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ON THE WELFARE GAINS OF REDUCING THE LIKELIHOOD OF ECONOMIC CRISES

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Abstract

Our aim in this paper is to obtain a measure of the potential benefit of reducing the likelihood of economic crises. We define an economic crisis as a Depression-style collapse of economic activity. Based on the observed frequency of Depression-like events, we estimate this likelihood to be approximately once every 83 years for the US. Even for this small probability of transiting into a Depression-like state, the welfare gain from setting it to zero can range between 1.05 percent and 6.59 percent of annual consumption, in perpetuity. These large gains arise because even though the probability of encountering a Depression-like state is small, it is highly persistent once it occurs. We also find that for some calibrations of the model, uninsured unemployment risk contributes significantly to the size of these gains.

1 Introduction

A central concern in macroeconomics has been whether policy should attempt to stabilize cyclical fluctuations. In a thought-provoking argument, Lucas (1987) suggested that the welfare gains from eliminating postwar variability in aggregate consumption was something on the order of one-tenth of one percent of annual U.S. consumption. In his view, these gains were too small to justify any new initiatives to stabilize cyclical fluctuations.

Lucas' calculation assumed that aggregate risk is shared equally among all individuals. Instead, Imrohoroglu (1989) examined the welfare cost of cyclical fluctuations in an environment in which individuals faced uninsured unemployment risk. She found that even when individuals cannot buy insurance against income fluctuations, their ability to accumulate a "buffer stock" of assets (or to borrow against future income, if permitted) gives them considerable scope to smooth consumption. Nevertheless, she estimated that in the presence of empirically plausible idiosyncratic income shocks the welfare gain from elimination of all cyclical volatility may be as high as three-tenths of one percent of total consumption (for a modest risk-aversion parameter). However, Atkeson and Phelan (1994) and Krusell and Smith (1999) pointed out that if countercyclical policies stabilize aggregate unemployment by simply removing the correlation between the unemployment risks faced by different individuals (leaving intact individual employment prospects), the welfare gain from stabilization policies are much smaller.

Following a different line of thought, a number of authors have pursued the implications of alternative and less restrictive preference specifications on the magnitude of the welfare gains in Lucas's representative agent calculation (Obstfeld (1994), Dolmas (1998), and Alvarez and Jermann (1999), among others). These studies have obtained much larger welfare costs of business cycles. However, Otrok (forthcoming) argues that when preference parameters are chosen to be consistent with business-cycle behavior, the welfare costs of business cycles are of the same order of magnitude as those obtained by Lucas.

The repeated findings of small gains of eliminating *cyclical* fluctuations motivates us to explore a different reason why stabilization policies might have a more significant quantitative effect on welfare.[1] The avenue we study is best motivated by Figure 1, which plots the annual unemployment rate for the period 1900 to 1998.

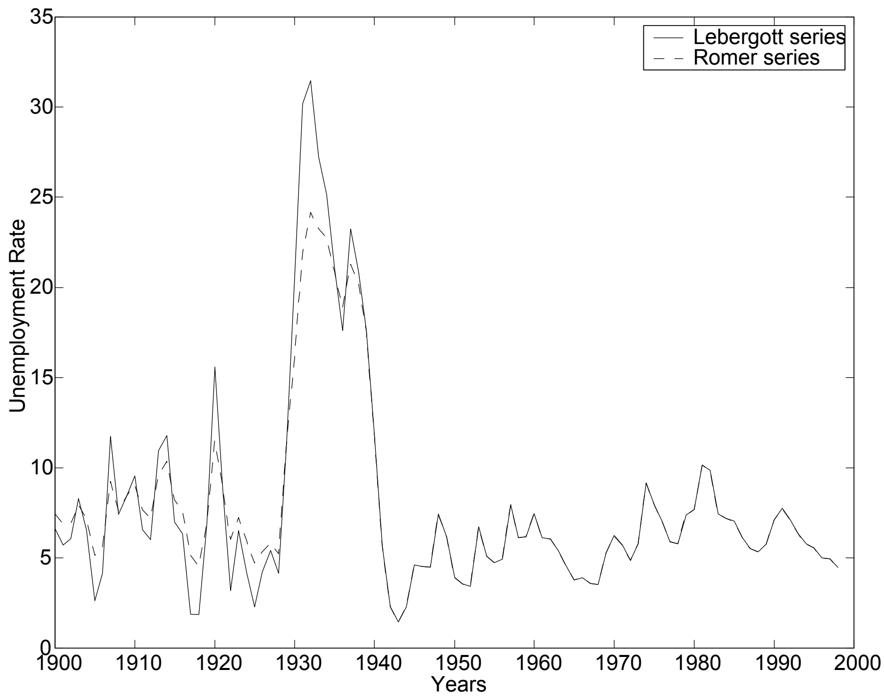

Figure 1: Unemployment Rate 1900-1998

As is evident, a striking aspect of this time series is the extraordinary rise in

[1] Other researchers have begun to explore alternative mechanisms through which cyclical volatility may have a more substantial effect on welfare. Beaudry and Pages (1999) examine the welfare costs of business cycles in an environment where frictions in contract enforcement cause workers to face cyclical wage risk. Portier and Puch (1999) examine the welfare effects of a reduction in volatility of fundamentals allowing for induced changes in the desired steady-state capital stock. Cohen (2000) examines the case where stabilization policies prevent shortfalls in economic activity and so affect both the mean and volatility of economic activity. Barlevy (1999), Jones, Manuelli and Stacchetti (1999), and Matheron and Maury (2000) reconsider the costs of cyclical volatility when such volatility can affect the growth rate of the economy.

unemployment between the years 1930 and 1939, generally identified in history as the Depression years.[2] One issue, among many, suggested by the picture is the potential for stabilization policies to lower the likelihood of economic crises. It is clear that the post-WWII sample studied by Lucas, Imrohoroglu, and others focusses on the benefits of stabilizing standard business cycle fluctuations and neglects the benefits of preventing economic crises like the Great Depression. With this in mind, the aim of our paper is to answer the 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 policies aimed at reducing the likelihood of economic crises.

To answer this question 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 an economic crisis 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 an asset whose return is lower than the (common) rate of time preference of individuals.[3] This environment permits us to model the defining characteristic of an economic crisis that is evident in Figure 1, namely, a very high unemployment rate of workers.

Our calculations start with an estimate of the current likelihood of depres-

[2]For 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 nonfarm 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.

[3]This assumption is consistent with the general equilibrium implications of imperfect insurance, as shown, for instance, by Aiyagari (1994).

sions; 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.[4] In fitting one Markov chain to the entire period we ignore any difference in the likelihood of depressions between pre- and post-Depression eras. Under this assumption, we estimate the current likelihood of encountering a depression to be once every 1000 months (or once every 83 years). For a conservative baseline calibration, the steady-state welfare gain from setting this small probability to zero is 1.05 percent of annual consumption, in perpetuity. Taking into account the welfare gain along the transition path, this estimate rises to 1.11 percent. Less conservative but more plausible calibrations generally imply higher gains, with one scenario yielding a 6 percent steady-state welfare gain and 6.6 percent welfare gain including transition effects.

Although our approach bears a methodological similarity to the literature on the welfare cost of business cycles, there are two key differences with that literature that are worth emphasizing. First, setting the likelihood of a Depression-like state to zero alters both the mean and volatility of individual earnings. The presence of these mean effects sets our welfare calculation apart from the literature on the welfare cost of business cycles that focuses solely on effects of changes in volatility. Second, welfare gains reported in that literature are in the nature of an upper bound because the elimination of all cyclical volatility (which is what's typically examined) may not be desirable. Such qualifications are unnecessary for the Great Depression which most everyone agrees was, at some level, preventable. The same is probably true of economic crises more generally. If policies can be found to eliminate the possibility of an economic crisis, the welfare gains reported in this paper, net of the cost of implementing such policies, are potentially achievable.

[4] An alternative approach to estimating the likelihood of a Depression-like event is to link it to the equity premium, as is done in Reitz (1988) and Danthine and Donaldson (1998).

2 Environment

Our environment builds on work by Imrohoroglu (1989). The economy evolves through good (g), bad (b), and depression (d) times that 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:

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

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 that 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, $\Pr\{i_{t+1} = e | i_t = u, \eta_{t+1} = g\} = \lambda^g_{eu}$ 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 depend on both the aggregate and individual states; that is, on the six pairs (η, i), $\eta \in \{g, b, d\}$ and $i \in \{e, u\}$. These six pairs are denoted by $\omega^1, \ldots, \omega^6$, 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 $\Phi = \left[\phi_{jk}\right]$, where $\Pr\{\omega_{t+1} = \omega^j \mid \omega_t = \omega^k\}$ $= \phi_{jk}$. The transition probabilities are determined by Λ and Λ^η. For example, if $\omega_t = \omega^1$, then the probability of $\omega_{t+1} = \omega^2$, i.e., ϕ_{21}, is given by $\lambda_{gg}\lambda^g_{ue}$.

While event-contingent insurance is not permitted, agents can insure themselves by holding stocks of some asset. For the moment, this asset is taken to be a storage technology with a zero real return (alternative asset market assumptions are explored later in the paper). 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 discounted dynamic program where the state variables are $s = s_t$ and $\omega = \omega_t$. Following standard notation, the Bellman equation for this program is:

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

subject to

$$c(s, \omega) = y(\omega) + s - s' \geq 0, \forall \omega. \tag{2}$$

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

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

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 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 is available at an annual frequency only. Because of this data limitation, we confine our three-state history to the period 1900 to 1998.[5]

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

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 to the 1930-1939 period generally known as the "Depression years."[6] 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.[7]

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).[8] Implementing this procedure for the whole sample yields the following estimate

[6] Cole and Ohanian (1999) also identify the ten years between 1930 and 1939 as the period during which output remained below trend.

[7] A more sophisticated alternative would be to fit a 3-state regime to the unemployment rate data using the procedure described in Hamilton (1989). We followed our simple procedure because for the pre-WWII period the NBER chronology is likely to a better proxy for the frequency of good and bad times than any that can be inferred from the noisy unemployment series (see Romer (1986) for a discussion of the pitfalls of the pre-WWII unemployment series for cyclical analysis).

[8] The 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 asymptotic standard errors of these estimates are given by:

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

of Λ, with standard errors in parentheses below:

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

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 is 0.0010. Third, the *unconditional* probability of a depression is 0.0975, which is an order of magnitude larger 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 probability of encountering a Depression-like event, conditional on not being in one, is quite small.[9]

A word about the precision of these estimates. The fact that there is only one depression episode in our sample might be thought to imply that none of the parameters relating to the third state (the third column and row of the Λ matrix) can be reliably estimated. That's not necessarily true. According to our history, the economy spent about 1,070 months in nondepression states. Thus, there were many instances in which the economy could have gone into a depression but didn't. The fact that the depression state was encountered only once out of more than 1000 trials suggests we can be quite confident that the probability of

[9] The unconditional probability of a good state is 0.6951, and the unconditional probability of a bad state is 0.2074.

transiting into a depression state is very low. Similarly, the economy spent 120 months in the depression state before transiting out of it. The fact that it took more than 100 trials for the economy to leave the depression state implies we can be reasonably confident that the probability of continuing in the depression state is quite high. As we shall see, these two features of a depression state, namely, the low probability of encountering one and its persistence once it is encountered, are the economically significant features. These features are well-supported by history.[10]

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^{η}, 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. 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

[10] We note, however, that the standard errors reported in parentheses are *asymptotic* standard errors and needn't be good estimates of the sampling variance in "small" samples. To investigate the small sample properties of our maximum likelihood estimate of Λ, we ran Monte Carlo simulations where the data generation process is given by $\widehat{\Lambda}$. As expected, the standard errors from the Monte Carlo simulations were larger than the asymptotic standard errors. Furthermore, we found an upward bias in the estimates of λ_{db} and λ_{gd}. Since correcting $\widehat{\Lambda}$ for these biases only led to *higher* welfare gains of eliminating the depression-like state, we retained the more conservative estimates of $\widehat{\Lambda}$ reported in the paper.

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.[11]

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 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 a 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.[12]

The choice of average duration of unemployment spells for each aggregate

[11]Because the unemployment rate falls during expansions and rises during contractions, our procedure for calibrating U^g and U^b underestimates the true difference between these parameters. As a check, we estimated the average unemployment rate for the last six months of each expansion and the average unemployment rate for the last six months of each contraction in the postwar period (according to Romer (1986), the unemployment rate process for 1900-1928 period is not significantly different from that in the postwar era, once allowance is made for likely measurement errors in the prewar unemployment data). The estimates were 4.70 percent and 6.74 percent respectively. Since this method of estimating $U^g$and U^b leads to uniformly lower values than what we estimate for our baseline calibration, we found that they led to higher welfare gains (of eliminating the likelihood of depressions) than those reported later in the paper.

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

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.[13]

These choices gave the following individual-level transition matrices for each aggregate state:[14]

Table 1

Good	Bad	Depression
$\Lambda^g = \begin{bmatrix} 0.9795 & 0.0205 \\ 0.3636 & 0.6364 \end{bmatrix}$	$\Lambda^b = \begin{bmatrix} 0.9773 & 0.0227 \\ 0.2667 & 0.7333 \end{bmatrix}$	$\Lambda^d = \begin{bmatrix} 0.9693 & 0.0307 \\ 0.1000 & 0.9000 \end{bmatrix}$

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.

[13] These 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.

[14] These matrices, along with Λ, imply the unconditional probabilities of being in states ω^j (i.e. $prob(\omega^j) = \phi_j$, $j = 1, ..., 6$) are given by $\phi_1 = 0.6568$, $\phi_2 = 0.0382$, $\phi_3 = 0.1922$, $\phi_4 = 0.0152$, $\phi_5 = 0.0756$, and $\phi_6 = 0.0220$.

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.[15]

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 corresponding to the average over good states.[16] Figure 2a plots the computed percentage deviations of the simulated per-capita consumption against the percentage deviation in actual per-capita consumption.[17] 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

[15] Darby (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.

[16] We obtain decision rules for optimal asset holdings by successive approximations on the value function $V(s, \omega)$. 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.

[17] The 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.

its "normal" level value by around 1945.[18] 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 contributes 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.

[18] The behavior of the path of consumption is explained in the next section.

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 $\widehat{\Lambda}$ matrix is replaced by

$$\Lambda^* = \begin{bmatrix} 0.9766 & 0.0234 \\ 0.0745 & 0.9216 + 0.0039 \end{bmatrix}$$

The off-diagonal elements of this matrix are identical to the corresponding elements of Λ, as is λ_{gg}. But the probability of remaining in the bad state is now higher by 0.0039. 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:

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

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 $\sum_s \sum_\omega \mu^*(s,\omega)V^*(s,\omega)$ with $\mu^*(s,\omega)$ 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, $\gamma=1.5$
1.11	1.05	0.01	0.3

The welfare gain including transition is 1.11 percent of consumption per month (or per year) and the steady-state gain is 1.05 percent. To put these numbers in perspective, note that Lucas estimated the welfare gain from eliminating all cyclical volatility in the 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 one hundred times Lucas's (1987) estimate of the gains from eliminating cycles and more than three times 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
$2-S$	0.9705	0.1178	0.9207	0.2856	0.9705	0.0738

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 0.85 percent (which implies that about 81 percent of the gain in welfare is due to the increase in mean earnings); second, the standard deviation of individual consumption is lower by 14.1 percent; and third, the average asset holdings is lower by 14.9 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 individual consumption is significantly higher in the economy with the 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 prepare very much 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 in 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 a 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 qualitative features of 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 a 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.[19]

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.

Finally, it may be of interest to know how much agents would be willing to pay to eliminate the depression state conditional on being in a depression. We find that agents are willing to pay, on average, 4.63 percent of consumption to receive the average steady-state utility of the depression-free economy.

7 Robustness and Sensitivity Analysis

Up to this point, we have kept to a conservative choice of parameter values in order to drive home the point that it does not take much for the possibility of a low-probability Depression-like event to impose significant welfare costs. In this section we examine how the estimate of the welfare gains from eliminating a Depression-like state is altered as we vary asset market assumptions and parameter values in plausible directions. Some of these variations have surprisingly little effect on the estimate of the welfare gains while others raise it significantly. Using this information, we present at the end of this section the combined effects of a less conservative but more plausible calibration of the model.

7.1 Alternative Asset Market Assumptions

So far we have focused on the labor market consequences of a Depression-like event. However, such an event is likely to have consequences for the asset markets as well. In this section, we examine the effect of some asset market

[19] 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 that may have occured during the Depression. Taking these effects into account would only raise our welfare gain estimates.

changes that may, plausibly, be associated with the occurence of a Depression-like event.

The Effects of a Price Level Drop During a Depression

In the baseline model we assumed the asset to have a zero real return. Now, we interpret this asset to be a noninterest-bearing nominal asset. It is well known that nominal 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 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 one 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 4.

Table 4

The Effect of Changes in the Price Level

Gain: $1-\alpha^{SS} = 1.06\%$, $1-\alpha = 1.10\%$

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	0.9705	0.0738	0.1178

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. Also, 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 5 reports the results.

Table 5

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

Gain: $1 - \alpha^{SS} = 1.07\%$, $1 - \alpha = 1.12\%$

Models	$\bar{s}$	$\sigma(s)$	$\bar{c}$	$\sigma(c)$	$\sigma(y)$
$3S$	1.38	0.62	0.9604	0.0786	0.1320
$2S$	1.24	0.39	0.9684	0.0652	0.1178

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 risk during normal times. Therefore, a rough way to capture this situation is to assume that both employed and unemployed workers receive the per-capita endowment in the good and bad states (so there is no risk of loss of income due to unemployment in these times) but confront uninsured unemployment risk in the depression state. Table 6 reports the results from this experiment.

Table 6

The Effect of Perfect Unemployment Insurance in Non-Depression States

Gain: $1-\alpha^{SS}=1.18\%$, $1-\alpha=1.27\%$

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	0.9705	0.0054	0.1178

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. In the three-state economy, the average asset holding is about one-fifth of monthly income while in the two-state economy it is zero. The latter result reflects the fact that in the two-state economy uncertainty in individual earnings is very small (it reflects only aggregate uncertainty), and with the discount rate substantially above the real rate of return all agents find it optimal to set consumption equal to per-capita earnings.

The welfare gain from eliminating the possibility of depressions is now higher. Comparing operating characteristics of this three-state economy with the three-state baseline model (reported in Table 2) we find the volatility of individual consumption is lower than in the baseline model, while mean consumption is identical. Thus, the higher welfare gains relative to the baseline model don't stem from higher volatility of consumption in the three-state world. Rather, it stems from the fact there is now virtually no uncertainty in consumption in the two-state economy. In effect, agents receive the certainty equivalent of the random consumption stream of the baseline two-state economy (mean consumption across these two-state economies is the same), and they are willing to pay more for that privilege. This is reflected in the fact that now the increase in mean consumption (between the two-state and three-state environments) accounts for only 73 percent of the increase in welfare (as compared with 80 percent in the baseline model).

7.2 Alternative Histories

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

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

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, and the average unemployment rate in the depression-like state is now slightly higher as well (24.98 percent versus 23.48 percent in the baseline model). The results of the welfare calculations (reported in Table 7) reveal that these changes roughly offset each other, leading a slight decline in the welfare gains from elimination of the depression-like state.

Table 7

Depression State Defined as Unemployment Rate in Excess of 20 Percent

Gain: $1-\alpha^{SS}=0.99\%, 1-\alpha=1.04\%$

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	0.9705	0.0738	0.1178

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.[20] Accordingly, we classified those 60 months as depression months. This alters the estimated aggregate transition matrix to

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

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 (reported in Table 8) show that the welfare gains from elimination of the depression state is now higher.

[20]See, for instance, Lebergott (1964, Table A-15), Romer (1986, Table 9) and Keyssar (1977, Ch. 2).

Table 8

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

Gain: $1-\alpha^{SS}=1.51\%, 1-\alpha=1.59\%$

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	0.9705	0.0738	0.1178

7.3 Variations in Other Parameters

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 of unemployment to 20 months, twice that of the baseline model. Table 9 reports the results.

Table 9

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

Gain: $1-\alpha^{SS}=1.11\%$, $1-\alpha=1.15\%$

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	0.9705	0.0738	0.1178

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 10

Risk-aversion Parameter $\gamma = 3.0$

Gain: $1 - \alpha^{SS} = 1.24\%, 1 - \alpha = 1.37\%$

Models	$\bar{s}$	$\sigma(s)$	$\bar{c}$	$\sigma(c)$	$\sigma(y)$
$3S$	2.17	1.00	0.9623	0.0678	0.1320
$2S$	1.86	0.53	0.9705	0.0543	0.1178

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 suggested by Greenwood, Rogerson and Wright (1995).

Table 11

Earnings-Loss Parameter is 1/5

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

Gain: $1 - \alpha^{SS} = 2.01\%, 1 - \alpha = 2.22\%$

Models	$\bar{s}$	$\sigma(s)$	$\bar{c}$	$\sigma(c)$	$\sigma(y)$
$3S$	3.39	1.56	0.9397	0.1106	0.2112
$2S$	2.89	0.78	0.9528	0.0894	0.1885

The greater variability in earnings results in much higher average asset holdings; compared with the baseline calibration, agents now hold more than three times as much assets in the three-state world. The volatility of consumption is higher as well compared with the baseline model. The steady-state welfare gain from eliminating depressions is now 2.01 percent, while the gain inclusive of transition effects is 2.22 percent. The component of this gain that results from an increase in mean consumption is around 69 percent. Thus, changes in the higher moments of the distribution of individual consumption contribute more to the increase in welfare than in the baseline model (the contribution of higher moments to change in welfare in the baseline model was 19 percent).

7.4 A Less Conservative Calibration

Our baseline case was computed under a conservative set of assumptions on key parameters. Here we consider a less conservative scenario where we assume the risk-aversion parameter is set at 3, the earnings-loss parameter is set at 1/5, the average duration of unemployment spells in a depression is 20 months, and there is perfect unemployment insurance in nondepression states. Thus, this less conservative calibration combines the experiments done in the previous sections. We report the results of this case in Table 12.

Table 12

A Less Conservative Calibration

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

Gain: $1 - \alpha^{SS} = 6.00\%, 1 - \alpha = 6.59\%$

Models	$\bar{s}$	$\sigma(s)$	$\bar{c}$	$\sigma(c)$	$\sigma(y)$
$3S$	1.47	2.61	0.9404	0.0952	0.2101
$2S$	0	0	0.9525	0.0086	0.1885

Now the welfare gain from elimination of a Depression-like state is 6 percent or more. Also, conditional on being in a depression, the steady-state gain from elimination of the depression state is almost 19 percent. These estimates are now strikingly large and, in our view, more indicative of the true welfare gains to be had from elimination of the likelihood of Depression-like events.

It is of some interest to note that the combined effect of the four departures from the baseline calibration is much larger than the sum of their separate effects. Separately, these departures raised the steady-state welfare gain by 0.19 percent (risk aversion raised to 3), 0.96 percent (earnings loss from unemployment raised to 4/5 of employed earnings), 0.06 percent (average duration of unemployment spells raised to 20 months), and 0.13 percent (perfect unemployment insurance in nondepression states) which brings their sum to only 1.34 percent.

It is also of interest to note that now the increase in mean consumption in the two-state environment accounts for only 21 percent of the increase in steady-state welfare. The rest of the gains come from changes in the higher moments of the consumption distribution. This decomposition is almost exactly opposite to that found for the baseline calibration.

8 Does Uninsured Earnings Risk Matter?

In this section, we assess the quantitative significance of uninsured employment risk for a Depression-like event. We do this by calculating the welfare gain from eliminating the depression state in an environment in which there is complete pooling of idiosyncratic unemployment risk. So, in this environment each agent receives the per-capita endowment of the economy in every aggregate state. Table 13 reports the results from this "representative agent" experiment when all parameter values are held at their baseline choices.

Table 13

The Effect of Full Unemployment Insurance in the Baseline Model

Gain: $1-\alpha^{SS}=0.94\%$, $1-\alpha=0.94\%$

Models	$\bar{s}$	$\sigma(s)$	$\bar{c}$	$\sigma(c)$	$\sigma(y)$
$3S$	0	0	0.9619	0.0266	0.1320
$2S$	0	0	0.9705	0.0054	0.1178

Eliminating uninsured employment risk eliminates the need to save. The uncertainty in earnings is too low to overcome the difference in the rate of return on savings (zero) and the rate of discount (six percent, annualized). As one would expect, allowing risksharing lowers the gains from the elimination of depressions. In particular, the steady-state welfare gains are roughly 12 percent higher in the baseline economy *without* unemployment insurance, and the gains inclusive of the transition path are 18 percent higher.

Thus, for the baseline calibration, the existence of uninsured earnings risk does raise the gains from eliminating depressions. However, the difference is not large. But the situation is quite different for the less conservative calibration discussed in the previous section. Table 14 reports the gain from eliminating depressions for that environment if there is perfect risk sharing.

Table 14

The Effect of Full Unemployment Insurance in the Less Conservative Model

Gain: $1-\alpha^{SS}=1.72\%$, $1-\alpha=1.72\%$

Models	$\bar{s}$	$\sigma(s)$	$\bar{c}$	$\sigma(c)$	$\sigma(y)$
$3S$	0	0	0.9390	0.0425	0.2101
$2S$	0	0	0.9525	0.0086	0.1885

As in the baseline model, complete risksharing eliminates the need to save. The gain from eliminating depressions is now 1.72 percent. For this less-conservative environment we imposed perfect insurance against loss of earnings from unemployment in the good and bad states but not in the depression state. The welfare gain from elimination of the depression state was calculated to be 6.00 percent and 6.59 percent (steady state and inclusive of transition effects, respectively). Therefore, in this case the existence of uninsured earnings risk matters a great deal. The welfare gain in the absence of complete risksharing is close to *four times* that when full risksharing is imposed.

9 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 in the US for the period 1900-1998. In principle our approach could be applied to economic crises in other countries and for other sample periods. For the US, we found that even when the probability of transiting into a Depression-like state is about once in every 83 years, the welfare gain from setting this small probability to zero can range between 1.05 percent and 6.60 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. We also find that uninsured unemployment risk may contribute significantly to the size of these gains. For instance, in the case where the gains are in excess of six percent, a representative agent calculation would yield a welfare gain that is only about one-fourth as large.

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 crises to zero. However, by pointing out the welfare gains from eliminating even a *small* probability of encountering a Depression-like state, we are suggesting that it's worthwhile to determine what policies reduce the likelihood of economic crises and how they would be implemented.

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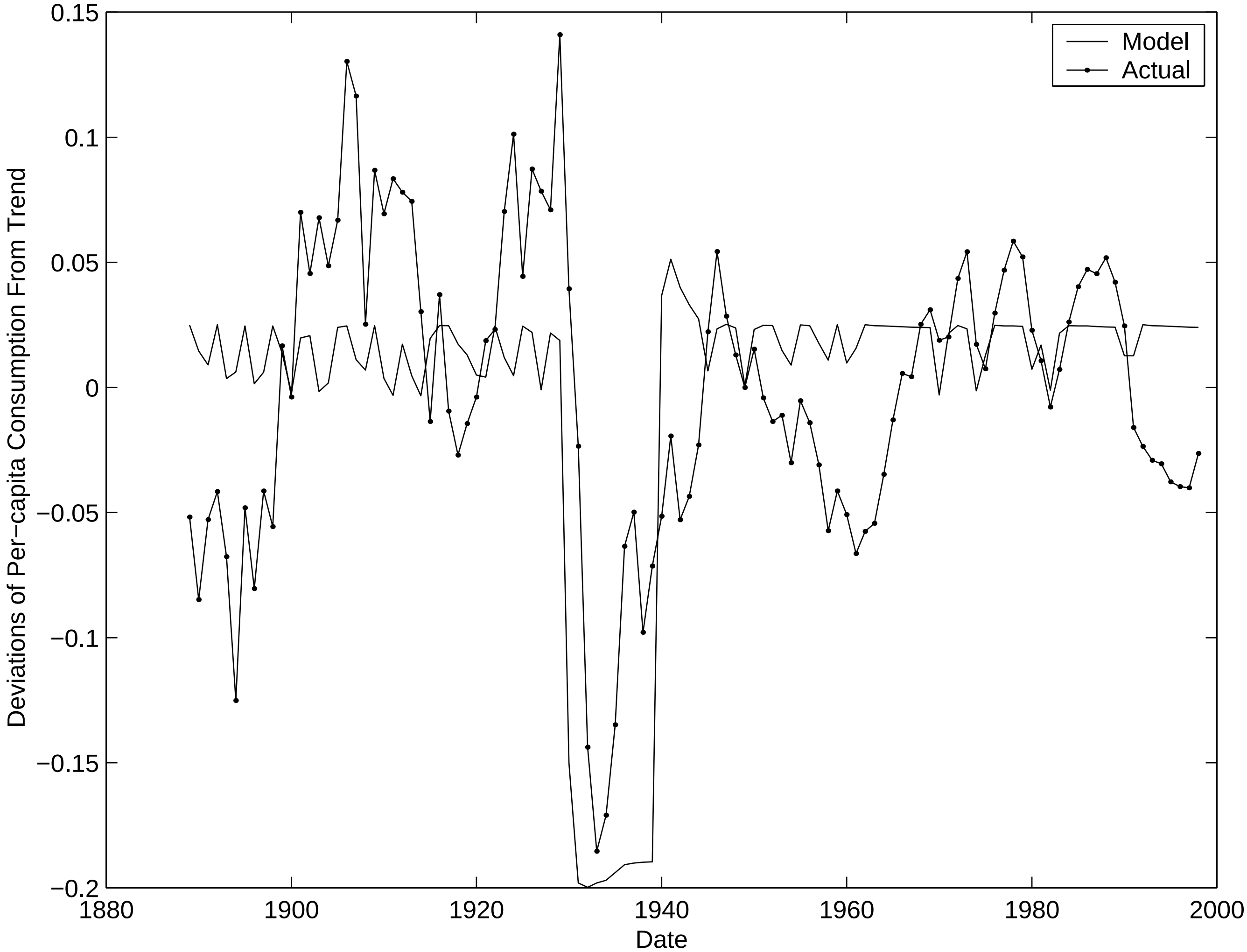
Fig.2a: Simulated and Actual Per−capita Consumption When All Home Production is Measured
Model
Actual
Deviations of Per−capita Consumption From Trend
Date
0.15
0.1
0.05
0
−0.05
−0.1
−0.15
−0.2
1880
1900
1920
1940
1960
1980
2000

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



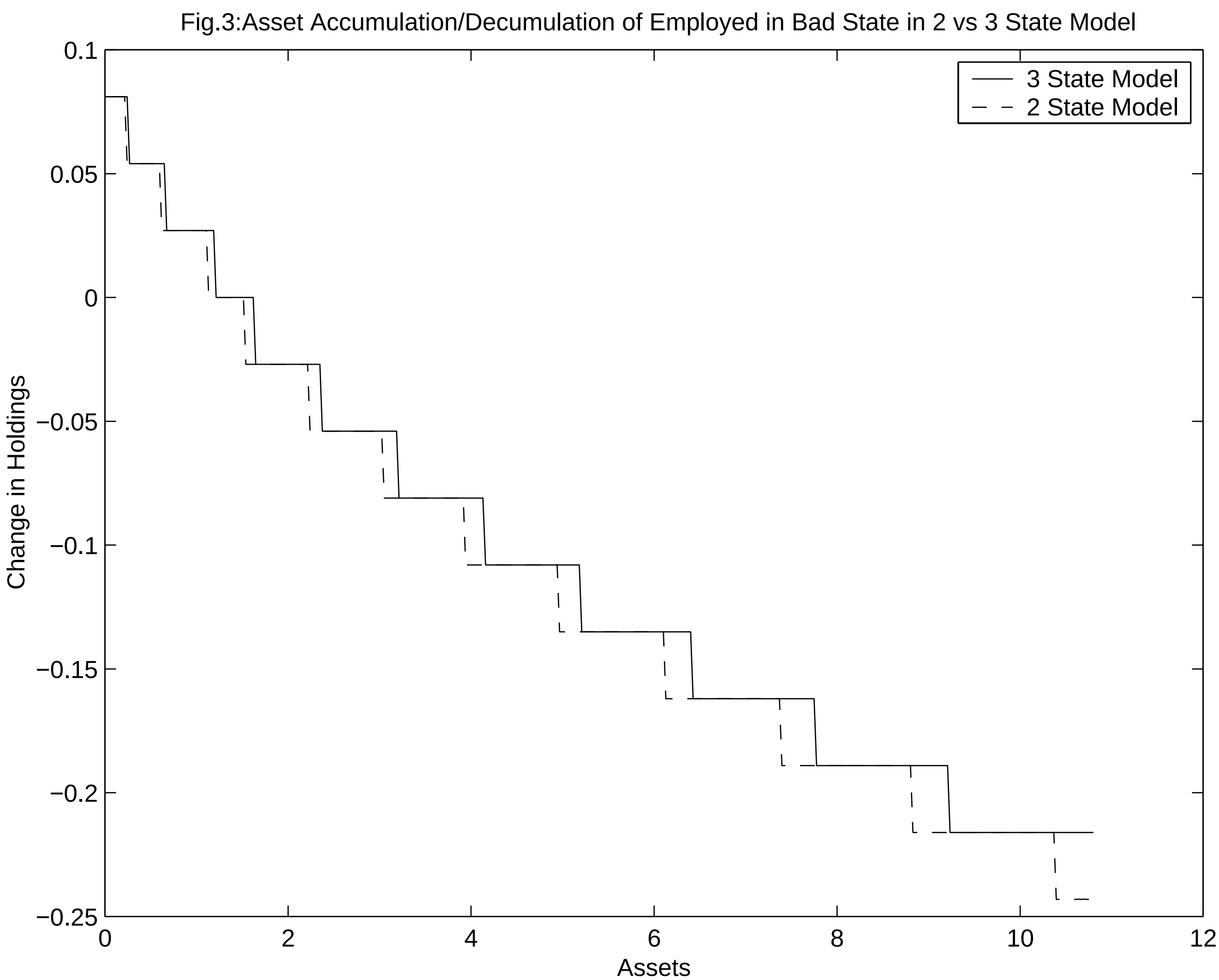


Fig.3:Asset Accumulation/Decumulation of Employed in Bad State in 2 vs 3 State Model
3 State Model
2 State Model
Change in Holdings
Assets
0.1
0.05
0
−0.05
−0.1
−0.15
−0.2
−0.25
0
2
4
6
8
10
12

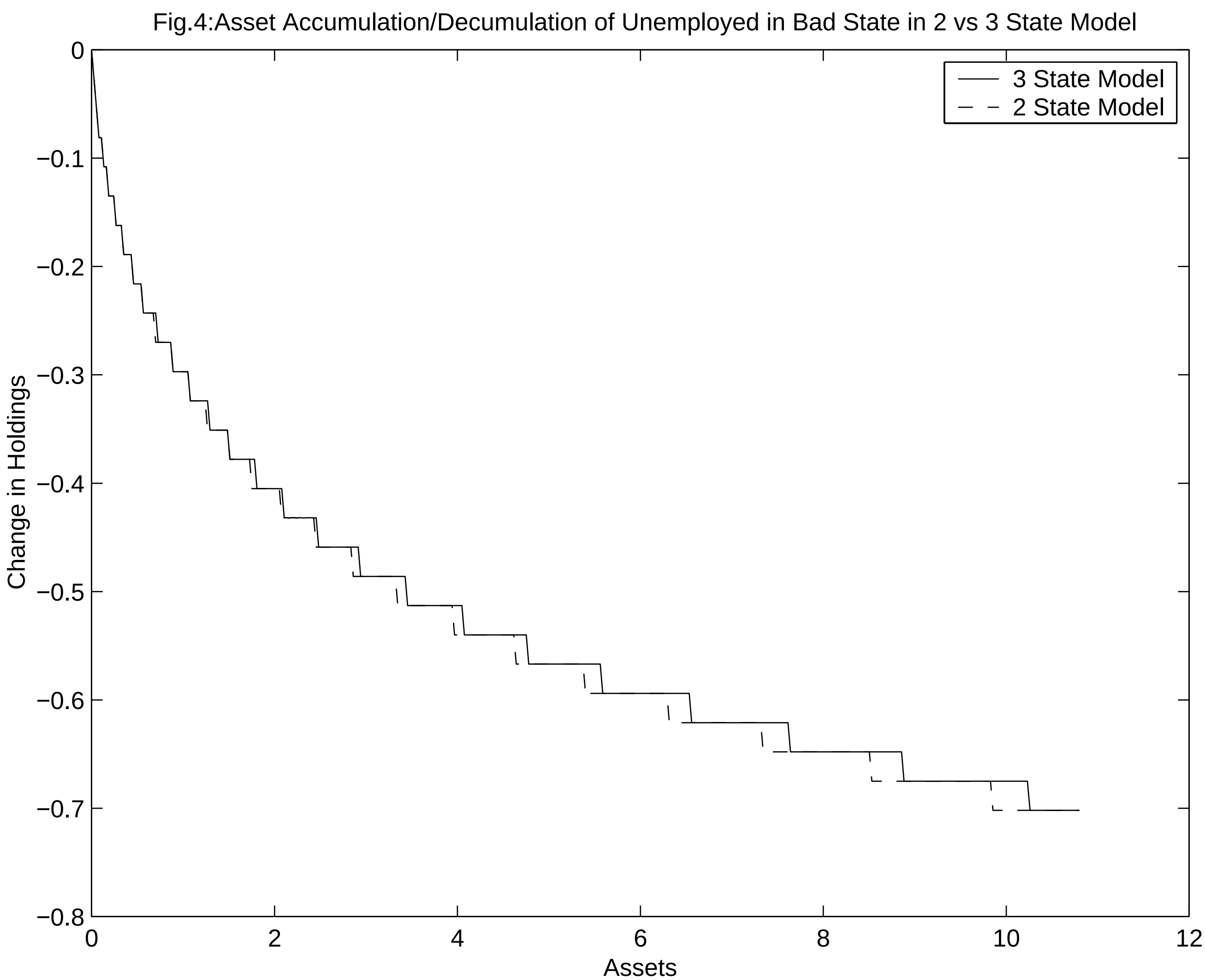


Fig.4:Asset Accumulation/Decumulation of Unemployed in Bad State in 2 vs 3 State Model
3 State Model
2 State Model
Change in Holdings
Assets
0
−0.1
−0.2
−0.3
−0.4
−0.5
−0.6
−0.7
−0.8
0
2
4
6
8
10
12

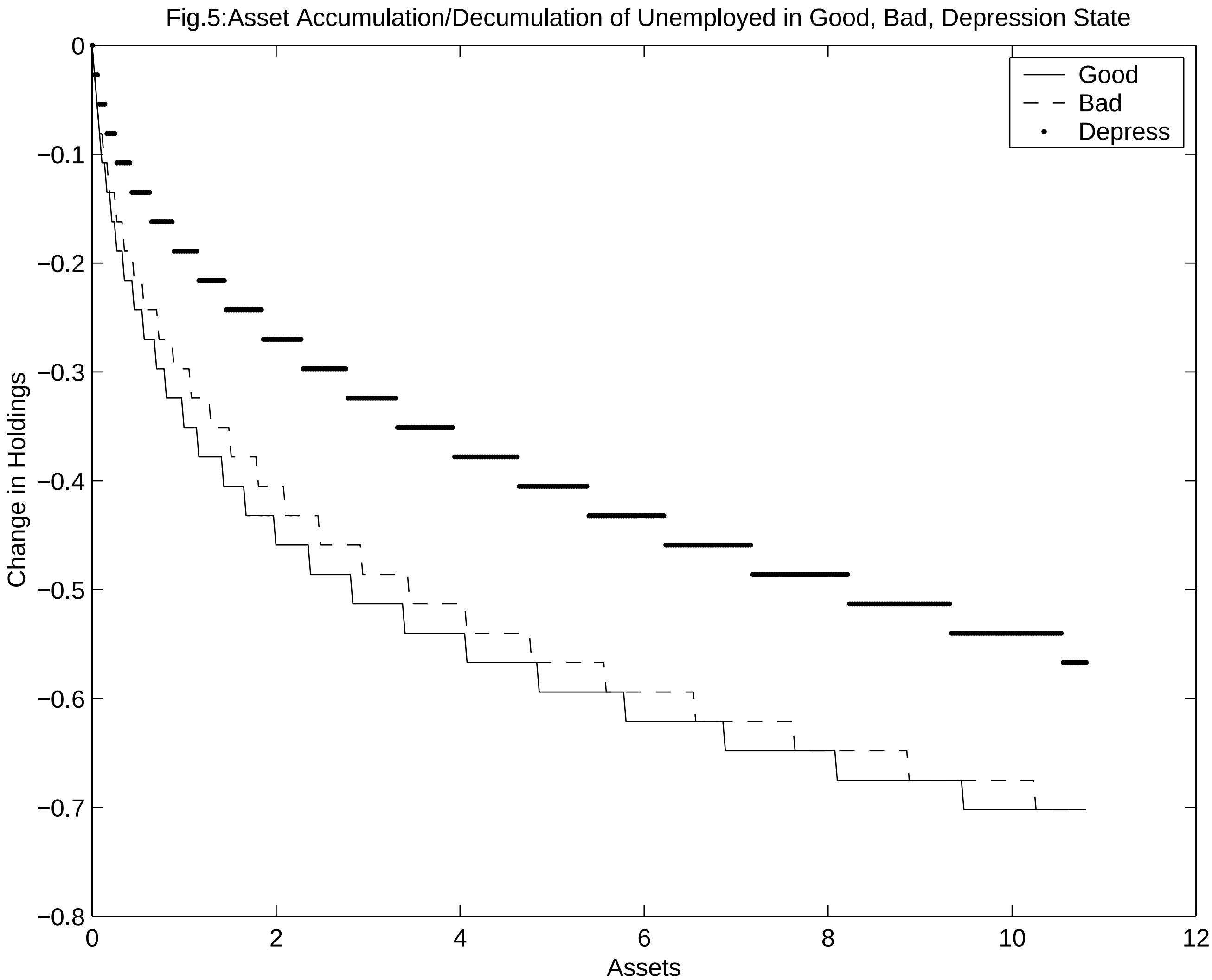


Fig.5:Asset Accumulation/Decumulation of Unemployed in Good, Bad, Depression State
Good
Bad
Depress
Change in Holdings
Assets
0
−0.1
−0.2
−0.3
−0.4
−0.5
−0.6
−0.7
−0.8
0
2
4
6
8
10
12

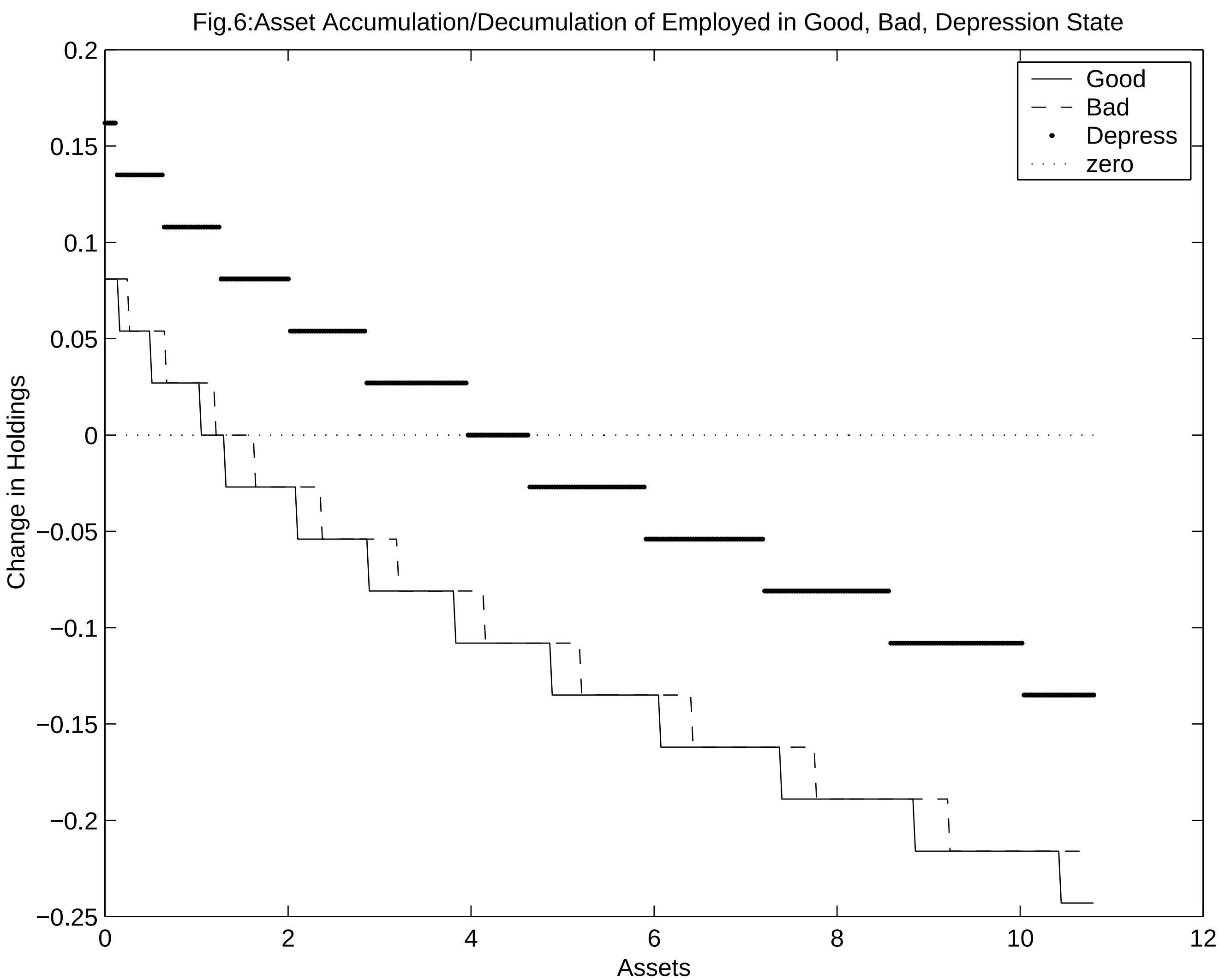


Fig.6:Asset Accumulation/Decumulation of Employed in Good, Bad, Depression State
Good
Bad
Depress
zero
Change in Holdings
Assets
0.2
0.15
0.1
0.05
0
−0.05
−0.1
−0.15
−0.2
−0.25
0
2
4
6
8
10
12

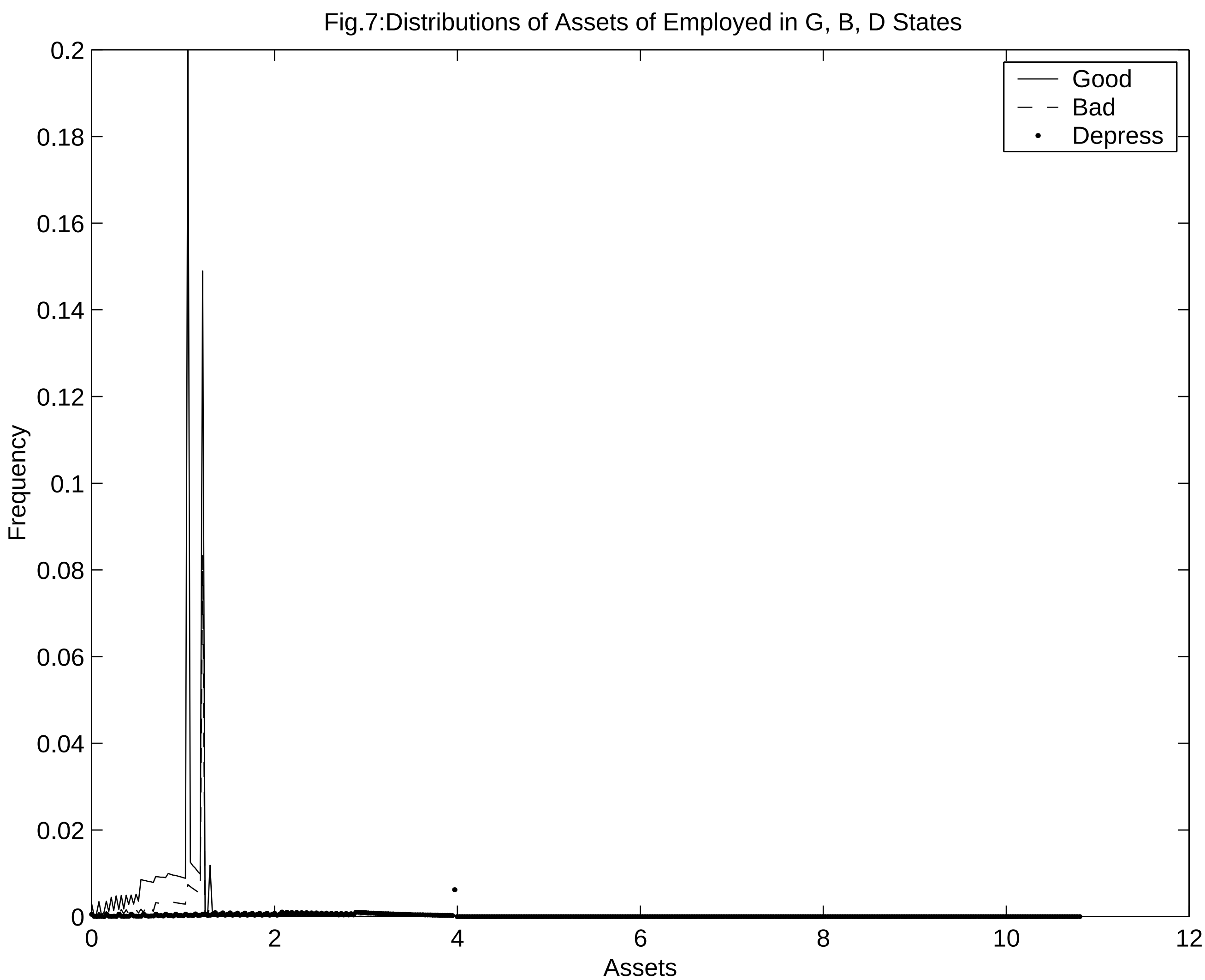


Fig.7:Distributions of Assets of Employed in G, B, D States
Frequency
Assets
0
0.02
0.04
0.06
0.08
0.1
0.12
0.14
0.16
0.18
0.2
0
2
4
6
8
10
12
Good
Bad
Depress

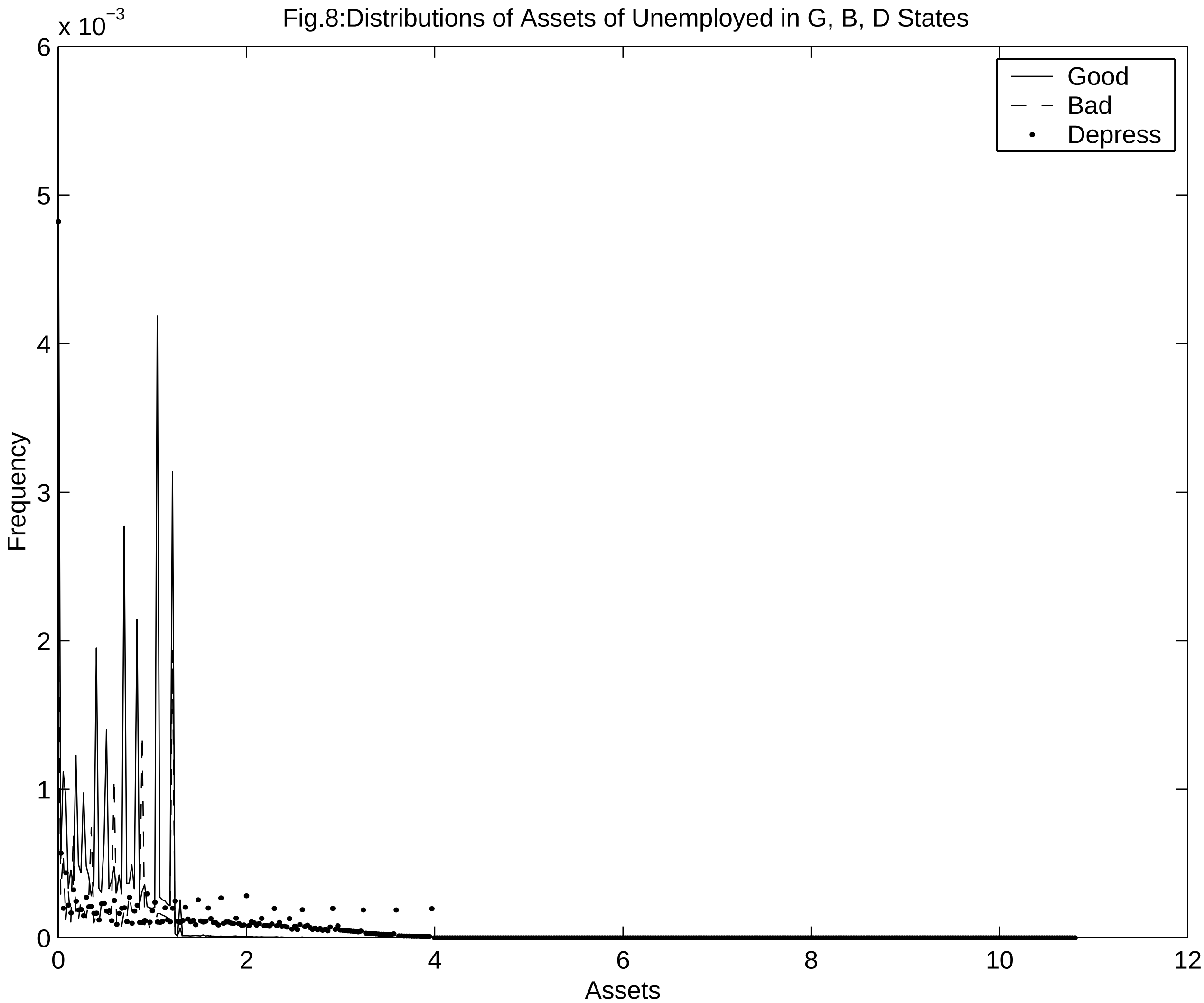


Fig.8:Distributions of Assets of Unemployed in G, B, D States
x 10^-3
6
5
4
3
2
1
0
Frequency
0
2
4
6
8
10
12
Assets
Good
Bad
Depress

Fig.9: Simulated Asset Holdings during the Depression

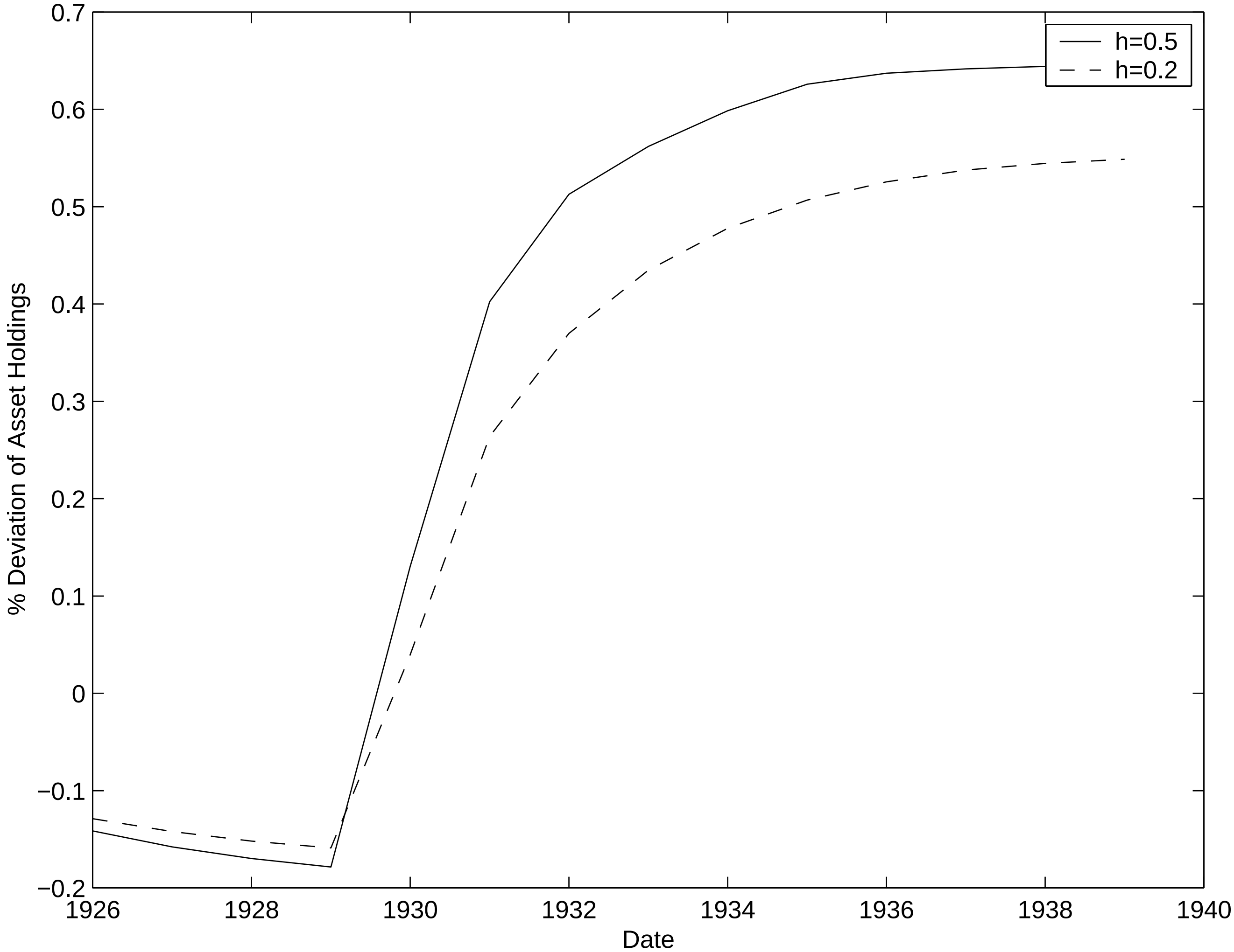
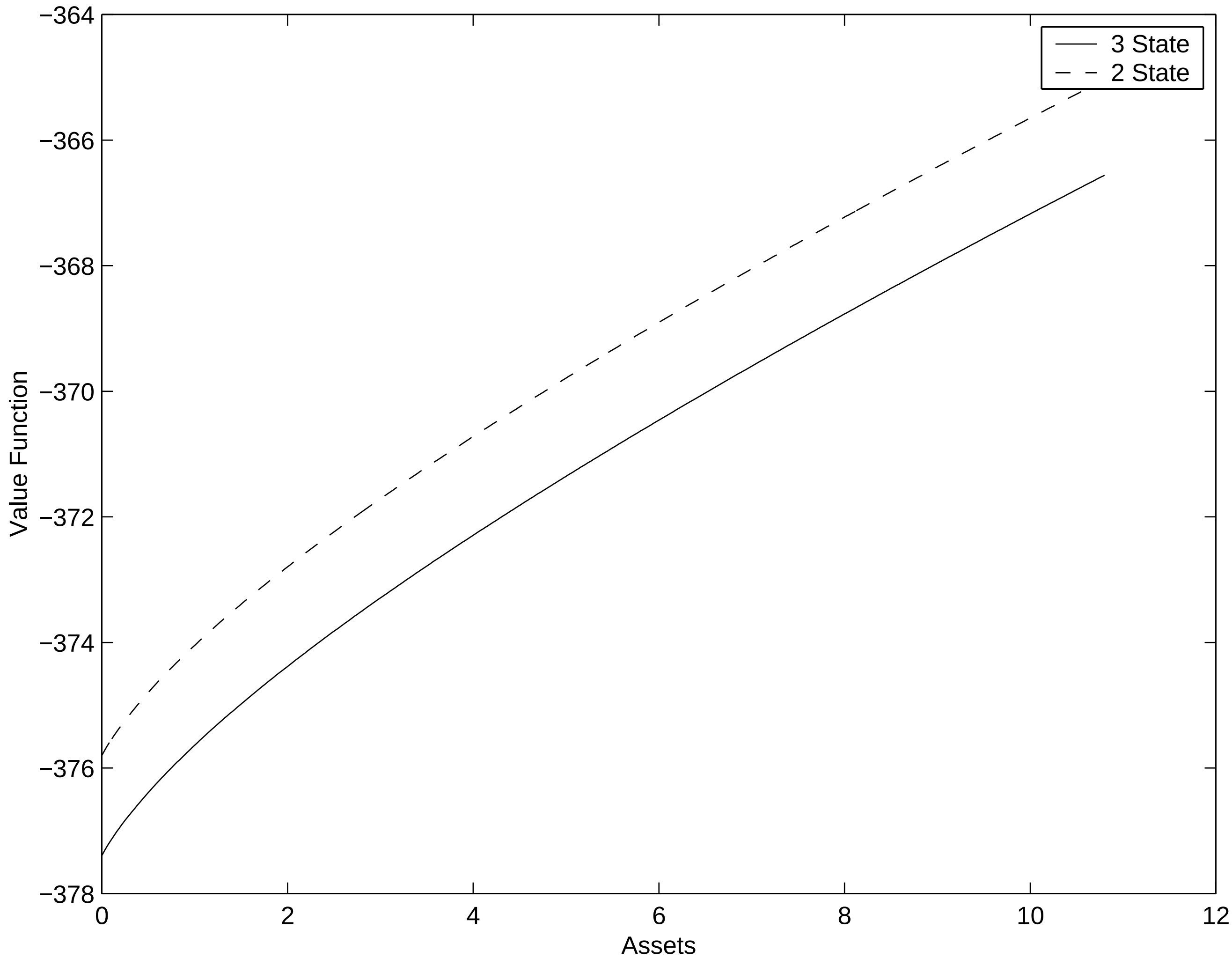


Fig.10:Value Functions of Unemployed in Bad State in 2 vs 3 State Model



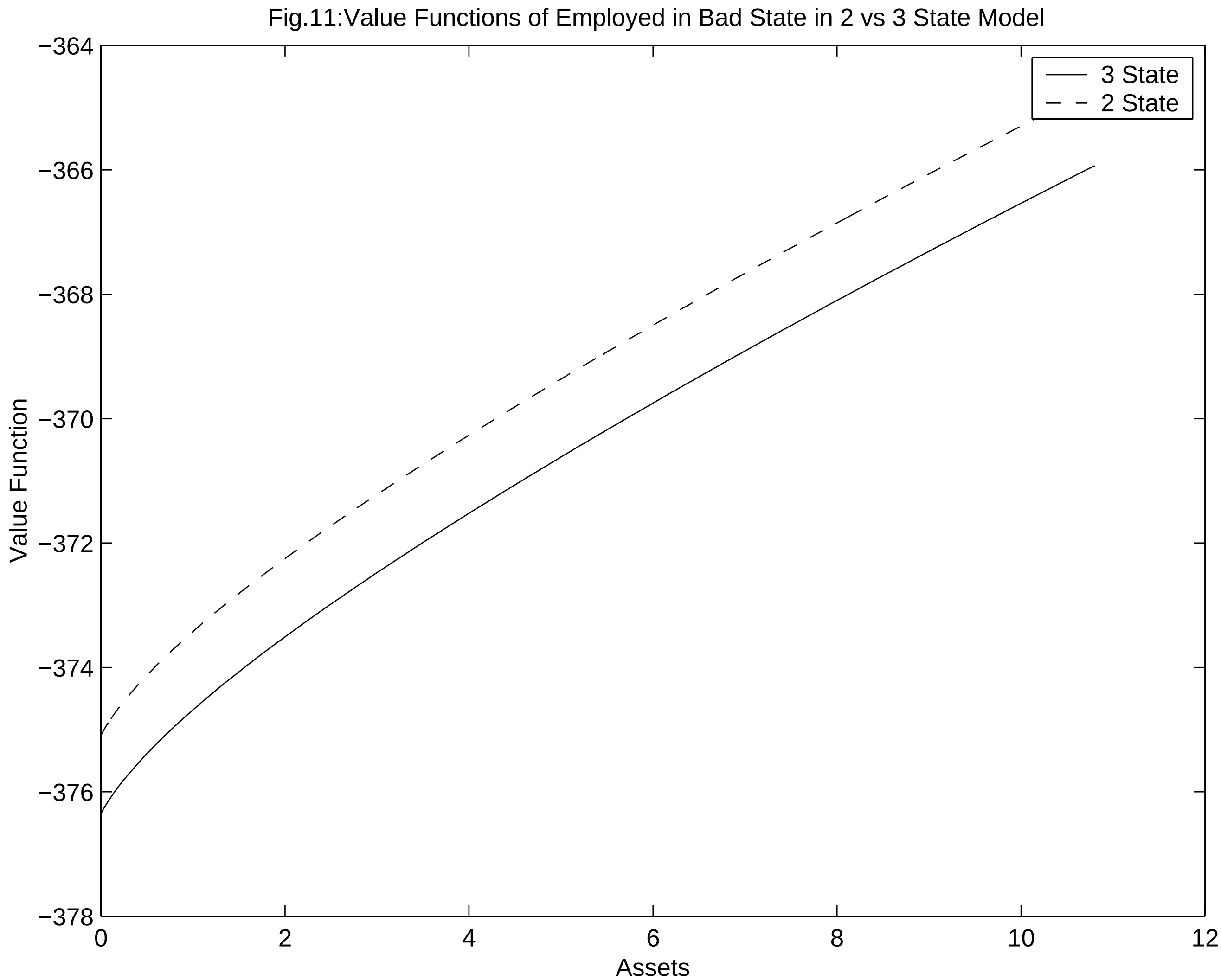


Fig.11:Value Functions of Employed in Bad State in 2 vs 3 State Model
−364
−366
−368
−370
−372
−374
−376
−378
Value Function
0
2
4
6
8
10
12
Assets
3 State
2 State