This paper examines a banking regime similar to the “convoy” scheme which prevailed in Japan through most of the 1990s. Insolvent banks are merged with solvent banks rather than closed, with the acquiring banks required to accept negative value banks at zero value. I demonstrate that a convoy scheme effectively taxes the acquiring bank and increases moral hazard by reducing bank effort towards enhancing its portfolio, even relative to a fixed-premium deposit insurance system, for negative value banks. However, for positive bank charter values, which are retained under the convoy scheme and lost under the deposit insurance program, these effects may be mitigated or even overturned.

I also find that the rules governing the convoy scheme can affect bank behavior. I compare two convoy regimes, one where acquiring banks are chosen at random and one where the weakest banks are paired with the strongest banks. Simulations reveal that the disparities in bank effort between the two convoy regimes are greater than those between the convoy regimes and the fixed-premium deposit insurance regime. I confirm the theoretical result above that the bank effort under either convoy program is increasing in bank charter value.

Perhaps the greatest puzzle in international finance over the previous decade has been the continued disappointing performance of the Japanese banking system. With the collapse of the “bubble economy” of the 1980s, Japan’s banking sector experienced heavy losses, from which recovery has been extremely slow. As of September 1998, estimates of bad loans in Japan’s banking sector still exceeded 7 percent of GDP (Hoshi and Kashyap 1999). In this paper, I examine whether the prevailing regulatory regime in Japan’s banking sector through most of the 1990s may have played a role in the sector’s slow movement towards recovery.

In particular, I examine the Japanese “convoy” system, under which the burden of maintaining the Japanese deposit safety net was to some extent placed on the banking industry as a whole. I first review the recent history of bank failures in Japan and demonstrate that banks were called upon to assist with failures, particularly systemic failures and those which occurred after the funds of the Japanese Deposit Insurance Corporation (DIC) were effectively exhausted in the mid-1990s.

I then introduce a simple theoretical model of bank lending under such a convoy system and compare bank behavior under that model to a standard self-financing fixed-premium deposit insurance benchmark. Under the fixed-premium regime, a bank is closed and liquidated when it is found to be insolvent.

I consider two types of “convoy systems”: one where acquiring banks are chosen at random from the set of solvent companies and one where regulators pursue a more activist policy, pairing the weakest failing banks with the strongest solvent banks. An important distinction between the two convoy regimes and the fixed-premium deposit insurance regime is that banks are not liquidated under the convoy regimes. Their charter values accrue to the acquiring bank. Under the fixed premium regime, in contrast, charter values are lost due to the bank’s liquidation.

The theoretical model demonstrates that the relative level of moral hazard in bank lending among the various regimes is dependent on bank charter values. For banks with negative values inclusive of charter values, I demonstrate that the level of moral hazard is greater under either of the convoy banking regimes than under the fixed-premium deposit insurance scheme. Surprisingly, however, the relative moral hazard under the randomly paired convoy scheme and the “best-with-worst” paired convoy scheme is ambiguous.
I then turn to simulations to investigate the quantitative importance of these disparities. My results confirm that the relative dominance of the deposit insurance regime is negatively related to bank charter values. For the set of parameters for which I found an interior solution with positive but uncertain probabilities of bank solvency, I found that the best-with-worst paired convoy system had lower levels of equilibrium bank effort and higher probabilities of bankruptcy than the deposit insurance regime. For sufficiently large levels of bank charter value, this dominance was reversed. The randomly paired convoy system had lower levels of moral hazard for all charter values that yielded interior solutions with positive default probabilities.

I. BACKGROUND ON THE JAPANESE CONVOY SYSTEM

Breakdown of the Deposit Insurance Corporation

The Japanese convoy approach to banking regulation was an outgrowth of its “main bank” system. Under this system, a set of informal practices, ensured through the guidance of both the Japanese Ministry of Finance (MOF) and the Bank of Japan, constituted Japan’s system of corporate finance throughout the postwar period. Under the main bank system, a firm would have a special long-term relationship with a bank, usually one that acted as its primary source of financing. Interactions between both banks and firms under this system were often complex, creating a significant degree of systemic risk if any component of the financial system should fail.1

The regulatory response to this systemic risk was to restrict lending levels by any individual bank so that banks in the system, particularly the large banks, would grow at roughly the same pace, hence the name “convoy.” In addition, the number of banks was restricted. This created monopoly rents within the banking industry, such that individual banks could increase their profits through expansion. The MOF was therefore placed in a strong regulatory position through its power to control bank branching and overall lending activities.

The convoy system also imposed responsibilities on commercial banks for the safety of their competitors. When banks found themselves experiencing extreme difficulties, the MOF typically intervened by merging the troubled smaller bank with a larger bank. It has been suggested that through this activity, the MOF compensated for the absence of effective stockholder control in the Japanese banking system.

It is unclear whether acquiring banks were damaged by the sporadic early merger activity. Aoki, et al. (1994) claim that the MOF used its discretion over branch licensing to compensate rescuing banks. Even if the acquired banks had negative asset value, the branching rights they brought to the acquiring bank may have provided adequate compensation.

The merger activity since the start of the 1990s, however, was distinct from the earlier mergers in at least two dimensions. First, the number of problem banks, and the severity of their problems, were much larger subsequent to the collapse of the “bubble” prices which prevailed in the 1980s. Second, financial liberalization, which had been taking place since the mid-1970s, eroded the pervasiveness of monopoly rents in the banking sector, particularly the shadow values of branching rights which accompanied acquisitions of problem banks.2

Table 1 identifies several notable mergers from the 1960s through the 1990s. Four examples from the 1995–1996 period illustrate the changes in the way mergers were handled. The merger between Tokyo Kyodo and Anzen Bank in 1995 included a 40 billion yen injection of capital from the deposit insurance corporation and a 20 billion yen contribution of new equity from private banks. In addition, the Tokyo metropolitan government contributed subsidized loans (Cargill, et al. 1997). The contribution of private banks represented a departure from previous mergers and probably reflected the deterioration in the financial condition of the DIC.

Also in 1995, the Cosmo Credit Corporation failed and was bailed out with funds primarily from Cosmo’s largest creditor, Sanwa, but also from a number of other banks, the National Federation of Credit Cooperatives, the DIC, and the Tokyo metropolitan government. Of the total estimated bailout cost of 240 billion yen, the contribution of the DIC was only 100 billion (Cargill, et al. 1997).

Several weeks later, the MOF closed the larger Hyogo Bank and Kizu Credit Corporation. The Hyogo Bank was to be reopened as a new entity while the Kizu Credit Corporation was liquidated. However, the government’s efforts to assist the Hyogo Bank were unsuccessful, and it was closed in 1995, marking the first bank liquidation in 70 years (Yamori 1999). The net cost to the DIC of resolving these two banks’ positions was estimated at 100 billion yen, effectively exhausting DIC funds.

A number of other closures followed. Finally, when the government moved to close the Hanwa Bank in 1996, it changed its policy. It ordered the bank to close operations and did not attempt to find a rescuing bank. Instead, the as-

1. For an overview of general aspects of the Japanese main bank system, see Aoki, Patrick, and Sheard (1994).

sets of the Hanwa Bank were placed in the Resolution and Collection Bank to be liquidated and the government promised to guarantee bank deposits.

The “Jusen” Problem

The financial strains faced by the Japanese financial system’s safety net took a turn for the worse when it became clear that the bank subsidiaries known as “jusen” companies were extremely troubled. These jusen banks were heavily exposed to the collapse in Japanese real estate prices, since they were exempted from the 1990 limits on real estate financing placed on banks by the MOF.

The magnitudes of jusen losses were impressive. The MOF estimated that, of the 12.8 trillion yen in outstanding loans, nonperforming loans amounted to 9.6 trillion yen, of which loans worth 6.4 trillion were unrecoverable. These losses were so large that certain financial institutions, most notably the agricultural credit cooperatives, lacked an adequate capital base to survive a write-off of a proportionate loss in their outstanding loans to jusen companies.

The regulatory response to the jusen problem once again followed “all Japan” features, in the sense that institutions’ contributions to the funding of the first stage of resolution costs of the jusen problem were not proportional to their initial exposure (see Table 2). One notable component of the jusen resolution plan was the limited value of the contribution by the agricultural credit cooperatives. The initial planned contribution of 1.1 trillion yen by the agricultural cooperatives was bargained down to 520 billion yen, with the MOF making up the 680 billion yen difference (Rosenbluth and Thies 1998).

The government plan was widely opposed, particularly the use of public funds. The government subsequently announced a modified plan under which banks would be required to streamline their operations, leaving them more profitable. The plan predicted that enhanced bank profits would yield 680 billion yen in additional corporate income.

3. For extensive reviews of problems surrounding the resolution of the jusen problem, see Cargill, et al. (1997), Milhaupt and Miller (1997), and Rosenbluth and Thies (1998).

### TABLE 1

<table>
<thead>
<tr>
<th>Year</th>
<th>Failed Bank or Credit Union</th>
<th>Acquiring Bank</th>
</tr>
</thead>
<tbody>
<tr>
<td>1965</td>
<td>Asahi</td>
<td>Dai-Ichi</td>
</tr>
<tr>
<td>1965</td>
<td>Kawachi</td>
<td>Sumitomo</td>
</tr>
<tr>
<td>1969</td>
<td>Toto</td>
<td>Mitsui</td>
</tr>
<tr>
<td>1986</td>
<td>Heiwa Sogo</td>
<td>Sumitomo</td>
</tr>
<tr>
<td>1991</td>
<td>Toho Sogo</td>
<td>Iyo</td>
</tr>
<tr>
<td>1992</td>
<td>Toyo Shinkin</td>
<td>Sanwa</td>
</tr>
<tr>
<td>1993</td>
<td>Kamaishi Shinkin</td>
<td>Iwate</td>
</tr>
<tr>
<td>1993</td>
<td>Osaka Fumin Credit Corp</td>
<td>Osaka Koyo Credit Corp</td>
</tr>
<tr>
<td>1994</td>
<td>Gifu Shogin Credit Corp</td>
<td>Kansai Kogin Credit Corp</td>
</tr>
<tr>
<td>1995</td>
<td>Tokyo Kyowa Credit Corp</td>
<td>Tokyo Kyodo</td>
</tr>
<tr>
<td>1995</td>
<td>Anzen Credit Corp</td>
<td>Kanagawa Labor</td>
</tr>
<tr>
<td>1995</td>
<td>Yuai Credit Corp</td>
<td>Tokyo Kyodo</td>
</tr>
<tr>
<td>1995</td>
<td>Cosmo Credit</td>
<td>Tokyo Kyodo</td>
</tr>
<tr>
<td>1995</td>
<td>Hyogo</td>
<td>Midori</td>
</tr>
<tr>
<td>1995</td>
<td>Kizu Credit Corp</td>
<td>Seiri Kaishu</td>
</tr>
<tr>
<td>1995</td>
<td>Osaka Credit Corp</td>
<td>Tokai</td>
</tr>
<tr>
<td>1995</td>
<td>Sanyo Credit Corp</td>
<td>Tanyo Credit Corp</td>
</tr>
<tr>
<td>1995</td>
<td>Kenmin Daiwa</td>
<td>Tanyo Credit Corp</td>
</tr>
<tr>
<td>1996</td>
<td>Taiheiyo</td>
<td>Wakashio</td>
</tr>
<tr>
<td>1996</td>
<td>Hanwa</td>
<td>Kii Yokinanri</td>
</tr>
<tr>
<td>1997</td>
<td>Hokkaido Takushogu</td>
<td>Chuo Trust, Hokuyo</td>
</tr>
<tr>
<td>1997</td>
<td>Tokuyo City</td>
<td>Sendai</td>
</tr>
<tr>
<td>1998</td>
<td>Long-Term Credit</td>
<td></td>
</tr>
<tr>
<td>1998</td>
<td>Nippon Credit</td>
<td></td>
</tr>
</tbody>
</table>


### TABLE 2

<table>
<thead>
<tr>
<th></th>
<th>Contribution (yen)</th>
<th>Outstanding Loans (yen)</th>
</tr>
</thead>
<tbody>
<tr>
<td>“Founder banks”</td>
<td>Abandonment of claims: 3.5 trillion</td>
<td>3.5 trillion</td>
</tr>
<tr>
<td>“Other lender banks”</td>
<td>Abandonment of claims: 1.7 trillion</td>
<td>3.8 trillion</td>
</tr>
<tr>
<td>“Agricultural credit cooperatives”</td>
<td>“Donation” 520 billion</td>
<td>5.5 trillion</td>
</tr>
<tr>
<td>Public contribution</td>
<td>680 billion</td>
<td></td>
</tr>
</tbody>
</table>

Source: Japan Ministry of Finance, 1996.
taxes and offset the cost of the government contribution. This plan was widely criticized as implausible, but the Diet passed a budget allocating the use of taxpayer funds to bail out the jusen after Prime Minister Hashimoto announced that he would pressure the financial sector to increase its contributions to the program. After rejecting an unsuccessful challenge to the plan by the opposition, the Diet passed a budget allocating the funds necessary to finance the resolution of the jusen companies at the old contribution rates in June of 1996.

However, it has been recognized that the initial funds may prove to be inadequate, particularly in the event of further real estate downturns. Here again, the burden is to be borne to some extent by the banking system as a whole. The government has announced an agreement with the parent banks of the jusen banks, commonly known as “founding banks,” to establish a Financial Stabilization Fund, under which founding banks would contribute more than 1 trillion yen in additional funds to offset half of the future jusen losses. The remainder is to be covered by public money (Kitami 1998). The bulk of regional banks, second tier banks, and insurance companies agreed to increase their contributions as well (Rosenbluth and Thies 1998).

Summary

The Japanese “convoy” banking system clearly placed some share of the burden of the safety net provided to Japanese depositors on the banking industry. In the early days of the convoy system, the empirical importance of the burden was questionable. The number of mergers was small, and side payments, such as enhanced branching opportunities, appear to have mitigated the losses from acquiring a failed bank.

However, with the turbulence experienced by the banking system in the 1990s, the banking system clearly bore some of the burden of failures within the system. Moreover, as financial liberalization eroded the share of bank finance, the charter values, such as bank branching rights, diminished.

The burdens faced by banks had little correspondence to their lending practices. This was particularly true for the jusen resolution program. As Rosenbluth and Thies (1998, p. 22) point out, under the jusen resolution plan “... stronger banks and nonbank financial institutions were asked to contribute to a bailout of the failing institutions, in rough proportion not to their exposure to the problem, but to their ability to pay.” This characterization was echoed by Milhaupt and Miller (1997), who describe the resolution plan as a “survival of the weakest” strategy, in that the smallest contributions were solicited from entities that were least equipped to bear losses. In the case of jusen problem, this was primarily the agricultural credit cooperatives.

II. A SIMPLE MODEL OF A CONVOY BANKING SYSTEM

In this section, I examine the implications of systems of bank resolution in which the burden of resolution is placed on the banking system rather than on a government deposit insurance system. I assume a simple lending model where regimes differ by their procedures for resolution of failed banks. I first model a fixed premium deposit insurance regime which results in the liquidation of a failing bank as a benchmark, and then compare the results under that regime to a “convoy” banking regime, in which the failed bank is merged with a solvent bank. I find that within the class of “convoy” regimes, the results can differ based on the method used to allocate failing banks. I consider two possible types of convoy regimes below.

A Fixed-premium Deposit-insurance System Benchmark

In order to understand the moral hazard implications of the “convoy” system, I first construct a fixed-premium deposit insurance benchmark against which it can be compared. I model the problem in terms of a representative bank. I assume that there are an infinite number of homogeneous banks of measure zero. Banks make fixed amounts of loans, which are financed by issuing insured deposits. Because the deposits are insured, they earn the risk-free rate. I assume that the deposit insurance premium, defined as \( \Psi_{dx} \), is paid up front, and set this premium to make the system self-financing.

The model has one period. The timing of the model is as follows. First, the bank pays its deposit insurance premium, \( \Psi_{dx} \), which is determined below, and chooses its effort level, \( \mu_i \). The effort level represents the bank’s investment in enhancing the quality of its loan portfolio. The cost of supplying an amount of effort equal to \( \mu \) is assumed to satisfy the function \( V(\mu) \), where \( V_\mu > 0 \) and \( V_{\mu\mu} > 0 \). For simplicity, I also assume that effort costs are borne up front. This simplifies the analysis by making this cost independent of the probability of bankruptcy, but drives none of our results.

Banks are assumed to play Nash, taking the equilibrium effort decision of the rest of the banking system, \( \mu \), as given. We define the equilibrium solution for the system as a value for \( \mu \) which satisfies the first-order condition for all of the banks in the system.

Second, each bank $i$ is hit with an idiosyncratic shock, $\varepsilon_i$, which is assumed to be distributed on the interval $[-\infty, +\infty]$. Finally, the bank is closed if it is insolvent. Define $n_i$ as the net value of assets minus liabilities of bank $i$. I assume that $n_i$ is a separable function of $\mu_i$ and $\varepsilon_i$, which satisfies

\[ n_i = n(\mu_i, \varepsilon_i), \]

where $n_i > 0$, $n_{\ast \ast} < 0$ ($x = \mu_i, \varepsilon_i$) and $n_{\mu, \varepsilon_i} = 0$. I assume that the bank is insolvent and closed if $n_i < 0$.

As in Marcus (1984), I assume that if the bank is allowed to continue, it has a charter value of $C$, which is taken as exogenous. This represents the expected future profits from continued banking operations, perhaps due to branching rights, and is not incorporated in the regulator’s closure rule.

Banks are assumed to have limited liability, having zero value under bankruptcy to their equity holders. Since bankruptcy leads to liquidation in the deposit insurance regime, I assume that the charter value of the failed bank is lost.

Define $\varepsilon_{\ast \ast i}$ as the minimum realization of $\varepsilon_i$ under which the regulator chooses to allow the bank to continue in operation under the fixed-premium deposit insurance system, which satisfies

\[ n(\mu_i, \varepsilon_{\ast \ast i}) = 0. \]

In particular, define $\varepsilon_{d i}$ as the minimum realization of $\varepsilon_i$ under which the regulator chooses to leave a bank with the average level of industry effort, $\mu$, open. The “fair” bank deposit insurance premium, $\Psi_d$, will then be equal to the expected resolution cost of a representative bank. $\Psi_d$ satisfies

\[ \Psi_d = -\int_{-\infty}^{\varepsilon_{\ast \ast i}} n(\mu_i, \varepsilon_i) f(\varepsilon_i) d\varepsilon_i. \]

Note that since the representative bank is small relative to the entire banking system, $\Psi_d$ is a function of $\mu$ but not a function of $\mu_i$.

The representative bank’s investment decision is to choose $\mu_i$ to maximize $\Pi$, expected bank value net of effort cost, which satisfies

\[ \Pi = \int_{\varepsilon_{\ast \ast i}}^{\varepsilon_d} (n(\mu_i, \varepsilon_i) + C) f(\varepsilon_i) d\varepsilon_i - \Psi_d - V(\mu_i), \]

where $f(\cdot)$ is the density of $\varepsilon_i$.

The bank’s first-order condition satisfies

\[ \int_{\varepsilon_{\ast \ast i}}^{\varepsilon_d} \frac{\partial n}{\partial \mu_i} f(\varepsilon_i) d\varepsilon_i - \left( \frac{\partial \varepsilon_{d i}}{\partial \mu_i} \right) C f(\varepsilon_{d i}) = V_{\mu_i}, \]

since $\partial \Psi_d / \partial \mu_i = 0$.

The two arguments on the left-hand side of equation (5) represent the marginal benefits of additional effort. The first term reflects the increased expected payoff in nonbankruptcy states, holding the probability of bankruptcy constant. The second term reflects the value of the change in the probability of bankruptcy which results from a marginal change in effort.

The well-known result that the combination of fixed-premium deposit insurance and limited liability can create moral hazard can be seen in equation (5). When making its effort decision, the bank considers only the improved payoff under solvency states. Because of limited liability and fixed-premium deposit insurance, expected bank value is independent of bank payoffs for realizations of $\varepsilon_i$ below $\varepsilon_{d i}$. Consequently, any potential improvements from increases in bank effort over this range do not enter into the bank’s maximization decision.

The fixed-premium deposit insurance regime precludes any consideration of the impact of effort on firm value in insolvency states. The impact of payoffs below $\varepsilon_{d i}$ would be considered if depositors lost their assets in bankruptcy states, i.e., in the absence of deposit insurance. If there were no deposit insurance, depositors would require higher premia in solvency states to offset their losses in insolvency states. The same would be true if deposit insurance terms were risk-weighted.

However, the severity of the moral hazard problem is mitigated by the bank charter value $C$. To the extent that the bank values continuing into the next period, the marginal increase in the probability of avoiding bankruptcy from increased bank effort will have greater weight. The value of continuing is precisely measured by the charter value $C$ by definition. The higher is $C$ then, the less severe is the moral hazard problem.

### A “Convoy” Banking System

I next turn to the severity of moral hazard in a convoy banking system. To facilitate comparison with the fixed-premium deposit insurance system, I keep the model as close to it as possible. I again examine a one-period lending problem where the bank chooses its level of effort in improving the quality of its lending portfolio. As above, banks are assumed to have limited liability, and I model the problem in terms of a representative bank.

Unlike the model above, however, I do not assume that there is an explicit deposit insurance system in place, which services bank liabilities following the liquidation of a failed bank. Instead, I assume that regulators pursue a “convoy” system, in which the assets and liabilities of a failed bank are given to a safe bank which is forced to acquire the balance sheet of the failed bank at par. However, since the failed bank is not liquidated, I assume that its charter value is gained by the acquirer bank. The net cost or benefit to a bank from acquiring a failed bank is then equal to the net balance sheet value of the failed bank plus its charter value.
I assume that all agents place zero weight on the probability of complete bankruptcy of the commercial banking system. The effect of this assumption is that a "convoy" banking system does much of the same work as the fixed premium deposit insurance system. First, it eliminates the possibility of banking panics, since depositors are left whole even in the wake of an individual bank failure. Second, since depositors face no possibility of losses due to individual bank failure, the interest terms faced by the bank are again invariant with respect to its effort decisions. In particular, depositors receive only the risk-free rate of interest.

An implication of this assumption is that there must be a minority of failed banks in the system, so that each failed bank has a solvent bank available for pairing with adequate funds. For the pairing schemes considered below, this is satisfied if \( \varepsilon^*_i \) is less than zero. This implies that given the equilibrium effort level, a realization of \( \varepsilon_i \) equal to its expected value leaves a bank solvent. I adopt this restriction, which seems to hold commonly.

I again assume that banks play Nash, in the sense that each bank takes the effort levels of the rest of the banking system, \( \mu_i \), as given when making its decision over \( \mu_i \).

So far, I have not discussed the method by which the acquiring bank is chosen. I consider two possibilities, each representing a different form of "convoy" system. First, I assume that the regulator randomizes over the set of solvent banks and pairs them one-to-one with the set of insolvent banks. Second, I assume that the regulator tries to merge the weakest banks with the strongest banks, under the logic that the strongest banks are best equipped to acquire the weakest banks without failing themselves. I show that the scheme by which banks are chosen to participate in the convoy program affects both bank incentives and bank behavior.

**Randomly Paired Convoy Program**

I begin with a "random" convoy program in which the set of failed banks is randomly paired with the set of solvent banks.

Define \( \Psi_i \), as the expected net change in bank asset value from the randomly paired convoy program. \( \Psi_i \) will be equal to the net asset plus charter value of a failed bank times the probability of being chosen as the acquirer of that failed bank. Given the average level of effort in the banking system, \( \mu_i \), we can write this formally as

\[
\Psi_i = \left( \int_{\varepsilon_i}^{+\infty} f(\varepsilon_i) d\varepsilon_i \right) \left( \int_{\varepsilon_i}^{+\infty} n(\mu_i, \varepsilon_i) + C \right) f(\varepsilon_i) d\varepsilon_i,
\]

where \( \varepsilon^*_i \) represents the minimum realization of \( \varepsilon_i \) which leaves a bank with effort level \( \mu_i \) solvent. \( \varepsilon^*_i \) satisfies

\[
(7) \quad n(\mu_i, \varepsilon^*_i) = 0.
\]

Note that \( \Psi_i \) is negative and independent of the individual bank’s choice of \( \mu_i \).

The expected value of bank \( i \) under a randomly paired convoy system is then equal to

\[
(8) \quad \int_{\varepsilon_i}^{+\infty} n(\mu_i, \varepsilon_i) + \Psi_i + C f(\varepsilon_i) d\varepsilon_i - V(\mu_i),
\]

where \( \varepsilon^*_i \) represents the minimum realization of \( \varepsilon_i \) which leaves a bank with effort level \( \mu_i \) solvent.

The bank’s first-order condition satisfies

\[
(9) \quad \int_{\varepsilon_i}^{+\infty} \frac{\partial n}{\partial \mu_i} f(\varepsilon_i) d\varepsilon_i - \left( \frac{\partial \varepsilon^*_i}{\partial \mu_i} \right) (\Psi_i + C) f(\varepsilon^*_i) = V(\mu_i).
\]

In equilibrium, banks are homogeneous, so we substitute \( \mu_i \) for \( \mu_i \). An equilibrium is then an effort choice \( \mu_i \) consistent with equation (9).

It is illustrative to compare equation (9) with equation (5). The only difference in the two first-order conditions is in the term modifying the effect of a change in the probability of bankruptcy with a change in bank effort. In the benchmark fixed-premium deposit insurance system, the value of avoiding bankruptcy was equal to the charter value \( C \). Under the convoy system, however, this value is affected by the expected loss from the possibility of being chosen as an acquiring bank, \( \Psi_i \).

In principle, this value could be positive or negative, depending on the probability and expected magnitude of bank failures relative to the charter value picked up after acquisition. This leads to our first proposition.

**PROPOSITION 1:** Given \( \Psi_i < 0 \), the equilibrium value of \( \mu_i \) is lower under the randomly paired convoy system than under the fixed-premium deposit insurance system. However, the opposite result obtains for \( \Psi_i > 0 \).

To prove Proposition 1, I totally differentiate equation (9) with respect to \( \mu_i \) and \( \Psi_i \). Recalling that \( n(\mu_i, \varepsilon^*_i, \mu_i) = 0 \) by definition, I obtain

\[
(10) \quad \frac{\partial \mu_i}{\partial \Psi_i} = \frac{\left( \frac{\partial \varepsilon^*_i}{\partial \mu_i} \right) f(\varepsilon^*_i)}{\left( \frac{\partial n}{\partial \mu_i} \right) f(\varepsilon_i) - \left( \frac{\partial \varepsilon^*_i}{\partial \mu_i} \right) (\Psi_i + C) f(\varepsilon^*_i) - V(\mu_i)} > 0.
\]

Given that the expected payoff from the randomly paired convoy program, \( \Psi_i \), is negative, the total change in effort moving from the fixed-premium deposit insurance system to the randomly paired convoy system satisfies
By inspection, one can see that the opposite result obtains for \( \Psi_r > 0 \), which completes the proof.

Before moving on, I must note a problem with the random pairing scheme. Under the random pairing scheme, it is possible that an otherwise solvent bank can be pushed into insolvency by being forced to acquire a sufficiently insolvent bank. Above, I have abstracted from this problem by only allowing banks to be closed prior to the allocation of failed banks to their acquisitors. However, this raises serious questions about the feasibility of a truly random scheme. It seems that some kind of explicit pairing is required to avoid this implausible outcome.

**“Best-with-worst” Pairing Scheme**

Alternatively, we consider the strategy of pairing the weakest failed banks with the strongest solvent banks. The motivation for such a strategy might be that the strongest banks are best equipped to digest the losses associated with the acquisition of the weakest banks without risking failure themselves. In particular, since the best-with-worst scheme does not merge a marginally solvent bank with a sufficiently insolvent bank, it avoids the potential for forcing the acquiring bank into bankruptcy.

I assume a simple pairing strategy: The bank with the largest net asset value is paired with the most insolvent bank. As above, I assume that banks play Nash, taking the effort choices of the other banks, \( \mu \), as given.

Define \( \varepsilon^*_p \) as the minimum realization a bank making effort level \( \mu \) would need to avoid closure. \( \varepsilon^*_p \) satisfies

\[
(12) \quad n(\mu, \varepsilon^*_p) = 0.
\]

Figure 1 illustrates the best-with-worst pairing scheme. All banks with negative realizations of \( n \) will be insolvent. Each failed bank is paired with a corresponding solvent bank, starting by pairing the most insolvent banks with the most solvent banks. Let \( \bar{n} \) represent the mean realization of the population of banks. We assume that the system as a whole is solvent, which implies that \( \bar{n} > 0 \). It can be seen that all banks with realizations of \( n \) greater than \( 2\bar{n} \) will be asked to acquire a failed bank under this scheme. For example, a bank with a realization of \( n \) equal to \( 2\bar{n} + \Delta \) will be paired with a bank with realization of \( n \) equal to \( -\Delta \). Note that the weakest set of solvent banks, those with realizations of \( n \) in the range \( 0 \leq n \leq 2\bar{n} \), are not paired with any bank under this system.

Because all banks make effort level \( \mu \) in equilibrium, the distribution is symmetric. A bank which receives a realization of \( \varepsilon_i \) which yields a value of \( n \) greater than \( 2\bar{n} \) will be paired with a bank with net value equal to \( n \) (\( \mu, -\varepsilon_i \)).

We next turn to the decision problem faced by our representative bank, which again plays Nash and takes the above distribution of pairings with realizations of \( n \) as given.
The value of \( n \) for a representative bank is a function of its effort choice \( \mu_i \) and its idiosyncratic shock realization \( \varepsilon_i \). Let \( \hat{n} \) represent the net asset value of the insolvent bank with which a bank with effort level \( \mu_i \) and a realization of \( \varepsilon_i \) which yields a value of \( n \) above \( 2\hat{n} \) is paired. \( \hat{n} \) will be a function of \( \mu_i \), \( \varepsilon_i \), and \( \mu \)

\[
\hat{n} = \hat{n}(\mu_i, \varepsilon_i, \mu),
\]

where \( \hat{n}_{\mu_i} < 0, \hat{n}_{\varepsilon_i} < 0, \) and \( \hat{n}_{\mu} > 0 \).

The intuition for the sign on the partial derivatives stems from the best-with-worst pairing method. An increase in either \( \mu_i \) or \( \varepsilon_i \) increases \( n \). Holding the distribution of payoffs to the rest of the banking system constant, this raises a bank’s relative performance standing. Under the best-with-worst pairing method, the bank is then asked to acquire a bank with a more negative asset position. An increase in \( \mu_i \) on the other hand, decreases the relative performance of a bank with effort level \( \mu_i \), giving it a realization of \( \hat{n} \) that is pushed upwards by an industry-wide increase in effort.

Finally, define \( \hat{e} \) as the realization of \( \varepsilon_i \) for a bank with effort level \( \mu_i \), which gives it a realization of \( n \) equal to \( 2\hat{n} \). \( \hat{e} \) satisfies

\[
2\hat{n} = n(\mu_i, \hat{e}).
\]

Rearranging terms, we can write

\[
\hat{e} = \hat{e}(\mu_i, \mu),
\]

where \( \hat{e}_{\mu_i} < 0, \) and \( \hat{e}_{\mu} > 0 \).

We can then define \( \Psi_p \) as the expected change in bank value stemming from the paired convoy program. \( \Psi_p \) satisfies

\[
\Psi_p = \int_{\hat{e}}^{\infty} \hat{n}(\mu_i, \varepsilon_i, \mu) f(\varepsilon_i) d\varepsilon_i.
\]

Let \( \varepsilon_{\mu_i} \) represent the minimum realization of \( \varepsilon_i \) which yields solvency for a bank with effort level \( \mu_i \). Note that \( \hat{e} > \varepsilon_{\mu_i} \) since marginally solvent banks are not paired with failed banks under the paired convoy system. The expected value of bank \( i \) under the paired convoy system will then equal

\[
\int_{\hat{e}}^{\varepsilon_{\mu_i}} [n(\mu_i, \varepsilon_i) + C] f(\varepsilon_i) d\varepsilon_i + \int_{\varepsilon_{\mu_i}}^{\infty} \hat{n}(\mu_i, \varepsilon_i, \mu) f(\varepsilon_i) d\varepsilon_i - V(\mu_i).
\]

The representative bank’s first-order condition then satisfies

\[
\int_{\hat{e}}^{\varepsilon_{\mu_i}} \frac{\partial}{\partial \mu_i} f(\varepsilon_i) d\varepsilon_i + \left( \int_{\hat{e}}^{\varepsilon_{\mu_i}} \frac{\partial \varepsilon_{\mu_i}}{\partial \mu_i} f(\varepsilon) d\varepsilon \right) + \int_{\varepsilon_{\mu_i}}^{\infty} \frac{\partial \hat{n}}{\partial \mu_i} f(\varepsilon_i) d\varepsilon_i = V(\mu_i),
\]

since \( \hat{n}(\hat{e}) = 0 \).

To solve for the equilibrium we note that since banks are homogeneous, \( \mu_i = \bar{\mu} \). The equilibrium is defined as a choice of \( \mu \) for all banks in the system which satisfies (17).

As above, we first compare the paired convoy system with the fixed-premium deposit insurance system. Comparing (5) and (17), the paired convoy system has an additional term representing the change in the expected loss due to the convoy program with a change in \( \mu_i \). An increase in \( \mu_i \) increases the bank’s expected relative performance and therefore reduces the expected net value of the insolvent bank, it will be forced to acquire under the convoy program. This leads to our second proposition.

PROPOSITION 2: Given \( \Psi_p < 0 \), the equilibrium value of \( \mu_i \) is lower under the best-with-worst paired convoy system than under the fixed-premium deposit insurance system. However, the result for \( \Psi_p > 0 \) is ambiguous.

Proposition 2 can be proven by inspection. Given \( \Psi_p < 0 \), the additional term in equation (17) is negative. Since the second-order condition holds, \( \mu_i \) needs to be reduced relative to the level that satisfies equation (5) to satisfy (17). However, the third term is unambiguously negative. This allows for the ambiguity when \( \Psi_p > 0 \).

However, comparison of equations (9) and (17) is more difficult because each has a unique term. The unique term in equation (9) reflects the reduction in the expected benefits with increasing the probability of solvency through an increase in \( \mu_i \) due to the convoy program. This term does not appear in equation (17) because the best-with-worst convoy program is marginally costless for marginally solvent banks since they are not asked to acquire failing banks. The unique term in equation (17) reflects the marginal reduction in the expected quality of the acquired bank under the best-with-worst paired convoy system resulting from an increase in bank effort \( \mu_i \). This term does not appear in equation (9) because banks are randomly matched under that program. Our results therefore indicate an ambiguity in the relative severity of moral hazard under the two convoy programs.

III. SIMULATIONS

To evaluate the relative degrees of moral hazard under the various banking programs, I turn towards simulations. I first adopt some specific functional forms. I set the net asset position of bank \( i \) undertaking effort level \( \mu_i \) as satisfying

\[
n_i = \alpha + (\mu_i)^{\beta} + \varepsilon_i,
\]

where \( \beta(0,1) \). Note that, as specified by the theory, \( n_i > 0 \), \( n_{\mu_i} \leq 0 \), and \( n_{\mu_i, \varepsilon_i} = 0 \). We also assume that the cost of effort is quadratic in \( \mu \)

\[
V(\mu) = \nu \mu^2.
\]

Finally, I specify that \( \varepsilon_i \) is distributed uniform on the unit interval \([0,1]\).

I will also have to place some parameter restrictions on \( C \). In particular, the value of \( C \) must be set low enough to
allow some positive probability of default, but high enough so that a minority of banks are expected to fail.

**Fixed-premium Deposit Insurance**

Let $\mu_f$ and $\epsilon_f$ represent the level of effort taken by the representative bank and the resulting level of $\epsilon_f$ under the fixed-premium deposit insurance system, respectively. By (18), this implies that the value of $\epsilon_f$ satisfies

$$\epsilon_f = -\alpha - (\mu_f)^\beta. \tag{20}$$

Substituting our functional forms into equation (5), the first-order condition for the fixed-premium deposit insurance regime satisfies

$$\frac{2v}{\beta} \mu_f^2 - \mu_f(1 + \alpha + C) = 0. \tag{21}$$

**Randomly Paired Convoy System**

Let $\mu_r$ represent the level of effort taken by the representative bank under the randomly paired convoy system. By (18), this implies that the value of $\epsilon_r$ satisfies

$$\epsilon_r = -\alpha - (\mu_r)^\beta. \tag{22}$$

Let $\mu$ represent the level of effort chosen by the rest of the banking system, which our representative Nash-playing banks take as given. By equation (6), the expected cost of the random convoy system, $\Psi_r$, is equal to

$$\Psi_r = \frac{1}{2} (\alpha + \mu^\beta) + C. \tag{23}$$

Substituting these functional forms into (9) yields the first-order condition

$$\frac{2v}{\beta} \mu_r^2 - \frac{3}{2} (\alpha + \mu_r^\beta) - 1 - 2C = 0. \tag{24}$$

**Best-with-worst Paired Convoy System**

Finally, I turn to the best-with-worst paired convoy system. Let $\mu_r$ represent the level of effort taken by the representative bank. By (18), this implies that the value of $\epsilon_r$ satisfies

$$\epsilon_r = -\alpha - (\mu_r)^\beta. \tag{25}$$

Again, let $\mu$ represent the level of effort chosen by the rest of the banking system, taken as given by our representative bank. $\bar{n}$ will satisfy

$$\bar{n} = \alpha + \mu^\beta + \frac{1}{2}. \tag{26}$$

A bank with a realization of $n$ which exceeds $2\bar{n}$ will be paired with a bank with net asset value plus charter value $\hat{n}$, which satisfies

$$\hat{n} = 2(\alpha + \mu^\beta + \frac{1}{2}) - n + C. \tag{27}$$

Substituting for $n$ for the representative bank,

$$\hat{n} = \alpha + 2\mu^\beta - \mu_f^\beta + 1 - \epsilon_f + C. \tag{28}$$

The value of $\hat{\epsilon}$, the realization of $\epsilon_f$ for which a bank with effort level $\mu_f$ satisfies $n = 2\bar{n}$, satisfies

$$\hat{\epsilon} = \alpha + 2\mu^\beta - \mu_f^\beta + 1. \tag{29}$$

Substituting these functional forms into (17) yields the first-order condition

$$\frac{v}{\beta} \mu_r^2 - \left(\alpha + \mu_r^\beta + \frac{1}{2} + C\right) = 0. \tag{30}$$

**Simulation Results**

Parameter values were chosen to yield interior solutions to the equations above with a positive probability of both bank failure and solvency, as well as some degree of moral hazard. The latter constraint operationally implies choosing parameters that yielded, $\mu_f < 1$ for all three regimes. In particular, I set $\alpha = -1.15$, $\beta = 0.5$, and $v = 1.7$. Under these values, convergence was achieved for values of $C \geq 0.5$.

The results of the simulation are summarized in Figures 2 and 3. A number of results emerge from the simulations: First, there is a significant difference between the effort levels and the probability of bankruptcy under the two convoy programs. The best-with-worst paired convoy system consistently yields lower effort levels and higher bankruptcy probabilities than the randomly paired system. For example, for the intermediate value of $C = 0.8$, the equilibrium value of $\mu$ under the best-with-worst paired convoy system is 0.37, yielding a 54 percent bankruptcy probability. These values are far closer to the 0.32 and 59 percent values obtained under the fixed-premium deposit insurance scheme than the 0.50 and 45 percent bankruptcy probability values obtained under the randomly paired convoy scheme.

Second, because of the high charter values necessary to obtain interior solutions under all three regimes, the randomly paired convoy program yielded higher effort levels over the entire range. However, I do find a change in the relative effort levels of the best-with-worst paired convoy system and the fixed-premium deposit insurance regime. As predicted by the theory, the relative effort is related to bank charter value levels. For low values of $C$, I find that the best-with-worst convoy scheme yields higher effort levels and lower bankruptcy probabilities than the deposit insurance regime. However, as $C$ increases, this disparity is reduced.
and is eventually reversed. As discussed above, raising $C$ increases the relative attractiveness of the two convoy programs because the charter value of the bank is retained under them.

IV. CONCLUSION

This paper introduces a model of lending with a bank regulatory regime similar to the “convoy” regime which prevailed in Japan throughout the postwar era. In particular, the convoy regime is characterized as one in which the resolution costs of problem banks are shared among the members of the banking system rather than borne by an outside agency, as in a fixed-premium deposit insurance scheme. The theoretical results demonstrate that the relative prevalence of moral hazard distortions in bank effort decisions is dependent on the expected cost of acquiring failed banks relative to their positive charter values. In particular, the theoretical analysis demonstrates that if the expected return from participation in a convoy program is negative, bank effort levels will be lower, and the probability of bankruptcy in the banking system will be higher, under the convoy program than under the fixed-premium deposit insurance regime benchmark. However, increases in bank charter values can mitigate and eventually overturn this disparity. As charter values increase, effort levels under the fixed-premium deposit insurance scheme diminish relative to either convoy scheme because the acquisition of valuable bank charters mitigates the costs to a bank of acquiring a failed bank with negative asset value.

In a sense, this relationship between charter value and the relative desirability of the convoy program can help explain the eventual breakdown of the program in Japan. During the early years of the convoy program, the probability of bankruptcy was very small and branch rights were considered relatively valuable. As a result, the theory would predict little if any disadvantage for the convoy program relative to a fixed-premium deposit insurance scheme. However, as the probability of bankruptcy in the Japanese banking system rose and the perceived value of branching rights diminished, the severity of moral hazard under the convoy regime increased. This increased moral hazard added to the overall probability of bankruptcy in the system and contributed to the eventual collapse of the regime.
REFERENCES


The amount of time required to sell a house is one of the more actively studied topics in real estate economics. The time to sale is inextricably linked to the pricing of real estate assets; thus, its importance to individual members of the economy cannot be overemphasized.

Researchers have few good theories about what should govern the time to sale. In most models of asset prices, time to sale is exactly zero. This is a consequence of the market-clearing condition that is often required to pin down equilibrium. But any model where the market clears must abstract from frictions, and frictions in the real estate market are so notoriously severe that they cannot be ignored. For example, unlike participants in financial securities markets, sellers of houses typically know much more about the asset for sale than prospective buyers know. In addition, buyers generally do not reveal how much they are willing to pay for a given house. Furthermore, each buyer in the market may be different, both in terms of financial means and tastes for the real estate good. And, most importantly, the real estate market is decentralized; buyers and sellers who want to trade must undergo a (sometimes costly) search process in order to complete a transaction.

In this paper I discuss some of the theoretical issues involved with modeling the time to sale of real estate assets. The key question I will address is why marketing periods for houses fluctuate so much over time (see Figure 1). It is not surprising that house values fluctuate over time and over different states of nature. Variation in interest rates and employment opportunities should cause variation in the value of the housing service flows provided by homeownership. But most economic theory predicts that fluctuations in fundamentals should be immediately reflected in prices. That is, if the value of a house changes by a certain amount, the price of the house should change by the same amount. The real estate market does not appear to work this way. Rather, when house values decline, sellers are slow to drop their prices. Thus, marketing times increase and the volume of sales declines. These are all features of a cold real estate market. The hot market has just the opposite characteristics. Real estate prices are typically rising during hot markets. However, prices do not appear to rise fast enough, as suggested by the fact that houses are quickly snapped up after they are brought to market.
The model developed in this paper is similar in structure to search models developed for real estate markets by Arnott (1989), Wheaton (1990), and Williams (1995). Stein (1995) also studies hot and cold real estate markets, but from a very different perspective. In Stein’s model, cold markets arise from credit market frictions. Whereas in this paper, hot and cold markets arise from search frictions and asymmetric information.

The paper is organized as follows. In the first section, I outline a theory of real estate prices and liquidity that captures the hot and cold markets phenomenon. The model used here is a search-theoretic model where prices and liquidity are derived from the maximizing behavior of both buyers and sellers. Agents who live in houses consume housing services or housing dividends. Trade in houses takes place because individuals are vulnerable to idiosyncratic shocks that sever the match with their house. This might happen because of a change in household size or a job transfer. When an agent loses his match, he moves out immediately and puts the old house up for sale. As a seller, the agent prices the house so as to maximize the expected value of having the house on the market. At the same time, the agent is temporarily homeless and must search for a new house to live in. As a potential buyer, the agent searches until he finds a house that offers him enough utility net of price to warrant leaving the market. Since both buyers and sellers are optimizing, price and liquidity are determined endogenously. When the per period housing service flow is allowed to vary, liquidity also varies so as to match the observed correlations between prices, liquidity, and sales volume.

In Section II, I use data from the San Francisco Bay Area housing market to investigate the determinants of time on the market. In this empirical exercise, the intent is not to test hypotheses or even to select between different models of the real estate transaction. Rather, the exercise is a reduced form investigation into the relationship between time on the market and certain economic variables and asks whether these relationships are consistent with the theory developed in Section I.

I. THEORETICAL MODELS OF TIME ON THE MARKET

The basic structure of a search model is a setting where a large number of agents engage in bilateral trade. The central assumption is that agents do not gather in a single market place where they view all assets for sale. Rather, agents form expectations about the kinds of transactions that are feasible in the economy and then meet potential trading partners sequentially. The challenge is to characterize agents’ decision rules in this environment. For example, based on the expectations a seller might have of how much buyers are willing to pay for a house, the seller must decide when to accept a bid and when to reject it. The fundamental trade-off for a seller, then, is to weigh the benefits of further searching against the costs of delaying the sale. The benefits of continued searching are obvious: a buyer may arrive who attaches greater value to the house. The delay associated with continued search can be costly because (a) the agent delays consumption and (b) once the agent rejects an offer, it is uncertain when, if ever, the next “good” offer will arrive.

A One-sided Search Problem

A simple example may help illuminate the basic structure of the search model. Suppose that an agent with a house for sale receives bids on the house one at a time. The agent believes that house prices are drawn from the continuous distribution $F$ and that draws from the distribution of prices (i.e., offers) are i.i.d. For simplicity, assume that once the agent has sold his house, he takes the cash from sale and exits the economy.

1. This section borrows from Lippman and McCall (1986) and Sargent (1987).
The lifetime expected utility of a seller with offer price \( p \) in hand can be expressed recursively by

\[
(1) \quad v(p) = \max \left[ p, \beta \int_0^\infty v(y) dF(y) \right].
\]

Lifetime expected utility is either the price \( p \) the seller receives from an immediate sale or it is the discounted expected utility of putting the house up for sale next period — whichever is greater. The parameter \( \beta \) is the seller’s discount factor.

Equation (1) is an example of a Bellman’s equation. Note that \( v \) is increasing in \( p \) and that the quantity \( \beta \int_0^\infty v(y) dF(y) \) is a constant. It follows that there exists a price \( p^* \), called the reservation price, such that

\[
(2) \quad p^* = \beta \int_0^\infty v(y) dF(y).
\]

The optimal decision rule in this problem is for sellers to accept all offers at least as high as \( p^* \) and to reject all offers below \( p^* \).

This search model is flexible. It should be apparent that it is possible to set up the problem from either the buyer’s or the seller’s perspective. The important point to notice, however, is that the model implies that time on the market depends solely on \( F \), the distribution of the bid arrival process. It is legitimate to ask where the seller’s beliefs about \( F \) actually come from. If buyers were to realize that sellers accepted all offers above \( p^* \), then no buyer would ever offer more than \( p^* \). This type of equilibrium quickly collapses when parties on both sides of the transaction are allowed to behave optimally.

A Two-sided Search Problem

A more natural way to model trade in housing markets is to view both buyers and sellers as searchers. Towards this end, I will sketch the outline of a two-sided search model. Suppose that houses, like any asset, have value because they produce a flow of services and assume that this service flow accrues to the homeowner each period for as long as the owner lives there. If the owner leaves the house, then the house ceases to yield a service flow and the owner proceeds to sell the house and look for a new house himself. Thus, when an agent leaves the house, the decisionmaking problem is to specify a pricing rule for the old house and a search strategy that will be utility maximizing. To make the problem interesting, assume that not all agents have the same preferences for houses that they visit. Differences in housing tastes imply that the search process may take time.

Proceeding more formally, assume there are a large number of risk-neutral agents in an economy where the traded goods consist of a consumption good and houses. The consumption good serves as the numeraire. There is no new construction and no depreciation of the existing housing stock. An agent who owns and lives in a house enjoys a per period housing service flow, \( \epsilon \), that is constant for as long as an agent stays in the house. When an agent vacates a house and searches for a new one, she draws a new \( \epsilon \) from the uniform distribution \( F \) on the interval \([0,1] \). Draws from this distribution by potential buyers are independent.

Trade in houses occurs because agents lose their “match” with their houses. This happens for purely exogenous reasons (e.g., the arrival of children, the departure of children), and occurs with probability \( 1 - \pi \) each period. For the moment, this is the only kind of uncertainty in the model. Once a homeowner loses the match, the house ceases to provide a service flow to its owner, and the owner puts it on the market, attempting to sell it for as much as possible.

Each period, a potential buyer visits the empty house. At this time, she draws from \( F \) and determines how much she likes the house. The seller sets a take-it-or-leave-it price before he learns anything about the buyer. It is assumed that buyers face no financial constraints. If the buyer chooses to buy, she pays the asking price immediately and starts to receive housing services at the beginning of the next period. Thus, houses are priced ex-dividend, as is the convention in the asset pricing literature. If the buyer chooses not to buy, she does not consume any housing services in that period and searches again in the next.

Figure 2 contains a schematic of the timing of events for a buyer and seller pair of agents. The agents meet at the beginning of the period. All cash flows and consumption takes place at this time. Upon visiting the house, the buyer observes the idiosyncratic dividend \( \epsilon \) yielded by this particular house and the listing price. If the buyer chooses to buy, then she pays the seller the cash price immediately. The house begins to yield dividends to its new occupant in the beginning of the next period. If the buyer chooses not to buy the house, then the house lies empty and the buyer is homeless for the period. The seller relists the house and the buyer visits a different house in the following period.

The steady state equilibrium in this economy consists of utility maximizing decision rules for both buyers and sellers. Let \( q \) be the expected value of having a house on the

---

2. This model and its properties are developed in Krainer and LeRoy (1998).

3. From here on sellers of houses will be male and buyers female.

4. Real world housing transactions, of course, are accompanied by hard bargaining. Take-it-or-leave-it pricing should be viewed as a Nash bargaining game where the seller has all the bargaining power.
FIGURE 2

DECISIONMAKING BETWEEN SELLER/BUYER PAIR

The agent will consume next period's housing service flow with certainty. With probability $\pi$ the match will persist for another period and the homeowner will continue to consume $\epsilon$. The match will fail next period with probability $1 - \pi$. In this case, the agent must put the house on the market and begin to search again. The house selling process, as we saw above, yields $q$ in expected value. The agent is also free to search for a new house at this point. The value of this recovered search option is denoted by $s$. Note that this is the value of a house to a particular agent. The value of a house to an owner depends solely on the service flow $\epsilon$ and is very different from the price.

If we consider a buyer who is contemplating buying a house with service flow $\epsilon$ for price $p$, then the optimal strategy is to buy if the expected value of the house net of price is greater than the option to search again next period. That is,

$$
(6) \quad \nu(\epsilon) - p \geq \beta s.
$$

This problem has the same form as the seller's problem in the one-sided search model above. Since $\nu$ is strictly increasing in $\epsilon$ and $\beta s$ is constant, there exists an $\epsilon^*$ such that a searching agent is indifferent between buying a house for the quoted price $p$ and searching again next period. That is, there exists an $\epsilon^*$ such that

$$
(7) \quad \nu(\epsilon^*) - p = \beta s.
$$

The service flow $\epsilon^*$ is the reservation service flow and plays the same role in the search process as the reservation price discussed above.

A searching agent continues searching if she draws $\epsilon < \epsilon^*$ and buys if she draws $\epsilon \geq \epsilon^*$. Therefore, we can write the expected value of search as

$$
(8) \quad s = F(\epsilon^*)\beta s + (1 - F(\epsilon^*))\left(\int_{\epsilon^*}^{\nu(\epsilon)}dF(\epsilon) - p\right).
$$

In order to close the model we note that the probability of sale is simply the probability of drawing $\epsilon \geq \epsilon^*$, or $\mu = 1 - F(\epsilon^*)$, or

$$
(9) \quad \mu = 1 - \epsilon^*,
$$

when $F$ is the uniform distribution on $[0,1]$.

Equilibrium is a price of housing $p$, an expectation of the value of a house on the market $q$, an expectation of the outcome from the search process $s$, a reservation service flow $\epsilon^*$, and a belief about the probability that a buyer will purchase a house $\mu$ when the price is $p$. All these variables must satisfy equations (3), (4), (7), (8), and (9). The equilibrium is a Nash equilibrium: the actions of both sellers and buyers are best responses to each other. Standard fixed-point arguments can be used to prove the existence of equilibrium. The nonlinear nature of the system of equations

market and let $\mu(p)$ be the probability that a house will sell when the list price is $p$. The seller chooses a price to solve

$$
(3) \quad q = \max_{\tilde{p}}\left\{\mu(\tilde{p})\tilde{p} + (1 - \mu(\tilde{p}))(\beta q)\right\}.
$$

With probability $\mu$ the seller receives the asking price for the house. Otherwise the seller puts the house back on the market and tries to sell it again in the next period. The parameter $\beta$ is a discount factor.

The first order condition that yields the optimal price $p$ is

$$
(4) \quad \frac{d\mu}{dp}(p - \beta q) + \mu(p) = 0.
$$

The retail price of housing, $p$, and the expected value of having a house on the market (or the wholesale price of housing), $q$, are determined in equations (3)–(4) in terms of $\mu$, the probability of sale function. This is the key point of departure between one-sided search models where $\mu$ is taken exogenously and the two-sided models where $\mu$ is derived endogenously.

We now describe the optimal behavior of a buyer. We start first with an agent who currently has match $\epsilon$ and is scheduled to consume the housing service flow at the beginning of the next period. Define $\nu(\epsilon)$ to be the lifetime expected utility of owning a house yielding service flow $\epsilon$,

$$
(5) \quad \nu(\epsilon) = \beta(\epsilon + \pi \nu(\epsilon) + (1 - \pi)(q + s))\ .
$$
makes it difficult to solve the system analytically, but it is routine to solve for the equilibrium numerically.

The primary object of interest in this model is the time a house is on the market. Given the per period probability of sale, \( \mu \), it is straightforward to derive the expected time on the market,

\[
(10) \quad \text{TOM} = \frac{1-\mu}{\mu}.
\]

The immediate observation is that \( \text{TOM} \) is an expected remaining duration. This expectation is a constant. It does not depend on the time a house already has spent on the market. This lack of time dependence is a consequence of the choice to abstract from all financing constraints. Sellers in this model are never forced to drop their prices and sell so as to finance a downpayment on another house.

Also, since there is no aggregate risk in the model, note that there can be no state dependence in \( \text{TOM} \). But aggregate risk can easily be incorporated in the model by redefining the housing service flow to consist of an idiosyncratic component \( \epsilon \) and an aggregate component \( x \),

\[
(11) \quad d = \epsilon + x.
\]

The idiosyncratic component \( \epsilon \) has the same interpretation as before. The variable \( x \) is aggregate in that all agents who live in houses receive exactly the same \( x \). We assume that \( x \) is a stochastic process that can take on one of two values, a high value \( x^H \) and a low value \( x^L \). Assume that \( x \) is a first-order Markov process with transition probability \( 1 - \lambda \). Thus,

\[
(12) \quad \Pr(x' = x^k \mid x = x^l) = \lambda, \text{ for } k = L, H.
\]

I adopt this specification because prices of individual houses tend to move together with those in the same neighborhood, city, or even within a broader geographical region. Since it is unlikely that idiosyncratic tastes vary much over time, it makes sense to model this covariation by assuming a common component in all housing service flows. The variable \( x \) is meant to reflect the aggregate state of the economy. A more concrete interpretation of \( x \) could include amenity levels such as school quality or the level of crime in the area.\(^5\) It is also possible to interpret \( x \) as a location-specific component in the housing service process that reflects the value of land. Under this interpretation, shocks to the productivity of the land or to job growth filter their way into house prices through \( x \).

By adding a random variable \( x \) to the housing service flow, the equations above that define equilibrium are adjusted to become functions of \( x \). Figures 3 and 4 show simulated values of the pricing function \( p(x) \) and the probability of sale function \( \mu(x) \) for different values of \( \pi \). Note that for all values of \( \pi, p(x^H) > p(x^L) \) and \( \mu(x^H) > \mu(x^L) \). Evidently, good liquidity corresponds to periods when the value of the housing service flow is high and prices are high. Since houses are more likely to sell during these periods, on average, more houses do sell and the volume of sales is greater in this state than in the low state. Thus, the model is able to match the observed correlations between liquidity, prices, and volume. Krainer (1999) argues that this is a natural outcome in markets where asset values fluctuate and agents must search for trading partners. When \( x \) is high and the value of housing is correspondingly high, sellers raise their prices, but not so high as to choke liquidity. In this kind of environment, sellers demand liquidity because if they fail to sell, they risk the possibility that the state of the economy changes and that they will be forced to sell on less advantageous terms. Likewise, in cold markets when \( x \) is low, sellers do not demand liquidity. That is, they do not drop their prices to maintain liquidity. Rather, it is optimal to keep prices high. Failure to sell in a cold market is not costly if sellers expect the state of the economy to improve. Thus, it is optimal for sellers to follow the old dictum and wait out a cold real estate market.

The modeling assumption that drives these results is the inability of sellers to hedge changes in the opportunity cost of failing to sell their houses. As stated above, pricing a

---

house high in a hot market is risky because the state variables of the economy are stochastic. Sellers are anxious to sell quickly in hot markets because they do not want to be caught with an empty house during a cold market. If sellers are allowed to rent out empty houses at a price that is perfectly correlated with the value of the housing service flow, then fluctuations in liquidity completely disappear and real estate prices incorporate all changes in real estate values. That is, expected returns for the marginal buyer are constant. The fact that moral hazard discourages many homeowners from renting out their empty houses suggests that fluctuating liquidity is a natural feature of owner-occupied real estate markets.

II. EMPirical STRATEGIES FOR STUDYING TIME ON THE MARKET

The model developed above is overly simplistic for the sake of tractability. There are two parameters in the model: \(1 - \pi\), the per period probability of moving, and \(1 - \lambda\), the per period probability that the state variable \(x\) changes value. The model places no restrictions on these probabilities except that they lie between zero and one. The chief result of the model is the joint derivation of a probability of sale function \(\mu(x)\) and a pricing function \(p(x)\) that implies that house prices, liquidity, and transaction volume be positively correlated, as in fact they are in the data. As far as causation, the model is silent and simply assumes that the evolution of the state variable \(x\) drives the economy. The remainder of this paper is devoted to searching for candidate \(x\) variables and assessing their ability to “explain” time on the market in a reduced form setting.

The most prevalent technique for studying durations of any kind is the use of hazard models. The hazard function specifies the time \(t\) probability of an event occurring at time \(T\), given that the event has not yet occurred. Formally, the hazard function is defined as

\[
\theta(t; x) = \lim_{dt \to 0} \frac{\Pr(t \leq T < t + dt | T \geq t, x)}{dt}.
\]

As in the theoretical section, \(x\) is a vector of covariates that influence the hazard function.

The probability of selling a house in a given period is analogous to the per period hazard rate. All predictions about how the probability of sale varies with time and with other variables are really predictions about the shape of the hazard function. In the model presented in this paper, the probability of sale is independent of how long the house has been on the market, implying that the hazard function is a constant function of time. The model predicts that the probability of sale depends on the aggregate state of the economy. Thus, one should detect a statistically significant relationship between the marketing times and variables such as employment growth and interest rates.

The first specification of the hazard function that I consider is the exponential hazard given by

\[
\theta(t; x) = \gamma \exp(x'\xi).
\]

Here, \(x\) is a vector of covariates and \(\xi\) a vector of parameters. The parameter \(\gamma\) is the underlying hazard rate, or the baseline hazard, which results when all covariates take on zero value. Note that the exponential hazard function, like the probability of sale function developed above, does not depend on time.

Since the constant hazard model is likely to be too constraining for empirical work, I also consider a generalization of the exponential hazard, the Weibull hazard function, given by

\[
\theta(t; x) = \gamma \alpha(\gamma)^{\alpha-1} \exp(x'\xi).
\]


7. It also is possible to make the covariates functions of time. This specification is useful for problems such as modeling the time to mortgage prepayment, where the time path of interest rates influences the decision. In this study, average times to sale are sufficiently short (two months), so I have elected not to incorporate time-varying covariates.
The Weibull model is characterized by a scale parameter $\alpha$, which, together with time $t$, determines the slope of the hazard function. If $\alpha > 1$ then the hazard is increasing, meaning that houses that have already been on the market a long time are more likely to sell. Increasing hazards might be observed if sellers lowered their asking prices after a long duration on the market. The opposite situation obtains if $\alpha < 1$. A decreasing hazard might result from buyers inferring that houses with long marketing times are lemons. The Weibull hazard reduces to the exponential hazard in the special case of $\alpha = 1$.

The third specification that I consider, the Cox model, is semiparametric in nature. Suppose that the hazard function for a particular house $i$ takes the form

$$\theta_i(t; x) = \theta_0(t) \exp(x^* \xi) .$$

Here, $\theta_0(t)$ is the baseline hazard. Given another house $j$, the hazard ratio takes the form

$$\frac{\theta_i(t; x)}{\theta_j(t; x)} = \exp(\Delta x^* \xi) ,$$

where $\Delta x$ is the difference between the covariates associated with the two houses. The Cox model is semiparametric because estimation of $\xi$ does not require one to specify the functional form of the underlying hazard $\theta_0(t)$.

All three specifications are examples of proportional hazard models. This model class is particularly useful because it enables researchers to compute easily how the hazard rate of otherwise identical houses varies with changes in one of the covariates. For example, in the Cox model, if $x_i$ is the mortgage interest rate (in percentage terms), then $\exp(x_i)$ is the relative likelihood that the same house will sell when the interest rate is one percentage point higher.

**Data and Results**

The data are from East Bay Regional Data (EBRD), a multiple listings service that covers Alameda County, Contra Costa County, and parts of Solano County. EBRD collects these data for, among other purposes, calculating the median house price in a given market, tracking the volume of sales, and providing member realtors with data to price houses using comparables. The data range from winter 1992 to spring 1998. This sample period corresponds to nearly one complete real estate cycle for the Bay Area.

I use data from six adjacent East Bay municipalities: Alameda, Albany, Berkeley, Emeryville, Oakland, and Piedmont. The raw dataset contains 29,305 observations. Of this total, 14,303 (49 percent) of the listings culminated in sales. The remaining listings were either allowed to expire or were withdrawn by the seller. In cases of withdrawals and expirations, the observation is treated as right-censored at the termination date. There are many instances where an owner lists a house, withdraws it, and then relists the house later. In this case, I treat the first listing as a censored observation and calculate time on the market to be the time elapsed between the second (or final) listing and the sale.

Each observation in the dataset includes the original list price, the final sale price, as well as property-specific information such as the address, the type of structure (single-family detached or condominium) the number of baths, the number of bedrooms, square footage, age, and whether or not the property is covered by a homeowner’s association. The dataset also includes the dates of original listing, the pending date or the date escrow is opened, and the closing date. For this study, time on the market corresponds to a marketing time. Thus, time on the market is calculated as the time elapsed between the original listing and the pending date. Summary statistics of the variables are set forth in Table 1.

The theory presented here suggests that time on the market depends on the aggregate state of the economy. In practice, the relevant set of state variables will include local economic variables and financial market variables. Homebuyers require a downpayment in order to purchase a house. Accordingly, variables that contribute to household wealth, such as the growth in personal income and the growth in employment, are candidates for covariates. Of these two variables, housing economists traditionally concentrate on the growth in local employment, because job creation not only adds to household wealth, but also stimulates housing demand due to the migration of households into the market to fill the newly created jobs. Growth in employment also may reflect an increase in local productivity, which should affect house prices if land is a part of the production function. The job growth data are provided by the Bureau of Labor Statistics.

As can be seen in Figure 5, Bay Area job growth has risen steadily over the course of the sample period. Leading into the hot market, local job growth was dramatic, eclipsing the national average.

Financial market variables also will affect the housing market because most people finance their housing purchases. Thus, the level and expectations about future mortgage interest rates will be important in the housebuying decision. The mortgage interest rate data used in this study are taken from Freddie Mac’s (Federal Home Loan Mortgage Corporation) primary mortgage market survey. Figure 6

---

8. The second list price is usually, but not always, lower than the first. Anecdotally, realtors report that sellers who withdraw a house often times perform mild renovations before relisting, such as painting the interior or improving the landscaping.

9. The Bay Area reporting region consists of San Francisco, Oakland, San Jose, Santa Rosa, and Vallejo-Fairfield-Napa MSAs.
TABLE 1

**Summary Statistics**

**Sample Characteristics of Houses Sold, 1992–1998**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bedrooms</td>
<td>2.70</td>
<td>0.94</td>
<td>1</td>
<td>9</td>
</tr>
<tr>
<td>Bathrooms</td>
<td>1.61</td>
<td>0.73</td>
<td>1</td>
<td>7</td>
</tr>
<tr>
<td>Square feet</td>
<td>1,575</td>
<td>744</td>
<td>420</td>
<td>11,067</td>
</tr>
<tr>
<td>Age</td>
<td>58</td>
<td>31</td>
<td>0</td>
<td>99</td>
</tr>
<tr>
<td>List price</td>
<td>244,354</td>
<td>171,287</td>
<td>14,900</td>
<td>3,950,000</td>
</tr>
<tr>
<td>Sold price</td>
<td>237,340</td>
<td>165,244</td>
<td>10,000</td>
<td>3,300,000</td>
</tr>
<tr>
<td>Time on market</td>
<td>68</td>
<td>78</td>
<td>1</td>
<td>816</td>
</tr>
<tr>
<td>Condominium</td>
<td>0.144</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>List in summer</td>
<td>0.268</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Observations</td>
<td>14,303</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**FIGURE 5**

**Annual Job Growth**

Source: Bureau of Labor Statistics

**FIGURE 6**

**Effective Cost of Mortgage Finance**

Source: FHLMC
plots the benchmark mortgage rate plus an adjustment for points charged. I have assumed that one point is worth ten basis points. I use this composite measure rather than each variable separately because there appears to have been a break in the points series during the winter of 1997—precisely the time when the Bay Area real estate market was heating up.

Ignored in the analysis up to this point is the notion that the real estate market is highly segmented by type and quality of the housing unit. Most realtors will testify that high priced houses and houses with unusual configurations have a longer waiting time on the market—allegedly because the demand is much thinner in these submarkets. No such segmentation exists in the theoretical model. However, it is possible to recast the degree of heterogeneity in housing segmentation exists in the theoretical model. However, it is possible to recast the degree of heterogeneity in housing characteristics either as a statement about the distribution of the housing service flow ε or as a statement about the waiting time until a potential buyer visits the house for sale. That is, it is possible to assume that potential buyers for a certain type of house arrive every period. Either way, in equilibrium, thinning out the market should cause the expected time on the market to increase.

Empirically, we can study how time on the market depends on features of the house in question by constructing an index that measures the degree to which a house is unusual. Following Haurin (1988), this index takes the form

\[ I_i = \sum_{j=1}^{J} \phi_j | h_{ij} - \bar{h}_j |. \]

In this specification a house i is defined by j different characteristics. The atypicality of house i is measured by the sum of the absolute deviations of the house’s characteristics from the sample means of the characteristics. These deviations, in turn, are weighted by the shadow prices of the house characteristics, \( \phi_j \). I assume that the shadow prices can be estimated from the hedonic pricing function

\[ p_i = \phi_0 h_{i0}^{q_0} h_{i1}^{q_1} \cdots h_{ij}^{q_j}. \]

The results from the hedonic regression are in Table 2. The price and house characteristic variables are in logs. I also included dummy variables for the year and season of listing.

The good fit and statistical significance of the explanatory variables in the table are typical of hedonic regressions. On the whole, the signs of the regression coefficients are not surprising. For example, houses with more square footage and more bathrooms command higher prices. The coefficient on the bedroom to square footage ratio is negative. At first, this may seem puzzling as houses with more bedrooms might be thought to be more valuable. However, a large number of bedrooms per square foot is an indicator that the house may be a rental property. The age of a house has a negative effect on its price. The interpretation of the age coefficient, however, is complicated. On the one hand, old houses can fall into disrepair or may not offer the same kitchen size or amount of closet space as more modern houses do. Alternatively, age also can serve as a proxy for an established neighborhood and have a positive effect on the house price.

In the specification above, prices are allowed to vary over time. But note that house characteristics are held constant. Wallace (1996) points out that new construction and remodeling can lead to large changes in the means of housing characteristics. We can imagine similar problems of drift over time if we were to generalize the hedonic function to include quality of life variables. While the East Bay has a dynamic housing market, it is unlikely that these mean shifts are important over this relatively short sample period.

### Table 2

<table>
<thead>
<tr>
<th>VARIABLE</th>
<th>COEFFICIENT</th>
<th>STANDARD ERRORS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>4.827</td>
<td>0.107</td>
</tr>
<tr>
<td>Bathrooms</td>
<td>0.147*</td>
<td>0.012</td>
</tr>
<tr>
<td>Bedrooms/sq feet</td>
<td>-0.181*</td>
<td>0.015</td>
</tr>
<tr>
<td>Square feet</td>
<td>0.904*</td>
<td>0.015</td>
</tr>
<tr>
<td>Age</td>
<td>-0.065*</td>
<td>0.004</td>
</tr>
<tr>
<td>Condominium</td>
<td>-0.113*</td>
<td>0.012</td>
</tr>
<tr>
<td>Piedmont</td>
<td>0.488*</td>
<td>0.021</td>
</tr>
<tr>
<td>( \bar{R}^2 )</td>
<td>0.61</td>
<td></td>
</tr>
<tr>
<td>( F(14, 14288) )</td>
<td>1.567</td>
<td></td>
</tr>
</tbody>
</table>

* Statistically significant at the 1% level.

Model Estimation

Once the atypicality variable has been constructed, it is possible to study the effects of various economic factors on time on the market. The estimation results are set forth in Table 3. All models are estimated by maximum likelihood.

The parameter estimates in Table 3 reflect the influence of the covariates on the hazard rate. Thus, a positive coefficient implies that the covariate is positively related to liquidity. The first point to notice is that, not only are the signs

of the estimated coefficients the same across the three different model specifications, but the estimates themselves are quite similar. Recalling that the exponential hazard model is just a special case of the Weibull model when \( \alpha = 1 \), we might think that the similarity in the coefficients is evidence in favor of the exponential hazard. However, a formal test of the hypothesis that \( \alpha = 1 \) is rejected.\(^{11}\)

As expected, the degree to which a house is atypical harms the liquidity of the asset. But note that the measured effect of atypicality is extremely small in all three models. We must bear in mind, however, that this coefficient does not imply that adding another bathroom reduces the house’s liquidity.

Whether or not the house is in Piedmont has a positive effect on liquidity. This is not surprising, as Piedmont is thought to be a desirable place to live for, among other reasons, the quality of its schools. The statistical significance of this location-specific variable does, however, serve as a reminder that neighborhood effects are important in real estate markets and can create omitted variable problems in statistical estimation.

Intuitively, high interest rates reduce the purchasing power of potential buyers in the market, and the data clearly support this notion. The coefficient on the effective cost of mortgage finance is \(-0.334\) and is statistically different from zero. This result suggests that when interest rates rise and housing becomes less affordable, sellers do not automatically lower their prices so as to maintain the liquidity of the market.

The term spread is defined to be the difference between the yield on the 30-year Treasury bond and the 3-month Treasury bill at the time of sale. This variable is meant to capture expectations about the future path of interest rates. If the expectations hypothesis is correct, then a steeply sloped term structure suggests that short-term rates will rise in the future. Of course, if the slope of the term structure is steeply sloped, then long-term interest rates (i.e., mortgage interest rates) also are likely to be high, and we might expect the coefficient on the term spread variable to be negative. However, the level of long-term rates is already controlled for by the mortgage interest rate variable. The positive coefficient on the term spread can be interpreted to mean that sellers are anxious to execute their trades before an expected change in rates. Thus, they are anxious to execute their trades before the change in state. Sellers price their houses so that they are liquid, and buyers search less.

The other local economic variable expected to influence the housing market is a measure of changes in wealth. While income growth and consumption in a narrowly defined region are difficult to measure accurately, employment growth is measured relatively more cleanly. In all three model specifications, the estimated coefficient on job growth is positive—markets that have experienced recent growth tend to be more liquid. Job growth affects the housing market directly by its impact on demand. New jobs often draw new workers into the area who will need housing. New jobs also might reflect a strong and stable economy, prompting existing homeowners to trade up. The link to the theory is that in settings where housing demand is strong, it is optimal for sellers to price their houses so as to be liquid.

One particularly useful feature of the Cox model is that the estimated coefficients can be used to calculate relative odds ratios. To do this, we compare the estimated hazard rates for two houses that are identical except for differences in one of the covariates. The covariates of primary interest are the two external covariates—the job growth variable and the interest rate variable. The experiment is to compare house liquidity at the height of the hot market (7 percent effective interest rate and 3.5 percent job growth) to predicted liquidity when these covariates take on their

\[^{11}\) The 95% confidence interval for \( \hat{\alpha} \) is [0.79, 0.81].
mean values. I also look at liquidity for a cold market scenario (10 percent interest rate and zero percent job growth). The results from this exercise are contained in Table 4.

For the case of single-family detached housing, a house is 1.34 times more likely to sell on any given day if the effective mortgage rate is 7 percent than it would if it were for sale when the effective rate was the sample average of 8 percent. Similarly, a 10 percent effective mortgage rate makes the house only 0.55 times as likely to sell on a given day, relative to the sample average. The estimated hazard rate is much more sensitive to interest rates than it is to job growth. For single-family houses, a house that is selling when the six-month job growth rate has been 3.5 percent (annualized) is 1.18 times more likely to sell than if it were listed during a time with average job growth (1.9 percent).

One interesting piece of evidence that emerges from the analysis is confirmation that the single-family housing market and the condominium market behave differently over the course of the real estate cycle. In terms of time series averages, the mean time on the market for a house is 95 days, while the mean time for condominiums is 124 days. The two markets also behave differently with respect to shocks. Note from Table 4 that the job growth sensitivities of the two markets are comparable, with the single-family housing liquidity slightly more volatile with respect to changes in the job growth rate. The responses of liquidity are more pronounced to interest rate shocks. The per period probability of sale of a condominium is 1.41 times higher when the effective mortgage rate is 7 percent, as opposed to a house that is 1.34 times as likely to sell during this low interest rate environment. This finding seems to agree with the idea that the condominium market has a different clientele from the single-family housing market. Condominium buyers, at least in the San Francisco Bay area, tend to be younger households for whom the binding constraint is meeting a monthly mortgage payment and, in particular, coming up with a downpayment.

**TABLE 4**

<table>
<thead>
<tr>
<th>RELATIVE ODDS RATIOS</th>
<th>HOUSES ONLY</th>
<th>CONDOMINIUMS ONLY</th>
</tr>
</thead>
<tbody>
<tr>
<td>House in Piedmont</td>
<td>1.59</td>
<td>—</td>
</tr>
<tr>
<td>7% effective interest rate</td>
<td>1.34</td>
<td>1.41</td>
</tr>
<tr>
<td>10% effective interest rate</td>
<td>0.55</td>
<td>0.50</td>
</tr>
<tr>
<td>Zero job growth</td>
<td>0.83</td>
<td>0.86</td>
</tr>
<tr>
<td>3.5% job growth</td>
<td>1.18</td>
<td>1.14</td>
</tr>
</tbody>
</table>

**NOTE:** Standard errors are in parentheses.

---

**Robustness**

Two primary questions arise from the empirical work. First, it is striking that the relationship between house characteristics and time on the market is so weak. In part this finding reflects the fact that large, atypical houses make up only a small fraction of the total observations in this sample. Perhaps understandably, final transaction data involving these houses often goes unrecorded. It is also possible that this weak relationship is due to the atypicality measure itself. One way to test whether the atypicality index is an adequate way of summarizing the relevant information about house characteristics is to insert observed house characteristics directly into the hazard function and study their influence on the hazard rate. Table 5 contains the estimates of the hazard function when the atypicality index is replaced by the number of bathrooms, the ratio of bedrooms to square footage, and the number of square feet.

Table 5 reveals that the coefficient estimates on the number of bathrooms and the square footage are not statistically significant from zero. In contrast, there is a strong negative relationship between liquidity and the ratio of bedrooms to square footage. This is not too surprising, as we already noted in the hedonic regression (Table 2) that this variable was strongly related to price. The estimated coefficients on the job growth variable are not markedly different from the specification where atypicality was measured by a single index. It is interesting, however, to note in Table 5 that the interest rate coefficients are much smaller in absolute value than in the original specification.

A second critique of the empirical work is that the estimated relationships between house marketing times and the covariates may not be robust, but rather are influenced by a low frequency time trend in the data. Recalling Figure 1, there has been a downward trend in the time on the market series beginning in the winter of 1994 and persisting to the end of the sample period in 1998. To address this concern, I add a time trend to the list of covariates and reestimate the models in Table 3. The results are contained in Table 6.

Once again, the coefficient on the atypicality index is insignificantly different from zero. The estimated coefficients on the interest rate and job growth variables retain the same signs as before. However, the estimated coefficients on the interest rate variables are slightly smaller in absolute value than in Table 3. The relationship between the job growth

---

12. It is possible to argue that the house characteristics collected in this dataset—the number and kinds of rooms and the size—are not the most important characteristics. Characteristics such as the neighborhood quality, nearby amenities, and other intangible qualities will influence price and liquidity, but remain essentially unobservable to the econometrician.
variable and liquidity is strengthened when a time trend is included in the hazard function. While these differences in coefficient estimates appear to be small, the differences are important in economic terms. Recall from the odds ratio exercise in Table 4 that changes in liquidity due to a unit change in the value of a covariate, say $x_1$, is calculated not as $\xi_1$, but as $\exp(\xi_1)$.

III. CONCLUSION

In this paper I develop a search model of the real estate market where prices and liquidity are determined endogenously. When the value of the housing service flow is allowed to fluctuate, liquidity also fluctuates. In periods when the housing service flow is high, sellers do not raise their prices to take full advantage of the increase. Rather, they demand greater liquidity so as to complete the sale before the market turns against them. In periods when the housing service flow is low, sellers do not drop their prices in order to achieve the same amount of liquidity as in the hot market. Rather, prices are sticky because sellers find it optimal to “fish” for a buyer who attaches an unusually high private value to the house. This fishing takes time, and the market becomes cold. This behavior by sellers is optimal because the opportunity cost of failing to sell in a cold market is relatively low—a seller can always wait until the next period hoping to sell in a better market.

Using data from the San Francisco Bay Area, I search for variables that drive the value of the housing service flow postulated in the theoretical section. I establish a statistical link between time on the market and the interest rate, the slope of the term structure, and the job growth rate. I detect a weak relationship between liquidity and the degree to which a house is atypical.
REFERENCES


One of the striking characteristics of the recent currency crises in East Asia is the sharp reductions in output that followed depreciations. This paper draws on an earlier literature on contractionary depreciations to motivate an empirical model of the relationship between exchange rate and output fluctuations in a panel of six East Asian economies. There is evidence of a negative relationship between economic activity and the real exchange rate in East Asia. Informal examination of output fluctuations around episodes of sharp depreciation over the 1975–1996 period conveys the impression that such episodes are associated with modest expansion and contraction cycles, with output above trend before a sharp depreciation episode and below trend after it. The cyclical pattern is accentuated when the sharp depreciation episode occurs during a banking crisis. The very steep output declines that followed the 1997 sharp depreciation episodes appear to reflect a high concentration of banking crises of unprecedented severity. However, explicitly accounting for sharp depreciation episodes or banking crises does not add to the explanatory power of the benchmark model over the period 1975–1996.

Depreciation and Recessions in East Asia

Ramon Moreno

Senior Economist, Federal Reserve Bank of San Francisco. The author thanks Mary Daly, Mark Spiegel, and participants at a Federal Reserve Bank of San Francisco seminar for helpful comments, and Guillermo F. Pinczuk for research assistance.

The recent currency and financial crises in East Asia have sparked a new round of theoretical and empirical research on the causes of such crises, leading to significant advances in our understanding of these issues. However, there has been relatively little recent discussion of the aftermath of these crises. In particular, one of the striking characteristics of the recent currency crises in East Asia is the sharp reductions in output that followed depreciations. At first glance, this outcome seems counterintuitive, as depreciations are generally expected to boost output.

Recent explanations for closely timed depreciations and output contractions focus on the interaction between external shocks and financial sector disruptions. In this view, low interest rates in industrial economies and sterilized intervention policies that kept interest rates high in emerging markets contributed to a surge in capital flows to the emerging markets in the first half of the 1990s (Calvo, Lederman, and Reinhart 1996). These capital flows supported credit growth and a boom in economic activity in East Asia that was associated with growing financial sector vulnerability. Financial liberalization also may have played a role in financial vulnerability (Diaz Alejandro 1985, Kaminsky and Reinhart 1999). According to these explanations, the unprecedented contractions in output observed in East Asia following the currency depreciations of 1997 were the result of financial crises. These in turn were caused either by panics in illiquid financial systems (Chang and Velasco 1998, Radelet and Sachs 1998) or by moral hazard that made financial systems vulnerable to shocks because of excessively risky lending or unhedged foreign currency borrowing (McKinnon and Pill 1998, Krugman 1998, Corsetti, Pesenti, and Roubini, 1998).

While the relationship between financial crises and currency crises in East Asia in 1997 is very evident and is broadly consistent with the experience in other emerging markets (Kaminsky and Reinhart 1999), the characteristics of past depreciations in East Asia—and their implications

---

1. For a recent overview of this literature of stylized facts around currency crises episodes, see IMF (1998). Glick and Moreno (1998) and Moreno (1999) discuss the predictive ability of alternative macroeconomic indicators on the eve of currency crises in East Asia. For discussions of the causes of these crises see also Corsetti, Pesenti, and Roubini (1998), Radelet and Sachs (1998), and Chang and Velasco (1998).
for output behavior—have not been so closely studied. In particular, it is of interest to inquire whether depreciations have been associated with output contraction in East Asia in the past, and whether currency and banking crises have played a significant role in explaining output fluctuations.

To address these questions, we draw on an earlier literature on contractionary depreciations to motivate an empirical model of the relationship between exchange rate and output fluctuations in a panel of six East Asian economies.

This paper is organized as follows. Section I discusses alternative ways in which a reduced-form relationship between the real exchange rate and output may be derived and interpreted and conditions under which contractionary depreciation may occur. Section II estimates regression models of the relationship between exchange rate behavior and output fluctuations. Section III highlights the behavior of exchange rates and output around periods of sharp depreciation and banking crises and extends the model to control for episodes of currency crises and banking crises. Section IV offers some conclusions.

I. Models of Contractionary Depreciation

To motivate the analysis of contractionary depreciations, consider the following reduced-form model of the relationship between the real exchange rate and output:

\[
y - \bar{y} = \tau_1(e - \bar{e}) + \tau_2(m - \bar{m}) + \tau_3(g - \bar{g}) + \tau_4(y^* - \bar{y}^*) + \tau_5(r^* - \bar{r}^*) + \xi,
\]

where bar superscripts refer to expected or trend values and

- \( y \) = output
- \( e \) = real exchange rate, measured so that an increase is a depreciation
- \( m \) = money
- \( g \) = government spending
- \( y^* \) = foreign output
- \( r^* \) = world interest rate, and
- \( \xi \) = reduced-form residual.

Equation (1) is broadly consistent with empirical models of contractionary depreciation that have been estimated in the literature, and it provides a reasonably complete description of possible influences to economic activity, as it accounts for domestic monetary and fiscal conditions, as well as external shocks. Researchers have been particularly interested in the coefficient \( \tau_1 \), which measures the direct relationship between the real exchange rate and output. If the coefficient is negative, depreciations are contractionary. Using panel data from developing countries Edwards (1989) and Agenor (1991) estimate equations similar to equation (1) and find evidence suggesting that depreciations are contractionary. As we shall see, \( \tau_2 \) and \( \tau_3 \) also may be affected by contractionary depreciation effects.

As much of the discussion that follows will focus on the derivation and interpretation of the first three coefficients of equation (1), it is worth discussing the external shocks briefly. The coefficient \( \tau_4 \) reflects the impact of foreign economic activity on domestic output, and its sign is expected to be positive.

The coefficient \( \tau_5 \) reflects the impact on domestic output of global interest rate shocks, which may occur through international capital flows and which is likely to be negative. A rise in world interest rates reduces capital inflows and may adversely affect investment demand and output. Research by Calvo, Leiderman, and Reinhart (1993, 1996) suggests that global interest rate shocks are important contributors to capital flows in developing countries. Agenor and Hoffmaister (1998) confirm that these results carry through in the East Asian context. Using VAR models, they find that world interest rates have a significant impact on capital flows and the real exchange rate in Korea, the Philippines, and Thailand. Agenor (1998) develops an intertemporal optimizing model that spells out the conditions that determine the impact of global interest rate shocks on capital flows.

Before estimating equation (1), two questions are worth addressing. First, what explanations may be offered for contractionary depreciation effects? Second, what type of macroeconomic framework is consistent with the reduced-form specification used in equation (1), and what do these models say about the signs of the various coefficients? In particular, to what extent can equation (1) be reconciled with equilibrium optimizing behavior by rational agents?

In the discussion that follows, we will review how the literature has addressed these questions by focusing on two models. One model, by Agenor (1991) shows how contractionary depreciation effects may reduce aggregate supply because of the use of imported inputs in production. Another model, by Gavin (1992) shows how depreciation may have a contractionary influence on demand if there is investment spending on imported capital goods. Thus, the two models provide complementary interpretations of equation (1). Agenor’s model will be discussed in some detail to provide a benchmark for alternative interpretations and to highlight the contributions and limitations of the literature on contractionary depreciation. We also will briefly discuss alternative explanations of contractionary depreciation effects, the difficulties associated with incorporating...
contractionary depreciation effects in fully specified intertemporal optimizing models, and the possible implications of sharp depreciation episodes and banking crises.

Depreciation Effects with Imported Inputs

Following Agenor (1991), consider a small open economy with a fixed exchange rate and a perfectly elastic supply schedule for imports. Two composite goods which are imperfect substitutes are traded in the economy, one produced domestically and the other produced abroad. The foreign good is both consumed and used as an intermediate input in production. Its foreign currency price is determined in world markets.

The analysis of the effects of depreciations on output proceeds in three stages. First, the behavior of producers is described in order to derive the demand for imported inputs and labor. Second, labor market equilibrium is derived, which permits a description of how shocks to prices, the real exchange rate, and productivity affect the supply of output. Finally, a simple ad hoc model of aggregate demand is introduced, which, when equated to aggregate supply, yields the relationship between the real exchange rate and output when markets clear.

Producers

Domestic output is produced using imported inputs \((N)\), and value added by a CES production function. Value added \((V)\) in turn is produced using labor \((L)\) and capital \((K)\) with Cobb-Douglas technology. The capital stock is fixed in the short run. That is,

\[
Q = B[\alpha N^\rho + (1 - \alpha)(L^{1 + K^\nu})^\rho]^{1/\rho} \exp(\varepsilon),
\]

\(0 < \rho < 1; 0 < \nu < 1,\)

where \(Q\) is the gross output of domestic final good in levels, \(B\) is a multiplicative constant, \(\varepsilon\) is a white noise productivity shock, and \(\nu\) is the share of capital in the production of value added.

Risk-neutral producers maximize expected profits by choosing short-run inputs \(N\) and labor \(L\). Using a log-linear approximation of equation (2) and taking the first-order conditions yields the derived demand for labor that depends on the real wage (deflated by the price level of the producer), the real exchange rate, and the productivity shock:

\[
l^d = -(1/\nu)(w - \rho_e) - (c_1/\nu c_2)e + (\varepsilon'/\nu c_2),
\]

where \(w\) is the log nominal wage, \(\rho_e\) is the log producer price for the domestic good, \(c_1 = \alpha(\bar{Q}/N)\) is the share of imported materials \((0 < c_1 < 1), c_2 = (1 - \alpha)(\bar{Q}/L)\) is the share of domestic value added \((0 < c_2 < 1, c_1 + c_2 = 1), e = (s + p_n - \rho)\) is the log of the real exchange rate, and \(s\) is the log nominal exchange rate.

The derived demand for imported raw materials depends on the same three variables:

\[
n^d = \left[\frac{(1 - v)}{\nu} - \left(\frac{1}{c_2}\right)\left(\sigma + c_1 \left(\frac{1 - v}{\nu}\right)\right)e\right] + \left(\frac{1}{\nu c_2}\right)\left(\sigma + (1 - v)\right)\varepsilon',
\]

where \(\sigma = 1/(1 + \rho) > 0\) is the elasticity of substitution between imported inputs and value added.

In equations (3) and (4), a real depreciation reduces the demand for labor and imported inputs, illustrating how contractionary depreciation effects arise in this model. In addition, the demand for imported intermediate goods are more sensitive to real exchange rate changes the greater the weight of imported raw materials in the production function.

Labor Markets

In order to guarantee that demand affects output, labor supply is assumed to depend on the expected (rather than the actual) real wage:

\[
\bar{p} = \beta(w - \bar{p}), \beta > 0,
\]

where \(\bar{p}\) is the log of the price level expected in the current period.

Equating labor supply (5) to labor demand (3) and using the first-order conditions for profit maximization yields expressions for labor demand and labor supply that depend on price surprises, the real exchange rate, and the productivity shock. These in turn can be used to obtain net output supply in terms of final goods:

\[
y^* = \gamma_1(p - \bar{p}) + \gamma_2 e + \gamma_3 e',
\]

where it can be shown from the profit maximization and the labor supply conditions that \(\gamma_1 > 0, \gamma_2 < 0, \text{and } \gamma_3 > 0.\)

---


5. It is worth noting that while firms react to the price of their own output \((p_e)\) in maximizing profits, workers react to the expected overall price level, \(\bar{p}\), since consumption depends on the price of the basket of consumption goods. The overall price level in logs is \(p = \delta \bar{p} + (1 - \delta)(s + p_n)\).

6. This involves substituting the labor and input demands into the log-linear version of the production function and then subtracting inputs from aggregate supply.
The supply side of the model has the property that price “surprises” have a positive impact on output, a “Phillips curve” relationship that is consistent with rational equilibrium behavior if agents cannot easily distinguish between aggregate and relative price shocks (Lucas 1972). This feature of the model allows shocks to aggregate demand to influence output, in the manner described below.

A real exchange rate depreciation has two main effects on the supply side. First, by increasing the relative price of the imported input expressed in domestic currency, it leads to a fall in the real wage, tending to increase output. Second, producers reduce the demand for labor and imported inputs, producing a fall in output.

To obtain a specification more in line with our estimation strategy (based on taking deviations from expected values or trend of all variables), we depart from Agenor (1991) to define the expected component of output supply in equation (6) as the value of output when the right-hand side variables are at their expected levels. In this case, we have

\[ \bar{y} = \gamma_2 \bar{e}. \]

Subtracting the expected output (7) from (6), we obtain the equation for deviations of output supply from its expected level:7

\[ y^d = \gamma_1 (p - \bar{p}) + \gamma_2 (e - \bar{e}) + \gamma_3 \varepsilon. \]

### Aggregate Demand

Aggregate demand depends on domestic and foreign conditions, according to the following reduced form equation:

\[ y^d = b_1 e + b_2 (m - p) + b_3 (g - p) + b_4 y^* + b_5 r^* + \varepsilon, \]

where \( e \) is the real exchange rate, \( m - p \) is real balances, \( g - p \) is real government spending, \( y^* \) is foreign real output, \( r^* \) is the foreign real interest rate, and \( \varepsilon \) is white noise. Equation (9) is Agenor’s (1991) aggregate demand specification expanded to take into account the world interest rate. The signs on the coefficients \( b_1 \) to \( b_4 \) in equation (9) are assumed to be positive. The sign of \( b_5 \) is ambiguous, but is likely to be negative. The plausibility of these assumed signs is discussed further below.

Equating aggregate demand (9) to aggregate supply (6), and manipulating the equation yields a reduced form expression for the determinants of deviations from expected output that corresponds to equation (1).8 The model implies that \( \tau_2, \tau_3, \tau_4 > 0 \), and \( \tau_5 < 0 \), as the signs of these coefficients are determined by the aggregate demand coefficients in equation (9).

As for \( \tau_1 \), it has an ambiguous sign because it combines the contractionary effects of the real exchange rate on supply with the effects on demand, which are assumed to be expansionary.

### Depreciation Effects on Investment Demand

Agenor (1991) extends an earlier literature that highlights how contractionary depreciation effects may arise on the supply side, by introducing aggregate demand effects in an economy where workers react to price surprises. However, the aggregate demand specification he uses describes neither the underlying consumer and investor behavior nor the transmission mechanism by which policy shocks influence output through the exchange rate. Such effects may imply that the signs of the coefficients on the money and government spending variables in equation (1) are not those suggested by Agenor’s model.

Gavin (1992) sheds light on a number of these questions by developing an open economy macroeconomic model in which investment decisions by rational agents are explicitly described. He also illustrates another channel by which contractionary depreciation effects may arise. In Gavin’s model, firms can convert domestically produced goods or imported goods into an investment good. The static optimization decision of firms implies that a share of investment expenditure falls on imported goods. This share is negatively related to the terms of trade, which is the ratio of the price of domestically produced goods to that of imported goods. As the terms of trade are the same as the real exchange rate in this model, the discussion that follows will refer to real exchange rate depreciation (a terms-of-trade deterioration).

---

7. Note that equation (7) is a simplified description of the expected level of output. In a more general specification, expected output would depend on other factors, notably an upward trending productivity component. We do not add this component as it would complicate the algebra without adding insights to our analysis of contractionary depreciation. In any case, the issue is addressed in our empirical analysis by taking deviations from a Hodrick Prescott trend.

8. Equating aggregate demand (9) to aggregate supply in equation (6), yields an expression for the price level. This expression can be used to take expectations and solve for \( \bar{p} \). Subtracting the resulting expectations from the actual price level yields the unanticipated movements in domestic prices. Substituting these into (8) yields (1). The estimating equation (1) differs from Agenor’s (1991) equation. Agenor focuses on the actual level of output rather than on deviations from the expected level and estimates versions of the following equation:

\[ y = \tau_1 (e - \bar{e}) + \tau_2 (m - \bar{m}) + \tau_3 (g - \bar{g}) + \tau_4 (y^* - \bar{y}^*) + \tau_5 (r^* - \bar{r}^*) + \tau_6 \varepsilon + \xi. \]

We estimate equation (1) instead because it allows us to transform all the variables in a similar manner to achieve stationarity.
Firms also maximize the present value of anticipated future cash flow. This forward-looking optimizing behavior allows the analysis of the short-run and long-run effects of permanent and temporary depreciations. The first-order conditions imply that net investment is an increasing function of Tobin’s $q$, the ratio of the firm’s shadow value of installed capital (typically represented by the market value of capital) and the replacement cost of capital. The precise effects of depreciation on investment are influenced by the fact that the numerator of Tobin’s $q$ depends on the anticipated real exchange rate, while the denominator depends on the current real exchange rate.

If there is some import content to investment, a permanent depreciation in the real exchange rate causes a reduction in the stock market valuation of domestic capital, because the value of the goods which the capital is used to produce has fallen in world markets. The result of depreciation is then a fall in Tobin’s $q$ and a decline in investment.

In the case of a temporary real depreciation that is sufficiently short, Tobin’s $q$ may rise and investment will increase because investors know that the price of output will recover and they will want to buy investment goods while the price is still cheap. However, the precise effect depends on the import content of investment. If all capital goods are imported, investment will be adversely affected by a real depreciation, no matter how short-lived. On the other hand, if no capital goods are imported, investment either responds favorably to an exchange rate depreciation or is unaffected (if the shock is permanent).

Gavin embeds his investment model in an open economy Keynesian framework and derives the effects of permanent and temporary monetary and fiscal policy shocks. Assuming sticky prices, a monetary expansion causes the real exchange rate to depreciate. Investment will tend to drop if the share of investment spending that falls on imported goods is large enough, and the duration of the monetary shock is sufficiently long. Thus, if some investment spending falls on imported capital goods, a monetary expansion, by causing a depreciation, may be contractionary.

In contrast, a fiscal expansion will tend to cause the real exchange rate to appreciate, which may cause investment to rise. Gavin shows that this requires that the share of spending that falls on imported goods be large enough and the duration of the fiscal shock be sufficiently long. Thus, fiscal stimulus tends to “crowd in” domestic investment by this channel, reinforcing the direct expansionary effect of a fiscal spending shock on output.10

Gavin’s model illustrates one way in which monetary and fiscal shocks may embed contractionary depreciation effects. Under plausible conditions in which such contractionary effects are present, $\tau_2 < 0, \tau_1 > 0$ in equation (1). In addition, it is clear that the coefficient $\tau_1$ must reflect fluctuations in the real exchange rate that are distinct from those caused by contemporaneous monetary and fiscal shocks, such as global or regional terms of trade shocks.

Taken together, the Agenor (1991) and Gavin (1992) models illustrate how depreciations may have contractionary effects on aggregate supply and demand because of spending on imports. The literature surveyed by Agenor and Montiel (1996) suggests other ways in which depreciations can reduce aggregate output, at least in the short run. These include reducing real income, and therefore consumer demand; reducing wealth and raising real interest rates, which may adversely affect both consumption and investment demand; redistributing income away from groups with a high propensity to spend, so that consumption or investment demand fall; and raising the cost of working capital financing, which would tend to reduce supply.

Although earlier research has advanced our understanding of how contractionary depreciation effects may arise, it is worth bearing in mind that the studies we have reviewed are not based on fully specified dynamic equilibrium models. One obstacle to using such models is that these traditionally have assumed flexible prices. Monetary shocks—which are considered to be an important source of exchange rate fluctuations—have no effect on output unless prices are rigid or there is imperfect information.12 Recent research (Obstfeld and Rogoff 1996, Chapter 10) clarifies the impact of monetary and fiscal policies in open-economy dynamic equilibrium models with sticky prices or wages. However, further research is needed to explain contractionary depreciation effects using such models.

---

9. The model includes the following elements: (1) saving is modeled as an increasing function of the difference between current disposable income and long-run (steady state) disposable income, (2) money demand depends on the domestic nominal interest rate and the level of output, and (3) inflation is a decreasing function of the gap between the domestic price level and its long-run steady state level (sticky prices).

10. Seven (1995) confirms the crowding-in impact of fiscal policy in a model with an investment sector very similar to that described by Gavin but in which agents optimize consumption over their lifetimes.

11. This effect is implicit in the Agenor (1991) model.

12. Calvo and Vegh (1999) describe equilibrium models in which an anticipated increase in the rate of devaluation can generate cyclical fluctuations in output. However, these fluctuations do not reflect contractionary devaluation effects of the kind discussed in the text.
Sharp Depreciation Episodes and Output Contraction

Our discussion so far has not focused on the implications for economic activity of sharp depreciation episodes or currency crises, which is one of the original motivations of the literature on contractionary depreciation. However, neither “first generation” (Krugman 1979) nor “second generation” (Obstfeld 1995) currency crisis models suggest any direct contractionary effects of currency crises. “Third generation” models, developed in the wake of currency crises and steep output contractions in Mexico in 1994 and in East Asia in 1997–1998, do suggest that sharp depreciation episodes may lead to output contraction by disrupting the operation of the financial sector.

There is disagreement on the reasons for the financial sector disruption. Some authors (Chang and Velasco 1998, Radelet and Sachs 1998) argue that economies that become open to foreign borrowing may become increasingly illiquid, even in a socially efficient equilibrium, making them vulnerable to sudden loss of confidence or panic. Others (Burnside, Eichenbaum, and Rebelo 1999, Corsetti, Pesenti, and Roubini 1998, Krugman 1998, McKinnon and Pill 1998) argue that government guarantees encourage risky behavior (moral hazard), and make the financial system vulnerable to shocks. In particular, moral hazard may encourage unhedged foreign currency borrowing that accentuates contractionary depreciation effects.

As sharp depreciation episodes and financial crises are relatively rare, it is not clear that output fluctuations around such episodes can be fully predicted by equation (1). We address this issue in more detail in our empirical analysis.

II. EMPIRICAL ANALYSIS

To test for the presence of contractionary depreciation effects in East Asia, we estimate the following version of equation (1):

\[ (z - \bar{z})_{it} = \tau_1(e - \bar{e})_{it} + \tau_2(m - \bar{m})_{it} + \tau_3(g - \bar{g})_{it} + \tau_4(y^* - \bar{y}^*)_{it} + \tau_5(r^* - \bar{r}^*)_{it} + \xi_i, \]

where

- \( z \) = log of real GDP, consumption, or gross investment from the national income accounts
- \( e \) = log of real trade-weighted exchange rate against the dollar, the yen and the deutschmark, adjusted by CPIs
- \( m \) = log of nominal M2
- \( g \) = log of ratio of government spending over CPI

\( y^* \) = trade-weighted industrial production of U.S., Japan, and Germany (see Data Appendix), and

\( r^* \) = real U.S. federal funds rate.

The coefficients of interest are \( \tau_1 \) and \( \tau_4 \), which may be negative if contractionary depreciation effects are present. Equation (10) was estimated using panel data for a sample of six East Asian economies over the period 1975–1996. Further details on the data are provided in a Data Appendix.

In equation (10) the variables are expressed as deviations from some anticipated value. We estimate Hodrick Prescott trends (with the penalty parameter set at 100, reflecting our use of annual data) to proxy for the anticipated values of output and the remaining variables in equation (10). This trend specification, which is widely used in the analysis of business cycles, has a number of advantages. First, since it is a measure of trend behavior, it is a plausible proxy for the expected value of a series. In this case, the trend is stochastic and is assumed to vary (gradually) over time. Second, the Hodrick Prescott trend does not require too much knowledge of theory, which is an advantage given that we are using a reduced form and that the literature has not advanced to the point of deriving contractionary depreciation effects from fully specified dynamic equilibrium models. Third, country-specific fixed effects are eliminated because we are taking deviations from the trends of each country series. (As expected, an F test does not reject the null hypothesis that country-specific dummies are zero and equal to each other.)

Estimation of equation (10) raises questions about the direction of causality. An increase in output can cause the real exchange rate to appreciate, which would imply simultaneous equation bias. Nominal M2 and real government spending also may respond contemporaneously to output behavior. To control for this, we estimate the model by instrumental variables. The trade-weighted real exchange rate, M2, and real government spending are treated as endogenous. The instruments used in the first-stage regression are a constant, the contemporaneous yen-dollar exchange rate, one lag of the monetary and government spending variables, and the contemporaneous values of foreign trade-weighted industrial production and the U.S. real federal funds rate. These variables are admissible as instruments on the assumption that the foreign variables are exogenous and the lagged domestic variables are predetermined.

Table 1, Panel A reports the results of estimation for the whole sample. In the case where output is the dependent variable (columns 1 and 2), we first report the OLS and then

the instrumental variable regression results. The OLS regressions suggest that shocks to real government spending and foreign output have an expansionary cyclical effect on output, while the real federal funds rate has a negative effect. In addition, real depreciations are contractionary, as the coefficient on the trade-weighted real exchange rate has a negative sign, significant at 1 percent. Monetary disturbances have no significant effect on output. One interpretation, suggested by our discussion of Gavin’s model, is that contractionary depreciation effects offset any expansionary effects of monetary shocks. The null hypothesis that the coefficients are zero is rejected at 1 percent for government expenditures and foreign output, and at 10 percent for the real fed funds rate.

The instrumental variable regression in column 2 gives similar qualitative results to the OLS regression; however, the null hypothesis that the coefficient on the real exchange rate is zero can now no longer be rejected, and the estimated coefficient value falls. The real fed funds rate is no longer significant either.

The impact of the explanatory variables on GDP reflects their effects on consumption and investment, which are reported in columns 3 and 4. Inspection of these results suggests that contractionary depreciation effects largely reflect the impact on investment (significant at 5 percent). As for the remaining explanatory variables, shocks to real government spending and foreign output have a significant impact on both consumption and investment. The coefficient on the real fed funds rate is significant at 5 percent in the case of consumption but not significant in the case of investment.

In Table 1, the yen-dollar exchange rate is one of the instruments used in the first-stage regression. To see whether the results are sensitive to the use of this instrument, we replace it by the lagged trade-weighted real exchange rate. The results (not reported in the table) are qualitatively similar. However, the negative coefficient on the real exchange rate is significant at the 7 percent level in the output equation but is not significant in the remaining equations.

**The Effects of Greater Capital Market Integration**

One question of interest is how the growing capital market integration apparent in the 1990s affects the results. In their survey of the sources of contractionary depreciation effects, Agenor and Montiel (1996) observe that in the absence of
capital mobility a depreciation may raise interest rates by reducing wealth, which may in turn reduce investment demand. This additional contractionary effect is absent when capital is mobile, as domestic interest rates are then anchored by world interest rates. The anchoring occurs because the exchange rate depreciation induces capital flows that may stimulate domestic investment spending. Goldberg and Klein (1998) provide evidence that this effect is important in East Asia. They show that after controlling for exchange rate movements of Southeast Asian currencies against the dollar, a real depreciation of Southeast Asian currencies against the Japanese yen is associated with an increase in Japanese direct investment into these economies.

An implication is that greater capital mobility may reduce contractionary depreciation effects. That is, if capital flows were indeed more important in the 1990s, the negative coefficient on the real exchange rate would tend to be larger and more significant before 1990 than over the full sample.

Columns 5–7 of Table 1, Panel B report regression results for the subperiod 1975–1990. The results are qualitatively similar to those reported for the full sample. One striking difference, however, is that the coefficients on the real exchange rate are indeed larger, and, for the real GDP equation, the coefficients now are significant at the 5 percent level. These findings are consistent with the hypothesis that greater capital mobility after 1990 tended to dampen contractionary depreciation effects. One caveat to this interpretation is that the coefficient on the real fed funds rate (columns 2 and 5) provides no additional information as it is insignificant for GDP over both the full sample and the subsample.

Overall, the results reported in Table 1 suggest that the real exchange rate has a significant effect on cyclical fluctuations in economic activity in East Asia. The effects are reflected most consistently on consumption and investment behavior, while the evidence of a significant impact on aggregate output is mixed, being sensitive to the sample period or the instrument used.

III. Sharp Depreciation Episodes, Banking Crises, and Output

As noted earlier, the traditional literature on contractionary depreciation was at least partly motivated by a desire to understand the implications of sharp depreciation episodes in developing countries, rather than the broad relationship between output and real exchange fluctuations that has been examined thus far. Our earlier discussion suggests at least three questions of interest.

First, are sharp depreciation episodes “different,” in the sense of being associated with an unusually sharp output contraction that is not entirely explained by the model estimated so far?

Second, what role have banking or financial crises played in influencing business cycle fluctuations in the region in the past?

Third, how do the 1997–1998 sharp depreciation episodes in East Asia differ from past experience and why?

To address these questions, we first identify episodes of sharp depreciation and banking crises and attempt to assess the relationship between these variables and the cyclical behavior of output.

The criteria for identifying sharp depreciation episodes are based on Frankel and Rose (1996), with some modifications. Using annualized monthly nominal exchange rate data, a sharp depreciation episode is identified whenever an East Asian currency depreciates against the U.S. dollar by more than 25 percent and by more than 10 percentage points than it did over the prior twelve months. To prevent double counting the continuation of the same episode, the data in the year after a crisis are excluded in identifying subsequent crises. In addition, to exclude depreciations that simply reflect the volatility of exchange rates (in which a currency may appreciate and then depreciate very sharply within a short period) we only count as crises those years in which the depreciation from year-end to year-end exceeds 5 percent.14 Fifteen sharp depreciation episodes are identified in this manner over the period 1975–1996, an average of about 0.7 per year. This compares to 6 episodes in 1997 alone (outside the estimation period).

To identify banking crises, we draw on a series used by Glick and Hutchison (1999), who rely on criteria developed by Caprio and Klingebiel (1996) and Demirgüç-Kunt and Detragiache (1998). As a lack of data complicates the identification of banking crises, most studies combine a number of criteria to date their occurrence. These include institutional events such as forced closures, mergers, government intervention in the operations of financial institutions or large-scale assistance to these institutions, bank runs, and balance sheet indicators (nonperforming or problem loans, etc.). According to the Glick-Hutchison data set, there are 18 observations in which banking crises occur

14. Frankel and Rose (1996) use a similar cutoff rule without the year-end condition. Their approach differs from ours because they identify crises using annual average data and a 3-year exclusion window.
in East Asia in the period 1975–1996, an average of nearly 1 per year. This compares to 5 banking crises in 1997 alone.

Figure 1 shows averages of the actual and predicted values for output, consumption, and investment around sharp depreciation episodes for the period 1975–1996. On the horizontal axis the figures show a 6-year window around depreciation episodes, where 0 is the date of the sharp depreciation. On the vertical axis log deviations from trend are reported. The fitted values are for the models reported in Table 1. The actual values are average deviations from trend during currency crises alone and during years in which a currency crisis coincides with a banking crisis.

Figure 1A reveals a cycle of expansion and contraction around sharp depreciation episodes. Periods of sharp depreciation are typically preceded by a cyclical expansion, with actual real GDP above trend. Real GDP falls below trend at the time of the episode and is still below trend in the third year after the episode. The fluctuations span approximately 3.5 percentage points from peak to trough. This may be compared to average growth rates of 7 percent a year over the sample period, ranging from a low of 3.6 percent for the Philippines to a high of 8.4 percent for Korea. The fitted value closely follows the actual before the episode. However, the predicted decline in output at the time of the episode is more moderate and the recovery quicker.

Figure 1B and 1C reveal that real consumption and real investment also follow expansion and contraction cycles around episodes of sharp depreciation, but investment tends to swing much more sharply.

Figure 1 also illustrates fluctuations in economic activity when the sharp depreciation episode coincides with a banking crisis as defined by Glick and Hutchison (1999). The expansion and contraction cycles tend to be more pronounced during such periods, suggesting a significant contractionary impact from banking crises.

To see how the most recent depreciation episodes compare to past episodes, Figure 2 shows actual and fitted values for output around the 1997 depreciation episodes (the coefficient values still correspond to the 1975–1996 period). On the figure’s horizontal axis, 0 corresponds to 1997. There is no fitted value for 1998 because data are incomplete. Figures for real consumption and real investment are not included because of missing data.

As is apparent in Figure 2, the boom in economic activity prior to the 1997 depreciation episodes was much larger than in the past. On average, real GDP peaks 4 percent above trend before the 1997 episodes, compared to about 1 percent for the full set of prior episodes. The model tracks some of the boom in economic activity prior to 1997, but less successfully than it did in prior depreciation episodes. The contraction that followed the depreciation episodes is
similarly unprecedented. Real GDP on average falls over 8 percent below trend in the year after the episodes. This compares to a peak decline of around 3 percent in the aftermath of the full set of sharp depreciation episodes up to 1996, and around 4.5 percent in the aftermath of sharp depreciation episodes accompanied by banking crises.

The figure suggests that one reason why the output contraction in the most recent episode is so large is that it is associated with a large number of banking crises in a short period of time. The 1997 currency collapses were associated with banking crises in five out of six countries affected (83 percent). Prior to that, sharp depreciation episodes and banking crises coincided less frequently, an average of 40 percent of the total of sharp depreciation episodes.

Another reason is that the costs of the most recent banking crises also appear to be much larger than in the past. For example, during the 1980s, according to Caprio and Klingebiel (1996), only two systemic banking crises were identified. One crisis was in the Philippines in 1981–1987, with central bank assistance peaking at about 3 percent of GDP. The other crisis was in Thailand in 1983–1987, at a cumulative cost of about 3.5 percent of GDP over the 5-year period. In contrast, in January 1999, government-issued bonds to finance the restructuring of the financial sector were expected to amount to 38 percent of GDP in Thailand, 25 percent of GDP in Indonesia, and 18 percent of GDP in South Korea (Lane, et al. 1999, Appendix 7.3). As the restructuring of the financial sectors in these economies is not complete, these costs may well be higher.

The figures create a distinct impression that combined episodes of sharp depreciation and banking crisis episodes have a more severe impact on output contractions than is the case for the average of sharp depreciation episodes. However, it remains to be seen whether the effects of these combined episodes on output fluctuations are statistically significant.

Statistical Analysis

To analyze the impact of sharp depreciation episodes and banking crises on output fluctuations more systematically, we create the variable DEPREC, which consists of intercept dummies for years in which a sharp currency depreciation episode occurred and the year after. We also create the variable BKCRISIS, which is taken from a data set of a much larger number of countries used by Glick and Hutchison (1999). The data set contains ones in the years in which a banking crisis is reported and zeros elsewhere. Thus, this variable refers to the entire span of banking crisis episodes rather than the period in which such crises coincide with periods of sharp depreciation, as in the figures.

Table 2 reports the results of regressing output and its components first on DEPREC and BKCRISIS alone, and then on an expanded equation (10) that includes these variables on the right-hand side. For purposes of the present analysis, we treat these episodes as exogenous, determined by factors outside the model. With this caveat in mind, the results in Table 2 suggest the following:

First, taking them in isolation, episodes of sharp depreciation and their aftermath, as well as banking crises, tend to be associated with below-trend real GDP, consumption, and investment. Second, when both sharp depreciation and banking crises are on the right-hand side of the equation, sharp depreciation episodes continue to be associated with below-trend output, consumption, and investment. Banking crises are associated with below-trend consumption, and, more weakly, investment and overall output (columns 3, 6, and 9, respectively). To see whether the sharp depreciation episodes and banking crises provide additional information to that provided by equation (10), we expand that equation to include DEPREC and BKCRISIS on the right-hand side of the equation (these two variables are treated as exogenous in the first-stage regression). The results, reported in Table 3, suggest that once we take into account the behavior of the explanatory variables in equation (10), banking crises have no additional effect on real GDP, while episodes of sharp depreciation
### TABLE 2

**Effects of Sharp Depreciation Episodes and Banking Crises on Economic Activity (OLS)**

<table>
<thead>
<tr>
<th></th>
<th>GDP</th>
<th>Consumption</th>
<th>Investment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>0.01***</td>
<td>8.0 x 10^{-3}***</td>
<td>0.01***</td>
</tr>
<tr>
<td></td>
<td>(0.00)</td>
<td>(0.00)</td>
<td>(0.00)</td>
</tr>
<tr>
<td><strong>DEPREC</strong></td>
<td>-0.03***</td>
<td>-0.02***</td>
<td>-0.03***</td>
</tr>
<tr>
<td></td>
<td>(0.00)</td>
<td>(0.00)</td>
<td>(0.00)</td>
</tr>
<tr>
<td><strong>BKCRISIS</strong></td>
<td>-0.03**</td>
<td>-0.02*</td>
<td>-0.05***</td>
</tr>
<tr>
<td></td>
<td>(0.01)</td>
<td>(0.07)</td>
<td>(0.00)</td>
</tr>
</tbody>
</table>

* * Significant at 10 percent.
** ** Significant at 5 percent.
*** *** Significant at 1 percent.

### TABLE 3

**Sharp Depreciation Episodes and Banking Crises in an Expanded Model of Economic Activity (Instrumental Variables)**

<table>
<thead>
<tr>
<th></th>
<th>GDP</th>
<th>Consumption</th>
<th>Investment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>5.6 x 10^{-3}</td>
<td>5.2 x 10^{-3}</td>
<td>7.1 x 10^{-3}*</td>
</tr>
<tr>
<td></td>
<td>(0.14)</td>
<td>(0.12)</td>
<td>(0.08)</td>
</tr>
<tr>
<td>Real Exchange Rate</td>
<td>-0.08</td>
<td>-0.06</td>
<td>-0.07</td>
</tr>
<tr>
<td></td>
<td>(0.26)</td>
<td>(0.49)</td>
<td>(0.34)</td>
</tr>
<tr>
<td>Nominal M2</td>
<td>-0.01</td>
<td>0.03</td>
<td>5.7 x 10^{-3}</td>
</tr>
<tr>
<td></td>
<td>(0.92)</td>
<td>(0.80)</td>
<td>(0.96)</td>
</tr>
<tr>
<td>Real Government Expenditure</td>
<td>0.18***</td>
<td>0.18**</td>
<td>0.17**</td>
</tr>
<tr>
<td></td>
<td>(0.01)</td>
<td>(0.01)</td>
<td>(0.02)</td>
</tr>
<tr>
<td>Foreign Output</td>
<td>0.18**</td>
<td>0.17**</td>
<td>0.17**</td>
</tr>
<tr>
<td></td>
<td>(0.02)</td>
<td>(0.04)</td>
<td>(0.03)</td>
</tr>
<tr>
<td>Real Fed Funds Rate</td>
<td>-6.5 x 10^{-4}</td>
<td>-1.9 x 10^{-4}</td>
<td>-6.3 x 10^{-5}</td>
</tr>
<tr>
<td></td>
<td>(0.70)</td>
<td>(0.92)</td>
<td>(0.97)</td>
</tr>
<tr>
<td><strong>DEPREC</strong></td>
<td>-0.01</td>
<td>-0.01</td>
<td>-0.01</td>
</tr>
<tr>
<td></td>
<td>(0.14)</td>
<td>(0.17)</td>
<td>(0.17)</td>
</tr>
<tr>
<td><strong>BKCRISIS</strong></td>
<td>-0.02</td>
<td>-0.01</td>
<td>-0.02</td>
</tr>
<tr>
<td></td>
<td>(0.19)</td>
<td>(0.28)</td>
<td>(0.17)</td>
</tr>
</tbody>
</table>

* * Significant at 10 percent.
** ** Significant at 5 percent.
*** *** Significant at 1 percent.
tend to have a negative effect, at a marginal significance level of 10 percent. Neither DEPREC nor BKCRISIS have additional effects on consumption or investment.\footnote{One question that may be raised about these results is the assumption that DEPREC and BKCRISIS are exogenous, determined by factors outside the model (they are included in our instrument set in the regressions reported in Table 3). To see whether the results are sensitive to this, we replace these two variables in our instrument set by (1) export growth in U.S. dollars lagged one period, and (2) the deviations of the trade-weighted real exchange rate from trend lagged one period (in addition to the contemporaneous value of the yen-dollar exchange rate). These variables appear to affect the likelihood of currency crises and, through their effects on output, may also affect banking crises. However, this change in specification had no qualitative effect on the results reported in Table 3.}

We may now suggest answers to the questions posed at the beginning of this section.

First, a visual inspection of output fluctuations around episodes of sharp depreciation over the 1975–1996 period suggest that such episodes are followed by negative deviations of output from trend. However, there is little if any additional explanatory power obtained from adding a sharp depreciation dummy variable to equation (1).

Second, there appears to be an even steeper drop in output below trend when sharp depreciation episodes coincide with banking crises. However, a banking crisis dummy variable has no significant effects on output fluctuations over the 1975–1996 period that are not already captured in our benchmark model.

Third, the 1997 sharp depreciation episodes were associated with output contractions that are orders of magnitude larger than those experienced in East Asia in the past. This appears to reflect a large concentration of banking crises whose magnitude is also larger than in past episodes of sharp depreciation.

IV. CONCLUSIONS

In this paper, we have discussed alternative ways in which a reduced-form relationship between the real exchange rate and output may be derived and interpreted, and conditions under which contractionary depreciation may occur. We have focused on how spending on imported inputs or imported investment goods may affect aggregate supply and aggregate demand, and also discussed the potential importance of capital flows and financial crises in explaining episodes of particularly severe output contraction. We also have noted that further research is needed to motivate contractionary depreciation effects using dynamic equilibrium models.

Our exploration of the relationship between the exchange rate and output in East Asia allows us to address the two questions posed in the introduction.

First, there is evidence of a negative relationship between economic activity and the real exchange rate in East Asia; that is, depreciations were contractionary in the region even before the most recent crisis. This relationship is more evident in the period before 1990, as greater capital market integration appears to have attenuated contractionary depreciation effects.

Second, informal examination (using figures) of output fluctuations around episodes of sharp depreciation over the 1975–1996 period convey the impression that such episodes are associated with modest expansion and contraction cycles, with output above trend before a sharp depreciation episode and below trend after it. The cyclical pattern is accentuated when the sharp depreciation episode occurs during a banking crisis. The very steep output declines that followed the 1997 sharp depreciation episodes appear to reflect a high concentration of banking crises of unprecedented severity. Statistical analysis suggests that prior to 1997, sharp depreciation episodes and banking crises, when taken in isolation, were associated with below-trend economic activity. However, these variables do not add to the explanatory power of our benchmark model in our 1975–1996 sample.
DATA APPENDIX

The countries included in the analysis are Indonesia, Korea, Malaysia, the Philippines, Singapore, and Thailand. The data span is 1975 to 1998. Unless otherwise indicated, the frequency is annual. Data are from the International Financial Statistics (IFS) of the International Monetary Fund, unless otherwise indicated. IFS codes for each data series are indicated in parentheses below.

**Consumer prices:** IFS 64.

**Exchange rates:** End-of-period nominal exchange rates (AE) were used in defining currency crisis episodes and in constructing real exchange rates. The trade-weighted real exchange rate was created by taking the trade-weighted sum of logs of the bilateral real exchange rates (defined in terms of CPI indices) against the U.S. dollar, the deutsche-mark, and the yen. The trade weights are based on the average bilateral trade with the U.S., Europe, and Japan in 1980 and 1990. An increase in this index is a real depreciation of the domestic currency.

**Money:** M2 (IFS 34 + 35).

National accounts data: Real GDP (99b.p). Forecasts for 1999 and 2000 were obtained from the Asia Pacific Consensus Forecasts (5/10/99) for use in the figures (not the regressions). Private Consumption (96f). Gross Fixed Capital Formation (93e). For Indonesia, we used Gross Capital Formation (93). 1998 GDP data were obtained from JP Morgan, World Financial Markets (7/30/99). Real consumption and investment variables were obtained by scaling by the CPI (62) (including consumption and investment, but not real GDP).

Real federal funds rate: The funds rate was taken from IFS line 60b for the United States, deflated by U.S. CPI inflation.

Trade-weighted industrial production: This series was created by taking the trade-weighted sum of logs of the industrial production indices for the U.S., Germany, and Japan. For the U.S. and Germany, the data are from the IFS (66.c). For Japan the data were taken from DRI’s International Economics Database (JQI90@JP). The trade weights were the same as those used in constructing the trade-weighted real exchange rates.
REFERENCES


