

On the Welfare Gains of Reducing the Likelihood of Depressions¹

Satyajit Chatterjee

Federal Reserve Bank of Philadelphia

Dean Corbae

University of Pittsburgh

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1 Introduction

The motivation for our paper derives from Figure 1 which plots the annual unemployment rate for the period 1900 to 1998.¹

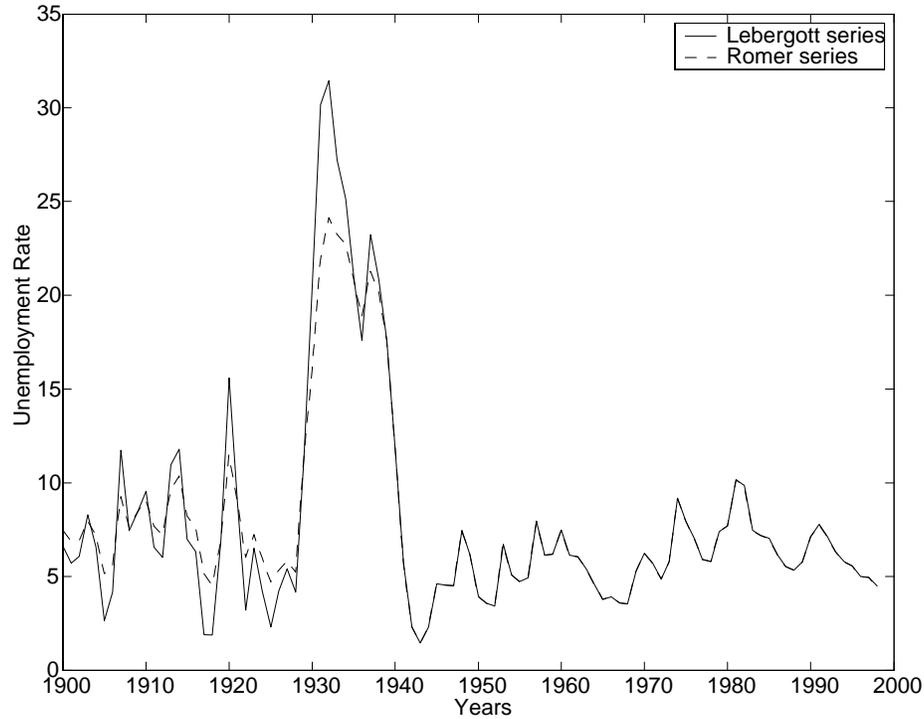


Figure 1: Unemployment Rate 1900-1998

As is evident, a striking aspect of this time series is the extraordinary rise in unemployment between the years 1930 and 1939, generally identified in history

¹For the period 1900-1940, the Lebergott series for industrial unemployment was constructed by dividing the total number of unemployed workers reported in Lebergott's Table A-3 by the sum of unemployed workers and non-farm workers also reported in that table. This construction assumes that most unemployed workers were in nonfarm occupations. The unemployment rates for 1941 and later are just those reported by the BLS. The Romer series was constructed by applying the corrections suggested by Romer (1986) to the industrial unemployment rate series.

as the Depression years. One issue, among many, suggested by the picture is the potential for economic policies to lower the likelihood of economic crises. With this issue in mind, the aim of our paper is to answer an important related question: “What fraction of consumption would a worker be willing to pay to set the current probability of a Depression-like event to zero?” The answer provides a rough guide to the benefit of pursuing governmental policies aimed at reducing the likelihood of economic crises.

We study an environment with the following features. There are a large number of workers who encounter stochastic employment opportunities. The probability of finding employment depends on the aggregate state of the economy. One of these aggregate states corresponds to a Depression-like event where the probability of finding employment in the private sector is much lower relative to the other aggregate states. Workers cannot buy insurance against shocks to their employment status, but they can self-insure by holding stocks of a zero-return asset. This environment contains the minimal set of features necessary to address the question posed in the paper. First, it permits us to model the defining characteristic of a Depression-like event, namely, a very high unemployment rate of workers. Second, it assumes that only a zero-return asset can serve as a buffer against the earnings-loss from unemployment. This feature roughly captures a second characteristic of a Depression-like event, namely, a widespread unwillingness on the part of investors to provide credit to the private sector. During such times safe (and hence low-return) assets are the preferred mode for precautionary savings.

Our calculations require an estimate of the current likelihood of a Depression-like event; the likelihood that we counterfactually set to zero in our welfare experiments. We obtain an estimate of this likelihood by fitting a three-state Markov chain to the observed monthly chronology of expansions, contractions, and depressions (in the U.S.) for the period 1900 to 1998. In fitting one Markov chain to the entire period we ignore any difference in the likelihood of a Depression-like event between pre- and post-Depression eras.² Under this

²An alternative approach to estimating the likelihood of a Depression-like event is to link

assumption, we estimate the current likelihood of falling into a depression to be somewhere around 1 in 1000. For the conservative baseline calibration of our model, the steady-state welfare gain from setting this small probability to zero is 1.07 percent of annual consumption, in perpetuity. Taking into account the welfare gain along the transition path, this estimate rises to 1.13 percent. Other calibrations generally imply higher gains, the largest being about 2.25 percent of annual consumption.

Our study bears a methodological similarity to the literature on the welfare costs of business cycles inspired by Lucas (1987) but there is a key difference. The welfare gains from eliminating the likelihood of a Depression-like event result from an increase in the expected value of individual earnings and a reduction in its variance. This is in contrast to the literature on the welfare cost of business cycles which focuses on the gain from setting the observed variance of aggregate consumption to zero (Dolmas (1998), Otrok (1999), Alvarez and Jermann (1999), among others), or the observed variance of aggregate employment to zero (Imrohoroglu (1989), Atkeson and Phelan (1994), and Krusell and Smith (1999)). Furthermore, while most studies on the welfare cost of business cycles reiterate Lucas' conclusion that the benefit from any new initiative to control business cycles is miniscule, we find that policies which eliminate even a small likelihood of a Depression-like event could potentially serve a useful social purpose.

2 Environment

Our environment builds on work by Imrohoroglu (1989). The economy evolves through good (g), bad (b), and depression (d) times which have implications for employment prospects. The state of the economy $\eta \in \{g, b, d\}$ is assumed to follow a first-order Markov process. The transition matrix of η is given by:

it to the equity premium, as is done in Reitz (1988) and Danthine and Donaldson (1998). In principle, this approach may permit us to link differences in the equity premium in the two eras (if any) to differences in the likelihood of a Depression-like event.

$$\Lambda = \begin{bmatrix} \lambda_{gg} & \lambda_{bg} & \lambda_{dg} \\ \lambda_{gb} & \lambda_{bb} & \lambda_{db} \\ \lambda_{gd} & \lambda_{bd} & \lambda_{dd} \end{bmatrix}$$

where, for example, $\Pr\{\eta_{t+1} = g | \eta_t = b\} = \lambda_{gb}$.

The economy consists of a large number of infinitely lived agents who differ at any point in time in their asset holdings and employment opportunities. They maximize

$$E \sum_{t=0}^{\infty} \beta^t U(c_t)$$

where $0 < \beta < 1$ is their discount factor and c_t is their consumption in period t . The utility function is given by

$$U(c_t) = \frac{c_t^{1-\gamma}}{1-\gamma}$$

where $\gamma > 0$.

Agents are endowed with one indivisible unit of time each period. Each agent receives an employment opportunity which is independent across agents. The employment opportunity has two states, $i \in \{e, u\}$. If the employed state occurs $i = e$, an agent produces y units of the consumption good. If the unemployed state occurs $i = u$, an agent produces θy units of the consumption good through household production, where $0 < \theta < 1$.

The individual-specific employment state is assumed to follow a first-order Markov process. The transition matrix is given by:

$$\Lambda^\eta = \begin{bmatrix} \lambda_{ee}^\eta & \lambda_{ue}^\eta \\ \lambda_{eu}^\eta & \lambda_{uu}^\eta \end{bmatrix}$$

where, for example, $\Pr\{i_{t+1} = e | i_t = u, \eta_{t+1} = g\} = \lambda_{eu}^g$ is the probability that an agent will be employed in good times at $t+1$ given the agent was unemployed in period t .

The overall employment prospects faced by each individual depends on both the aggregate and individual states; that is, $\omega = (\eta, i)$. There are six such states, where ω^1 stands for employed in a good state, ω^2 stands for unemployed in a good state, ω^3 stands for employed in a bad state, ω^4 stands for unemployed in a bad state, ω^5 stands for employed in a Depression state, and ω^6 stands for unemployed in a Depression state. The process governing ω is a first-order Markov process with transition matrix given by $\Phi = [\phi_{jk}]$, where $\Pr\{\omega_{t+1} = \omega^j \mid \omega_t = \omega^k\} = \phi_{jk}$. The transition probabilities are determined by Λ and Λ^n . For example, if $\omega_t = \omega^1$, then the probability of $\omega_{t+1} = \omega^2$, i.e., ϕ_{21} , is given by $\lambda_{gg}\lambda_{ue}^g$.

While event-contingent insurance is not permitted, agents can insure themselves through a storage technology. The real return to the storage technology is assumed to be zero. Agents enter period t with individual savings s_t held over from the previous period. An agent's budget constraint can be written:

$$c(\omega_t) + s_{t+1} = y(\omega_t) + s_t, \forall t, \omega$$

$$s_t \geq 0$$

The maximization problem faced by an individual in this economy can be represented as a dynamic programming problem where the state variables are $s = s_t$ and $\omega = \omega_t$, while the decision variable is $s' = s_{t+1}$ and the future state variable is $\omega' = \omega_{t+1}$. The Bellman equation can be written:

$$V(s, \omega) = \max_{s' \geq 0} U(c(s, \omega)) + \beta \sum_{\omega'} \Phi(\omega', \omega) V(s', \omega') \quad (1)$$

subject to

$$c(s, \omega) = y(\omega) + s - s' \geq 0, \forall \omega \quad (2)$$

Since agents face idiosyncratic shocks, they may hold different levels of savings. Let $\mu_t(s, \omega)$ be the probability that an individual attains state (s, ω) . Then, the probability that state (s', ω') occurs is given by:

$$\mu_{t+1}(s', \omega') = \sum_{\omega} \sum_{s \in \Xi(s', \omega)} \Phi(\omega', \omega) \mu_t(s, \omega) \quad (3)$$

where $\Xi(s', \omega) = \{s : s' = s'(s, \omega)\}$. Under mild regularity conditions (ergodicity of the Markov process and the absence of cyclically moving subsets) the sequence of recursively defined distributions converges to a unique invariant distribution $\mu(s, \omega)$ from any initial distribution. The distribution $\mu(s, \omega)$ gives the fraction of time an individual is in state (s, ω) .

3 Estimates of the Aggregate State Transition Matrix

In order to estimate the aggregate state transition matrix we proceed by constructing a history of these aggregate states. We begin with the monthly NBER business cycle chronology which date from December 1854. We associate NBER expansions with the good state and NBER contractions with the bad state. This *two-state* history is then augmented with a definition of what it means to be in a depression. If that definition is observed to be satisfied by some month, then that month's NBER classification is changed to the third, or depression, state.

As noted in the introduction, we take the defining characteristic of a depression to be very high incidence of unemployment among industrial workers. But unemployment rate data is available only for the period beginning 1900 and for the pre-WWII portion of that period it's available at an annual frequency only. Because of this data limitation, we confine our three-state history to the period 1900 to 1998.³

For our baseline calculation, we classified all months of any year in which the unemployment rate exceeded 17 percent as depression months. This definition simply picks out the 120 months corresponding the 1930-1939 period as a

³There is some fragmentary information on unemployment rates for the last decade of the nineteenth century. One of the sensitivity analysis performed later in the paper takes this information into account.

depression.⁴ Accordingly, we changed the NBER classification of these months to the depression state. An alternative definition considered later in the paper classifies all months of any year in which the unemployment rate exceeded 20 percent as depression months.

Given this three-state history, the maximum likelihood estimate of λ_{kj} , the (j, k) th element of the aggregate state transition matrix, is the ratio of the number of times the economy switched from state j to state k to the number of times the economy was observed to be in state j (Ross (1972) pp. 240-242).⁵ Implementing this procedure for the whole sample yields the following estimate of Λ , with standard errors in parentheses below:

$$\hat{\Lambda} = \begin{bmatrix} 0.9766 & 0.0234 & 0 \\ (0.0053) & (0.0053) & (0) \\ 0.0745 & 0.9216 & 0.0039 \\ (0.0164) & (0.0168) & (0.0039) \\ 0.0083 & 0 & 0.9917 \\ (0.0083) & (0) & (0.0083) \end{bmatrix}$$

The estimated matrix has several noteworthy features. First, because there is only one depression episode in our sample, there is only one transition into and one transition out of the depression state. In the three-state history we construct, the depression follows contractionary months and is followed by expansionary months. Hence $\lambda_{dg} = \lambda_{bd} = 0$. Second, the estimated matrix implies that conditional on not being in a depression, the probability of falling into one

⁴Cole and Ohanian also identify these 10 years as the Depression years (1999).

⁵The estimated transition probabilities are given by

$$\hat{\lambda}_{kj} = \frac{\sum_{t=1}^{T-1} 1\{\eta_{t+1} = k\}1\{\eta_t = j\}}{\sum_{t=1}^{T-1} 1\{\eta_t = j\}}$$

Given the Markov structure of our problem, the standard errors are given by

$$\sqrt{\frac{\hat{\lambda}_{kj} (1 - \hat{\lambda}_{kj})}{\sum_{t=1}^T 1\{\eta_t = j\}}}$$

is 0.0010. Third, the *unconditional* probability of a Depression is 0.0975, which is an order of magnitude bigger than the conditional probability. The large discrepancy between these two probabilities reflects the fact that the depression state is very persistent. This discrepancy is one reason why the welfare loss from the possibility of a Depression-like event is relatively large, even though the conditional probability of encountering a Depression-like event is quite small.⁶

4 Calibration of Other Parameters

The calibration of the remaining parameters involves selecting parameter values for the elements of the individual-level transition matrices Λ^n , the preference parameters β and γ , and the earnings-loss parameter θ .

The Individual State Transition Matrix

The individual-level state transition matrix for each aggregate state is built up from two pieces of information pertaining to that state, namely the average unemployment rate in that state and the average duration of unemployment spells in that state.

The average unemployment rate in the good, bad and depression states were fixed at the average unemployment rate for these states in the whole sample. These were 5.33 percent, 7.86 percent, and 23.48 percent, respectively.⁷

The duration of unemployment spells in good and bad times are based on the monthly average duration of unemployment rate reported by the BLS. These were determined to be 2.75 months during expansions and 3.75 months during contractions. The only available data on the duration of unemployment spells for the Depression are for 1930 and 1931. By early 1930, 56 percent of male

⁶ The unconditional probability of a good state is 0.6951 and the unconditional probability of a bad state is 0.2074.

⁷ Since the unemployment rate data is available at only annual frequencies for the pre-WWII era, the average unemployment rate for each state was calculated for annual data. All non-Depression years in which there were at least nine expansionary months were classified as “good” years and all other non-Depression years as “bad” years.

unemployed workers had been without work for at least nine weeks. The special census of unemployment undertaken in January 1931 reported that of the male workers unemployed in Boston, New York, Philadelphia, Chicago, and Los Angeles, 45.3 percent, 60.9 percent, 45.2 percent, 61.0 percent, and 33.2 percent, respectively, had been jobless for at least 18 weeks. In effect, the median unemployment duration had doubled in less than a year. The fact that the unemployment rate remained elevated for the next *seven* years suggests that the median duration of unemployment by the end of the Depression was probably good deal higher than 18 weeks. We fixed the average duration of unemployment spells in the Depression state as 10 months, roughly twice the median duration seen in 1931.⁸

The choice of average duration of unemployment spells for each aggregate state fixes λ_{uu}^η for $\eta \in \{g, b, d\}$ (and, also $\lambda_{eu}^\eta = 1 - \lambda_{uu}^\eta$). We chose the remaining elements to match the average unemployment rate in each aggregate state. Note that the evolution of the aggregate unemployment rate is given by:

$$U_t = U_{t-1}\lambda_{uu}^{\eta(t)} + (1 - U_{t-1})\lambda_{ue}^{\eta(t)}$$

where $\eta(t) \in \{g, b, d\}$. Since λ_{uu}^η etc. depend only on the current state, U_t converges to a constant if the state remains unchanged for some length of time. For each aggregate state, these limiting unemployment rates solve:

$$U^\eta = U^\eta\lambda_{uu}^\eta + (1 - U^\eta)\lambda_{ue}^\eta.$$

We chose the values of $\lambda_{ue}^\eta, \eta \in \{g, b, d\}$, so that U^g, U^b , and U^d matched 5.3 percent, 7.86 percent, and 23.48 percent, respectively.⁹

These choices gave the following individual-level transition matrices for each aggregate state:¹⁰

⁸We perform a sensitivity analysis with respect to the average duration of unemployment in the Depression later in the paper.

⁹These choices imply that average unemployment rate in the good state is somewhat larger than U^g , and the average unemployment rate in the bad and Depression states are somewhat less than U^b and U^d , respectively. However, since all three states are highly persistent, these discrepancies are minor.

¹⁰These matrices, along with Λ , imply the unconditional probabilities of being in states

	Good			Bad			Depression			
$\Lambda^g =$	0.9795	0.0205		$\Lambda^b =$	0.9773	0.0227		$\Lambda^d =$	0.9693	0.0307
	0.3636	0.6364			0.2667	0.7333			0.1000	0.9000

Preference and Earning-Loss Parameters

We set $\beta = 0.9946$, which is equivalent to an annual discount rate of 6 percent. We arrived at this number by assuming a rate of time preference equal to 4 percent at an annual rate as well as assuming that the constant monthly survival probability is equal to $1 - 1/(40 * 12)$ so that agents have a working life of 40 years.

For the baseline calibration, we set the risk aversion parameter, γ , to 1.5. The value of θy is given by “home production.” According to Greenwood, Rogerson, and Wright (1995) “attempts to measure the value of the output of home-production come up with numbers between 20 and 50 percent of the value of measured market GNP.” To be conservative, we set the earning loss parameter θ to 0.5 in the baseline calibration.¹¹

5 The Response of Per-capita Consumption in a Depression

Since our main interest is in the Depression-like state, it is of interest to see how well the model captures the decline in per-capita consumption during the Great Depression. To do this, we simulated our model with the observed history of aggregate states, starting with an initial distribution of asset holdings

ω^j (i.e. $prob(\omega^j) = \phi_j, j = 1, \dots, 6$) are given by $\phi_1 = 0.6568, \phi_2 = 0.0382, \phi_3 = 0.1922, \phi_4 = 0.0152, \phi_5 = 0.0756, \text{ and } \phi_6 = 0.0220$.

¹¹Darby (1976) pointed out that workers engaged in government relief programs during the Depression were counted as unemployed. Darby also reports that the average wage earned by these “unemployed” workers during the years 1930-1939 was about 41 percent of the average wage during those years which is lower than our baseline calibration of 50 percent.

corresponding to the average over good states.¹² Figure 2a plots the computed percentage deviations of the simulated per-capita consumption against the percentage deviation in actual per-capita consumption.¹³ In the simulation, per-capita consumption drops by about 12 percent in 1930, about 13 percent in 1931, and then recovers to a decline of about 10-12 percent for the duration of the Depression. As the economy emerges from the Depression, per-capita consumption rises sharply to around 5 percent above trend and then gradually declines to its “normal” level value by around 1945.¹⁴ In the data, per-capita consumption doesn’t fall below trend until 1931 and reaches its trough of around 19 percent in 1933. Then there is a recovery, with the path of consumption ending up in the neighborhood of the simulated consumption path by around 1945.

The fact that the actual decline in consumption is deeper and occurs later than in the simulation is not surprising. In the model, agents know right away that they are in the Depression whereas the realization that something had gone very wrong was gradual in reality. Also, actual unemployment peaked at more than 30 percent, whereas the unemployment rate in the model peaks at less than 24 percent. These differences suggest that a better metric for judging how well the Depression is captured is to compare the cumulative consumption loss between 1930 and 1945. In the model, the cumulative consumption loss is 78 percent of mean aggregate consumption; in the data the cumulative consumption loss over the same period is 107 percent. While the consumption loss in the model may seem too low in relation to the data, the data pertain only to consumption goods purchased in the market. Because home production con-

¹²We obtain decision rules for optimal asset holdings by successive approximations on the value function $V(s, \omega)$. Following Imrohorglu (1989), we discretize the state space of asset holdings to lie between 0 and 10.8 in increments of 0.027 for a total of 401 grid points. The upper bound is roughly equal to 11 months of income if the employed state continues for that long. In equilibrium, this constraint is never binding.

¹³The consumption series is based, in part, on the annual Kendrick real consumption series for 1889-1953 reported in Appendix B of Gordon (1986), deflated by population. The percentage deviations shown in the figure are taken from a quadratic trend.

¹⁴The behavior of the path of consumption is explained in the next section.

tributes to consumption in the model, we need to make some assumption about how much of the output of home production is actually measured as GNP. Figure 2a assumed that all of home production is measured. Figure 2b is drawn for the polar opposite case where none of it is measured. The decline in per-capita consumption is now much steeper because consumption in excess of home production only is included for unemployed agents. The cumulative consumption loss between 1930 and 1945 is now 170 percent, greater than in the data. If it is assumed that 30 percent of home production is unmeasured, the cumulative loss in consumption in the model matches that in the data.

To summarize: the predictions of the baseline model for the path of per-capita consumption during a Depression does not appear to be grossly inconsistent with observations. We now turn to our welfare comparisons.

6 Welfare Comparisons

Our focus is on the welfare gains from elimination of the Depression-like state. In other words, we wish to compare the utility gain from moving to an environment for which the $\hat{\Lambda}$ matrix is replaced by

$$\Lambda^* = \begin{bmatrix} 0.9766 & 0.0234 \\ 0.0784 & 0.9216 \end{bmatrix}$$

The diagonal elements of this matrix are identical to the corresponding elements of Λ , as is λ_{bg} . But the probability of transiting from the bad to the good state is now higher by 0.0010. The individual level transition matrices for the good and bad state are the same. The parameters γ , β and θ remain the same as well. Let $V^*(s, \omega)$ be the value function for this new, depression-proof, economy.

The welfare calculations are done in two ways. Imagine that the three-state economy has attained its stochastic steady state. At some random date, agents are given the choice of living in an environment with Λ^* . At that instant, the economy will be in one of three possible states and there will be a joint distribution of agents across asset holdings and employment status. We can

imagine asking each agent in this distribution, the maximum he is willing to pay each period in the two-state Depression-proof environment for the privilege of living in that environment.

In the first type of welfare calculation we assume that each individual begins the new regime with his current asset-holding and employment status. In addition, we assume that if the economy is in the good or bad state then the new regime will begin in that state as well, and if the economy is in the depression state then the new regime will begin in the bad state. Thus, the fraction of consumption the agent is willing to give up if he is currently in state $(s, \omega), \omega \leq 4$, is found by computing $1 - \alpha(s, \omega)$, where $\alpha(s, \omega)$ solves:

$$V(s, \omega) = \alpha(s, \omega)^{1-\gamma} V^*(s, \omega).$$

If the economy is in a depression, then $\alpha(s, 5)$ and $\alpha(s, 6)$ are computed as follows:

$$\begin{aligned} V(s, 5) &= \alpha(s, 5)^{1-\gamma} V^*(s, 3) \\ V(s, 6) &= \alpha(s, 6)^{1-\gamma} V^*(s, 4) \end{aligned}$$

Denoting the invariant measure for the (three aggregate state) depression-prone environment by $\mu(s, \omega)$ (this probability distribution is the unconditional probability of an agent having assets s in state ω) the average gain in welfare across agents is given by $1 - \bar{\alpha} = 1 - \sum_s \sum_\omega \mu(s, \omega) \alpha(s, \omega)$. This calculation takes into account the fact that in the depression-proof (two aggregate state) environment agents hold less assets and so includes the consumption spree permitted by this decumulation.

In the second type of calculation we assume that each agent is offered the *average* lifetime utility in the depression-proof environment. In this case $\alpha^{SS}(s, \omega)$ is given by:

$$V(s, \omega) = \alpha^{SS}(s, \omega)^{1-\gamma} \bar{V}^*$$

where \bar{V}^* is $\sum_s \sum_\omega \mu^*(s, \omega) V^*(s, \omega)$, $\mu^*(s, \omega)$ being the invariant distribution in the depression-proof economy. Then, $1 - \bar{\alpha}^{SS} = 1 - \sum_s \sum_\omega \mu(s, \omega) \alpha^{SS}(s, \omega)$.

Thus, in this experiment the welfare gain from decumulation of assets along the transition path is ignored. We refer to this measure as the *steady-state* gain in welfare. Both calculations are reported in Table 2.

Table 2

% Welfare Gains in the Baseline Model From Eliminating Depression

From Eliminating Depression		Estimates of Gains From Eliminating Cycles	
$1 - \alpha$	$1 - \alpha^{SS}$	Lucas, $\gamma = 1$	Imrohoroglu, $\gamma = 1.5$
1.13	1.07	0.01	0.3

The welfare gain including transition is 1.13 percent of consumption per month (or per year) and the steady state gain is 1.07 percent. To put these numbers in perspective, note that Lucas estimated the welfare gain from getting rid of all cyclical volatility in postwar era to be 0.01 percent of consumption for $\gamma = 1$ and Imrohoroglu estimated it to be 0.3 percent for $\gamma = 1.5$. Thus, the welfare gain from getting rid of a Depression-like state is more than 100 times Lucas's (1987) estimate of the gains from eliminating cycles and more than three time as large as Imrohoroglu's (1989) estimate.

Where do these gains come from? This question can be answered by comparing the operating characteristics of the three-state and two-state models.

Table 3

Steady-State Characteristics of the 2-state and 3-state Models

Models	\bar{y}	$\sigma(y)$	\bar{s}	$\sigma(s)$	\bar{c}	$\sigma(c)$
3 - S	0.9623	0.1320	1.0816	0.5907	0.9623	0.0859
2 - S	0.9706	0.1176	0.9206	0.2857	0.9706	0.0742

Table 3 indicates that the gain in welfare in the first experiment comes from three different sources. First, average consumption in the two-state model is higher by 0.86 percent; second, the standard deviation of consumption is lower by 13.62 percent; and third, the average asset holdings is lower by 14.8 percent. The welfare gain in the steady-state experiment is due to the first two of these three sources.

The largest contribution to welfare in both experiments comes from the increase in mean income, and hence mean consumption, in the depression-proof economy. Even though the probability of falling into a depression (conditional on not being in one) is very low, the fact that the depression state is very persistent makes mean income in the Depression-prone (three-state) economy slightly lower than the mean income in the depression-proof economy.

In addition, the volatility of consumption is significantly higher in the economy with possibility of a depression. Because a depression is a low-probability event, it does not influence decision rules for normal times very much. This can be seen by comparing the asset accumulation/decumulation decisions of employed/unemployed agents in the bad state with and without the possibility of a depression. As shown in Figures 3 and 4, these decision rules are very similar. In this sense, agents do not do very much to prepare for a depression. Consequently, when a depression does materialize, the consumption paths of all agents change dramatically. As shown in Figure 5, unemployed agents decumulate assets at a much *slower* pace (and consequently take a much bigger hit on consumption) during a depression than at other times. Also, as shown in Figure 6, employed agents recognizing the heightened probability of unemployment accumulate assets at much *faster* rate during a depression relative to other times. Thus, employed agents also experience a decline in consumption during a depression.

The differences in the decision rules between the depression and other times helps explain the path of aggregate consumption shown in Figure 2a and 2b. The distribution of asset holdings for employed and unemployed agents at the start of our simulated Depression is shown in Figures 7 and 8. Note that there is a large measure of employed agents with assets between 0.9 and 1.1, and a fairly dispersed distribution of unemployed agents across asset holdings. As the Depression hits, the optimal asset accumulation for the bulk of employed agents jumps from a little above zero to somewhere between 0.10 and 0.15, and their level of consumption declines. At the same time, unemployed agents

begin conserving their asset holdings and their consumption level drops as well. These drops in consumption for everyone in the economy accounts for the initial drop in aggregate consumption in Figure 2a. As the Depression proceeds, the rate of asset accumulation of employed agents begins to fall as they get closer to their target asset level of little over 4. Figure 9 shows the accumulation of assets during the Depression. Thus, consumption of employed agents begins to recover. This recovery is the reason why aggregate consumption begins to recover as well. One factor that helps in this recovery is that agents who become unemployed later in the Depression experience less of a decline in consumption because they get the chance to accumulate more assets in the meantime. Thus, even though the unemployment rate rises through the Depression, its negative influence on aggregate consumption becomes less marked.

The changes in consumption in our model occur even though the depression is assumed not to affect the income of employed or unemployed agents. Thus we ignore any decline in productivity which may have occurred during the Depression. Taking these effects into account would surely raise our welfare gain estimates.

It is worth noting that the value functions for both employed and unemployed agents are close to linear around the steady state range of asset holdings (Figures 10 and 11). This is consistent with Bewley's (1977) result that when the discount factor is close to one, the marginal utility of asset holdings is nearly constant.

7 Robustness

In this section we study the robustness of our findings with respect assumptions that might seem key to the results. As we show in this section, barring one exception, changing these assumptions in plausible directions raises the estimates of the welfare gains.

The Effect of Changes in the Price Level During Depressions

In the baseline model we assumed the asset to have a zero real return. Now, we interpret this asset to be a non-interest bearing nominal asset. It is well known that prices fell drastically during the Depression. If agents save in a nominal asset, the fall in the price level would provide some relief to unemployed workers. Does this effect change the welfare estimates?

Inspection of de-trended CPI series shows that prices fell by about 14.8 percent very quickly with the onset of the Depression and stayed at the level until 1937 and then fell some more in 1938 and 1939. To model this change in prices, we assumed that the price level remains constant at 1 during good and bad states and then declines to 0.852 in depressions. The operating characteristics and welfare gain (from eliminating depressions) of this economy are shown in Table 5.

Table 5
The Effect of Changes in the Price Level
Gain: $1 - \alpha^{SS} = 1.07\%$, $1 - \alpha = 1.12\%$

Models	\bar{s}	$\sigma(s)$	\bar{c}	$\sigma(c)$	$\sigma(y)$
3S	1.08	0.54	0.9622	0.0858	0.1320
2S	0.92	0.29	0.9706	0.0742	0.1176

As is evident, there is very little change in the welfare estimate. Basically, whatever gain unemployed workers receive with a fall in the price level at the onset of a depression is reversed when the depression ends and prices go back up again. Note that there are more unemployed workers at the *end* of a Depression than at the beginning.

The Effect of A Positive Asset Return in Non-Depression States

It seems plausible that the rate of return on the asset may change with the onset of a depression. In particular, the asset may have a positive return during normal times, but a zero return in depressions. Ignoring price level changes,

this may happen if the asset is a government bond. During normal times, the government competes with private liabilities and so must pay a positive return on its securities. During depressions, when there is a flight to liquidity, the interest rate on the government bond may well go to zero. With this in mind, we calculated the welfare gains when the real return on the asset is 2 percent in good and bad times but zero in depressions. Table 6 reports the results.

Table 6

The Effect of a Positive Asset Return in Non-Depression States

Gain: $1 - \alpha^{SS} = 1.08\%$, $1 - \alpha = 1.14\%$

Models	\bar{s}	$\sigma(s)$	\bar{c}	$\sigma(c)$	$\sigma(y)$
3S	1.38	0.62	0.9604	0.0786	0.1320
2S	1.23	0.38	0.9786	0.0652	0.1176

Again, there is very little change in the estimate of the welfare gain.

The Effect of Perfect Unemployment Insurance in Non-Depression States

Here we attempt to capture the following situation. Suppose that there are two kinds of assets, private and government. In normal times, the return on the private asset is close to the rate of discount and the return on the government asset is zero. In a depression, return on the government asset is still zero, but the private assets become worthless. In this kind of a world, it's reasonable to suppose that workers will accumulate stocks of the private asset to self-insure themselves against the risk of unemployment in normal (i.e., good and bad) times but use the government asset to insure against unemployment during depressions. If the rate of return on the private asset is close to the rate of discount, we know from Bewley (1977) that the worker will accumulate enough assets to almost perfectly insure against unemployment during normal times. Therefore, a rough way to capture this situation is to assume that workers can buy insurance against the risk of unemployment in normal times but cannot do so during depressions. This means that both employed and unemployed workers

receive the per-capita endowment in the good and bad states. Table 7 reports the results from this experiment.

Table 7

The Effect of Perfect Unemployment Insurance in Non-Depression States

Gain: $1 - \alpha^{SS} = 1.19\%$, $1 - \alpha = 1.28\%$

Models	\bar{s}	$\sigma(s)$	\bar{c}	$\sigma(c)$	$\sigma(y)$
3S	0.19	0.66	0.9623	0.0544	0.1320
2S	0	0	0.9706	0.0053	0.1176

As one would expect, asset holdings are lower in this economy since workers no longer need to hold assets to insure against loss of employment during normal times. Also, asset holdings are virtually zero in the two-state economy. There is large difference in the standard deviation of consumption between the two economies and this is reflected in the somewhat higher welfare gains from elimination of depressions.

Depression State Defined as Unemployment Rate in Excess of 20 percent

In this experiment, we defined depression months to be all months of any year in which the unemployment rate exceeded 20 percent. We re-estimated the aggregate state transition matrix based on this new history. Now, the period 1930-1939 is broken up into two depression episodes, one between 1930 and 1935 and another between 1937 and 1938. This alters the estimated aggregate transition matrix to

$$\hat{\Lambda} = \begin{bmatrix} 0.9766 & 0.0234 & 0 \\ (0.0053) & (0.0053) & (0) \\ 0.0714 & 0.9214 & 0.0071 \\ (0.0154) & (0.0161) & (0.0050) \\ 0 & 0.0208 & 0.9792 \\ (0) & (0.0146) & (0.0146) \end{bmatrix}$$

Notice that since the duration of the depression state has fallen, λ_{dd} has fallen relative to the baseline. On the other hand, the two instances of transition to the depression state raises the conditional probability of entering a depression λ_{db} relative to the baseline. The average unemployment rate in the depression-like state is now 24.98 percent.

The results of the welfare calculations are reported in Table 8.

Table 8

Depression State Defined as Unemployment Rate in Excess of 20 percent

Gain: $1 - \alpha^{SS} = 1.01\%$, $1 - \alpha = 1.06\%$

Models	\bar{s}	$\sigma(s)$	\bar{c}	$\sigma(c)$	$\sigma(y)$
3S	1.06	0.49	0.9628	0.0850	0.1312
2S	0.92	0.29	0.9706	0.0742	0.1176

The estimated welfare gains actually decline slightly in this experiment. This suggests that the persistence of a Depression-like state may be more important for welfare than the frequency by which the state is entered and/or the level of unemployment.

Include 1890-1899, with 1894:01-1898:12 Classified as Depression Months

There is some fragmentary information on industrial unemployment for the last decade of the 19th century. In this experiment we extend our history of aggregate states back to 1890:01 and use this information to determine if any of those months should be classified as depression months. The information available suggests that industrial unemployment for the five years 1894-1898 was very high. Accordingly, we classified those 60 months as depression months. This alters the estimated aggregate transition matrix to

$$\hat{\Lambda} = \begin{bmatrix} 0.9549 & 0.0451 & 0 \\ (0.0127) & (0.0127) & (0) \\ 0.0562 & 0.9326 & 0.0112 \\ (0.0173) & (0.0188) & (0.0079) \\ 0.0111 & 0 & 0.9889 \\ (0.0078) & (0) & (0.0078) \end{bmatrix}$$

Given the fragmentary nature of unemployment rate data for this period, we continued to assume that the average unemployment rate in the two Depression episodes was 23.48 percent. The results of the welfare experiment are reported in Table 9.

Table 9

Sample: 1890-1998, with 1894:01-1898:12 Also Classified as Depression Months

Gain: $1 - \alpha^{SS} = 1.52\%$, $1 - \alpha = 1.60\%$

Models	\bar{s}	$\sigma(s)$	\bar{c}	$\sigma(c)$	$\sigma(y)$
3S	1.40	0.63	0.9589	0.0906	0.1374
2S	0.92	0.29	0.9706	0.0742	0.1176

As is evident, the welfare gains are higher.

The Effect of Higher Duration of Unemployment in Depressions

There is uncertainty about the duration of unemployment spells during the Depression. In this experiment, we raised the duration unemployment to 20 months, twice that of the baseline model. Table 10 reports the results.

Table 10

Average Duration of Unemployment Spells in a Depression is 20 months.

Gain: $1 - \alpha^{SS} = 1.12\%$, $1 - \alpha = 1.17\%$

Models	\bar{s}	$\sigma(s)$	\bar{c}	$\sigma(c)$	$\sigma(y)$
3S	1.05	0.54	0.9627	0.0900	0.1313
2S	0.92	0.29	0.9706	0.0742	0.1176

As one would expect, the estimated welfare gains from eliminating a Depression like state is now higher than in the baseline model. But the increase in the gain is not substantial. One reason for this is that when the duration of unemployment spells is raised, the calibration of the model forces us to lower the probability with which an employed worker gets unemployed in a depression. Without this offsetting change, the average unemployment rate in a depression would rise above 23.48 percent. This factor tends to pull down the estimated welfare gains.

The Effect of Higher Risk Aversion

In this experiment, we raised the risk aversion parameter to 3, twice that of the baseline model..

Table 11

Risk-aversion Parameter $\gamma = 3.0$

Gain: $1 - \alpha^{SS} = 1.26\%$, $1 - \alpha = 1.39\%$

Models	\bar{s}	$\sigma(s)$	\bar{c}	$\sigma(c)$	$\sigma(y)$
3S	2.17	1.00	0.9623	0.0678	0.1320
2S	1.85	0.53	0.9706	0.0543	0.1176

Not surprisingly, the welfare gain from elimination of the Depression state is higher.

The Effect of Greater Earnings Loss

In this experiment, we set the earnings-loss parameter to 0.2, which is the lower end of its likely range.

Table 12

Earnings-Loss Parameter is 1/5

Steady-State Characteristics of the 2-state and 3-state Models

Gain: $1 - \alpha^{SS} = 2.04\%$, $1 - \alpha = 2.25\%$

Models	\bar{s}	$\sigma(s)$	\bar{c}	$\sigma(c)$	$\sigma(y)$
3S	3.39	1.56	0.9397	0.1106	0.2112
2S	2.88	0.78	0.9530	0.0891	0.1882

The steady state welfare gain from eliminating Depressions is now 2.04 percent, while the gain inclusive of transition effects is 2.25 percent.

8 Conclusion

Our aim in this paper was to obtain a measure for the potential benefit of policies that reduce the likelihood of a Depression-style collapse of economic activity. We found that even when the probability of transiting into a Depression is 1 in 1000, the welfare gain from setting this small probability to zero can range between 1.07 percent and 2.25 percent of annual consumption, in perpetuity. By standards of welfare analysis, these are large gains. In particular, they are more than 100 times larger than the estimated welfare gains from eliminating normal business cycle volatility reported in Lucas (1987) for comparable risk-aversion parameters. These large gains arise because even though the probability of transiting to a Depression-like state is small, it's highly persistent. This persistence plays a large role in the estimates of welfare gain reported in this paper.

While we have quantified the potential gain from pursuing policies that reduce the likelihood of economic crises, we have not said anything about the potential costs of doing so. In particular, we have not specified any policy arrangement that could set the probability of economic crisis to zero. While this sort of criticism can be levelled against the literature on the welfare cost of business cycles as well, it carries great force here. To begin with, the issue of what policies can eliminate all business cycle volatility is moot if the

gain from such policies is miniscule. That is not the case here; the welfare gain from policies that eliminate even a small probability of a Depression-like event appear large, making the issue of their feasibility and cost pertinent. At the same time, we appear to lack a theory of the Depression that can serve as an aid to policy design. While the model of trade-collapse presented in Diamond's (1982) influential work could explain the Depression as an instance of a self-perpetuating low-activity equilibrium, the multiplicity of equilibria inherent in this class of models pose a serious challenge for policy analysis.¹⁵ On the other hand, as shown by Cole and Ohanian (1999, 2000), a standard neoclassical macroeconomic model that maps technology, preferences, and policies to unique outcomes has great difficulty in accounting for the Depression. It appears that we must await an adequate theory of economic instability before the welfare gains estimated in this paper can be put into proper perspective. Still, by pointing out that their existence we hope to draw attention to a potentially fruitful area of policy research.

¹⁵Cooper and Corbae (2000) examine how expansionary monetary policy can be used to pull an economy out of a Depression-like state resulting in mean and variance changes.

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Fig.2a: Simulated and Actual Per-capita Consumption When All Home Production is Measured

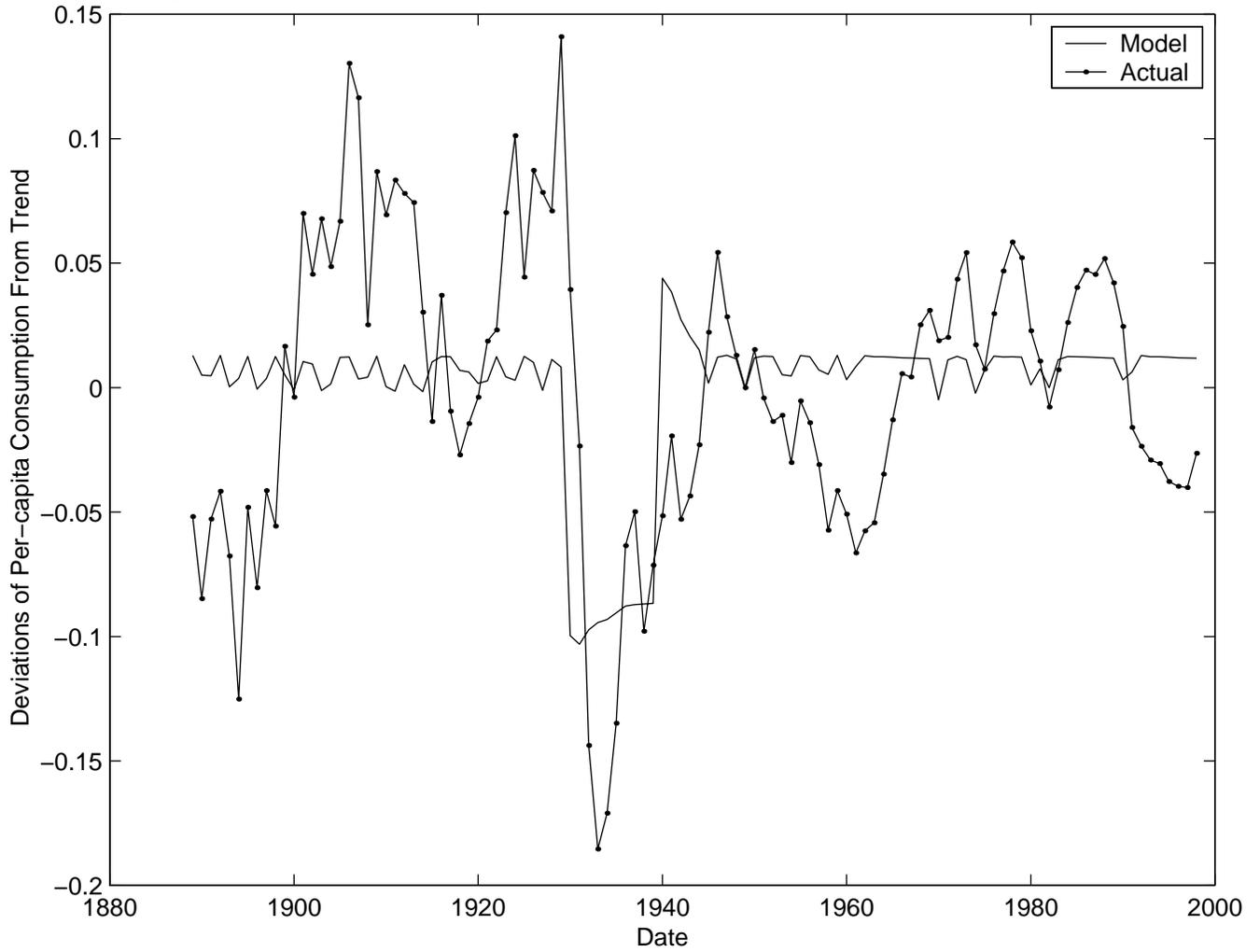


Fig. 2b: Simulated and Actual Per-capita Consumption When All Home Production is Unmeasured

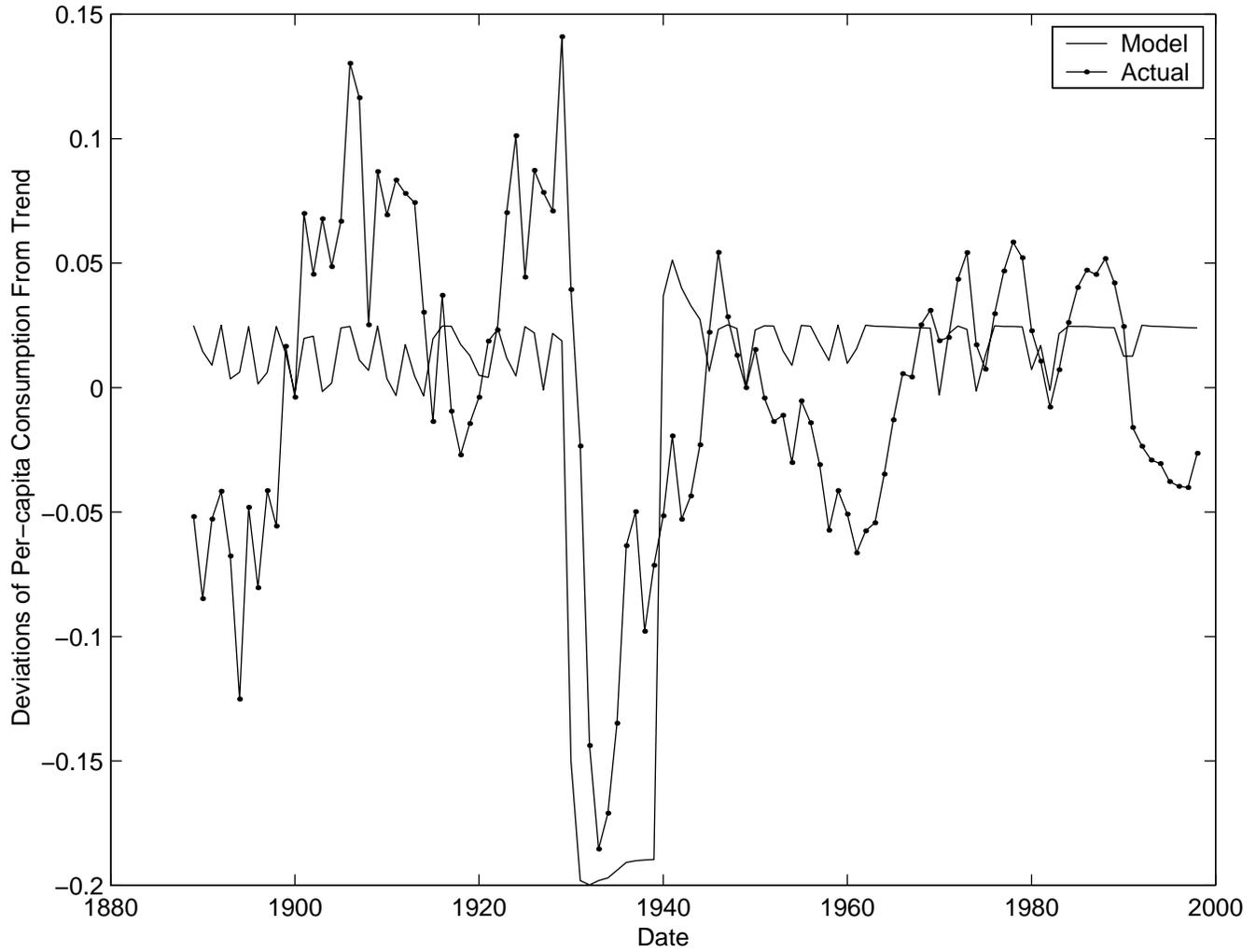


Fig.3: Asset Accumulation/Decumulation of Employed in Bad State in 2 vs 3 State Model

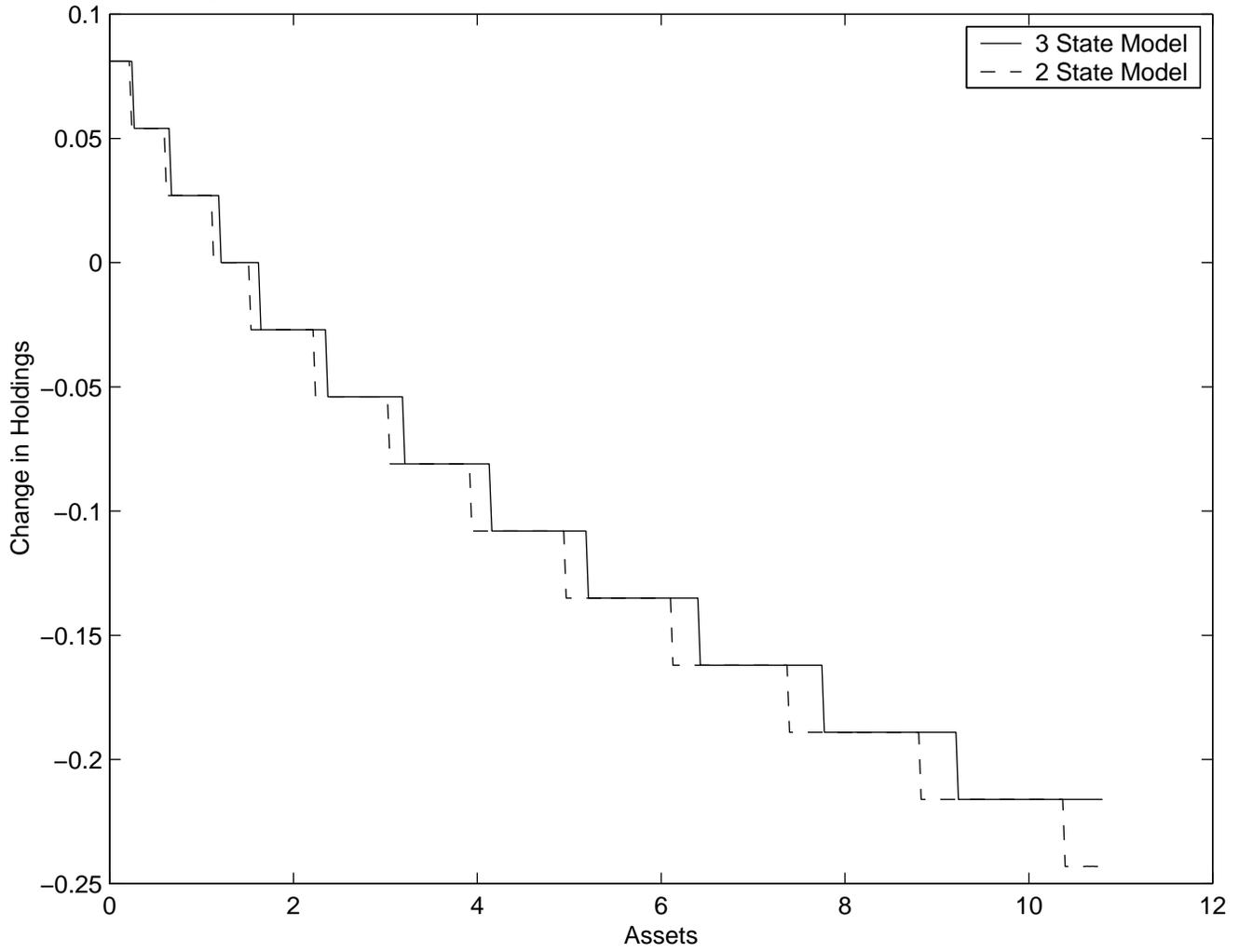


Fig.4:Asset Accumulation/Decumulation of Unemployed in Bad State in 2 vs 3 State Model

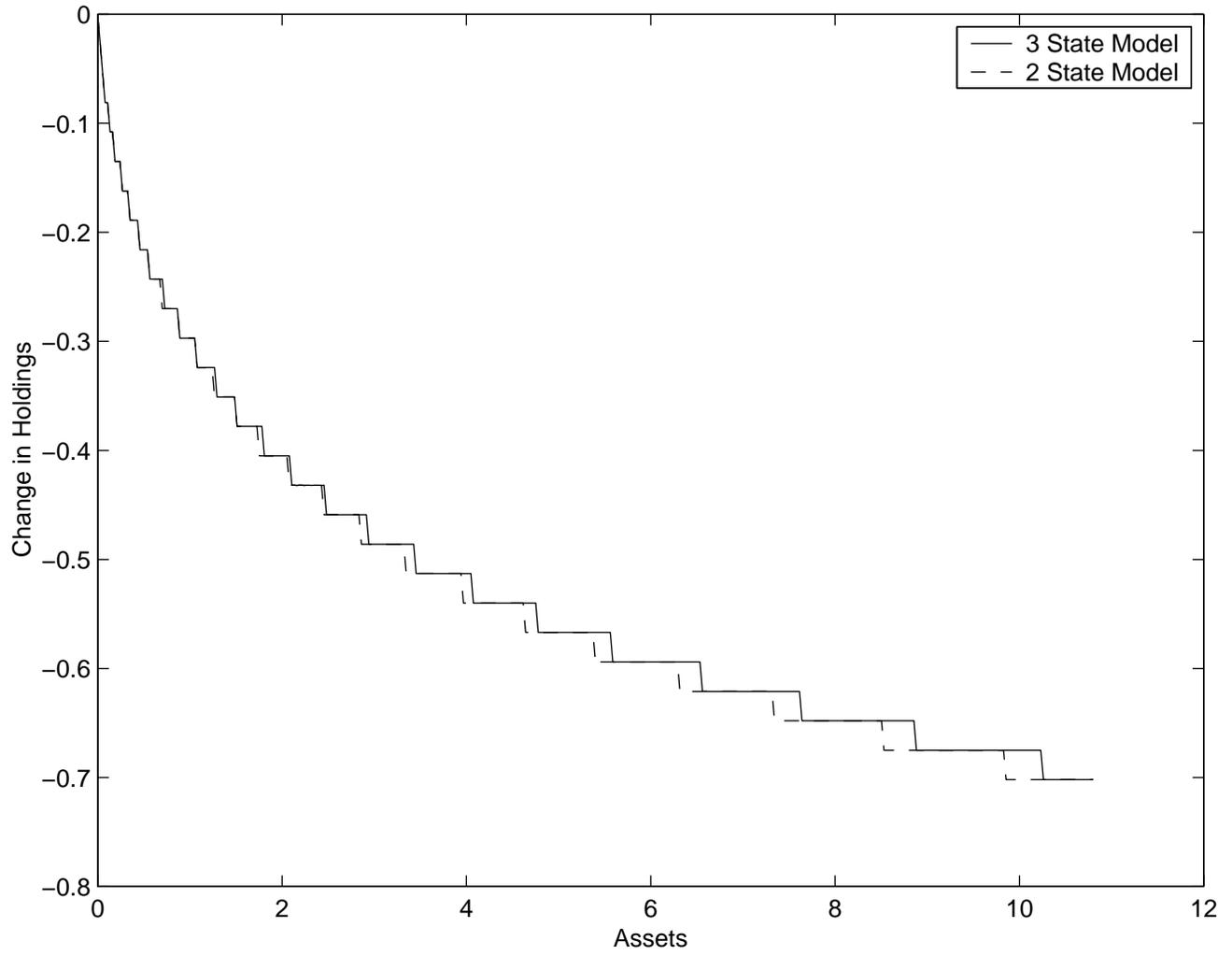


Fig.5: Asset Accumulation/Decumulation of Unemployed in Good, Bad, Depression State

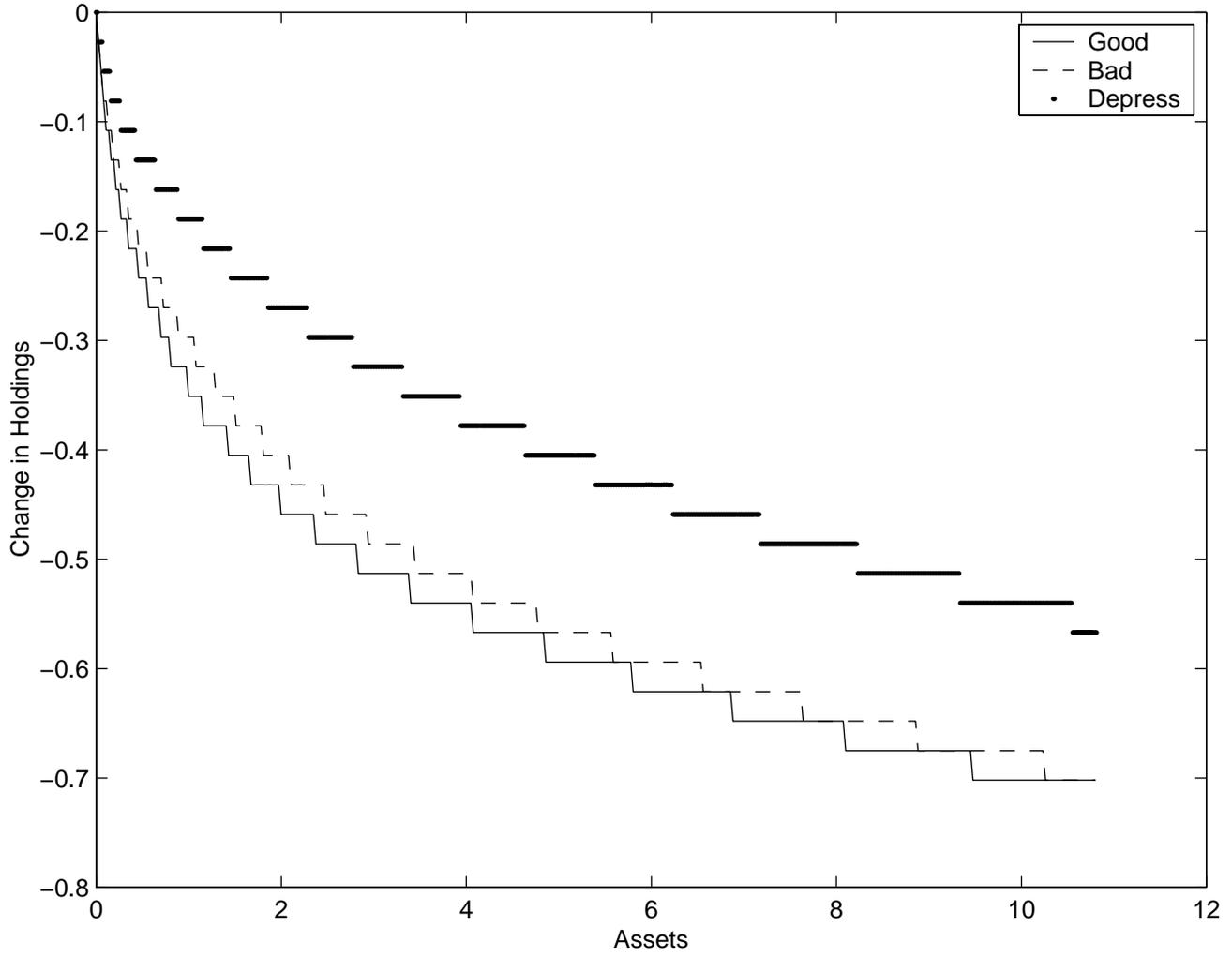


Fig.6:Asset Accumulation/Decumulation of Employed in Good, Bad, Depression State

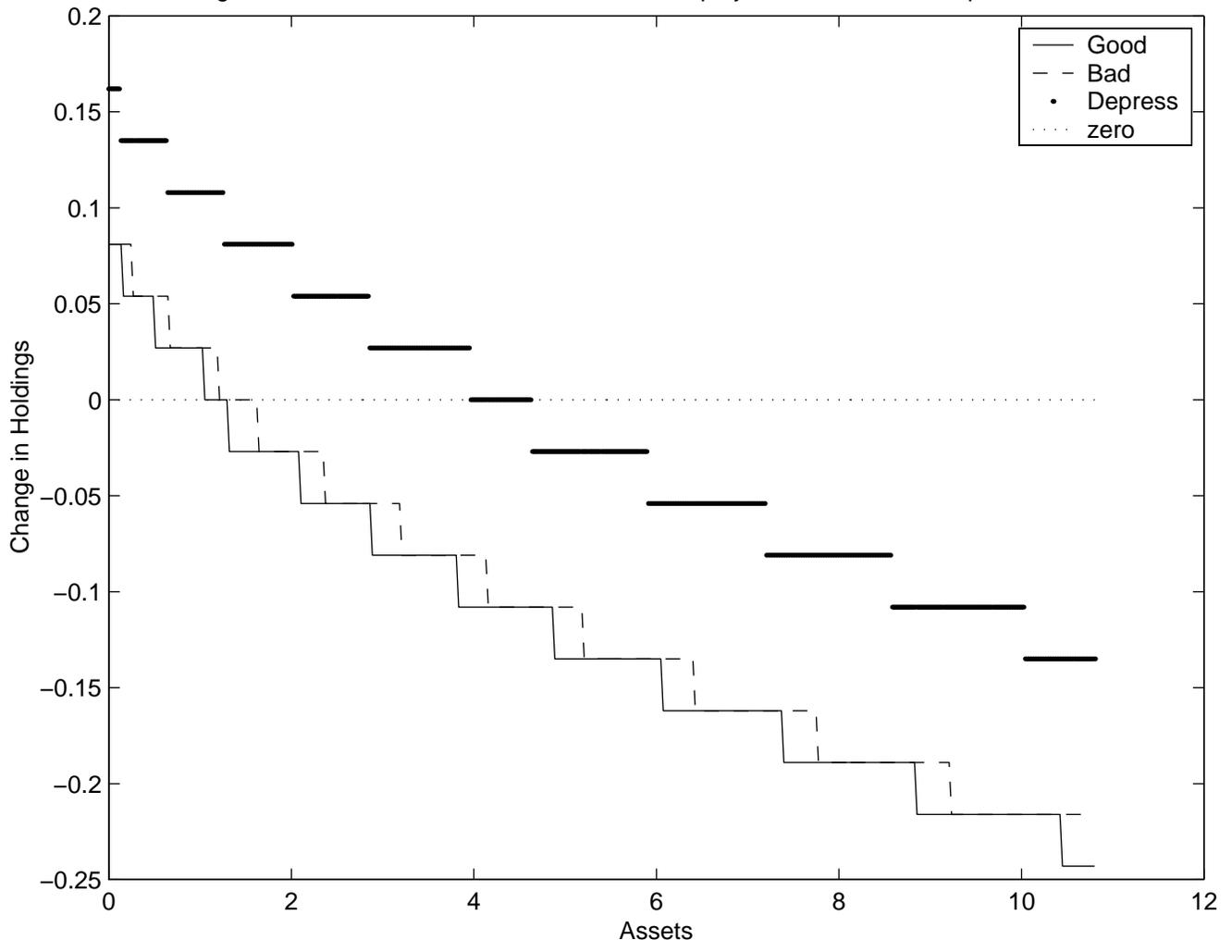


Fig.7:Distributions of Assets of Employed in G, B, D States

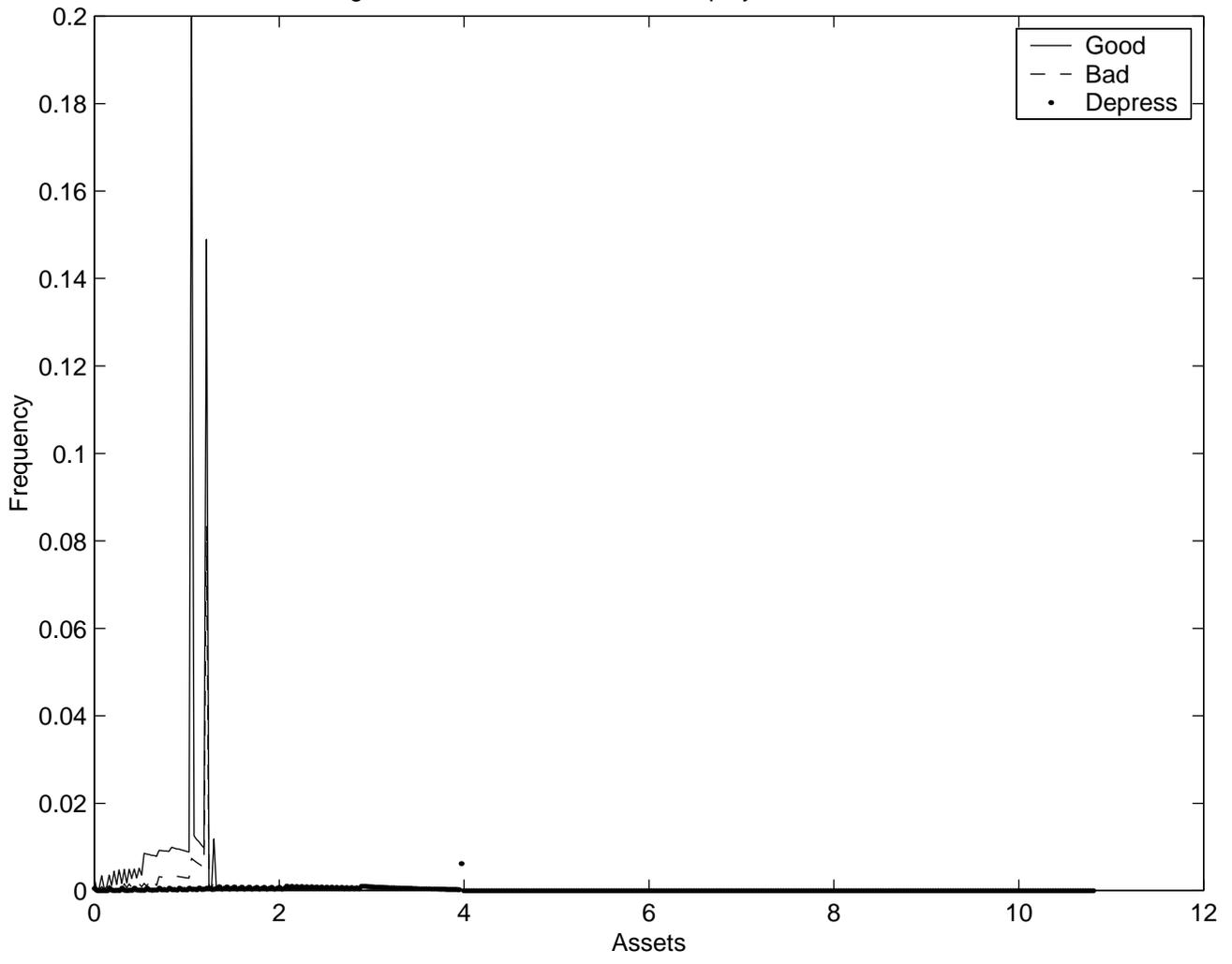


Fig.8:Distributions of Assets of Unemployed in G, B, D States

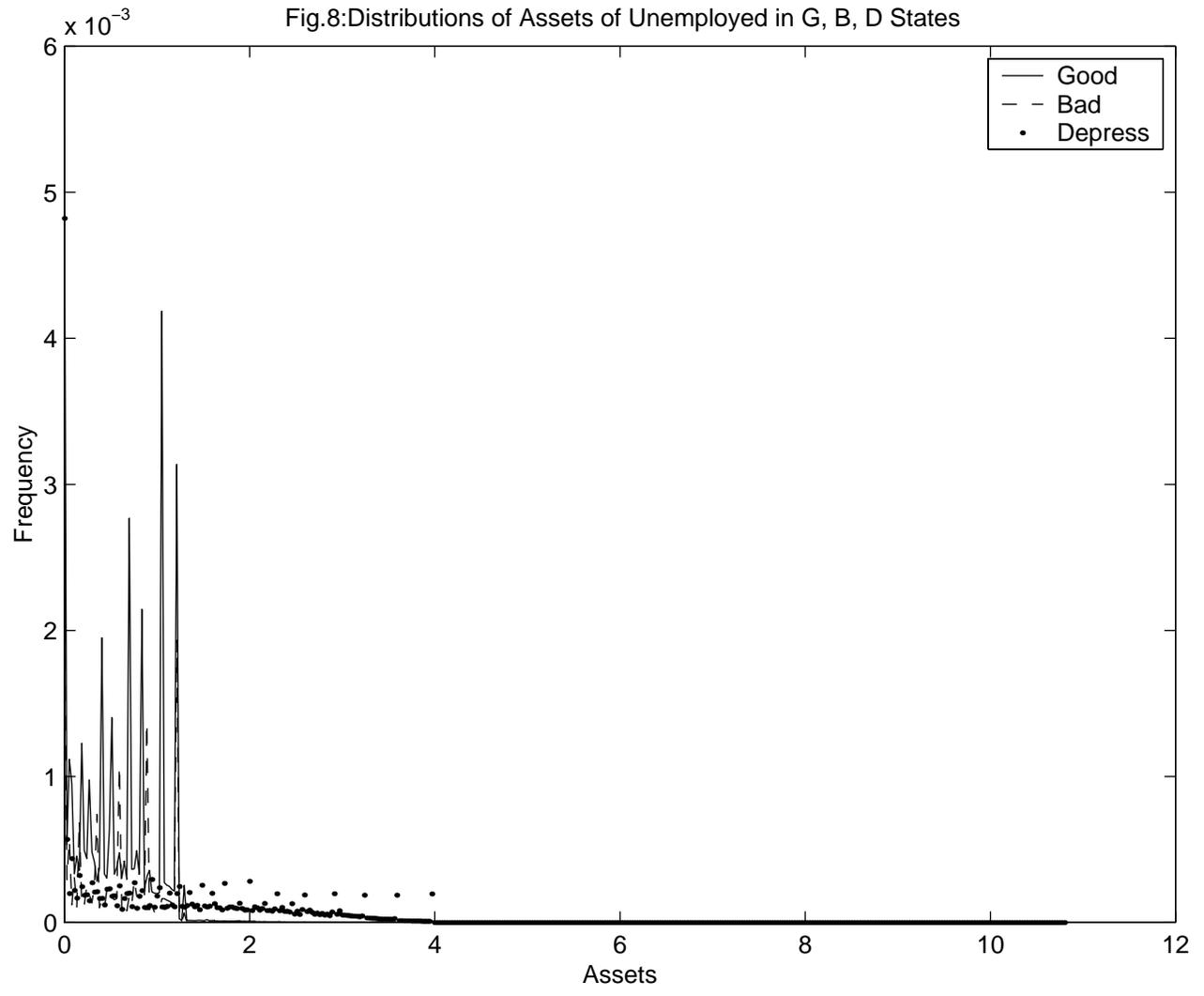


Fig.9: Simulated Asset Holdings during the Depression

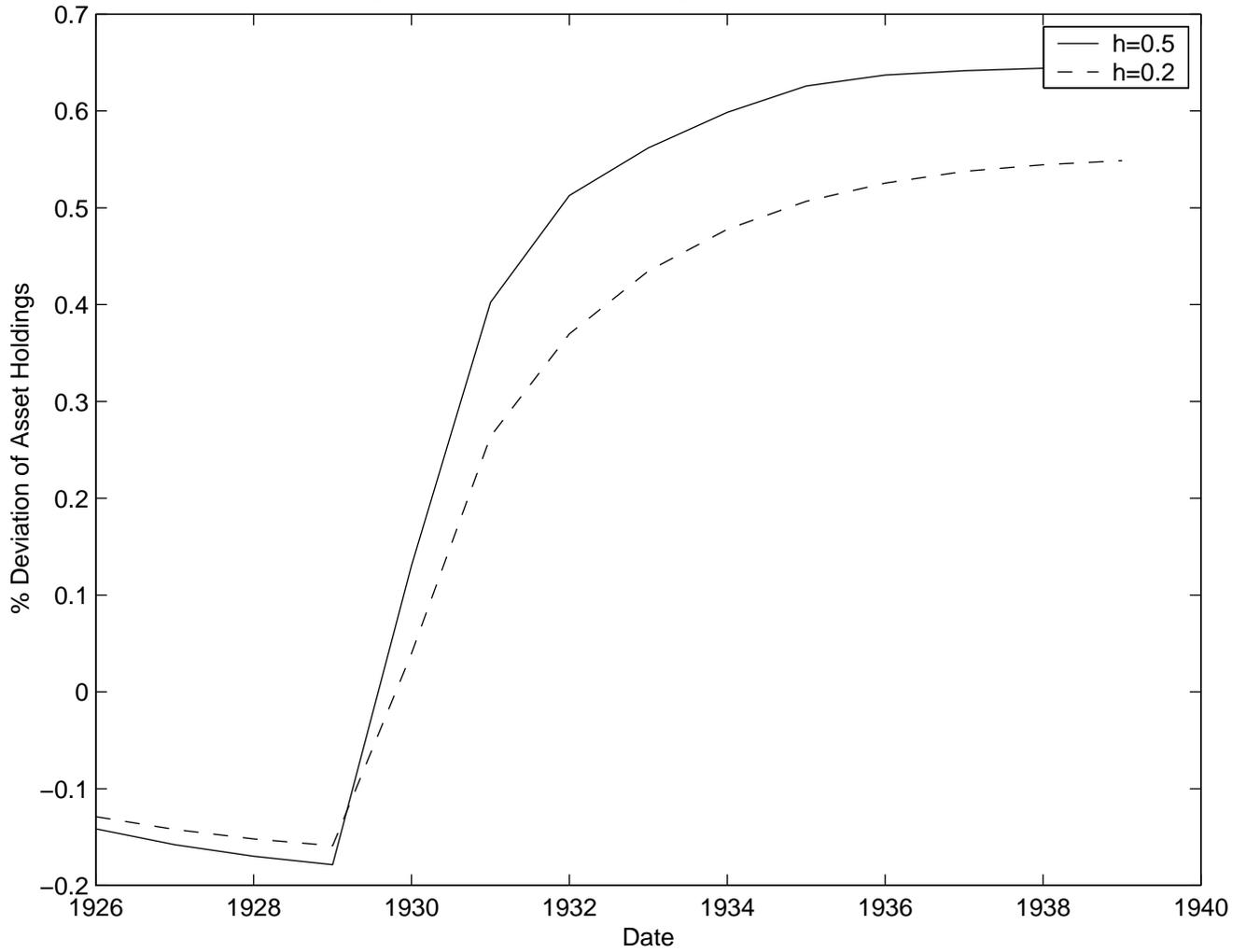


Fig.10: Value Functions of Unemployed in Bad State in 2 vs 3 State Model

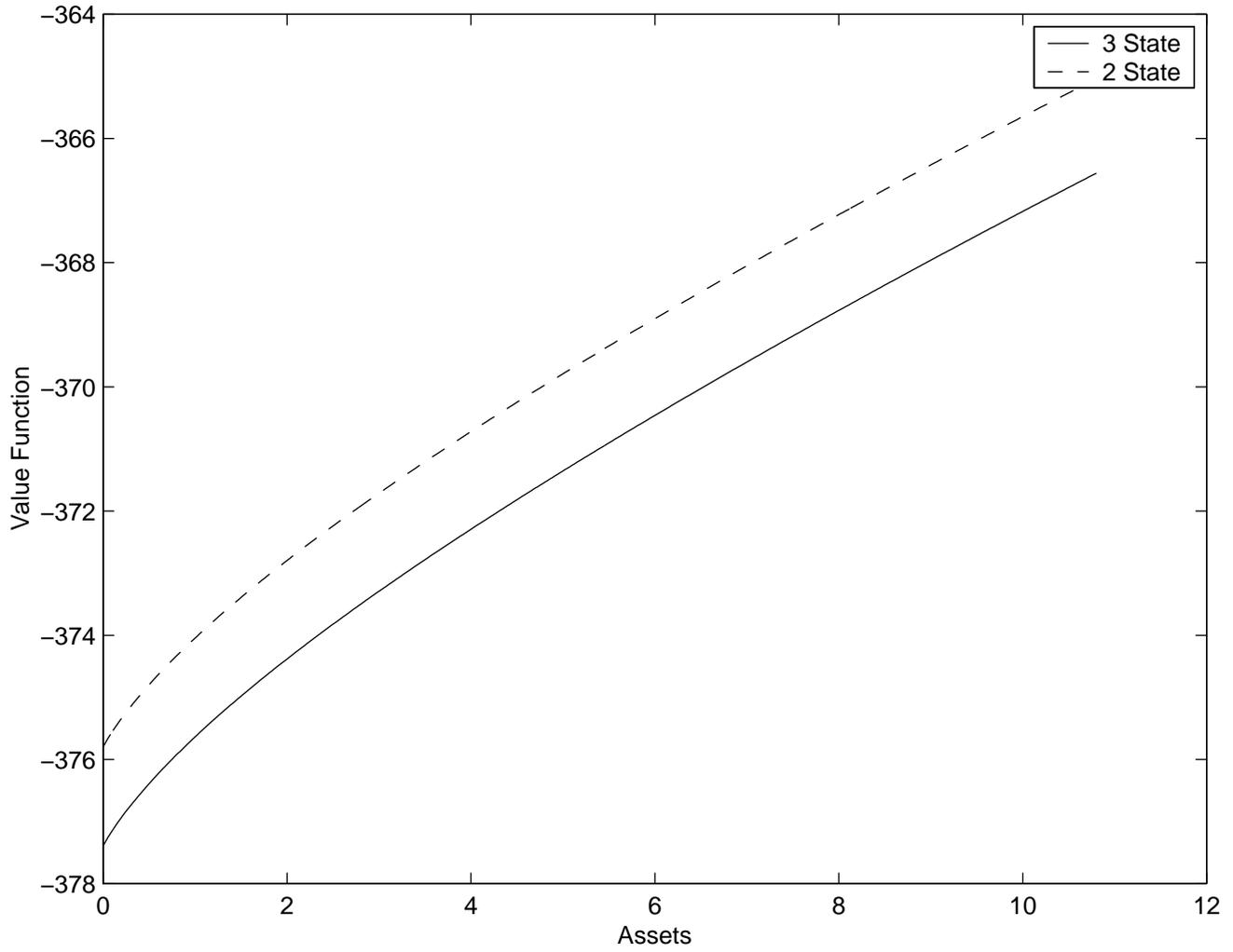


Fig.11: Value Functions of Employed in Bad State in 2 vs 3 State Model

