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Abstract

This paper quantifies the effect of time-varying employment risks on the fluctuations of aggregate consumption in a dynamic general equilibrium with incomplete markets. A government's redistribution policy through provision of unemployment insurance can cause a positive correlation between aggregate consumption and government's payments due to precautionary savings effects. The

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underlying mechanism is that a reduction of unemployment risk increases expected lifetime income substantially across a wide range of asset-holding groups when the risk reduction is sufficiently persistent. By contrast, the correlation between consumption and government becomes negative when the government intervention hampers supply of goods.

Keywords: Time-varying idiosyncratic risk, employment risk, precautionary savings, regime-switching fiscal policy

JEL codes: E21, E62

1 Introduction

In this paper, we ask in what circumstances fiscal policies lead to the comovement of aggregate consumption and government expenditure. We focus on the comovement mechanism via time-varying unemployment risks. Consider a government project that will hire a fraction of unemployed workers. The reduced unemployment rate decreases an idiosyncratic unemployment hazard that workers will face. This change in risk environment induces the workers to consume more, since they reduce the precautionary savings in incomplete markets where consumers cannot insure against their idiosyncratic unemployment risk. The purpose of this paper is to quantify the movement in consumption when various types of fiscal policies affect the magnitude of idiosyncratic unemployment risks.

This paper is motivated by recent developments in empirical estimation on the effects of fiscal policy on consumption. Researchers such as Fatás and Mihov [10], Blanchard and Perotti [3], and Galí, Valleés, and López-Salido [12] have found a positive correlation between consumption and government spending in identified VAR estimation. Their findings contrast with the negative estimates obtained for war-time events by Ramey and Shapiro [17], Edelberg, Eichenbaum, and Fisher [8], and Burnside, Eichenbaum, and Fisher [4].

Galí et al. proposes a model of rule-of-thumb consumers to account for the positive comovement between consumption and government expenditure, whereas the standard dynamic general equilibrium model with fiscal shocks such as Baxter and King [2] is consistent with the negative correlation. We propose a different avenue to account for the comovement. We highlight the macroeconomic effects of precautionary savings, which have been analyzed by authors such as Aiyagari [1], Carroll [5], and Huggett [13].

The precautionary motive of savings provides a possible answer to the excess sensitivity of consumption which states that consumption seems to respond to a change in income more than the permanent income hypothesis predicts. In incomplete markets where there is no insurance provided for individual employment shocks, households can partially insure against such hazard by accumulating wealth. The precautionary savings behavior implies a concave consumption function with respect to wealth. Thus, a windfall of income to the households in a low wealth group would generate an increase in consumption that is larger than the small wealth effect implied by the permanent income hypothesis. If this channel of income effect is quantitatively large, it can have important consequences on macroeconomic predictions such as the impact of the expansionary fiscal policy on the aggregate demand.

Krusell and Smith [14] formally analyze a dynamic stochastic general equilibrium model with incomplete markets and with aggregate and idiosyncratic shocks. They find that the consumption function in such an economy is almost linear in wealth, and therefore the aggregate consequence of incomplete markets in the business cycles frequency is limited. Carroll [5] argues that Krusell and Smith's model can underestimate the effect of precautionary savings, because it generates a fairly centered wealth distribution whereas the curvature of the consumption function concentrates on the low wealth levels.

This paper focuses on a different channel of precautionary effects on consumption: time-varying idiosyncratic risk. The demand for precautionary savings are affected by the magnitude of idiosyncratic employment risk that individual households bear. We consider that the magnitude of the employment risk fluctuates as the unemployment rates vary. When the unemployment is high, there is a higher chance of losing jobs for the households who are currently employed, and a lower chance of finding jobs for those who are unemployed. Since the unemployment rate fluctuates in the business cycles frequency, it is possible that the households' savings decision also fluctuates in this frequency. Namely, the households consume less when the unemployment rate is high, because the high unemployment implies high risk for the current and future employment and thus induces households to save so that they can partially hedge against the risk.

There has been little formal quantitative analysis on the impact of the changing unemployment risk on the aggregate consumption. We find that aggregate consumption can respond strongly to the employment risk under conventional calibration. Consider the case where a fiscal intervention reduces the unemployment rate. This policy has an obvious effect on consumption through an increased level of employment: a fraction of workers switch from the unemployed status to the employed status, and they increase consumption. There is a less obvious effect of this policy: all the households perceive the reduction in the employment risk, and thus they start to dissave their wealth. This effect is observed for a wide range of wealth levels of households. Thus, the wealth distribution seems to matter less than the case of a windfall income.

It is hard to quantify the effect of precautionary savings analytically, and thus we use the numerical method developed by Krusell and Smith. The original Krusell and Smith model does contain a time-varying idiosyncratic risk, as the unemployment hazard in the model depends on the time-varying aggregate state. However, it is hard to identify the contribution of the time-varying idiosyncratic risk to consumption in their model, because the magnitude of risk moves along with aggregate productivity. Instead, here we associate the time-varying risk to switching regimes of fiscal policy. We consider two kinds of fiscal policy. First, we consider a simple model of unemployment insurance. In one regime, government is non-interventionist. In the other regime, government provides a fraction of unemployed workers with unemployment compensation that is financed by lump sum taxation. In the second model, we consider a switching rate of corporate tax. The employment rate fluctuates along with the corporate tax, and so does the unemployment hazard rate.

Our main findings are following. First, a pure transfer of wealth from the employed to the unemployed through the unemployment insurance policy can increase aggregate consumption, and thus cause a comovement of consumption and government payments. While the correlation coefficient is substantial, the impact on consumption is quantitatively small. Secondly, the impact on consumption becomes large, while the correlation between the consumption and government payments remains positive, if the provision of the unemployment compensation comes along with an increase in the resource available to the economy. We consider two such cases: the case of productive government activity and the case of foreign trade. Thirdly, we consider the case of switching corporate tax rather than the unemployment insurance. A combination of a reduced tax and a reduced government spending enhances the employment of private firms. In this case, the magnitude of consumption response is as large as the case of productive government, while the correlation between consumption and government spending becomes negative in a balanced budget scheme. These findings seem to fit well with the mixed results on the comovement between consumption and government spending found in the empirical literature.

Government's employment is similar to the unemployment insurance in the function that they both transfer wealth from the employed workers to the unemployed. Finn [11] studies the macroeconomic effects of the government's employment in a dynamic general equilibrium model with complete markets. Cavallo [6] finds that the model with government labor purchases helps explain the consumption response in the Ramey-Shapiro episodes. Our contribution in this context is to provide quantitative assessments of the effect of government labor expenditures on consumption in an economy with incomplete markets, where the precautionary savings effect plays an important role. The link between the unemployment insurance and the precautionary savings is pursued by Engen and Gruber [9], who find evidence for the effect that the insurance reduces the savings in households data.

Next section presents the model economy. Section 3 shows main results, and Section 4 concludes the paper. Details of computation is deferred to Appendix.

2 Model

We consider a dynamic stochastic general equilibrium model with incomplete markets, uninsurable employment shocks, and aggregate shocks as Krusell and Smith [14] (KS henceforth). The economy is populated by a continuum of households with population normalized to 1. The household maximizes the utility subject to the budget constraints:

$$\max_{c_t, k_{t+1}} \mathrm{E}_0 \sum_{t=0}^{\infty} \beta^t c_t^{1-\sigma}/(1-\sigma) \tag{1}$$

$$\text{s.t.} \qquad c_t + k_{t+1} = (r_t + 1 - \delta)k_t + w_t h_t - \tau_t, \quad \forall t \tag{2}$$

where c_t is the consumption, k_t is the capital asset, h_t is the labor, τ_t is the lump sum tax, r_t is the gross return to capital and w_t is the real wage where the consumption good is the numeraire. The capital depreciates at the rate δ, and the future utility is discounted by β. The household is either unemployed ($h_t = 0$) or employed ($h_t = 1$), and h_t follows an exogenous process as discussed shortly.

The representative firm produces goods with the technology specified by a Cobb-Douglas production function with constant returns to scale $Y_t = K_t^{\alpha} H_t^{1-\alpha}$ where Y_t is the aggregate goods produced and K_t and H_t are the aggregate capital and labor. The firm maximizes its profit in a competitive market, where the following conditions hold:

$$r_t = \alpha (K_t/H_t)^{\alpha-1} \tag{3}$$

$$w_t = (1-\alpha)(K_t/H_t)^{\alpha}. \tag{4}$$

Our model features a fiscal policy as the aggregate shock. We first consider a partial provision of an unemployment insurance by the government. The fiscal policy z_t follows a Markov process with two states $\{0, 1\}$ and with a transition matrix $[\pi_{zz'}]$. The government is inactive in state $z_t = 0$. The lump sum tax is set at zero and the aggregate unemployment rate stays at a high rate u_0. In state $z_t = 1$, the government provides a full unemployment compensation w_t for a fraction of the unemployed households. We can interpret the unemployment compensation as a “buy-out” of the fraction of the unemployed labor force and thus it constitutes a wage expenditure of the government. The fraction of the households who are neither employed by the firms nor bought-out by the government is u_1, which is strictly less than u_0. The lump-sum tax is equal to the aggregate amount of contemporaneous unemployment compensation. Thus, the lump sum tax per worker is:

$$\tau_t = \begin{cases} 0 & \text{if } z_t = 0 \\ w_t(u_0 - u_1) & \text{if } z_t = 1 \end{cases} \tag{5}$$

In this set up, the aggregate labor supplied for firms is exogenously constant at $H_t = 1 - u_1$ for any t regardless of z_t, whereas the total workers employed by firms or government is either $1 - u_0$ or $1 - u_1$ depending on z_t.

We consider that the aggregate shock z_t affects the transition probability of the individual employment status h_t. Let Π denote the transition matrix for the pair of the individual labor and the fiscal policy status, (h_t, z_t). The transition probability from (h, z) to (h', z') is denoted by $\pi_{hh'zz'}$. In our model, the aggregate shock z determines both the employment level and the fiscal policy regime. We set the regime switching probability so that the average duration of each regime is 8 quarters in the benchmark calibration, following KS. In an alternative calibration, we set the transition probability by using Davig's [7] estimates on the regime switching of the US fiscal policy.

A recursive competitive equilibrium is defined as follows. The household's maximization problem is written as a dynamic programming with state variables (k, h, z, Γ) where Γ is the cross-section distribution of (k_i, h_i) across households $i \in [0, 1]$. The law of motion for (h, z) is determined by the exogenous transition matrix Π. Define a transition function T that maps Γ to the next period distribution Γ'. The recursive competitive equilibrium is defined by the value function $V(k, h, z, \Gamma)$, the policy function F of the household, and the transition function T, such that V and F solve the household's problem under T and the competitive factor prices that satisfy (3,4), that they are consistent with the market clearing conditions $K = \int k_i d\Gamma$ and $H = \int h_i d\Gamma$, and that T is consistent with F and Π. The goods market clears by Walras's law, $C + K' - (1-\delta)K = Y$, where $C = \int c_i di$ is the aggregate consumption.

We calibrate parameters largely following KS for the sake of comparison. The transition matrix Π must satisfy:

$$u_z(\pi_{00zz'}/\pi_{zz'}) + (1-u_z)(\pi_{10zz'}/\pi_{zz'}) = u_{z'}, \quad z \in \{0,1\} \tag{6}$$

to be compatible with the aggregate labor employed by firms or government, $1-u$. We also restrict Π so that the mean duration of unemployment is 1.5 quarters for the state 0 and 2.5 for 1, and that $\pi_{0001} = 0.75\pi_{0011}$ and $\pi_{0010} = 1.25\pi_{0011}$ following KS. These restrictions fully determine Π. The calibration of the other parameters draws on KS as $\alpha = 0.36$, $\beta = 0.99$, $\delta = 0.025$, $\sigma = 1$, $u_0 = 0.1$, and $u_1 = 0.04$. We approximate the transition function T by a linear mapping of $\log K$. Following Mukoyama and Şahin [15], we specify that the slope of the function is common but the constants can vary across z:

$$\log K' = a_z + b \log K_z + \epsilon, \quad z \in \{0,1\} \tag{7}$$

Simulations show that the linear transition function on the first moment provides a sufficiently accurate forecast on the future aggregate capital as in KS.

3 Results

3.1 Unemployment insurance

We first consider the model with unemployment insurance which is financed by contemporaneous lump sum tax (5), leaving the government budget balanced all the time. This is a pure transfer policy that levies lump sum tax and distributes the proceeds to a fraction $u_0 - u_1$ of randomly selected unemployed workers. Aggregate production is not affected by this policy, unless capital level is changed. Table 1 shows the consumption for different states. C_z denotes the average aggregate consumption for policy state z. C_z^e and C_z^u denote the average consumption for the employed and the unemployed, respectively, for z. In parentheses are the standard errors for the estimated moments obtained by 30 iterated runs. The current model specification corresponds to the policy regime "UI I" in the table.

In Table 1, we note that the consumption of the unemployed increases by 1.54% by the provision of unemployment insurance (the policy transition from 0 to 1). This shows the precautionary savings effect: since the government policy reduces the unemployment hazard, the households with low current income and wealth is inclined to increase consumption. Next, we note that the average consumption of the employed is reduced by 0.21%. This is because the employed suffers from the policy that transfers a part of their wealth to the unemployed.

The overall consumption is increased by 0.03% by the policy. Note that the precautionary motives affect all groups of workers. The lump-sum transfer per se also affects the consumption of all workers negatively. The point of the exercise here is to quantify the difference in the effects of the two forces on the employed and unemployed groups. We observe a positive overall impact of the transfer policy on the aggregate consumption, which indicates that the positive precautionary effect outweighs the negative wealth effect.

To distinguish the precautionary effect, we decompose the overall effect as in Table 2. We consider three groups of workers: $u_1 = 4\%$ of workers who remain unemployed before and after the policy transition, $u_0 - u_1 = 6\%$ of workers who transit from the unemployed to the employed by the policy, and $1 - u_1 = 90\%$ of workers who remain employed before and after. Note that the composition of each group reshuffles in each

z	UI I C_z^e	UI I C_z^u	UI I C_z	UI II C_z^e	UI II C_z^u	UI II C_z	UI III C_z^e	UI III C_z^u	UI III C_z
0	2.4766	2.4083	2.4698	2.5253	2.4642	2.5192	2.3830	2.3038	2.3751
	(0.0001)	(0.0006)	(0.0000)	(0.0018)	(0.0025)	(0.0019)	(0.0018)	(0.0025)	(0.0019)
1	2.4715	2.4458	2.4704	2.5546	2.5373	2.5539	2.4094	2.3825	2.4083
	(0.0001)	(0.0004)	(0.0001)	(0.0017)	(0.0022)	(0.0017)	(0.0018)	(0.0022)	(0.0018)
log diff.	-0.0021	0.0154	0.0003	0.0115	0.0293	0.0137	0.0110	0.0336	0.0139

Table 1: Consumption changes in policy transition for average workers in different groups. UI I is the case of unemployment insurance as a means of pure wealth transfer, UI II is the case of government's productive employment, and UI III is the case of storage or trade by government.

	$(1-u_0)\log C_1^e/C_0^e$	$u_1 \log C_1^u/C_0^u$	$(u_0-u_1)\log C_1^e/C_0^u$	$\log C_1/C_0$
UI I	-0.0019	0.0006	0.0016	0.0003
UI II	0.0104	0.0012	0.0022	0.0137
UI III	0.0099	0.0013	0.0027	0.0139

Table 2: Contributions to aggregate consumption growth by different groups of workers

period during the new policy regime, but it does not affect the aggregate property of the group, because each group consists of uncountably many workers who are ex-ante identical. Each of the workers in the first group (unemployed to unemployed) increases consumption by 1.54%, and thus the group as a whole contributes to the rise of total consumption by 0.06 percentage. Each worker in the second group (unemployed to employed) increases consumption by 2.59% ($\log C_1^e - \log C_0^u$), which amounts to 0.16 percentage rise in total consumption. Finally, each worker in the third group (employed to employed) reduces the consumption by 0.21%, which results in 0.19 percentage reduction in total consumption. The net increase in overall consumption is 0.03%. Note that the fall in consumption by the employed workers in the third group is almost cancelled out by the increase in consumption by the workers in the second group who newly receive compensations from the government. This corresponds to the direct effect of the wealth transfer from the employed to the unemployed. The net increase in total consumption thus comes from the contribution of the unemployed workers, who dissave precautionary savings due to the reduced unemployment risk. This shows that the precautionary savings effect is present in aggregation, and that its quantitative importance is limited at least in the case of pure wealth transfer.

Table 3 summarizes the key aggregate statistics obtained by the simulation. Government expenditure G_t is the payment for the unemployed, and satisfies $G_t = \tau_t$. We note that G_t correlates positively with aggregate consumption C_t. Thus, the government's transfer of wealth from the employed to the unemployed causes a positive correlation with total consumption. The correlation between C and G is fairly high at 0.43. We should note, however, that the magnitude of the movement is small, as the standard deviation of the total consumption is only 0.03%. We also observe that the output and government spending are almost uncorrelated. This is because the

	s.d. Y	s.d. C	corr(Y,C)	corr(Y,I)	corr(Y,G)	corr(C,G)
UI I	0.0002	0.0003	0.2724	0.5116	-0.0491	0.4352
	(0.0000)	(0.0000)	(0.0167)	(0.0311)	(0.0225)	(0.0228)
UI II	0.0234	0.0125	0.7363	0.9326	0.9707	0.5525
	(0.0002)	(0.0004)	(0.0068)	(0.0036)	(0.0013)	(0.0040)
UI III	0.0061	0.0129	0.9642	-0.7720	1.0000	0.9642
	(0.0002)	(0.0005)	(0.0030)	(0.0149)	(0.0000)	(0.0030)
Tax I	0.0235	0.0123	0.6157	0.9240	-0.9574	-0.3623
	(0.0002)	(0.0004)	(0.0124)	(0.0034)	(0.0016)	(0.0094)
Tax II	0.0254	0.0189	0.7458	0.8529	-0.9191	-0.4235
	(0.0004)	(0.0007)	(0.0110)	(0.0073)	(0.0033)	(0.0074)

Table 3: Second moments for different policy schemes

	C^e/C^u	C	I/Y	k	$\hat{R}^2$	$\hat{a}_0$	$\hat{a}_1$	$\hat{b}$
UI I	1.0197	2.4702	0.2523	33.3489	0.9986	0.0053	0.0054	0.9985
	(0.0005)	(0.0000)	(0.0000)	(0.0030)	(0.0002)	(0.0000)	(0.0000)	(0.0000)
UI II	1.0157	2.5367	0.2451	32.9508	0.9999	0.1358	0.1321	0.9616
	(0.0005)	(0.0022)	(0.0001)	(0.0375)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
UI III	1.0229	2.3915	0.2703	32.6184	1.0000	0.1377	0.1339	0.9610
	(0.0006)	(0.0025)	(0.0004)	(0.0412)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Tax I	1.0153	2.5301	0.2429	32.4711	1.0000	0.1322	0.1281	0.9626
	(0.0003)	(0.0015)	(0.0001)	(0.0290)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Tax II	1.0156	2.4438	0.2685	32.4567	0.9999	0.1326	0.1266	0.9627
	(0.0006)	(0.0037)	(0.0001)	(0.0705)	(0.0000)	(0.0000)	(0.0000)	(0.0000)

Table 4: Other estimates

workers hired by the government are not productive in this experiment. Thus, the level of productive employment stays fixed during policy transitions. The fluctuation of output is solely caused by the small movement of capital. Table 4 lists the other estimates. The column C^e/C^u shows the ratio of average consumptions between the employed and unemployed. While households partially hedge the unemployment risk by accumulating wealth, a substantial gap (1.97%) remains uninsured. The last three columns show the approximated law of motion for the capital distribution. The R^2 shows that the approximation is quite accurate.

The benchmark model above indicates the positive effect on consumption caused by the provision of unemployment insurance through precautionary motives of savings. However, the effect is quantitatively small, because the policy does not affect production. From now on, we explore the models in which a rise in employment by the government policy increases contemporaneous resources available to the economy.

First we consider a variation of the benchmark model, in which government has a linear technology to produce goods. Namely, the government employs $u_0 - u_1$ workers and produces $(u_0 - u_1)w_t$ value added. The employment is financed by the sales of the goods at the goods market, and thus no tax is levied: $\tau_t = 0$ for all t. This is a model of productive government activities. A linear production function is natural for the government, because GDP statistics include government's salary expenditure as value added. The government's output adds to the supply side of the goods market, thus the goods market clearing condition becomes $C + K' - (1-\delta)K = Y + (u_0 - u_1)w$.

The simulation results for this model of productive government are reported under "UI II" in the tables. We first note that the output and consumption fluctuates much more than the benchmark case UI I. In Table 3, the standard deviations of output and consumption amounts to 2.34% and 1.25%, respectively. This is a direct consequence of the switching activities of the productive government.

Second, we note that the consumption is increased for the employed as well as for the unemployed in the periods of insurance provision. Table 1 shows that the consumption of the employed increases by 1.15%. In the benchmark setup, the consumption of the employed decreases because they have to pay the lump sum tax during the regime of insurance provision. In the present setup, there is no tax levied for the insurance policy. Thus, the expected lifetime income of the employed workers increases by the prospect of less unemployment hazard in the near future. This reduces the need for precautionary savings and thus increases the consumption of the employed. While the increase in average consumption of the employed is modest at 1.15% compared to 2.93% increase for the unemployed, its contribution to the total consumption is large because of its large share among workers. As seen in the decomposition in Table 2, the employed groups contributes more than three quarters of the increase in total consumption (1.04/1.37). The correlation between C and G is also high at 0.55.

Note that the wage rate is determined only by the capital level and not affected by the policy regime, because the employment of firms does not change by the policy. Thus, when the policy switches, the expected lifetime income changes largely through the change in perceived employment risks in future. The big impact on the consumption of the employed workers indicates that the risk environment is important in determining the consumption demand of the large mass of workers.

We consider another variation of the benchmark model, in which government has a storage technology. The government collects lump-sum tax in every period and stores the proceeds. The government transfers the storage to the unemployed workers during the periods when it adopts the unemployment insurance policy. One example of such storage technology is a trade with foreign countries. Government can accumulate foreign assets during the inactive periods, and use the assets to import goods in the periods of active policy. To finance the storage/trading activities, the government collects lump sum tax that is constant across periods. In this setup, workers face a constant tax burden across time, and the government budget is generally imbalanced as the policy switches.

The simulation results for this model are reported under "UI III" in the tables. We observe that the statistics are similar to the case of productive government (UI II): the output and consumption fluctuate much more than the benchmark case UI I, and the correlation between consumption and government payment is positive. The consumption of the employed is increased during the active policy periods by 1.1%, and it accounts for 71% of the total consumption increase. The mechanism is similar as the productive government model. Since the policy regime does not affect the wage nor the tax the workers pay in every period, the increase in the expected lifetime income is largely caused by the prospect of less unemployment hazard in future.

3.2 Corporate tax

In this section, we consider an alternative government intervention. We replace the unemployment compensation program with a regime-switching tax rate as studied in Davig [7]. We will see that the government-consumption correlation hinges on how the government intervention affects the contemporaneous resources available to the economy.

We consider that the government levies a flat-rate tax on firms' revenue. The tax rate ξ_t fluctuates between two states according to the Markov process specified by Π. We continue to assume the exogenous aggregate employment process that fluctuates between two states u_0 and u_1 along with the policy status $z \in \{0, 1\}$. An implicit mechanism underlying the exogenous employment process is that, when the tax rate is low, labor demand shifts out and employment is increased. The production factors are paid for their after-tax marginal products: $r_t = (1 - \xi_t)\alpha(K_t/(1 - u_t))^{\alpha-1}$ and $w_t = (1-\xi_t)(1-\alpha)(K_t/(1-u_t))^{\alpha}$. We set the tax rate so that real wage is independent of the policy status. Then the tax rate is set as:

$$\xi(z) = 1 - (1 - u_z)^{\alpha}, \quad z = 0, 1. \tag{8}$$

When $z_t = 0$, the tax is high at $\xi(0)$ and the unemployment is high at u_0. When $z_t = 1$, the tax is low at $\xi(1)$ and the unemployment is low at u_1.

We consider two cases for the government expenditure. In the first case, which we call "Tax I", the tax proceeds are rebated to the households in a lump sum manner. By

z	Tax I C_z^e	C_z^u	C_z	Tax II C_z^e	C_z^u	C_z
0	2.5238	2.4666	2.5181	2.4291	2.3710	2.4233
	(0.0015)	(0.0020)	(0.0015)	(0.0032)	(0.0040)	(0.0033)
1	2.5425	2.5238	2.5417	2.4649	2.4479	2.4642
	(0.0014)	(0.0018)	(0.0014)	(0.0029)	(0.0033)	(0.0029)
log diff.	0.0074	0.0229	0.0093	0.0146	0.0319	0.0168

Table 5: Consumption changes in policy transition for average workers in different groups. Tax I is the case of corporate tax with lump sum rebates, and Tax II is the case of corporate tax and wasteful government spending.

	$(1-u_1)\log C_1^e/C_0^e$	$u_1 \log C_1^u/C_0^u$	$(u_0-u_1)\log C_1^e/C_0^u$	$\log C_1/C_0$
Tax I	0.0066	0.0009	0.0018	0.0093
Tax II	0.0132	0.0013	0.0023	0.0168

Table 6: Contributions to aggregate consumption growth by different groups of workers: Case of corporate tax

abuse of notation, we redefine $-\tau_t$ as the lump sum transfer. Then $-\tau_t = \xi_t Y_t$. Using this notation, the household's budget constraint continues to be written as (2). In the second case ("Tax II"), the tax proceeds are used by the government for non-productive activities (i.e., thrown into the ocean). In this case, the transfer τ_t is zero for every t. The government expenditure G_t is equal to the tax proceeds $\xi_t Y_t$, and it appears in the demand side of the goods market clearing condition: $C + K' - (1-\delta)K + G = Y$.

Table 5 shows the consumption for various states. We note that the consumption increases in the periods of low tax for both the employed and the unemployed workers in both models Tax I and II. Table 6 shows the decomposition of the total consumption growth into the contributions of the groups of workers according to the employment status. The contribution of the employed workers is substantial in both models: 71% in Tax I and 79% in Tax II.

In Tax I, the tax proceeds are rebated back to the households, so the tax is a distortionary transfer from the firms to the households. The lowered tax rate induces higher labor demand and larger output. While the real wage is held fixed, the lump sum transfer to the households is reduced during the low tax periods. The reduced transfer income should hurt the consumption demand of the unemployed. Nonetheless, the consumption of the unemployed is increased by 2.29% by the tax reduction. This shows that the wealth effect of the prospect of low unemployment hazard overwhelms the effect of less transfer income.

This wealth effect can be directly observed in Tax II. In Tax II, both the real wage and the government transfer (zero) are fixed during the policy transitions, and thus the contemporaneous income of the employed workers is not affected by the policy at all. Table 5 shows that the consumption of the employed is increased considerably by 1.46%.

The magnitude of the fluctuations in consumption and output is as large in the corporate tax model as the productive government model of the unemployment insurance (UI II) as seen in Table 3. This is because the reduction of the corporate tax increases productive employments in the firms sector. The corporate tax models and the productive government model share the similar supply side mechanism and the consumer behavior, which leads to the similarity in the moment properties in output, consumption, and investment.

The correlations between government expenditure (or transfer) with output and consumption become negative in the tax models. The reason is that the government's intervention is distortionary and suppresses labor input, and thus less government activities induce more production and consumption. This result contrasts with the model of unemployment insurance. This shows that the correlation of the government expenditure and consumption depends on whether the government activity suppresses production or not.

We conduct two sets of sensitivity analysis. First, we increase the risk aversion parameter to $\sigma = 3$. The results are shown in Appendix C. We note that the consumption effect of pure wealth transfer in UI I is doubled. This is consistent with our intuition: the households who are sensitive to risks respond more to the reduced risks. Other statistics are similar to the case of $\sigma = 1$. In the second sensitivity analysis, we set the parameters following Davig's [7] estimation of the regime-switching fiscal policy. The results are shown in Appendix D. Overall, we observe more fluctuations and larger responses to the policy. This is because the average duration of policy regimes is much longer under this calibration. The results are consistent with our expectation that the effect of policy is amplified when the policy regime is more persistent.

4 Conclusion

This paper quantitatively studies the dynamic stochastic general equilibrium model with idiosyncratic employment risk, when the magnitude of employment risk is changed over time as fiscal policies switch between two regimes stochastically. In the experiments, we consider two kinds of fiscal policies: unemployment insurance and corporate tax. The unemployment insurance model provides a simple case which facilitates our interpretations of the result, whereas the corporate tax model examines the case where government activities hinder private sector's production.

We find that the government policy that reduces the unemployment hazard can increase the aggregate consumption demand by a non-negligible magnitude. In a pure wealth transfer from the employed to the unemployed workers, we observe a positive correlation between the aggregate consumption and the government's transfer payments, but it's magnitude is small. The correlation is positive and the impact of policy on consumption becomes large, if the unemployment insurance program enhances the resources available to the economy. We show two examples: the case where the government's employment generates value added, and the case where the government can trade with foreign countries. Finally, we find that the correlation between the consumption and government spending is negative, when we consider a distortionary corporate tax. This shows that the consumption-government correlation depends on how the policy affects the supply of goods.

We decompose the impact of the policy on the aggregate consumption into three effects: the increased fraction of employed households, the reduced unemployment hazard for the employed workers, and the increased employment chance for the unemployed workers. We find the effect of reduced employment hazard for the employed workers considerably large, when the tax burden for the employed workers is held fixed. The effect of the reduced risk can be large, because it affects not only the unemployed but also a wide range of the employed households. It makes a contrast with the effect of a windfall income which affects a relatively small fraction of workers whose borrowing constraints are binding.

Appendix

A Details of computation

The state space for the household's capital k_i is discretized by 1000 grids equally divided in the range $[-3, 100]$. The lower bound is chosen so that the gap in the consumption growth rates between the low asset and the high asset holders roughly matches with Zeldes' estimate [18, 16]. The upper bound is chosen to be high enough so that households do not reach the upper bound in simulated paths. The number of the grids is chosen to be high enough so that the further increase of the grids does not change simulated mean capital. The state space for the mean capital is discretized by five grids.

Given the approximated law of motion of the joint distribution of the capital holding and the employment states, the value function is obtained by the iteration of the Bellman equation. To evaluate the value function at the forecasted mean capital in the next period, we interpolate the value function in the dimension of the mean capital by the spline method.

Once the value function is obtained, we simulate the equilibrium path with 1000 households for 10000 periods. In each period of the simulation, the policy function is interpolated at the current mean capital level by the spline method, and the interpolated policy function evaluated at the current mean capital and the current aggregate state is further fitted by a quadratic function for each employment state. Fitting by the higher-degree polynomial functions does not alter the results. The fitted function is then used to compute the next-period capital holding for each household. The simulated mean capital path for the last 9000 periods is used to estimate the law of motion of the form (7). The tolerance for the value function iteration is 0.01 in the sup norm. The tolerance for the law of motion is 0.001 for the coefficients in (7).

B Simulation plots

B.1 Sample paths of output and consumption for different models

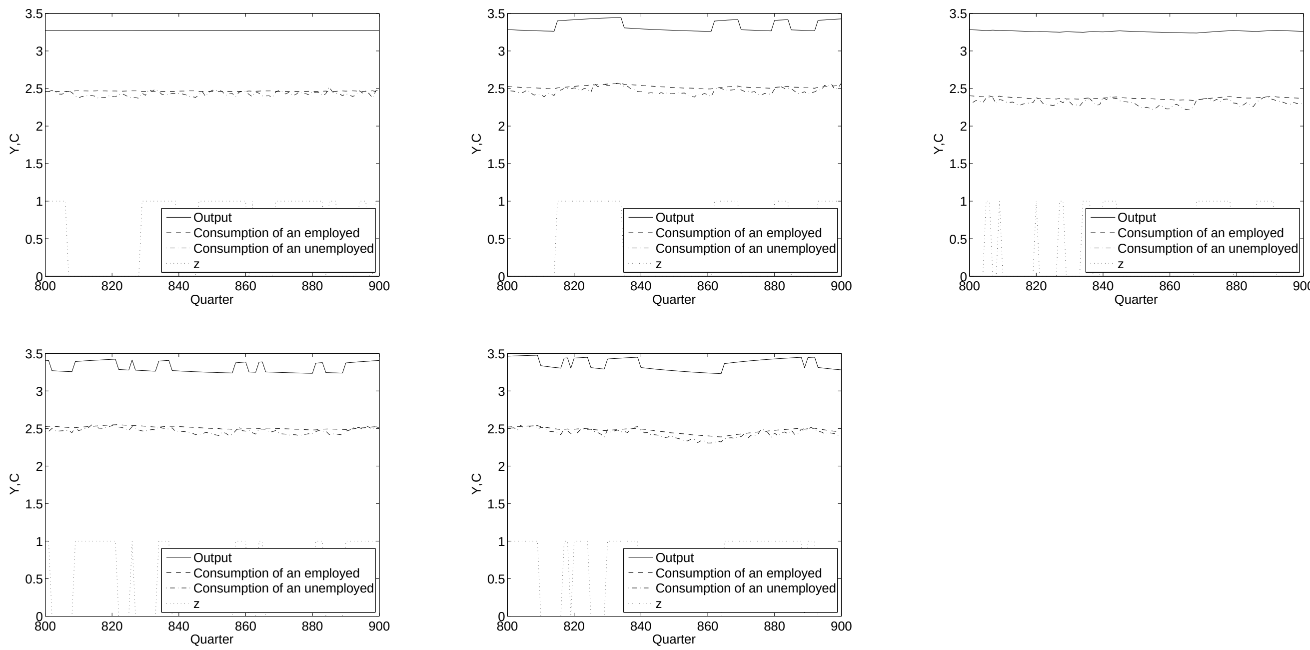

Figure 1: Sample time series of Y and C. The policy regime z is shown by the dotted line. Top: UI I, II, and III. Bottom: Tax I and II. Note that there is little output volatility for UI I and UI III.

B.2 Computed functions for UI II when $\sigma = 1$

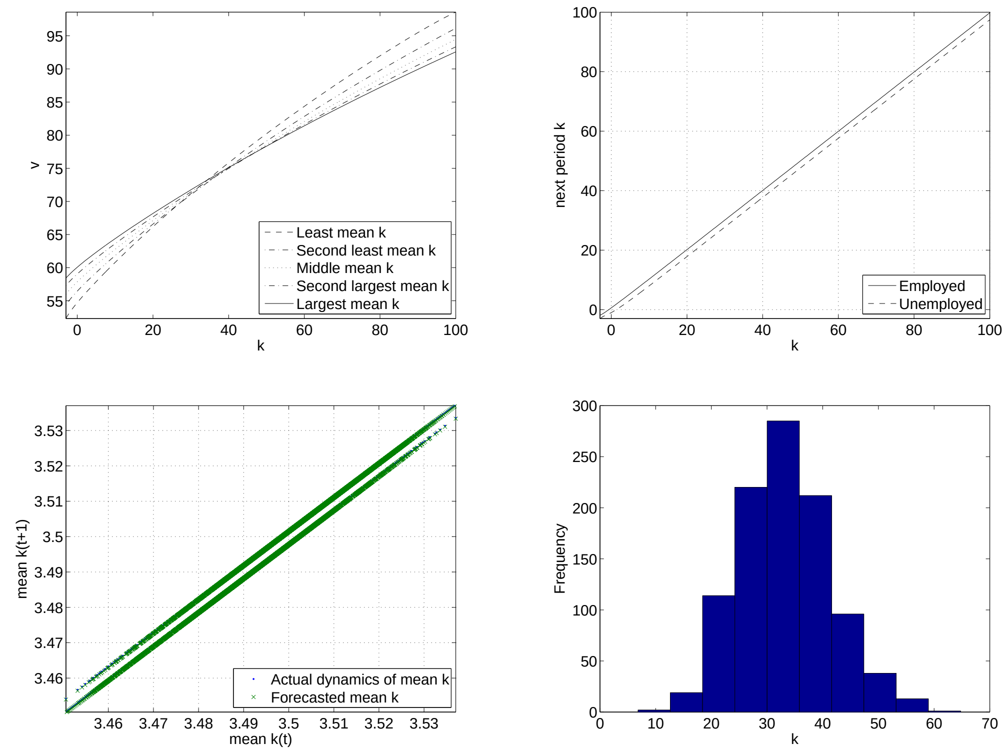

Figure 2: From top left clockwise, value functions, policy functions at medium capital level, cross-section distribution of capital, and the law of motion of capital and its approximation, for model UI II and $\sigma = 1$.

B.3 Computed functions for UI II when $\sigma = 3$

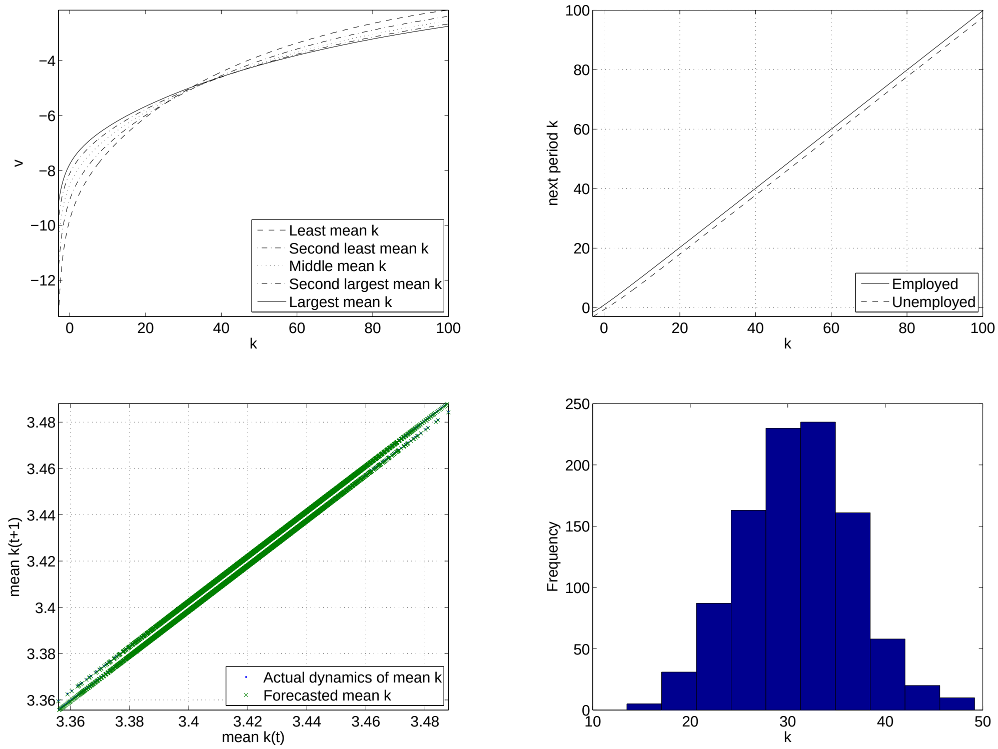

Figure 3: Same plot as Figure 2 when $\sigma = 3$

C Sensitivity analysis I: Higher risk aversion

z	UI I C_z^e	UI I C_z^u	UI I C_z	UI II C_z^e	UI II C_z^u	UI II C_z	UI III C_z^e	UI III C_z^u	UI III C_z
0	2.4442	2.3250	2.4323	2.5046	2.3858	2.4927	2.3688	2.2335	2.3553
	(0.0001)	(0.0006)	(0.0001)	(0.0023)	(0.0032)	(0.0024)	(0.0018)	(0.0027)	(0.0019)
1	2.4363	2.3749	2.4339	2.5223	2.4663	2.5200	2.3852	2.3164	2.3824
	(0.0001)	(0.0004)	(0.0001)	(0.0023)	(0.0027)	(0.0023)	(0.0021)	(0.0024)	(0.0021)
log diff.	-0.0032	0.0212	0.0007	0.0070	0.0332	0.0109	0.0069	0.0364	0.0114

Table 7: Same as Table 1 when $\sigma = 3$

	$(1-u_0)\log C_1^e/C_0^e$	$u_1 \log C_1^u/C_0^u$	$(u_0-u_1)\log C_1^e/C_0^u$	$\log C_1/C_0$
UI I	-0.0029	0.0008	0.0028	0.0007
UI II	0.0063	0.0013	0.0033	0.0109
UI III	0.0062	0.0015	0.0039	0.0114

Table 8: Same as Table 2 when $\sigma = 3$

	s.d. Y	s.d. C	corr(Y, C)	corr(Y, I)	corr(Y, G)	corr(C, G)
UI I	0.0006	0.0006	0.4125	0.6351	-0.0420	0.5238
	(0.0000)	(0.0000)	(0.0226)	(0.0281)	(0.0248)	(0.0189)
UI II	0.0242	0.0118	0.7287	0.9442	0.9472	0.4710
	(0.0003)	(0.0004)	(0.0076)	(0.0025)	(0.0024)	(0.0036)
UI III	0.0079	0.0119	0.9667	-0.2466	1.0000	0.9667
	(0.0003)	(0.0005)	(0.0029)	(0.0167)	(0.0000)	(0.0029)
Tax I	0.0242	0.0116	0.6922	0.9421	-0.9302	-0.3796
	(0.0003)	(0.0005)	(0.0127)	(0.0032)	(0.0041)	(0.0062)
Tax II	0.0270	0.0179	0.7964	0.8985	-0.8678	-0.3913
	(0.0006)	(0.0008)	(0.0112)	(0.0047)	(0.0070)	(0.0042)

Table 9: Same as Table 3 when $\sigma = 3$

	C^e/C^u	C	I/Y	k	$\hat{R}^2$	$\hat{a}_0$	$\hat{a}_1$	$\hat{b}$
UI I	1.0385	2.4331	0.2369	30.2065	0.9994	0.0023	0.0023	0.9993
	(0.0005)	(0.0001)	(0.0000)	(0.0067)	(0.0001)	(0.0000)	(0.0000)	(0.0000)
UI II	1.0361	2.5063	0.2339	30.6059	1.0000	0.0868	0.0827	0.9752
	(0.0007)	(0.0028)	(0.0002)	(0.0668)	(0.0000)	(0.0000)	(0.0000)	(0)
UI III	1.0449	2.3688	0.2598	30.5267	1.0000	0.0895	0.0855	0.9744
	(0.0006)	(0.0023)	(0.0002)	(0.0550)	(0.0000)	(0.0000)	(0.0000)	(0)
Tax I	1.0295	2.5003	0.2321	30.2269	1.0000	0.0819	0.0777	0.9766
	(0.0007)	(0.0032)	(0.0003)	(0.0813)	(0.0000)	(0.0000)	(0)	(0.0000)
Tax II	1.0351	2.4164	0.2576	30.2020	1.0000	0.0838	0.0776	0.9763
	(0.0007)	(0.0040)	(0.0001)	(0.1032)	(0.0000)	(0)	(0)	(0.0000)

Table 10: Same as Table 4 when $\sigma = 3$

	Tax I			Tax II		
z	C^e_z	C^u_z	C_z	C^e_z	C^u_z	C_z
0	2.4985	2.4000	2.4887	2.4098	2.2981	2.3986
	(0.0028)	(0.0037)	(0.0029)	(0.0035)	(0.0044)	(0.0036)
1	2.5136	2.4686	2.5118	2.4369	2.3846	2.4349
	(0.0026)	(0.0030)	(0.0026)	(0.0037)	(0.0044)	(0.0037)
log diff.	0.0060	0.0282	0.0093	0.0112	0.0369	0.0150

Table 11: Same as Table 5 when $\sigma = 3$

	$(1-u_1)\log C_1^e/C_0^e$	$u_1 \log C_1^u/C_0^u$	$(u_0-u_1)\log C_1^e/C_0^u$	$\log C_1/C_0$
Tax I	0.0054	0.0011	0.0028	0.0093
Tax II	0.0101	0.0015	0.0035	0.0150

Table 12: Same as Table 6 when $\sigma = 3$

D Sensitivity analysis II: Persistent policy

Parameter values are changed as $\alpha = 0.33$ and $\beta = 0.9916$. Most noticeably, the transition probability of the policy $\pi_{zz'}$ is changed. Following Davig's estimates, the policy switches from the high tax regime to the low tax regime in average 25 years, and the low to high tax regime in average 11 years. This is much more persistent than the benchmark calibration at 8 quarters.

	UI I			UI II			UI III		
z	C_z^e	C_z^u	C_z	C_z^e	C_z^u	C_z	C_z^e	C_z^u	C_z
0	2.0933	1.9833	2.0823	2.1060	1.9928	2.0947	1.9924	1.8524	1.9784
	(0.0002)	(0.0009)	(0.0002)	(0.0018)	(0.0033)	(0.0019)	(0.0016)	(0.0025)	(0.0017)
1	2.0856	2.0567	2.0845	2.2039	2.1799	2.2030	2.0866	2.0479	2.0851
	(0.0001)	(0.0004)	(0.0001)	(0.0008)	(0.0012)	(0.0008)	(0.0008)	(0.0011)	(0.0008)
log diff.	-0.0037	0.0363	0.0011	0.0454	0.0897	0.0504	0.0462	0.1003	0.0525

Table 13: Same as Table 1 for persistent policy

	$(1-u_0)\log C_1^e/C_0^e$	$u_1 \log C_1^u/C_0^u$	$(u_0-u_1)\log C_1^e/C_0^u$	$\log C_1/C_0$
UI I	-0.0033	0.0015	0.0030	0.0011
UI II	0.0409	0.0036	0.0060	0.0504
UI III	0.0416	0.0040	0.0071	0.0525

Table 14: Same as Table 2 for persistent policy

	s.d. Y	s.d. C	corr(Y, C)	corr(Y, I)	corr(Y, G)	corr(C, G)
UI I	0.0008	0.0009	0.3296	0.6601	-0.5965	0.5204
	(0.0000)	(0.0000)	(0.0177)	(0.0236)	(0.0230)	(0.0382)
UI II	0.0231	0.0235	0.9918	0.9162	0.9923	0.9686
	(0.0010)	(0.0011)	(0.0005)	(0.0016)	(0.0004)	(0.0018)
UI III	0.0047	0.0246	0.8945	-0.8181	1.0000	0.8945
	(0.0002)	(0.0010)	(0.0127)	(0.0201)	(0.0000)	(0.0127)
Tax I	0.0284	0.0230	0.9245	0.8762	-0.9595	-0.7798
	(0.0011)	(0.0010)	(0.0061)	(0.0013)	(0.0015)	(0.0133)
Tax II	0.0308	0.0335	0.9683	0.7425	-0.9443	-0.8324
	(0.0013)	(0.0017)	(0.0033)	(0.0034)	(0.0027)	(0.0118)

Table 15: Same as Table 3 for persistent policy

	C^e/C^u	C	I/Y	k	$\hat{R}^2$	$\hat{a}_0$	$\hat{a}_1$	$\hat{b}$
UI I	1.0259	2.0839	0.2400	26.3253	0.9995	0.0662	0.0664	0.9797
	(0.0012)	(0.0000)	(0.0000)	(0.0058)	(0.0000)	(0)	(0.0000)	(0.0000)
UI II	1.0239	2.1707	0.2331	26.3967	0.9996	0.1421	0.1401	0.9568
	(0.0020)	(0.0051)	(0.0002)	(0.0361)	(0.0001)	(0.0000)	(0.0000)	(0.0000)
UI III	1.0345	2.0536	0.2562	26.8844	0.9972	0.1451	0.1431	0.9559
	(0.0020)	(0.0042)	(0.0012)	(0.0328)	(0.0002)	(0)	(0.0000)	(0.0000)
Tax I	1.0194	2.1757	0.2366	26.9754	0.9999	0.1335	0.1297	0.9597
	(0.0015)	(0.0048)	(0.0002)	(0.0838)	(0.0000)	(0.0000)	(0)	(0.0000)
Tax II	1.0293	2.1231	0.2597	27.5422	0.9991	0.1338	0.1291	0.9597
	(0.0019)	(0.0071)	(0.0004)	(0.1133)	(0.0001)	(0.0000)	(0.0000)	(0)

Table 16: Same as Table 4 for persistent policy

	Tax I			Tax II		
z	C_z^e	C_z^u	C_z	C_z^e	C_z^u	C_z
0	2.1249	2.0277	2.1151	2.0451	1.9266	2.0333
	(0.0034)	(0.0043)	(0.0035)	(0.0050)	(0.0063)	(0.0051)
1	2.2023	2.1846	2.2016	2.1653	2.1312	2.1639
	(0.0018)	(0.0023)	(0.0018)	(0.0023)	(0.0028)	(0.0023)
log diff.	0.0358	0.0745	0.0400	0.0571	0.1009	0.0623

Table 17: Same as Table 5 for persistent policy

	$(1-u_1)\log C_1^e/C_0^e$	$u_1 \log C_1^u/C_0^u$	$(u_0-u_1)\log C_1^e/C_0^u$	$\log C_1/C_0$
Tax I	0.0322	0.0030	0.0050	0.0400
Tax II	0.0514	0.0040	0.0070	0.0623

Table 18: Same as Table 6 for persistent policy

E Other plots

E.1 Computed functions for the models other than UI II

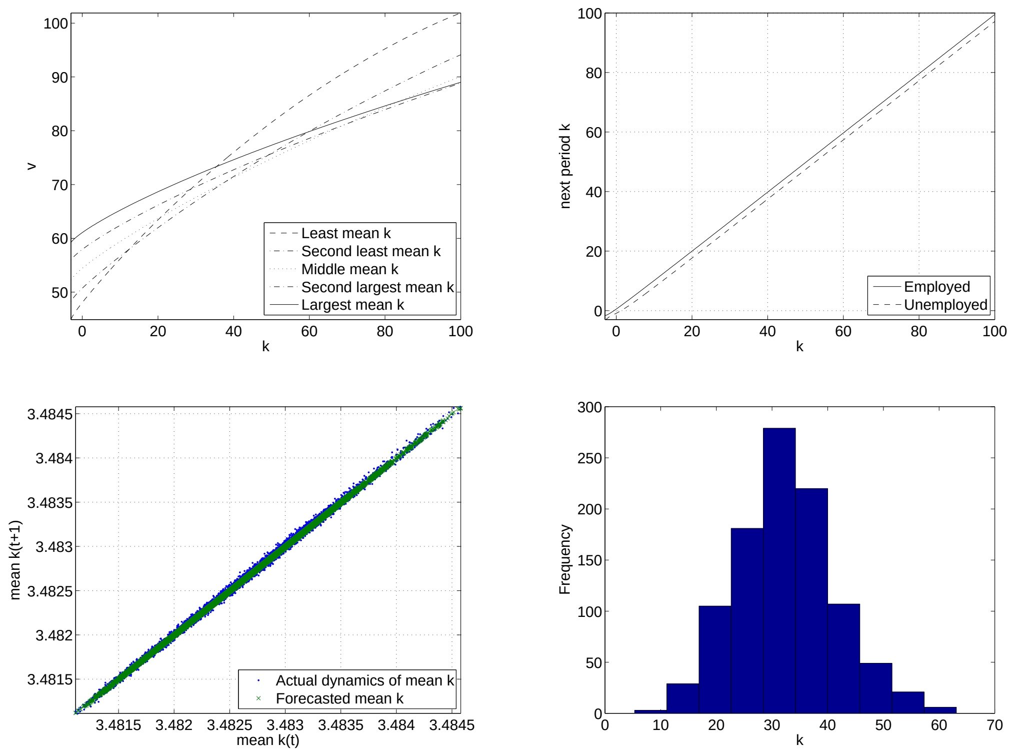

Figure 4: Same plot as Figure 2 for UI I and $\sigma = 1$.

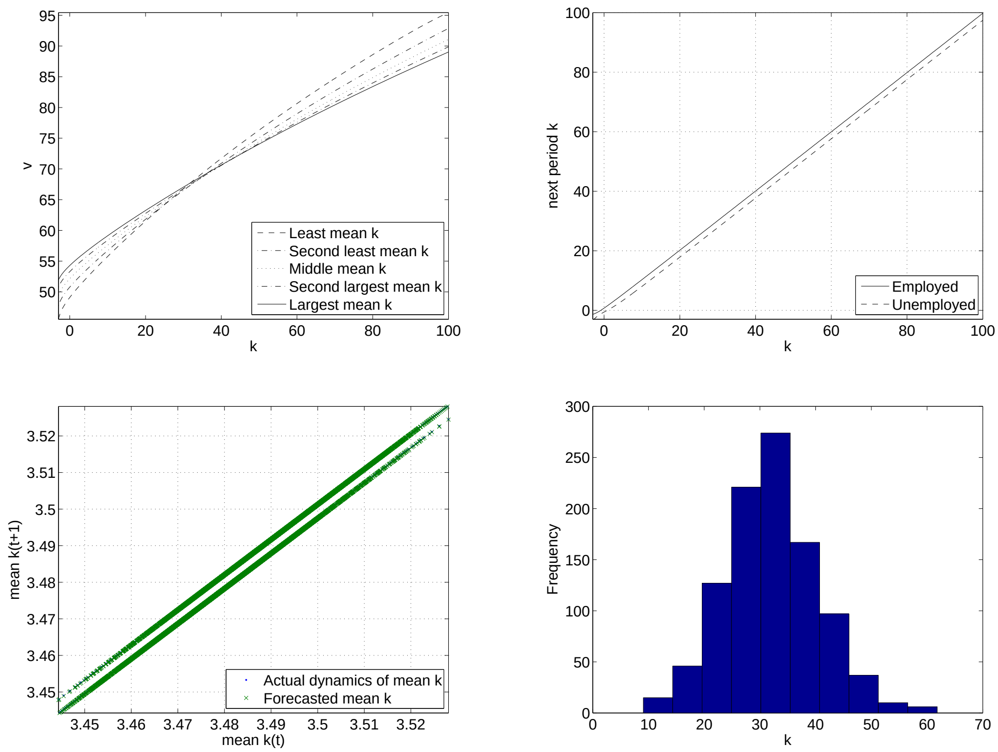

Figure 5: Same plot as Figure 2 for UI III and $\sigma = 1$.

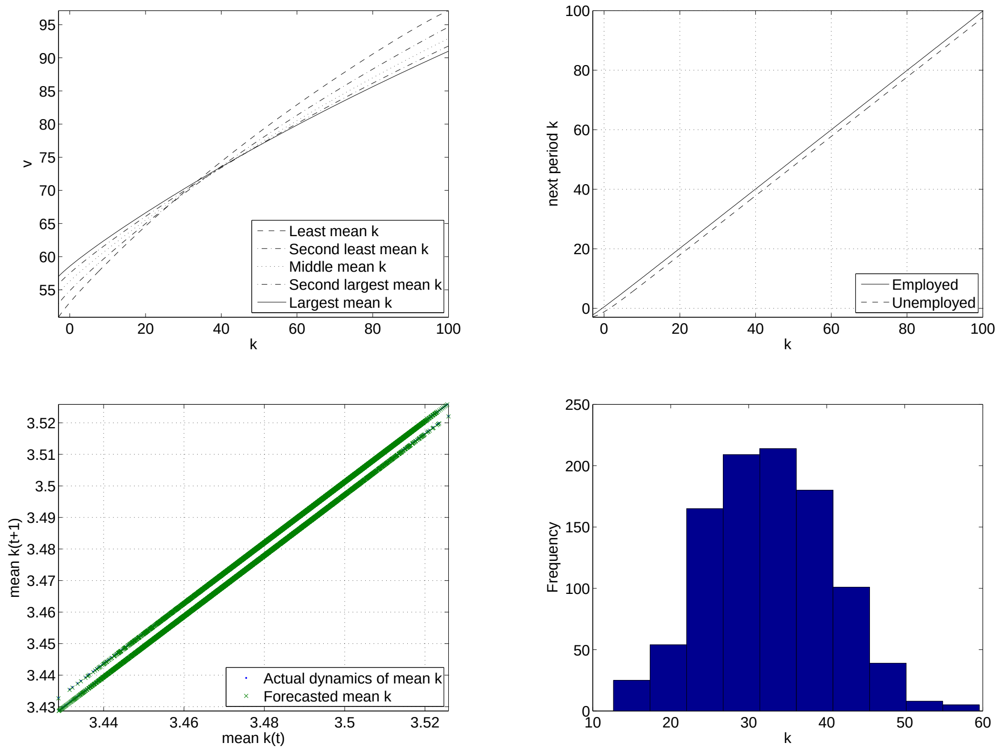

Figure 6: Same plot as Figure 2 for Tax I and $\sigma = 1$.

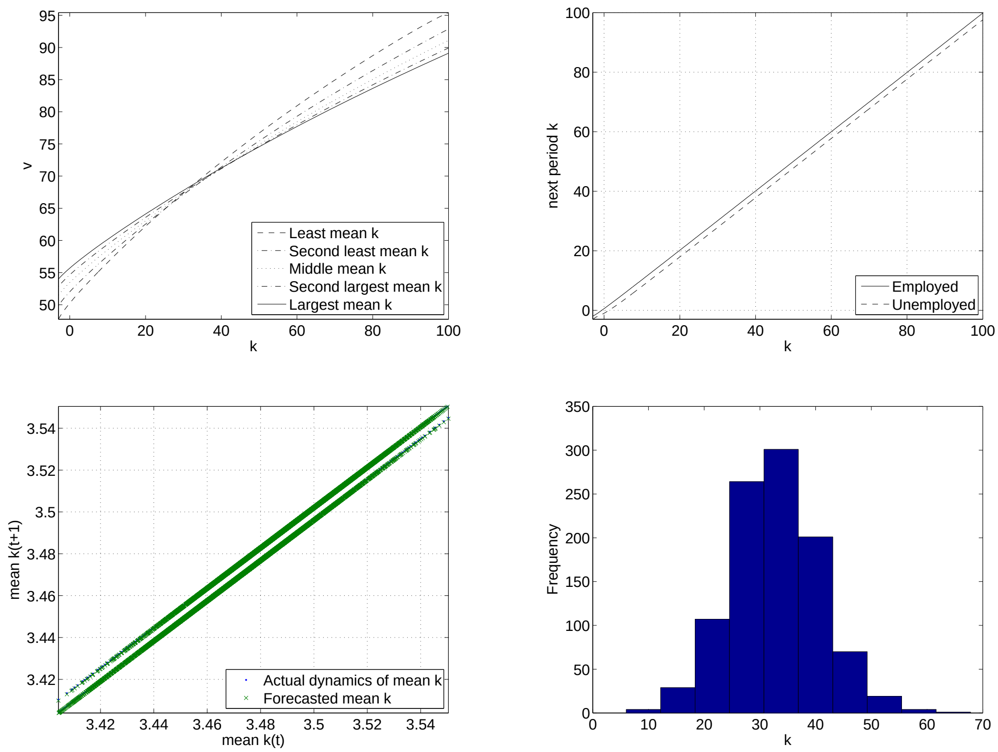

Figure 7: Same plot as Figure 2 for Tax II and $\sigma = 1$.

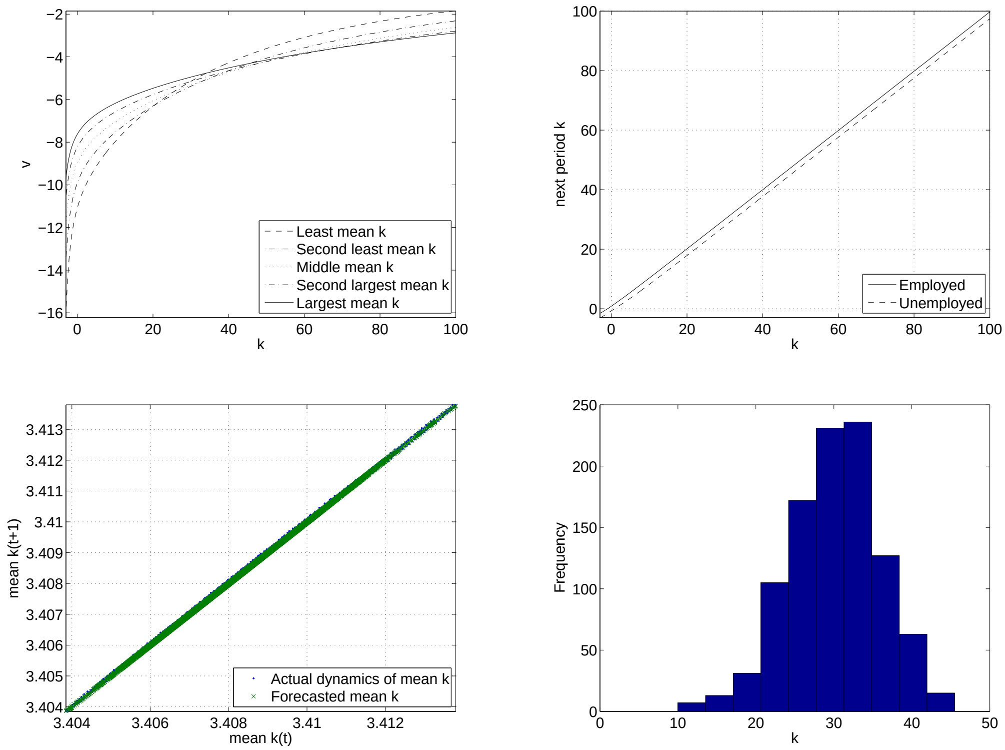

Figure 8: Same plot as Figure 2 for UI I and $\sigma = 3$.

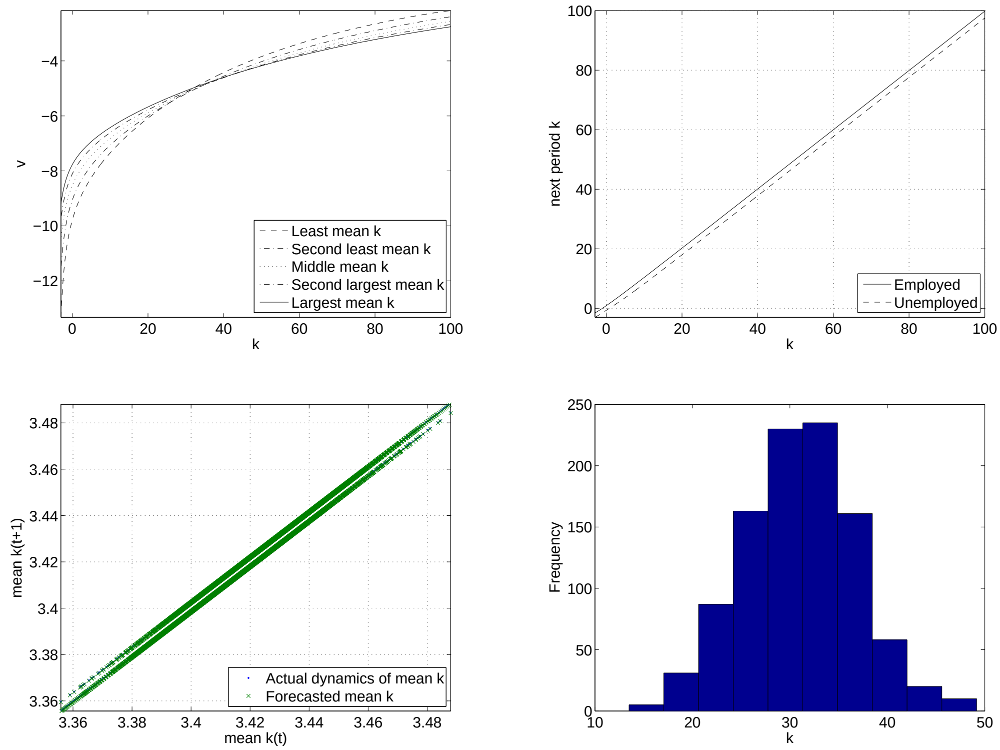

Figure 9: Same plot as Figure 2 for UI II and $\sigma = 3$.

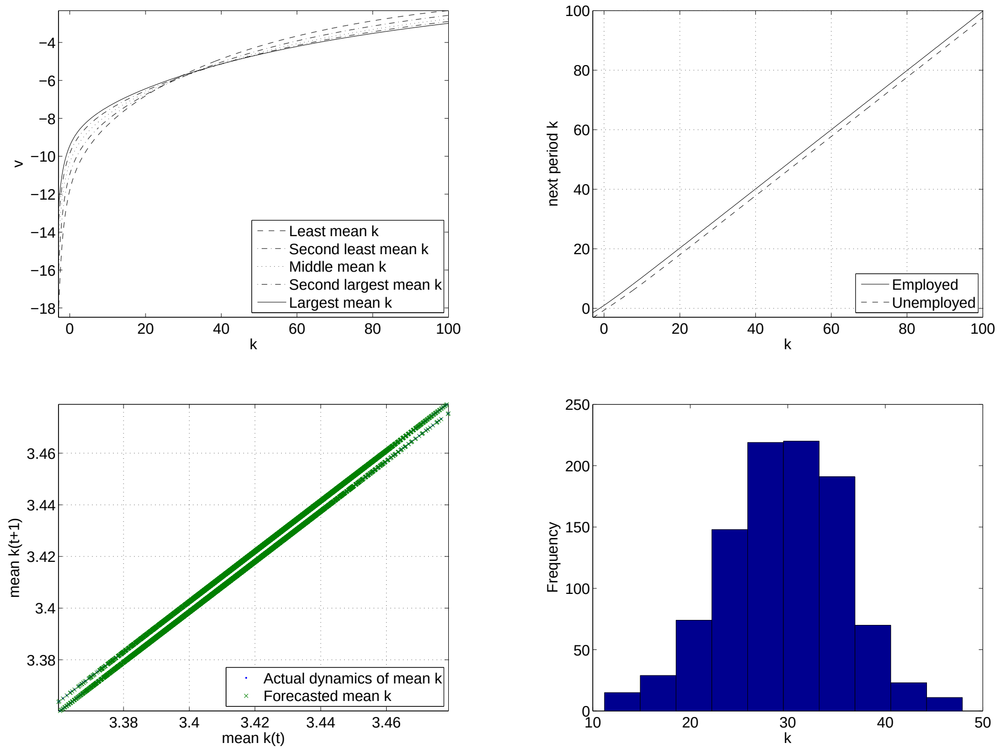

Figure 10: Same plot as Figure 2 for UI III and $\sigma = 3$.

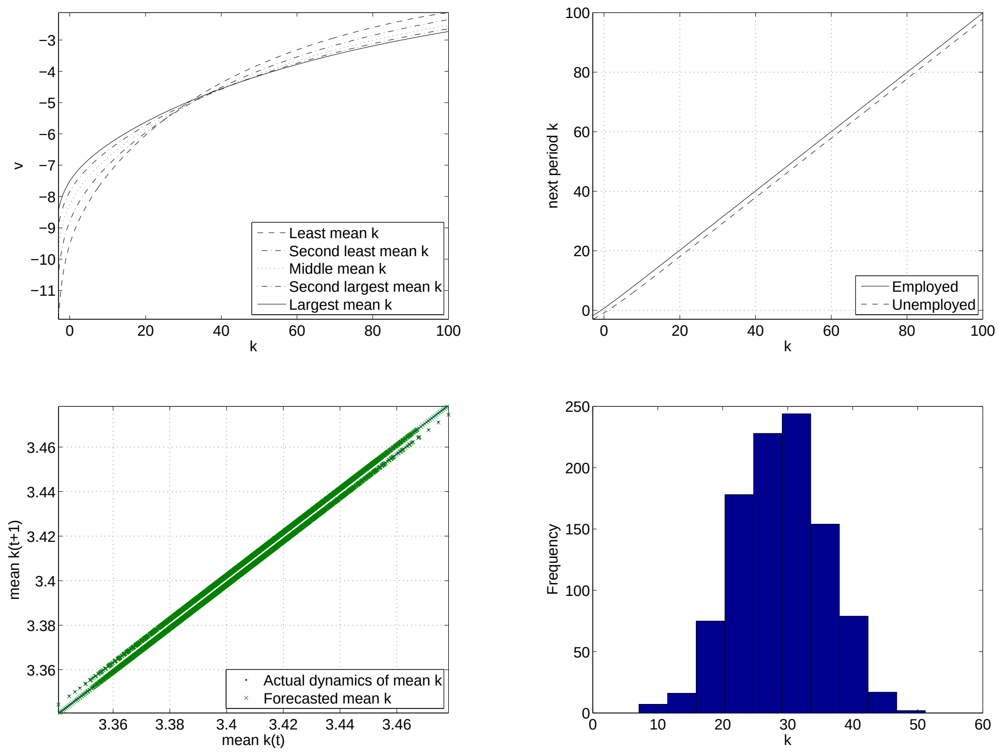

Figure 11: Same plot as Figure 2 for Tax I and $\sigma = 3$.

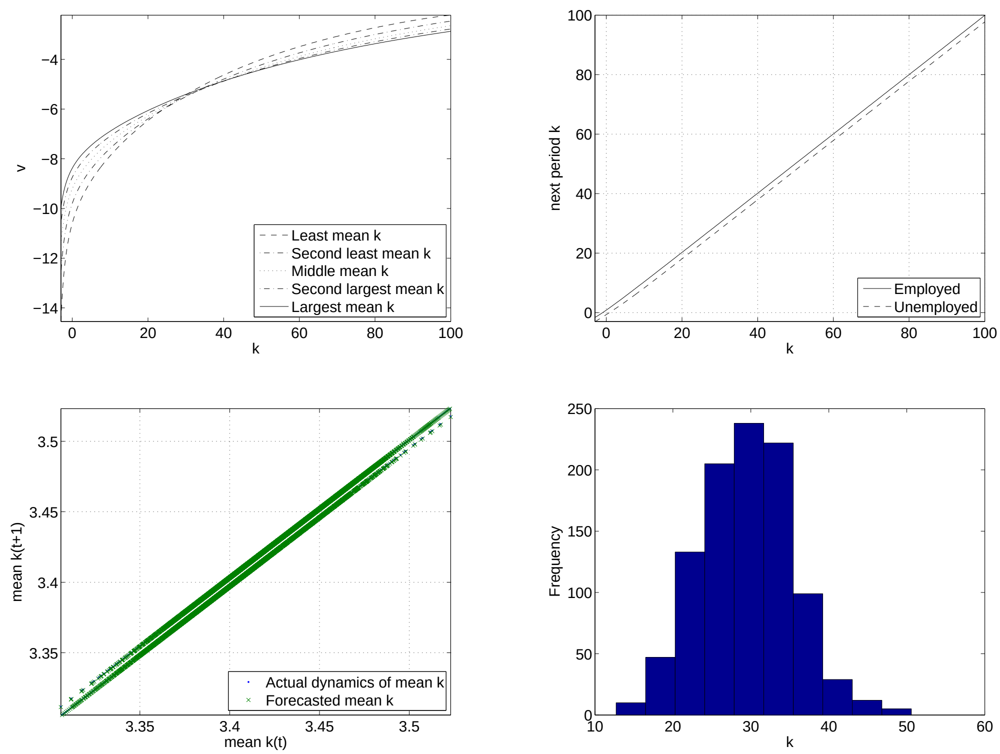

Figure 12: Same plot as Figure 2 for Tax II and $\sigma = 3$.

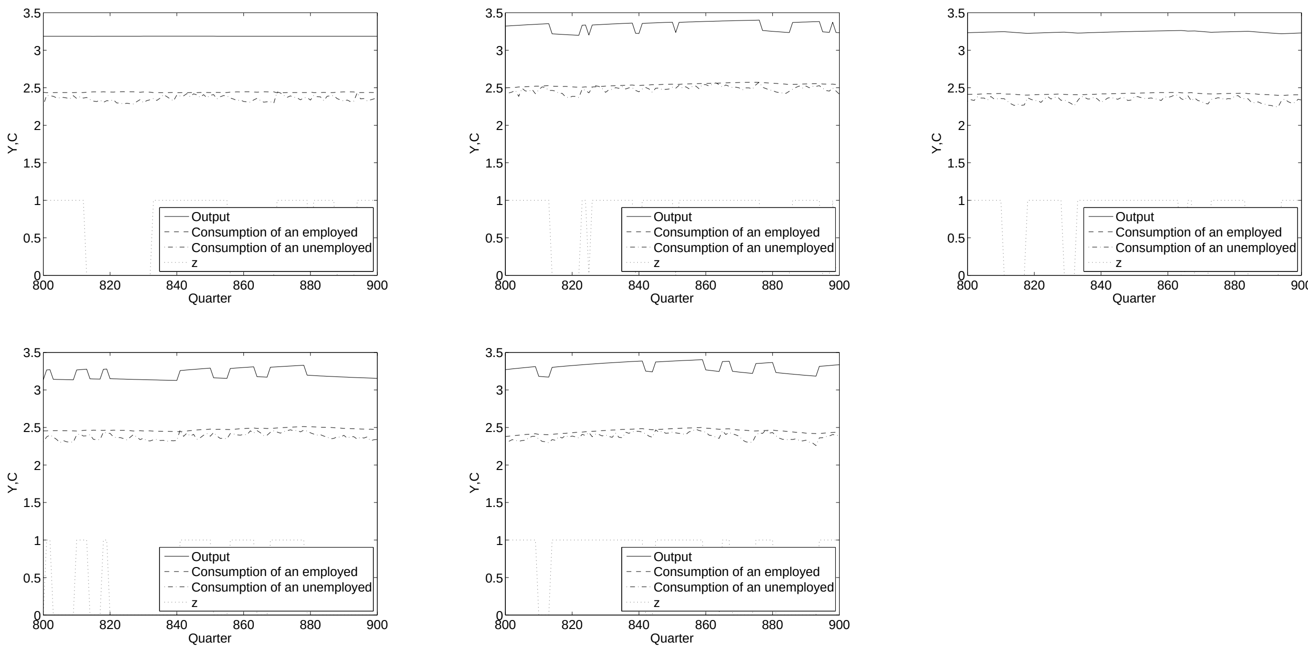

Figure 13: Sample time series of Y and C for the case $\sigma = 3$. Top: UI I, II, and III. Bottom: Tax I and II.

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