Uncertain Taxation, Government Transfer, and Household Inequality

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Abstract

I study the effects of labor tax, tax policy uncertainty and lump-sum transfer on wealth distribution in a modified Krusell-Smith model. Households face uninsurable idiosyncratic unemployment shocks as well as aggregate taxation shocks. Through this setup, I find that labor tax and lump-sum transfer increases the wealth inequality, while the tax policy uncertainty decreases it. Labor tax suppresses the major income sources of the poor: labor wage. The effect of tax policy uncertainty on the wealth distribution and inequality depends on households' degree of risk aversion. When risk aversion is higher, the rich maintain similar levels of consumption by slowing down their capital accumulation process, while this relationship is reversed for the poor, resulting in decreasing wealth inequality. Lump-sum transfer serves as a insurance for idiosyncratic and aggregate shocks. Therefore, lump-sum transfer replaces part of the role of capital and reduces the incentive for the poor to accumulate capital. As a result, lump-sum transfer mitigates some effects of the uncertainty but worsens wealth inequality.

Keywords: Uncertain taxation, Government transfer, Wealth inequality

JEL Codes: E21, E22, E23, E27, E62

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1 Introduction

Policy uncertainty is a critical issue that can impact many important outcomes, such as economic growth. While there is abundant research on this relationship[1], there is a distinct lack of general equilibrium models that study the theoretical effects of policy uncertainty on wealth inequality. However, there is abundant empirical evidence on this effect. Both IMF (2014) and Ravallion (2014) conclude that income and wealth inequality have increased in recent years, especially in emerging countries. Furthermore, the stylized facts in Azzimonti and Talbert (2014) show that emerging countries suffer from higher policy uncertainty, which may be generated by political instability. Therefore, I propose a general equilibrium model to study the impact of uncertain labor taxation and lump-sum government transfer in a modified Krusell-Smith model.

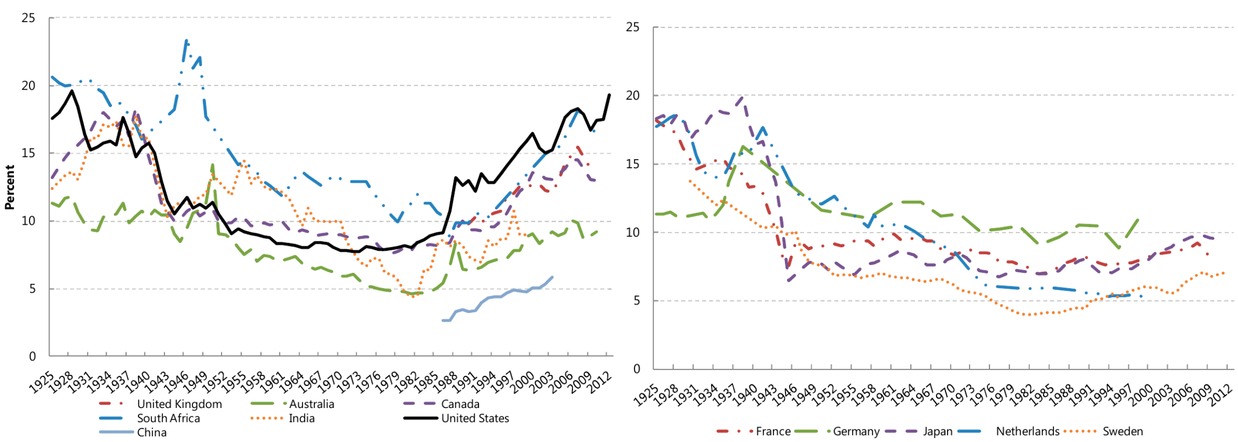
My main focus is to identify and quantify three components of an uncertain tax policy that affect the wealth distribution measured by the Gini coefficient on capital: (a) labor tax, (b) tax policy uncertainty, and (c) lump-sum transfer. First, I find that labor tax plays a major role in generating wealth inequality. Over 90% of the total increase in the Gini coefficient is seen in the model that only introduces a labor tax when compared to the baseline in Krusell and Smith (1998) model. In addition, labor tax impacts the concentration of wealth in every selected quantile. Second, contrary to my hypothesis, tax policy uncertainty decreases the Gini coefficient. The effect of tax policy uncertainty is robust to different degrees of risk aversion. The marginal propensity to consume for the rich is relatively lower, which allows them to slow down the wealth accumulation in exchange for current consumption. On the other hand, the consumption smoothing motive for the poor is simulated by tax policy uncertainty, causing the poor to accumulate more capital. Notice that the decrease of wealth inequality does not represent that households are better off; instead, they are worse off. Finally, the lump-sum transfer surprisingly facilitates wealth inequality by replacing the function of capital as insurance against idiosyncratic and aggregate shocks. Being an imperfect substitute for the only intertemporal asset, lump-sum transfer satisfies the consumption smoothing motive and dampens the wealth accumulation process. As wealth accumulation slows, its impact weighs more on the poor than the rich, and thus the poor remain poor, and the wealth inequality increases.

Two empirical papers, IMF (2014) and Ravallion (2014), shed light on important details needed to understand international inequality. For income inequality, despite the poverty rates are decreasing in most countries, IMF (2014) suggests that the top 1 percent's share

[1] Such as Azzimonti and Talbert (2014), Frankel and Rose (1998), Clark and Wincoop (2001), Baxter and Kouparitsas (2005)

of total income has increased substantially in most English-speaking countries as well as China and India. Figure 1 shows that this phenomenon appears in both advanced and emerging countries. Meanwhile, there is more public support for redistribution in countries with rising inequality (see figure 2). Stiglitz (2012) and Alvaredo et al. (2013) attribute this phenomenon to rent-seeking behavior and wealth accumulation that can arise from an uneven income distribution. Their argument is shown in panel (b) in figure 3. This panel shows that wealth inequality is larger than income inequality. The average Gini coefficient for wealth in a sample of 26 countries is 0.68, while for disposable income, it is only 0.36. The higher the income inequality in figure 1, the higher the wealth inequality in figure 3.

Figure 1: Gross Income Share of Top One-Percent in Selected Advanced and Developing Economies, 1925–2012

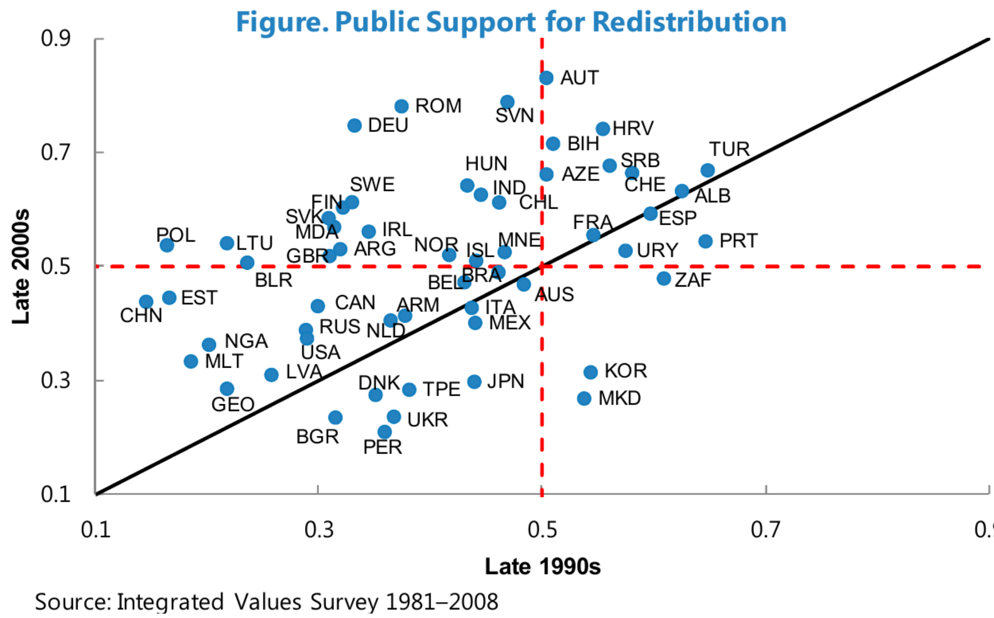


Source: IMF (2014)

Another piece of the empirical evidence lies in four stylized facts documented in Azzimonti and Talbert (2014) for emerging countries: (i) wider business cycles; (ii) higher policy uncertainty; (iii) less political stability; and (iv) policy uncertainty grows with political instability. In figure 4, Azzimonti and Talbert (2014) show a clear positive correlation between economic policy uncertainty and political polarization. The left panel and the middle panel show such a relationship between volatility of government revenue proportional to GDP and volatility of government spending proportional to GDP, respectively. For the right panel, since the political risk index represents an inverse relationship with the political risk, this positive relationship is downward sloping. While Azzimonti and Talbert (2014) proposed a "polarized business cycle" model to match the above stylized facts analytically, they cannot quantitatively measure both the welfare loss and the distortion in households' wealth distribution.

Besides the empirical findings, literature on the impact of fiscal policies has also emerged in recent years. Frenkel and Razin (1986) study the behavior of two large economies in general

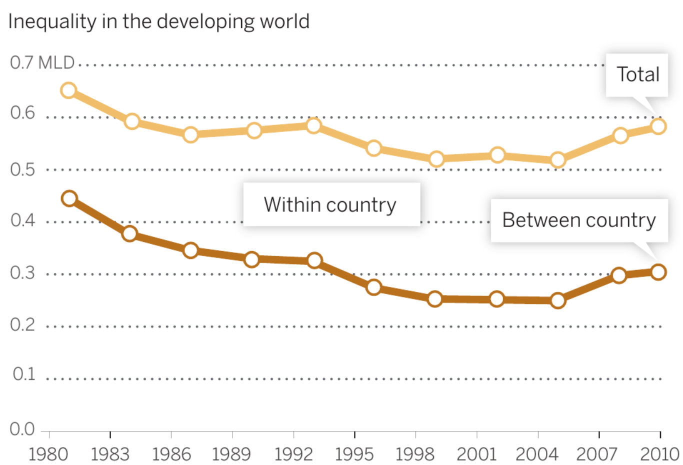
Figure 2: Public supports for redistribution



Source: IMF (2014)

Figure 3: Worldwide Income and Wealth Inequality

(a) Within country income inequality ↑



(b) Wealth Inequality > Income Inequality

Source: Panel (a) - Ravallion (2014); Panel (b) - IMF (2014)

equilibrium They analyze how fiscal policies affect the world interest rate, consumption, and other important aggregates. They find that the impact of fiscal policy depends on whether the country runs surplus or deficit in its national account. On the other hand, Aguiar and Amador (2016) investigate the optimal fiscal policy for a small open economy in a limited commitment environment. Under the standard Ramsey problem structure, they create an environment where zero labor tax and non-zero capital tax are optimal in the long run, a

Figure 4: Economics policy uncertainty and polarization

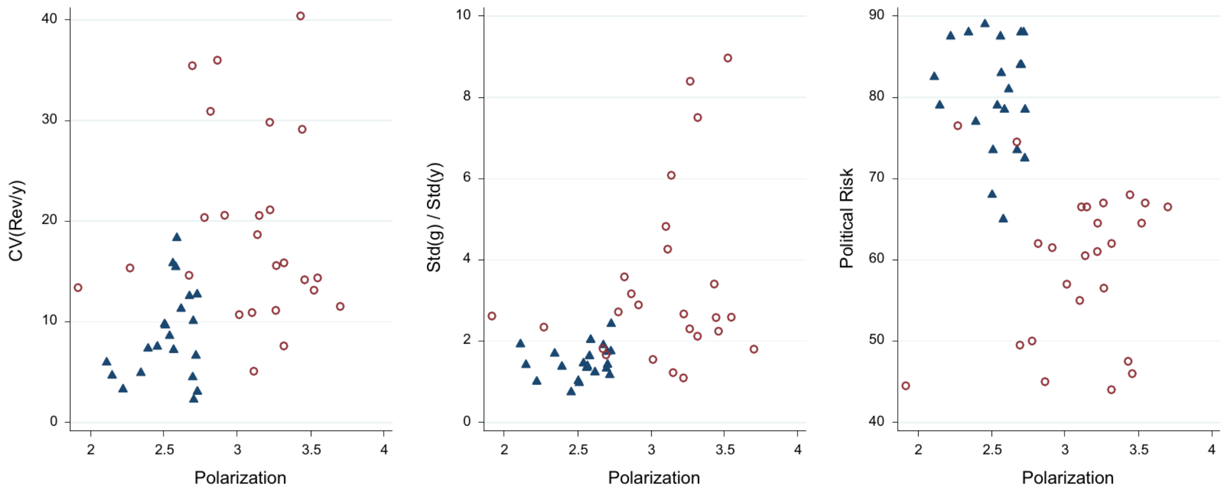


Fig. 1. Economic policy uncertainty and polarization. Notes: Economic policy uncertainty is proxied by two policy-based indices. Left panel: coefficient of variation of revenues as a percentage of output from 1960 to 2003. Central panel: relative standard deviation of government consumption to output, series detrended using a band-pass filter (2-20). Right panel: political risk index (from ICRG). Political polarization is obtained from Lindqvist and Ostling (2010). ▲ Developed and ○ Emerging.

Source: Azzimonti and Talbert (2014)

direct contradiction to the standard literature. The sovereign constraints they introduced can accommodate both the quasi-hyperbolic preference in the participation constraint introduced in Aguiar and Amador (2011), as well as the participation constraint that the government is more impatient than the household in Aguiar et al. (2009). All the above papers are representative agent models, and thus they are unable to analyze the distributional impact from fiscal policies.

The organization of this paper is listed as follows. Section 2 describes the model environment for uncertain labor taxation and other alternations for comparison. Section 3 shows the results of calibration, including parameter choices, the result for the uncertain labor taxation model (called main model afterward). Section 4 discusses the drawbacks of the main model, and possible extensions to resolve its weaknesses. Section 5 concludes.

2 Environment and Model Arrangement

I describe the model environment in this section. Following Krusell and Smith (1998), I propose a heterogeneous agent model with uncertain tax policy shocks and lump-sum government transfer. This model is a production economy with a continuum of agents, and the total mass of agents is 1. Each period, agents are hit with two exogenous shocks: (a) an aggregate tax shock $\tau \in \{\tau_h, \tau_l\} \equiv \mathbb{T}$, where τ_h represents the high labor tax rate, and τ_l is the low labor tax rate, and (b) an idiosyncratic unemployment shocks $\epsilon_i \in \{0,1\} \equiv \mathbb{E}$, where $\epsilon_i = 0$ represents agent i is unemployed, and $\epsilon_i = 1$ represents agent i is employed. The tax shock follows a stationary Markov process with transition probability $\pi^{\tau}_{pq} = \Pr\{\tau_q = \tau' \mid \tau_p = \tau\}$. The unemployment shock is affected by the aggregate shocks, and thus the joint transition probability is $\pi^{\epsilon}_{no}(p,q) = \Pr\{\epsilon_o = \epsilon' \mid \epsilon_n = \epsilon\}$, given today's tax rate is τ_p and tomorrow's tax rate is τ_q. The aggregate employment is purely a function of the exogenous aggregate state, i.e., $L = l(\tau)$. Agent's utility function $u(c)$ is CRRA utility function. Production requires two inputs from household: capital and labor. The wage, capital rent, and government lump-sum transfer are pre-determined by the realization of aggregate states, given as follows:

$$\begin{aligned} r\left(\overline{k},\tau\right) &= \alpha \overline{k}^{\alpha-1} l(\tau)^{1-\alpha} + 1 - \delta \\ w\left(\overline{k},\tau\right) &= (1-\tau)(1-\alpha)\overline{k}^{\alpha} l(\tau)^{-\alpha}, \\ T &= \tau(1-\alpha)\overline{k}^{\alpha} l(\tau)^{-\alpha} \end{aligned} \tag{1}$$

where $\overline{k}$ is the aggregate capital, defined by

$$\overline{k} = \int_{\mathbb{K}\times\mathbb{E}} k\mu\left(d\left[k\times\epsilon\right]\right). \tag{2}$$

Integrating the price functions, the household's maximization problem is given by

$$\begin{aligned} v(k,\epsilon_n;\mu,\tau_p) &= \max_{c,k'} \left(u(c) + \beta \sum_{p=1}^{2} \pi^{\tau}_{pq} \sum_{o=0}^{1} \pi^{\epsilon}_{no}(p,q)\, v\left(k',\epsilon_o;\mu'_q,\tau_q\right) \right) \\ c + k' &\leq r\left(\overline{k},\tau\right) k + w\left(\overline{k},\tau\right) \tilde{l}\epsilon_n + T \\ c &\geq 0; \quad k' \geq 0; \quad \mu'_q = \Gamma(\mu,\tau_p,\tau_q) \end{aligned}. \tag{3}$$

Capital is the only non-contingent asset. Borrowing capital is not allowed in this economy, i.e., the borrowing limit $k' \geq 0$. Since there are 4 independent states at each $(\tau';\epsilon')$, and capital is not state-contingent, the market is incomplete.

The recursive equilibrium is a set of value functions $v(k,\epsilon;\mu,\tau)$, capital decision rules $g(k,\epsilon;\mu,\tau)$, a law of motion $\Gamma(\mu,\tau_p,\tau_q)$, prices r, w, and T such that v solves (3); r, w, and T are given by (1), $\overline{k}$ is determined by (2), and $\Gamma(\mu,\tau_p,\tau_q)$ is determined by

$$\mu'(B) = \int_{\{(k,\epsilon)|(g(k,\epsilon;\mu,\tau),\epsilon')\in B\}} \mu\left(d\left[k\times\epsilon\right]\right), \tag{4}$$

given τ_p and τ_q.

I follow Krusell and Smith (1998) and utilize state space approximation to reduce the dimensionality problem. I replace the distribution μ, a high-dimension object, with a small set of moments of aggregate state m. Thus, I can simplify the original household problem into the following form:

$$\begin{aligned} v\left(k, \epsilon_n; m, \tau_p\right) = \max_{c,k'} & \left(u\left(c\right) + \beta \sum_{p=1}^{2} \pi_{pq}^{\tau} \sum_{o=0}^{1} \pi_{no}^{\epsilon}\left(p,q\right) v\left(k', \epsilon_o; m_q', \tau_q\right) \right), \\ c + k' \leq r\left(\overline{k}, \tau\right) k + w\left(\overline{k}, \tau\right) \tilde{l}\epsilon_n + T & \\ c \geq 0; \quad k' \geq 0; \quad m' = \Gamma_m\left(m, \tau_p\right) & \end{aligned} \tag{5}$$

where Γ_m is the log-linear function that replaces the unknown Γ function:

$$m' = \exp\left(\beta_0\left(\tau_p\right) + \beta_1\left(\tau_p\right)\log m\right). \tag{6}$$

I compare the main model with six different alternatives to know the effect of lump-sum transfer and tax policy uncertainty:

(A) baseline model in Krusell and Smith (1998) (called baseline afterward),

(B) baseline with certain taxation but without transfer,

(C) baseline with certain taxation and transfer,

(D) uncertain taxation model without transfer,

(E) stationary equilibrium with certain taxation but without transfer, and

(F) stationary equilibrium with certain taxation and transfer (called stationary afterward).

The certain taxation in model (B), (C), (E), and stationary treat the labor tax rate as a parameter. The value for labor tax rate is determined by the certainty equivalence of the exogenous uncertain tax policy, i.e., $\tau_c = \tau_{pq}^{\tau}\tau_h + \left(1 - \tau_{pq}^{\tau}\right)\tau_l$.

3 Results

I separate this section into five subsections: Section 3.1 highlights parameters that different from baseline model. Section 3.2 introduces the calibration results of uncertain taxation model. Section 3.3, 3.4 and 3.5 compare different models to identify the effect of labor tax, lump-sum transfer and tax policy uncertainty, respectively.

3.1 Parameters choice

Most of the parameters are the same as Krusell and Smith (1998). They are listed in table 1. What's different from the original paper is that unemployment rate under different tax shock values as well as the transition matrix. Instead of unemployment in good time is $u_g = 0.04$ and in bad time, it is $u_b = 0.10$, I assume that unemployment in high tax rate is $u_h = 0.10$, and in low tax rate it is $u_l = 0.04$, implying that higher tax rate results in higher unemployment. The duration of unemployment is 2.5 quarters in high tax rates and 1.5 quarters in low tax rates. Also, I impose $\pi_{hl00}\pi_{hl}^{-1} = 0.75\pi_{bb00}\pi_{bb}^{-1}$ and $\pi_{lh00}\pi_{lh}^{-1} = 1.25\pi_{hh00}\pi_{hh}^{-1}$, i.e., the probability of remaining unemployed is higher at the start of periods in high tax rate and lower in low tax rate.

Table 1: Parameters

	Description	Value		
α	Capital share of production	0.36		
β	Discount factor	0.99		
σ	CRRA coefficient	1.0		
δ	Depreciation rate	0.025		
$\tilde{l}$	Agg. hours of worked	0.3271		
$\underline{k}$	Borrowing constraint	0		
τ	Labor tax rate	Uncertain tax	0.40	0.20
		Certain tax	0.3	0.3
π^τ	Tax transitional matrix	$\begin{bmatrix} 0.8750 & 0.1250 \\ 0.1250 & 0.8750 \end{bmatrix}$		

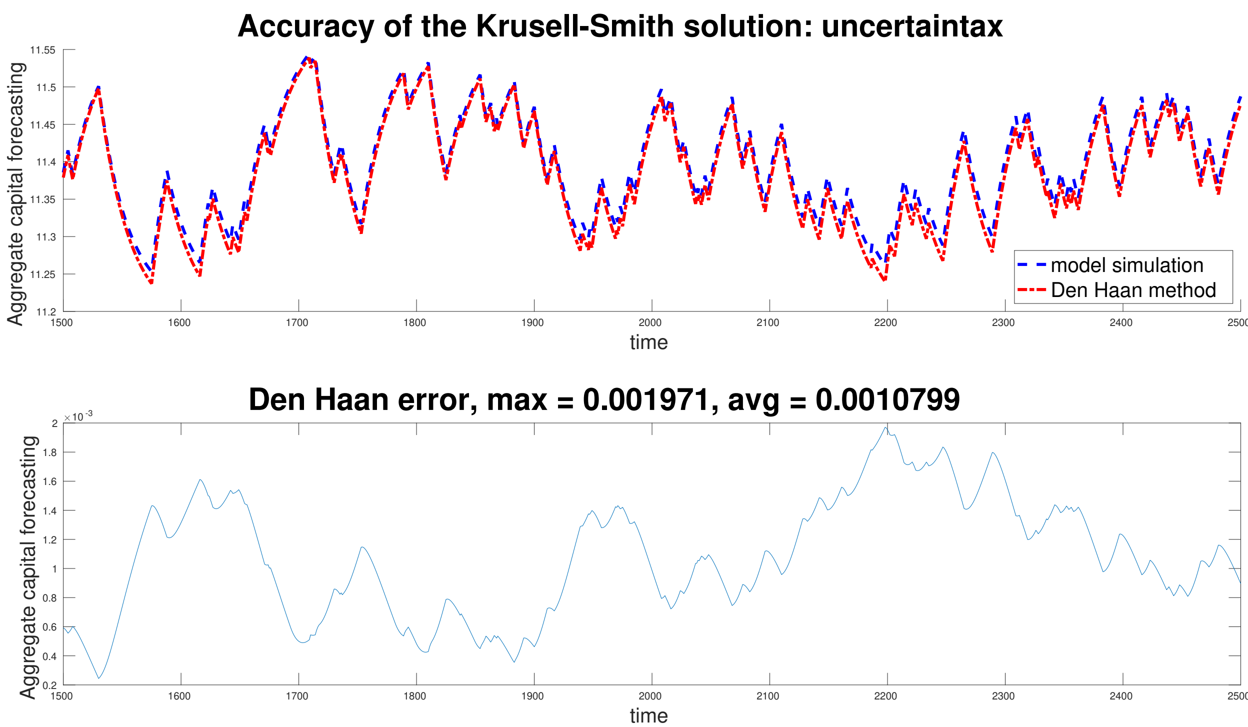
3.2 Calibration on uncertain taxation

With log-linear forecasting rules and approximation for the distribution using the aggregate capital, the corresponding approximate equilibrium is

$$\begin{array}{llll} \log m' = 0.077066 + 0.967854 \log m; & R^2 = 0.999748; & \hat{\sigma} = 3.6 \times 10^{-7}, & \tau = \tau_h \\ \log m' = 0.084620 + 0.965283 \log m; & R^2 = 0.999811; & \hat{\sigma} = 3.7 \times 10^{-7}, & \tau = \tau_l \end{array}. \quad (7)$$

The high R^2 and low standard deviation of regression error $\hat{\sigma}$ shows, in my opinion, a good fit from today's capital to tomorrow's capital. Haan (2010) points out that there is no consensus on how high the R^2 is good enough. Gomes and Michaelides (2007) is happy with the R^2 value larger than 0.99, while the R^2 in baseline Krusell and Smith (1998) model is 0.999998 in both good time and bad time. In my replication, I found R^2 in the baseline model is 0.999979 in good time and 0.999983 in bad time. This difference in R^2 value between Krusell and Smith (1998) and my replication on the same baseline model may due to different solution method in value function iteration. Krusell and Smith (1998) use cubic spline when interpolating individual capital, while I am using linear interpolation with a log-spaced grid on individual capital. Using a log-spaced grid allows me to mitigate the drawbacks of linear interpolation, i.e., the inability to capture nonlinearity when capital level is close to the borrowing limit. Therefore, I accept both R^2 to be a good enough fit as a forecasting rule. Another measure of goodness of fit is Den Haan error in Haan (2010). Figure 5 shows the difference between model simulation and the true value obtained from Den Haan's algorithm. The maximum of Den Haan error is 0.19%, and the average is 0.10%. I believe the forecasting rule is precise enough for the state space approximation to be successful.

Figure 5: Den Haan Error: the main model



In figure 6, the decision rules are linear for those employed and unemployed, and are consistent in four different settings of tax rate τ and aggregate capital m. After closely scrutinizing all four diagrams, I found that there are two tiny nonlinearities in each figure: one for the poorest household, and the other for the richest household. For the poorest, getting employed or not affects their capital decisions. Therefore, the capital decision for those who are unemployed is slightly smaller than those employed. The above observation is in line with the findings in Krusell and Smith (1998), while the other finding on the richest is missing. The decision rules of the employed richest are tilted downward and move toward the decision rules of the unemployed richest. This represents the effect of labor tax on capital accumulation. For the richest, labor earning is only a small share of total income. Thus, employment states have little impact on them. Another finding on decision rules is that the labor tax blurs two employment states. Notice that from figure 8, the difference between the decision rules of the employed and the unemployed in the uncertain taxation model is smaller than the baseline model. The employed earn less and the unemployed earn more. Uncertain labor tax with lump-sum transfer blurs the difference between two idiosyncratic states. The insignificance of employment states continues in value function. As in figure 7, the employment states only matter for those the very poorest.

Figure 6: Decision rules: the main model

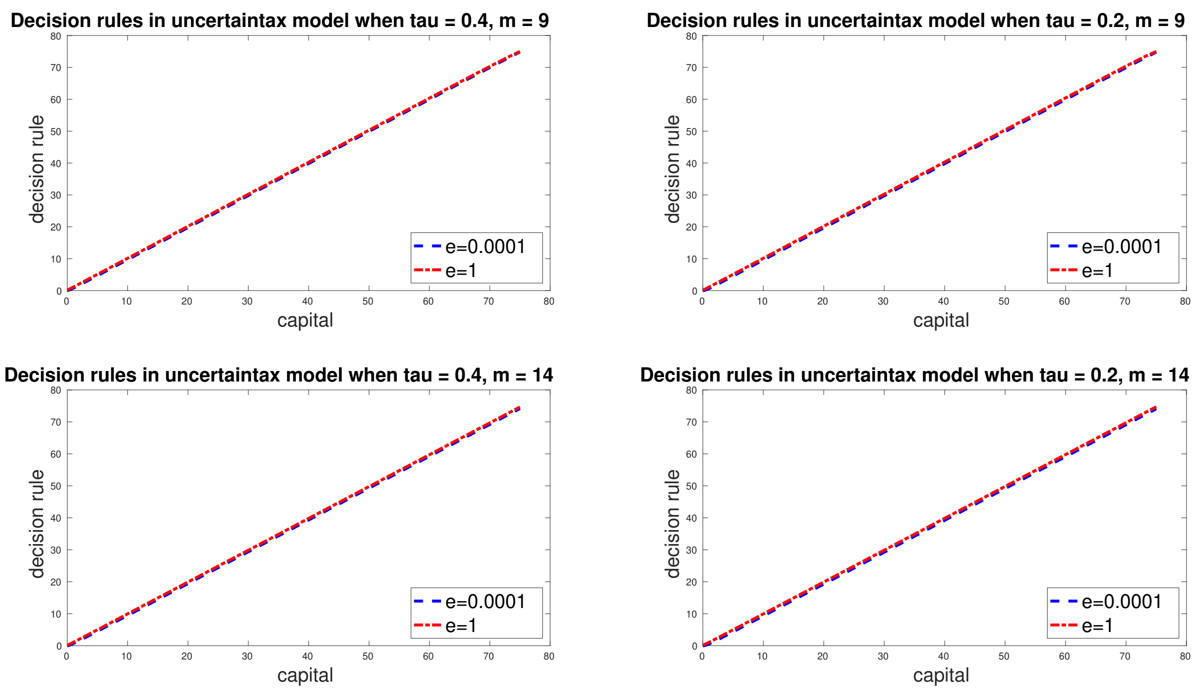


Figure 9 shows the distribution of the household's capital holding in terms of aggregate state variable τ and idiosyncratic state variable ϵ in both the main model and the baseline model. The distribution is positively skewed, with a long right tail. The highest density of all four distributions are lower than 10 units of capital, which is the highest density in distributions for baseline model. This shows that a household's ability in intertemporal substitution is dampened by the labor tax. Since the households do not value leisure, they devote all their labor productivity to work and earn the labor wage. The labor tax is a direct depression on a households' income, and further decreases their ability to

Figure 7: Value functions: the main model

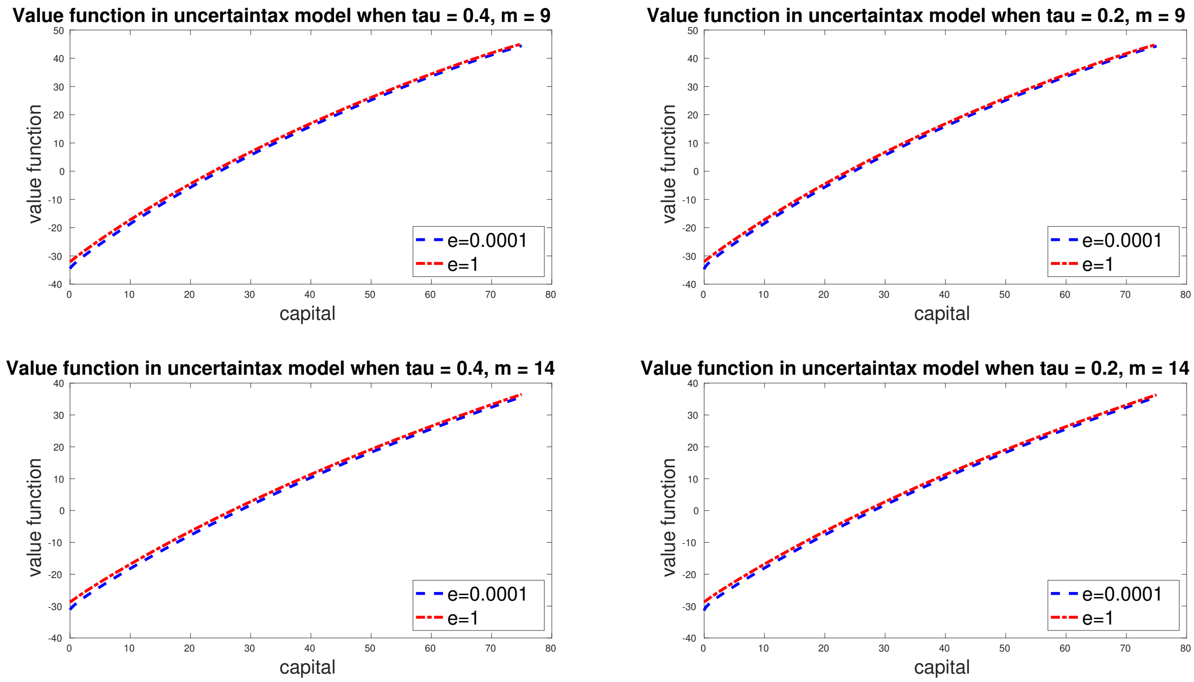
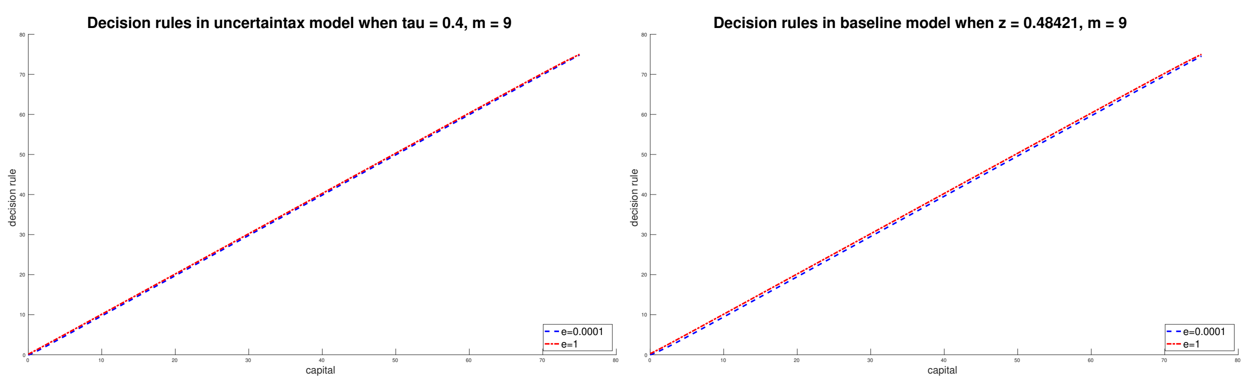


Figure 8: Comparison in decision rules: the baseline model and the main model



buy capital. As households' ability against idiosyncratic shocks is impeded, their wealth accumulation process is hindered, creating higher wealth inequality. As shown in figure 10, the Gini coefficient in baseline model is 0.22686, and in main model, it is 0.30583. Also, the insignificance of employment states revisits in this figure. The difference between $\epsilon = 0.0001$ and $\epsilon = 1$, unemployed and employed, is smaller in the distribution of the main model than that of the baseline model.

Figure 9: Distribution on capital: main model

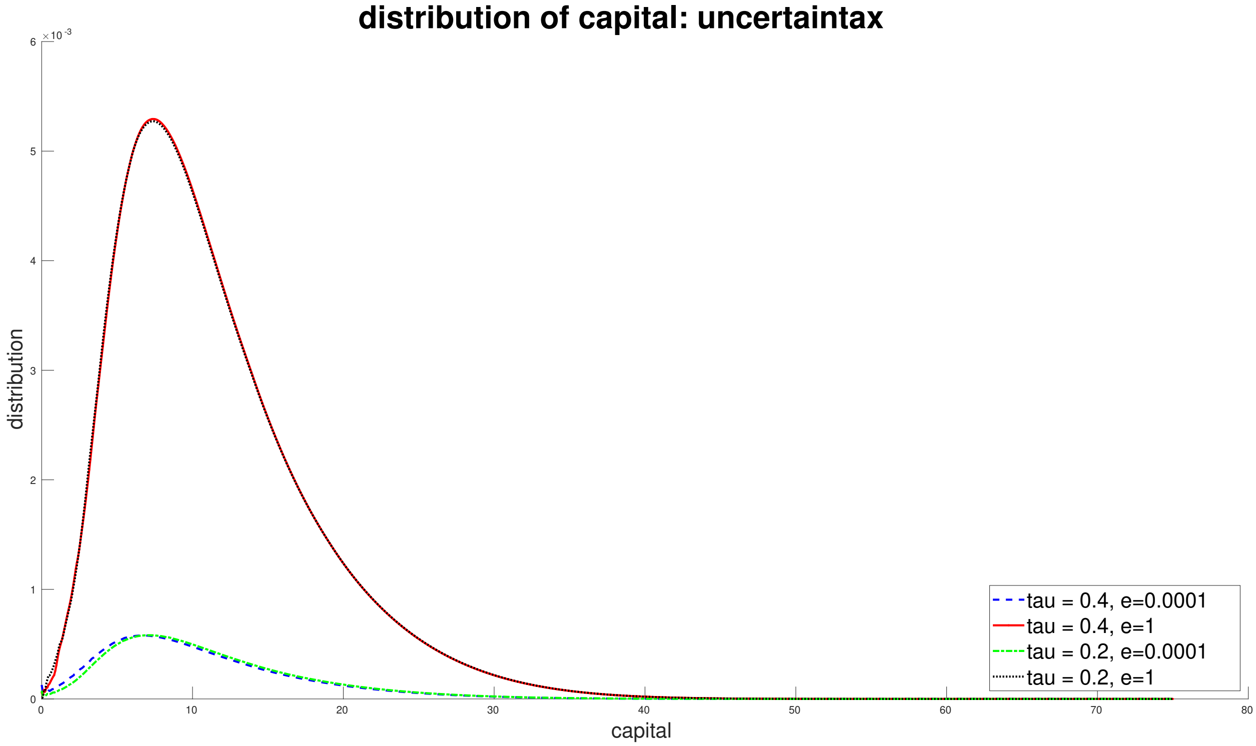
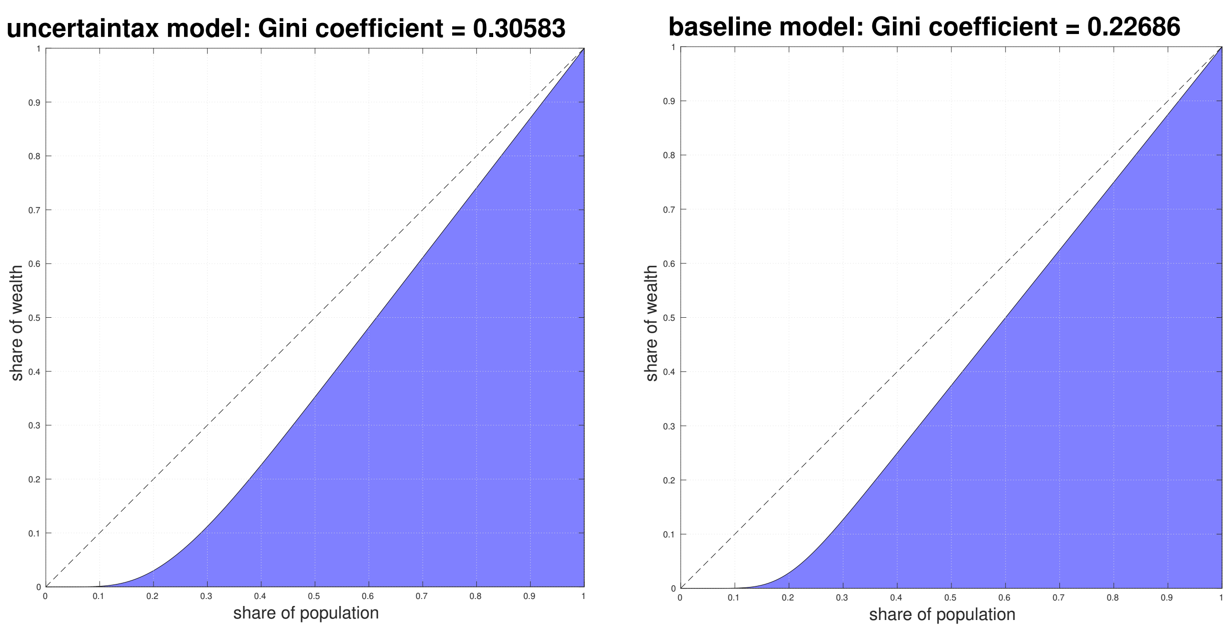


Figure 10: Lorenz curve: main model and baseline model



3.3 Comparison: effect of taxation

The taxation effect plays quantitatively an important role in generating wealth inequality. It is obtained by comparing baseline model with model (C), i.e., baseline with certain taxation and transfer. Switching from baseline model to model (C) contributes 90% of the total increase in Gini coefficient, from 0.2269 to 0.2962. Furthermore, as shown in table 2, all the accumulated wealth held by households at top quantiles increases. The percentage of total wealth held by the top 1% of households increases from 2.2% to 3.1%, and the gap between baseline and model (C) increases as more top households are involved. For the top 30% of households, they own 44% of total wealth under baseline model, but under model (C), they own over 50% of the total wealth.

Table 2: Distribution of top percentile wealth holding and Gini coefficient

	1%	5%	10%	20%	30%	Gini
baseline	2.2978	9.7934	17.9277	32.1756	44.6782	0.2269
model (C)	3.1009	12.2765	21.6553	37.1897	50.1030	0.2962
main model	3.1037	12.5604	22.1893	37.9762	50.9399	0.3058

Note: baseline is the baseline model in Krusell and Smith (1998); model (C) is baseline model with certain taxation and transfer; main model is the uncertain taxation model.

3.4 Comparison: effect of tax policy uncertainty

The magnitude of the effect of tax policy uncertainty is tiny, roughly 1% of contribution in terms of increase in Gini coefficient. In table 3, Gini coefficients increase from 0.3057 of stationary model to 0.3058 of main model. The reason why the difference in the Gini coefficient is so small is that the effect of tax policy uncertainty is driven by households' consumption smoothing motives. For the top 1%, 5%, and 10%, households in the stationary model hold more wealth than those in the main model, but reversed for the top 20% and 30%, Recall that the utility function is slightly concave ($\sigma = 1$). When the labor taxation is uncertain, the rich have a lower marginal propensity to consume, and their disposable income is high enough so that they are affected less by the uncertainty, causing less motivation to purchase the capital. On the other hand, the poor have a higher marginal propensity to consume, and thus their consumption is affected by the tax policy uncertainty more, which stimulates their consumption smoothing motive and forces them to buy more capital. Furthermore, such an effect is also observed in TFP shocks. Comparing the model (C) and stationary model in table 3, the wealth inequality also shrinks when adding TFP shocks. The Gini coefficient of the stationary model is 0.3057, while of model (C) it is 0.2962. Moreover, the rich hold more wealth in the stationary model than the model (C), as 1% households hold 3.1009% of total wealth in the model (C), while in the stationary model, it is 3.1539. In conclusion, the rich save less, the poor save more, and the wealth inequality decreases.

Furthermore, as the degree of risk aversion increases, the rich hold comparatively less wealth in the main model, while the poor hold more wealth, and thus eventually the Gini coefficient in the main model will be lower than it is in the stationary model. In table 4, I present the change for each quantile of the wealth distribution as well as the Gini coefficient at each level of risk aversion. When $\sigma = 2$, the top 1% of households hold 3.09% of the total wealth in the stationary model, while in the main model they only hold 2.93% of the total wealth, and this difference continues in other percentiles. As σ increases to 3, 5, and 10, the difference between the stationary model and the main model enlarges. The Gini coefficient for stationary model (0.2957) is larger than that for main model (0.2926) at $\sigma = 2$. The disparity betweens Gini coefficients is monotonically increasing with a higher degree of risk aversion. When $\sigma = 10$, the Gini coefficient is significantly different between the stationary model and the main model, i.e., the former is 0.237, while the latter is only 0.136. All the above observation shows the heterogeneous response to the uncertainty from the rich and the poor is a critical factor in determining the overall uncertainty effect. Notice that it does not mean that households enjoy tax policy uncertainty. Households still suffer from aggregate uncertainty. To see this, compare figure 7 and 11, the range of value function at each capital level is roughly $[-30, 30]$ for the main model, while it is $[15, 65]$ for the stationary model. The aggregate labor tax shocks hit all households, and households at different wealth levels react to tax shocks differently, causing the wealth inequality to drop.

3.5 Comparison: effect of lump-sum transfer

Surprisingly, the lump-sum transfer generates higher wealth inequality. Table 5 shows that the Gini coefficients decrease without government transfer. Comparing the main model with the model (D), the main model without lump-sum transfer, the Gini coefficient decreases from 0.30 to 0.26. There are two channels for lump-sum transfer to increase wealth inequality. The first channel is that lump-sum transfer serves as an imperfect substitute to capital as insurance against idiosyncratic shocks. If households get lump-sum transfer disregarding

Table 3: Distribution of top percentile wealth holding and Gini coefficient: tax policy uncertainty

	1%	5%	10%	20%	30%	Gini
baseline	2.2978	9.7934	17.9277	32.1756	44.6782	0.2269
model (C)	3.1009	12.2765	21.6553	37.1897	50.1030	0.2962
stationary	3.1539	12.6515	22.2265	37.8793	50.7873	0.3057
main model	3.1037	12.5604	22.1893	37.9762	50.9399	0.3058

Note: baseline is the baseline model in Krusell and Smith (1998); model (C) is baseline model with certain taxation and transfer; stationary is the stationary equilibrium of Krusell and Smith (1998) model with certain taxation and transfer; main model is the uncertain taxation model.

Figure 11: Decision rules and value functions: stationary model

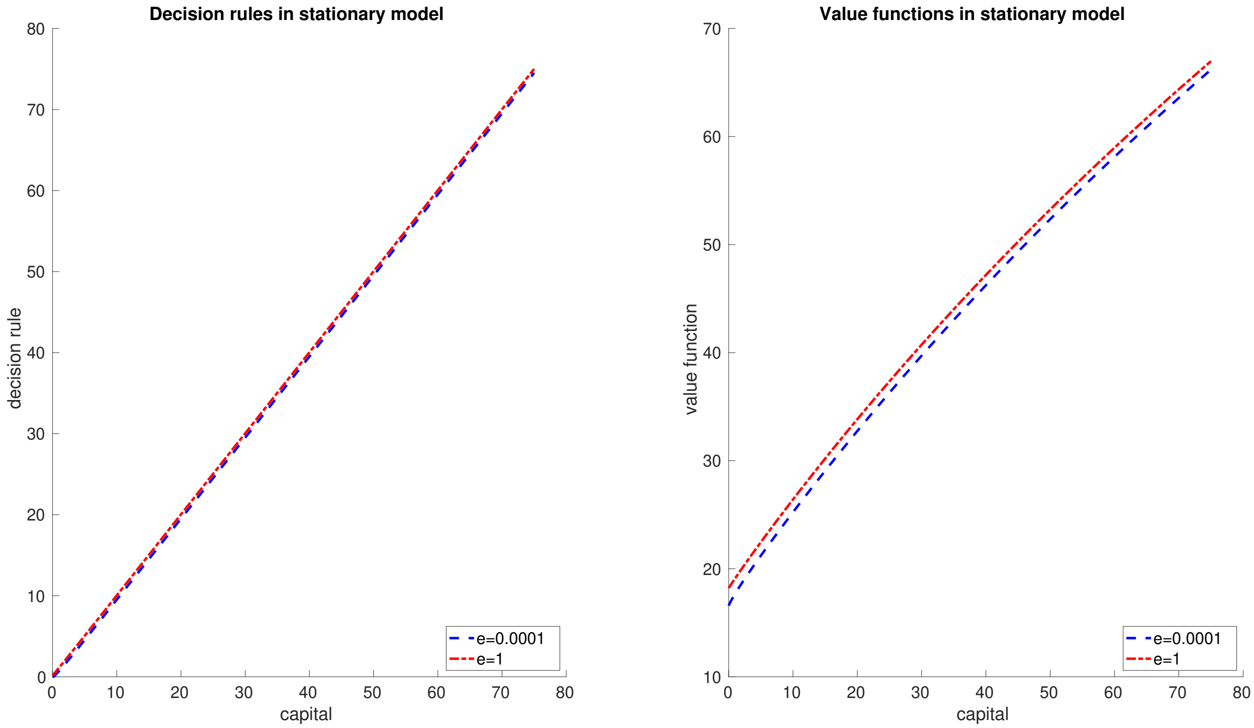


Figure 12: Stationary distribution: stationary model

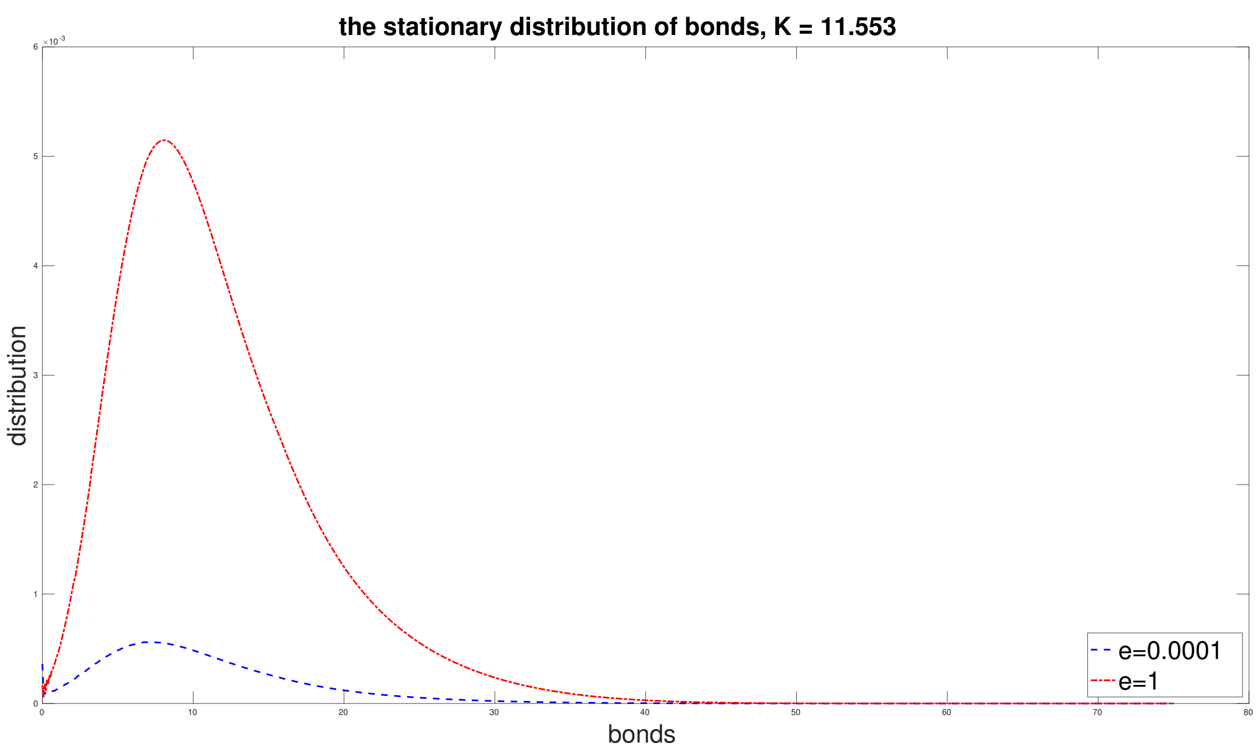


Table 4: Numerical analysis on uncertainty effect: Distribution of top percentile wealth holding and Gini coefficient

σ	Models	1%	5%	10%	20%	30%	Gini
1	stationary	3.1539	12.6515	22.2265	37.8793	50.7873	0.3057
	main model	3.1037	12.5604	22.1893	37.9762	50.9399	0.3058
2	stationary	3.0906	12.3861	21.7773	37.2120	50.0300	0.2957
	main model	2.9396	12.0199	21.3877	36.9571	49.9016	0.2926
3	stationary	3.0129	12.0778	21.2717	36.4859	49.2198	0.2850
	main model	2.6834	11.1276	20.0106	35.0907	47.9058	0.2674
5	stationary	2.8359	11.4026	20.1933	34.9728	47.5485	0.2629
	main model	2.1758	9.4135	17.3771	31.4756	43.9527	0.2158
10	stationary	2.4701	10.4101	18.8487	33.3073	45.7581	0.2370
	main model	1.5943	7.3780	14.1087	26.6578	38.3454	0.1361

Note: stationary is the stationary equilibrium of Krusell and Smith (1998) model with certain taxation and transfer; main model is the uncertain taxation model.

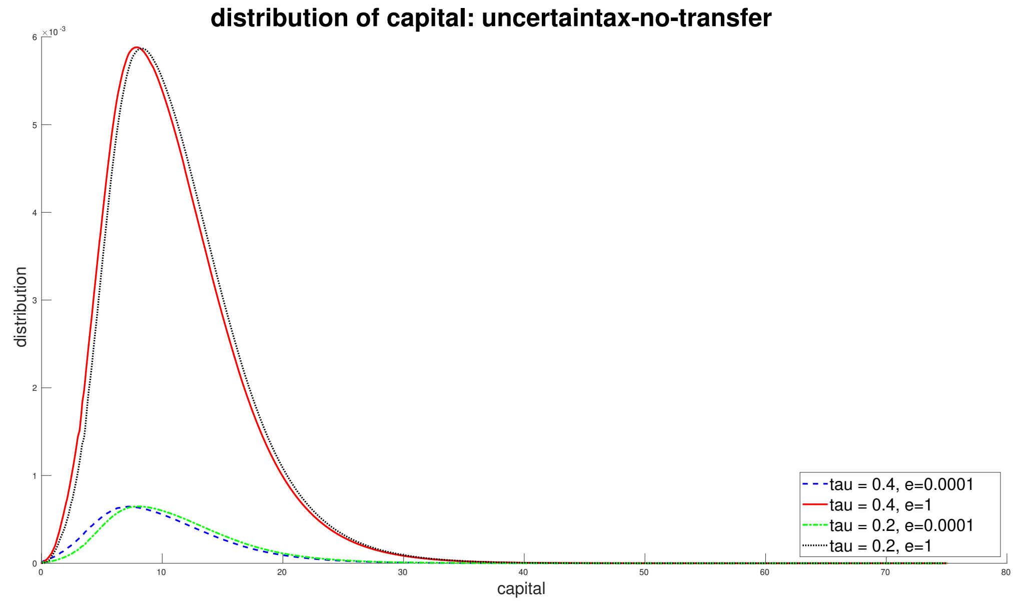
their capital choice, their consumption smoothing motive is already satisfied. Therefore, there is less motivation for the poor household to accumulate wealth, and thus the poor remains poor. The second channel is that lump-sum transfer blurs the difference between two aggregate taxation states. The distribution of capital for model (D) in figure 13 shows clear gap between $\tau_h = 0.4$ and $\tau_l = 0.2$, given $\epsilon = 1$, i.e., the distribution between high tax rate and low tax rate has distinct gap, given households are employed. In figure 9, the main models with lump-sum transfer have no such clear gap between two distributions conditional on employed. Since the lump-sum transfer is funded by the labor tax revenue, the higher the labor tax rate, the higher the lump-sum transfer. In other words, the lump-sum transfer also serves as insurance against aggregate shocks. As a consequence, the incentive for households to purchase capital decreases. In conclusion, the lump-sum transfer distorts the consumption smoothing motive by serving as insurance against both idiosyncratic and aggregate shocks and creates higher wealth inequality

Table 5: Distribution of top percentile wealth holding and Gini coefficient: lump-sum transfer

	1%	5%	10%	20%	30%	Gini
model (B)	2.7417	11.1725	19.9886	34.9379	47.6624	0.2640
model (D)	2.8387	11.3914	20.2364	35.1814	47.8912	0.2671
main model	3.1037	12.5604	22.1893	37.9762	50.9399	0.3058

Note: model (B) is baseline model with certain taxation but without transfer; model (D) is the uncertain taxation model without transfer; main model is the uncertain taxation model.

Figure 13: Distribution on capital: model (D)



4 Discussion and Extension

Table 6 shows the forecasting rules, maximum regression error, minimum regression error, the standard deviation of regression error, and R^2 for five models regarding aggregate uncertainty. Unsurprisingly, the forecasting rules in all models predict the future aggregate capital equally well. However, in terms of wealth inequality, the main model fails to (a) reproduce a realistic wealth distribution, and (b) generate large enough wealth inequality compared with the model (B), (C), (D), (E), and stationary model. Table 7 shows all the details of these two failures.

Compared with all other six models, the main model is slightly closer to the data. However, it still fails to match each important quantile. For example, the top 1% households should hold 30% of total wealth, but in the main model, they only hold 3.1%. Since each important quantile of the distribution is not reproducible by the uncertain taxation model, neither does the Gini coefficient. The Gini coefficient is 0.79 in data, but only 0.30 in uncertain taxation model. All the above comparisons show that my model requires adjustment to match the wealth distribution in the real world.

Compared with the stationary model, the main model also fails to create a difference from its certainty equivalence counterpart. From table 7, most of the important quantiles are the same as the unit digit. As discussed in section 3.4, the effect of tax policy uncertainty depends on the households' heterogeneous response based on their marginal propensity to consume. The rich can cut their capital accumulation to maintain consumption level during

Table 6: Forecasting rules

		1	$log(m)$	max.err	min.err	std.err	R^2
baseline	$z = z_b$	0.085058	0.964351	0.000020	0.000000	0.000004	0.999978
	$z = z_g$	0.095551	0.962234	0.000025	0.000000	0.000005	0.999984
model (B)	$z = z_b$	0.074098	0.968769	0.000013	0.000000	0.000003	0.999983
	$z = z_g$	0.083561	0.966710	0.000017	0.000000	0.000003	0.999986
model (C)	$z = z_b$	0.085598	0.964069	0.000011	0.000000	0.000002	0.999973
	$z = z_g$	0.091901	0.963090	0.000013	0.000000	0.000003	0.999977
model (D)	$\tau = \tau_h$	0.060426	0.972385	0.000128	0.000000	0.000029	0.999995
	$\tau = \tau_l$	0.096061	0.963789	0.000223	0.000000	0.000039	0.999995
main model	$\tau = \tau_h$	0.089817	0.962795	0.000004	0.000000	0.000000	0.999861
	$\tau = \tau_l$	0.092450	0.962268	0.000002	0.000000	0.000000	0.999899

Note: baseline is the baseline model in Krusell and Smith (1998); model (B) is baseline model with certain taxation but without transfer; model (C) is baseline model with certain taxation and transfer; model (D) is the uncertain taxation model without transfer; main model is the uncertain taxation model.

Table 7: Distribution of top percentile wealth holding and Gini coefficient: model and data

	1%	5%	10%	20%	30%	Gini
data	30.0000	51.0000	64.0000	79.0000	88.0000	0.7900
baseline	2.2978	9.7934	17.9277	32.1756	44.6782	0.2269
model (B)	2.7417	11.1725	19.9886	34.9379	47.6624	0.2640
model (C)	3.1009	12.2765	21.6553	37.1897	50.1030	0.2962
model (D)	2.8387	11.3914	20.2364	35.1814	47.8912	0.2671
model (E)	2.6384	10.8078	19.3581	33.9493	46.5008	0.2490
stationary	3.1539	12.6515	22.2265	37.8793	50.7873	0.3057
main model	3.1037	12.5604	22.1893	37.9762	50.9399	0.3058

Note: baseline is the baseline model in Krusell and Smith (1998); model (B) is the baseline model with certain taxation but without transfer; model (C) is the baseline model with certain taxation and transfer; model (D) is the uncertain taxation model without transfer; model (E) is the stationary equilibrium of the Krusell and Smith (1998) model with certain taxation but without transfer; stationary is the stationary equilibrium of the Krusell and Smith (1998) model with certain taxation and transfer; the main model is the uncertain taxation model with transfer.

high labor taxation, while the consumption smoothing motive for the poor is stimulated. Since all of the important quantiles are the same, the Gini coefficients are also similar, with 0.3057 for the stationary model and 0.3058 for the main model.

Others might suspect that uncertain taxation on capital [2] will create more distortion on wealth distribution, while I conjecture that uncertain taxation on capital will decrease rather than increase the wealth inequality. In this paragraph, I will discuss the possible outcome of two models: (a) uncertain capital taxation without lump-sum transfer and (b) uncertain capital taxation with the lump-sum transfer. The effect of capital tax on wealth

[2] The return on capital in equation 1 should be modified as $r\left(\overline{k},\tau\right) = (1-\tau)\,\alpha\overline{k}^{\alpha-1}l\left(\tau\right)^{1-\alpha} + 1 - \delta$, and the wage should be $w\left(\overline{k},\tau\right) = (1-\alpha)\,\overline{k}^{\alpha}l\left(\tau\right)^{-\alpha}$

distribution is twofold: (a) direct effect depressing the incentive to purchase capital for the rich, and (b) substitution effect for the poor to buy capital at relatively low prices. Both effects shrink the wealth inequality in terms of capital. Therefore, I suppose that the first model cannot generate high enough wealth inequality to reproduce the wealth distribution in the real world. Furthermore, in the model with uncertain capital taxation and lump-sum transfer, the source of the lump-sum transfer comes from capital taxation, and capital is the only asset that households can buy against the idiosyncratic unemployment shocks. Since the part of money households pay to buy capital is going to be other households' lump-sum transfer, both the incentive for the rich and the poor to purchase capital as insurance is going to be weakened by the lump-sum transfer. Therefore, I suspect that the lump-sum transfer in capital taxation will dampen rather than facilitate the capital accumulation for all households, and thus decrease the wealth inequality.

I conjecture that the ineffectiveness of labor tax uncertainty comes from the fact that households do not value leisure. In a model in which households value leisure, the aggregate labor supply is determined by the interaction between labor taxation and households' optimal labor decision. When the tax rate is high, the aggregate labor supply is depressed, and therefore the rent for capital and wage are both affected, leading to a lower level of total production. As production decreases, the rich can avoid the disutility of working by renting out capital, while the poor have no choice but to work. As a result, I suppose that wealth inequality will increase. In appendix B in Krusell and Smith (1998), they've introduced the model with valued leisure and TFP shocks. Based on their model, the modified household's problem with uncertain labor taxation as in equation 5 is

$$\begin{aligned} v\left(k,\epsilon_n;m,\tau_p\right) &= \max_{c,k'}\left(u\left(c,l\right)+\beta\sum_{p=1}^{2}\pi_{pq}^{\tau}\sum_{o=0}^{1}\pi_{no}^{\epsilon}\left(p,q\right)v\left(k',\epsilon_o;m_q',\tau_q\right)\right) \\ c+k' &\leq r\left(\overline{k},\tau\right)k+w\left(\overline{k},\tau\right)l\epsilon_n+T \\ c\geq 0;\quad k'&\geq 0;\quad m'=\Gamma_m\left(m,\tau_p\right);\quad \overline{l}=\Gamma_L\left(m,\tau_p\right) \end{aligned} \quad . \tag{8}$$

where $\overline{l}$ is the aggregate labor supply, and $\Gamma_L(\cdot)$ is the state space approximated law of motion for aggregate labor supply, which is assumed to be a log-linear function:

$$\log\overline{l}=\beta_0^L\left(\tau_p\right)+\beta_1^L\left(\tau_p\right)\log m. \tag{9}$$

In terms of utility function choice, there are two candidates in Krusell and Smith (1998):

$$\begin{aligned} u(c,l) &= \lim_{\nu \to \sigma} \frac{\left[c^{\theta}(1-l)^{1-\theta}\right]^{1-\nu} - 1}{1-\nu}. \\ u(c,l) &= c + (1-l)^{\gamma} \end{aligned} \tag{10}$$

The former choice allows the interaction between consumption and leisure to be Cobb-Douglas, which might work against aggregation using the state space approximation because of the wealth effect. The latter assumes a linear relationship between consumption and leisure, and thus the preciseness of aggregation is going to be better for this specification. In Krusell and Smith (1998), they found that both specifications are precise enough under TFP shocks.

5 Concluding Remarks

At the beginning of this paper, I present empirical evidence on the positive correlation between political instability, policy uncertainty, and wealth inequality. To investigate the effect of aggregate uncertainty in taxation and lump-sum transfer on the wealth distribution and wealth inequality, I calibrate a general equilibrium model with an incomplete market similar to Krusell and Smith (1998), where the only intertemporal asset is capital. I find both the uncertain labor taxation and lump-sum transfer increase the wealth inequality. Uncertainty in taxation helps to spark the consumption smoothing motive for the rich, and the lump-sum transfer weakens the needs for the poor to purchase capital. I document the importance of taxation by comparing the baseline model in Krusell and Smith (1998) and the baseline model with certain labor taxation and lump-sum transfer, showing quantitatively how it contributes to most of the distortion in the wealth distribution. In contrast, tax policy uncertainty decreases wealth inequality, and the magnitude is dependent on the degree of risk aversion and the level of wealth holdings. As households become more risk averse, the rich sacrifice the capital accumulation process to maintain their consumption level, while the poor purchase more capital as insurance against a possible future high labor tax. I also scrutinize the impact of lump-sum transfer by comparing the main model and the model with only uncertain taxation no lump-sum transfer. Lump-sum transfer serves as insurance for both idiosyncratic and aggregate shocks, and thus dampens the wealth accumulation process for the poor.

However, all the models that I have presented in the above sections cannot reproduce the wealth distribution in the real world. Even the main model, the model with uncertain taxation and lump-sum transfer, fails to match each quantile of the wealth distribution in data by almost 30%. This deficiency, in turn, leads to possible extension in future research. A model where agents have leisure preferences can capture the changes in hours worked due to the uncertain taxation, and thus the impact on wealth inequality. I suppose that the rich have the flexibility to work more or less based on the realization of the labor tax level, while the poor have no such privilege and have to work relatively more even under high labor tax. This disparity in the labor force decision between the rich and the poor can potentially amplify the uncertainty effect and therefore create higher wealth inequality.

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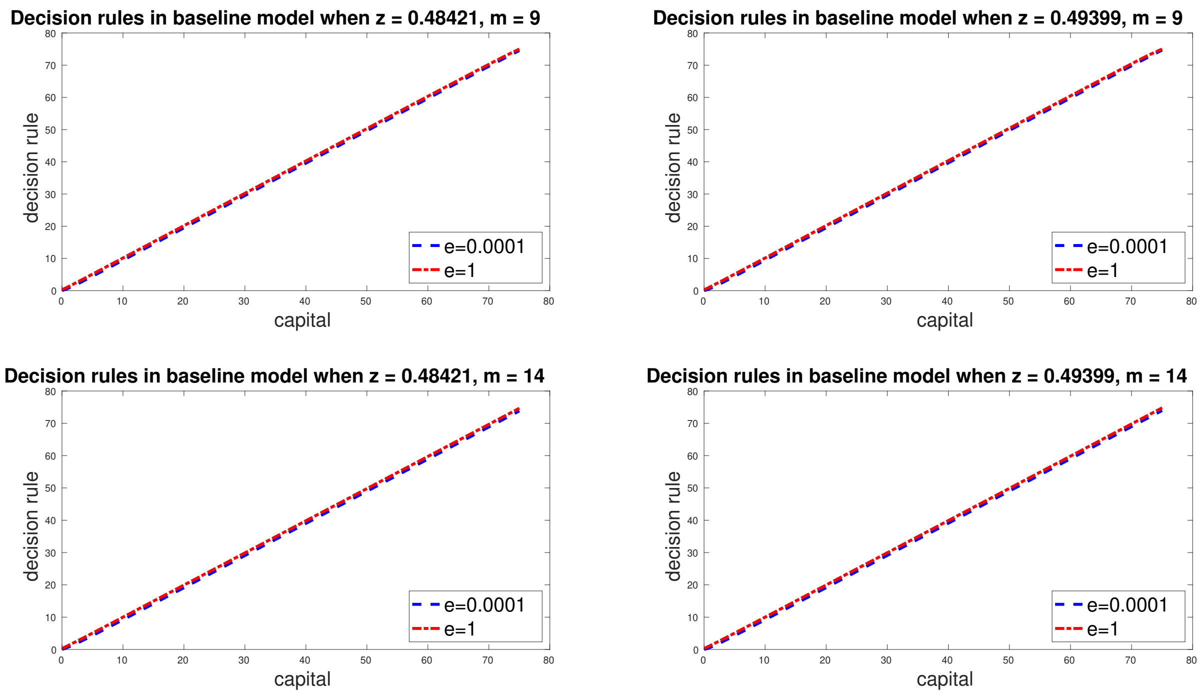
A Robustness Check

This section reviews the decision rules, value functions, Den Haan errors, Lorenz curve, and distribution for four alternative models.

The difference between two employment states in baseline model is significant for both figure 14 and 15. For decision rules, the difference can be seen clearly in figure 8, where I put decision rules for uncertain taxation model with high tax rate τ_h and baseline model with lower TFP shocks z_b together. For value functions, I notice that the value function for the uncertain taxation model is relatively smooth around the borrowing limit, while there is a significant drop in utility for those poorest households. They are willing to borrow capital, i.e., having a negative level of capital, to smooth their consumption, but the zero borrowing limit stops them from doing so. The R^2 and the Den Haan error in figure 16 for forecasting rules perform nearly perfectly well, showing that replacing cubic spline with linear interpolation does not affect the effectiveness of state space approximation.

Figure 14: Decision rules: baseline model



Since the baseline model with certain taxation is simply adding labor tax parameters on the budget constraint without changing the aggregate structure of the baseline model, I interpret this model as purely the effect of labor tax. The figure 17 and 19 shows that simply adding the certainty equivalence of the uncertain taxation $\tau_c = 0.3$ is able to approximate the result displayed in section 3.2. Taking a closer look at figure 18, the comparison of the decision rules between uncertain taxation model and taxation model, there is barely any difference between the two sub-figures. Furthermore, the sharp drop of the value function in the baseline model when approaching to borrowing limit disappeared in the baseline model with certain taxation. This leads me to doubt whether the uncertainty matters. As there is no alternation in the aggregate structure, the R^2 and the Den Haan error in figure 20 is performed equally well in both baseline model and baseline model with certain taxation.

Figure 15: Value functions: baseline model

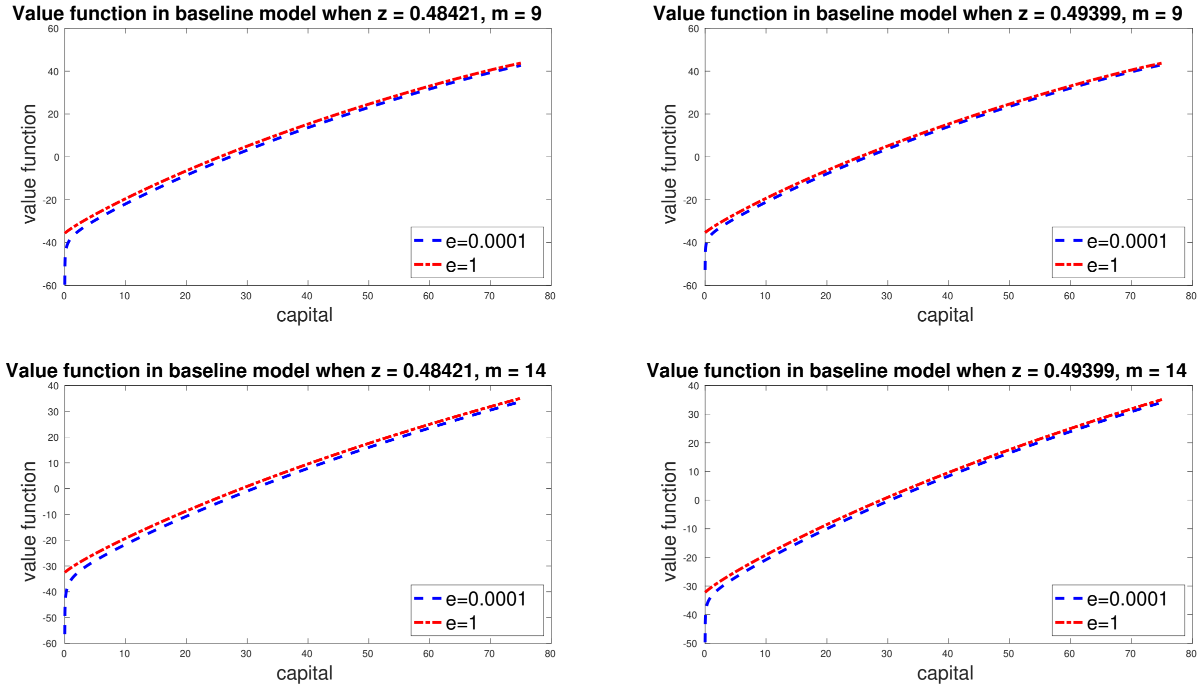


Figure 16: Den Haan Error: baseline model

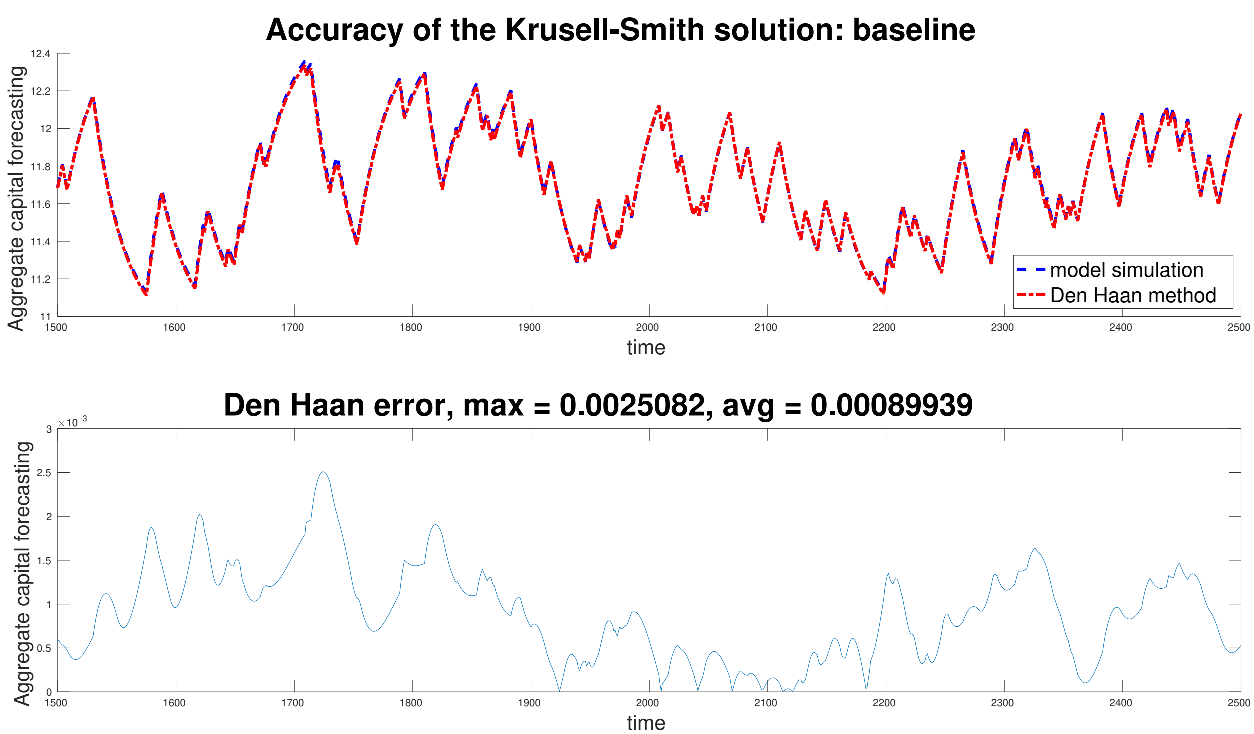


Figure 17: Decision rules: baseline model with certain taxation

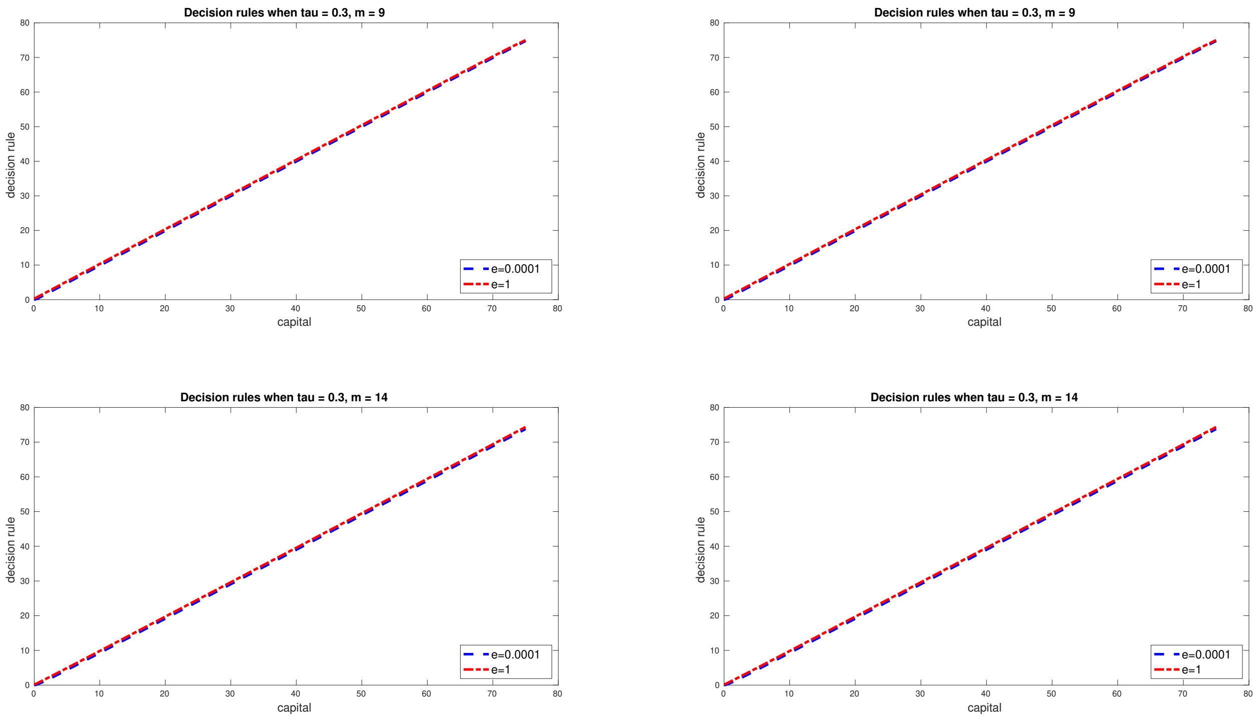


Figure 18: Comparison in decision rules: certaintax and uncertaintax

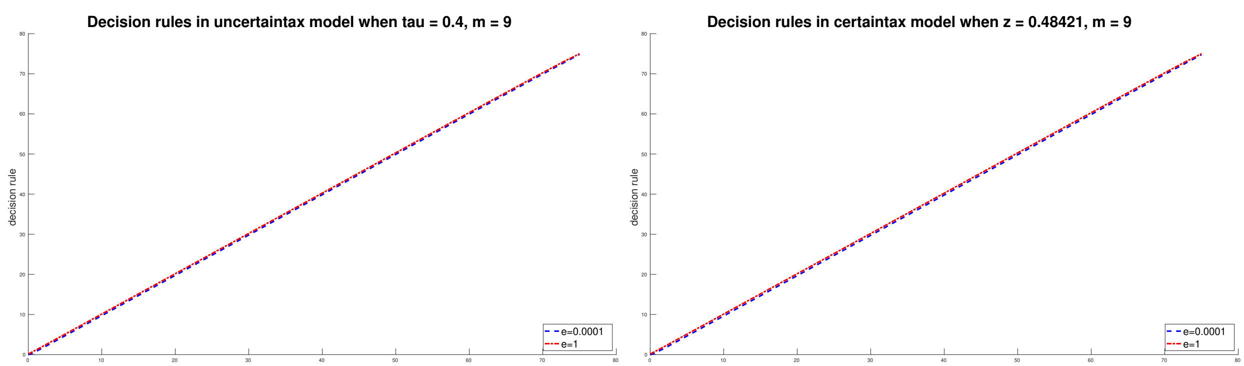


Figure 19: Value functions: baseline model with certain taxation

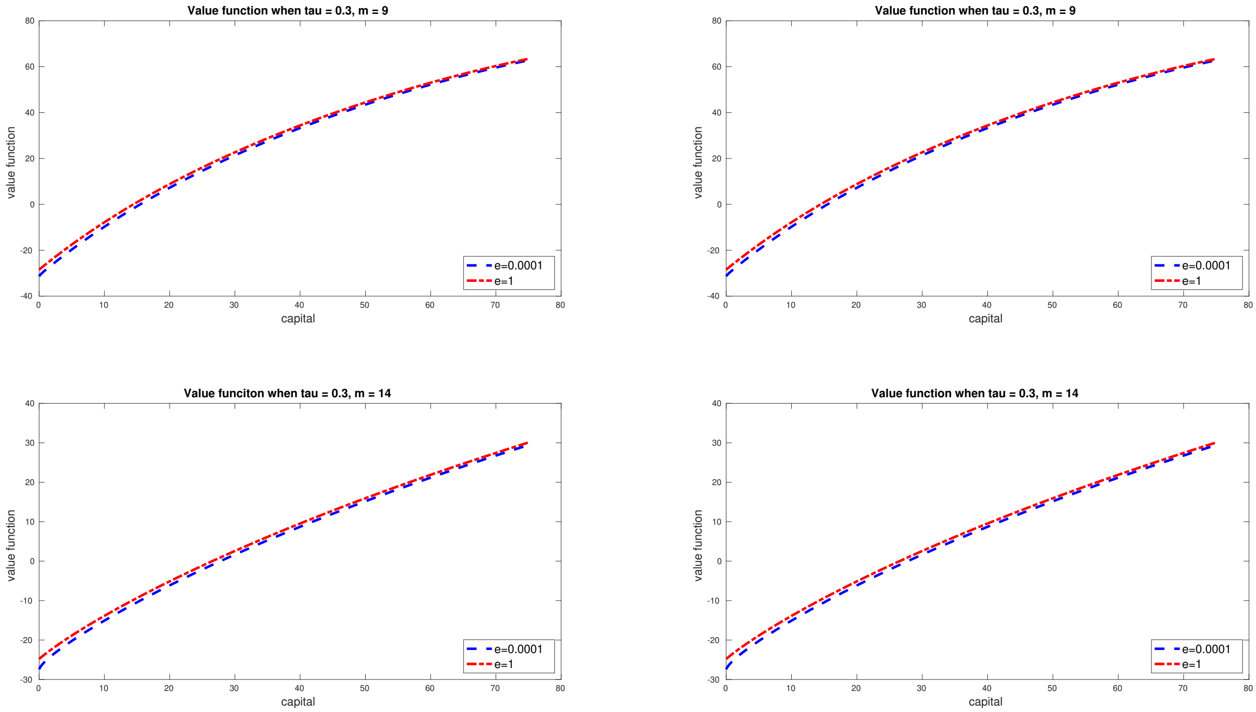
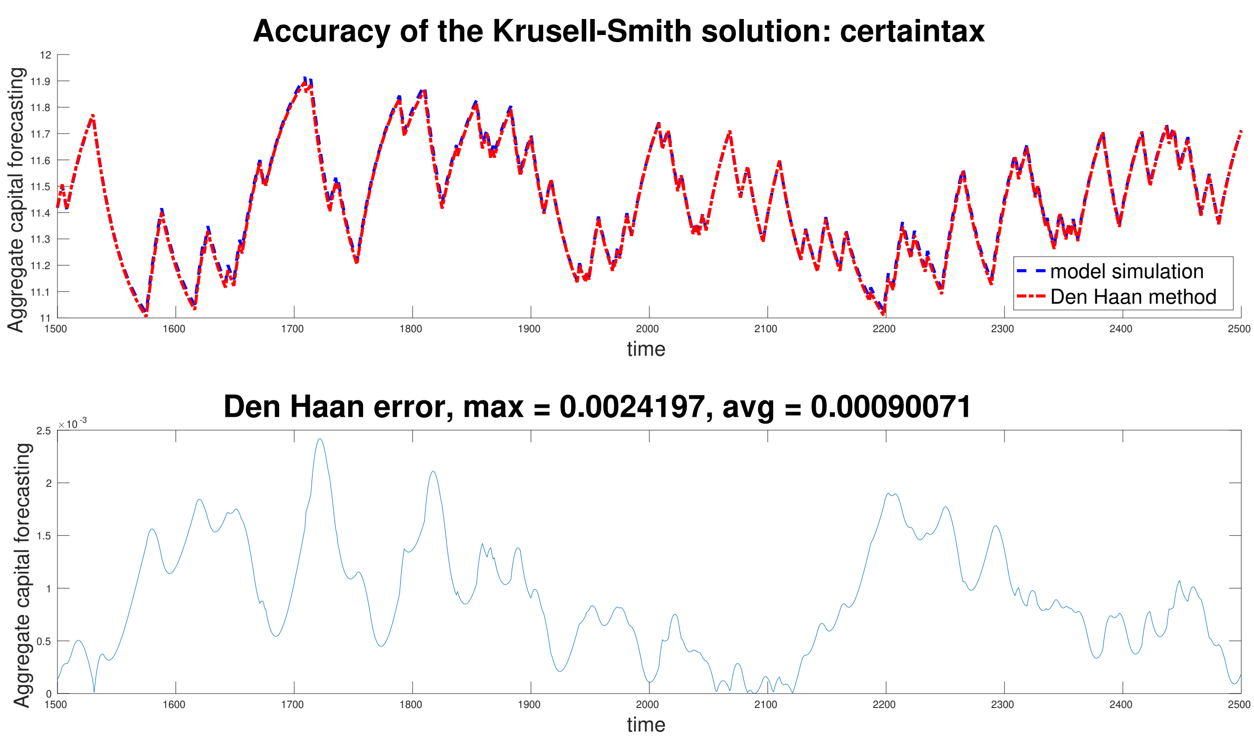


Figure 20: Den Haan Error: baseline model with certain taxation



B Supplement Figures

Figure 21: Distribution on capital: baseline

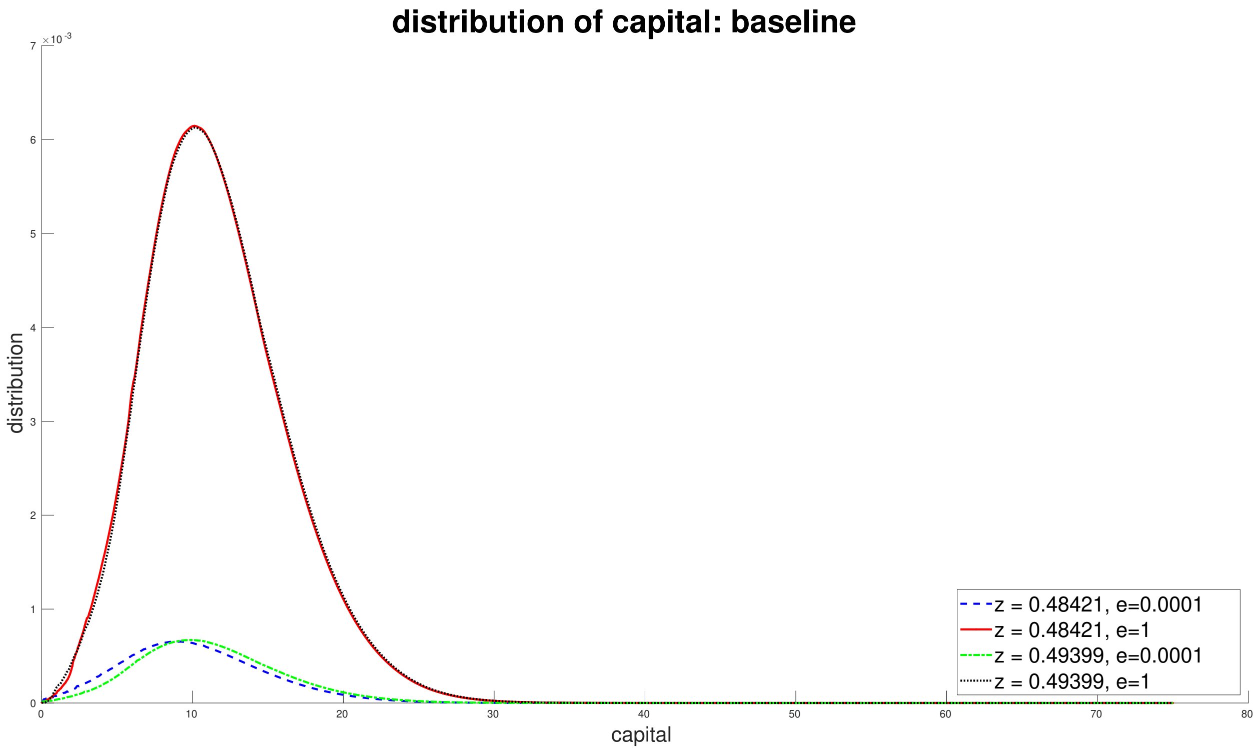


Figure 22: Distribution on capital: certain taxation

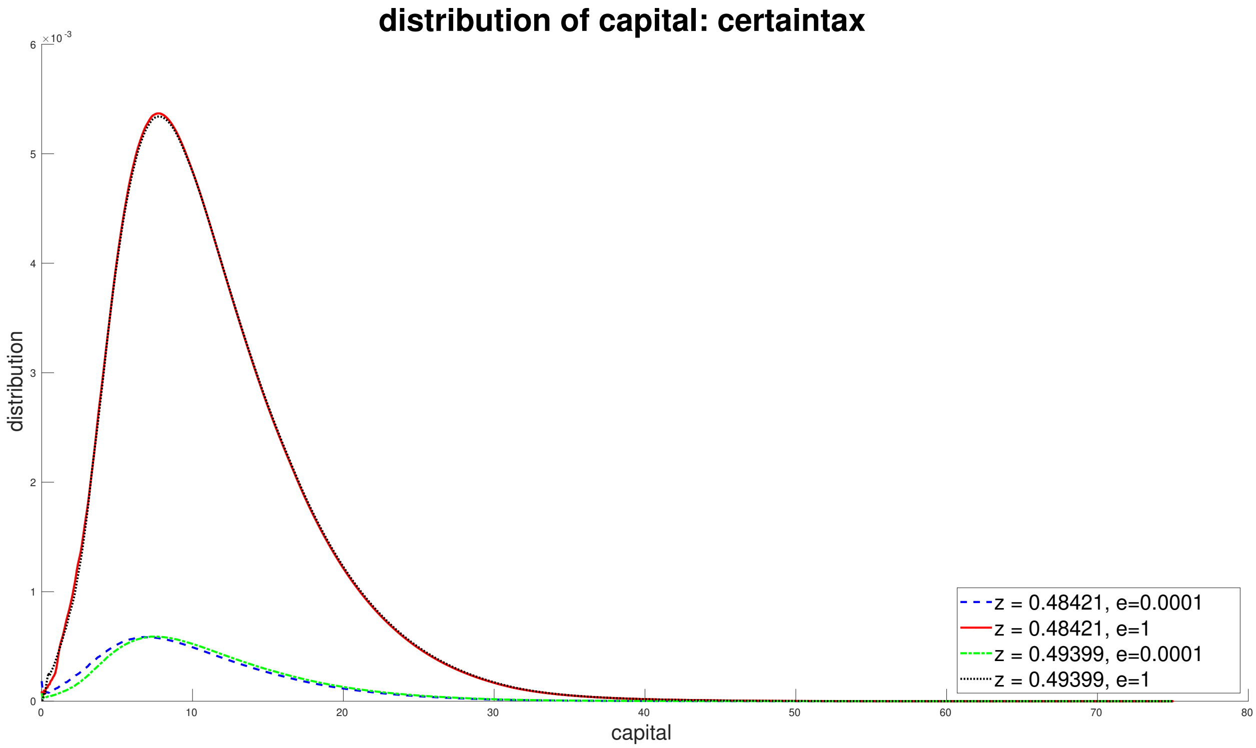


Figure 23: Lorenz curve: uncertain taxation and baseline model with certain taxation

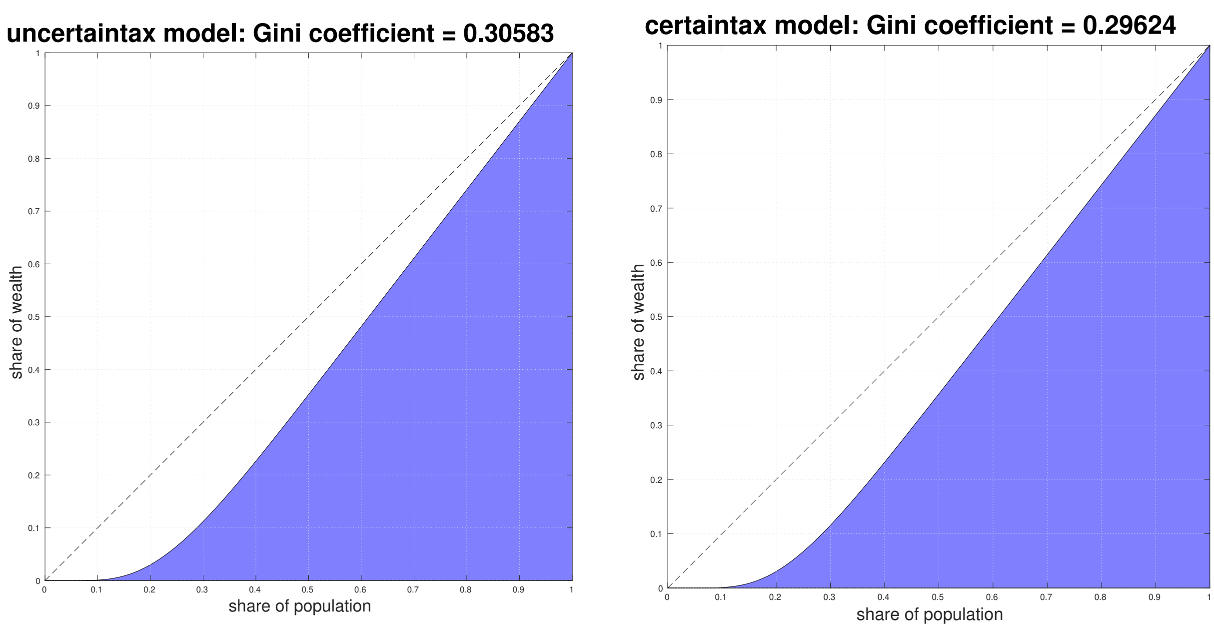


Figure 24: Decision rules: certaintax-no-transfer

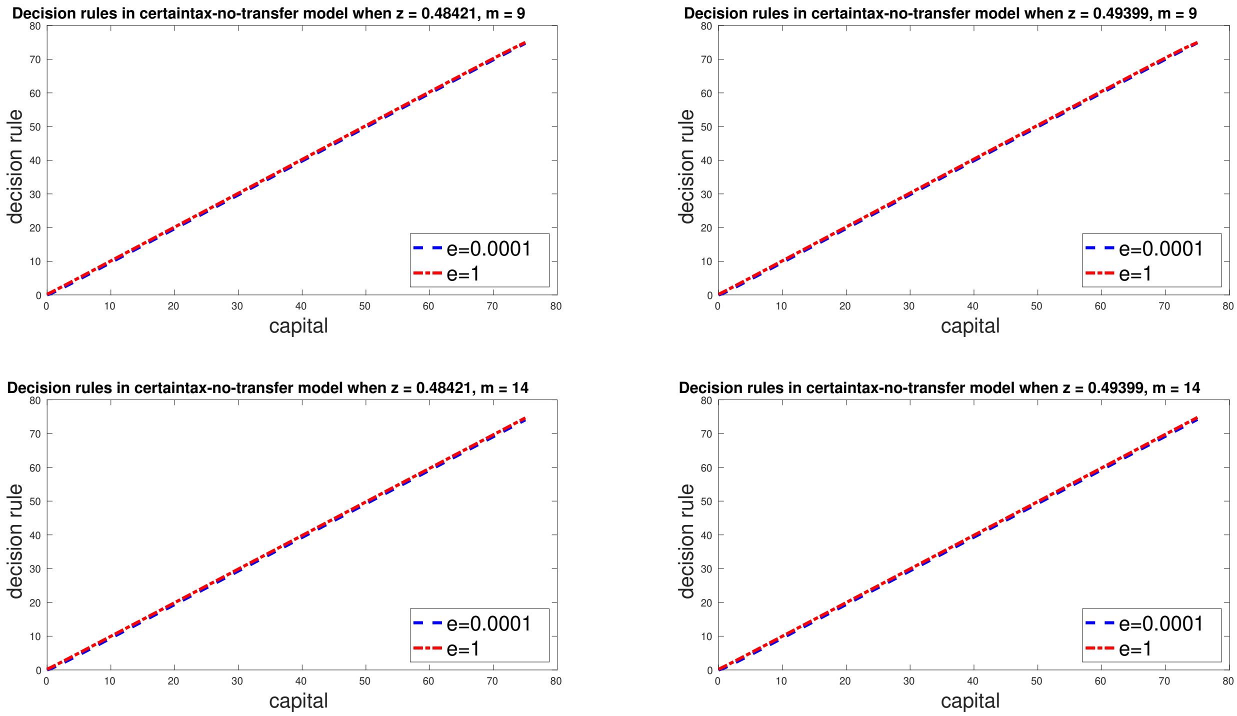


Figure 25: Value functions certaintax-no-transfer

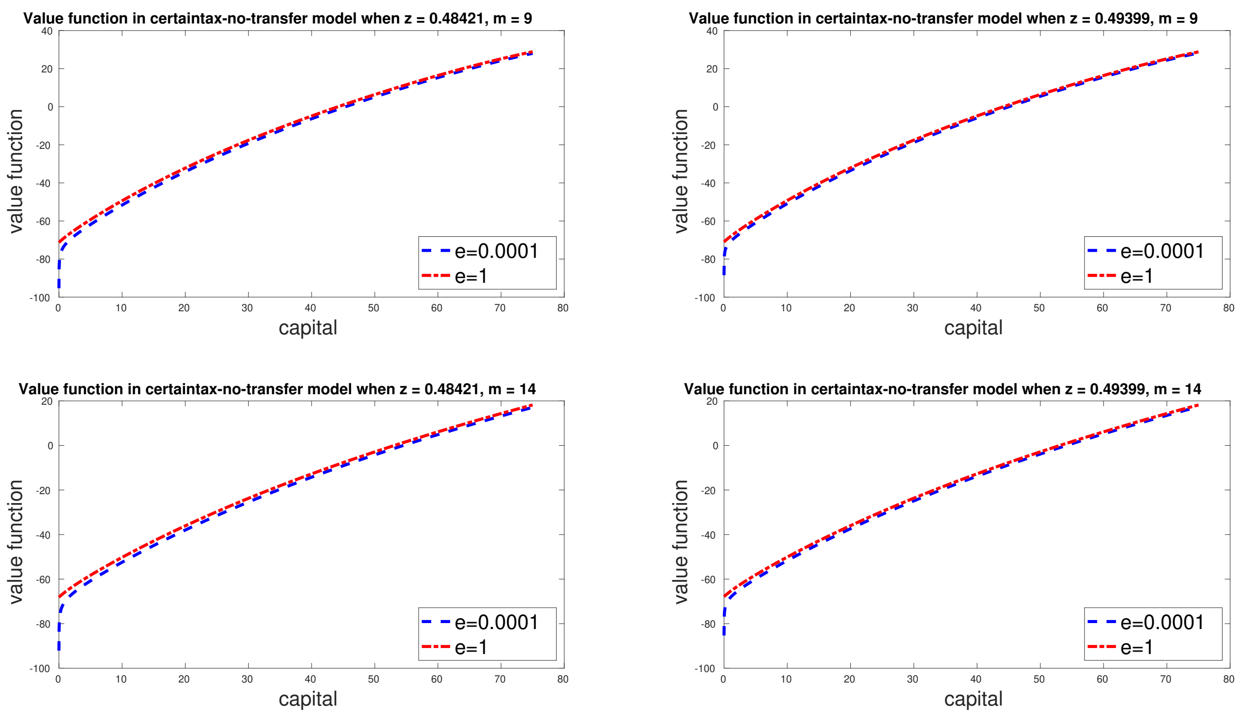


Figure 26: Den Haan error: certaintax-no-transfer

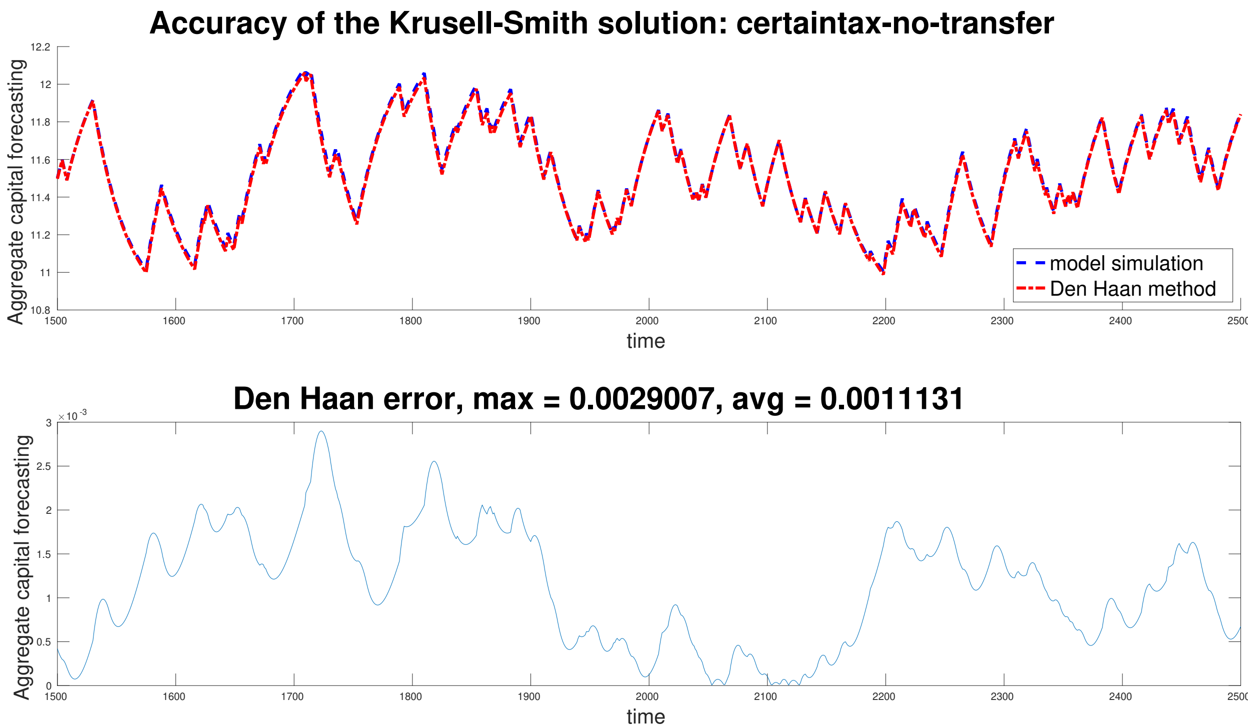


Figure 27: Distribution on capital: certaintax-no-transfer

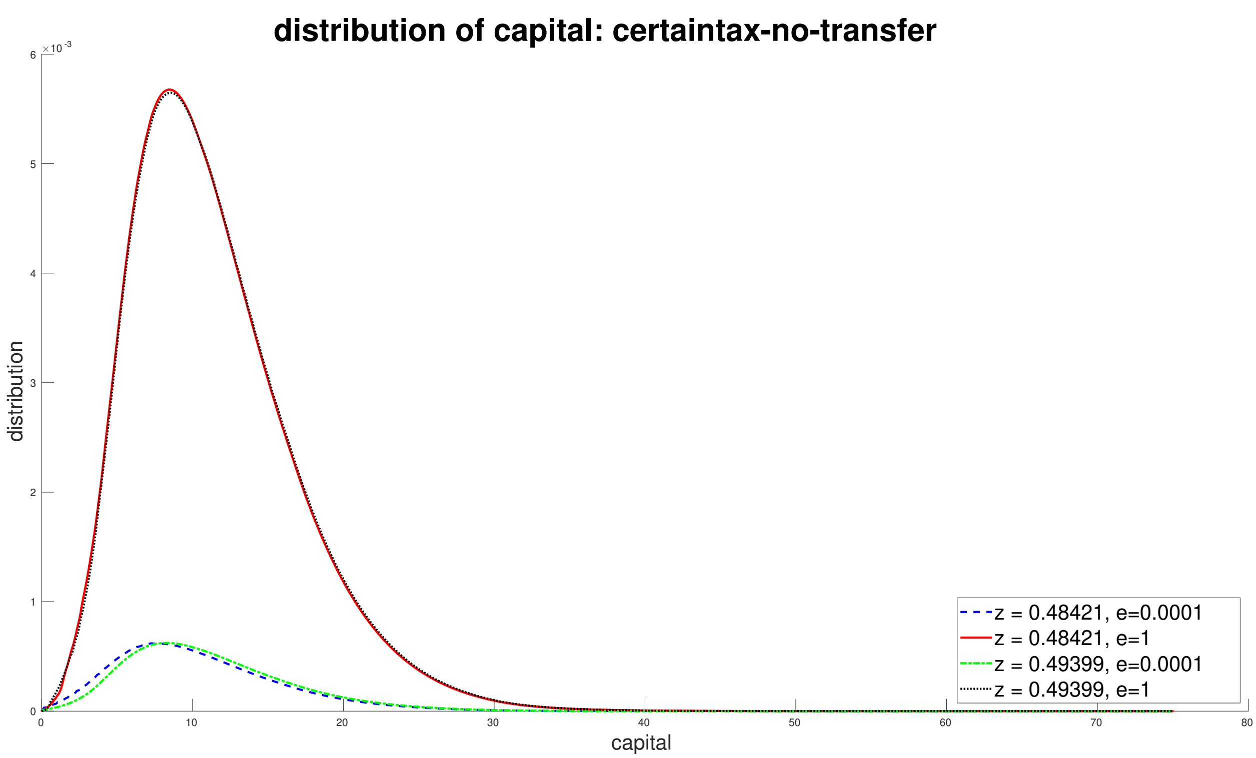


Figure 28: Decision rules: uncertaintax-no-transfer

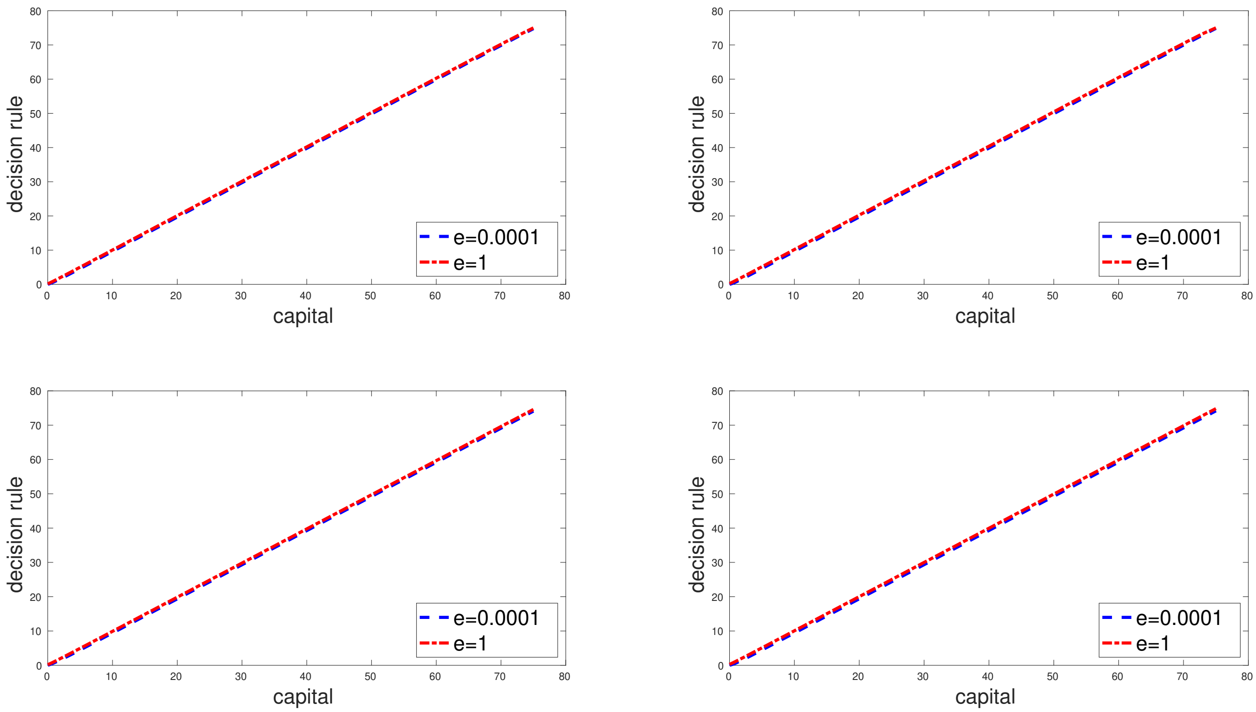


Figure 29: Value functions uncertaintax-no-transfer

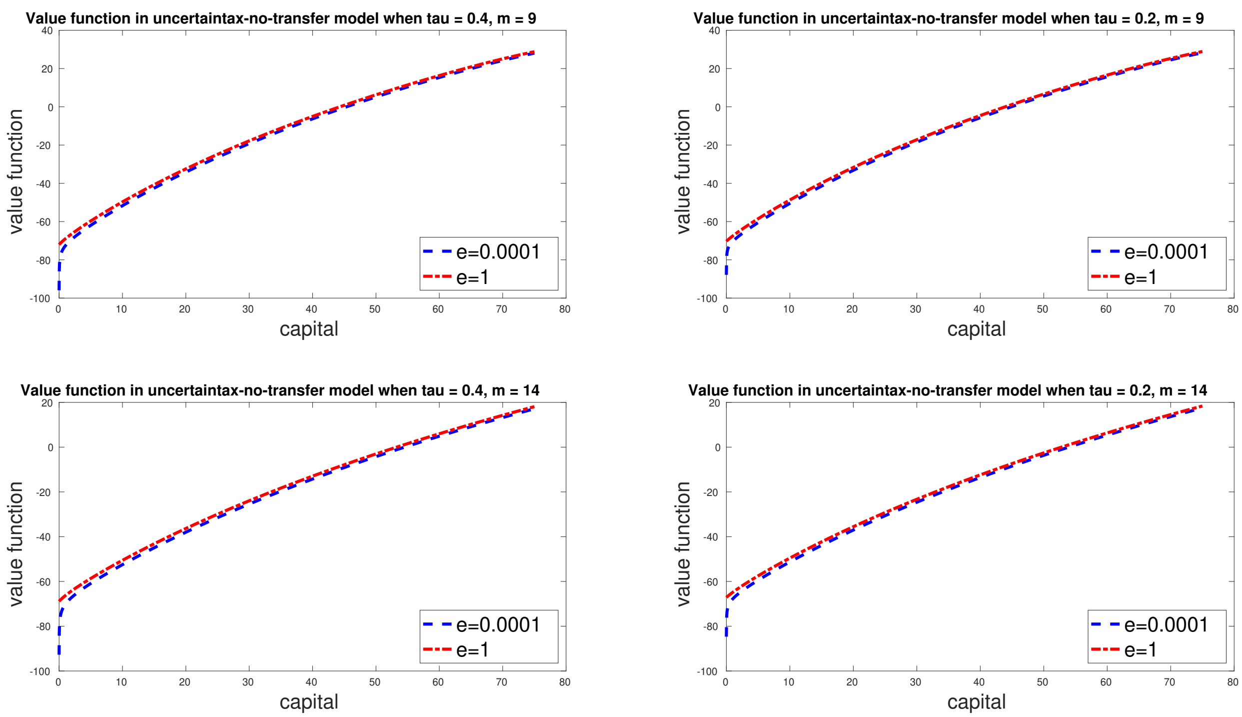


Figure 30: Den Haan error: uncertaintax-no-transfer

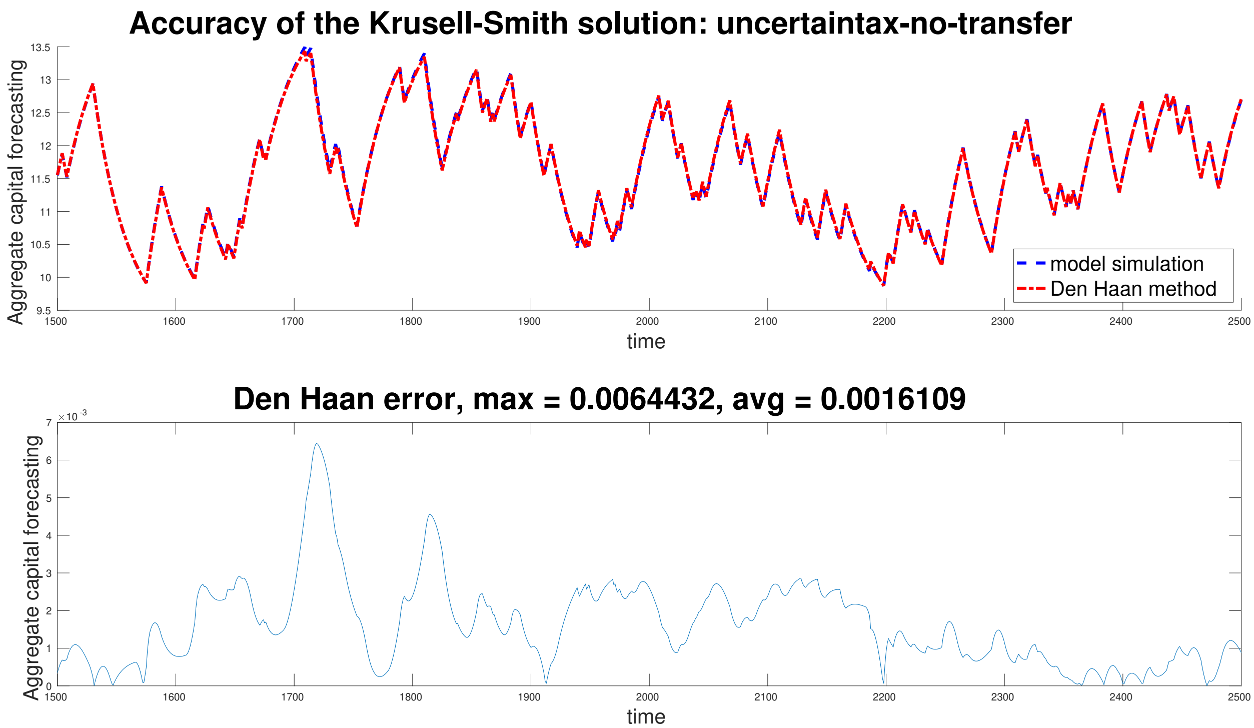


Figure 31: Decision rules and value functions: model (E)

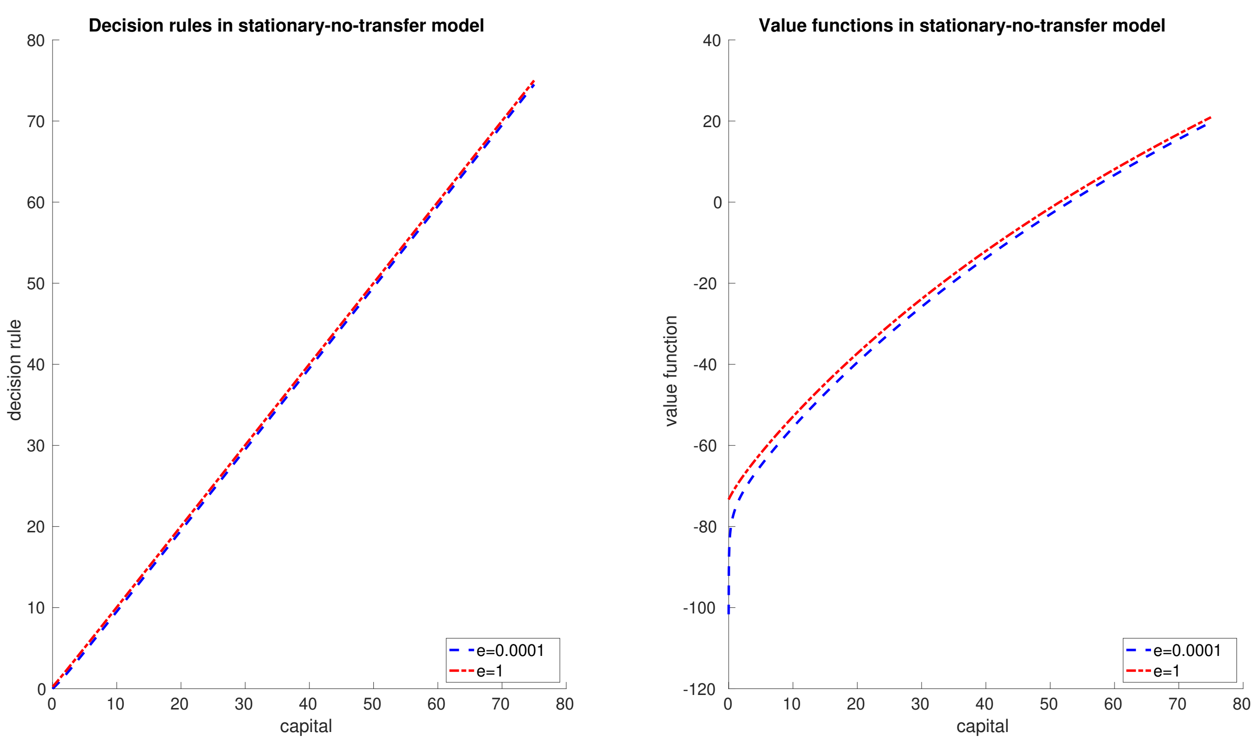


Figure 32: Stationary distribution: model (E)

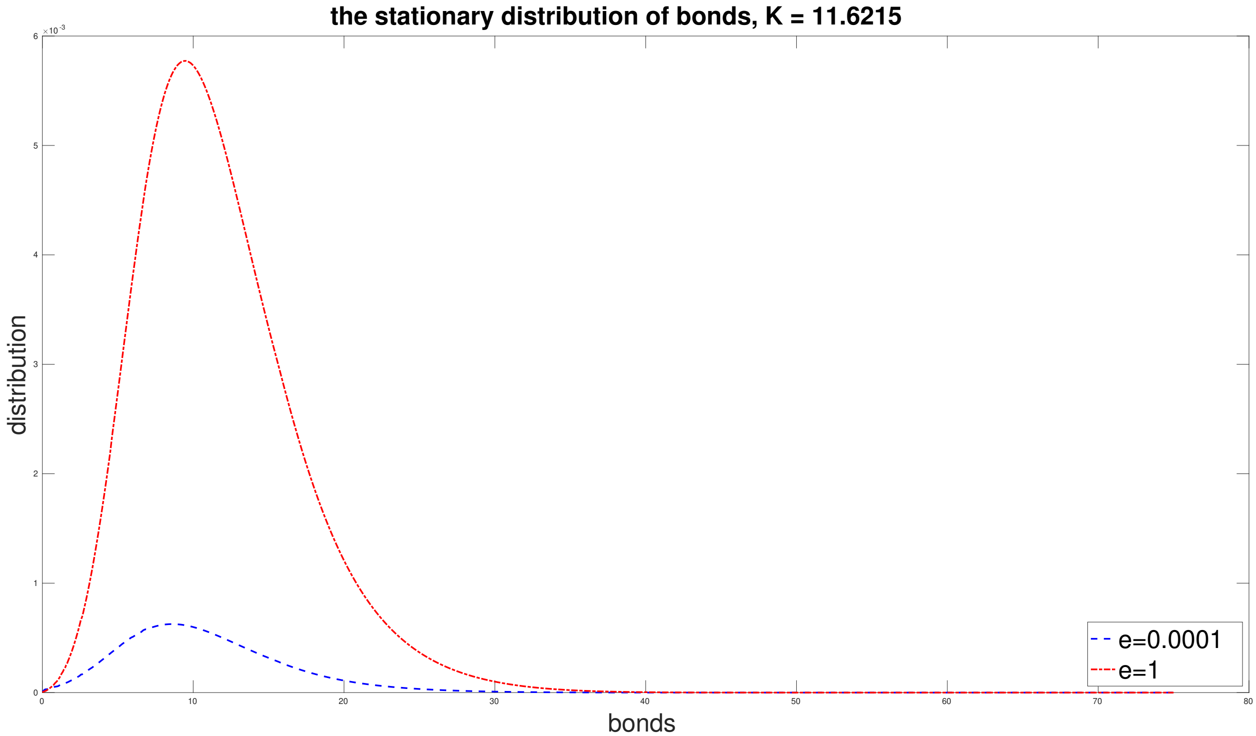


Figure 33: Lorenz curve: stationary model v.s. model (E)