Basic Income and Macroeconomic Consequences

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Abstract

Basic income (BI) is the simple idea of granting everybody an unconditional amount of income. As simple the idea, so controversial are the suggestions about its impacts. We implement a version of a Bewley model with uninsured uncertainty about future productivity from individual perspective and borrowing constraints. Capital, labor and wages are endogenous and determined by the aggregate behavior of the households. We solve for a stationary equilibrium to study consequences of a tax financed BI in a general equilibrium framework. We find a clearly positive correlation between BI and unemployment rates. Nevertheless, all BI rates considered are moderately welfare improving. Output and consumption, however are clearly decreasing in BI.

Contents

1 Introduction

The idea of basic income (BI) finds advocates as well as opponents at the most different ends of the political spectrum. Thus, definitions and terms as well as the line of argumentation differ widely in the public discussion. A universally viable definition of BI should be the following:

BI is a guaranteed income, paid on an individual basis without requiring any present or past work performance or the willingness to accept a job if offered.

In short: BI is granted - no matter what. This idea is in sharp contrast to the common concept of unemployment insurance as financial support for those who have *involuntarily* lost their job. One of the main issues in the literature about optimal unemployment insurance is how to minimize moral hazard, i.e.the risk that people *voluntarily* quit their jobs or reject job offers while unemployed and nevertheless claim unemployment benefits. Two results regarding incentives that minimize moral hazard rates have been confirmed repeatedly. The first one regards optimal time sequencing of benefits and says, that unemployment benefits should be declining over time [SW79], [HN97], [CL72] [1]. Second, empirical as well as theoretical literature on job search suggests, that the existence of moral hazard necessitates monitoring and sanction systems to speed up transitions to employment (see [FH03] for a recent review). BI neither features a declining profile nor sanctions for loafers. As a consequence BI might lead to an economy of loafers receiving BI, where output rates approach zero - a scenario that is unlikely to be favored by economists.

[1] However, Hassler/Rodriguez Mora(2002) have shown for a partial equilibrium model with moral hazard and endogenous savings that the optimal benefit sequence is constant.

Some groups of the society are however clearly attracted by the idea of reduced output and consumption in exchange for a reduced work load and additional leisure. Van Parijs [VP92] points out, that members of Green movements on average attach comparatively little importance to income and the acquisition of goods, and rather great importance to free time. Bertrand Russell was one of the first and most prominent representatives of this stream of thought. 'In Praise of Idleness' [Rus36] he suggests that nobody should work more than 4 hours a day, and those who don't find work should likewise receive an income to live on. [Rus36].

Socialists like to invoke Joseph Carlier, whose 'Solution of the Social Question' [Car48] contains a first formulation of a genuine BI. A "territorial dividend", based on the rental value of all real estate should end "the domination of capital over labour"[Car48]. Modern socialists who argue for BI do so on similar grounds, though favouring higher levels to assure an even more effective redistribution towards the poor.

However, BI has not only been brought forward by socialist utopians, but also by rather conservative economists. The BI idea gained popularity among economists in the 1960s when attention was driven to the fact that post second world war welfare states had so far failed to effectively reduce poverty. Unemployment traps, poverty traps[2] and the existence of needy people not receiving benefits are main issues addressed in the discussion about poverty in the welfare state [Mea72]. In a first attempt to solve these problems Milton and

[2]Unemployment traps are referring to the fact, that people receiving unemployment benefits are likely to reject job offers, if the replacement ratio is high and thus a move to employment would lead to no significant increase in overall income. Poverty traps are referring to situations, where an increase in earnings leads to no significant increase in overall income due to the combined effect of taxes and transfers, that yield marginal tax rates of 100 percent and more [Fit99, Mea72].

Rose Friedman ([FF62]) proposed a negative income tax (NIT). The NIT not only avoids a massive bureaucracy, but guarantees everybody a subsistence level by linking eligibility to nothing but the current income ([FF80]). At the same time it retains work-incentives: a gradual phase-out up to some predefined level amounts to an employment subsidy for the low-paid and alleviates unemployment traps. Friedmans' NIT proposal was taken up by the Nixon administration under the label 'Family Assistance Plan' - a plan that could never be enforced (see [Moy73] for the political background).

The debate that has begun in the 1960s continues today. Whether BI is an appropriate mean to reform the welfare states remains an issue of dissension. Most controversially debated are the consequences of BI on work incentives and the financial viability of BI. Contributions to the discussion of the latter aspect tend to ignore the former, restricting to mere arithmetic exercises (for example [Atk95], Chapter 6 and [Hoh07]). These issues are immediately linked to each other though. Obviously tax revenues will usually depend crucially on the number of employed people in an economy, who are the ones to produce, consume, invest and earn the wages.

In the present paper we choose an approach which allows us to examine both aspects: work incentives and financial viability. Our model belongs to the class of Bewley models [Bew77](see section 2 for details). There is a continuum of ex-ante identical agents who solve an infinite horizon savings problem. Their productivity is determined in each period by a stochastic process, which makes them different ex post and allows us to draw conclusions regarding distributional effects of BI on different income classes. To study incentive effects agents are given a choice regarding whether or not they wish to work each period, given their productivity endowment, i.e. the employment decisions on extensive margins are included.

Employment decisions on intensive margins are definitely interesting to study in this context, but are left out here to keep things tractable. A government, which raises taxes to finance the BI expenditures is included to guarantee that only balanced budget solutions are considered and financial viability is ensured. Agents can save but borrowing is not allowed. Average behaviour of the agents determines the average capital, effective laborforce and hence output as well as wages in the economy. This general equilibrium framework allows us to study a large set of possible macroeconomic consequences of BI like impacts on unemployment rates, wages, output and aggregate savings.

The paper is organized as follows. The next section briefly overviews the existing literature. Our model is presented in section 3, followed by a detailed solution procedure and remarks on practical problems of implementation in section 4. Results are presented and analyzed in section 5. Section 6 draws final conclusions. I finish with some remarks in section 7. Our Matlab implementation code of the Bewley model is provided in the appendix.

2 Literature

Any theoretical framework for studying BI should include some essential features. It should allow for the possibility of involuntary unemployment or uncertainty about future productivity on individual level: otherwise there is nothing to insure against. Market incompleteness regarding private insurance should allow for the possibility of welfare improving social insurance systems. An explicit budget constraint for the state should guarantee that the BI is financially feasible. Finally, a general equilibrium framework should provide a coherent view of the implications.

An early attempt to combine these elements - albeit not to study BI but unemployment insurance - was made by Easley, Kiefer and Possen [EU85]. They analyze a two period model with two individuals, who face uncertainty about their individual future productivity. As individuals cannot hold any assets they cannot insure against this uncertainty. Unemployment can arise voluntarily or involuntarily, where involuntary unemployment occurs with a certain exogenously given probability. Easley et al. demonstrate that in this framework the introduction of unemployment insurance can be pareto improving.

Atkinson [Atk95] proposes a theoretical framework for analyzing BI. He suggests a dual labor market model with efficiency wages being paid in one sector.[3] Some other authors have used the efficiency wage concept to analyze BI.

[3] *Efficiency wages* refer to the following concept. In an economy where output depends on the effort of the workers and this effort cannot be perfectly monitored, firms will be willing to employ less workers at higher wages to induce a higher effort level. (In fact, effort is assumed to depend positively on the wage.) Thus the *efficiency wage* exceeds the market clearing wage and involuntary unemployment results. The efficiency wage model thus incorporates involuntary unemployment as an equilibrium phenomenon.

Bowles [Bow92] for example focuses on the relationship between income security and work effort in an economy with efficiency wages. He seeks to answer the question whether it is possible to introduce BI without reducing the profitability of investment. Profitability is measured by the after-tax profit share of output which is equivalent to the ratio of labor effort e to the wage w in this model. He compares a setup where money is given to the unemployed only with a setup where the unemployment benefits are replaced by BI. As a result the effort to wage ratio e/w rises. This is not surprising though. Effort is assumed to depend negatively on the fall-back-option. The fall-back-option is downsized since the same total amount of unemployment benefits is distributed among a greater number of people now in the form of BI. Consequently effort must rise for given wages. However, introducing taxes τ on hours worked to finance higher BI levels decreases the after-tax wage $(1-\tau)w$ which reduces e/w in turn. Furthermore, increasing amounts of BI improve the fall-back-option and hence reduce the effort to wage rate e/w. Consequently the maximum feasible (i.e. not detoriating profitability) BI level is rather small.

Another model with efficiency wages was employed by Moutos and Scarth [MS02]. They study the effects of capital tax financed BI in a closed economy as well as in an open economy setting. In the closed economy setting capital is exogenous and they find that macroeconomic variables like output and productivity remain unaffected. In the open economy capital is mobile internationally. By assumption, the interest rate r must equal the marginal product of capital and at the same time the after tax rate $(1-\tau)r$ must equal the interest rate in the rest of world $\bar{r}$. This is how capital becomes endogenous to the model. In the open economy setting BI financed by taxing capital leads to lower wages. This translates to lower productivity, lower labor income and decreased output. Enhancing the model by savings, they suspect possible effects of BI on long-run wealth accumulation. This important aspect, which they however do not elaborate any further, might increase support for BI.

Involuntary unemployment can also arise as an equilibrium phenomenon in economies where wages are bargained between unions and firms. Van der Linden [VdL01] develops a dynamic general equilibrium model of a unionized economy to analyze the effect of BI on the unemployment rate. Interest rates are exogenous. Wages are determined in a Nash-Bargaining between firms and unions. Firms decide on investment and employment unilaterally. BI is financed by taxing earnings. Introducing BI there are two competing effects. First, progressivity in taxes in taxation increases with rising amounts of BI. In the wage-bargaining framework higher progressivity in taxation acts as an incentive for wage moderation and thereby reduces the unemployment rate. Second, BI pushes up both, in-work-income and the income for jobless workers. But BI favours the latter relatively speaking. This leads to a relatively improved fall-back-option for the workers and pushes up bargained wages as well as the unemployment rate.

All reviewed authors cope with the essential model features that were mentioned at the beginning of this section. But none of the models incorporates self-insurance of the agents via the accumulation of assets. Self-insurance, however, can illustrate far-reaching macroeconomic consequences of BI, especially if savings are assumed to determine the capital stock of the economy and thereby influence aggregate output. An adequate theoretical framework to study these issues are Bewley models [Bew77]. They are characterized by the following features (see [LS04]). There is a large number of agents who are indiscriminately exposed to labor endowment shocks which are uninsured. Agents can self-insure against this uncertainty by holding assets, but borrowing is constrained by a lower bound on asset holdings. Agents face an infinite horizon savings problem. Some of the prices which individual households have to account for parametrically in their decision making are determined by the average behavior of all households. Invented by Bewley, researchers have extended and varied the model to study various issues. In the present thesis we follow variants of the Bewley model due to [HI92] and [Aiy94] as suggested by Uhlig [Uhl07].

İmorohoğlu and Hansen [HI92] study the role of unemployment insurance in an economy with liquidity constraints and moral hazard. Workers can reject the employment opportunity they face and will still receive benefits with a positive probability. This probability Π embodies the *moral hazard rate* of the economy. They find that an increase of Π from 0 to 0.1 leads to sharp drops in the optimal replacement ratio of average wages from 65% to 15%. Note that optimality is equivalent to maximizing average utility here. They do not explicitly study effects of BI. But BI is equivalent to unemployment insurance with a moral hazard rate equal to one in this set-up. Accordingly their results suggest that the optimal level of BI is unlikely to exceed zero significantly.

In Aiyagaris [Aiy94] model agents cannot reject the employment opportunity they face. Consequently unemployment arises only involuntarily. Aiyagari studies the quantitative importance of precautionary savings to aggregate savings. The average employment rate is determined by the exogenously given labor endowment probabilities. But the capital stock which determines output as well as wages and returns on capital, depends entirely on the individual savings decision.

Below, we implement, analyze and discuss the following variant of a Bewley model. With respect to capital endogeneity we proceed along the lines of [Aiy94]. This allows us to study effects of BI on aggregate savings and implications for output and wages. To study work supply responses we incorporate voluntary unemployment and draw upon [HI92].

3 The Model

Our basic assumptions are as follows. Workers are identical ex ante but different ex post. Time is discrete. Average employment rate as well as average capital level are endogenous. For notational convenience, lower case indices refer to time t, and upper case indices are used for any other specifications.

3.1 Balanced government budget

The government is assumed to raise taxes to finance expenditures for the social insurance system. This is the only purpose of the government here. We require a balanced budget: the government is neither allowed to borrow nor to lend money. Therefore expenditures must equal revenues at all periods. There are different taxes available: τ^c, τ^l and τ^k denote the tax rates on consumption, wage earned income and capital respectively.

3.2 Workers and productivity

Workers face stochastic productivity levels that are governed by an exogenous Markov process $\{s_t\}$. The Markov property requires

$$Prob[s_{t+1}|s_t, s_{t-1}, ..., s_{t-k}] = Prob[s_{t+1}|s_t]$$

for all $k \geq 1$ and all t. We assume that the productivity state s can only take values of a finite set $\mathcal{S}$ specified by

$$\mathcal{S} = \{s^1, ..., s^n | s^1 = 0 < s^2 < ... < s^n\}.$$

The matrix P defines the stochastic transition process from time t to time $t+1$. P is assumed to remain unchanged through all periods, i.e. the transition process is time-invariant. The elements of P are

$$P^{ij} = P(s_{t+1} = s^j | s_t = s^i).$$

By assumption P is a stochastic matrix such that $(P^{ij})^n > 0$ for some value of $n \geq 1$ and all (i, j). This ensures that the process becomes asymptotically stationary with a unique limiting probability distribution λ, where λ is a $(n \times 1)$ probability vector with $\lambda(i) = Prob[s = s^i]$ for $i = 1, ..., n$ and

$$\lambda = P'\lambda. \tag{3.1}$$

As a special feature of this model our agents can choose whether they wish to accept the productivity level or reject it. Rejecting an offer is equivalent to voluntarily choosing zero productivity, i.e. unemployment. We assume that the productivity at $(t + 1)$, s_{t+1} depends on the productivity that was actually chosen in the previous period t. This assumption differs from [HI92] where the offer tomorrow does not depend on the actual choice today, but only on the offer today. My approach refers to recent studies which emphasize negative effects on employment rates for workers that were temporarily laid off (see [LS98]). The chosen state is denoted by $\tilde{s}_t$ to illustrate notationally the difference between a choice $\tilde{s}_t$ and an offer s_t at time t. To account for these additional assumptions we redefine P slightly by

$$P^{ij} = P(s_{t+1} = s^j | \tilde{s}_t = s^i). \tag{3.2}$$

Hence, the relevant transition process - from one chosen state $\tilde{s}_t$ to another chosen state $\tilde{s}_{t+1}$ - is no longer completely described by the matrix P. We will get back to this in the next section when we describe agent's choice process in more detail.

3.3 Save or consume and work or relax

Agents choose not only whether or not to work but also whether and how much to save. They can accumulate capital and insure thereby against future bad times with no or low productivity. Alternatively they may dissave and enjoy higher present consumption. More precisely, for given values of wages and dividends (w, d) which are considered to be fixed parameters from the individual perspective and given initial values (k_0, s_0) of capital and offered productivity, workers choose a policy $\{k_{t+1}, \tilde{s}_t\}_{t=0}^{\infty}$ to maximize their expected utility

$$E_0 \sum_{t=0}^{\infty} \beta^t u(c_t, l_t) \tag{3.3}$$

where $0 < \beta < 1$ is the discount factor and c_t and l_t denote consumption and leisure at time t. Leisure is related to the state choice by

$$l_t = \begin{cases} 1, & \text{if} \quad \tilde{s}_t = s^1 \\ (1-h), & \text{else.} \end{cases} \tag{3.4}$$

The fixed parameter $0 < h < 1$ denotes the time spent at work for any employed. This assumption expresses that labor is indivisible: agents can either choose to work a certain amount of hours or not at all. Capital k evolves according to

$$k_{t+1} = (1-\delta)k_t + x_t \tag{3.5}$$

where x_t denotes investments and δ the fixed depreciation rate of capital. By assumption $k_t \in \mathcal{K} = \{0 = k_1 < ... < k_m\} \bigvee t$. Finally, a budget constraint must be satisfied for each household:

$$c_t + x_t = w_t \tilde{s}_t + d_t k_t. \tag{3.6}$$

where d_t are the dividends on capital. Wage income is given by the product of the endogenous wage rate w (which is taken as exogenously given by the workers) and the chosen productivity state $\tilde{s}$. Accordingly, we will use the terms productivity levels and wage income classes interchangeably. Combining the preceding two equations and introducing taxes τ^c, τ^l, τ^k and basic income b leads to

$$(1+\tau^c)c_t + k_{t+1} = (1-\tau^k)(1 + d_t - \delta)k_t + (1-\tau^l)w_t \tilde{s}_t + b. \tag{3.7}$$

By assumption each household will maximize the expected utility (3.3) subject to the budget constraint (3.7). For each possible combination of capital and productivity state offer $\{(k_t, \tilde{s}_t)|k \in \mathcal{K}, s \in \mathcal{S}\}$ they seek a combination of $\{(k_{t+1}, \tilde{s}_t)|k \in \mathcal{K}, s \in \{s^1, s_t\}\}$ which maximizes expected utility and respects the budget constraint. Since this optimal response is time invariant we can drop time indices and refer to any current state with s while s' refers to any state of the subsequent period. The solution of the utility maximization provides a decision rule mapping, where each pair (k, s) is mapped to the optimal feasible capital and state choice $(k', \tilde{s})$.

$$g : (\mathcal{K} \times \mathcal{S}) \to (\mathcal{K} \times \mathcal{S})$$

$$g : (k, s) \mapsto (k', \tilde{s}).$$

This mapping g can be represented by a $(mn \times mn)$ matrix G which consists of ones and zeros. If we order the state vector by

$$sv = [(k^1, s^1), (k^1, s^2), ..., (k^1, s^n), (k^2, s^1), ..., (k^m, s^n)],$$

then G is given by

$$G(i, j) = \begin{cases} 1, & \text{if} \quad g(sv(j)) = sv(i) \\ 0, & \text{else.} \end{cases} \tag{3.8}$$

Let $\lambda_t(i) = Prob[(k_{t+1}, \tilde{s}_t) = sv(i)]$. Then the transition process is given by

$$\lambda_{t+1} = \underbrace{G(I_{m\times m} \otimes P')}_{PP_{big}} \lambda_t. \tag{3.9}$$

The $(n \times n)$ matrix P is the productivity states transition matrix (3.2). The Kronecker product $\otimes$ of the $(m \times m)$ identity matrix $I_{m\times m}$ and P' multiplies each element of $I_{m\times m}$ with the matrix P'. This Kronecker product is the exogenous part of the transition process and describes the transition from any choice of capital and productivity at t $(k_{t+1}, \tilde{s}_t)$ to the values the agent faces at $t+1$ (k_{t+1}, s_{t+1}). Note that capital is unaffected in this step. Then the agent chooses $(k_{t+2}, \tilde{s}_{t+1})$. The matrix G represents this choice process. Consequently the combination of these two steps, denoted PP_{big} in (3.9) determines the transition from the choice at t to the choice at $t+1$ for any t. When it comes to solving for a stationary distribution of PP_{big}, we must keep in mind that PP_{big} might no longer be ergodic, and hence the stationary distribution may not be unique.

3.4 Production, wages and return on capital

Output of the economy is determined by the aggregate production function F which takes the standard Cobb Douglas form and displays constant returns to scale. The arguments are the endogenous average level of capital K and effective workforce N

$$F(K, N) = K^{\alpha} N^{1-\alpha}. \tag{3.10}$$

and $(1-\alpha)$ and α are labor and capital's share of output. The wage rate is determined by the marginal condition

$$w = \partial F(K, N)/\partial N. \tag{3.11}$$

The return $R = 1 + d_t - \delta$ on capital is assumed to be fixed at a rate slightly above zero. This is in line with the empirical literature [IS79]. Moreover it is the easiest way to ensure $\beta R < 1$ by simply setting $d_t = d = 1/\beta \bigvee t$. This must hold to guarantee that there exists an upper bound of capital which is never binding. The Euler equation, which can be derived as a necessary condition from the household maximization problem states: $U'(c_t) = \beta R E_t[U'(c_{t+1})]$. Suppose $\beta R > 1$. Then optimality requires that $U'(c_t) > U'(c_{t+1})$. The concavity of the utility function implies that this inequality holds only if $c_t < c_{t+1}$. This means that our agents will always prefer to postpone consumption to the future and accumulate infinite amounts of savings. Hence, any upper bound on capital, which we need to define to be able to solve the model, will always be binding. Above all, keeping the return

R on capital fixed makes convergence of the numerical solution, and hence reliable solutions of the problem, more likely.

3.5 Definition of equilibrium

Let us summarize the above model considerations. We seek a stationary equilibrium, i.e. a policy function $g : (k, s) \mapsto (k', \tilde{s})$, a probability distribution $\lambda(k, \tilde{s})$ and positive real numbers (K, N, w) such that

- $w = \partial F(K, N)/\partial N$;
- The policy function $g : (k, s) \to (k', \tilde{s})$ solves the household optimization problem;
- The probability distribution $\lambda(k, \tilde{s})$ is a stationary distribution associated with PP_{big} (see equation (3.9)); that is it satisfies

$$\lambda(k, \tilde{s}) = PP_{big}\lambda(k, \tilde{s})$$

4 Model Implementation and Calibration

4.1 Four model economies

In the following we consider four model economies. An economy without BI or any other kind of unemployment insurance serves as a benchmark case. We then compare three taxation models and derive taxrates $\{\tau^l, \tau^c, \tau^k\}$ such that a budget neutral equilibrium exists. Each taxation model features exactly one tax rate. We do not consider any combinations of different taxes precisely because we are interested in comparing these different taxes and their interaction with BI. Furthermore, we will consider four different levels of BI for each model economy, BI $= 0.12, 0.24, 0.36, 0.48$. These levels correspond to wage/BI ratios of about 10% to 40% with respect to the wage rate in the model economy without BI.

4.2 Numerical solution strategy

Our numerical approach to solve for a stationary equilibrium of the economy is similar to the one described by İmorohoğlu and Hansen [HI92], [İ89]. Productivity states, capital-holdings and tax-rates are restricted to values on predefined grids. The solution procedure is as follows

1. For prescribed BI level b and a prescribed tax policy we guess a tax rate τ and a wage w.

2. Given τ and w, we perform the *value function iteration* (see 4.2.2). The solution implies a *decision rule mapping* g.

3. We define the transition matrix according to equation (3.9) and calculate average capital, effective workforce and resulting wages w^{new}. As long as $|w - w^{new}| > 0$, we set $w := w^{new}$ and repeat step 2, the *value function iteration*, with the new wage w. Once $|w - w^{new}| \approx 0$ - hopefully wages will really converge - we continue with step 4.

4. We check whether government expenditure equals government earnings on average. If the government surplus clearly differs from zero we guess a new tax rate employing a secant method (see 4.2.1) and repeat the procedure starting with step 2.

4.2.1 Solving for a balanced budget - the secant method

To determine the budget balancing tax rate $\tau*$ we proceed via bisection, modified by standard linear interpolation. More precisely, given taxrates τ^0 and τ^1 with corresponding surpluses σ^i, $i = \{1, 2\}$ such that $\sigma^0 < 0 < \sigma^1$ we define a

$$\tau* = \frac{-\sigma^1}{\sigma^0 - \sigma^1}\tau^0 + \frac{\sigma^0}{\sigma^0 - \sigma^1}\tau^1.$$

In the next step we calculate the corresponding surplus. If $\sigma* > 0$ we replace (τ^1, σ^1) by $(\tau*, \sigma*)$ and keep the values (τ^0, σ^0). If, on the other hand, $\sigma* < 0$, (τ^0, σ^0) is replaced by $(\tau*, \sigma*)$ and (τ^1, σ^1) is kept. To start the iteration we universally took $\tau^0 = 0$. Trivially, $\tau_0 = 0$ features a negative surplus σ^0 for any basic income $b > 0$. In preparation of the implementation we made a guess for τ^1 and verified that the guessed tax rate features a positive surplus. This preparation is definitely worth the effort since the secant method converges rapidly. After one step only surpluses differed from zero by less than 10^{-2} in absolute value. This is a remarkable improvement compared to a prohibitively time consuming brute force approach with, say, 100 steps of 1% to cover the total range of possible tax rates. One might argue that our method solves for one tax rate solution only. If we assume that the Laffer curve describes the shape of the function of government earnings in the tax rate, however, there should be at least two solutions. Our method will in this case solve for the lowest possible tax rate. Our choice is hence supported by practical considerations regarding political enforceability.

4.2.2 Value function iteration

The center piece of the numerical solution is the value function iteration. Recall, that households maximize their expected infinite horizon utility 3.3 subject to the budget constraint 3.7. The Bellman equation for each $i \in (1, ..., m)$, $j \in (1, ..., n)$ is

$$V(k^i, s^j) = \max_{k', \tilde{s}} \{u(c, l(\tilde{s})) + \beta \sum_{q=1}^{n} P_{\tilde{s}s^q} V(k', s^q)\} \tag{4.12}$$

where

$$c = \frac{1}{1+\tau_c}[(1+d-\delta)k^i(1-\tau_k) + w\tilde{s}(1-\tau_l) + b - k']$$

To solve (4.12) numerically one could use 'Howard's Improvement Algorithm', a 'Guess and Verify' method, or do a 'Value function iteration'(see [LS04],chapter 3 for a review of these methods). For superior performance and convergence we choose the value function iteration here. Indeed, based on a 'convergence-criterion' of a difference of less than 1/3 in absolute value for all elements of the value function, the iteration converges after between 40 to 140 steps. The idea of a value function iteration and the solution procedure is the following: If we knew all $(m \times n)$ entries of V we could proceed simply the following step, call it step 'solve':

- Given (k_i, s_j) calculate the r.h.s. of (4.12) for all feasible combinations of $k' \in \mathcal{K}$ and $\tilde{s} \in \{s_1, s_j\}$. The pair $(k', \tilde{s})$ that maximizes the r.h.s. is optimal and defines the policy function in (k_i, s_j).

But V is unknown. Therefore some V is guessed to start with and step 'solve' is performed for all pairs (k_i, s_j). The optimal pairs $(k', \tilde{s})$ define another matrix, say V^*. In the next iteration step V^* becomes V and step 'solve' is repeated with the new V. This procedure is continued until V and V^* are sufficiently close.

4.2.3 Practical problems of the transition process

As mentioned before, given the set of choices that can be made, the transition matrix PP_{big} may have multiple eigenvalues one, i.e. the stationary distribution may not be unique. This is a feature economists are usually keen to avoid (by ensuring that transition matrices are defined in a way that guarantees ergodicity) since dealing numerically with repeated eigenvalues = 1 is difficult for several reasons. First, it is extremely hard to detect all eigenvalues equal to 1, since a considerable amount of eigenvalues that actually are equal to 1 might be 'numerically' slightly above or below 1 due to rounding mistakes. Second, given one solved the first problem, one could either consider all possible distributions or one could make a choice, for example by defining an initial distribution and care only about the limes of this distribution as the 'relevant' stationary one. Given that the latter option would crucially depend on the choice being made and the former one being very unhandy for our purposes we follow economic mainstream this time and simply 'make' the transition matrix ergodic [4]. This can be done by setting all zero entries of J equal to some $\varepsilon > 0$ and adjusting the ones correspondingly such that columns still add up to one. Again, consider a (2×2) example, where this time

$$J = \begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix}, P_{big} = \begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix} \Rightarrow PP_{big} = J \times P_{big} = \begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix}$$

$\lambda_1 = Prob(k_1, s_1)$ and $\lambda_2 = Prob(k_2, s_1)$. PP_{big} has two stationary distributions: $\lambda = (1,0)'$ and $\lambda^* = (0,1)'$. Now we define

$$J = \begin{pmatrix} 1-\varepsilon_1 & \varepsilon_2 \\ \varepsilon_1 & 1-\varepsilon_2 \end{pmatrix} \Rightarrow PP_{big} = J \times P_{big} = \begin{pmatrix} 1-\varepsilon_1 & \varepsilon_2 \\ \varepsilon_1 & 1-\varepsilon_2 \end{pmatrix}$$

[4] Nevertheless, multiple stationary distributions are interesting to study, exhibiting features like the possibility to shift an economy from one stationary equilibrium to another by some kind of government intervention or shocks, that create a new 'initial distribution'.

It it intuitive that the unique stationary distribution will incorporate λ as well as λ^*. But interestingly the relative weight of the two distributions depends fundamentally on the relation between ε_1 and ε_2. This can be shown easily by simply solving for the unit-eigenvalue of PP_{big}:

$$(PP_{big} - I)\lambda = 0 \Leftrightarrow (\varepsilon_1, -\varepsilon_2) \perp (\lambda_1, \lambda_2) \Leftrightarrow (\varepsilon_1, \varepsilon_2) \parallel (\lambda_1, \lambda_2)$$

So, obviously, choosing a relation of ε_1 and ε_2 is crucially influencing the relative weight of λ to λ^*, making any stationary distribution possible.

We weight all stationary distributions equally, using the same replacing $\varepsilon > 0$ for all zeros. So, note that the results are reliable concerning the 'intra-structure' within the originally multiple distributions; but the 'inter-structure' between these distributions in the artificial unique distribution is just assumed to be equal.

4.3 Specific Choices and Calibration

4.3.1 Utility function

The concave utility function is specified by

$$u(c, l) = \frac{(c^{1-\alpha} l^{\alpha})^{1-\eta} - 1}{1 - \eta} \tag{4.13}$$

This utility function is widely used in real business cycle literature and displays constant relative risk aversion η and an elasticity of substitution between consumption and leisure equal to one. It is common in real business cycle literature to set $\alpha = 0.67$, see for example [KP82]. [HI92] suggest, that $\eta = 2.5$ is consistent with various empirical studies. For example [Bai77] find values for $\hat{\eta}$ between 1 and 2 for cases where utility is a function of consumption only. When utility depends on leisure and consumption, [HI92] argue, η must solve the equation $(1 - \alpha)(1 - \eta) = 1 - \hat{\eta}$, where $\alpha = 0.67$ [KP82] and $\eta = 1.5$ [Bai77]. This holds for $\eta = 2.5$. In line with [KP82] we fix a personal discount rate β=0.995. The parameter h finally, which determines leisure when employed, is set equal to 0.45. This value is based on the assumption that agents are endowed with 98 hours substitutable time a week, of which they spend 45 hours at work when employed [HI92].

4.3.2 The grids $\mathcal{K}$ and $\mathcal{S}$

Choosing the spaces of the grids one faces a basic dilemma: allow for more grid points to achieve more precise results versus fast computations for reasonably small grids. To keep these aspects in balance we choose the following grids:

- $\mathcal{S} = \{0, 0.5, 1\}$. This grid can be interpreted to represent 3 possible productivity endowments, and accordingly 3 income classes of the society: no wage, low wage and high wage respectively. This seems to be a reasonable division to study distributional effects of BI as well as work supply responses to BI for different groups of the society.

- $\mathcal{K} = \{0, 0.2, 0.4, 0.6, ...16\}$. Defining the $\mathcal{K}$ grid is a tricky task. It is important that grid points are sufficiently close to each other since large gaps will heavily bias the results. At the same time one should ensure that the upper bound is not binding. This is the case for $\mathcal{K}$ in the model economy with zero BI. When BI is introduced, however, the upper bound turns insufficient. Workers in the highest productivity state will never dissave, no matter how high their capital holdings are. Reasonable changes in step sizes as well as upper bounds did not lead to any changes of that situation. Due to practical limitations - neither high performance computing resources nor sufficient time for this fascinating research had been granted to this poor author - I have to restrict my reader and myself to such a grid. I will account for that when analyzing the results.

4.3.3 The transition matrix P

The entries of P are mostly based on a calibration of hiring and firing rates for Germany by Brown, Merkel and Snower [Bro06]. They make various distinctions between workers which are not included in our model. We therefore coarsen their data and downscale their model for our purposes. For example the hiring rate for the unemployed in our model corresponds to the medium of the average hiring rates for long-term and short-term unemployed. The average itself is a weighted average of three ability classes. P is thus given by

$$P = \begin{pmatrix} .5 & .5 & 0 \\ .1 & .7 & .2 \\ .05 & 0 & .95 \end{pmatrix}.$$

5 Results and Interpretation

5.1 BI and consumption taxes

The relationship between increasing levels of consumption tax financed BI and work incentives is eye-catching (see figures 7.7 and 7.1). While high-wage earners remain unaffected in their behavior, low-wage earners respond to increasing amounts of BI by rejecting job offers. More precisely, there is a critical value of capital holdings at which low-wage earners decide that they can afford to enjoy more leisure and choose voluntarily unemployment. This critical value decreases with higher levels of BI. Theoretically, BI avoids unemployment traps, since it is not phased out at any level. Our results, however suggest that it is the level of the fall-back-option which is decisive for worker's labor supply choice on extensive margins. Hence, BI does come with increased levels of unemployment despite of theoretically avoiding unemployment traps.

Comparing the utility of BI for our three different groups of society we observe that the unemployed population is the well-defined beneficiary of BI (see figure 7.10). It is definitely not surprising that unemployed are better off with than without BI. But, what might be astonishing is the fact that BI makes the unemployed to the richest people of the economy in terms of utility. We might wonder why not everybody chooses unemployment as a result. We claim that this is due to the risk-aversion of the agents in our economy. Agents in the highest productivity state face pretty good chances of keeping their high-wage job, while the chances to return to that kind of job once unemployed are poor. Hence, high-wage earners are willing to dispense with free time and endure lower utility levels throughout their life to keep their well-paid job and accumulate savings for the day, they might be fired (see figure 7.8). The same mechanism is at work regarding low-wage earners. In addition, the higher consumption taxes that come along with higher BI levels see (figure 7.24) hit them naturally harder than high-wage earners. Hence, for wealthy low-wage earners the security motive to keep the job is outweighed by an increasingly attractive consumption versus leisure substitution possibility (see figure 7.9).

We briefly account for technical details. The wealth distribution is fairly equalized. We encounter the highest density for low to medium wealth. However, we face exceptional high density at the very upper end of the wealth distribution. This is due to the fact that our upper bound on capital is binding. Therefore all well paid agents who would actually like to save even more than the highest possible level concentrate at the far right end of the distribution and make the density peak (see 7.11). Nevertheless, we expect our described mechanisms to be likewise at work if the upper bound on capital is relaxed.

5.2 BI and flat taxes on wage income

In the flat tax model, for amounts of BI equal to 0.12 and 0.24 everything looks like business as usual. We encounter again an increased unemployment rate with increasing amounts of BI (see figure 7.12). It is basically the same effect as before: wealthy low wage earners decide to enjoy more leisure. However, it is noteworthy that unemployment is increasing much more rapidly for the flat tax than for the consumption tax case. Intuition is straightforward: Higher tax rates are needed to finance higher BI levels. Higher BI levels improve the fall back option while higher tax rates reduce after tax wages. Consequently, the ratio of BI to average after tax wages is even more improved. More and more low-wage earners will voluntarily choose unemployment and necessitate thereby even higher tax rates to finance BI. We face a self-accelerating process.

For the rest we find similar results as for the consumption tax model without any striking differences (see figures 7.15 7.16 7.13 7.14).

At an elevated level of BI, however, we encounter an interesting phenomenon. As noted in the description of the solution procedure (see section 4.2) we need to solve for equilibrium wages by iteration. For all reviewed cases up to this point wages converged rapidly (see figure 7.17). For a BI level equal to 0.36, however, labor, capital and hence wages do not converge (see figures 7.17 7.18 7.19). It would definitely be an interesting task to study this seemingly cyclical behavior in greater detail. For our purpose, however, we simply state that it does not make any sense to solve for a stationary equilibrium in an economy where non convergent behavior occurs.

Interpretation for the highest BI level (BI=0.48) is straightforward again. Agent's state choice is unemployment no matter whether they are in the high or low productivity state. Consequently, a BI=0.48 is not feasible in our flat tax economy.

5.3 BI and capital taxes

Introducing taxes on capital for welfarian purposes might provoke my reader to recall Chamley's [Cha86] well-known findings that that the optimal capital income tax is zero in the long run. Aiyagari [Aiy95], however, shows that for the class of Bewley models with incomplete insurance markets and borrowing constraints the optimal tax rate on capital income is positive, even in the long run. The capital tax prevents risk-averse agents from the welfare decreasing overaccumulation of assets.

Unfortunately, we are prevented from taking a stand on the welfare improving potential of a BI/ capital tax combination. Every considered level of capital tax financed BI led to non-converging dynamics of the wages, similar to what we observed for the flat tax model with BI=0.36 (see section 5.2). For now, we can merely assess a non convergent behavior (see figure 7.20) and leave deeper studies of this issue for future research .

5.4 Macroeconomic consequences of BI

We now compare the macroeconomic effects for those examined cases which exhibited converging behavior (see tables 8 8). Those are the consumption tax model *c.t.m.* and the flat income tax model *f.t.m.*, the latter one only for low BI levels with b equal to 0.12 and 0.24.

Both, the *c.t.m.* and the *f.t.m.* feature: decreased levels of effective workforce n, output y and consumption c and increased unemployment rates for elevated levels of BI.

Wage responses to BI do differ. While wages in the *c.t.m.* increase sharply for a small BI elevation and decrease again for higher amounts of BI, wages in the *f.t.m.* increase only marginally and after-tax wages are falling. We can assume that the economy wide labor supply is increasing in wages.[5] The sharper rise of unemployment rates in the flat tax economy can therefore be explained by a decrease of after-tax wages here. The weaker rise of unemployment rates in the *c.t.m.* can be attributed to the increased wages there.

But what is the cause of the higher wage rates in the *c.t.m.*? We recall equation 3.11 and note that the increased labor force in the *c.t.m.* will decrease wages. But an augmented capital stock enhances the wage rate and this is decisive here. Agents in the *c.t.m.* decide

[5]We do not have to worry about the relative size of income and substitution effects here, since we do not consider labor supply decisions on intensive but on extensive margins only.

to save more, since taxes have made consumption more expensive and hence they substitute consumption by investments. These increased savings augment the capital stock and thereby wages.

We proceed with welfarian and distributional aspects of BI. In the *c.t.m.* average utility u is increasing in BI (see tables 8.1, 8.2). But interestingly, average utility within the three different income classes is always decreasing in BI, except for a first surge in the low and no income groups when BI is introduced (see table 8.5). The increase in economy wide average utility is hence due to a shift in the distribution over the income classes. Except for the labor tax equal to 0.36 our results suggest that the proportion of unemployed is increasing whereas the the proportion of wage income earners is decreasing in BI (see table 8.3). Unemployed, however enjoy on average the greatest utility among the three groups for any BI level (see table 8.5). We therefore encounter greater economy wide utility levels at enhanced levels of BI simply because more people are unemployed and enjoy full leisure.

6 Conclusions

Implementing a version of a Bewley model with involuntary unemployment and endogenous capital we have studied macroeconomic consequences of BI. Technical problems were encountered at three stages. First, solving for a stationary distribution we encountered transition matrices with multiple eigenvalues one. To avoid dealing with multiple stationary distributions we made the transition matrix ergodic by replacing any zero transition probability by some positive probability value. Employing this method we have shown, however, that the 'inter-structure' between the multiple distributions that are melted into one artificial unique distribution is implicitly determined by the choice of the proportion between the artificial positive probabilities (see section 4.2.3). Second, solving for a budget balancing tax rate, we found a brute force method prohibitively time consuming. We employed a secant method (see section 4.2.1) and assessed rapid convergence. The surplus deviation decreased to less than 10^{-2} after only one iteration step. Third, in some cases we encountered non-converging behavior of labor, capital and thus wages. We excluded these cases from further analysis since they can not be solved for a stationary equilibrium.

For the cases which could be solved for a stationary, budget balancing equilibrium, we found the following relationships. The unemployed are the clear cut winners of BI. Not only do they enjoy higher utility levels at any BI level than without BI. They also get ahead of the high wage earners, who clearly loose in terms of utility for every BI level considered here. The utility of BI, however is decreasing in BI for every group - unemployed, low wage as well as high wage earners. The more the merrier seems to be simply wrong in the case of BI - even from loafer's perspective. Economy wide average utility, however is moderately increasing in BI. This is due to the fact that the unemployment rate is increasing in BI and the unemployed are the happiest people in our model economies with BI.

Macroeconomic variables clearly slope downwards with enhanced levels of BI. The only positive effect we can denote concerns a positive effect on capital accumulation for moderate amounts of BI financed by a consumption tax. But we suggest that this effect must be attributed rather to the consumption tax itself than to the introduction of BI. Output and consumption are clearly reduced for higher BI levels.

Hence, from a materialistic perspective, which economists usually take, BI can hardly be justified. Nor is the case for BI convincing from a welfarian perspective. Nevertheless, as noted by Bowles [Bow92] BI might help to correct what Schor [Sch86] has termed the output-bias of capitalism.

7 Figures

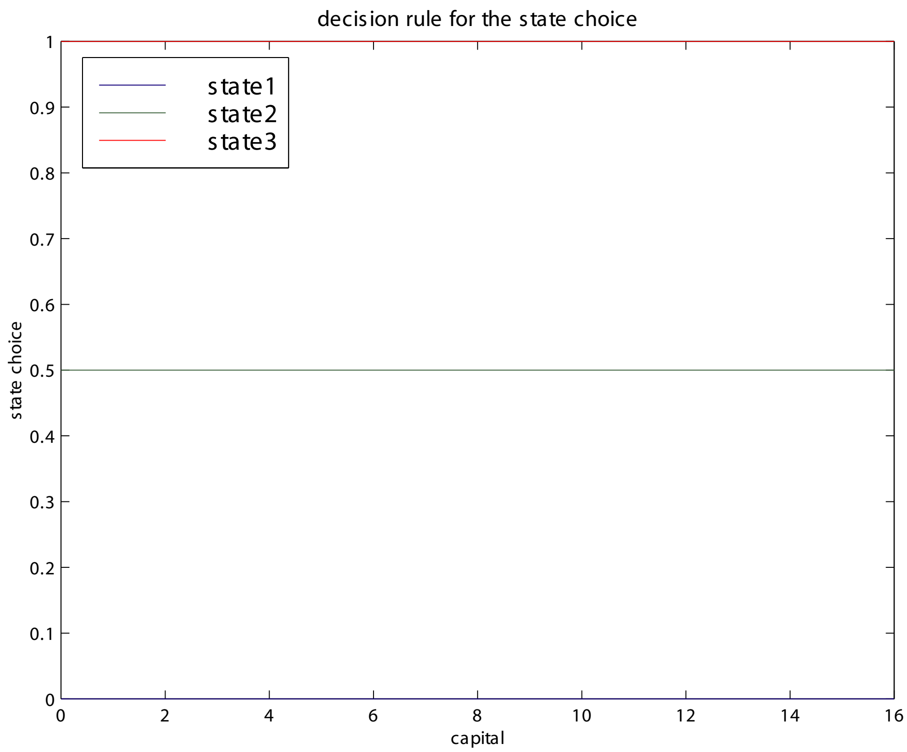

Figure 7.1: Agent's choice of the productivity state versus agent's capital holdings if BI=0.

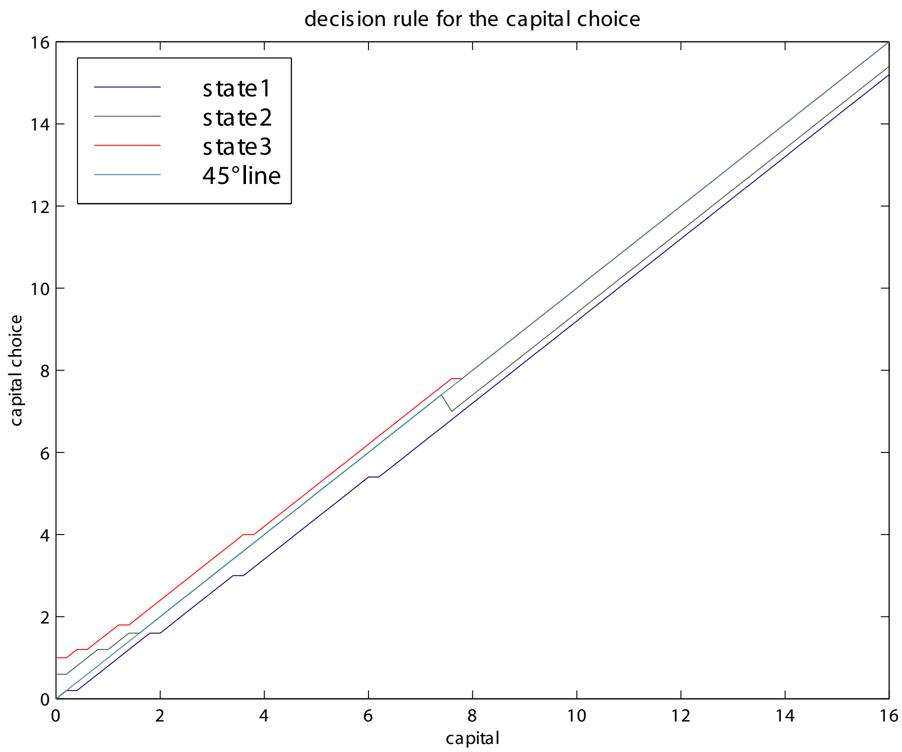

Figure 7.2: Agent's choice of capital k' versus agent's capital holdings k if BI=0.

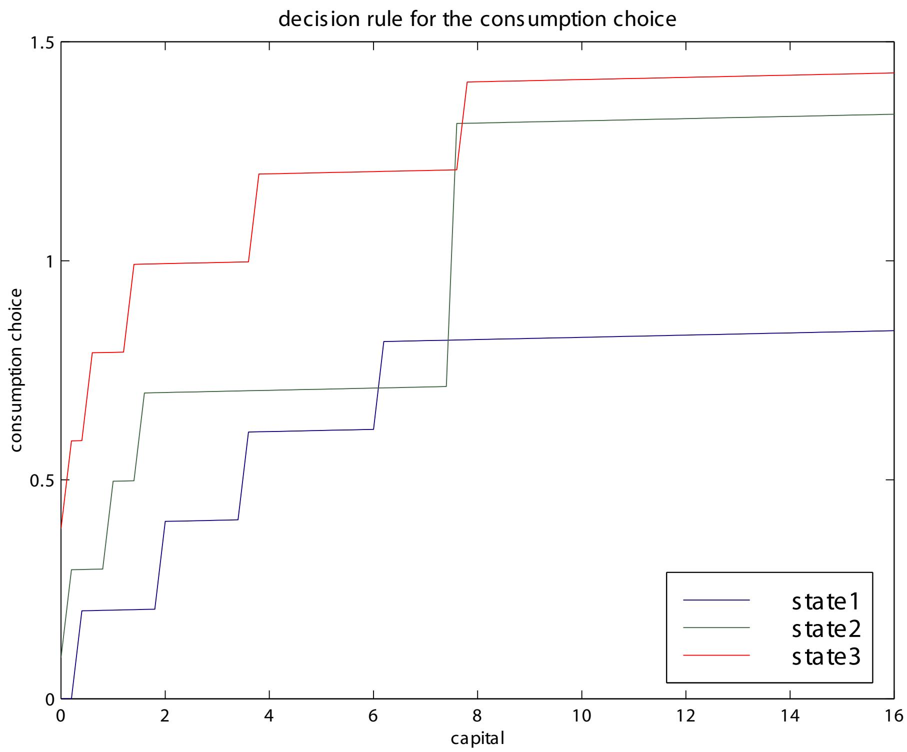

Figure 7.3: Agent's choice of consumption versus agent's capital holdings if BI=0.

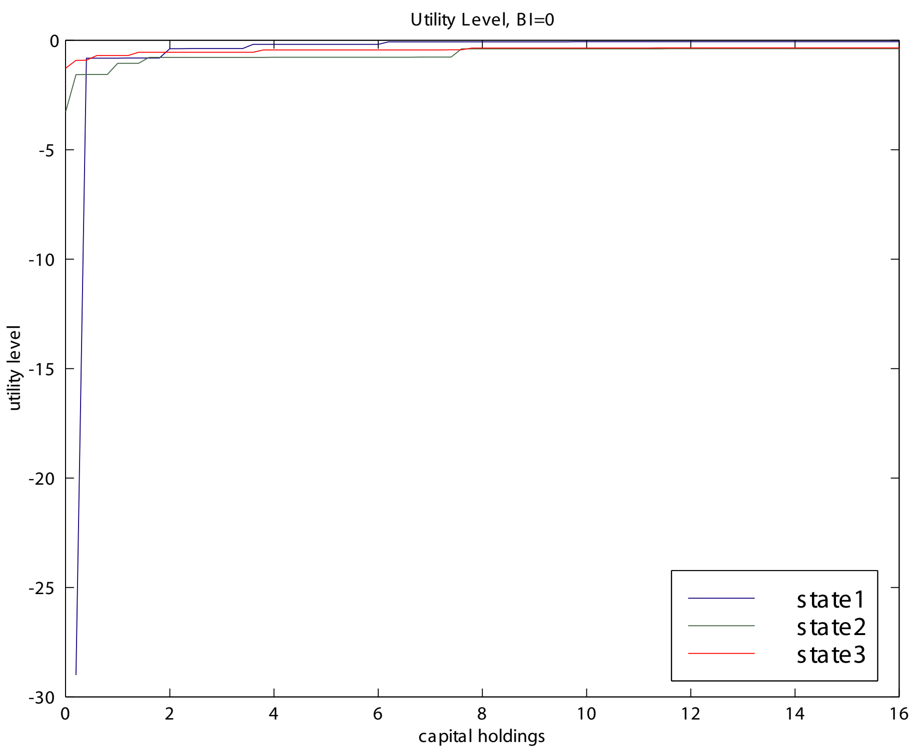

Figure 7.4: Agent's utility level versus agent's capital holdings if BI=0.

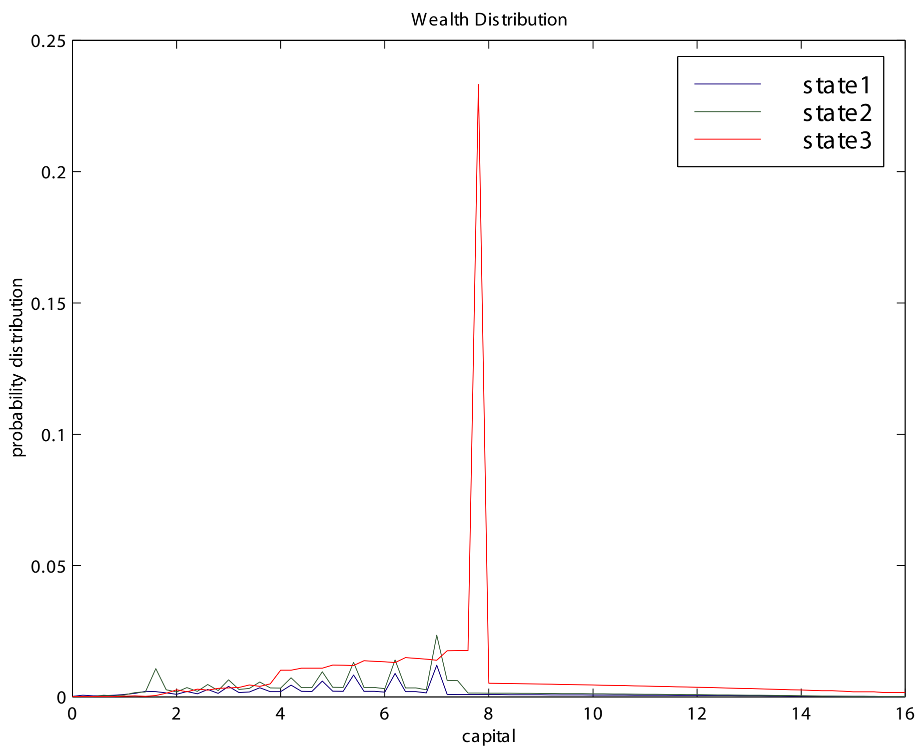

Figure 7.5: The wealth distribution if BI=0.

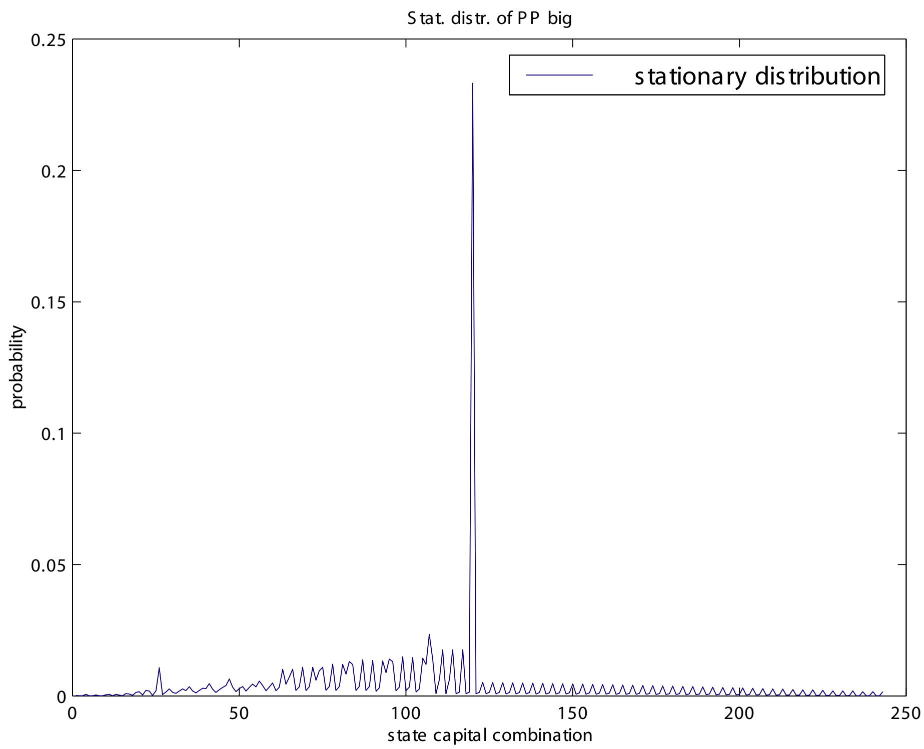

Figure 7.6: The stationary distribution of PP_{big} if BI=0.

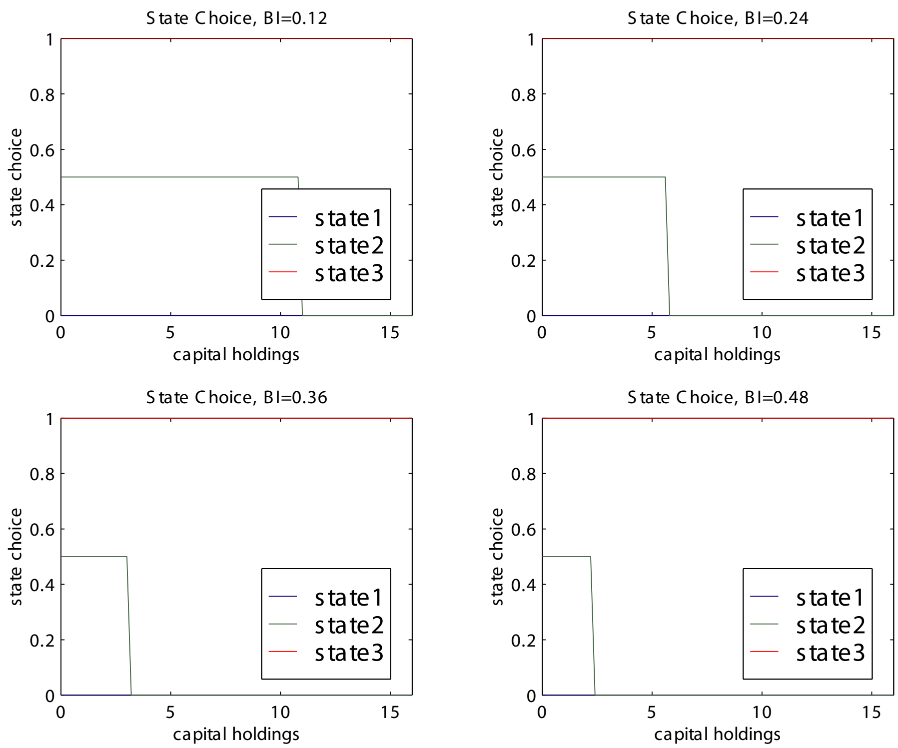

Figure 7.7: Agent's choice of the productivity state versus agent's capital holdings for the BI/consumption tax model.

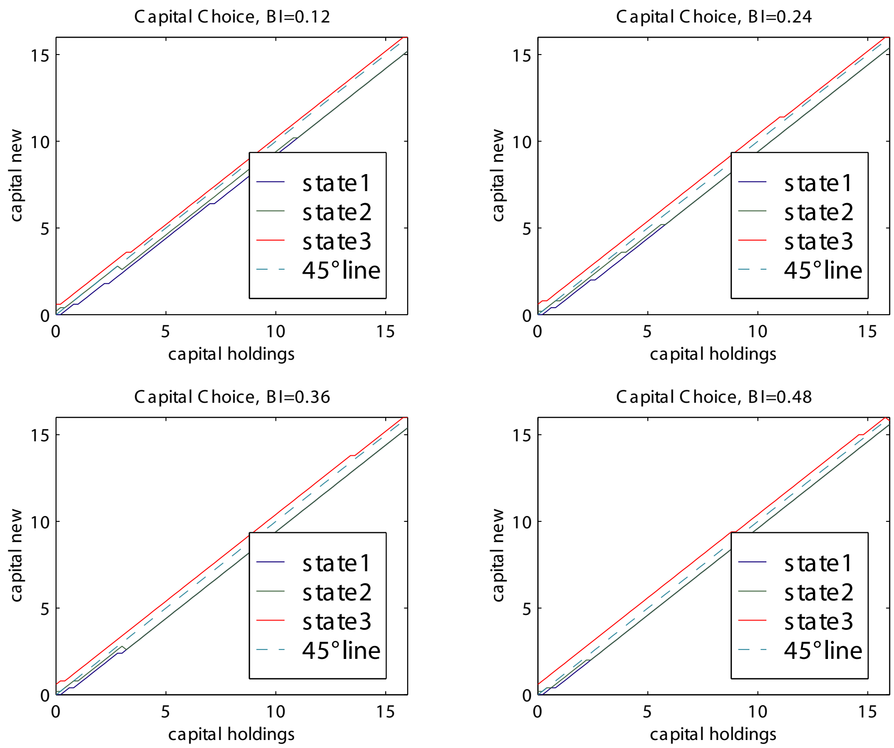

Figure 7.8: Agent's choice of capital k' versus agent's capital holdings k for the BI/consumption tax model.

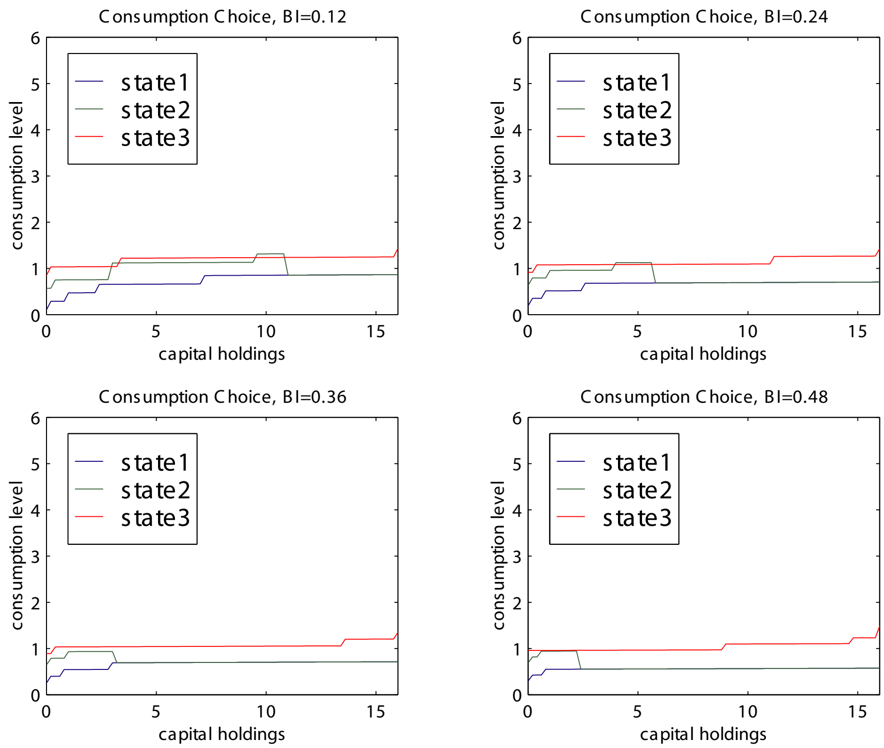

Figure 7.9: Agent's choice of consumption versus agent's capital holdings for the BI/consumption tax model.

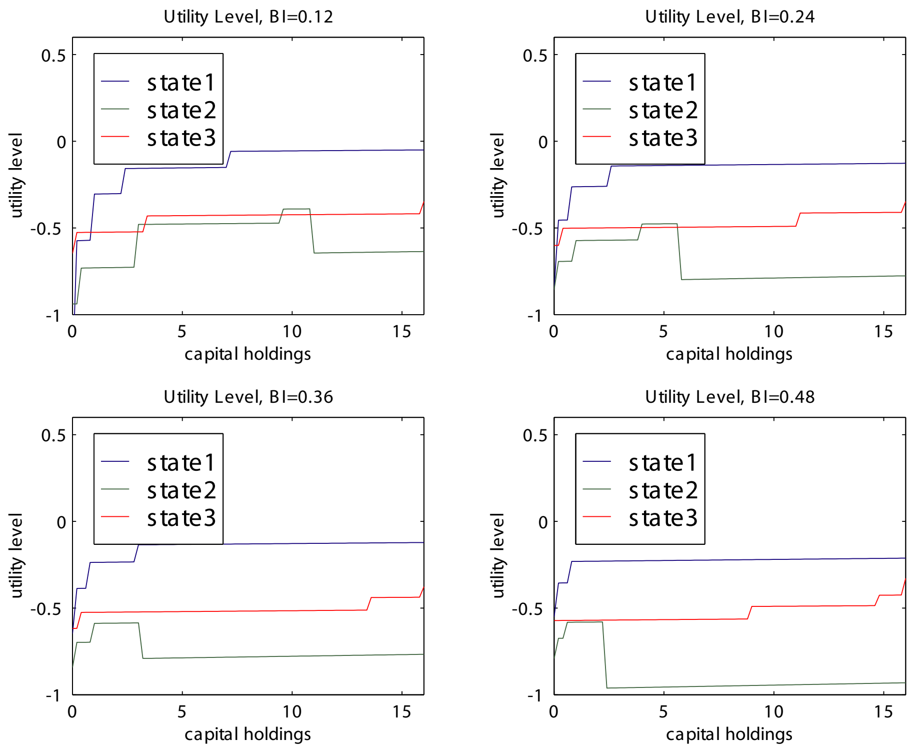

Figure 7.10: Agent's utility level versus agent's capital holdings for the BI/consumption tax model.

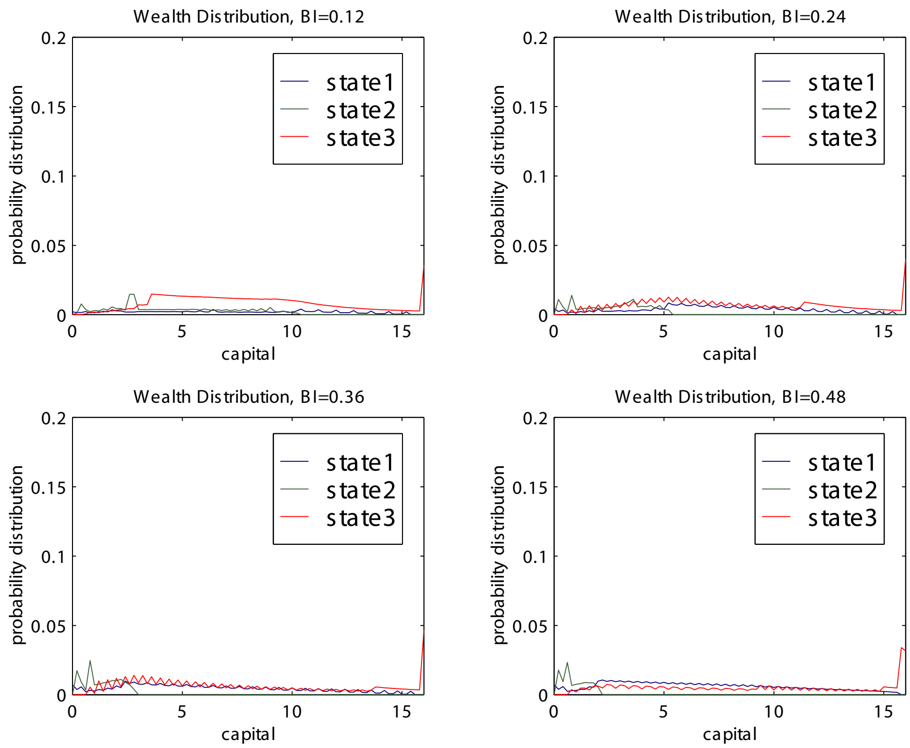

Figure 7.11: The wealth distribution for the BI/consumption tax model.

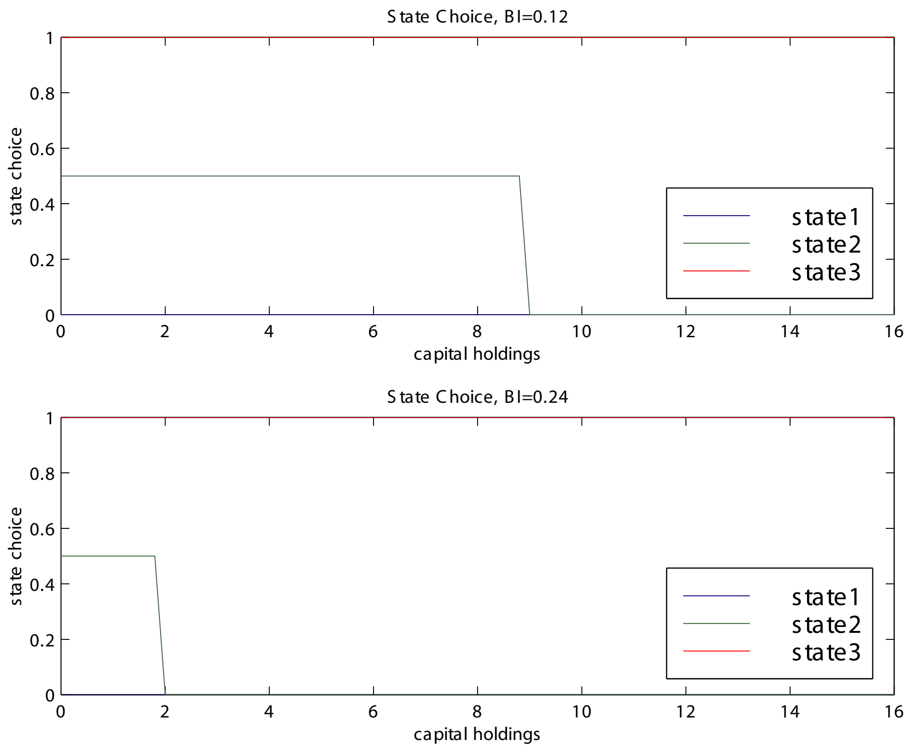

Figure 7.12: Agent's choice of the productivity state versus agent's capital holdings for the BI/flat tax model.

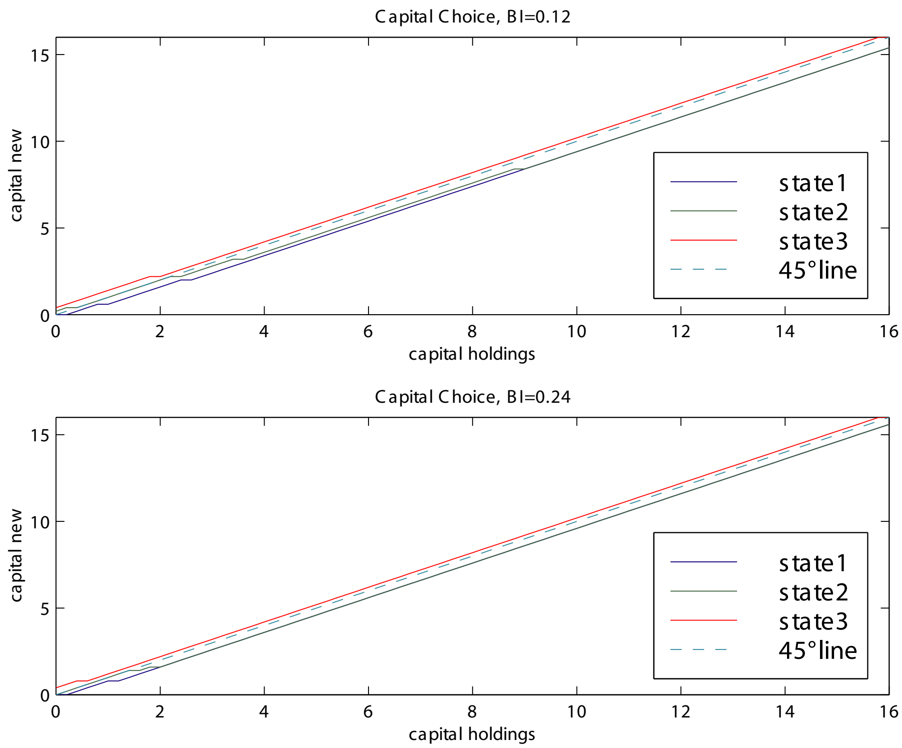

Figure 7.13: Agent's choice of capital k' versus agent's capital holdings k for the BI/flat tax model.

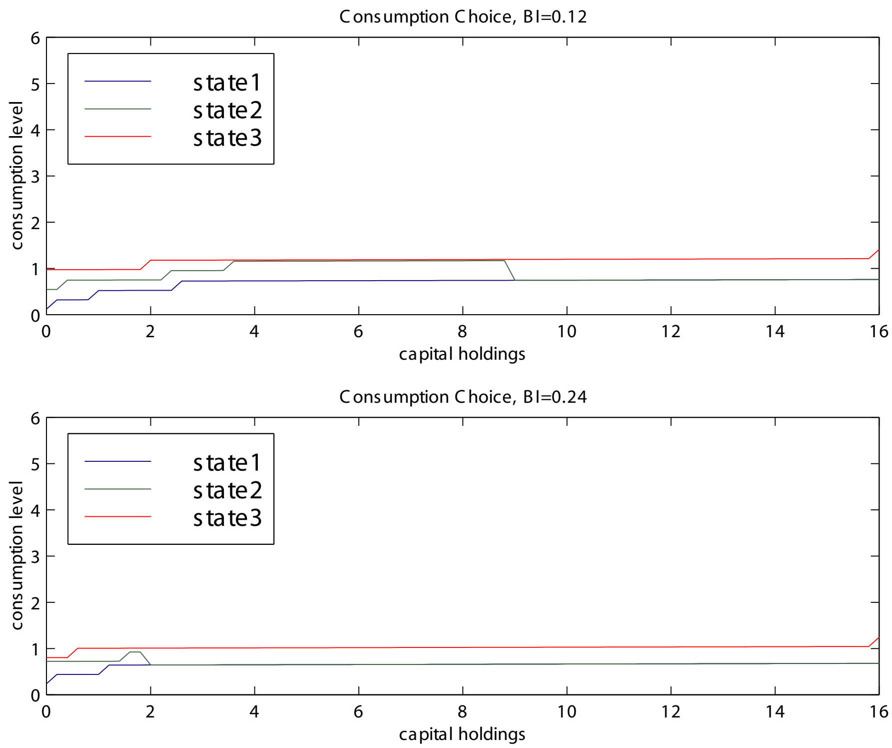

Figure 7.14: Agent's choice of consumption versus agent's capital holdings for the BI/flat tax model.

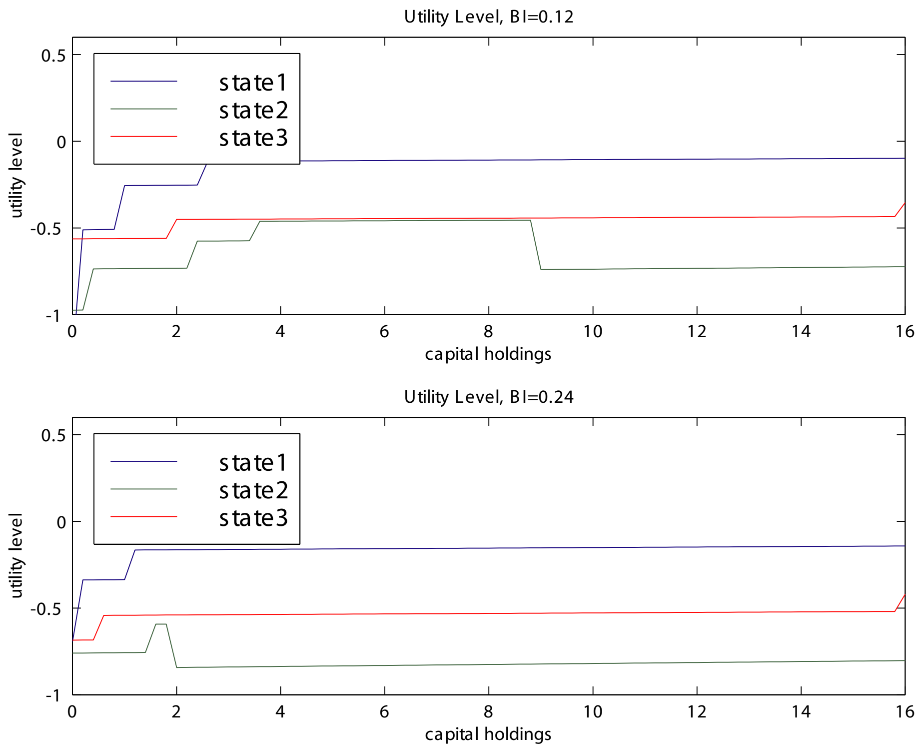

Figure 7.15: Agent's utility level versus agent's capital holdings for the BI/flat tax model.

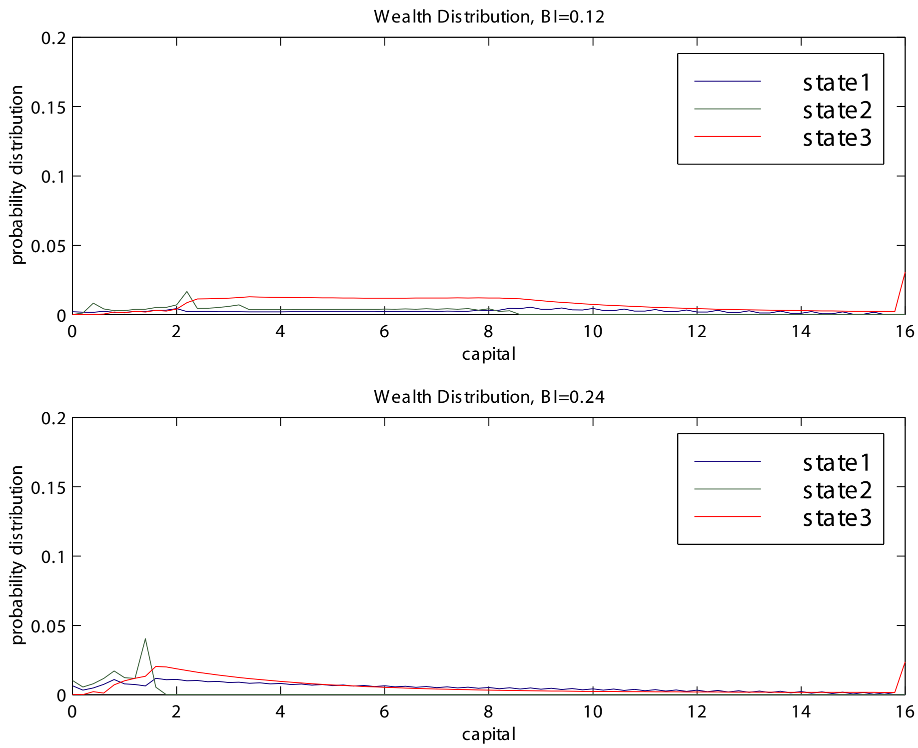

Figure 7.16: The wealth distribution for the BI/flat tax model.

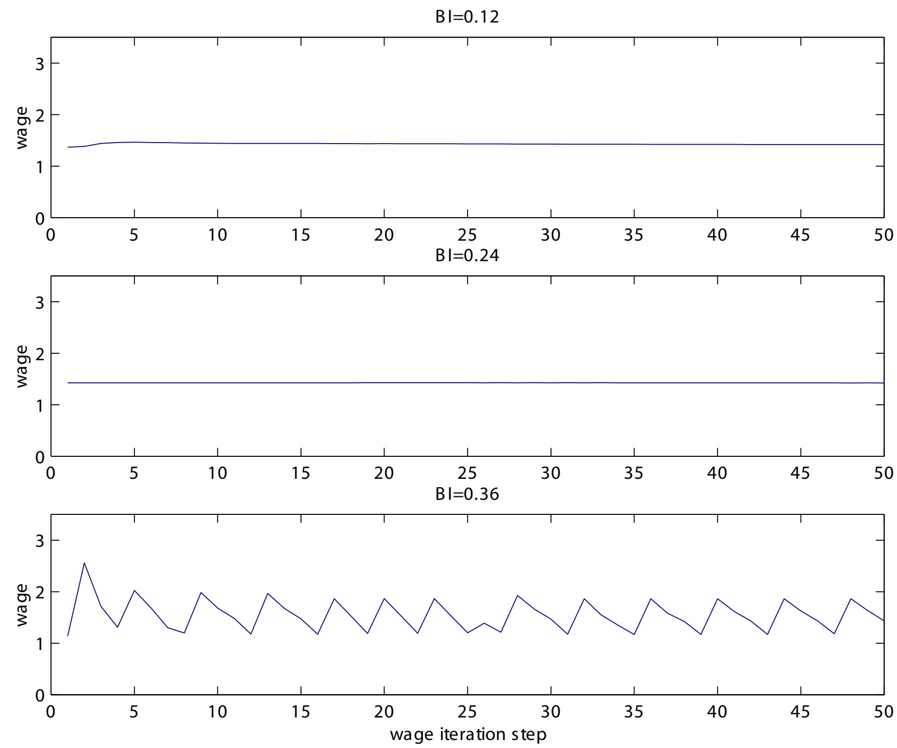

Figure 7.17: Convergence behaviour of wages for the BI/flat tax model.

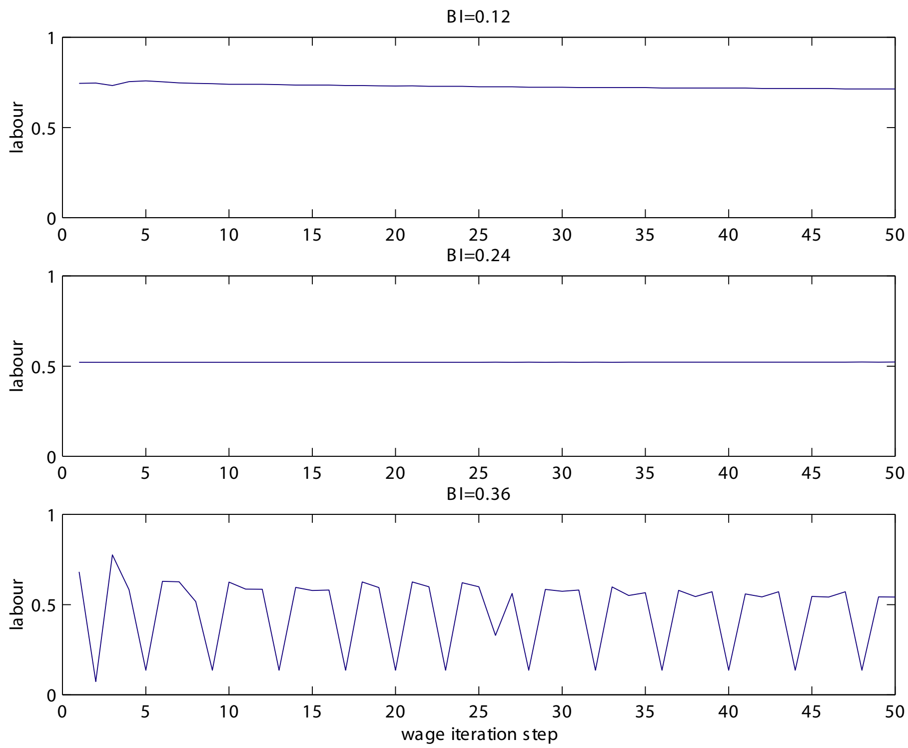

Figure 7.18: Convergence behaviour of labor for the BI/flat tax model.

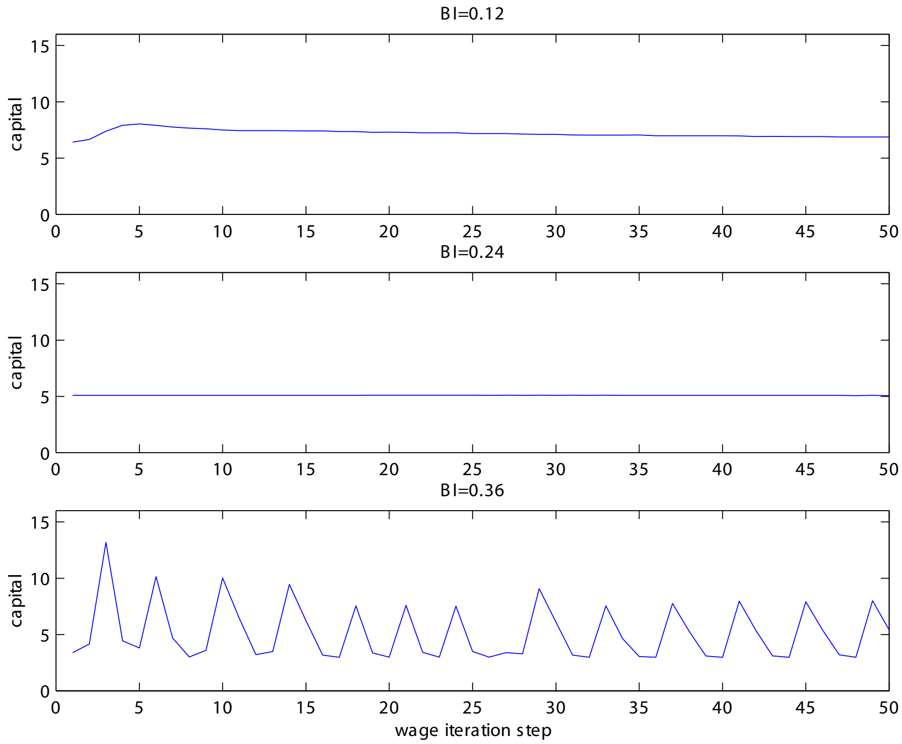

Figure 7.19: Convergence behaviour of capital for the BI/flat tax model.

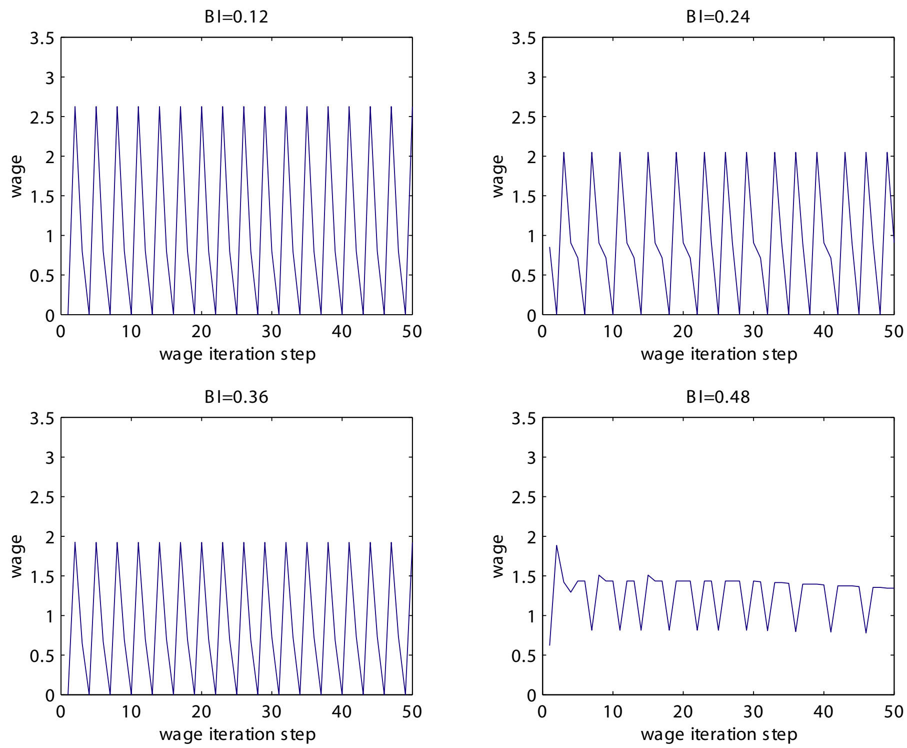

Figure 7.20: Convergence behaviour of wages for the BI/capital tax model.

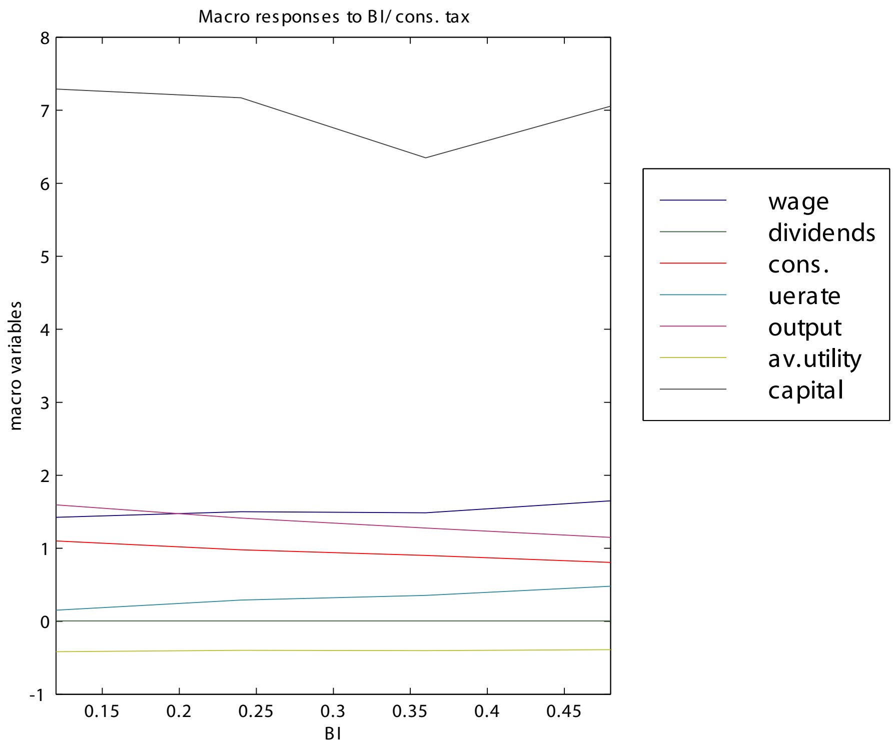

Figure 7.21: Macroeconomic consequences for the BI/consumption tax model.

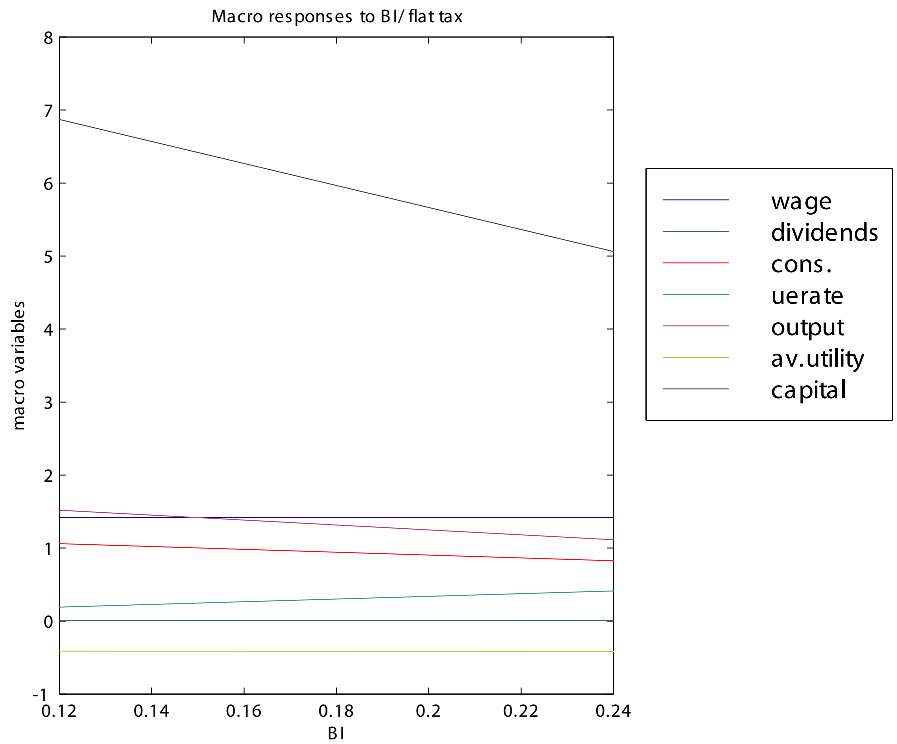

Figure 7.22: Macroeconomic consequences for the BI/flat tax model.

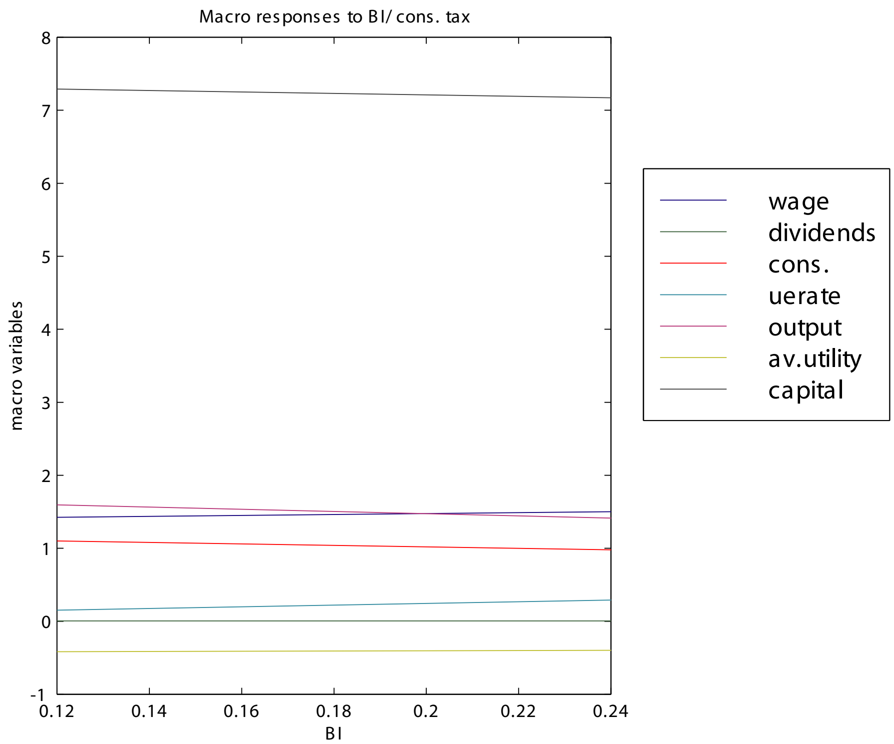

Figure 7.23: Macroeconomic consequences for the BI/consumption tax model.

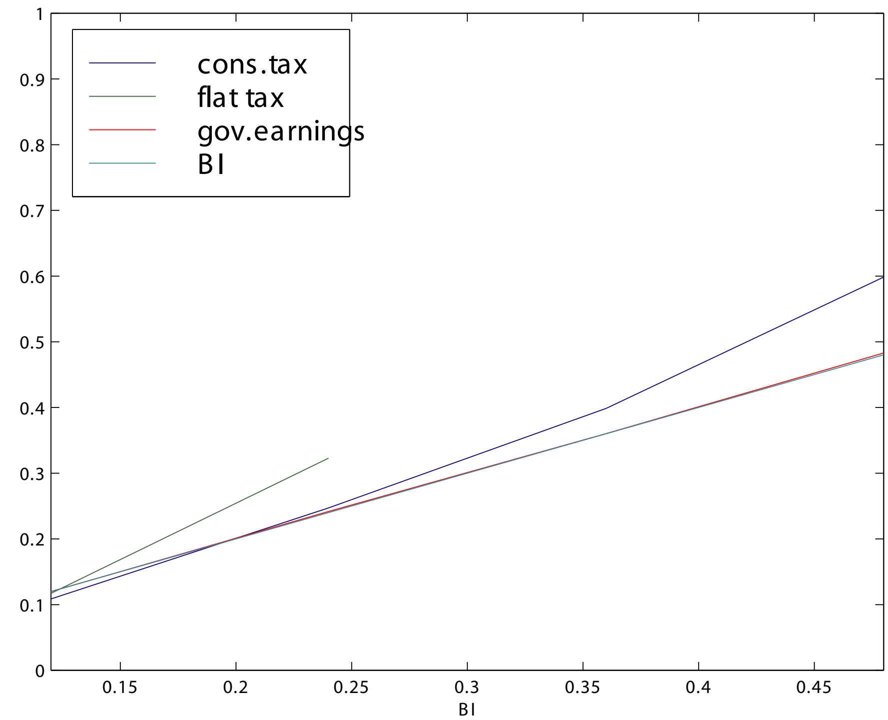

Figure 7.24: Balanced budget tax rates versus BI.

8 Tables

	$BI = 0$	$BI = 0.12$, τ^c	$BI = 0.24$, τ^c	$BI = 0.36$, τ^c	$BI = 0.48$, τ^c
τ	0	0.1087	0.2471	0.3986	0.5984
uerate	0.1196	0.1530	0.2908	0.3545	0.4802
k	7.0055	7.2899	7.1706	6.3497	7.0557
n	0.7755	0.7467	0.6277	0.5727	0.4641
y	1.6151	1.5959	1.4136	1.2770	1.1496
c	1.1245	1.1013	0.9784	0.9037	0.8072
w	1.2231	2.0470	1.8132	1.6379	1.4745
u	-inf (-0.4661)	-0.4152	-0.3963	-0.4006	-0.3875

Table 8.1: Macroeconomic consequences of consumption tax financed BI

	$BI = 0$	$BI = 0.12,\ \tau^c$	$BI = 0.12,\ \tau^l$	$BI = 0.24,\ \tau^c$	$BI = 0.24,\ \tau^l$
τ	0	0.1087	0.1172	0.2471	0.3228
uerate	0.1196	0.1530	0.1912	0.2908	0.4122
k	7.0055	7.2899	6.8703	7.1706	5.0617
n	0.7755	0.7467	0.7137	0.6277	0.5228
y	1.6151	1.5959	1.5182	1.4136	1.1143
c	1.1245	1.1013	1.0601	0.9784	0.8258
w	1.2231	2.0470	1.2514	1.8132	1.2638
u	-inf (-0.4661)	-0.4152	0.4120	-0.3963	-0.4148

Table 8.2: Macroeconomic consequences of consumption vs. flat tax financed BI

	no wage	low wage	high wage
BI=0	0.1196	0.2097	0.6707
BI=0.12,τ^c	0.1530	0.2006	0.6464
BI=0.12,τ^l	0.1912	0.1902	0.6186
BI=0.24,τ^c	0.2908	0.1630	0.5462
BI=0.24,τ^l	0.4122	0.1300	0.4578
BI=0.36,τ^c	0.3545	0.1457	0.4998
BI=0.48,τ^c	0.4802	0.1114	0.4083

Table 8.3: The distribution of the population over the productivity states for different BI levels and tax schemes

	no wage	low wage	high wage
BI=0	0.6391	0.8068	1.3104
BI=0.12,τ^c	0.7119	0.9888	1.2283
BI=0.12,τ^l	0.6937	0.9852	1.1963
BI=0.24,τ^c	0.6618	0.9558	1.1538
BI=0.24,τ^l	0.6311	0.7300	1.0282
BI=0.36,τ^c	0.6552	0.8699	1.0899
BI=0.48,τ^c	0.5541	0.8893	1.0825

Table 8.4: Weighted average consumption levels divided by income groups

	no wage	low wage	high wage
BI=0	-inf (-0.4147)	-0.7192	-0.3962
BI=0.12,τ^c	-0.1552	-0.5709	-0.4284
BI=0.12,τ^l	-0.1529	-0.5729	-0.4426
BI=0.24,τ^c	-0.1636	-0.5806	-0.4651
BI=0.24,τ^l	-0.1803	-0.7536	-0.5298
BI=0.36,τ^c	-0.1669	-0.6371	-0.4974
BI=0.48,τ^c	-0.2314	-0.6265	-0.5058

Table 8.5: Weighted average utility levels divided by income groups

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I hereby confirm that I have authored this diploma thesis independently without use of any others than the indicated resources.

Angela Fiedler, August 21, 2007