product of land in farming is greater than in gathering, whereas if farmers hold all the land, then the marginal product of land in gathering is greater.

At the start of each period, exchange takes place in four markets: (i) a spot commodity market in which fruit is bought and sold, (ii) a real estate market in which land is exchanged, (iii) a domestic bond market in which farmers and gatherers borrow and lend amongst themselves, and (iv) an international capital market that absorbs the difference between domestic production and domestic expenditure. Fruit is assumed to be the numeraire, with price normalized to unity. The time t price of a unit of land is denoted q_t, and the (constant) gross world interest rate is R (both expressed in units of fruit).

Farmers and gatherers solve the maximization problem in (1) subject to a sequence of budget constraints. If b_t denotes the time t debt of either a farmer or a gatherer, then these constraints take the following form (in the aggregate):[7]

$$(5) \qquad q_t(K_{f,t} - K_{f,t-1}) + Rb_{t-1} + c_t = \sigma a K_{f,t-1} + (1 - \sigma)e_t + b_t$$

for farmers, and

$$(6) \qquad q_t(K_{g,t} - K_{g,t-1}) + Rb_{t-1} + c_t = \sigma G(K_{g,t}) + (1 - \sigma)e_t + b_t$$

for gatherers.

The right-hand sides of these constraints are the sources of time t funds, which consist of current fruit production of surviving farmers and gatherers, endowments of the newborn, and issues of new debt. The left-hand sides are the uses of time t funds, given by land purchases, debt repayments, and consumption expenditures.

6. Note, however, that foreigners cannot buy land.

7. Mortality risk implies that the interest rate on individual loans is R/σ. However, in the aggregate, this risk is fully diversifiable, so the sectoral budget constraints take the forms in (5) and (6).

The key ingredient of the model is a constraint limiting the debt, b_t, of farmers. This constraint arises from their inability to commit to work, along with the assumption that no fruit is produced without labor. Kiyotaki and Moore argue that with perfect foresight no farmer will be able to take out a loan that exceeds the present value of his current land holdings, given that lenders recognize the incentive of farmers to default if debt were to exceed this value. However, when land prices are stochastic, the future value of collateral is unknown, and it is not clear how this uncertainty will affect the required level of collateral.[8] For simplicity, I just assume that farmers are able to borrow up to the *expected* present value of their land, less an additive "risk premium," $\phi > 0$, so that with uncertainty the borrowing constraint takes the form:[9]

$$b_t \le \frac{1}{R} K_{f,t} E_t q_{t+1} - \phi, \tag{7}$$

where R appears rather than R/σ since when a farmer dies his land remains. In general, one would expect the risk premium ϕ to depend on the left tail of the support of the endowment shock process. That is, when the potential for negative shocks increases, greater collateral will be required. However, absent a formal analysis, this is just a conjecture.

I assume that in equilibrium equation (7) is binding for all realizations of e_t. (This implies a restriction on the relationship between the farmer's marginal product of land, a, and the world interest rate, R, which is derived below.) Using (7) at equality to substitute out for b_t in the (aggregate) budget constraint of farmers yields:

$$\begin{aligned} u_t K_{f,t} + c_t = {} & \sigma a K_{f,t-1} + (1-\sigma)e_t \\ & + \sigma \varepsilon_t K_{f,t-1} + (R-1)\phi, \end{aligned} \tag{8}$$

where

$$u_t \equiv q_t - \frac{1}{R} E_t q_{t+1} \tag{9}$$

is the time t "user cost of capital," or in this case, the required down payment on a fully mortgaged unit of land, and where $\varepsilon_t \equiv q_t - E_{t-1} q_t$. Thus, the term $\varepsilon_t K_{f,t-1}$ represents unanticipated capital gains from holding land. This term is, of course, missing from Kiyotaki and Moore's perfect foresight version of the model.

Solving (1) subject to the budget constraint in (8) yields the following decision rule for farmers' investment expenditure on land:

$$u_t K_{f,t} = \beta\sigma[\sigma a K_{f,t-1} + (1-\sigma)e_t + \sigma\varepsilon_t K_{f,t-1} + (R-1)\phi]. \tag{10}$$

That is, farmers spend a fixed fraction of their time t net worth on land. The remaining fraction, $1 - \beta\sigma$, is spent on consumption.

Equation (10) is one of the two fundamental equations of the model. The second fundamental equation summarizes optimal behavior by gatherers. Since gatherers do not face borrowing constraints, their land purchases are based on a no-arbitrage condition. In particular, gatherers must be indifferent between lending and buying land (or, alternatively, between borrowing and selling land). This will be the case when the following equality holds:

$$\frac{G'(K_{g,t})}{u_t} = \frac{R}{\sigma}. \tag{11}$$

The left-hand side of (11) is the rate of return from buying a unit of land, and the right-hand side is the return from lending. (Remember that a mortality risk premium is charged on individual loans.)

If we use the market-clearing condition, $\bar{K} = K_{g,t} + K_{f,t}$, and the definition of u_t in equation (9), then equations (10) and (11) can be reduced to two equations in the two unknown stochastic processes, q_t and $K_{f,t}$. If (11) is used to substitute out for u_t in (10), we get the following nonlinear stochastic difference equation that determines the equilibrium path of farmers' land holdings:

$$\begin{aligned} \frac{\sigma}{R} G'(\bar{K} - K_{f,t}) K_{f,t} = {} & \beta\sigma\big[\sigma a K_{f,t-1} + (1-\sigma)e_t \\ & + \sigma\varepsilon_t K_{f,t-1} + (R-1)\phi\big]. \end{aligned} \tag{12}$$

The following two propositions summarize the essential properties of this difference equation.

PROPOSITION 1: *There exists a unique positive steady state allocation of land. If the world interest rate satisfies the restriction,* $R\beta > 1$, *and the production function parameters satisfy the restrictions in (4), then in the steady state farmers' land holdings are:*

$$K_f^* = \frac{[\beta R\sigma a - (b_0 - b_1\bar{K})] + \sqrt{[\beta R\sigma a - (b_0 - b_1\bar{K})]^2 + 4b_1\beta R[(1-\sigma)\bar{e} + (R-1)\phi]}}{2b_1}. \tag{13}$$

8. See Hart (1995, pp. 112–115) for a brief discussion of the complications that arise with uncertainty.

9. Lacker (1998) provides a formal (two-period) analysis of optimal borrowing contracts and discusses the circumstances under which collateralized debt supports an informationally constrained Pareto optimum. In some versions of his model a term like ϕ appears, which is a Lagrange multiplier on the constraint that collateral transfers not exceed the borrower's holdings of collateral. Another possibility would be to incorporate a (multiplicative) margin requirement. See Edison, Luangaram, and Miller (1998) for an analysis of this case.

PROOF: From (3), $G'(\bar{K} - K_{f,t}) = b_0 - b_1(\bar{K} - K_{f,t})$. Hence, the left-hand side of (12) is quadratic. To solve for the steady state, set $K_{f,t} = K_{f,t-1} = K_f^*$, $e_t = \bar{e}$, and and $\varepsilon_t = \bar{\varepsilon} = 0$. This gives $b_1 K_f^{*2} + [(b_0 - b_1\bar{K}) - \beta R\sigma a]K_f^* - \beta R[(1-\sigma)\bar{e} + (R-1)\phi] = 0$. By inspection, the product of the roots is negative. Therefore, there is always one positive root and one negative root. Given the parameter restrictions, equation (13) is the positive root. o

Linearizing (12) around K_f^* gives us:

PROPOSITION 2: *In the neighborhood of the steady state, farmers' land holdings follow a stationary AR(1) process given by:*

$$(14)\qquad K_{f,t} = K_f^0 + \lambda K_{f,t-1} + \frac{\lambda}{\sigma a}\left[(1-\sigma)e_t + \sigma\bar{K}\varepsilon_t\right],$$

where

$$(15)\qquad \lambda = \frac{\beta R\sigma a}{\beta R\sigma a + \sqrt{[\beta R\sigma a - (b_0 - b_1\bar{K})]^2 + 4b_1\beta R[(1-\sigma)\bar{e} + (R-1)\phi]}}$$

and

$$K_f^0 = \frac{b_1\bar{K}^2}{b_0 - b_1\bar{K} + 2b_1K_f^*}\ .$$

PROOF: Apply Taylor's theorem to (12) and use (13). o

Once we have determined the equilibrium $K_{f,t}$ process, we can use equation (11) to derive the equilibrium q_t process.

COROLLARY 1: *In the neighborhood of the steady state, land prices are given by the following stationary AR(1) process:*

$$(16)\qquad \begin{aligned} q_t &= \bar{q} + \left[\frac{\sigma b_1}{R-\lambda}\right]K_{f,t} \\ &= \left[(1-\lambda)\bar{q} + K_f^*\frac{\sigma b_1}{R-\lambda}\right] + \lambda q_{t-1} \\ &\quad + \frac{\lambda b_1}{a(R-\lambda)}\left[(1-\sigma)e_t + \sigma\bar{K}\varepsilon_t\right] \end{aligned}$$

where

$$\bar{q} = \frac{\sigma(b_0 - b_1\bar{K})}{R-1} - \frac{\sigma b_1 K_f^0}{(R-\lambda)(1-\lambda)}\ .$$

PROOF: From (9) and (13) we have $q_t - {}^1\!/_R(E_t q_{t+1}) = {}^\sigma\!/_R[b_0 - b_1(\bar{K} - K_{f,t})]$. Iterating forward (i.e., applying a transversality condition on land prices), plugging in for $K_{f,t}$ from (14), and then evaluating the resulting expected present discounted value gives equation (16). o

Later it will be shown that the parameter λ increases when borrowing constraints become more important. Thus, from inspection of equations (14) and (16), borrowing constraints both magnify and prolong the economy's response to shocks.

So far, the fact that the economy is open and has access to world capital markets has been kept in the background. At this point we need to bring international considerations to the foreground. Since R is exogenous, there is no guarantee that for any given value of R domestic expenditures will equal domestic production. If they don't, then the country will have a current account deficit or surplus. The next order of business, therefore, is to characterize the stochastic properties of the current account and make sure it is well-behaved.

By definition, the current account surplus is equal to the trade surplus plus net interest receipts on foreign assets. Letting F_{t-1} denote the stock of net foreign assets at the end of period $t-1$ we have:

$$(17)\qquad CA_t = Y_t - C_t - I_t + (R-1)F_{t-1}\,.$$

Differencing both sides and using the identity $CA_t = F_t - F_{t-1}$ give us:

$$(18)\qquad CA_t = R\cdot CA_{t-1} + \Delta Y_t - \Delta C_t - \Delta I_t\,.$$

The first thing to note is that in this economy $I_t = 0$ for all t. This is simply because the aggregate supply of land is fixed. Land changes hands, but there is no way to augment its supply. Hence, in the aggregate, investment is always zero. The second thing to note is that as long as $R < 1/\beta\sigma$ farmers will not want to lend. To see this, note from (10) that if ϕ and realizations of e_t, are "small" relative to $K_{f,t}$, then the steady state value of u_t is approximately

$$u^* \approx \beta a\sigma^2\,.$$

Therefore, since the steady state rate of return on land in farming is a/u^* and the rate of return on lending is R/σ, if $R < 1/\beta\sigma$, farming is more attractive than lending.

As a result, since farmers cannot *borrow* on the international capital market, only the decisions of gatherers have a direct bearing on the current account. Given log preferences, gatherers allocate their net worth between investment and consumption in the same way that farmers do. However since gatherers do not face borrowing constraints, their net worth is given by a conventional present value calculation, and their consumption decisions resemble the standard permanent income hypothesis.

A gatherer's net worth has two components. First, unlike farmers, gatherers have a concave technology that yields a stream of profits, denoted by π_t. These profits are the difference between revenue from selling next period's fruit output, discounted at the individual interest rate R/σ, and the current cost of land inputs. That is,

$$\pi_t = \frac{\sigma}{R} G(K_{g,t}) - u_t K_{g,t} \,. \tag{19}$$

The capitalized value of these profits, denoted Π_t, is given by:

$$\Pi_t = E_t \sum_{j=0}^{\infty} \left(\frac{\sigma}{R}\right)^j \pi_{t+j} \,. \tag{20}$$

The second component of gatherers' aggregate net worth is their pre-existing holdings of foreign assets, F_{t-1} (or foreign debt if negative). Combining these two components, the aggregate net worth of gatherers, V_t, is:

$$V_t = \Pi_t + R \cdot F_{t-1} \,. \tag{21}$$

Aggregate consumption can then be written as,

$$C_t = (1 - \beta\sigma)\,(Y_t + q_t \bar{K} + V_t). \tag{22}$$

That is, aggregate consumption is just a fixed fraction of the economy's net worth, where net worth is given by the flow of current fruit output, the value of land, the present value of gatherers' profits, and net foreign assets.

We are now in a position to characterize the equilibrium dynamics of the current account.

PROPOSITION 3: *In the neighborhood of the steady state the economy's current account is a stationary ARMA(2,1) process, which has the following representation:*

$$\begin{aligned} CA_t &= \beta\sigma CA_{t-1} + \beta\sigma \Delta Y_t \\ &\quad - (1-\beta\sigma)\left[\bar{K}\Delta q_t + E_{t-1} \sum_{j=0}^{\infty} \left(\frac{\sigma}{R}\right)^j \Delta\pi_{t+j} + \omega_t \right], \end{aligned} \tag{23}$$

where the i.i.d. process ω_t represents revisions in expectations of future profits and, hence, is uncorrelated with the time-$(t-1)$ information set.

PROOF: Plug (22) into (18) using the definitions in (20) and (21), and use the fact that $\Delta F_{t-1} = CA_{t-1}$. To verify that (23) is ARMA(2,1), evaluate the present value, use (16) to substitute for q_t, apply the operator $(1 - \lambda L)$ to both sides, and then use Granger's Lemma to express the numerator polynomial as an MA(1). o

In sum, it has been shown that this economy features a unique positive steady state allocation of land, that in the neighborhood of this steady state land prices and the equilibrium allocation of land follow stationary AR(1) processes (with identical AR roots), and finally, that the economy's current account balance follows a stationary ARMA(2,1) process, with AR roots $\beta\sigma$ and λ.

Our final task is to investigate the welfare economics of this equilibrium. The essential aspect of the equilibrium from a welfare standpoint is that as long as $R < 1/\beta\sigma$, too little land is held by farmers in the steady state. To see this, remember that the steady state rate of return on farming is a/u^*. Since gatherers are free to equate margins, their steady state rate of return is the market rate, i.e., R/σ. Plugging in the previous (approximate) expression for u^* shows that in the steady state the rate of return in farming exceeds the rate of return in gathering. This discrepancy is a crucial feature of the model. It implies that marginal reallocations of land have first-order consequences for output and asset prices.

In reckoning the welfare cost of borrowing constraints I will follow standard practice and compute the area of a Harberger triangle, which is implied by this return differential. To make the result free of units, I express the cost as a share of GDP. The result is given by the following proposition.

PROPOSITION 4: *The steady state welfare cost of borrowing constraints, expressed as a share of GDP, is given by:*

$$\frac{WC}{Y} = \left(\frac{1-s}{8\eta}\right)\left[\left(1 - \frac{\beta R\sigma}{\lambda}\right) + \frac{s}{1-s}\eta\right]^2, \tag{24}$$

where η is the absolute value of the elasticity of gatherers' land demand, evaluated at the first-best equilibrium, and s is the first-best equilibrium share of land allocated to farmers.

PROOF: First, the area of the Harberger triangle is $\tfrac{1}{2}[a - G'(K_g^*)][K_f^{\text{opt}} - K_f^*]$, where K_f^{opt} denotes the first-best allocation of land to farmers. Besides this, every element of the triangle has already been computed. To compute K_f^{opt} we just need to find the value of K that equates the marginal product of land in farming to the marginal product of land in gathering. By direct calculation, this turns out to be:

$$K_f^{\text{opt}} = \frac{a - (b_0 - b_1\bar{K})}{b_1} \,.$$

Using this with (13) gives us

$$K_f^{\text{opt}} - K_f^* = \frac{2a - (b_0 - b_1\bar{K}) - \beta R\sigma a/\lambda}{2b_1} \,, \tag{25}$$

where use has been made of equation (15). The rest follows from straightforward algebraic manipulation, noting that in the first-best equilibrium $Y = a\bar{K}$. o

As you would expect, the welfare costs of borrowing constraints increase as the elasticity of demand increases and as the (first-best) steady state share of the farming sector increases. More interesting is the following result, which shows that welfare costs increase with the persistence of land price (and output) fluctuations.

Corollary 2: *If* $\lambda > \beta R\sigma(1-s)/(1-s+s\eta)$, *then the steady state welfare costs of borrowing constraints are increasing with the persistence of land price (and output) fluctuations.*

Proof: Differentiate (24) with respect to λ, and verify that $\partial(WC)/\partial\lambda > 0$ if $\lambda > \beta R\sigma(1-s)/(1-s+s\eta)$. o

The condition on λ in Corollary 2 derives from the fact that even in the first-best equilibrium there will be some persistence in the economy's response to shocks. As it turns out, $\beta R\sigma(1-s)/(1-s+s\eta)$ is the first-best equilibrium value of λ. Notice that while increases in s and η raise the cost of borrowing constraints, they reduce the first-best equilibrium value of λ.

In Section III I use equation (24), along with econometric estimates of λ, to compute estimates of the welfare costs of borrowing constraints for a set of Pacific Basin countries. Before we get to these results, however, I first discuss the data.

II. The Data

In principle, when estimating and evaluating this model one would like to obtain broad measures of collateral, including equipment, structures, land, etc., as well as actual transactions-based data on prices. Also, since it is dynamics that we are interested in, it would be desirable to obtain long enough time series to permit accurate estimates of auto- and cross-correlations. Unfortunately, in practice these data are rarely available, particularly for developing countries. As a result, I limit the scope of the analysis to just three countries—Hong Kong, Japan, and Korea. Moreover, I ignore all forms of collateral other than "land."

The data from these countries are of varying quality. Hong Kong and Japan publish data on actual transactions-based land prices, disaggregated according to use. For both countries I use a series that consolidates the residential and commercial sectors. The data for Hong Kong are from Table 5.9 in the *Hong Kong Monthly Digest of Statistics* (various issues). The series is labeled "Private Domestic/Overall" Although this series is available on a quarterly basis, I sample at an annual frequency. The data run from 1976 through 1997. The data for Japan are from Table 119 in the Bank of Japan's *Economic Statistics Annual* (various issues). The series is labeled "Land Price Indexes of Urban Districts/All Urban Districts."

It is based on surveys of residential, industrial, and commercial land prices in 223 Japanese cities. Although the series is available on a semiannual basis, I again sample at an annual frequency. The data run from 1957 through 1997.

The data for Korea are of more dubious quality. Rather than being observations on land *prices*, they are just indices of the cost of *housing*. Changes in this kind of index more likely reflect changes in rental rates than in capitalized values. Of course, rental rates and purchase prices should be highly correlated, but changes in interest rates could weaken the link.

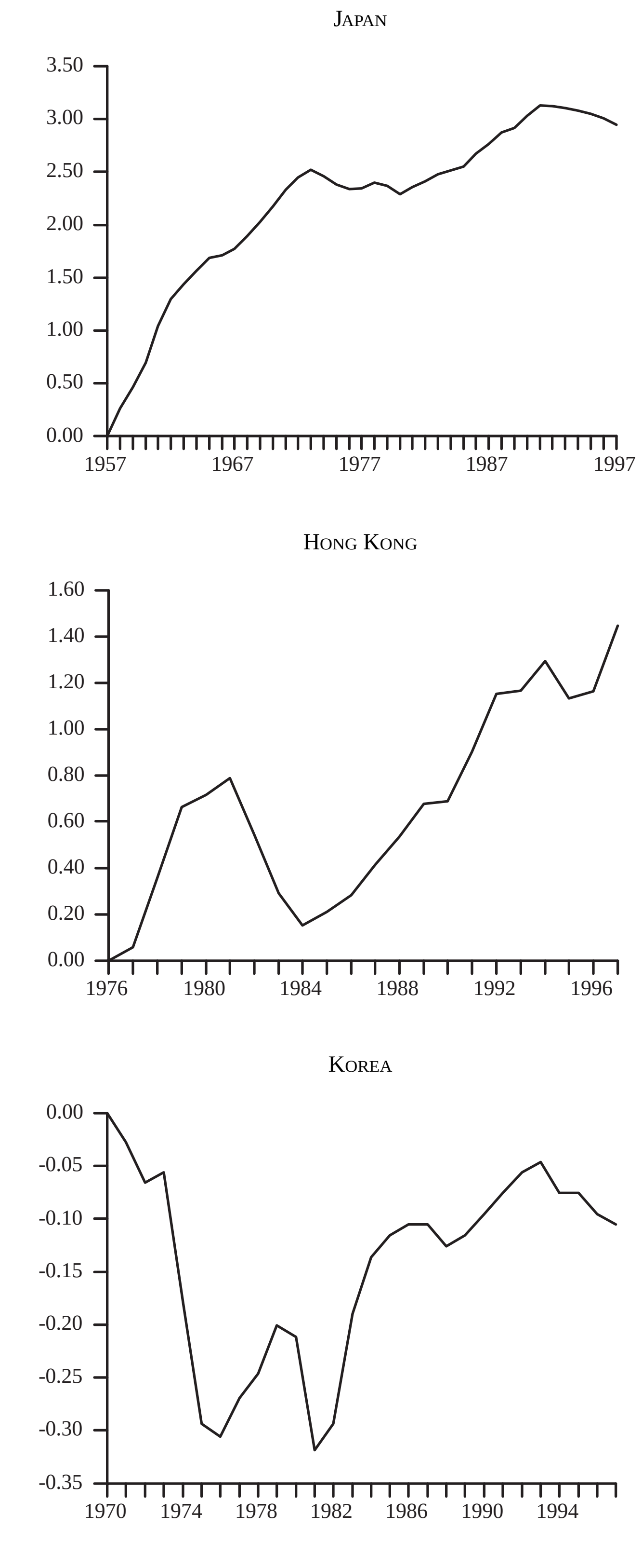
The index for Korea is from Table 103 in the Bank of Korea's *Economic Statistics Yearbook* (various issues). This table provides data on the "All Cities Consumer Price Indexes," and I use the series corresponding to the "Housing Rent" subgroup. The data are sampled annually from 1970 through 1997.

Figure 1 contains plots of each "land price" series. Each series has been deflated by the overall CPI and is graphed on a logarithmic scale. The plots for Japan and Hong Kong seem broadly consistent with informal verbal accounts of their real estate markets. According to these data, Japanese land prices peaked in 1991, and since then have fallen on average by about 18%. Of course, certain segments of the market have declined much more than this (e.g., prime commercial space in downtown Tokyo), but given the rather inclusive definition of the series, an 18% drop seems about right. Notice that an even greater decline occurred in Hong Kong's real estate market during the early 1980s. This of course reflected uncertainty associated with the Sino-British negotiations that were taking place at the time, which also triggered declines in the foreign exchange and stock markets. Since the data end in 1997, the significant declines that occurred in Hong Kong during 1998 as a result of the Asian crisis do not show up here. In fact, the plot reveals that until the crisis hit, the Hong Kong real estate market had been experiencing a boom.

Turning to Korea, the feature that stands out is the dramatic fall in "land prices" that took place during the early 1970s. According to the figure, real land prices declined by over 30% from 1970 to 1975. However, most of this is due to the 1973–74 oil shock, to which Korea was especially vulnerable. During 1973 and 1974 Korean inflation averaged about 25%, so part of the decline probably reflects more of a terms of trade shock than anything else. In fact, in absolute terms land prices rose during the period. The other thing that stands out is that the real estate market in Korea appears to have suffered for several years before the crisis hit at the end of 1997. According to the figure, land prices actually peaked in 1993.

FIGURE 1

LOG OF RELATIVE LAND PRICE



III. EMPIRICAL RESULTS

Kiyotaki and Moore construct their model for the express purpose of studying fluctuations. In doing this, it is useful to abstract from growth. However, the first thing that confronts you when taking the model to data is the presence of trends in land prices (and the prices of other collateralizable assets, for that matter). It would of course be preferable to model trends and cycles simultaneously. One thing we've learned from the Real Business Cycle literature is that factors causing growth can have important cyclical consequences. Nevertheless, the model is complicated enough already, and for now at least I handle trends in the time-honored manner of just mechanically detrending by regressing the logarithms of the series on a linear time trend, with due acknowledgement to the work of Nelson and Kang (1981) on the dangers of inducing spurious cyclicality as a result.[10]

Figure 2 presents the detrended land price series. Along with each series I also plot the fitted values from an AR(1), which according to the model, should characterize the cyclical component of land prices. Not surprisingly, the AR coefficients are highly significant, and imply a high degree of persistence. Estimates range from 0.764 in Korea to 0.867 in Japan. Hong Kong lies in the middle, with a λ estimate of 0.806. These estimates imply that land price cycles have half-lives of between three and five years.

Two notes of caution should be raised about these estimates. First, it is apparent that substantial autocorrelation remains after fitting an AR(1) to detrended land prices. In each case, a second lag enters significantly. Interestingly, estimates from an AR(2) imply humpshaped impulse responses, in which shocks at first cumulate for a few years, as opposed to the monotonic AR(1) dynamics of the model. Second, from Nelson and Kang (1981) we know that fitting a linear time trend to a random walk produces on average a first-order autocorrelation in the residuals of about $1 - 10/T$, where T is the sample size. Given a 25- to 35-year sample we would expect to obtain λ estimates of between 0.6 and 0.7, even when the true data-generating process contains no cyclical component.

With these caveats in mind, Figure 3 uses the estimates of λ to plot out equation (24) for each country. This gives us a measure of the "welfare" or efficiency costs of borrowing constraints, expressed as a share of GDP. Doing this, however, first requires the specification of several free parameters. A reasonable value for the product, $\beta R\sigma$, is

10. I have done some experimenting with univariate Beveridge-Nelson decompositions. Estimates of the cyclical component of land prices turn out to be qualitatively similar, but overall, somewhat less persistent.

FIGURE 2

Actual vs. Fitted Cyclical Components

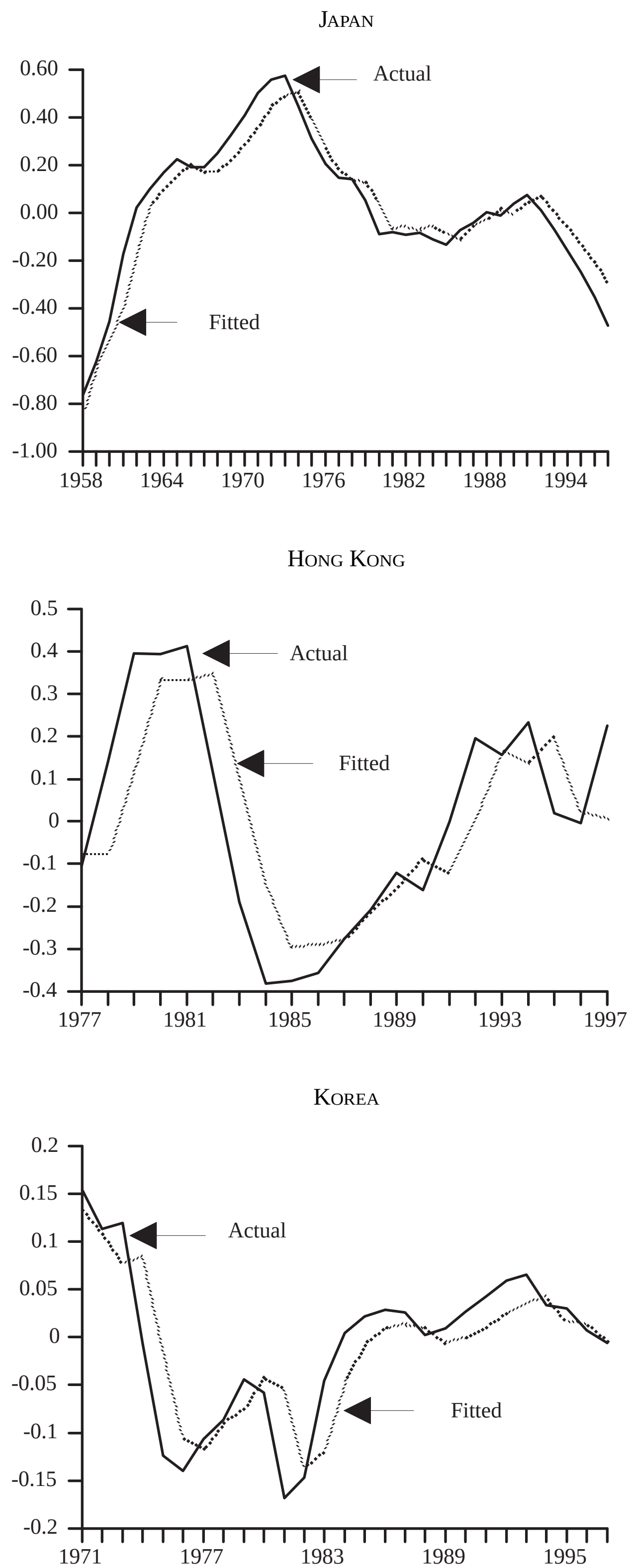
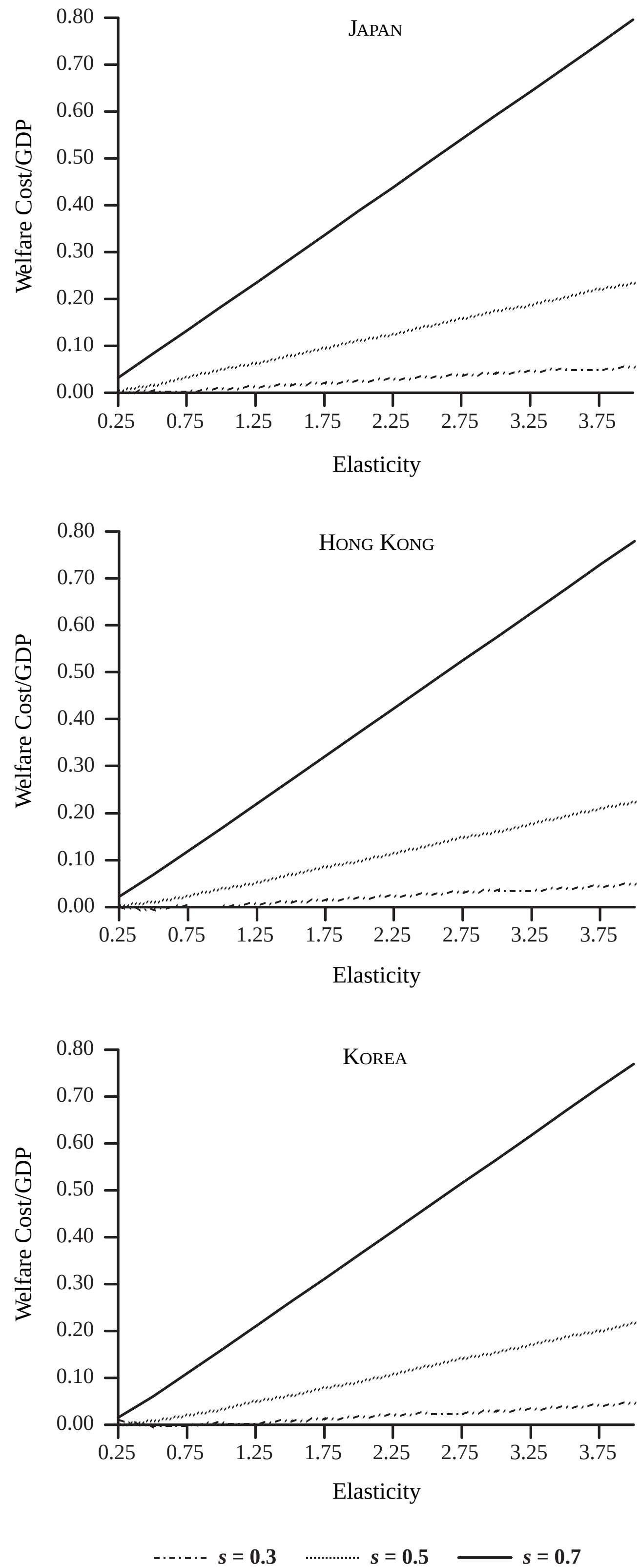


FIGURE 3

Estimates of Welfare Costs



relatively easy to obtain. The model restricts the world interest rate to lie between $1/\beta\sigma$ and $1/\beta$. Economically plausible values of β and σ exceed 0.95, so this is a relatively tight range. Without much loss in generality, I just split the difference and assume R lies at the midpoint of this range, so that $R = 0.5(1/\beta\sigma + 1/\beta)$, which then implies $\beta R\sigma = 0.5(1 + \sigma)$. Thus, we are left with just specifying the demographic parameter, σ. I assume $\sigma = 0.96$, which implies a 25-year planning horizon. The results are insensitive to small perturbations of this parameter.

The remaining two parameters, s and η, are more difficult to specify a priori. These parameters measure the size of the constrained sector and the ease with which land can be transferred between farming and gathering. Since these structural features of the economy are likely to be country-specific and are unidentified in any case given our single parameter estimate, I just plot out the welfare cost function for a grid of η values for each of three different s values. The η values range from a highly inelastic value of 0.25 to a relatively elastic value of 4.0. The share parameter takes on values of 0.3, 0.5, and 0.7.

Evidently, if the share of the constrained sector is less than 0.3, borrowing constraints do not cost the economy much forgone output, regardless of the elasticity of demand. Welfare cost estimates never exceed 6 percent of GDP, even for the highest values of η and λ. However, it is clear that costs rise more than proportionately with s. By the time s reaches 0.7, borrowing constraints are consuming 25–40 percent of the economy's output for intermediate values of η.

Looking across countries, we know that given our λ estimates, Japan will have the highest cost of borrowing constraints and Korea will have the lowest (all else equal). However, the costs are not that sensitive to variations in λ. For example, if $s = 0.5$ and $\eta = 2$, costs range from 9 percent of GDP in Korea, where $\lambda = 0.764$, to 11 percent of GDP in Japan, where $\lambda = 0.867$. Thus, if we assume that roughly half the firms and households in these countries face binding borrowing constraints, then given the size of their economies relative to the U.S., where annual per capita income is about \$25,000, we can say that borrowing constraints cost each person about \$1,667 per year in Japan and Hong Kong, where per capita GDP is roughly two-thirds of U.S. per capita GDP, while they cost about \$1,012 per year in Korea, where per capita GDP is about 45 percent of U.S. per capita GDP.

IV. CONCLUSION

This paper has applied a version of the Kiyotaki-Moore credit cycle model to land price data in Hong Kong, Japan, and Korea. It was shown that land prices can be approximated by an AR(1) process, where the AR coefficient depends positively on the importance of borrowing constraints. It was also shown that borrowing constraints accentuate the economy's initial response to shocks. From a welfare standpoint, it was shown that inferences about the efficiency costs of borrowing constraints can be drawn from estimates of the persistence of land price fluctuations. All else equal, greater persistence implies larger costs. It turns out that estimates of welfare costs are quite sensitive to the steady state share of the constrained sector, which is a parameter that is left unidentified by the model. Based on the parameter estimates, the model suggests that if the share of the constrained sector is between 30–50 percent of the economy, then the welfare costs of borrowing constraints are in the range of 1–10 percent of GDP.

Perhaps the most serious shortcoming of this analysis from the perspective of trying to understand the recent "Asian crisis" is its lack of attention to the source and magnitude of the initial negative impulse(s) that initiated the crisis. For the most part, this paper has focused on the *propagation* of shocks. The model demonstrates that leverage effects can greatly prolong an economy's response to shocks, just as Veblen had conjectured nearly 100 years ago. To the extent that a Kiyotaki-Moore model accurately describes the economies of Asia, one could argue that,absent outside intervention, we should not expect the crisis to abate anytime soon.

A promising avenue for future work would be to try to combine the impulse and propagation mechanisms within a single analytical framework. As recent work by Azariadis and Smith (1998) and Edison, Luangaram, and Miller (1998) has shown, these kinds of models are capable of producing dynamics that are much more exotic than stationary autoregressions. For example, Azariadis and Smith show that multiple steady states can arise, which then opens the door to sunspot equilibria that switch between booms and busts. This would be one way to unite the impulse and propagation problems within a single model.

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