Understanding the Welfare Effects of Unemployment Insurance Policy in General Equilibrium*

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Abstract

This paper analyzes the welfare effects of unemployment insurance reforms in a general equilibrium incomplete market model. In particular, it decomposes the total welfare effect for each individual into different factors. I consider a model where the consumers face an uninsurable unemployment risk, can save in an interest-bearing asset, and are subject to a borrowing constraint. The labor market is modeled using a Diamond-Mortensen-Pissarides style search and matching model. The decomposition exercises reveal how each factor contributes to the heterogeneity of welfare effects among different consumers.

Keywords: Welfare Effect, Unemployment Insurance, Heterogeneous Agents
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1 Introduction

Unemployment insurance (UI) allows consumers to cope with the risk of large fluctuations in income due to job loss. It provides a method of smoothing consumption while unemployed, particularly for consumers who are constrained in borrowing. Because this type of insurance is difficult to provide through the private market, UI has long been viewed as an important government policy. There has been a large amount of research devoted to analyzing the effect of government-provided UI, on both theoretical and empirical fronts.

In the past 30 years, many papers have been written on "optimal UI policy." These papers typically consider a set of available UI policy options, and select the "optimal" policy based on certain welfare criteria. Existing papers vary widely in terms of the environments they consider and the restrictions that they put on the available policy instruments. Some papers analyze environments with only one consumer,[1] some consider environments with many heterogeneous consumers,[2] and others construct a general equilibrium environment with production.[3] Some papers consider a fully duration-dependent UI benefit,[4] some only consider a constant benefit with various levels,[5] and others analyze a benefit that is non-constant but has restricted flexibility.[6]

The quantitative papers differ substantially on their recommendation of the "optimal UI benefit."[7] The results depend on the details of the model, and the models typically involve many elements that are affected by the change in the UI benefit, so that it is difficult to identify which details are driving differences in the results. To learn from the models and draw lessons for actual policy making, it does not seem productive to simply list various numbers that are obtained from different settings. Rather, it is necessary to *understand* how these quantitative conclusions are drawn. By understanding what is behind these numbers, one can gain *intuitions* that are robust to the details of the model.

This paper contributes to this understanding. Instead of calculating the optimal UI scheme, I analyze the welfare effect of a simple UI reform that permanently increases the benefit from a baseline level. The model that I consider is a dynamic general equilibrium model with uninsured idiosyncratic unemployment risk. In particular, my model belongs to a class of models called Bewley-Huggett-Aiyagari models.[8] These models assume that consumers cannot insure against

[1]For example, Shavell and Weiss (1979), Hopenhayn and Nicolini (1997), Shimer and Werning (2008).

[2]For example, Hansen and İmrohoroğlu (1992), Abdulkadiroğlu et al. (2002), Joseph and Weitzenblum (2003), and Lentz (2009).

[3]For example, Costain (1999), Young (2004), and Krusell et al. (2010).

[4]For example, Shavell and Weiss (1979), Hopenhayn and Nicolini (1997), and Shimer and Werning (2008).

[5]For example, Hansen and İmrohoroğlu (1992), Young (2004), and Krusell et al. (2010)

[6]For example, Abdulkadiroğlu et al. (2002).

[7]For example, Hansen and İmrohoroğlu (1992) calculate the optimal replacement rates of 0.65 to 0.05 depending on the degree of moral hazard, Wang and Williamson (2002) suggest 0.24 (when the benefit is perpetual) as optimal with one type of workers, Young (2004) recommends zero unemployment insurance, and Lentz (2009) finds the optimal replacement rates of 0.76 to 0.27 depending on the worker's state.

[8]See Bewley (undated), Huggett (1993), and Aiyagari (1994).

idiosyncratic risk directly, have access to an interest-bearing asset (and thus are able to self-insure), and are subject to a borrowing constraint. One notable aspect of the model is that consumers are heterogeneous with respect to employment status and asset levels at a given point in time. This makes it difficult to evaluate the welfare effects of a policy change—the welfare effects for a particular consumer depend on her individual state at the time of the policy change.[9] The analysis in this paper describes the individual-level welfare effects and *decomposes* them into various factors. The novel contribution of this paper is this decomposition analysis.[10] As will become clear, this decomposition makes it possible to understand the intuitions in these complex dynamic general equilibrium models with heterogeneous agents.

The model endogenizes the labor market using Diamond-Mortensen-Pissarides-style search and matching model (Pissardies, 1985). This type of model has been used for the analysis of UI in several papers in the past. Examples include Pollak (2007), Reichling (2007), Krusell et al. (2010), Vejlin (2011), Kristoffersen (2012), and Nakajima (2012). The model in this paper is mainly based on Krusell et al. (2010). The main difference here from the analysis of Krusell et al. (2010) is that I explicitly consider transition dynamics, whereas they focus on steady-state comparison. It turns out that considering these transition dynamics is essential to properly analyze the welfare effect of the policy reform.

The quantitative model shows that the welfare gain from reforms that increase the UI benefit is higher for a consumer who is unemployed at the time of reform than for a consumer who is employed. The gain also tends to be decreasing in the level of wealth at the time of reform. The decomposition exercise reveals which factors contribute to these patterns. For the first pattern, the main reason is that the policy reform implicitly includes a transfer of expected future income from employed consumers to unemployed consumers. There is another effect in the opposite direction that works through a change in job-finding probability, but quantitatively it is dominated by the effect of this implicit transfer. The second pattern is affected by three different factors. First, a poor consumer benefits more from a better opportunity for consumption smoothing—this is the insurance effect of a more generous UI. Second, the return on assets declines for a significant period after reform, hurting asset-rich consumers more than asset-poor consumers. The third effect works in the opposite direction—a decline in job-finding probability hurts a poor worker more, since they rely more on the labor income. Quantitatively, this effect is dominated by the first two. It turns out that the second effect through asset returns occurs during the transition to the new steady-state, and a steady-state comparison would yield the opposite conclusion about the welfare effect of the change in asset returns. There, an endogenous movement of the labor market also plays a crucial role.

The paper is organized as follows. The next section builds the model and carries out the

[9] One can imagine that this heterogeneity in welfare effects has politico-economic consequences: in a majority-voting setting, for example, a policy reform is taken up when the majority of voters benefit from the reform. Pallage and Zimmermann (2001) analyze a voting equilibrium in a model similar to Hansen and İmrohoroğlu (1992), where the voting decision is based on a steady-state welfare comparison.

[10] In the context of a social security reform, Conesa and Kruger (1999) conduct an experiment with "fixed prices," which corresponds to my "partial equilibrium experiment."

main analysis. Section 3 concludes.

2 Model

The model setup is similar to Krusell et al. (2010). The asset market is incomplete and consumers can hold only one type of asset, which is not contingent on individual idiosyncratic shocks. The asset is a combination of the capital stock and a claim to the profit (dividend) of the representative firm—these two yield identical returns because the rental rate of capital and the profit of the representative firm both depend only on the aggregate situation of the economy (and there are no aggregate shocks). The labor market has a Diamond-Mortensen-Pissarides style structure (Pissarides, 1985): the representative firm posts vacancies and receives profit from the jobs which are matched to the workers. The wages are determined by Nash bargaining. In this framework, the wage depends on the asset level of the worker. The government finances the unemployment benefit by a proportional tax on labor income (including the unemployment benefit). The government balances the budget every period.

The policy reform is *permanent* and *unexpected*—that is, at a certain point in time (call it time 0), the unemployment benefit changes suddenly and permanently, and neither the consumers nor the firms take the possibility of this change into account before time 0. After time 0, the consumers and the firm know that the change is permanent, and they behave accordingly. The economy experiences transition dynamics after time 0, since the unemployment and the capital stock do not adjust immediately. I evaluate the welfare effect of this policy reform by comparing the present value of expected utilities of each consumer at time 0 in the case of the reform at time 0 and no reform at all. My calculation explicitly takes the transition dynamics into account.

2.1 Setup

Time is discrete and there is a continuum of infinitely-lived consumers with population normalized to 1. A consumer maximizes the discounted lifetime utility

$$\mathbf{U} = E_{t_0}\left[\sum_{t=t_0}^{\infty} \beta^{t-t_0}\mathcal{U}(c_t)\right], \tag{1}$$

where $\beta \in (0,1)$ is the discount factor, c_t is the consumption at time t, $\mathcal{U}(\cdot)$ is an increasing and concave period utility function, and $E_{t_0}[\cdot]$ denotes the expectation at time t_0, where $t_0 < 0$. I assume that the economy is already in its steady state at time 0. The consumer can hold only one kind of asset; let a_t be the individual asset holding at time t. The asset is a combination of the capital stock and the claim to the profit (dividend) of the representative firm (equity). These two can be considered as one asset, since the returns from both are identical, as will be shown. A consumer is either employed or unemployed at a point in time. When employed, the consumer works $\bar{h}$ fixed hours, and is paid the wage w_t per hour. The consumer also faces a borrowing constraint: $a_{t+1} \geq \underline{a}$, where $\underline{a}$ is an exogenously given borrowing limit. While unemployed, the consumer receives an unemployment benefit b. The government finances UI through a proportional tax on labor income (including the unemployment benefit). The government balances the budget every period, and the tax rate at time t is denoted as $\tau_t \in [0, 1]$.

The employment status of a consumer is determined by a random draw. Each period, an employed consumer is separated from her job with probability $\sigma \in (0, 1)$; an unemployed consumer finds a job with probability λ_w. The separation probability σ is given exogenously. The job-finding probability λ_w is endogenously determined, as will be explained below.

There is one representative firm which acts competitively. The firm is owned by the consumers through tradable equity. The firm cannot hire workers immediately: it has to post a vacancy, and with some probability the vacancy is filled. The firm can be viewed as a collection of the filled jobs, each of which generates profit. Note that the consumers can own the equity of the entire firm (that is, the claim to the total profit), but are not allowed to trade the claim to the profit of an individual job. The frictions in the labor market are summarized by the aggregate matching function:

$$M(u_t, v_t) = \chi u_t^{\eta} v_t^{1-\eta},$$

where $\eta \in (0, 1)$ and $\chi > 0$ are parameters. $M(u_t, v_t)$ represents the amount of "meeting" between vacancies and unemployed workers at time t when there are u_t unemployed workers and v_t vacancies posted by the firm. The meeting is entirely random. Therefore, the probability that a vacancy finds a worker is

$$\lambda_f(\theta_t) = \frac{M(u_t, v_t)}{v_t} = \chi \left(\frac{v_t}{u_t} \right)^{-\eta} = \chi \theta_t^{-\eta}$$

and the probability that an unemployed consumer finds a job is

$$\lambda_w(\theta_t) = \frac{M(u_t, v_t)}{u_t} = \chi \left(\frac{v_t}{u_t} \right)^{1-\eta} = \chi \theta_t^{1-\eta},$$

where $\theta_t \equiv v_t/u_t$ represents the labor market tightness at time t. In the calibrated settings analyzed in this paper, each meeting always generates a match (i.e. a combination of a filled job and an employed worker)—there is no rejection or voluntary separation.

Consumers own capital stock, k_t, and equity, x_t. The capital stock is a factor of production—at each matched job, the production function is

$$y_t^f = (k_t^f)^{\alpha} \bar{h}^{1-\alpha},$$

where y_t^f is output, k_t^f is the capital input that is rented for this job (k_t^f does not have to be the same as the worker's own k_t—I assume that there is a competitive rental market for capital), and $\alpha \in (0, 1)$. The equity is the ownership of the representative firm, which consists of many jobs (filled vacancies) that generate profit. This profit is paid out to the equity holders as dividends every period. I normalize the total amount of equity to 1 and denote the post-dividend unit price of equity at time t as p_t. Let the amount of the dividend at time t be d_t.

Let the rental rate of the capital stock at time t be r_t and the depreciation rate of the capital stock be $\delta \in (0,1)$. Since there is no aggregate uncertainty in this economy and the returns from capital and equity only depend on aggregate conditions, their returns must be the same. Therefore,

$$\frac{d_{t+1} + p_{t+1}}{p_t} = 1 + r_{t+1} - \delta \tag{2}$$

holds.[11]

The consumer's budget constraint is

$$c_t + k_{t+1} + p_t x_{t+1} = (1 + r_t - \delta)k_t + (p_t + d_t)x_t + \mathcal{E}_t,$$

where $\mathcal{E}_t$ is after-tax labor earnings (including UI benefit) at time t. Once I define $a_t \equiv k_t + p_{t-1}x_t$, using (2), this can be rewritten as

$$c_t + a_{t+1} = (1 + r_t - \delta)a_t + \mathcal{E}_t.$$

Thus the consumers can be regarded as holding only one type of asset, which is a combination of capital stock and equity, in the value a_t. Since the capital stock and the equity have identical returns, the portfolio choice of each consumer is indeterminate. However, the portfolio composition affects how each consumer is affected by the unanticipated policy change in the following experiment, since these two assets are affected differently by the policy change. In the following, I assume that all consumers hold the same proportions of capital and equity (that is, k_t/x_t is same for all consumers).

Consumers maximize utility (1). The wage is determined by a generalized Nash bargaining between the firm and the worker (with the worker's bargaining weight $\gamma \in (0,1)$) every period, as in Krusell et al. (2010). The Nash bargaining process is detailed in Appendix A. It turns out that the wage is a function of the worker's current wealth, and I denote the wage w_t as a function $w_t = \omega_t(a_t)$. Then the Bellman equations are

$$W_t(a_t) = \max_{c_t, a_{t+1}} \mathcal{U}(c_t) + \beta[(1-\sigma)W_{t+1}(a_{t+1}) + \sigma U_{t+1}(a_{t+1})]$$

subject to

$$c_t + a_{t+1} = (1 + r_t - \delta)a_t + (1 - \tau_t)\omega_t(a_t)\bar{h}$$

and

$$a_{t+1} \geq \underline{a}$$

[11] The equation (2) has to hold both in the steady state and transition, and both before and after the reform, as long as the future path of the aggregate state is anticipated by the consumers. The only exception is the very moment when the unexpected policy change happens (i.e. at time 0). At time 0, the value of p_{-1} has to be reevaluated with the different stream of future profits, and p_{-1} drops. The details of what happens at time 0 are explained in Section 2.2.1.

for employed consumers and

$$U_t(a_t) = \max_{c_t, a_{t+1}} \mathcal{U}(c_t) + \beta[\lambda_w(\theta_t) W_{t+1}(a_{t+1}) + (1 - \lambda_w(\theta_t)) U_{t+1}(a_{t+1})]$$

subject to

$$c_t + a_{t+1} = (1 + r_t - \delta)a_t + (1 - \tau_t)b$$

and

$$a_{t+1} \geq \underline{a}$$

for unemployed consumers. Let the decision rules for the consumers' next period asset holdings be $a_{t+1} = \psi_t^i(a_t)$, where $i = e$ for an employed consumer and $i = u$ for an unemployed consumer.

The firm's objective is to maximize the discounted present value of its profits for the shareholders. From (2), the shareholders discount the future profit at the rate $(1 + r_{t+1} - \delta)$. To produce, the firm has to create jobs and rent capital. To create a job, the firm must first post a vacancy. The flow cost of posting a vacancy is ξ, and each vacancy faces a probability $\lambda_f(\theta_t)$ of finding a worker. Because the matching process is random, each vacancy can potentially be filled by any worker, but the resulting profit can differ depending on the worker's wealth level. Because the wage depends on the worker's wealth level, matching with one worker can be more beneficial than matching with another worker. I denote the value from matching with a worker with asset level a_t at time t as $J_t(a_t)$. Let f_t^u be the measure of unemployed consumers at time t over the asset levels. Then the expected value of the match in the next period (conditional on meeting with someone) is $\int (J_{t+1}(\psi_t^u(a))/u_t) f_t^u(da)$. The value of posting a vacancy at time t, V_t, is therefore

$$V_t = -\xi + \frac{1}{1 + r_{t+1} - \delta}\left[(1 - \lambda_f(\theta_t))V_{t+1} + \lambda_f(\theta_t) \int J_{t+1}(\psi_t^u(a)) \frac{1}{u_t} f_t^u(da)\right]. \tag{3}$$

I assume free entry to vacancy posting (that is, the representative firm posts vacancies until the marginal value of posting becomes zero), so that in equilibrium $V_t = 0$ in (3) for all t with a positive amount of vacancy posting. The free entry condition $V_t = 0$ determines the equilibrium value of θ_t (and therefore v_t) every period.

The value of a filled job is

$$J_t(a_t) = \max_k \quad k^\alpha \bar{h}^{1-\alpha} - r_t k - \omega_t(a_t)\bar{h} + \frac{1}{1 + r_{t+1} - \delta}[(1 - \sigma)J_{t+1}(\psi_t^e(a_t)) + \sigma V_{t+1}].$$

The firm's first-order condition for k is

$$r_t = \alpha k^{\alpha - 1} \bar{h}^{1-\alpha}.$$

Let K_t be the aggregate capital stock. Because there are $(1 - u_t)$ filled jobs that have an identical productivity, each job employs $\tilde{k}_t \equiv K_t/(1 - u_t)$ amount of capital stock in equilibrium. Therefore, the equilibrium interest rate is:

$$r_t = \alpha \tilde{k}_t^{\alpha - 1} \bar{h}^{1-\alpha}.$$

Denoting $L_t = (1 - u_t)\bar{h}$ as the aggregate labor input, this can also be rewritten as

$$r_t = \alpha \left(\frac{K_t}{L_t} \right)^{\alpha - 1}. \quad (4)$$

This implies that r_t is a decreasing function of K_t/L_t.

The period profit for each job can be calculated as

$$\pi_t(a_t) = \tilde{k}_t^{\alpha} \bar{h}^{1-\alpha} - r_t \tilde{k}_t - \omega_t(a_t)\bar{h}.$$

Aggregating each firm's profit (minus the vacancy cost) yields the dividend:

$$d_t = \int \pi_t(a) f_t^e(da) - \xi v_t,$$

where f_t^e is the measure of employed consumers over the asset levels at time t. With d_t, the equity price p_t can be calculated from (2) and an appropriate transversality condition, using the equilibrium interest rate (4).

The asset market equilibrium condition determines the value of K_t at each period. From the definition of a_t for each consumer (and indexing each consumer by the superscript i),

$$\int k_{t+1}^i di + \int p_t x_{t+1}^i di = \int a_{t+1}^i di$$

has to hold. Because $\int k_{t+1}^i di = K_{t+1}$ and $\int x_{t+1}^i di = 1$ hold in equilibrium,

$$K_{t+1} = \int a_{t+1}^i di - p_t.$$

At the aggregate level, the unemployment rate moves following the transition equation

$$u_{t+1} = \sigma(1 - u_t) + (1 - \lambda_w(\theta_t))u_t.$$

The government balances the budget every period:

$$\tau_t \int \omega_t(a) \bar{h} f_t^e(da) + \tau_t u_t b = u_t b.$$

The measures f_t^e and f_t^u evolve following the decision rules and the matching/separation probabilities at each period.

2.2 Results

The model calibration follows the standard practice. One period corresponds to one month. The discount factor β is set at 0.9967, which makes the net annual rate of asset return approximately 4%. The value of $\bar{h}$ is set at 1/3. The period utility function is assumed to be a logarithmic function.[12] The production function parameter α corresponds to the capital share, and is set at 1/3. The depreciation rate is $\delta = 0.004$, which corresponds to an annual value of 4.8%, following the value used in Cooley and Prescott (1995). The borrowing limit $\underline{a}$ is zero.

For the labor market parameters, first I follow Shimer (2005) and set $\eta = \gamma = 0.72$. I assume that (again, following Shimer, 2005) the baseline value of θ is 1, that is, $\theta = 1$ in the steady state before the policy change. This means that the job-finding rate $\lambda_w(\theta_t)$ is equal to χ in the steady state before the policy change. I set $\chi = 0.26$, which implies that the average duration of unemployment is about 17 weeks. This is in line with the U.S. experience since the 1980s (Mukoyama and Şahin, 2009). The separation rate σ is set at 0.02, and the steady-state unemployment rate $\bar{u}$ becomes 7.1%. The value of ξ is set so that the free-entry condition $V_t = 0$ is satisfied with V_t in (3) before the policy change (with $\theta = 1$).

The computation of the steady state is similar to Krusell et al. (2010) and thus the details are omitted here. The computation of the transition path after the policy reform is explained in Appendix C.

Below, I consider two different baselines. The first baseline is a "low UI" situation: $b = 0.1$. In the initial steady state, the average value of the pre-tax monthly earnings ($\omega(a)\bar{h}$) turns out to be about 1.46. This implies a replacement ratio of about 7%. The value of ξ in this case is 0.49, which is about 34% of the pre-tax monthly earnings. The tax rate τ_t in the initial steady state is 0.5%. The second baseline is "high UI" situation: $b = 0.8$. The average pre-tax monthly earnings is 1.48 and thus the replacement ratio is about 54%. The value of ξ is 0.24 (16% of the pre-tax monthly earnings) and τ_t is 4.0%.

Figure 1 shows the populations of employed and unemployed consumers for each wealth level. Once again, note that the average of the pre-tax monthly earnings is about 1.46, so that one unit of the horizontal axis is about 2/3 of the monthly earnings. The wealth distributions are right-skewed, as in the data. However, as is well known, the Aiyagari (1994) model with only unemployment risk cannot replicate the dispersed wealth distribution that is seen in the data (see, for example, Krusell and Smith, 1998). Here, the same property holds, and the dispersion of wealth is smaller than what is seen in the data.[13] Another strong feature of the wealth distribution from the model is that very few consumers are close to the borrowing constraint. This seems to be at odds with empirical observations that many young consumers own little financial wealth.[14] Appendix D constructs a model in which each consumer faces a risk of losing all her wealth overnight. With this modification, many consumers are close to the borrowing constraint. It turns out that the main results below are qualitatively robust to this modification.

[12] Appendix B considers a different form of utility function, and finds qualitatively similar results to these in the main text.

[13] An earlier version of this paper (Mukoyama, 2012) includes an analysis of a model (with a simpler labor market structure) that is similar to Krusell and Smith (1998) and Krusell et al. (2009). It successfully matches the wealth distribution in the data by introducing a heterogeneity in the discount factor β. It turns out that the qualitative results of the welfare analysis with heterogeneous β are similar to the ones with homogeneous β.

[14] See, for example, Carroll (1997, Table V).

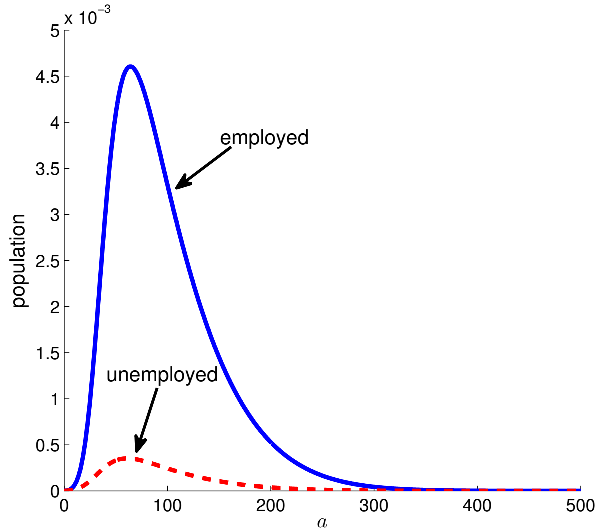

Figure 1: Wealth distribution: populations of employed consumers and unemployed consumers, $b = 0.1$

2.2.1 Policy reform

I assume that, before time 0, the economy is at the steady state with the baseline value of b. Then, at the beginning of period 0, the value of b unexpectedly (and permanently) increases to $\tilde{b}$ by the amount of 0.3 (that is, $b = 0.1$ to $\tilde{b} = 0.4$ in the "low UI" case and $b = 0.8$ to $\tilde{b} = 1.1$ in the "high UI" case). In the "low UI" case, the replacement ratio increases from 7% to 27%. In the "high UI" case, the replacement ratio increases from 54% to 74%.

When the reform occurs at time 0, some variables jump, and some variables experience gradual transitions towards the new steady state. In particular, two aggregate variables, K_t and u_t (and therefore $L_t = 1 - u_t$), move gradually. Figures 2 and 3 plot time paths of K_t and u_t in both policy experiments.

In both cases, K_t falls over time in the long run. There are two reasons for this. First, K_t/L_t falls in the long run, because the consumers are better insured and they reduce their precautionary savings. Second, as can be seen in Figure 3, u_t increases over time and therefore L_t decreases. For a given K_t/L_t, this makes K_t fall.

The unemployment rate goes up when the UI benefit increases. The mechanism is as follows. An increase in b increases the worker's value outside of employment, and therefore increases the worker's bargaining power. This leads to a higher wage and a lower profit for the firm.[15] A

[15] One shortcoming of the current analysis is that the eligibility requirement for receiving UI is not incorporated (it is assumed that everyone is qualified as long as she is unemployed). When one has to work for a certain period in order to obtain eligibility for UI benefits, an increase in the benefit *increases* the relative value of employment compared to unemployment for an unqualified worker. This effect therefore pushes down the wages

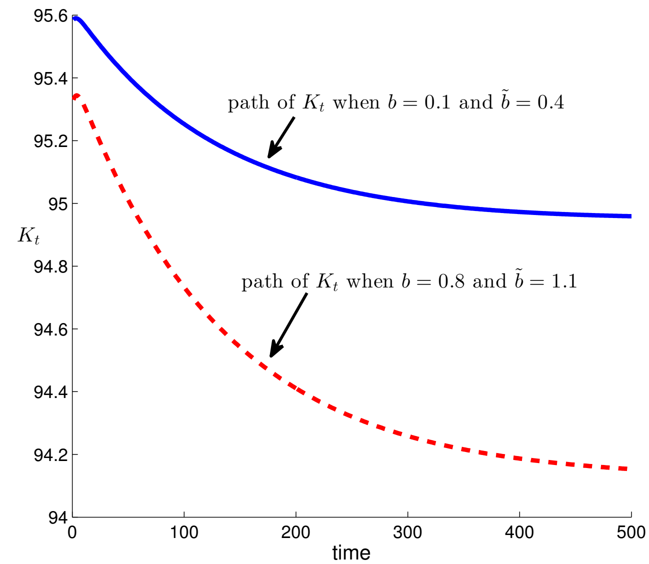

Figure 2: Transition path of aggregate capital (K_t) after the policy change

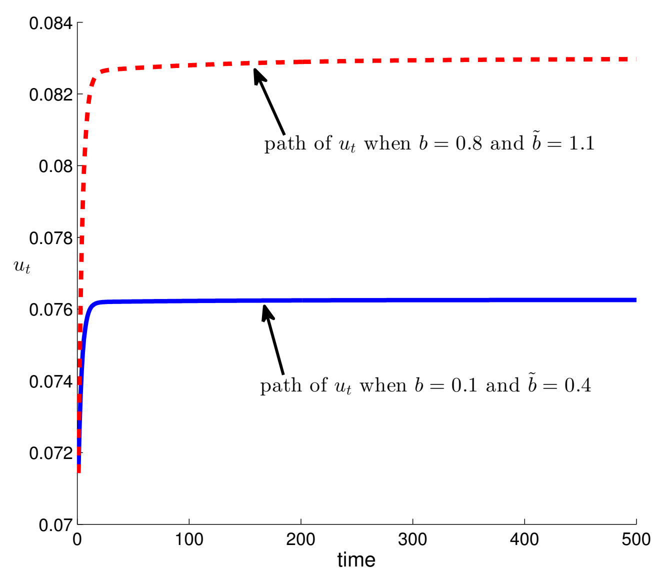

Figure 3: Transition path of the unemployment rate (u_t) after the policy change

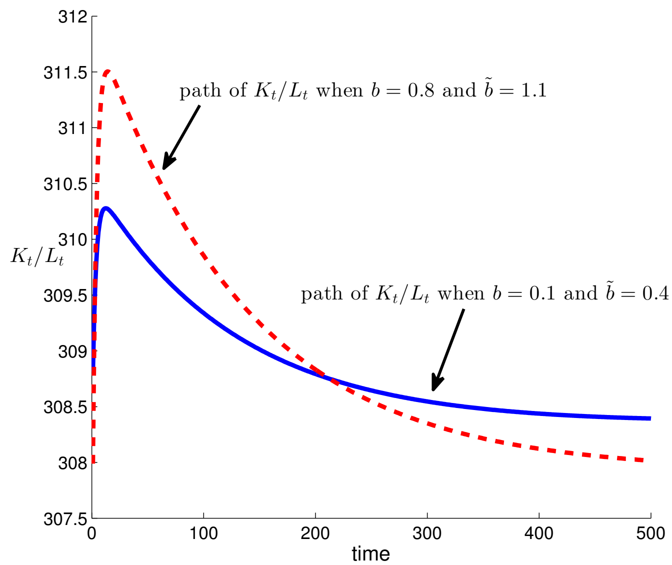

Figure 4: Transition path of aggregate capital-labor ratio (K_t/L_t) after the policy change

lower profit, in turn, decreases the incentive for the firm to post vacancies. As a result, v_t falls, and thus $\theta_t = v_t/u_t$ falls, and as a consequence the job-finding probability $\lambda_w(\theta_t)$ falls. This leads to a gradual increase in the unemployment rate. Therefore an increase in b eventually leads to an increase in the unemployment rate.[16] The decline is larger in the "high UI" case. This is because the same *amount* of the increase in UI benefit reduces the firm's profit more in *percentage* terms in the "high UI" case, since the level of profit is already low.[17]

The transition of unemployment rates in Figure 3 is much quicker than the transition of K_t in Figure 2. This is because the labor market involves a massive amount of gross flows. As a result, the adjustment of the labor market to a change in environment is very quick.

The movement of the capital-labor ratio K_t/L_t has important implications for the workers' welfare, because it affects both wages and the rental rate of capital. The wages are increasing

for unqualified workers (which is the opposite of the current argument). The same caveat applies to a model where workers make effort to find a job. See, for example, Mortensen (1977).

[16]Some existing papers emphasize different channels for an increase in the unemployment rate as a consequence of a more generous UI benefit. One of the frequently analyzed channels is through the change in workers' search effort. When the job-finding probability depends on the unemployed workers' search effort and the effort is not observable to the government, a more generous UI benefit reduces workers' search effort and therefore reduces the job-finding probability. The change in job-finding probability there is thus supply-driven, while the channel in this paper is demand-driven. See, for example, Wang and Williamson (2002) and Young (2004) for macroeconomic analysis of such a mechanism. An earlier version of this paper (Mukoyama, 2012) also analyzes such a model.

[17]See, for example, the discussions in Costain and Reiter (2008).

in K_t/L_t, since a higher K_t/L_t increases the output per match. The rental rate r_t is decreasing in K_t/L_t from (4). Since both K_t and L_t decline over time during the most of the transition process, the movement of K_t/L_t depends on which one declines faster. Figure 4 plots the time path of K_t/L_t. It increases first, and then declines to a level which is lower than the original level. This reflects the fact that the adjustment of L_t (increase of u_t) is much faster than the adjustment of K_t. Note that the short-run effect (increase in K_t/L_t) is the opposite of the long-run effect (decrease in K_t/L_t) here, and the short-run effect is coming from the endogenous response of the labor market.

2.2.2 Welfare effect of the policy reform: benchmark

Now I calculate the welfare effect of the policy reform in the full general equilibrium model ("benchmark"). The welfare calculation takes the transition process into account. The welfare criterion used in this paper follows Lucas (1987). For each individual, I calculate μ that satisfies

$$E_0\left[\sum_{t=0}^{\infty}\beta^t\mathcal{U}((1+\mu)c_t^o)\right] = E_0\left[\sum_{t=0}^{\infty}\beta^t\mathcal{U}(c_t^n)\right], \quad (5)$$

where c_t^o is consumption at time t under the original policy ("o" for "original") and c_t^n is consumption at time t under the new policy ("n" for "new"). Note that the μ's are different for individuals with different asset levels and employment statuses at time 0. If $\mu > 0$, the consumer enjoys a welfare gain from the policy change, and if $\mu < 0$ the consumer experiences a welfare loss due to the policy change.

Figure 5 plots the welfare effect for the "low UI" case. The average value of μ is -0.004%[18]: the average gain is negative and small.[19] But there is substantial heterogeneity. For a given

[18] Note that this is the average of individual μs. This is different from a single value of μ that makes the "average consumer's utility" indifferent. Mukoyama (2010) discusses the different methods of aggregating the welfare effects in a complete-market framework.

[19] When the utility function is linear, the Hosios condition (see Hosios, 1990 and Pissarides, 2000, Ch. 8) guarantees the Pareto efficiency of the outcome with zero UI benefit. It is also known that a similar condition holds in the concave utility setting with complete asset markets (see Merz, 1995 and Andolfatto, 1996). The Hosios condition is expressed as $\eta = \gamma$ in our notation. Intuitively, this balances (i) the negative externality of vacancy postings in the matching process (too many vacancy postings if the posting is fully rewarded) and (ii) the (insufficient) reward from the vacancy posting (the worker takes a part of the benefit). The first effect is large when η is large (more curvature in the matching function on the vacancy side) and the second effect is large when γ is large (lower share for the firm). If $\eta > \gamma$, there are too many vacancy postings and if $\eta < \gamma$ there are too few vacancy postings. Because I set $\eta = \gamma$ in the calibration, the optimal UI benefit is zero when the asset market is complete. Therefore, it is natural that I obtain a negative effect from increasing the UI benefit overall. If I set $\eta > \gamma$ instead, the welfare gain from increasing the UI benefit should be larger. In an earlier version of this paper (Mukoyama, 2012), it is formally shown that the optimal unemployment insurance (when "optimal" is defined as maximizing the discounted present value of output subject to the search frictions) is strictly positive if and only if $\eta > \gamma$ when the utility function is linear and tax is lump-sum. It also contains a numerical experiment of a case where $\eta > \gamma$ and shows that indeed the desirability a high UI benefit increases compared to the case of $\eta = \gamma$.

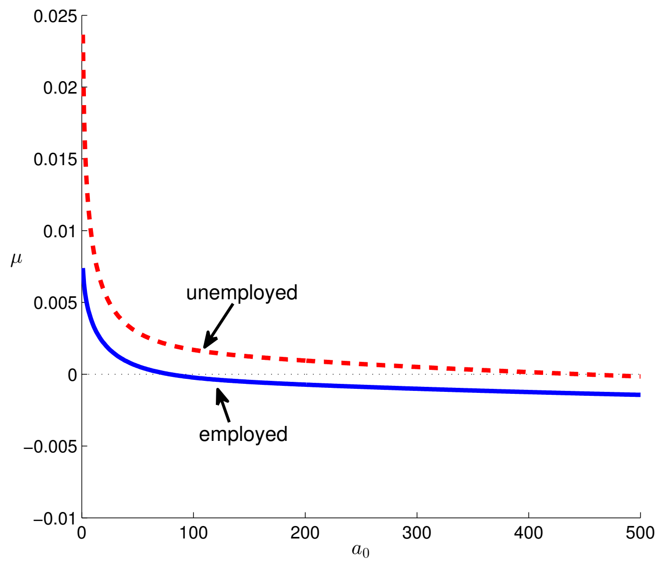

Figure 5: Welfare effects of the policy change, $b = 0.1$ and $\tilde{b} = 0.4$ ("low UI" case)

asset level, an unemployed worker tends to gain more from the reform than an employed worker. In fact, almost all unemployed workers gain from the reform ($\mu > 0$) while almost all employed workers lose from the reform ($\mu < 0$). It can also be seen that a low-asset worker tends to gain more than a high-asset worker. Figure 6 plots the welfare effects for the "high UI" case. The level of μ is lower than the "low UI" case (the average value is -0.6%), but the overall pattern of the plot is similar.

A natural question from Figures 5 and 6 is: *why* does μ have such a relationship to employment status and the initial level of assets? In order to answer this question, I decompose this welfare effect into different factors. Here I will focus on three factors[20] that are mutually exclusive. Although they do not numerically add up to Figures 5 and 6 (because of nonlinearities arising from a large change in UI), the decomposition helps us understand which economic forces contribute to the benchmark outcome. The first of these factors is the "partial equilibrium welfare effect," that is, the welfare effect of the change in UI benefits and taxes when one worker faces this change in isolation. Compared to the baseline general equilibrium outcome, the prices and the job-finding probability are unchanged. Here the worker faces (i) a higher UI

[20]The decomposition analysis here is slightly different from the analysis in earlier versions of this paper (Mukoyama, 2012). The earlier versions consider three additional decompositions: (i) the effect of the change in benefit, (ii) the effect of the change in tax, and (iii) the pure effect of insurance. The first two together make up the "partial equilibrium welfare effect" below, and the third is one component of the partial equilibrium welfare effect. Another difference is that in the earlier versions, the "tax effect" includes the effect of the additional tax burden due to the future increase in u_t.

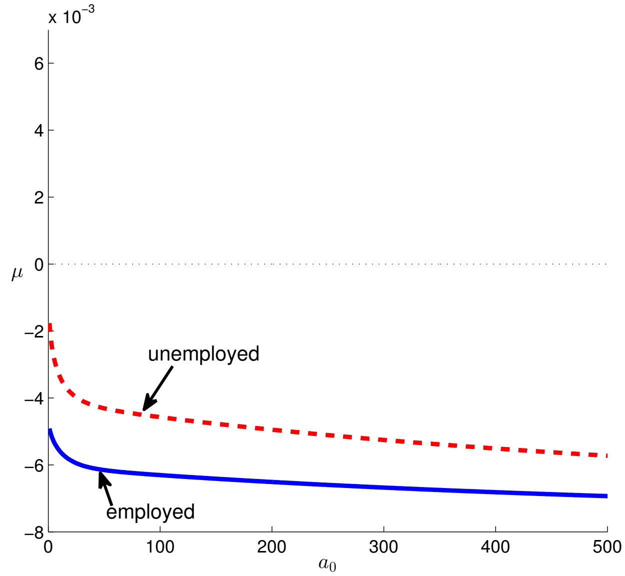

Figure 6: Welfare effects of the policy change, $b = 0.8$ and $\tilde{b} = 1.1$ ("high UI" case)

benefit and (ii) a tax increase that is proportional to the increase in the benefit. I also abstract from an additional increase in taxes which is present in the benchmark general equilibrium analysis—the tax increases further because the total UI payment increases with the future increase in u_t. The other two are general equilibrium effects. The second factor is the effect of the change in prices. There are three prices that change as a result of the reform: the rental rate of capital r_t, the wages $\omega_t(a_t)$, and the equity (stock) price p_t. These price changes have an impact on the workers' utility—I call them the "price effects." The third factor is the effect coming from a change in the job-finding probability. I call this effect the "matching effect."

2.2.3 Decomposition 1: Partial equilibrium

The first factor is the "partial equilibrium" outcome. This is the welfare change, evaluated by μ in (5), where the new environment for the consumers has the same price and job-finding probability as the original steady state. The only changes are the UI benefit increase (from $b = 0.1$ to $\tilde{b} = 0.4$ in the "low UI" case and from $b = 0.8$ to $\tilde{b} = 1.1$ in the "high UI" case) and the new tax rate $\tau^n = (\tilde{b}/b)\tau^o$, where τ^o is the original tax rate in the pre-reform steady state. The welfare changes here reflect the pre-reform (net) valuation of UI, when purchased with the "price" of the tax increase,[21] by various type of agents.[22]

Figures 7 and 8 plot the welfare effects of this partial equilibrium change, for the "low UI" case and the "high UI" case. Comparing Figures 5 and 7, it can be seen that the large gain for low-asset workers in Figure 5 comes from the partial equilibrium effect. In fact, this is the consumption-smoothing benefit from the UI[23]—a more generous UI enables an asset-poor unemployed worker to smooth consumption when there is very little income otherwise.[24] This part of the effect is the pure insurance benefit of the UI reform.[25] An important point here is that there are noticeable differences between Figure 5 and Figure 7. For example, the asset-rich unemployed workers experience a positive gain from reform in partial equilibrium, but in fact they suffer from a welfare loss in general equilibrium. A similar comparison can be made for Figures 6 and 8—in fact, the overall difference between the partial equilibrium effect and the total effect in the benchmark general equilibrium model is even larger for Figures 6 and 8.

The partial equilibrium welfare effect involves an important component in addition to the pure insurance effect. In both Figures 7 and 8, the welfare gain for an unemployed consumer is higher than for an employed consumer for a given initial wealth level. The reason is that there is an implicit transfer built into this policy reform. When the reform is implemented at time 0, the benefit jumps up and the tax also jumps up. If a consumer is unemployed at that point, the probability that she is unemployed in near future is higher than the corresponding probability for an employed consumer. Thus she enjoys more of this additional benefit in expected present value term than an employed consumer does. Similarly, a consumer who is employed at time 0 bears more of the additional tax burden than an unemployed consumer does. Although the UI reform is usually not intended as a targeted transfer policy, there is an unintended "hidden" implicit transfer from employed consumers to unemployed consumers.[26]

One takeaway from the analysis in this section is that the discrepancy between the partial equilibrium welfare effect and the general equilibrium welfare effect can be significant. Macroeconomic policy recommendations based solely on the partial-equilibrium analysis can therefore be dangerous.

The partial equilibrium analysis reveals some of the factors that contribute to these patterns

[21]Note that the increase in tax, viewed as the price of the additional insurance, is not actuarially fair since a worker unemployed at the time of reform is more likely to experience unemployment in the immediate future than an employed worker. This is the source of the implicit transfer explained below.

[22]I thank one of the referees for pointing this out.

[23]See, for example, Gruber (1997) for an empirical analysis of the consumption-smoothing benefit of the UI.

[24]Note, however, not many people are in the region where there is a substantial gain—in Figure 1, almost no one is at the borrowing constraint (only 0.006% consumers are in $a \leq 5$), and only 0.6% of consumers are in $a \leq 20$.

[25]An earlier version of this paper (Mukoyama, 2012) discusses a method of separating the pure insurance effect.

[26]Mukoyama (2010) discusses this implicit transfer in an complete-market framework. An earlier version of this paper (Mukoyama, 2012) contains a model where the job-finding probability is a function of the wealth level due to the effort choice by the unemployed workers (as in Wang and Williamson, 2002 and Young, 2004). There, an implicit transfer across workers with different wealth levels is also present.

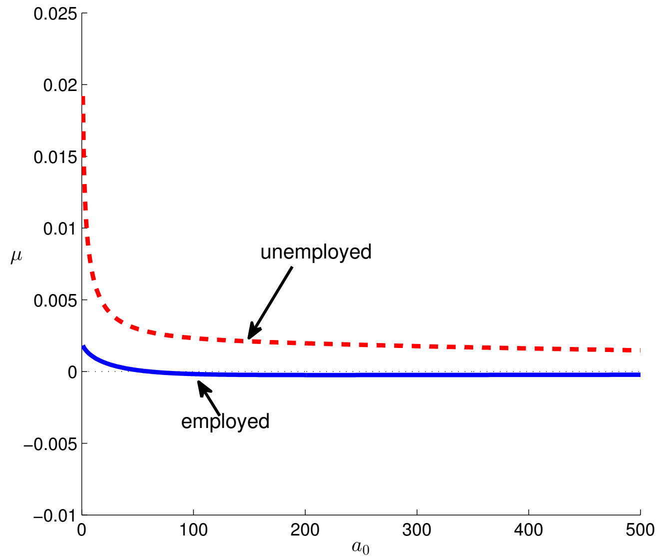

Figure 7: The partial equilibrium welfare effects, $b = 0.1$ and $\tilde{b} = 0.4$ ("low UI" case)

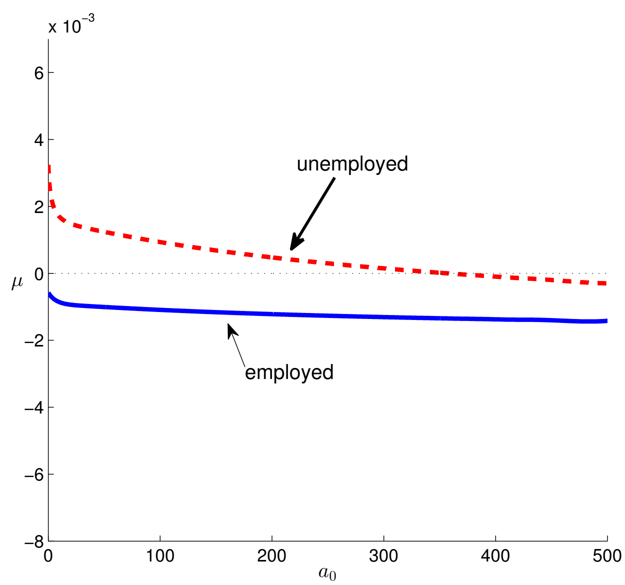

Figure 8: The partial equilibrium welfare effects, $b = 0.8$ and $\tilde{b} = 1.1$ ("high UI" case)

in Figures 5 and 6. Regarding the difference between the unemployed consumers and the employed consumers, the implicit transfer clearly makes the unemployed consumers relatively better off. Regarding the heterogeneity across different wealth levels, the pure insurance effect benefits the consumers who are close to the borrowing limit. However, the partial equilibrium analysis still does not fully explain why the welfare gain decreases with wealth at the high wealth level in the benchmark (that is, why Figures 7 and 8 are more "flat" compared to Figures 5 and 6).

In order to fill the gap between the partial equilibrium analysis and the benchmark general equilibrium analysis, it is necessary to explicitly analyze the general equilibrium elements. Next I will examine the additional effects that arise from the benchmark model's general equilibrium structure in more detail.

2.2.4 Decomposition 2: Price effect

Among the additional effects that come from the model's general equilibrium, here I consider the effect of the change in prices.[27] In calculating the welfare after the reform, I feed the equilibrium prices from the transition path of Section 2.2.1 into the consumer's decision problem while keeping everything else the same as the original steady state. Then I let the consumer optimize under this environment. The welfare effect of the price change is evaluated using (5). Here, the prices include three objects: the rental rate of capital, the wages, and the equity price.

The rental rate of capital r_t is a decreasing function of K_t/L_t, as can be seen from (4). Since K_t/L_t first increases and then decreases (see Figure 4), r_t decreases and then increases. The increase in r_t happens far in future (and it is quantitatively very small, since the change in precautionary savings is very small), and the effect of the short-run decrease dominates in the present value of utility. This has a negative effect on a consumer who is asset-rich at time 0, since these consumers are likely to have large asset holdings in the future, whose return is affected negatively as a result of the reform. Note that here the change in r_t that matters for the consumers' welfare is the short-run effect during the transition. An analysis that compares between two steady states would misleadingly predict the opposite welfare effect through this channel.[28]

The wages $\omega_t(a_t)$ change for two reasons. First, the output per match changes with the capital per match, $K_t/(1-u_t)$. Since $K_t/(1-u_t) = \bar{h}K_t/L_t$, it moves together with K_t/L_t. Thus, after the reform, this makes the wages to go up initially and then go down eventually.

[27] This model does not feature life-cycle saving motive or international asset markets. In a life cycle model, the response of saving to the change in environment would differ from a infinite-horizon model, and this will affect the response of prices. If there are international asset markets, the response would also be different. In particular, in an extreme case of a small open economy, the effect through r_t would be absent. The effect through the wage is still present. The effect of the equity price depends on how much of the equity is owned domestically.

[28] The point made here is different from the one made by Joseph and Weitzenblum (2003)—their emphasis is on the asset accumulation at the *individual level* during the transition.

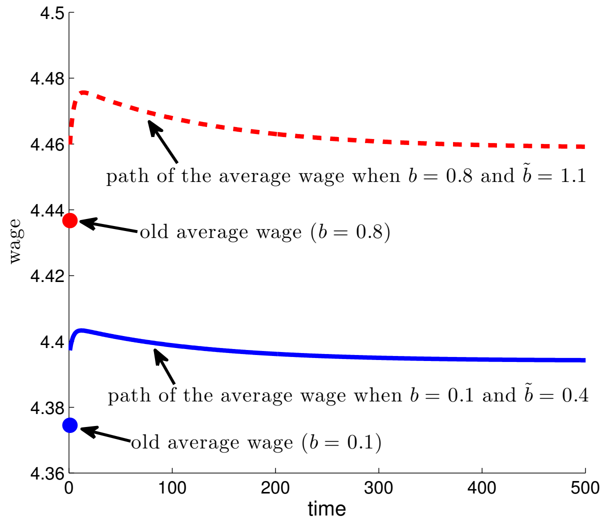

Figure 9: Transition path of the average wage after the policy change in the experiments of Section 2.2.1

As in the case of r_t, the long-run effect is dominated by the short-run effect in the welfare calculation. Second, the increase in the UI benefit raises the outside option of the workers in the wage bargaining. This increases $\omega_t(a_t)$. Figure 9 plots the path of wages in the benchmark experiments in Section 2.2.1. In both cases, the wage jumps up at the moment of reform and stays high. This benefits all workers.

The equity price changes as a consequence of the change in period profit. The period profit changes due to (i) the change in the output per match and (ii) the change in the wages. Here, the effect of the increase in wages (in Figure 9) dominates and the profit decreases in each period. From (2), the equity price in the beginning of period 0 (that is, before the dividend payment at period 0) satisfies

$$p_{-1} = \frac{d_0 + p_0}{1 + r_0 - \delta}.$$

Because d_t and r_t for $t = 0, 1, 2, ...$ change due to the policy reform, p_{-1} has to be re-evaluated in order to be consistent with the new environment. Since the asset holding for each worker satisfies $a_0 = k_0 + p_{-1}x_0$, a_0 has to be re-evaluated because of the fall in p_{-1}. I assume that k_0/x_0 is common for everyone, therefore everyone incurs a capital loss (a fall in a_0) due to the fall in p_{-1}. As a result of this re-evaluation, the equity price jumps down at the moment of the policy change at time 0. After that, p_t experiences a gradual transition to the new steady-state level (which is lower than the original level).

Figures 10 and 11 display the results for the price change experiment. In both cases, the welfare gain is decreasing in wealth—this is consistent with the patterns that are observed in

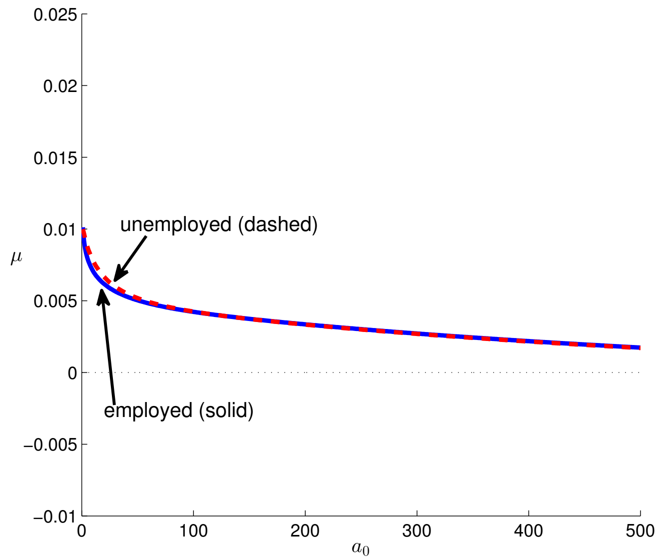

Figure 10: Welfare effects of the policy change: price effect ($b = 0.1$ and $\tilde{b} = 0.4$: "low UI" case)

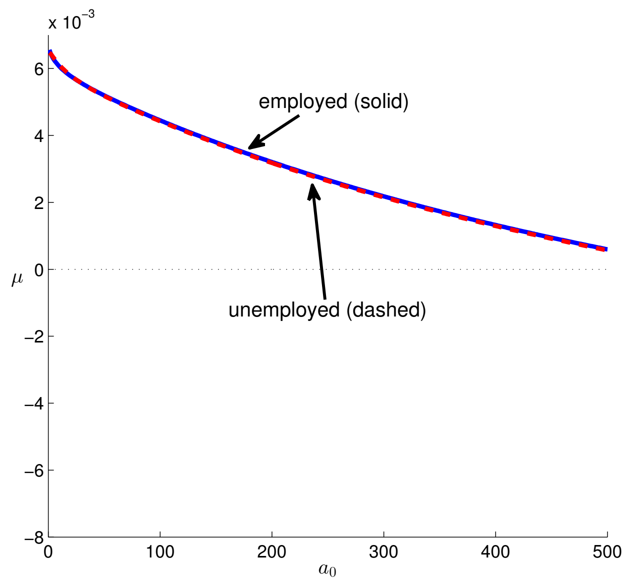

Figure 11: Welfare effects of the policy change: price effect ($b = 0.8$ and $\tilde{b} = 1.1$: "high UI" case)

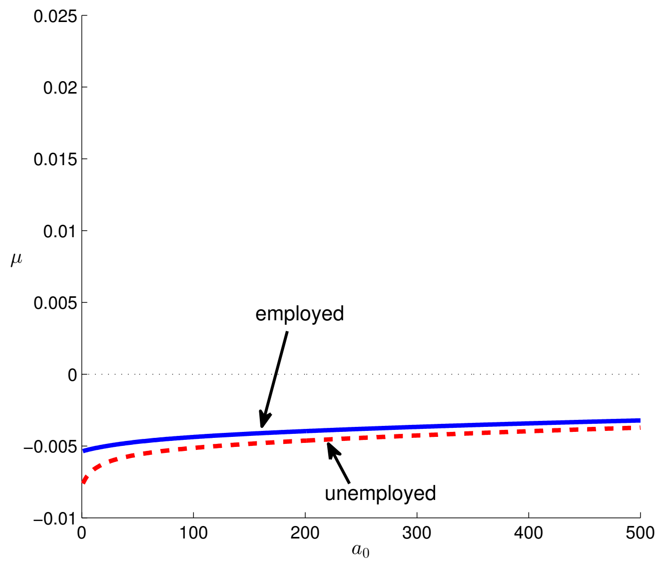

Figure 12: Welfare effects of the policy change: matching effect ($b = 0.1$ and $\tilde{b} = 0.4$: "low UI" case)

Figures 5 and 6. Here, this pattern emerges because a large part of the asset-rich workers' income comes from their asset income, and the (short-run) decline in the asset return (and the drop of the stock price because of the increase in wages) hurts them. Asset-poor workers rely mainly on labor income, and they tend to gain because of the wage increase. Because the price change affects everyone, there is no significant difference between the employed and the unemployed. Thus the "price effect" does not contribute to explaining the gap between the employed and the unemployed in Figures 5 and 6.

2.2.5 Decomposition 3: Matching effect

From a consumer's perspective, the change in the job-finding probability as a result of policy reform comes as an "exogenous" change (in the sense that it is outside her control). Thus I categorize this as a part of the effects that come from the model's general equilibrium. Here I compute the worker's (optimized) welfare when she faces the time series of $\lambda_w(\theta_t)$ that is the same as the transition path in the benchmark experiment of Section 2.2.1, while everything else is the same as the original steady state. The welfare gain is again calculated using (5).

Figures 12 and 13 plot the result. The fall in job-finding probability hurts everyone, though it has a larger impact on unemployed consumers' welfare because they are the ones who are currently looking for a job. An employed consumer suffers from this fall once they are unemployed, but it does not have an immediate effect. This relative pattern is the opposite of that

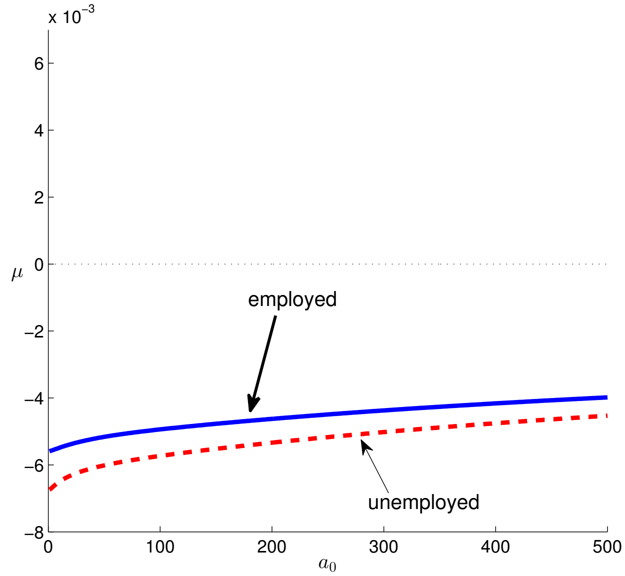

Figure 13: Welfare effects of the policy change: matching effect ($b = 0.8$ and $\tilde{b} = 1.1$: "high UI" case)

observed in Figures 5 and 6. The difference in the effect here is quantitatively smaller than the difference in the partial equilibrium effect in the opposite direction, and therefore it is dominated by the partial equilibrium effect in generating the pattern observed in the benchmark outcomes.

The curves in Figures 12 and 13 are positively sloped. This is because an asset-poor consumer suffers more from the fall in the job-finding probability, since they rely more on labor income to finance their consumption. This pattern contrasts with the Figures 5 and 6—the negative slope coming from the price effect (Figures 10 and 11) tends to be steeper (in absolute value) than the positive slope here, and the slope of the matching effect is dominated in generating the pattern observed in the benchmark outcomes.

3 Conclusion

This paper analyzed the welfare effects of a UI policy reform using a general equilibrium incomplete market model with search and matching frictions in the labor market. I evaluated (unexpected and permanent) UI policy reforms that make the UI benefit more generous starting from different original levels. The main goal of the analysis was to understand the contributions of different factors in the welfare evaluations of the policy reforms.

The quantitative general equilibrium analysis (the "benchmark") shows that the welfare gains from a reform that makes the UI more generous tend to be higher for a consumer who is unemployed and asset-poor at the time of the reform. The decomposition analysis reveals that several factors contribute to this pattern. The implicit transfer that exists in the partial equilibrium analysis is responsible for the difference in welfare change between the unemployed and the employed. The pure insurance effect, which is a part of the partial equilibrium effect, is stronger for a consumer who is poorer at the time of the reform. The decline in asset returns and the capital loss due to the decline in firm value make the rich suffer, generating the difference in welfare change between the asset-rich and the asset-poor. The fall in the job-finding probability produces the opposite tendencies in terms of both the gap between the unemployed and the employed and the difference between the asset-rich and asset-poor, but these tendencies are weak and dominated by other effects.

The analysis in this paper incorporates the transition path of the economy from the old steady state to the new steady state. It turns out that this is important—after the reform, the capital-labor ratio, which determines the rental rate of capital, moves non-monotonically over time, and the initial (short-run) movement is in the opposite direction of the eventual (long-run) movement. An analysis that compares the old steady state with the new steady state, without considering the transition, would entirely miss this short-run movement. Indeed, this short-run movement is critical for welfare analysis because the transition process is relatively long and the future is discounted. It is also crucial that the model has an endogenously moving unemployment rate—the capital-labor ratio increases initially after the reform because the unemployment rate rises very quickly.

The decomposition method in this paper can easily be applied to different policy analyses. Over the recent years, the dynamic general equilibrium models that are used for policy evaluations have become more and more complex. In these models, often many different (sometimes conflicting) effects are at work in generating the final outcome. As is demonstrated in this paper, the decomposition method developed here can be useful in disentangling different effects in a complex general equilibrium model. Understanding the various mechanisms behind complex models can help to develop intuition, and ensures that policy recommendations are robust to the details of the particular models used for policy evaluation.

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Appendix

A Wage bargaining

To analyze the wage bargaining, first consider the auxiliary problem for an employed consumer with a given current wage level w:

$$\tilde{W}_t(w, a_t) = \max_{c_t, a_{t+1}} \mathcal{U}(c_t) + \beta[(1-\sigma)W_{t+1}(a_{t+1}) + \sigma U_{t+1}(a_{t+1})]$$

subject to

$$c_t + a_{t+1} = (1 + r_t - \delta)a_t + (1 - \tau_t)w\bar{h}$$

and

$$a_{t+1} \geq \underline{a}.$$

Let the solution to this problem for a_{t+1} be $a_{t+1} = \tilde{\psi}_t^e(w, a_t)$. The auxiliary problem for the firm is

$$\tilde{J}_t(w, a_t) = \max_k \quad k^\alpha \bar{h}^{1-\alpha} - r_t k - w + \frac{1}{1 + r_{t+1} - \delta}[(1-\sigma)J_{t+1}(\tilde{\psi}_t^e(w, a_t)) + \sigma V_{t+1}].$$

Given these values, the wage is determined by the (generalized) Nash bargaining:

$$\omega_t(a_t) = \arg\max_w \quad (\tilde{W}_t(w, a_t) - U_t(a_t))^\gamma (\tilde{J}_t(w, a_t) - V_t)^{1-\gamma}, \tag{6}$$

where $\gamma \in (0, 1)$.

B Robustness Check: The case with a different utility function

Here I repeat the same experiments as in Section 2.2 with a different utility function. Instead of a log utility function, I use $\mathcal{U}(c_t) = c_t^{1-\zeta}/(1-\zeta)$, where I set $\zeta = 3$. This change increases the workers' risk aversion. The other parameters are set identically to Section 2.2, except for ξ which is set so that $\theta = 1$ in the benchmark steady state. The following figures correspond to the ones in Section 2.2. Naturally, the gain from better insurance tends to be higher in this case, especially for the consumers who are close to the borrowing constraint. This change is particularly noticeable in the "low UI" case. Except for this change, the relationships across different experiments are qualitatively very similar to Section 2.2, although it is harder to see them in the "low UI" case figures because of the scaling. The intuitions for the results are identical to those in Section 2.2.

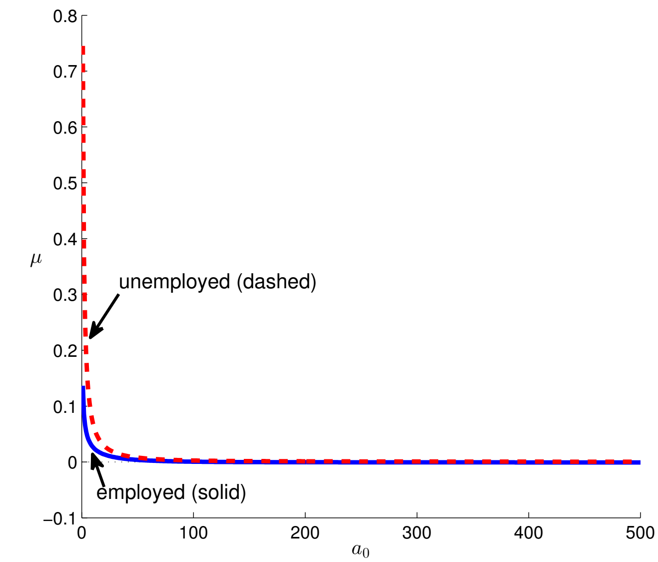

Figure 14: Welfare effects of the policy change, $b = 0.1$ and $\tilde{b} = 0.4$ ("low UI" case)

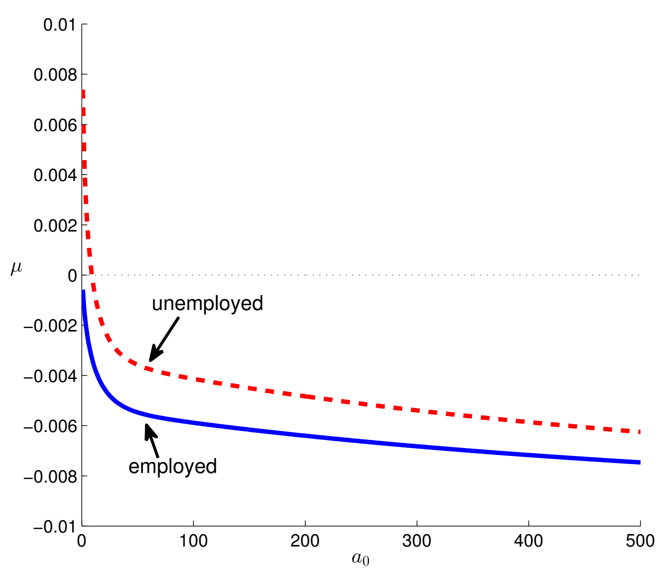

Figure 15: Welfare effects of the policy change, $b = 0.8$ and $\tilde{b} = 1.1$ ("high UI" case)

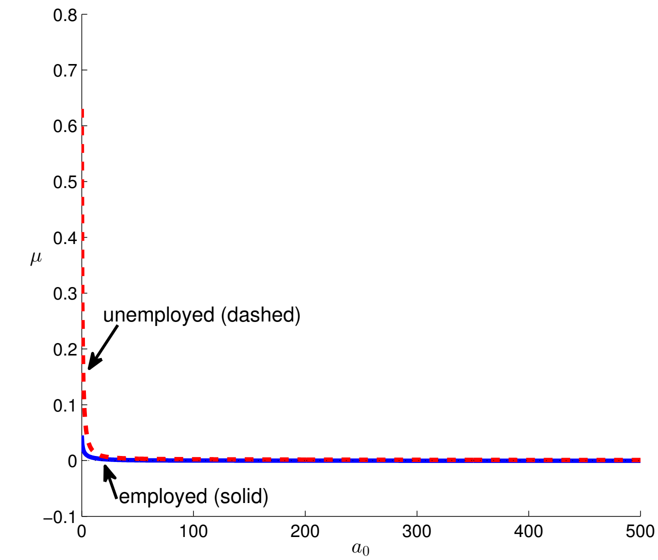

Figure 16: The partial equilibrium welfare effects, $b = 0.1$ and $\tilde{b} = 0.4$ ("low UI" case)

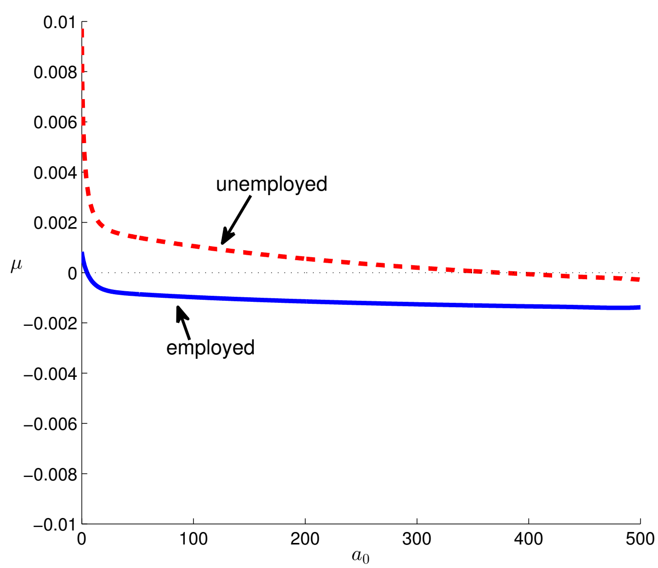

Figure 17: The partial equilibrium welfare effects, $b = 0.8$ and $\tilde{b} = 1.1$ ("high UI" case)

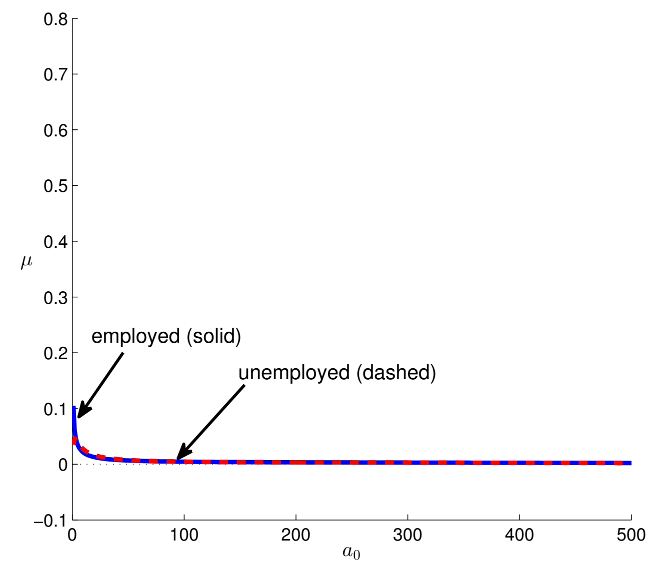

Figure 18: Welfare effects of the policy change: price effect ($b = 0.1$ and $\tilde{b} = 0.4$: "low UI" case)

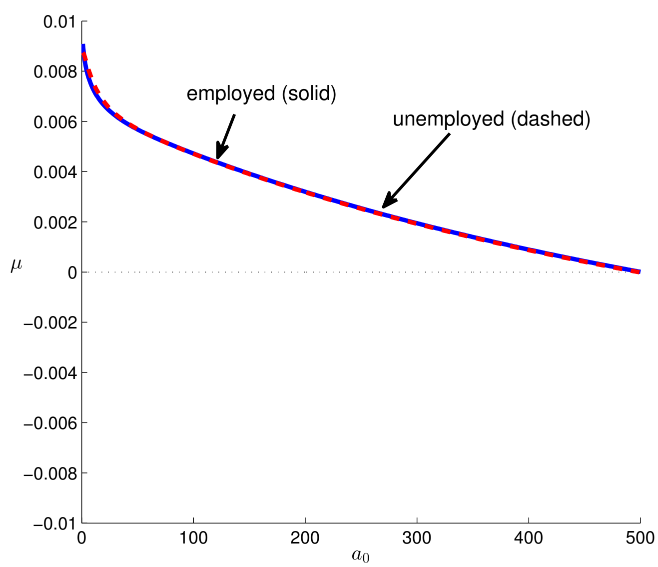

Figure 19: Welfare effects of the policy change: price effect ($b = 0.8$ and $\tilde{b} = 1.1$: "high UI" case)

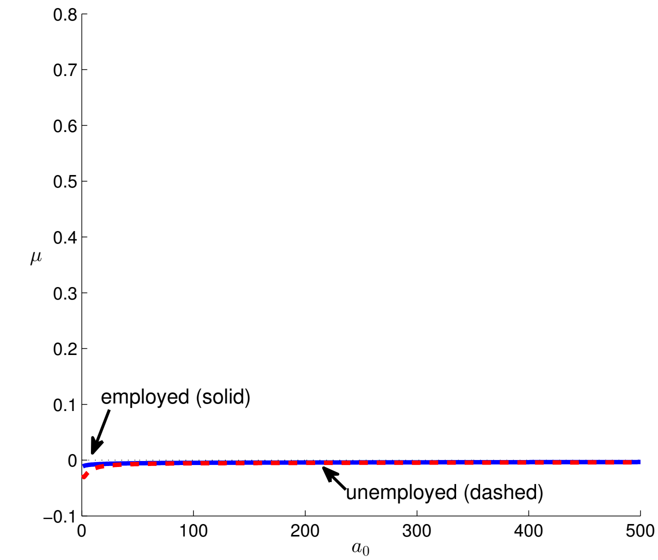

Figure 20: Welfare effects of the policy change: matching effect ($b = 0.1$ and $\tilde{b} = 0.4$: "low UI" case)

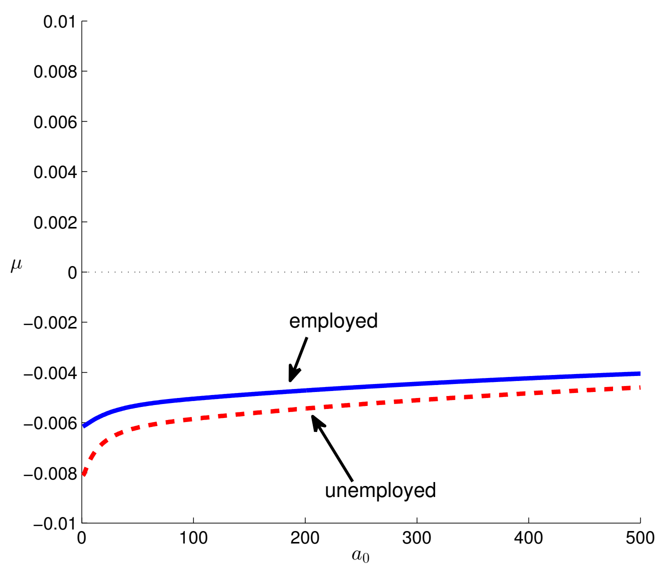

Figure 21: Welfare effects of the policy change: matching effect ($b = 0.8$ and $\tilde{b} = 1.1$: "high UI" case)

C Computation of the transition path

The transition path after the policy reform in the benchmark experiment is computed with the following steps.

1. Compute the original steady state.

2. Set a large value N_1 (I set $N_1 = 700$) and suppose that the economy is in the new steady state after period N_1. Compute the new steady state.

3. Guess the path of aggregate variables $\{K_{t+1}, p_t, \theta_t, \omega_t(a_t), \tau_t\}_{t=0}^{N_1}$ and p_{-1}. Given this path, solve the consumers' optimization problems backwards from $t = N_1$. Also solve the value of a filled job.

4. Simulate the economy from $t = 0$ to N_1, using the solution above. Note that a_0 has to be adjusted to reflect the drop in the equity price at the moment of the reform. During the simulation, compute the values of $\{K_{t+1}, p_t, \theta_t, \omega_t(a_t), \tau_t\}_{t=0}^{N_1}$ and p_{-1} implied by the simulated individual decisions. The simulated K_{t+1} can be calculated by

$$K_{t+1} = \int a_{t+1}^i di - p_t,$$

where a_{t+1}^i comes out from the simulation (here, one can use the p_t that is guessed above). The simulated p_t can be calculated by

$$p_{t-1} = \frac{d_t + p_t}{1 + r_t - \delta},$$

where d_t can be calculated from the profit stream in the simulation (one can use r_t based on the guessed K_t and L_t). θ_t can be calculated from the free-entry condition for vacancy posting. $\omega_t(a_t)$ can be calculated from the Nash bargaining. τ_t can be computed from the government budget constraint.

5. If the simulated path of the aggregate variables in the previous step is the same as the guess in the step 3, I am done. Otherwise, revise the guess and repeat from step 3.

D Robustness check: a mass of consumers at zero wealth

The model is the same as that in the main text, except that I assume each consumer faces a risk of losing all wealth overnight ("loss-of-wealth shock"). This is meant to bring in a flavor of a life-cycle model, where young consumers typically have low assets. This can be seen as similar to Blanchard-Yaari "perpetual youth" model, although there is no explicit "death" of a consumer in this formulation (in particular, the employment relationship continues even after a loss-of-wealth shock).

More formally, assume that, between time t and $t+1$, a consumer faces a risk of completely losing her asset. Let this probability be ϵ. In order to avoid an artificial loss of real resources, I assume that the asset that is lost is redistributed to everyone in a lump-sum manner (similarly to Blanchard-Yaari model).

An employed consumer's Bellman equation is now

$$W_t(a_t) = \max_{c_t, a_{t+1}} \mathcal{U}(c_t) + \beta[(1-\sigma)\hat{W}_{t+1}(a_{t+1}) + \sigma\hat{U}_{t+1}(a_{t+1})]$$

subject to

$$c_t + a_{t+1} = (1 + r_t - \delta)a_t + (1-\tau_t)\omega_t(a_t)\bar{h} + T_t$$

and

$$a_{t+1} \geq \underline{a},$$

where

$$\hat{W}_{t+1}(a_{t+1}) \equiv (1-\epsilon)W_{t+1}(a_{t+1}) + \epsilon W_{t+1}(0)$$

and

$$\hat{U}_{t+1}(a_{t+1}) \equiv (1-\epsilon)U_{t+1}(a_{t+1}) + \epsilon U_{t+1}(0).$$

Here, T_t is the lump-sum transfer of the lost assets:

$$T_{t+1} = \epsilon \int a_{t+1}^i di,$$

where a_{t+1}^i is the saving of consumer i made at time t.

An unemployed consumer's Bellman equation is

$$U_t(a_t) = \max_{c_t, a_{t+1}} \mathcal{U}(c_t) + \beta[\lambda_w(\theta_t)\hat{W}_{t+1}(a_{t+1}) + (1-\lambda_w(\theta_t))\hat{U}_{t+1}(a_{t+1})]$$

subject to

$$c_t + a_{t+1} = (1 + r_t - \delta)a_t + (1-\tau_t)b + T_t$$

and

$$a_{t+1} \geq \underline{a}.$$

On the firm side, the value of vacancy is

$$V_t = -\xi + \frac{1}{1 + r_{t+1} - \delta}\left[(1-\lambda_f(\theta_t))V_{t+1} + \lambda_f(\theta_t)\int \hat{J}_{t+1}(\psi_t^u(a))\frac{1}{u_t}f_t^u(da)\right],$$

where

$$\hat{J}_{t+1}(\psi_t^u(a)) \equiv (1-\epsilon)J_{t+1}(\psi_t^u(a)) + \epsilon J_{t+1}(0).$$

The value of a job matched with a worker whose asset level is a_t is

$$J_t(a_t) = \max_k \quad k^\alpha \bar{h}^{1-\alpha} - r_t k - \omega_t(a_t)\bar{h} + \frac{1}{1 + r_{t+1} - \delta}[(1-\sigma)\hat{J}_{t+1}(\psi_t^e(a_t)) + \sigma V_{t+1}].$$

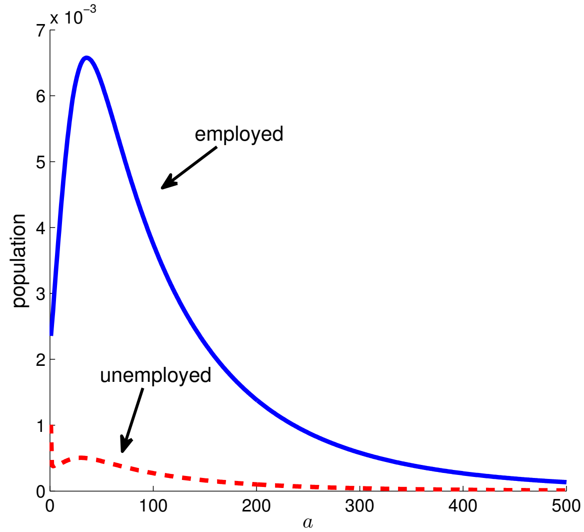

Figure 22: Wealth distribution: populations of employed consumers and unemployed consumers, $b = 0.1$

The rest of the model is the same as that in the main text.

The value of ϵ is set at 0.002. With one period being a month, this implies that a consumer is hit by the loss-of-wealth shock once in 40 years on average. This is meant to capture one consumer's working life (from 20 years old to 60 years old).

Figure 22 plots the asset distributions. Compared to Figure 1, there are more consumers at the bottom distribution, reflecting the loss-of-wealth shock. Below I present the case of the "low UI" experiment.

Figure 23 presents the path of K_t/L_t after the policy change. As in Figure 4, K_t/L_t goes up first and then gradually go down. The initial increase reflects the quick decline of L_t, while K_t/L_t eventually move towards a new steady state, which is lower than the old steady state (reflecting smaller precautionary savings). This implies that the movement of the rental rate of capital is qualitatively similar to those in the experiments in the main text. Figure 24 plots the movement of the average wage after the policy change. Again, this movement is qualitatively similar to the experiments in the main text (see Figure 9).

Figure 25 plots the welfare effects of the policy reform for each individual state (asset level and employment status) at the time of reform. Figures 26 to 28 are its decompositions. The relationship between μ and the individual state is qualitatively similar to the results in the main text. One notable difference is the level of the total welfare effect—the increase of the UI is beneficial to everyone. This mainly comes from the partial-equilibrium effect. Even a rich consumer faces a possibility of becoming very poor in the next period (due to the loss-of-wealth shock) and providing a high UI is beneficial for them, considering that possibility.

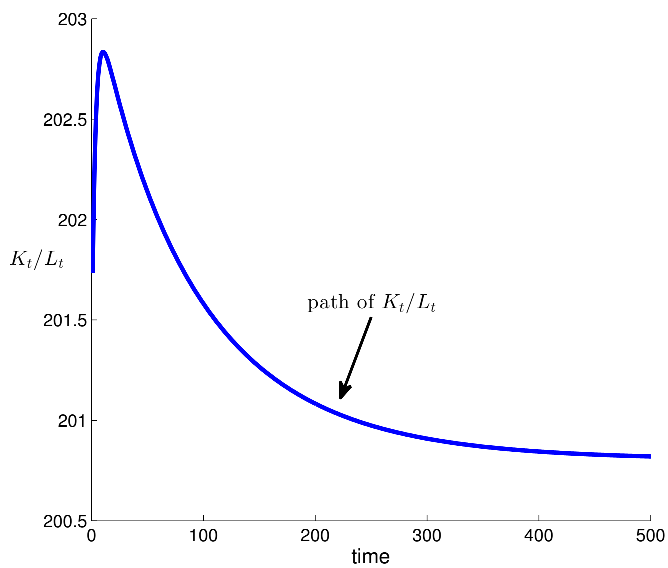

Figure 23: Transition path of aggregate capital-labor ratio (K_t/L_t) after the policy change

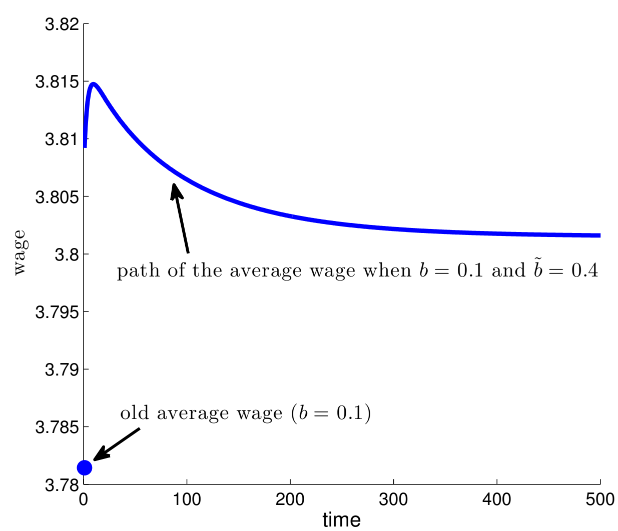

Figure 24: Transition path of the average wage after the policy change

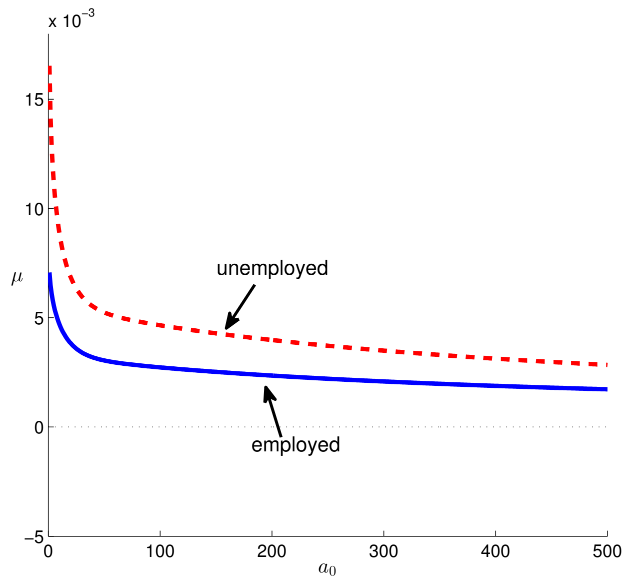

Figure 25: Welfare effects of the policy change, $b = 0.1$ and $\tilde{b} = 0.4$ ("low UI" case)

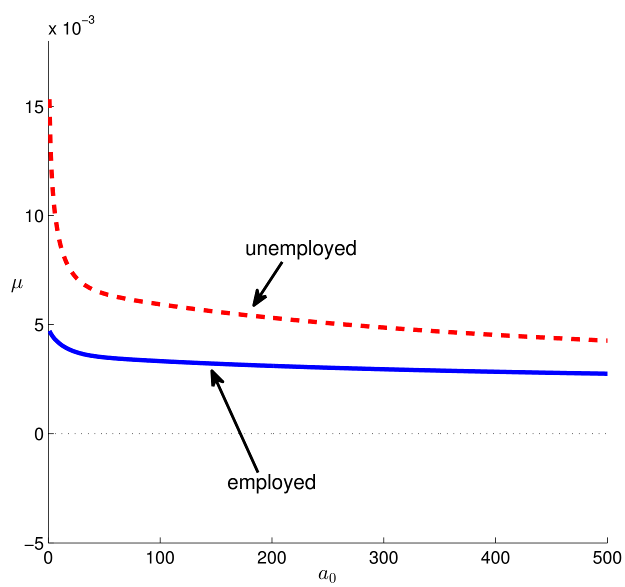

Figure 26: The partial equilibrium welfare effects, $b = 0.1$ and $\tilde{b} = 0.4$ ("low UI" case)

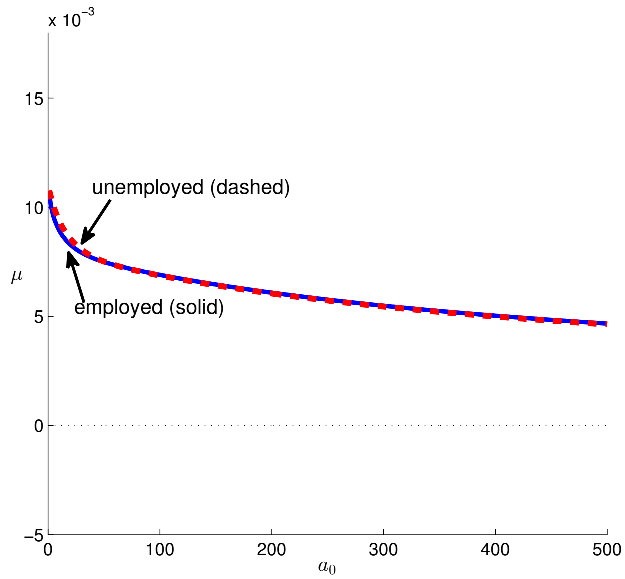

Figure 27: Welfare effects of the policy change: price effect ($b = 0.1$ and $\tilde{b} = 0.4$: "low UI" case)

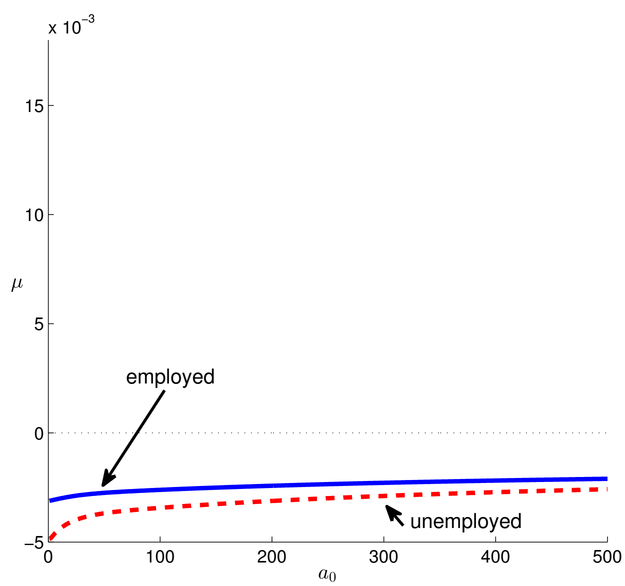

Figure 28: Welfare effects of the policy change: matching effect ($b = 0.1$ and $\tilde{b} = 0.4$: "low UI" case)