UNEMPLOYMENT BENEFITS FOR HETEROGENEOUS WORKERS

THE DANISH WELFARE STATE IN A TURBULENT ENVIRONMENT

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ABSTRACT

This thesis examines unemployment benefits in a framework with heterogeneous agents in a model calibrated for the Danish economy. Initially the analysis utilizes the general equilibrium search model developed by Ljungqvist and Sargent (1998), who use it to explain an increase in unemployment in Europe, through the introduction of economic turbulence in terms of skill shocks. This model is extended by introducing a two-tier benefit system, mimicking the one currently observed in Denmark with limited benefit durations and re-entitlement periods. The results show that these policies diminish the effect of the turbulence, which in turn indicates that the conclusions from the original paper are not robust, and the model is deemed unfit to explain the observed empirical data. Furthermore the results point to a less generous welfare state being superior to that of the current one, even though the continuous implementation of limited durations has improved the efficiency of the state significantly. This is mainly due to disincentive effects observed for the highly skilled part of the population, which can be lowered significantly with a lower replacement rate. These results are however ambiguous, due to the exclusion of active labor market policies in the model, which could have the potential to legitimize a higher replacement rate. Finally the aspect of heterogeneous workers is analyzed in the extended model, where it is found that this dynamic introduces important incentives, through the risk of losing skills and the potential for accumulating skills. These effects still appear to be dominant when introducing the two-tier system, and the skill mechanism is a powerful tool when modeling worker incentives and income differences.

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ACRONYMS

E	Employed and eligible for unemployment insurance
N	Employed and ineligible for unemployment insurance
SA	Social Assistance
UI	Unemployment Insurance
LF	Laissez-Faire economy
LS	Ljungqvist and Sargent model
$c(s)$	Search costs given search intensity
D	Duration
I	Income
I_g	Government set income threshold
s^*	Optimal search intensity
$b(I)$	Level of UI payments given income, I
w	Wage
$\bar{w}_i$	Reservation wage for $i \in SA, UI, N, E$
z	Level of SA payments
β	Discount factor
γ	Probability of losing UI eligibility
ϕ	Probability of gaining UI eligibility
λ	Probability of layoff
μ_e	Skill transition probability, employed
μ_u	Skill transition probability, unemployed
μ_l	Skill transition probability, layoff
$\pi(s)$	Job search function given search intensity
Π	Surplus of job value
ρ	Replacement rate
τ	Tax rate
χ	Degree of economic turbulence

1 INTRODUCTION

In a welfare state the concept of unemployment insurance (UI) functions as a way of stabilizing lifetime income for risk-averse agents. In the absence of UI, these workers could suffer great income losses from layoffs which would lead to volatile consumption levels, assuming they are incapable of individually accumulating the necessary savings. Since governments should at least in some part act as a social planner, which seeks to optimize the lifetime wellbeing of households, the introduction of an UI scheme in an economy with volatile labor market states can be an improvement to the population. A central question then regards the specific construction of such a scheme. UI systems have long been discussed because of the potential downsides that are associated with these policies. These mostly relate to incentive theory, since higher benefit levels and durations for unemployed citizens can diminish the incentives for finding a new job, and therefore cause more frequent and extended periods of unemployment. Additionally adverse selection and moral hazard issues can arise, since the institution supplying the benefits (governmental or private) suffers from asymmetric information and limited monitoring of the skills, the effort, etc. of the agent. It is with all this in mind that policy makers have to decide on a construction of the UI system that offers incentives for the workers to reduce their time spent in unemployment. This especially becomes critical in times of recession or depression, since extreme negative shocks or turbulent times have the potential to destroy the equilibrium of the welfare economy, if the number of unemployed increases drastically, which in turn causes devastating government expenditure.

The subject of unemployment benefits has received a lot of attention over the last 40 years, starting with seminal papers by Mortensen (1977), Burdett (1979), and Shavell and Weiss (1979). The two former find adverse effects regarding the incentives for the unemployed to find a job when benefit durations are limited, which can lead to longer unemployment periods. On the other hand, Mortensen finds a positive entitlement effect, since non-insured workers want to obtain a job in order to qualify for benefits. Baily (1978) was one of the first to look at the ingredients for an optimal UI scheme, and looked at the correlation between benefits and unemployment duration, the drop in consumption when unemployed, and risk aversion for workers. Shavell and Weiss were the first to really study the benefit profile of a UI system, where they found that the UI payments over time should decline when moral hazard issues are present. This has later been confirmed by additional other studies. Later on Gruber (1997) finds positive effects characterized by a smoothing of lifetime consumption, which will be superior for risk averse agents.

This thesis concentrates on a number of the above mentioned issues concerning UI schemes. Different UI systems are analyzed relative to each other, by looking at the incentives that agents react on in the various environments. In relation to this and in order to differentiate the incentives, the work force consists of heterogeneous agents with regard to skills and income, where the government only has limited abilities to observe these aspects. Therefore, analyzing the dynamics that exists in an environment full of different individuals is one of the main themes.

The thesis' central issue, however, is directly related to the work of Ljungqvist and Sargent (1998, 2008), who analyze an increase in structural unemployment observed in the late 1970s in European countries, and the instability of generous welfare systems in what they call turbulent economic environments. In order to do this, the authors analyze the labor supply by utilizing a general equilibrium search model which incorporate stochastic skill accumulation and deterioration in order to create a heterogeneous work force. By studying the incentives and behaviors of workers in an economy that features unemployment benefits compared to a laissez-faire economy, they find that economic turbulence has a significant effect on the behavior of the agents in the welfare economy. This turbulence is characterized by stochastic losses of human capital or job skills following exogenous layoffs, which is equal to drops in potential income or worker desirability. This definition is inspired by empirical findings concerning income losses following layoffs by Jacobsen, LaLonde, and Sullivan (1993) and a change in the distribution of income observed by Gottschalk and Moffitt (1994).

They find that the increase in structural unemployment observed in the late 1970s in Europe can be explained by considering that the economic environment in later times has been more turbulent than before. They rationalize this change of environment with the spreading of new information technology, declines in government regulations, and more globalization. Following their model, this turbulence has the ability to destabilize the generous welfare states in the European area, who otherwise thrived in tranquil times.

This thesis raises the question of whether or not these results can be found when altering the specifications in order to allow for additional welfare policies. More specifically, it is the introduction of limited insurance durations and re-entitlement periods that will be tested. The model is designed to be re-calibrated to mimic the structure of the unemployment benefit system as it appears in the state of Denmark.

Like most European countries, Denmark utilizes a rather generous unemployment insurance system, where workers have a solid safety net and the country has also experienced sustained increases in unemployment rates since the late 1970s. Therefore the analysis done by Ljungqvist and Sargent (1998, 2008) should also apply to the Danish economy. Historically, the unemployment insurance scheme in Denmark has experienced a number of cutbacks in the last 30 years, where UI durations have decreased and re-entitlement periods have increased. It is mainly the current system that will be used in the calibration, even though the original setup, before the cutbacks, will also be shortly applied. The main aspects and differences that the Danish system incorporates, compared to the original model, is the application of a two-tier benefit system, as well as a rather high replacement rate. Therefore the model constructed by Ljungqvist and Sargent is expanded to include a high-tier benefit state, UI, and a low-tier, nonzero paying state, SA. The high level benefits have a limited duration and, when lost, an agent must retain a job in a certain period of time in order to be re-entitled to the high-tier benefits. By analyzing this model in the same environments as in the original paper, it is possible to test whether or not their model and conclusions are robust to the inclusion of these policies that now exist in most countries in Europe. This, in turn, will be evidence that a persisting level of high unemployment due to increased turbulence is not completely the result of a generous welfare state as proposed by the original paper, but rather due to more complex, unidentified impacts.

The main focus of the thesis is therefore not on the optimal structure of unemployment benefits, since this has been analyzed multiple times, even with a heterogeneous workforce (see for an example Pollak (2007)). The part of the thesis concerning these elements, is partly an exercise within the field of unemployment insurance and heterogeneity, and partly a gateway to the re-analysis of the Ljungqvist and Sargent model, which is where this thesis may bring something new.

The thesis is composed as follows: First a literature review is carried out in Chapter 2 followed by Chapter 3 concerning facts about the Danish unemployment program and the development of unemployment rates. Then Chapter 4 and Chapter 5 introduces the baseline model of the thesis and how the dynamics of the model work. Chapter 6 concerns the calibration of the numerical simulation, which then leads to the initial results which are presented in Chapter 7. A discussion regarding the results is found in Chapter 8, which is followed by an introduction of economic turbulence and skill shocks in Chapter 9 and Chapter 10. Finally Chapter 11 will draw conclusions to the questions presented in this introduction, based on the theoretical results. Additionally, Appendix A presents the source code written in order to numerically solve the problem.

2 LITERATURE REVIEW

The chapter will present some of the existing literature relevant to the aspects of the thesis. Due to the rather vast amount of work within this field of study, it is beyond the scope of this thesis to provide a full review of unemployment and UI systems. The main focus is on the reasons for having an insurance system, the optimal scheme, search and matching theory, and active labor market policies.

Initially the framework used in the thesis will be presented. Within labor economics concerning unemployment, most work is done in the framework of search or matching theory. These models incorporate frictions in the labor market originating from costly and time consuming search for jobs. This in turn leads to steady state unemployment, that better matches what is seen in the empirical findings. The search framework is the simplest and earliest, developed by McCall (1970) and only works with the supply side of the labor market, and therefore it does not include firms. Later on this was extended to the more substantial matching theory framework (see Pissarides (2000) for an introduction to the framework), which featured a bargaining between workers and firms over profits. This led to more opportunities to study the field of unemployment as a whole. The framework has however been criticized for not generating the observed empirical data when analyzing in the context of business cycles (Shimer, 2005).

On the subject of unemployment benefits, there are basically three points of positive effects and two identified negative qualities from UI (Nakajima, 2011, p. 3). Consumptions smoothing, the liquidity effect, and better resulting matches due to the unemployed being less picky are the three positive effects. The consumptions smoothing effect is studied by Gruber (1997), who finds that the introduction of an UI system leads to consumption smoothing that is beneficial to risk averse agents. Second is the liquidity effect presented by Chetty (2008), who argues that when workers are liquidity constrained, a UI system is welfare improving. He still recognizes, however, that it is only one of two effects, since there also exists moral hazard or adverse substitution effects, where the UI system distorts the incentives of the unemployed. The third effect, studied by Acemoglu and Shimer (2000), finds positive sides of the generous benefits, since it allows people to wait for better matches, which causes higher productivity. Since the model presented here does not include liquidity and since the third effect requires a firm side, it is mostly consumption smoothing that is seen as a positive side. The two negative aspects emphasized are the ones of moral hazard and of skill depreciation. The latter is a firm part of Ljungqvist and Sargent (1998), who argues that such depreciation is an important part of the unemployment dilemma in Europe. The former effect is the most common argument against generous benefits, since it is said to it distort the incentive of people, and cause them to act less efficient than without these benefits.

The optimal profile and structure of the benefits have been a majorly researched area, due to the practical implications in the real political economy. In a seminal paper, Shavell and Weiss (1979) show in a principal-agent model that unemployment compensation should decrease monotonically over the duration of unemployment, which has later been confirmed by Hopenhayn and Nicolini (1997). While allowing for human capital depreciation, Pavoni (2009) also finds that a decreasing scheme is optimal. This decreasing benefit compensation supplies the agents with incentives to search actively for a new job, since they realize that an extended unemployment spell will lead to income loss. In contrast, Pollak (2007) analyzes optimal UI schemes with a heterogeneous workforce, calibrated to the German economy, where he finds that the optimal replacement rates should increase with unemployment, since people experiencing short spells of unemployment are capable of self-insurance. If agents are not able to save for unemployment, the prospect of declining benefits does seem superior. In relation to the optimal replacement rate, Crossley and Low (2011) show that the rate varies significantly with variables such as age, presence of children, discount rates and access to credit. This exactly showcases the points regarding consumption smoothing and liquidity constraints, which directly influences the need for unemployment insurance.

It is the feature of declining benefits during unemployment that sets the foundation for the two-tier benefit system. This has been analyzed by Fredriksson and Holmlund (2001) in a general equilibrium matching model who find that such a program unambiguously dominates that of a system with indefinite UI payments. They also find an "entitlement" effect, which was originally presented by Mortensen (1977), where unemployed who are not entitled to high benefits search more intensively for a job, in order to regain entitlement. For a review concerning incentives and optimal unemployment insurance, see Fredriksson and Holmlund (2006).

Concerning the structure of the two-tier benefit system, Hopenhayn and Nicolini (2009) studies a principal-agent model with moral hazard and asymmetric information, and finds that if it is impossible to distinguish between resignations and layoffs, benefits should increase with previous employment spells. In other words, this argues towards having a re-entitlement work period in the benefit system. Kristoffersen (2013) studies optimal UI schemes and finds that a longer reentitlement period can be a substitute for benefit durations. Concerning the UI duration, it has been found to increase the expected unemployment spell by seminal studies such as Moffitt and Nicholson (1982), Moffitt (1985) and Katz and Meyer (1990) who estimate that a 1 week duration increase leads to a $0.1 - 0.2$ weeks increase in expected unemployment duration. Newer studies continue to support this claim, with Farber and Valletta (2013) who look at an extension of benefit durations in the US and also discover a higher expected duration of unemployment. In other economies, Alba, Arranz, and Munoz-Bullon (2012) and Lauringson (2011) show similar effects by looking at exit rates from unemployment.

A final branch of studies is the area of active labor market policies, where the government uses various forms of institutions and policies that helps unemployed people obtain a job faster. Especially in very generous welfare states this can be used to make the system more efficient and remove distortionary effects of unemployment benefits as argued by Keuschnigg and Davoine (2010) and Andersen and Svarer (2014).

3 THE DANISH SYSTEM

The following is an introduction to the danish unemployment benefit system and its historical development [1]. In Denmark there are two tiers of unemployment benefits, where the high one, Unemployment Insurance (*Dagpenge* in danish) is governed by private institutions (*A-kasse* in danish), thus it is required that a worker is a member of one of these organizations in order to qualify for UI. Even though this is governed by private institutions the benefits are highly state subsidized, which also means that the entire sector is highly regulated. Additionally, in order to be eligible a worker must have been a member for more than a year prior to an unemployment period.

For all members there is a limited duration in which benefits can be received, which currently stands at two years within a period of three years. Other limitations come in the form of active labor market policies, where unemployed people are subject to a number of availability requirement. These include being registered at a job center, being able to start working with a day's notice, staying in Denmark during unemployment, actively searching for jobs, and participating in meetings and activities hosted by the job center. Generally, the usage of these policies are very extensive in Denmark, and a more thorough presentation can be seen in Andersen and Svarer (2007).

A full time insured member of the system is subject to a replacement rate of 90% of the average income during the last three months of employment, however with a maximum level of 815 DKK. per work day. This means that the effective replacement rate is a downwards sloping function of latest income. In order to qualify for the system, one must fulfill a certain work requirement, more specifically a worker must have amassed a total $1,924$ working hours within the previous three years, according to current rules.

Concerning the high tier benefits, there have been important cutbacks during the last 25 years, where the re-entitlement and duration periods have been changed. The former used to be 26 weeks, but was doubled in 2010 to 52 weeks, while the latter has been changed multiple times beginning in 1994, where it was lowered from being virtually infinite to being 7 years. During the 1990's this was again lowered to first 5 and then 4 years until 2010, where it was lowered to the current level at 2 years.

The second level of unemployment benefits is the Social Assistance (*kontanthjælp* in danish). This benefit level depends on more param-

1 The description is based upon a number of Danish reports, Mailand (2010), Arbejdsmarkedskommissionen (2009) and information from the Danish Ministry of Labor: http://bm.dk/da/Beskaeftigelsesomraadet/Ydelser/Dagpenge.aspx

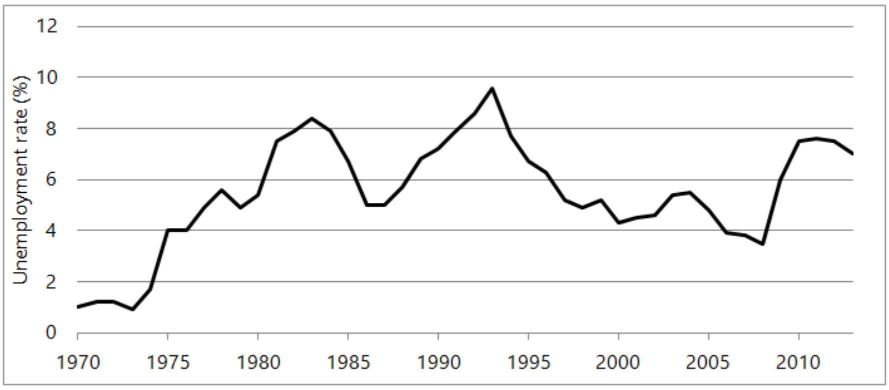


Figure 3.1: Unemployment rate in Denmark from 1970 to 2013. Source: OECD

eters than the UI payments do, since factors like age, children, living place, and mental state are considered. The payments then range from 3, 324 to 14, 203 DKK. Additional restrictions apply, since an unemployed person with any form of wealth is not allowed to collect SA, and a person who are married or lives with a partner suffers proportional deductions in the SA level in relation to the partner's income.

3.1 DANISH UNEMPLOYMENT

As mentioned earlier, the analysis by Ljungqvist and Sargent are based on a change in the unemployment in the European area beginning at the end of the 1970s as seen in figure 1 in Ljungqvist and Sargent (1998, p. 515). In order to show that the same was the case in Denmark, the historical unemployment rate is shown from 1970 to 2013 in Figure 3.1, where it can be argued that the general level of unemployment after the 1970s is at a higher level or at least that it has been very volatile. So it is with this empirical increase in the unemployment rate in mind that the analysis in the thesis is made. Relating this figure to the above section, it could be argued that the decreasing generosity of the danish UI system was a part of the decrease in the unemployment rate experienced from the early 1990s, which would theoretically make sense. However, with the increase during the latest crisis, it is not clear whether or not the unemployment rate would have continued the downwards trend and therefore would violate the assumption made in this section about a higher general unemployment level. Therefore the assumption stands. Concerning levels of unemployment durations, it has not been possible to find statistics dating beyond the mid 1980s for the Danish economy.

This concludes the brief introduction to the Danish welfare system and a look at the development of unemployment. For a more detailed look refer to Andersen (2012); Andersen and Svarer (2007).

4 MODEL AND THEORETICAL FRAMEWORK

4.1 MOTIVATION

The model presented in this thesis is an extension of the general equilibrium McCall search model (McCall, 1970) developed in Ljungqvist and Sargent (1998). To my understanding, the extension concerning the inclusion of a two-tier benefit system into this model and redoing the analysis has not been done. Ljungqvist and Sargent has gone on to include various other aspects, such as *employment protection* (Ljungqvist and Sargent, 2007, 2008), *age groups* (Ljungqvist and Sargent, 2008), and different model specifications of search and matching models (Ljungqvist and Sargent, 2004, 2007), but never a two-tier benefit program. In such a system, the unemployed are only allowed to obtain relatively high benefits, which depends on previous earnings, for a limited period of time, after which they collect a lower, flat rate of social assistance instead. I then go on to analyze whether or not the inclusion of such a system can alter the adverse effects of a turbulent economic environment as analyzed by Ljungqvist and Sargent (1998), since the probabilities of losing the generous benefits should alter the incentives of workers. The model has also been challenged earlier by den Haan, Haefke, and Ramey (2001), whose results, however, were the product of changes in underlying assumptions and were therefore dismissed. This will be presented more thoroughly in Section 9.2. The extension of the model, as well as the general analysis of the dynamics of a heterogeneous workforce, are my main motivations for analyzing this exact model.

4.2 INTRODUCTION

The model functions in discrete time space, where a constant continuum of workers act in a labor market, and where they are either employed at an exogenously drawn wage level or unemployed and looking for work. Opposite stands a government, who collects taxes and redistribute these as unemployment benefits, depending on specific information about the unemployed. Workers are assumed to behave rationally given their information sets at any given point in time, and have full information on the distribution associated with wages and the probabilities regarding job search, firing, and benefit durations.

4.3 WORKERS

The workers in this model live infinitely and form a constant population mass.

The first and most important element of heterogeneity is the skill variable, h, referring to a workers skill level, which increases and deteriorates during employment and unemployment, respectively. The finite number of skill levels should be viewed as a mix of human capital and specific job skills, which here refers to a production factor consisting of skills, competencies, and knowledge of workers accumulated during their life. The skill transition is governed by a Markov process, meaning that the conditional probability distribution of future states of the process depends only on the present state, and not on the sequence of previous states that predates it. More formally,

$$P(X_{t+1} = x_{t+1} | X_t = x_t, \ldots, X_0 = x_0) = P(X_{t+1} = x_{t+1} | X_t = x_t),$$

where P is a probability operator and X_t is a random variable at time t with a state space equaling the number of skill levels.

This means that the transition of skill levels only depends on the employment status of the worker at that given point in time. During employment, the worker faces a probability $\mu_e(h, h')$ of improving to a higher skill level h' at the beginning of the next period, and a probability $1 - \mu_e(h, h')$ of staying at the same level. Similarly, the stochastic deterioration during unemployment happens at the probability $\mu_u(h, h')$, where $h > h'$. The last transition probability occurs immediately after a layoff, and is given by $\mu_l(h, h')$, where $h > h'$, which only persist for one period. After this the worker is unemployed and confronts the normal unemployment transition probability until finding a job with a suitable wage rate. Within this, it is also assumed that workers cannot lose skills while employed, and similarly that the unemployed are not able to experience any skill increase. Additionally this system functions such that it is only possible to change one skill step at a time during employment and unemployment. Therefore if an employed agent experience a stochastic skill increase, she can only reach the next skill level in the progression during this step. This does not necessarily apply to the layoff transition, where multiple skill levels can be lost, which will be the case in Chapter 9. Formally the following applies,

$$\begin{aligned}
&\mu_e(h, h') = 0 \quad \forall\, h' < h && \mu_e(h_i, h_j) = 0 \quad \forall\, j \neq \{i, i+1\} \\
&\mu_u(h, h') = 0 \quad \forall\, h' > h && \mu_u(h_i, h_j) = 0 \quad \forall\, j \neq \{i, i-1\} \\
&\mu_l(h, h') = 0 \quad \forall\, h' > h,
\end{aligned}$$

where the prime in h' symbolizes the next round skill level, and the i, j indexes symbolize the specific entries in the skill level vector.

In the beginning of each period, the worker starts out by observing her current skill level. Based on this information set, the worker's objective is to optimize the expected value of after-tax income,

$$\max_{y_{t+i}} E_t \sum_{i=0}^{\infty} \beta^i y_{t+1},$$

where E_t is the rational expectation operator given the information present at time t, β is a discount factor, and y_{t+i} is the after-tax income in period $t+i$ after subtracting potential search costs.

4.4 POPULATION

In order to introduce search frictions into the economy, the mass of workers experience stochastic shocks that move them in and out of employment. These stochastic transitions are governed by Poisson processes, where the different events have individual probabilities, which will be introduced separately for employed and unemployed agents.

4.4.1 *Unemployment*

Unemployed agents are split into two different groups, which again functions as an element of heterogeneity. The first group consists of the people receiving unemployment insurance (UI), where a replacement rate, ρ, decides how much an unemployed agent receives in benefits, $b(I)$, in each round. The level of benefits is a discrete function increasing in the level of earnings, I, that the agent received in her last job. This unemployed agent chooses a search intensity, which represents the amount of work and time, the person invests into finding a new job. A function, $\pi(s)$, which is concavely increasing in the search intensity, s, governs the probability of finding a new job in each period. It is assumed that $\pi(s) \in [0, 1]$. The function only controls the probability of encountering a job offer, which means it is independent of the wage rate the job offer presents. Searching does not necessarily lead to a job offer, but if one is encountered the wage is decided by a random draw from the wage distribution, $F(w) = Pr[w_{t+1} \leqslant w]$. The offered wage is subsequently accepted or rejected, based on the reservation wage of the specific agent. Rejection of an offer leads either to continued UI with probability $1-\gamma$ or to social assistance (SA) with probability γ given that the rejected wage is below a threshold decided by the government. If the proposed wage is above or equal to this threshold, a rejection leads to SA status no matter what. With probability $1-\pi(s)$ no offer has been received and the agent remains in unemployment. Here the person experiences a probability γ of being demoted to SA. This rate is exogenously given and concerns the finite duration for which an unemployed person is allowed to receive

UI. The expected duration of the high tier benefits is therefore $\frac{1}{\gamma}$. At the time of choosing to accept or reject an offer, the agent is aware of whether or not she is still eligible for UI benefits.

The second group of unemployed are subject to the lower tier benefit program, SA. An agent in this group collects payment, z, each period, which is a flat rate decided by the government. By definition, this benefit level will always be smaller or equal to the UI benefits, which in other words means that the value, z, also defines the minimum level of $b(I)$. This group of people are subject to the same search function as the UI group, where a person chooses a search intensity that may or may not lead to a job offer. If no job offer is received, the agent will stay in SA for the next period. On the other hand, if an offer has been obtained, it is subsequently accepted or rejected. Since there is no lower group of benefits, a rejection will only lead to the agent staying in the SA pool. In the same sense, there is no income threshold set by the government, since there is no lower group to place the unemployed person in.

Identical for all groups is the fact that searching for a job causes immediate dis-utility for the unemployed. The intuition behind this is that the person must invest time and work into searching at higher intensities. This means less time for leisure, and it is also assumed that nobody truly likes to look for jobs, thus searching is always a cost. This leads to a search cost function, $c(s)$, that increases in the search intensity, s.

4.4.2 *Employment*

Employed workers are split into two groups, depending on whether the worker is eligible for UI if she were to be fired.

The first group of employed agents are the ones who qualify for UI (denoted E), and who have accepted a wage, w, that will apply until the person either is fired or resigns from her job. This implies further that on-the-job search is excluded from the model. A worker is exogenously fired with rate λ, and if fired the worker shifts to the UI state.

The second group are the employed workers (denoted N), who have not yet been working long enough to be eligible for receiving UI in case of a layoff. This group also face an exogenous probability of being laid off, λ, which then leads to a shift to the SA state. On the other hand, if the person does not get fired in a period, she can either advance to state E or stay at N with probabilities ϕ and $1-\phi$ respectively. The parameter ϕ is exogenously given, and $\frac{1}{\phi}$ denotes the duration that a worker must expect to work in order to (re)qualify for UI.

A worker's income is the product of her wage and current skill level, $w \times h$. This implies that even though the wage is constant during employment, the income can increase until the top skill level has been reached. Each period the worker chooses whether to keep working given her current skill level and wage. This leads to the reason for why any worker would want to quit a job that was initially accepted. When the skill level increases it can become more valuable to quit, especially if the initial wage rate was rather low, since the worker can only increase a certain amount of skill levels. The alternative to keeping the job is to be shifted to SA, since by definition the wage an employed works at is above the threshold set by the government. This is due to wage level being set as a percentage of the workers latest income divided by her current skill level. So quitting a job is viewed the same way as rejecting a job offer with a wage above the government threshold.

4.5 GOVERNMENT

In this model, the government operates as the insurer, even though this does not exactly mimic the Danish system, where unemployment insurance is handled by private firms. This error is disregarded, since the UI institutions are under strict government policies and since the model primarily concerns the worker incentives, meaning that the government side is not the essential issue. There are however differences between running a state governed UI program and letting private institutions do this, since memberships are required in the latter, which introduces the possibility of adverse selection problems regarding workers. This is however not within the scope of this thesis.

The task of the government, therefore, is to supply the unemployed with benefits, regardless of which benefit group they belong to. Taxes are then levied on the population in order to finance these benefit expenses. This tax is a percentage of an agent's income τ, and the entire population is taxed no matter the status of the specific person, since this is the case in the Danish system. The government has limited monitoring powers, since it only has knowledge of a person's total income, not the wage nor skill level. By monitoring the income, an unemployed is offered when encountering a new job, the government is able to enforce a minimum level of earnings, $I_g(I)$. If an offer implying this level of income or above is rejected, the agent loses her claim on UI, since the offered earning level is deemed suitable. By assumption, the claim on SA cannot be lost in this fashion, due to simplification. This income level threshold depends on the level of previous earnings, since it equals the received amount of benefits, $b(I)$. The sanction of losing the UI status is not a permanent state, since the worker can regain eligibility for the UI program by being reemployed and holding the job for an extended period of time. It is additionally assumed that the government runs a balanced budget in the steady state, thus the taxes received equals the benefits supplied to the unemployed. Formally, the budget constraint is

$$\begin{aligned}
&\sum_h \left[\int_{\bar{w}_E(h)} e_E(w,h)\tau wh \; dw + \int_{\bar{w}_N(h)} e_N(w,h)\tau wh \; dw \right] \\
&+ \tau \Big[\sum_h [u_{SA}(h) \cdot z] + \sum_{I,h} [u_{UI}(I,h) \cdot b(I)] \Big] \\
&= (1-\tau) \Big[\sum_h [u_{SA}(h) \cdot z\,] + \sum_{I,h} [u_{UI}(I,h) \cdot b(I)] \Big], \qquad (4.1)
\end{aligned}$$

where the left side represents tax revenues and the right is total benefits paid to the two types of unemployed agents. $e_E(w,h)$ and $e_N(w,h)$ are the masses of employed people in the two states, respectively, who earn the wage, w and have the skill level, h. This mass then pays taxes, τ, of their income, wh. The bottom limits on the integrals are the reservation wages for each state. This is the lowest wage level that a person in that state will be willing to work at, which changes with skill levels. The upper level is naturally restricted by the highest possible wage level. Similarly, $u_{SA}(h)$ and $u_{UI}(I,h)$ are the masses of unemployed people in each unemployment state. They receive benefits, z and $b(I)$, respectively, where they pay a percentage, τ, back to the state and keep the rest, $1-\tau$, for themselves. These unemployment masses both depend on current skill level, h, and the UI recipients also depends on latest earnings, I, since their reservation wages and search intensities change with these variables. This will be shown later in Chapter 7.

4.6 BELLMAN EQUATIONS

By putting together the information from the previous sections, four main value functions can be defined for each of the four possible labor market states, as well as two stated for simplicity. First of all the value of the optimization problem for an employed worker in state E is $V_E(w,h)$, which depends on the wage of the worker, w, and the current skill level, h. Secondly the optimization problem regarding an employed worker in state N is $V_N(w,h)$, which also depends on the accepted wage and current skill level. For an unemployed agent in the UI group the value function is denoted by $V_{UI}(I,h)$, which depends on the last earnings that the worker experienced, I, as well as her current skill level, h. The last main value function is the problem facing an unemployed agent receiving SA, which is defined as $V_{SA}(h)$. This value only depends on the current skill level, h, since the income for SA recipients is independent of last earnings or wages. Finally two functions concerning the value of keeping a job, $J_E(w,h)$ and $J_N(w,h)$, are defined in order to simplify the other functions and some future equations. Thereby the Bellman equations can be written as,

$$V_E(w,h) = \max_{\text{accept, reject}} \Big\{ J_E(w,h), V_{SA}(h) \Big\} \tag{4.2}$$

$$V_N(w,h) = \max_{\text{accept, reject}} \Big\{ J_N(w,h), V_{SA}(h) \Big\} \tag{4.3}$$

$$\begin{aligned} V_{UI}(I,h) = \max_s \Big\{ & -c(s) \\ & + (1-\tau)b(I) + \beta \sum_{h'} \mu_u(h,h') \\ & \times \Big[\Big(1-\pi(s)\Big)\Big(\gamma V_{SA}(h') + (1-\gamma)V_{UI}(I,h')\Big) \\ & + \pi(s)\Big(\gamma \int V_N(w,h')dF(w) \\ & + (1-\gamma)\Big[\int_{w \geqslant \frac{Ig(I)}{h'}} V_E(w,h')dF(w) \\ & + \int^{w < \frac{Ig(I)}{h'}} \max_{\text{accept, reject}} \Big\{ J_E(w,h'), V_{UI}(I,h') \Big\} dF(w) \Big]\Big)\Big]\Big\} \end{aligned} \tag{4.4}$$

$$\begin{aligned} V_{SA}(h) = \max_s \Big\{ & -c(s) + (1-\tau)z + \beta \sum_{h'} \mu_u(h,h') \\ & \times \Big[\Big(1-\pi(s)\Big)V_{SA}(h') + \pi(s)\int V_N(w,h')dF(w)\Big]\Big\} \end{aligned} \tag{4.5}$$

$$\begin{aligned} J_E(w,h) = & \ (1-\tau)wh \\ & + \beta\Big[(1-\lambda)\sum_{h'} \mu_e(h,h')V_E(w,h') \\ & + \lambda \sum_{h'} \mu_l(h,h')V_{UI}(wh,h')\Big] \end{aligned} \tag{4.6}$$

$$\begin{aligned} J_N(w,h) = & \ (1-\tau)wh \\ & + \beta\Big[(1-\lambda)\sum_{h'} \mu_e(h,h')\Big[\phi V_E(w,h') + \\ & (1-\phi)V_N(w,h')\Big] + \lambda \sum_{h'} \mu_l(h,h')V_{SA}(h')\Big] \end{aligned} \tag{4.7}$$

The solution to this equation system is governed by a number of decision functions concerning reservation wages and search intensities. The former concerns the decision a worker must make on either to accept/retain a job or to go into unemployment, where the reservation wage pins down the lowest wage level that a worker will accept. The latter concerns the intensity with which an unemployed will search for a new job, which then obviously only relates to state SA and UI. At the time of these choices, the worker is aware of which of the four states she is currently positioned in, where each state has an individual reservation wage - and search intensity function. First the state of employment, E, which is associated with the reservation wage, $\bar{w}_E(h)$. Here the worker has a choice between retaining her job in state E, or transferring to the low tier benefits, z, in state SA. Quitting a job will automatically lead to state SA, even though the worker does qualify for the high level benefits, UI. This is due to the government income threshold, $I_g(I)$, which will always be lower than the worker's current income level. Therefore the reservation wage only depends on the current skill level, h, since the worker's only alternative to accepting is state SA, which only depends on h. The dependence on current skill level also comes from the properties of the Markov chain, where accepting a job leads to the potential for reaching higher levels, while rejecting one can mean even further deterioration of skills. Second is the employment state N, in which the choice stands between continuing a job in state N, or settling with the low level benefits, z, in state SA. The reservation wage here is defined as $\bar{w}_N(h)$, which again depends only on the current skill level for practically the same reason as for state E. Third is the unemployment state SA, where the unemployed in a period decides an optimal level of search intensity, $s^*_{SA}(h)$, which then may or may not lead to a job offer in the following period. This depends on the current skill level for the same reasons as the reservation wages explained above. If such an offer is received, the unemployed can either accept and transition to employment state, N, or reject and stay in unemployment. This is exactly the same decision that an employed in state N has to make which means that,

$$\bar{w}_{SA}(h) = \bar{w}_N(h).$$

The fourth and last state contains the unemployed who receive the high tier benefits, UI. Again a level of search intensity is chosen, where the optimal is defined as $s^*_{UI}(I, h)$. This depends on the current skill level and last earnings, where the latter is due to the fact that this directly relates to the level of UI benefits an agent receives. If a job offer is obtained, the person must decide whether to accept and transfer to employment state E or reject and either return to state UI or transfer to state SA, if the rejected wage leads to an income that is higher than the government determined suitable income. Therefore the reservation wage for state, UI, is defined as a separated function,

$$\bar{w}_{UI}(I, h) = \begin{cases} \bar{w}_E(h) & \text{if } w \geqslant \frac{I_g(I)}{h}, \\ \bar{w}_{UI}(I, h) & \text{if } w < \frac{I_g(I)}{h}, \end{cases} \tag{4.8}$$

which depends on current skill level, h, and last earnings, I.

To summarize, the model is only associated with three individual reservation wage functions, $\bar{w}_{UI}(I, h)$, $\bar{w}_N(h)$, and $\bar{w}_E(h)$ and two optimal search intensity functions, $s^*_{SA}(h)$ and $s^*_{UI}(I, h)$. These optimal functions are used in order to solve the equations regarding population dynamics to find the time-invariant, steady state employment- and unemployment distributions.

4.7 LIMITATIONS & EXTENSIONS

The extended model, I propose, does have some limitations that I would like to discuss and present. The framework of the model is a one-sided search model, which does not utilize any matching properties as developed by Diamond, Pissarides and Mortensen[1]. This leads to a number of issues. There is no firm side of the model, which means that everything on that side, such as production functions and decisions on job creation/destruction are exogenous or non-existent. This means that the model is further away from mimicking the true economy, since these features could be used to make the model more realistic in terms of the real world. This mechanism was implemented in Ljungqvist and Sargent (2007), which led to similar conclusions as explained in Ljungqvist and Sargent (2008, p. 26). Therefore the degree of additional complexity does not show enough benefits to outweigh the cost, and the matching mechanism is therefore excluded in this thesis.

This additionally means that there is no wage bargaining (or Nash bargaining as is usually implemented). Because of this, one cannot give either side more or less bargaining power, which might have been useful in assessing turbulence, where one side could be thought to lose part of this power relative to the other.

When looking at the income vector in the model, it is also evident that the model only looks at lower income agents, which is also a significant exclusion. This comes from the fact that all income levels can achieve UI payments equal to a ρ percentage of their old income. The original model is also called a Blue-collar worker model, due to skill transition and learning on the job that is best suited for factory workers etc. This also means that the results will most likely look more dreadful than they truly are, concerning the welfare system. For the

1 see Pissarides (2000) for textbook treatment of the theory

relevant conclusions, however, and when considering that all simulations follow the same guidelines, it should work. It was additionally considered to use a replacement rate measure that is more of an average of the population, but this would take into account the high income people, who are unlikely to follow the same type of skill accumulation mechanism. This inclusion would then skew the results for the low income agents, and therefore the pure government determined replacement rate is used.

In relation to wage bargaining, there is the aspect of *on-the-job* job search, where workers are allowed to look for better jobs while they are still employed. All else being equal, this would probably lead workers to lower their reservation wages, since they could always look for a better job after accepting a job with a lower wage than they would otherwise accept. This would, however, complicate the model further, and there would be the issue of how exactly to implement it, since different search functions should be used for employed and unemployed. It could be argued that the target group in this model search less on the job than the more educated and high wage groups. Empirical evidence, at least, shows that manual labor workers search less and highly qualified workers more (Pissarides and Wadsworth, 1994). This also means that the only way to obtain a new wage is through a new job, which can only be found after a layoff or a voluntary resignation. This assumption could be slacked by allowing for a stochastic new wage draw on the job.

Regarding the unemployment system, the model does not implement active labor market systems, which is foremost an integral part of the Danish system, and which has been found beneficial by recent literature. This will be discussed in Chapter 10.

On another note, the model only allows for full time employment, leading to intensive labor margins being excluded. In the real world, a large part of the population works part time due to a number of various reasons, which is not included in this model. Introducing this would significantly complicate the model, since it would create another dimension on decisions, where workers have to choose overall whether to work or not as well as how much to work. Therefore this is left for future academics to consider.

Another point of exclusion in the model is that the model does not take any form of informal sector into account. It is assumed that unemployed workers are not able to do any work or receive any income except for unemployment benefits. The existence of an informal sector would distort the behavior and incentives of the model, so I assume that everyone in the model are law abiding citizens.

Finally, one issue that is always the subject of discussion, when it comes to Macroeconomic models, is the assumption of *Rational Expectations*, where agents in the economy are assumed to behave optimally based on the available information at a given point in time.

5 MODEL DYNAMICS

This chapter takes a closer look at the Bellman equations, Equation 4.2, 4.3, 4.4, and 4.5. First the decision functions associated with the solutions of the system are pinned down. Second, the population distribution equations will be defined based on the information in Chapter 4. Third, some statistics will be accounted for. Due to the complexity of the model, it has not been possible to derive any relevant analytical results for the model, and so this chapter is merely aimed at giving an understanding of the optimal decision functions and their effects on population distributions and statistics.

5.1 DECISION FUNCTIONS

When solving the Bellman equations in Section 4.6, three functions regarding reservation wages are pinned down. The first, $\bar{w}_{UI}(I, h)$, concerns the specific wage level offered to a UI recipient that leads to her being indifferent between accepting or rejecting the offer. In other words it is the point where the surplus, Π_{UI}, from taking a job compared to going back to being unemployed is equal to zero. Mathematically, the reservation wage function is the set of wage values, w, that solves the following,

$$\Pi_{UI}(\bar{w}_{UI}(I,h)) = \begin{cases} J_E(\bar{w}_{UI}, h) - V_{UI}(I,h) = 0 & \text{if} \bar{w}_{UI} < \frac{I_g(I)}{h}, \\ J_E(\bar{w}_{UI}, h) - V_{SA}(h) = 0 & \text{if} \bar{w}_{UI} \geqslant \frac{I_g(I)}{h}, \end{cases} \tag{5.1}$$

On the other hand, the reservation wage facing workers in state E is simply the second line from Equation 5.1, which determines the surplus from keeping a job relative to going back to SA. Therefore the reservation wage, $\bar{w}_E(h)$, is the set of wage rates that solves

$$\Pi_E(\bar{w}_E(h)) = J_E(\bar{w}_E, h) - V_{SA}(h) = 0. \tag{5.2}$$

Finally, the reservation wage concerning the employed in state N, is the point given current skill level, h, where the continued value from taking a job in state N equals the value of transitioning to SA. As mentioned in Section 4.6, this equals the reservation wage for a person in state SA. Formally,

$$\Pi_N(\bar{w}_N(h)) = J_N(\bar{w}_N, h) - V_{SA}(h) = \Pi_{SA}(\bar{w}_{SA}(h)) = 0. \tag{5.3}$$

5.2 POPULATION DISTRIBUTIONS

Given the optimal decisions, s^*_{UI}, s^*_{SA}, $\bar{w}_{UI}$, $\bar{w}_N$ and $\bar{w}_E$, the steady state unemployment, and employment rates can be found. Additionally, the wage threshold $\frac{I_g(I)}{h}$ is used which is decided by the government. The equations for these rates are constructed by taking into account all transition rates that shift the employment status. In order to visualize this further, Figure 5.1 illustrates these transition rates from one period to the next [1]. Let $u_{i,t}(\cdot)$ be the mass of unemployed people at a point in time, t, where $i = UI, SA$ refers to the two types of unemployment, UI and SA. The mass of unemployed is a function of the current skill level, h' for SA recipients and a function of h' and last level of earnings, I, for UI receivers. At any given point in time, the mass of unemployed receiving SA is

$$
\begin{aligned}
u_{SA,t}(h') = \Bigg[\sum_{h} \Big[\mu_u(h,h') \Big(\pi(s^*_{SA}(h)) F(\bar{w}_N(h')) \\
+ \big[1 - \pi(s^*_{SA}(h))\big] \Big) u_{SA,t-1}(h) \Big] \\
+ \sum_{h,I} \Big[\mu_u(h,h') \Big(\big[1 - \pi(s^*_{UI}(I,h))\big]\gamma + \pi(s^*_{UI}(I,h)) \Big[\gamma F(\bar{w}_N(h')) \\
+ (1-\gamma) \left[1 - F\left(\frac{I_g(I)}{h'} \right) \right] F(\bar{w}_E(h')) \Big] \Big) u_{UI,t-1}(I,h) \Big] \\
+ \sum_{h} \Big[\mu_e(h,h')(1-\lambda) \big[(1-\phi) \int^{w<\bar{w}_N(h')} e_{N,t-1}(w,h) dw \\
+ \phi \int^{w<\bar{w}_E(h')} e_{N,t-1}(w,h) dw \big] + \mu_l(h,h')\lambda \int e_{N,t-1}(w,h) dw \Big] \\
+ \sum_{h} \Big[\mu_e(h,h')(1-\lambda) \int^{w<\bar{w}_E(h')} e_{E,t-1}(w,h) dw \Big] \Bigg]. \qquad (5.4)
\end{aligned}
$$

The first summation refers to the part of the population that did not manage to find a suitable job during the period and therefore stays in SA. The second summation concerns the unemployed who lost their entitlement to UI in the previous round, and did not find a suitable job, and also the ones who declined an income level above the threshold. Third are the employed who were not entitled to UI, and either decided to quit due to a change in skills, or were fired. The last summation is the employed in state E who voluntarily decided to quit their job. Concerning the unemployed receiving UI, the mass of this group is

1 The symbol , ω, is used as the wage instead of, w, due to problems in Visio 2013, where the figure was made. This is a simplified version, where the cumulative distribution functions, $F(\bar{w})$ should be viewed such that only the agents with wages less than that particular reservation wage transition to the specific state. Conversely, the function $1 - F(\bar{w})$ refers to people with wages above the reservation wage. Never the less, the figure supplies a good picture of how the transitions function.

$$
\begin{aligned}
u_{UI,t}(I,h') = \Bigg[\sum_{h} \Big[\mu_l(h,h')\lambda \int_{wh>I_{-1}}^{wh=I} e_{E,t-1}(w,h)dw \Big] \\
+ \sum_{h,I} \Big[\mu_u(h,h') \Big(\big[1-\pi(s^*_{UI}(I,h))\big](1-\gamma) + \pi(s^*_{UI}(I,h)) \\
\times (1-\gamma) F\left(\frac{I_g(I)}{h'}\right) F(\bar{w}_{UI}(I,h')) \Big) u_{UI,t-1}(I,h) \Big] \Bigg]
\end{aligned} \tag{5.5}
$$

Only two states can lead to the UI-eligible unemployment state. The first summation concerns the employed people in state E, who were fired in the previous period. The second summation refers to the mass that stays in the UI system, either because they did not manage to obtain a job offer or because they received one below the government threshold, which was subsequently rejected.

The transition probabilities are used in a similar fashion regarding the employed mass of workers, $e_{j,t}(w,h')$, where $j = E, N$, which is a function of current skill level, h', and current wage level, w. Equation 5.6 explains the mass of employed, who qualify for UI

$$
\begin{aligned}
& e_{E,t}(w,h') = \\
& \Bigg[\sum_{h} \Big[\mu_e(h,h')(1-\lambda) e_{E,t-1}(w,h) \Big] \\
& + \sum_{h} \Big[\mu_e(h,h')(1-\lambda)\phi e_{N,t-1}(w,h) \Big] \Bigg], w \geqslant \bar{w}_E(h') \\
& + \begin{cases} \sum_{h,I} \Big[\mu_u(h,h')\pi(s^*_{UI}(I,h))(1-\gamma)Pr(w) u_{UI,t-1}(I,h) \Big], \\ \qquad w \geqslant \frac{I_g(I)}{h'} \wedge w \geqslant \bar{w}_E(h'). \\ \sum_{h,I} \Big[\mu_u(h,h')\pi(s^*_{UI}(I,h))(1-\gamma)Pr(w) u_{UI,t-1}(I,h) \Big], \\ \qquad w < \frac{I_g(I)}{h'} \wedge w \geqslant \bar{w}_{UI}(I,h'). \end{cases}
\end{aligned} \tag{5.6}
$$

The first line describes the workers who stayed employed, while the second line describes the workers who have become eligible for UI. The two first lines are dependent on the wage being above the level set by $\bar{w}_E(h')$. The last part refers to the unemployed UI recipients who are still eligible to receive UI and received job offers that were accepted. The government income threshold causes this split function, because wage levels below and above this leads to different choices and thereby reservation wages. Additionally, the $\Pr(w)$ represents the probability of drawing the specific wage level, w.

$$\begin{aligned}
&e_{N,t}(w,h') = \\
&\Bigg[\sum_{h}\Big[\mu_e(h,h')(1-\gamma)(1-\phi)e_{N,t-1}(w,h)\Big] \\
&+\sum_{h,I}\Big[\mu_u(h,h')\pi(s^*_{UI}(I,h))\gamma \Pr(w)u_{UI,t-1}(I,h)\Big] \\
&+\sum_{h}\Big[\mu_u(h,h')\pi(s^*_{SA}(h))\Pr(w)u_{SA,t-1}(h)\Big]\Bigg], w \geqslant \bar{w}_N(h')
\end{aligned} \tag{5.7}$$

Here the first summation concerns the employed in state N, who stayed there, while the second shows the unemployed from state UI, who lost the benefit eligibility and obtained a job. Last are the people from state, SA, who accepted a job. All these are conditional on the wage level being above the reservation wage, $\bar{w}_N(h')$.

In the steady state, the unemployment- and employment rates are time-invariant, thus the outflows from each state must equal the inflows to that state i. e. $u_{UI,t} = u_{UI,t-1}$. Therefore, the overall unemployment rate, u, will also be time-invariant, so $u_t = u_{t-1} = u$. It must also be the case that the summation of these population distributions equals 1 at all times so the mass is constant.

5.3 STEADY STATE STATISTICS

After the decision values and the population dynamics have been decided in the steady state, a number of statistics are calculated in order to analyze the model. Here, five are presented. First is a measure of aggregate earnings or Gross National Product (GNP), which is calculated as

$$\begin{aligned}
\mathrm{GNP} = &\sum_{h}\Big[h\int_{\bar{w}_E(h)} e_E(w,h)w\ dw\Big] \\
&+\sum_{h}\Big[h\int_{\bar{w}_N(h)} e_N(w,h)w\ dw\Big].
\end{aligned}$$

Second is the average productivity or earnings of the employed part of the population, which is defined as

$$\text{Avg. productivity of employed} = \frac{\mathrm{GNP}}{e}.$$

Third is the average wage of the employed, calculated as

$$\begin{aligned}
\text{Avg. wage of employed} = &\frac{\sum_h\Big[\int_{\bar{w}_E(h)} e_E(w,h)w\ dw\Big]}{e} \\
&+\frac{\sum_h\Big[\int_{\bar{w}_N(h)} e_N(w,h)w\ w\Big]}{e}.
\end{aligned}$$

Fourth is the expected (average) duration (D) of unemployment, which is estimated by following a homogeneous unemployed mass and tracking how many leaves unemployment in each period. This means that initially the expected duration of unemployment is calculated for each different unemployed person, i. e. $u_{SA}(h)$ and $u_{UI}(I,h)$ as follows,

$$E\left[D_{UI(I,h)}\right] = \sum_{n=1}^{\infty} \left[nH_{UI(I,h)}(n)S_{UI(I,h)}(n-1)\right]$$
$$E\left[D_{SA(h)}\right] = \sum_{n=1}^{\infty} \left[nH_{SA(h)}(n)S_{SA(h)}(n-1)\right].$$

The function $S_{UI(I,h)}(n-1)$ (here for state UI) is a 'survivor' function showing the remaining fraction of the original mass of people with previous earnings I and current skills h who are still unemployed at time $n-1$, no matter the unemployment state they are at. The function $H_{UI(I,h)}(n)$, is a hazard function that shows the fraction of the remaining unemployed that leaves unemployment at time n. This calculation converges towards a certain number, due to the fraction of still-unemployed approaching zero, as time goes towards infinity. Then, by taking a weighted average of these two durations, with the weights being the steady state population distributions, it is possible to estimate the average duration of unemployment for the mass of all unemployed agents. This is the unconditional expected duration, since it ignores the history of the unemployed in the steady state. More specifically it ignores how long a person has been unemployed, it simply considers her current state and position. It is written as

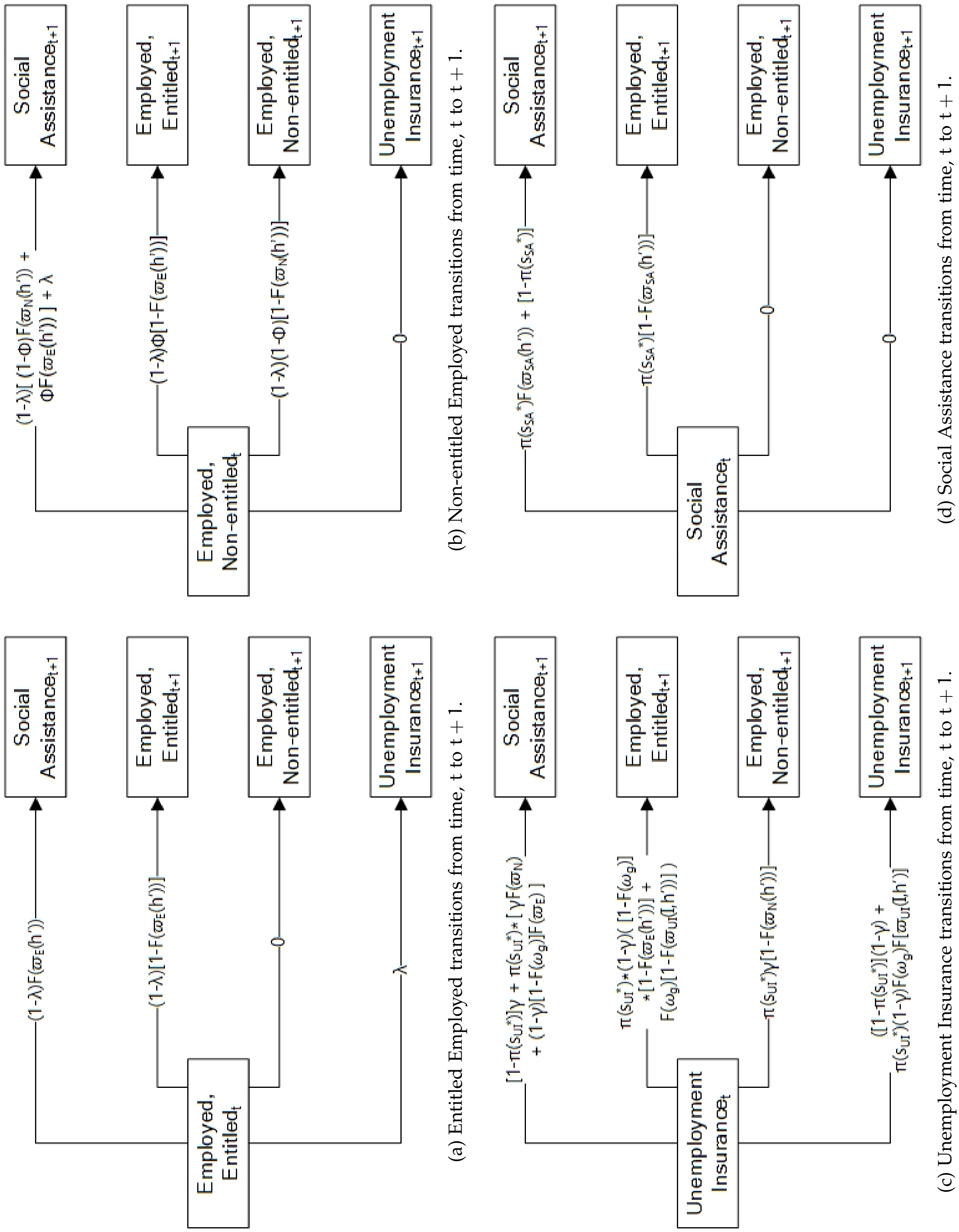
$$E[D] = \frac{\sum_h \left[u_{SA}(h) \times E\left[D_{SA(h)}\right]\right]}{u} + \frac{\sum_{I,h} \left[u_{UI}(I,h) \times E\left[D_{UI(I,h)}\right]\right]}{u},$$

which then in turn can be doubled in order to obtain the expected duration in weeks, because of one period being two weeks.

Fifth is the value of consumption, calculated as a weighted average of the value functions in1 Equation 4.2 – Equation 4.5,

$$\begin{aligned}\text{Cons. Value} = &\sum_h \left[\int_{\bar{w}_E(h)} V_E(w,h)e_E(w,h)\ dw\right] \\ &+ \sum_h \left[\int_{\bar{w}_N(h)} V_N(w,h)e_N(w,h)\ dw\right] \\ &+ \sum_{h,I} \left[V_{UI}(I,h)u_{UI}(I,h) + V_{SA}(h)u_{SA}(h)\right]\end{aligned}$$

This concludes the main statistics that will be used to analyze the economy both with and without turbulence and shocks. Next follows the calibration and method used to simulate the economy.



(a) Entitled Employed transitions from time, t to t + 1.

(b) Non-entitled Employed transitions from time, t to t + 1.

(c) Unemployment Insurance transitions from time, t to t + 1.

(d) Social Assistance transitions from time, t to t + 1.

Figure 5.1: Total transition rates between the three possible states.

6 CALIBRATION AND METHOD

In order to solve the model, the method of value function iteration (Ljungqvist and Sargent, 2000, p.32) is used. This relies on the model converging to a specific point, given the parameters chosen. If this does not occur, if the values diverge, the method will not lead to any suitable results. Starting from given, arbitrary values of V_E, V_N, V_{UI}, and V_{SA}, Equation 4.2, 4.3, 4.4, 4.5 are calculated. Subsequently, these results are used as inputs in calculating the equations again. This is done repeatedly until the results converge and become time-invariant, which then give the true values of the four labor market states at any given point in time. From these steady state values, it is possible to calculate the steady state decision policies as shown in Section 5.1. Subsequently, these results are used in the estimation of population distributions, where the same method of iteration is used on Equation 5.4 - 5.7. After this step, the budget constraint for the government is calculated in order to find out if the condition is satisfied. In case the constraint is violated, the tax rate is changed, and the entire script is re-executed until Equation 4.1 is upheld. When this occurs, it is then possible to calculate the various statistics from the previous section.

Fundamentally, the model is solved using the computer software 'R', and the script written for this purpose can be found in its entirety in Appendix A. In order to verify the validity of the script, the economy from Ljungqvist and Sargent (1998) was recreated in order to see if the exact same results would be found. Minor differences did occur in this recreation concerning the tranquil economy, which remains unresolved, but they were insignificant with regard to the results, for which reason they are disregarded. Some more clear differences occurred in the turbulent environment, where statistics regarding unemployment durations were biased, but this did not change the conclusions, and so the script is deemed suitable for the purpose.

Many of the parameters in this model are calibrated as in Ljungqvist and Sargent (1998). The reason for this decision is two-fold. First, they base part of their calibrations on a list of previous work in the field, which have been empirically verified. Second, it is evident that if the model proposed here is to be compared with the conclusions of their model, the calibrations must be similar.

The model operates in an economy where each period is set at two weeks, which gives the number of periods per year, $n_{year} = 26$. The discount factor, β, is set to 0.9985, which is equivalent to an annual interest rate, i, of

$$i = \frac{1}{\beta^{n_{year}}} - 1 = \frac{1}{0.9985^{26}} - 1 \approx 4\%,$$

which is a common discount factor value. Regarding the exogenous layoff probability, λ, it assumes the value 0.009, meaning that there is a 0.9% probability of getting fired each period, given that the worker does not quit her job. This furthermore leads to the expected duration of employment, again assuming no resignation, of

$$E[D_e] = \frac{1}{\lambda \times n_{year}} = \frac{1}{0.009 \times 26} \approx 4.3 \text{ years},$$

which therefore means that a person obtaining a job has an expected employment run of 4.3 years. This value is based on Hall (1982), who investigated the number of jobs a worker will hold during an average career.

The skill system consists of 21 discrete levels, evenly distributed on the interval [1, 2]. Regarding the transition of skills, an employed agent with a given level has a 0.1 probability of reaching the next skill level (increase in h of 0.05) at the beginning of the following period, presuming no layoff occurs. Conversely the worker faces a 0.9 probability of remaining at the same skill level in the following period. If a worker has reached the maximum skill level of 2, she will remain at this point until being laid off. This means that the expected duration for a given agent with the lowest skill to reach the highest, assuming constant employment, is

$$\frac{1}{mu_e(h, h') \times n_{year}} \times n_{levels} = \frac{1}{0.1 \times 26} \times 20 \approx 7.7 \text{ years}.$$

The probability of experiencing skill deterioration of one level during unemployment is 0.2. If the stochastic decrease does not occur, the agent retains her current skill level in the following period. Therefore the depreciation of skills happens twice as fast, as the accumulation of said skills. This parameterization is based on Keane and Wolpin (1997), who provided econometric estimates for the deterioration of skills for blue collar workers. Among their findings was an estimated annual loss of 10% of skills for unemployed people. In contrast, the model presented here results in a skill depreciation of zero to 21 percent annually, which is obviously varying because the stochastic drop in skill levels is an absolute constant value. Similar to the skill transition for employed workers, there is an absorbing state where the skill deterioration ends, which is at the minimum skill level $h = 1$. Here an agent will continue to retain this level until she finds employment and experience a stochastic skill increase. For the sake of simplicity in the model, the agent observes her skill level in the beginning of a period before deciding whether or not to accept a job.

Another transition in the model is the probability of obtaining a job offer through search. When unemployed people look for a job, there is some disutility from search, which is assumed to be a linear function, $c(s) = 0.5s$, where $s \in [0, 1]$. This is set as this in order to make search costly, but still not to such a degree that it completely annihilates the incentives for looking for a job. The positive effect of search comes from the probability of obtaining a suitable job. The job offer rate is set at, $\pi(s) = s^{0.3}$, which means that the probability of getting such an offer in a given period, is bounded by $[0, 1]$. For the purpose of the model, the most important property for the search function is that the it is strictly concave in chosen search intensity, to allow for diminishing returns of search.

As mentioned in Section 4.4.2, the income of the worker is decided by the product of the wage and the skill level. In a McCall search model, the wage is exogenously distributed, which here is calibrated to be a normal distribution with mean equal to 0.5 and variance equaling 0.1. Additionally the distribution is truncated to the unit interval and normalized to integrate to one. Practically, this means that $w \in [0, 1]$, which in turn leads to the interval of earnings being $[0, 2]$. These levels of income are used to determine the UI payments. The government divides the earning scale into 15 evenly distributed income classes, where the upper limit of each class is denoted, W_I, with $I = 1, 2, \ldots, 15$. UI recipients with last earnings belonging to class I in the main model will receive $b(I) = \rho \times W_I$, where the replacement rate, $\rho = 90\%$, fits the Danish UI system. This benefit level additionally equals the government threshold level for suitable income, so $I_g(I) = b(I)$. The lower bound of the UI is determined by the SA level, z, which is set as a smaller flat value. Two different values are chosen for z. First a rather high value equaling the 7^{th} entry in the $b(i)$ vector, and second a lower level equaling the 2^{nd} entry in the income vector, W_i. The first should fit the Danish level in relative terms very well, while the lower level is chosen for the sake of sensitivity analysis. I argue, however, that several rules apply to the second tier of the benefit program, e. g.that a person must use up all savings (including real estate) before qualifying for SA and cannot have a spouse who earns significant income. Therefore it can be argued that the true value is somewhere between the two chosen, but since liquidity is not a feature included, this is disregarded.

Finally remains two transition rates, which are constant and exogenously given. First, the UI duration, γ, is initially set to 0.0195, which means an expected benefit duration of approximately two years. Second, is the re-entitlement period, ϕ, which is chosen as 0.0385, which approximately leads to a duration of one year, as is the case in Denmark.

6.1 DIFFERENT SIMULATIONS

A number of different simulations will be run in order to isolate the effects of various parameters and variables. A total number of seven different models will be simulated for this purpose, where graphical and numerical results can be found in Chapter 7 and Chapter 9. In addition, some minor sensitivity analysis will be performed, but not presented, in order to detect small differences and trends. Aside from the two main models (also called the proposed models) with a 90% replacement rate and with either a high or low z there will be five additional models. First and foremost two versions close to the original Ljungqvist and Sargent (LS) model will be simulated, where the replacement rate, ρ, is at 70% and 90%, respectively. This means, more specifically, that $b(i) = 0.7 \times W_i$ and $b(i) = 0.9 \times W_i$. Since there is no second tier benefit level in this model, the social assistance benefit level $z = 0$. Then a Laissez-Faire economy is simulated for the purpose of seeing how a non-governmental economy would react. Here the replacement rate, the tax rate, and the z are all zero, and only two states, E and SA, exist. Last, two versions of the main model are simulated, but with an alternative replacement rate equal to 70% for the sake of general analysis. This enables a discussion of the LS analysis without the distortion of the higher replacement rate, and also allows for analysis of the rate in Denmark. Aside from this change in replacement rates in these last two models, everything stays the same. After the models have been simulated as stated above in tranquil times, two additional sets of simulations will be performed in more turbulent environments. The specific parameterization regarding this will be presented in Section 9.2, immediately before it is applied.

7 SIMULATION AND RESULTS

The seven different variations of the model described in Chapter 6 have been run, in order to be able to observe the differences that the proposed model presents, as well as allowing for the analyses of other policy choices. The four main versions used are first the two models presented in Chapter 4 containing a 90% replacement rate and two varying z values, which are then compared to the original LS model (70% replacement rate), which has been slightly altered to fit the calibration in Chapter 6, and finally the Laissez-Faire economy. Additionally the LS model with a 90% replacement rate was simulated, which will be briefly presented immediately here. In this model, the disincentive effects of the indefinite, generous UI state led the unemployment to explode, which in turn means that no tax rate can satisfy the government budget constraint, and therefore no valid steady state is found. This happens because nearly all of the population eventually qualify for the top UI level and then, after being laid off, falls to the lowest skill level. Here they do not have the incentives necessary to find a new job and escape unemployment, and thus they are stuck in this state. Therefore no usable results were obtained and thus not presented. This means that from here on out, the model referred to as "LS" will be the original model containing a 70% replacement rate, and only results from this will be presented below. The results regarding the optimal worker decisions found by running the final two simulations (the proposed models with a 70% replacement rate) are shown in Section 7.2. All versions that include governmental actions have different tax rates that satisfy the government budget constraint, see Equation 4.1. In the following, the results from the four main simulations will be presented, beginning with Table 7.1.

This table shows the steady state results of the four main versions of the model. These preliminary results already show distinct differences in the four different economies, where the model developed in this thesis already exhibit significant adverse effects. This is evident from a significantly longer average duration of unemployment, the substantial amount of people who are long-term unemployed, and the higher unemployment rate. It is also indicative that the tax rate is more than twice the amount of the LS version, which directly means a much higher level of government expenditure since the budget is equaled to zero. Because the only expense the government has is the unemployment benefits, it directly equals adverse effects. Additionally it is noticed that the differences seen in the 'high z' and 'low z' versions are limited, which suggests that it is not the second tier ben-

Table 7.1: Steady-state values for the various economies

	High z	Low z	LS Model	Laissez-Faire
Tax Rate (%)	7.80	7.15	2.93	0.0
Replacement Rate (%)	90.0	90.0	70.0	0.0
GNP per capita	1.619	1.623	1.635	1.648
Avg. productivity of employed	1.793	1.787	1.761	1.754
Avg. wage of employed	0.913	0.908	0.888	0.883
Avg. skill level in the population	1.956	1.959	1.978	1.983
Unemployment rate (%)	9.72	9.17	7.12	6.03
Avg. unemployment duration (weeks)	20.69	20.15	13.43	11.88
Unemployed $\geqslant 6$ months (%)	27.57	26.51	11.75	8.75
Unemployed $\geqslant 12$ months (%)	6.41	5.91	1.26	0.60
Consumption Value	$1,059.4$	$1,061.1$	$1,066.8$	$1,070.7$

GNP and average productivity are calculated for 2 weeks

efit level that is the most important factor in the worker incentives. It should, however, be noted that the lower level does perform better in terms of all statistics, and sensitivity analysis regarding this parameter suggest that a positive optimal value of z does exist. This value lies relatively close to the 'low' level. Due to the social assistance not being the deciding factor, this section will focus mostly on the 'high z' version of the proposed model, when the dynamics of the model will be analyzed, but the graphical results from the 'low z' model will still be featured. In order to uncover the underlying causes of the differences in Table 7.1, the decision rules and population dynamics will be presented in the following. This should also clarify the decisions and dynamics of the heterogeneous workforce, where workers react differently according to the skill level and benefit claim that they are subjected to.

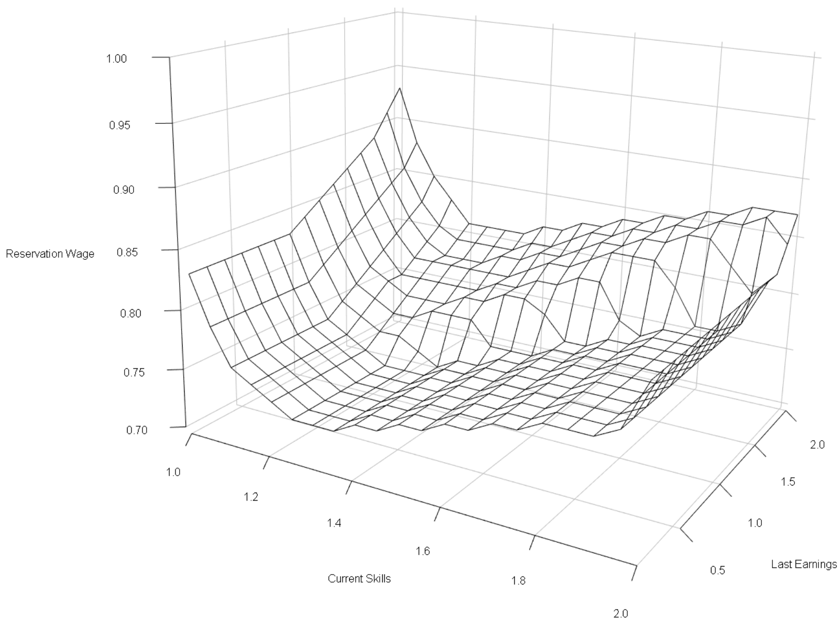


Figure 7.1: Reservation wage for UI recipients as a function of their current skills and last earnings in the economy with a high z level

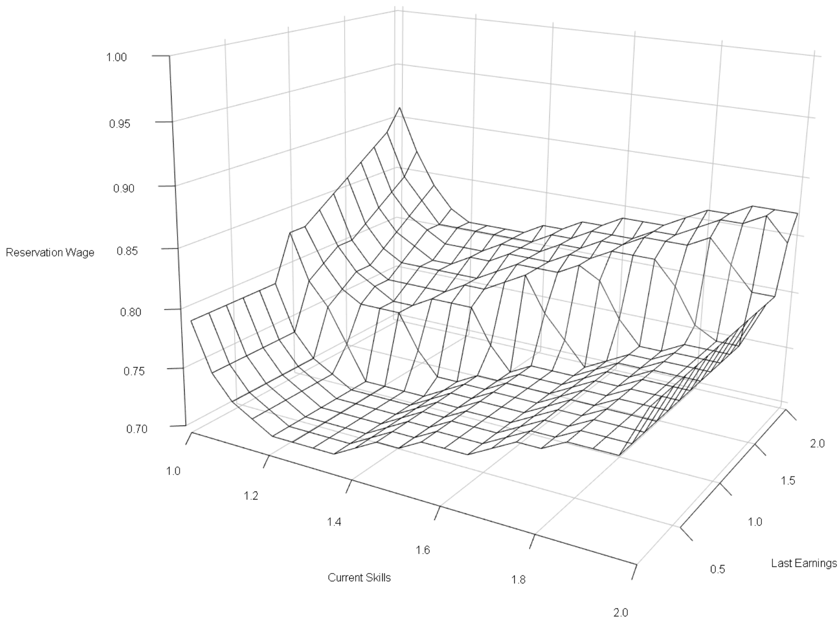


Figure 7.2: Reservation wage for UI recipients as a function of their current skills and last earnings in the economy with a low z level

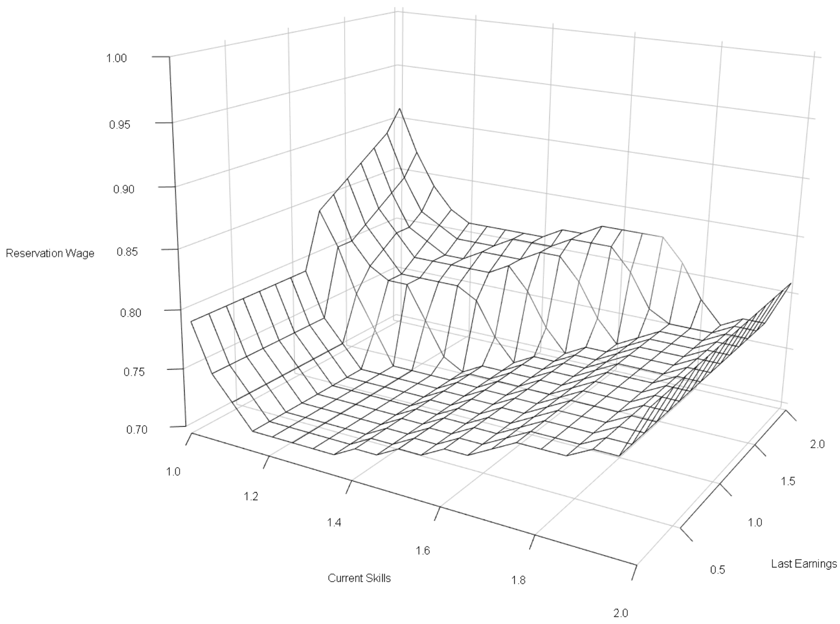


Figure 7.3: Reservation wage for UI recipients as a function of their current skills and last earnings in the LS economy

7.1 steady state decision rules

As mentioned in Section 4.6, the decision functions for reservation wages and for search intensities are the ones governing the results in the model. The reservation wages for UI recipients are presented in Figure 7.1, 7.2 and 7.3 for the economy with a high second tier benefit level, z, the low z, and for the LS model.

The three dimensions of the reservation wages are the current skill level-, the previous earnings-, and the reservation wage of the unemployed person. When looking along the different dimensions, three features appear: First, the reservation wage is a positive function of last earnings, which is evident in that the level of benefit received is positively correlated with last earnings, which in turn is the main opportunity cost of obtaining a job. Second, a lot of the wage levels in the three dimensional model do not vary with the last earnings, which is a product of the income threshold appointed by the government. This limit affects which decision a worker must make, whether it is between employment and UI or between the job and SA. Therefore, if the government threshold is low, which means that even small incomes are above the threshold, then it is the two-dimensional reservation wage, $\bar{w}_E$, (see Figure 7.4) that governs the decision. This is independent of last earnings, as explained in Section 4.6, which then explains the area of the UI reservation wage figure that does not correlate with previous earnings. Here the 'high z' version of the model appears different from the other two, because of the higher second tier benefit level, which directly causes the two-dimensional reservation wage to increase. Third, is the correlation between the current skill level and the reservation wage, and here it is clear that the situation is slightly different. Here a U-shape appears, as long as the income threshold does not interfere, which will, in most cases, cause a double U-shape. This U-shape is an interesting feature of the skill system, which is the result of opposite effects from waiting for the right job offer. On the one hand, an agent has an incentive to decline a job and wait for a possibly better job in the following period. On the other hand, by doing this, the agent is exposed to both the probability of losing the UI qualification, which must then be re-earned, as well as the risk of moving to a lower skill level, which is equivalent to a lower potential income. For the high skilled part of the population ($h \to 2$), the reservation wage is increasing. This occurs because of the construction of the income. Higher income can be split into two parts: The first is a higher skill level, and the second is a higher wage. An increase in either part will lead to income increasing independent of the other part (as long as $w \neq 0$). When the skill is already relatively high, the potential to increase income through the Markov process becomes very low. This leads the high skilled people to look for better wages in order to obtain a higher level of earnings, instead of relying on becoming more skillful. This causes the reservation wages to increase. In the other end of the scale, the low skilled agents do not fear the probability of losing skill levels, because of the absorbing minimum state in the skill transition. Therefore the only negative side of waiting, for these agents, is the probability of transferring to the SA state. Therefore these agents have strong incentives to wait for a relatively high wage, since this will increase their income significantly, for when they obtain higher skill levels through an extended period of employment. In comparison, the agents in the midrange skill levels both have the fear of losing skills, while also having the potential to increase income significantly through job experience. This leads them to lower their reservation wages relative to the extreme ends of the skill grid. These features regarding the reservation wages are universal in the economy, and apply to all the economies, which means that one of the most important dynamics is the Markov process of skill transitions that all the models have in common.

The differences between the two tier models and the LS economy, are clearly evident. The most striking feature is the disincentive effects that appear for high skilled agents with upper level previous earnings. Here the reservation wages are significantly higher in the two tier benefit models. In general, the former models have larger areas, where the three-dimensional reservation wage applies, than the LS version. This means that the effect of the government threshold is lower. These differences are clearly an effect of the model setup, where the government threshold is a directly determines the bene-

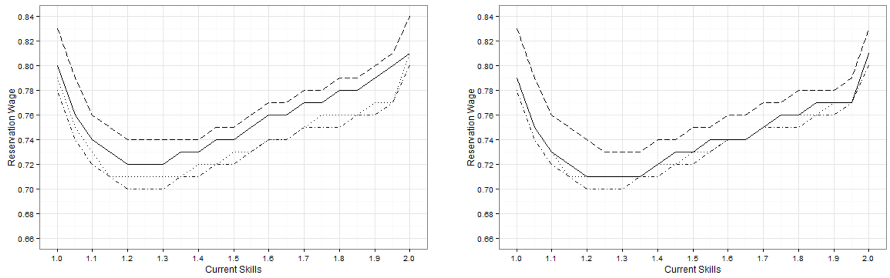


Figure 7.4: Reservation wages for unemployed in state, N, (equally state SA) (left) and for employed in state, E, (right) as a function of their current skills. Dashed and solid lines refer to the high- and 'low z' economies, respectively. Dotted and dot-dashed lines refer to the LS and LF economies, respectively

fit payments that an agent receives. Therefore, when the replacement rate increases, the effect of the threshold becomes lower, due to the unchanged boundaries of the possible wages. As mentioned, the 'high z' version shows the added adverse effect of a higher level of the two-dimensional reservation wage compared to the other models, which can be seen by the higher fall in reservation wages when the income threshold applies. An alarming point concerning 'high z' model is the higher reservation wage for agents who used to belong to the top income group and have transitioned down to the lowest skill level. These agents have even worse incentives to exit unemployment and get a job than in the other two models, which could be problematic if too many people transition down to this point, as was seen in the simulation of the LS model with a 90% replacement rate. In order to eliminate the effect of the higher replacement rate, a simulation has been run of the proposed models with an alternative 70% rate. As mentioned earlier, these results are presented in Section 7.2, where the question of disincentives will be resumed.

The reservation wages in the states E and N, as well as in state E for the LS and Laissez-Faire economies, can be seen in Figure 7.4. Here all the four economies are placed, and it must be noted that it is only in the proposed model where the distinction between state E and N exists; so the reservation wages for the LS and LF economies are the same in each graph and concern state E (and SA— the reservation wage in these two states are the same). It can be seen the that the level of reservation wages for the high and low z economies are higher regardless of the state, which is a direct product of the positive value of SA benefits, z. The left graph shows the reservation wages for agents in states SA and N, meaning it is people without UI eligibility. By comparison, the right hand side graph concerns people in state E, and it is evident that the levels here are generally lower than on the left hand side. I argue that this is due to the re-entitlement period, since people in state E realize that they must go through a period of reacquiring their eligibility if they quit their jobs. This is again a direct

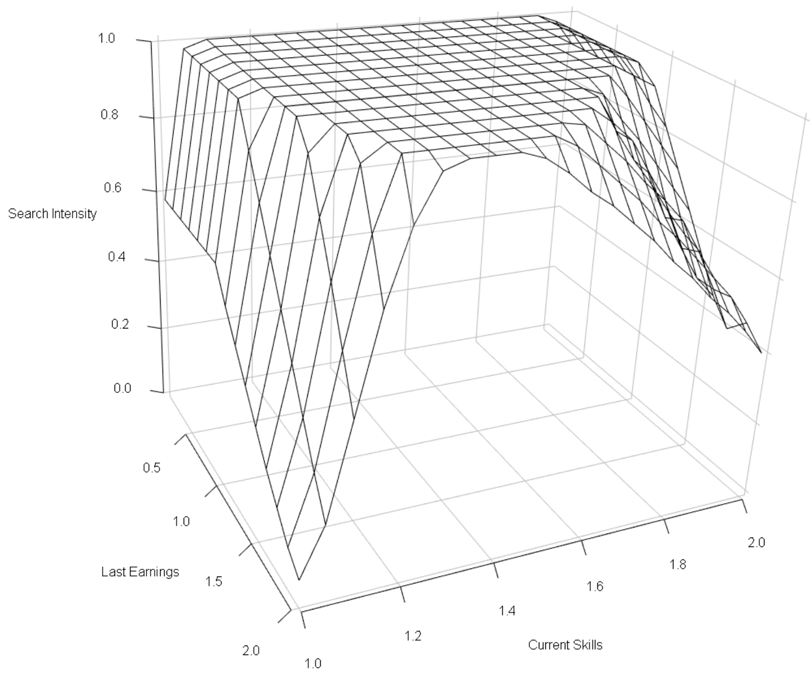


Figure 7.5: Search intensity for UI recipients as a function of their current skills and last earnings in the economy with a high z level

result of the government threshold that removes UI eligibility when a suitable income is declined. Therefore, these agents will accept working at lower wages (equivalent to lower incomes), than the agents in state N or SA. One may notice that this is actually the opposite of the re-entitlement effect identified by Mortensen (1977), where workers who where non-eligible would accept lower wages. So even though the positive z raises the reservation wage, the increase is partly counteracted by the re-entitlement period. It is however not sufficient to get reservation wage below the level of the LS model.

The other main decision functions are the intensities at which the unemployed agents decide to look for a new job with. Figure 7.5, 7.6 and 7.7 show the search intensities for UI recipients in a three-dimensional graph, in the same fashion as with the reservation wages. The striking difference is that agents generally search less for a new job in the proposed models. The group of people, who choose to search more intensively than in the LS model, are the ones with higher skills and earnings. The figures show that the 'low z' model provides better incentives than the 'high z' version, but still show lower or equal search in most areas. This is explained by the limited duration that the agents can receive benefits and the re-entitlement period, due to which the agents understand what they lose if they do not obtain a job. Additionally, the relatively higher reservation wage that these people have, compared to the original model, means that

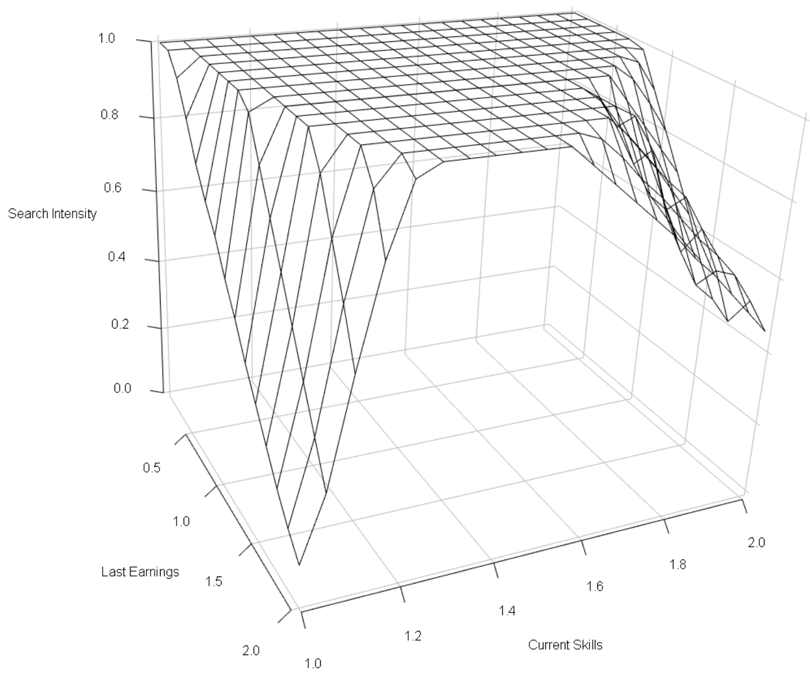


Figure 7.6: Search intensity for UI recipients as a function of their current skills and last earnings in the economy with a low z level

they search more in order to increase their chances of obtaining a suitable job offer.

All other people search less or an equal amount, even though they run the risk of losing their benefits. Several elements decide this outcome. A higher replacement rate causes universally lower search intensities directly due to an increased opportunity cost. This is seen through the simulations with the model containing a replacement rate of 70% (like in the original paper) in Section 7.2. The results from these simulations for both 'high' and 'low z' levels show that agents in this environment will search more actively. Therefore, the lower search intensity observed in Figure 7.5 is due to the higher replacement rate. Additionally, the non-zero SA level has a negative effect on the search intensity, which is more evident for low income agents. This happens because this class of individuals either receives the same UI benefits as a SA recipient or only slightly more. This effect, concerning low income agents, is very clear in the comparison between Figure 7.5 and 7.7, while the 'low z' version in Figure 7.6 shows significant incentive improvements for this specific problem.

Finally, one can look at the search intensities for people in the SA state. In all economies except for the 'high z' version, all agents receiving SA benefits will choose the maximum level of search, no matter their current skill levels. It is natural that the 'high z' version is the one that includes disincentive effects regarding job search for SA unem-

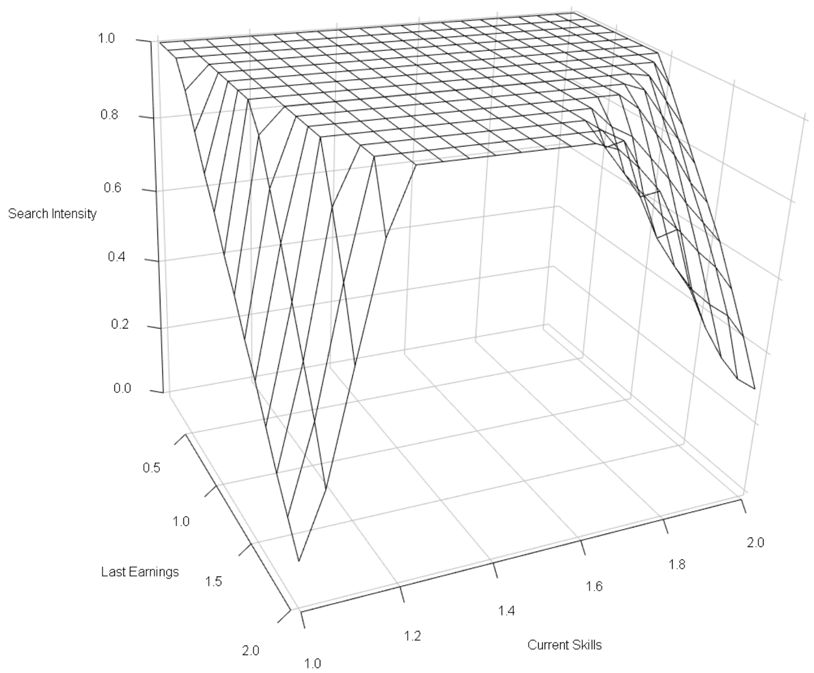


Figure 7.7: Search intensity for UI recipients as a function of their current skills and last earnings in the LS economy

ployed, due to the benefit level, z, being the immediate opportunity cost of obtaining a job. More specifically, it is the two lowest and two highest skill levels, where the optimal search is below the maximum. This is due to the high reservation wages that the people with these skill levels have, and due to the concave nature of the search function, where the highest levels of intensities do not increase the chance of getting a job offer significantly. So, since these people realize that if they receive an offer, the chance of this actually being above the reservation wage, is relatively low, they 'save' some of the searching cost by limiting their intensities, which in turn does not have a great effect on the actual probability of getting a job offer.

7.2 Sensitivity analysis

Before continuing with the main model results, a few notes will be presented regarding a form of sensitivity analysis concerning the replacement rate. In order to uncover the effect of this parameter, the rate has been reduced to 70% as in the original model. The steady state results are shown in Table 7.2.

Comparing this table to Table 7.1 uncovers the positive effects from the introduction of a two tier benefit system, since the values are significantly improved compared to the proposed model. The 'low z' version outperforms the LS model in every aspect, while the 'high z'

Table 7.2: Steady-state values for economies with 70% replacement rates

	High z, 70%	Low z, 70%	LS Model	Laissez-Faire
Tax Rate (%)	3.92	2.84	2.93	0.0
Replacement Rate (%)	70.0	70.0	70.0	0.0
GNP per capita	1.644	1.642	1.635	1.648
Avg. productivity of employed	1.781	1.762	1.761	1.754
Avg. wage of employed	0.900	0.889	0.888	0.883
Avg. skill level in the population	1.975	1.979	1.978	1.983
Unemployment rate (%)	7.68	6.86	7.12	65.03
Avg. unemployment duration (weeks)	14.11	13.28	13.46	11.88
Unemployed $\geqslant 6$ months (%)	13.38	11.62	11.84	8.75
Unemployed $\geqslant 12$ months (%)	1.45	1.12	1.29	0.60
Consumption Value	$1,069.2$	$1,069.4$	$1,059.0$	$1,070.7$

GNP and average productivity are calculated for 2 weeks

model still performs worse with regard to unemployment rates, even though they are significantly better than in the proposed model. This also shows that the social assistance level does have an effect on the steady state with an estimated higher unemployment level of 0.82 percentage points for the 'high' level compared to the 'low' level.

Regarding the decision rules, the reservation wages and search intensities for the 'high -' and 'low z' models are shown in Figure 7.8, 7.9, 7.10 and 7.11. The graphs follow the same basics as explained in the previous section, while the results are different. Beginning with the reservation wages, these show that the effect from the limited duration and the re-entitlement period leads to lower reservation wages, in the area where the government threshold is not constraining (the area where the graph is three dimensional). This shows that the impacts from these policies do help to counteract the adverse effects from the generous UI system. Additionally, the area where the threshold binds becomes smaller, which also means a lower reservation wage for many agents.

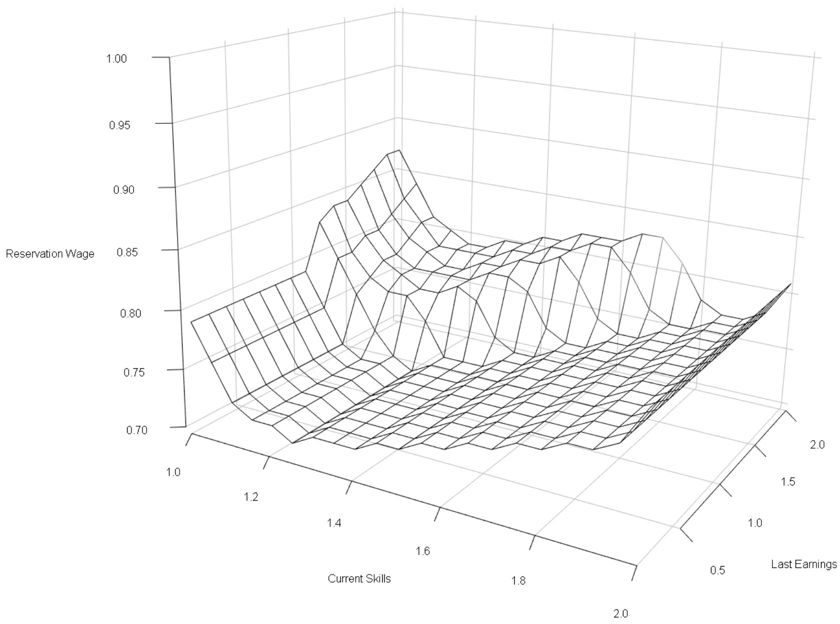


Figure 7.8: Reservation wage for UI recipients as a function of their current skills and last earnings in the economy with a low z level and 70% replacement rate

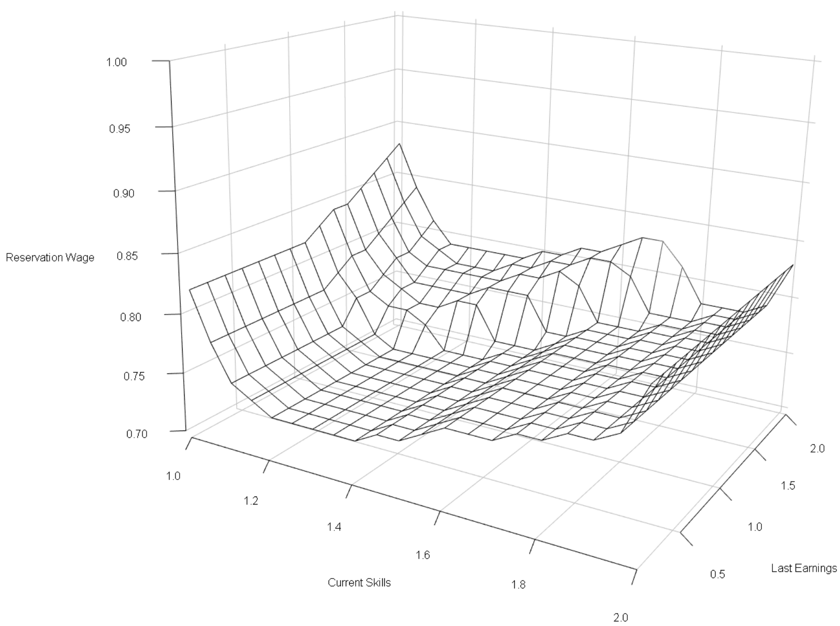


Figure 7.9: Reservation wage for UI recipients as a function of their current skills and last earnings in the economy with a high z level and 70% replacement rate

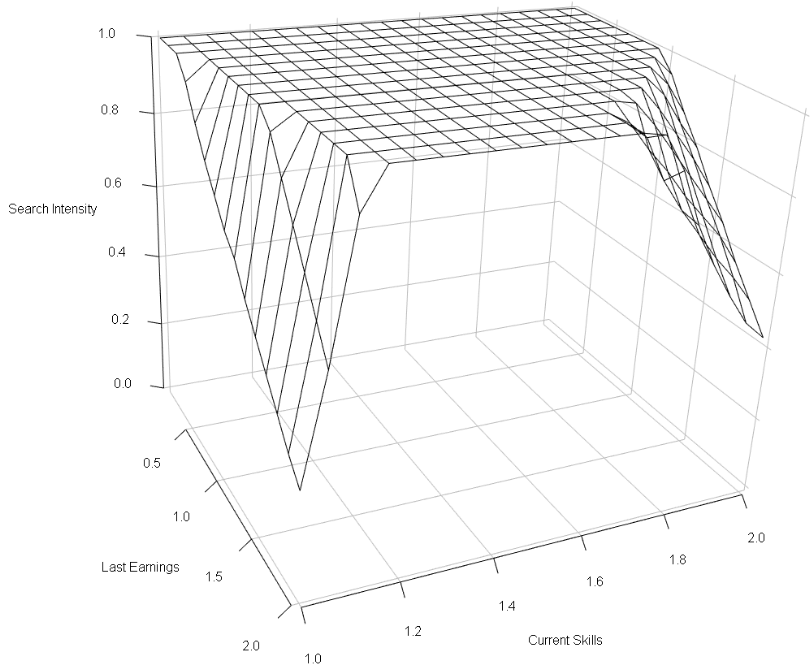


Figure 7.10: Search intensity for UI recipients as a function of their current skills and last earnings in the economy with a low z level and 70% replacement ratel

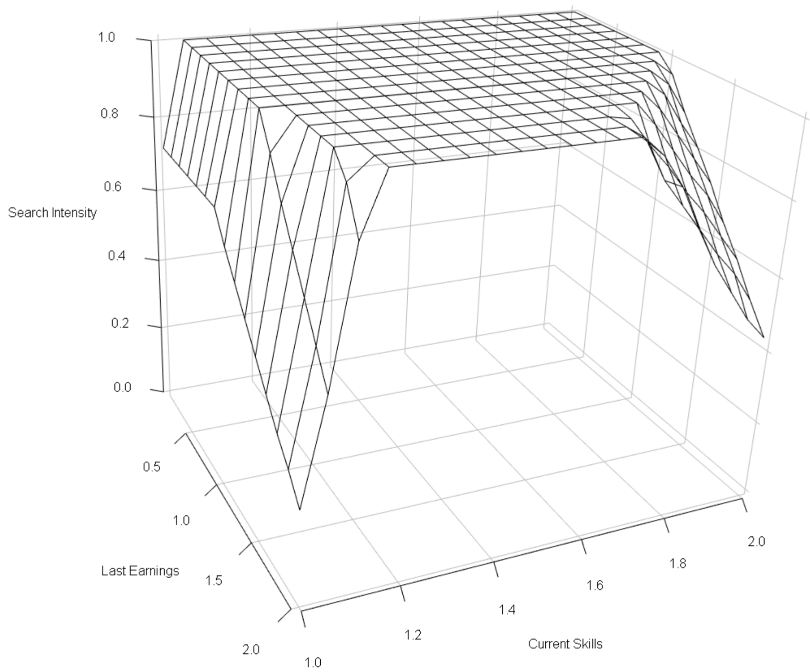


Figure 7.11: Search intensity for UI recipients as a function of their current skills and last earnings in the economy with a high z level and 70% replacement rate

This makes sense, since this is the area determined by the choice between work or UI, which also is the reason why the two dimensional part of the graph is not different. It can also be seen that the reservation wage for agents with the highest income ($I = 2$) features a double U-shape so high skilled people, who loses their jobs will experience a relatively lower reservation wage after a couple of periods, which leads to a faster transition back into employment. All these aspects point to this specific system as providing better incentives for people to obtain a job if unemployed. Additionally, it can be determined that the increased replacement rate does seem to dominate the effect from the duration policies due to the poor performance of the proposed models, therefore in general, these results point in the direction that the replacement rate is a very dominant factor in the model.

Turning the attention to the search intensities for agents receiving UI reveals that they are more engaged in searching when faced with a lower replacement rate. Both the 'high' and 'low z' economies show that agents search more actively compared to Figure 7.5 and 7.6. This also points to the lower levels of search observed in the proposed model is a direct effect of the increased replacement rate. If looking at the simulations compared to the LS model, it becomes clear that there is a positive effect from the limited duration and re-entitlement period of unemployment insurance on the intensity of search. This is mostly evident when comparing the lower z level simulation with the LS model, which shows universally higher levels of search for agents.

This section shortly showed the isolated effect of the higher replacement rate, and now the analysis concerning the main models continues by looking at population distributions in the steady states.

7.3 POPULATION DISTRIBUTION

In order to truly examine which of the differences shown above leads to any significant changes, one most also look at the distribution of the population in the steady state. This is because of two things: First, it is close to impossible to actually grasp the dynamics of the results only from the decision functions, due to the large number of parameters that are involved in the model. This makes it tough to isolate what exactly causes the differences seen in Table 7.1. Second, the differences in the worker decisions only have significant impact if a considerable amount of people are actually distributed where the differences occur. In all models, the mass of people with the highest level of skills ($h = 2$) is by far the largest group. The mass of this group ranges from $71\% - 82\%$ of the entire population in the various models. Therefore this is the most interesting place to start, since any change in decisions for this skill level will have significant effects. It turns out, that the increased reservation wage, which was observed for high skilled workers in the model featuring a 'high z' level, has a significant effect. This is evident by looking at the mass of people in the LS economy with this skill level, which is 0.078 (or 7.8% percentage points) higher than the fraction in the 'high z' version. It is catastrophic for the economy when the high skilled people do not have significant incentives to work, which in this case both leads to higher unemployment but also lower tax revenues, since the highest paying people are now fewer in number. The decrease in taxes is, however, slightly limited by the fact that the distribution of employed people with the highest skill level is altered. In the LS version, the most populated income level for mostly skilled employed is the third highest, while it is the second highest in 'high z' model. This shift of the largest mass of people from one income level to a higher one is, however, not enough to completely offset the tax revenue loss, and this should be viewed as a negative effect.

When looking at the employed mass along the entire skill grid, the 'high z' version has fewer people employed at the highest two skill levels and more at all lower levels. This result truly shows some negative impacts, since the optimal incentives should cause the opposite effect, where relatively more people should be employed at the higher skill levels, leading to more tax revenue and higher total income. The same pattern can be seen in the differences between the 'low z' economy and the LS model with no significant differences; thus it can be assessed that the level of the second tier benefit level does not have a truly significant effect on the distribution of the employed. The reason for this effect seems to come from two different elements. First, it is an effect from the increased reservation wages that is experienced by high skilled unemployed UI recipients, who receive some of the highest benefits. The higher reservation wages makes it harder for people to find a suitable job, and so a larger fraction of the unemployed transitions down to lower skill levels before finding such a job. In turn, this then leads to a greater part of the population appearing in lower skilled jobs, compared to the LS model. Second, there is a mechanism in the LS model, where there is a drop in reservation wages for the second and third highest skill levels due to the government threshold. This in turn protects against the unemployed sliding down to lower skill levels. These two effects together can explain the differences in employment along the skill grid.

From the employed mass of people, the focus is now moved to the unemployed part of the population; initially the part of the unemployed receiving the high tier benefits, UI. First, it is interesting to observe the overall mass of people in this state, with the 'high z', 'low z', and LS economies having 8.0%, 7.8% and 3.9%, respectively. Again the z does not seem to create any significant changes, but the part of high benefit recipients are twice as large as in the LS model. This indicate some major disincentive effects for this state compared to the LS version. In order to analyze this, the mass of

UI recipients are summed on current skills and last earnings, respectively. Along the former dimension, there are rather significant differences between the LS model and the 'high z' model. The summation along current skills leads to a vector with the mass of UI recipients for each level of previous income (vector of length 15). Across the board, the proposed model has higher levels of unemployment in the UI state for the various last incomes. Especially the unemployed who receive high UI payments are overrepresented. For the three highest 'previous earning levels', there is a difference of 2.27, 1.69, and 1.24 percentage points. This means that the probability of losing the high benefits through the limited duration, does not outweigh the disincentive effect from the high reservation wage that these people face. Summation along the previous earnings, lead to a vector containing the mass of UI recipients for the different current skill levels. Here the masses of unemployed are also universally higher for the 'high z' model compared to the LS one, where the largest differences are present within the higher skill levels. This is also consistent with the valley seen in the UI reservation wage graph for the LS model. Here the wage level decreases for the second and third highest skill levels, which again is a product of the government income threshold coming into play. In the high- and 'low z' models, there is a more continuously rising reservation wage along the skill levels. This valley in the wage for the LS model, causes people from these higher skill levels to enter employment easier or at least letting them fall to state SA, instead of having them staying in UI and transition down to lower skill levels as in the proposed model.

Another interesting fact about the group of people and the decision functions relates to the search intensity that was seen in Figure 7.5 and 7.7. Here is it clear that the lowest skilled people with low previous incomes search significantly less in the former figure, compared the latter. This, however, does not have any significant effect, since there are no people distributed in that part of the skill and income levels, where a fraction of people do not appear until the income index with the level 0.93. Therefore, what seems like a rather significant difference becomes irrelevant in the analysis. This is related to the reservation wages, because the agents require a relatively high wage rate, and it turns out that this is the lowest income level that anybody will work at across the entire proposed model with the high z.

Concerning the population distribution for SA recipients, this segment does not truly differ between the proposed model and the LS model. For high skilled people, the LS model have a higher mass in this state due to the 70% replacement rate that lower government threshold wage, which leads more people to transition to this lower state. For smaller skill levels, the 'high z' economy has higher masses, but in absolute terms the numbers are not truly significant.

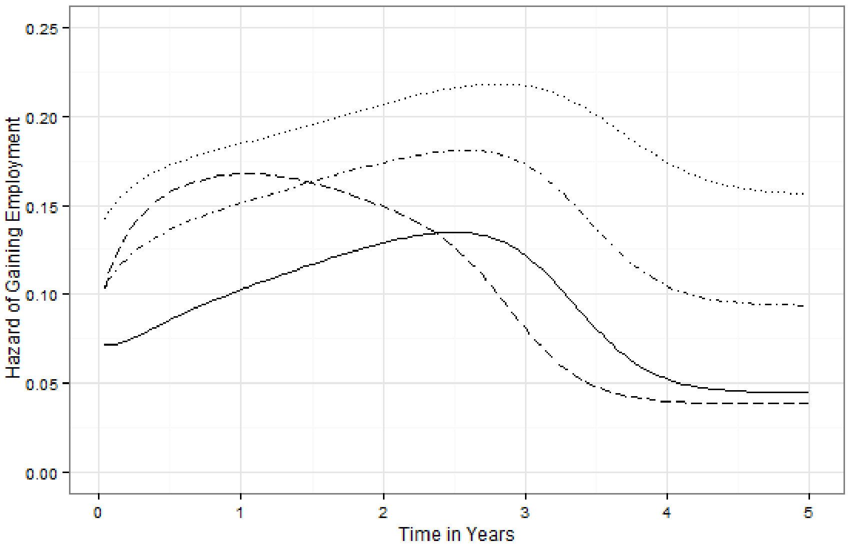


Figure 7.12: Hazard rates over time for becoming reemployed after a layoff for the second highest income group (where it applies). The dotted line is the Laissez-Faire model, the long-dashed is the LS version, the dot-dashed and the solid lines are the N - and E state employed for the 'high z' model.

Last, a few words on the fourth state introduced by the proposed model, N, where the agents do not qualify for UI: Only roughly 5% of the population is placed in this group in the steady state in the 'high z' version and 4.5% in the 'low z' model. This occurs because only 1.8% and 1.4% are second tier benefit recipients. This result also indicates that the re-entitlement period and UI duration has a limited impact in this economy.

7.4 HAZARD RATES

In order to give a graphical presentation of the adverse effects, Figure 7.12 shows hazard rates of being re-employed for people who have experienced layoffs. More specifically, it shows the part of the remaining mass of unemployed who gains employment in a given period. It presents results for individuals who have attained the highest skill level before the layoff in the 'high z', LS, and LF economies. The solid line represents hazard rates for people previously employed in state E, who were at the second highest income level, which, as mentioned, is the most populated part of the distribution. The LS version takes the same income level, while the last two lines are the LF model and people employed in state N, where income does not matter due to the agent not being eligible for UI. The most striking feature is the low probability of finding employment for the laid off who are earning UI in the 'high z' model (solid line). This clearly shows the adverse effects from the higher reservation wage as presented above.

The lines all increase in the beginning until they converge to some lower number. This is due to the U-shaped reservation wages with regard to the skill level, where the medium skilled have lower reservation wages, since they fear losing all their skills and see potential in getting a higher income through skill transitions. The reason for the high hazard rate for the LS economy, in the early years, is the double U-shape of the reservation wage. Here those who are fired and lose one or two skill levels have significantly lower reservation wages, and therefore a higher probability of escaping unemployment.

7.5 AGGREGATE RESULTS

Going back to Table 7.1, it is now more clear why the differences in the models occur. It is clear that most of the observed differences stem from an increased reservation wage for especially the higher skilled part of the population. This causes fewer to be employed in the part of the population with the highest potentials and it also causes more people to slip down through the transitions into lower skill levels. This is especially important since most of the population is located in the top skill levels, and therefore the high reservation wages there will keep many of these people unemployed for extended periods of time. This, therefore, leads to the higher expected duration of unemployment as well as the fraction that becomes long term unemployed. The higher tax is directly related to this, since the additional people in high payment UI are expensive for the government, which then require taxes to increase in order to finance the system. This in turn again raises reservation wages, even though taxes are also levied on the unemployed, since in absolute terms the value functions of the employed will become worth less than before.

8 DISCUSSION

This section features a discussion regarding the findings from Chapter 7 in relation to the expectations I had when I initiated the project. A few words will also be put on the heterogeneity featured in the model.

By introducing the benefit duration and re-entitlement period in the system, I expected the model to counteract the adverse effects that a welfare system leads to. In theory it has two dynamics: First the limited UI period should decrease the reservation wage, since an unemployed person now has a fear of transitioning to the lower SA state, thus she should accept jobs with lower wages, all else being equal. Second, the re-entitlement period should have the effect that people in UI have even lower reservation wages. This is because they realize that if the UI entitlement is lost, they will have to work an extended period before regaining eligibility, which, all else being equal, would lead to more people in the SA state instead of the expensive UI state.

On the other hand, I did expect that the second tier non-zero SA level would have negative effects on the behavior of the people. This would dim the effects of the limited UI duration, since the transition to SA would mean less of a drop in income. I expected the 'high z' version to be too generous, while the low level of z was thought to provide a better steady state, which, as a matter of fact, did seem to be the case.

The results found were universally worse than the LS version, which means that in the steady state, the Danish system does seem to be rather inefficient compared to other systems. The results were actually a lot more drastic than anticipated in the tranquil economy steady state, and as such various aspects of the model will be discussed below.

When looking at the values for the duration period, it becomes clear that the they appear insignificant compared to the prospect of descending in the skill grid. The stochastic probability of moving from state UI to SA was set at 0.0195, which is roughly ten times lower than the probability of losing a skill level during unemployment. This means, more specifically, that any unemployed person loses an expected 10 skill levels before she loses her UI claim. Therefore the skill loss should be of much more concern to the unemployed in relation to future income, than the loss of high benefits. Therefore the duration effect will be larger for the lower skilled part of the population, which, however, is fairly underrepresented in tranquil times. Another point associated with this issue is the expected unemployment period, which, even though it is significantly higher than in the LS or LF versions, is still lower than the 2 years that is the expected UI duration; so most unemployed will not experience this transition and loss of eligibility. It would only seem to have an effect for the people who have the most disincentives, which is the case for high income agents who have lost all skills. These are however highly underrepresented, and as such the effects are small.

The social assistance benefit level did have an effect, but not as significant as the replacement rate. It impacted the reservation wage for the employed, which however did not transfer into significant impacts on the steady state. This can partly be explained by an effect from the generous replacement rate that in turn decides the government income threshold. In the proposed models, the limit does not interfere with the reservation wages for high skilled UI recipients with top-tier previous income levels (h and I close to 2), because the threshold lies above the reservation wages chosen by these people. This is seen in Figure 7.1, where the reservation wage function of current skill levels, given $I = 2$, shows a single U-shape, instead of a double U-shape as in Figure 7.3, where the threshold is binding. Since most of the population is employed in this area of the distribution, the increased reservation wage, $\bar{w}_E$, had little actual effect. Even though the effect was not grand, the results did show that a lower social assistance level could be beneficial for the economy, since it would lead to lower unemployment and higher consumption. By applying some sensitivity analysis, it can be shown that when the social assistance level becomes too low, the value of consumption will fall again. So, lowering the benefit level can improve the incentives for the unemployed, but setting it too low will hurt the income more than it increases the incentives, so people end up with lower consumption.

In Section 7.2 the steady state results for the proposed model simulated with a 70% replacement rate are shown. Here it is clear that the introduction of the second tier benefit level, and the stochastic transitions between the states, actually has the positive effects explained in the beginning of this section. Here the 'low z' economy outperforms the LS version, even though the differences are not truly significant. This does however show that the supreme, dominating factor of the model is the replacement rate, where the higher one seen in Denmark has an extreme effect on the outcome. This is also evident from the simulation with an infinite UI duration and a 90% replacement rate, which did not lead to any sustainable steady state. In practice this is most likely an issue of the construction of the theoretical model, where only the low income, manual labor part of the population is actually represented. It is not surprising that such an economy cannot exist, due to the high constant replacement rate that applies to all. Here it can be argued that the model should have included the entire population, or at least a larger spread of its income levels. Doing this would, however, require a rethinking of the skill variable, since this, as stated, is based on blue collar jobs.

Aside from this problem, the results do indicate that in a tranquil environment, there are efficiency gains to find if the replacement rate is lowered. This would improve the incentives of workers by lowering reservation wages and increasing search intensities, which would cause a lower unemployment rate and higher general wealth. The lower income during unemployment is counteracted by the improved incentives, which means that the expected value of consumption increases when the replacement rate is lowered. This can be seen when Table 7.2 is compared to Table 7.1. As a final observation the sensitivity of the UI duration was shortly tested, where the parameter was increased marginally. The results for a 1 week increase in the duration led to an approximate mere 0.05 weeks of increased expected duration of unemployment, which is somewhat less than the empirical findings of Moffitt and Nicholson (1982), Moffitt (1985) and Katz and Meyer (1990). The differences are however not catastrophically different.

8.1 HETEROGENEITY

The inclusion of the skill system, and the corresponding transitions, shows that job skills and human capital does have an important place in the analysis of unemployment benefits and worker decisions. When these benefit schemes are designed, it is essential to consider which incentives one gives to the different groups of people in the economy. It seems especially important to provide incentives for the high skilled to quickly get back into employment instead of choosing to suffer prolonged periods of unemployment. Such an unemployment spell hurts the income potential later on, and in turn the production or gross national product of the economy. This happens because that part of the population has strong incentives to wait around for a very good job, since they cannot obtain substantial gains through the skill transition. Therefore it becomes highly important to find a way to provide incentives for these people, so as to avoid this behavior. This could be avoided if some sort of renegotiation or on-the-job search would be allowed, since the unemployed, then, would be willing to take on lower paying jobs. Additionally, since the government most likely cannot observe the skill levels of the unemployed directly, as is the case in this model, the idea of a government income threshold is sound, since this influences the incentives. It is however evident, from the proposed models, that this must be done in a fashion so that the threshold has a specific impact on the targeted population group, as was not the case here. In practice this is a situation where the high degree of active labor market policies that exist in Denmark can come into play. These programs have the potential to give an insight into the skill level of an unemployed agent, through the large number of interviews and training sessions that an unemployed must go through in order to collect UI. Therefore the UI institutions might better assess whether a job offer is suitable for that specific person, and then force a threshold on the unemployed.

8.2 sub-conclusion

To summarize, the conclusion, at this point, is that the expanded model does not seem to indicate that the current Danish system should do any better than the economy analyzed in the original paper. The system is indeed better than the older Danish systems with indefinite UI durations, which led the model to diverge even in tranquil times. However, it can be argued that significant welfare improvements can be found by making the benefit system less generous, both in terms of replacement rates and social assistance. The question is then, however, whether some of these initial adverse effects of the expanded model can be erased when analyzing the model in an economy that features adverse skill shocks and turbulent times. This would contain the real answer to whether the current system is more stable than the economy analyzed in the original paper, which in turn reveals if the same conclusions can be drawn. Additionally, if it is assumed that turbulence is higher in the world today, it must be included when analyzing benefit policies.

9 SHOCKS AND TURBULENCE

As mentioned in Chapter 1, the original analysis was based on empirical findings regarding skill losses after layoffs. It was found that workers who received involuntary layoffs saw deep decreases in potential future income from a new job. In order to analyze this, the skill transition matrix after a layoff will be changed to allow for losses in human capital and job skills, which will be done in two ways, in the following.

9.1 TRANSIENT SKILL SHOCK

The first analysis consists of introducing a transient skill shock, which will be a one-time shock with an increased firing rate, as well as a layoff skill transition where the laid off will shift to the lowest skill level no matter how skilled the worker was before. After the shock, the various economic statistics are tracked in order to analyze how long it takes for the economy to return to the steady state. During the shock, the layoff rate is increased to 0.18, and in all following periods it returns to the original level. The shock is characterized as unexpected, and it is the agents know that it will not happen again. Additionally, the tax rate will stay the same, where any state deficit will be covered by lump-sum taxes. Both these features contributes in such a way that people in the economy do not adjust their decision rules because of the shock, and therefore their reservation wages and search intensities stay unchanged.

This analysis is done in order to illustrate and achieve an understanding of how the people transition through the states and, more importantly, how fast they transition, since this would indicate that the specific unemployment system could be better fit for a turbulent environment.

First is the shock concerning overall unemployment in the economy as shown in Figure 9.1. Obviously this increases at the time of the shock, since 18% of the employed become unemployed in this period. The graph shows the deviation from the steady state unemployment rate in percentage points. The four lines represents the four main economies: the 'high-' and 'low z', the LS, and the LF versions. By looking at the graph, it can be seen that the lines overshoot the steady state, which occur because it is the overall unemployment which is examined. The negative values happens because of the lower reservation wages in the middle of the skill grid, that causes more people to be employed here than in the steady state. Eventually, the lines will

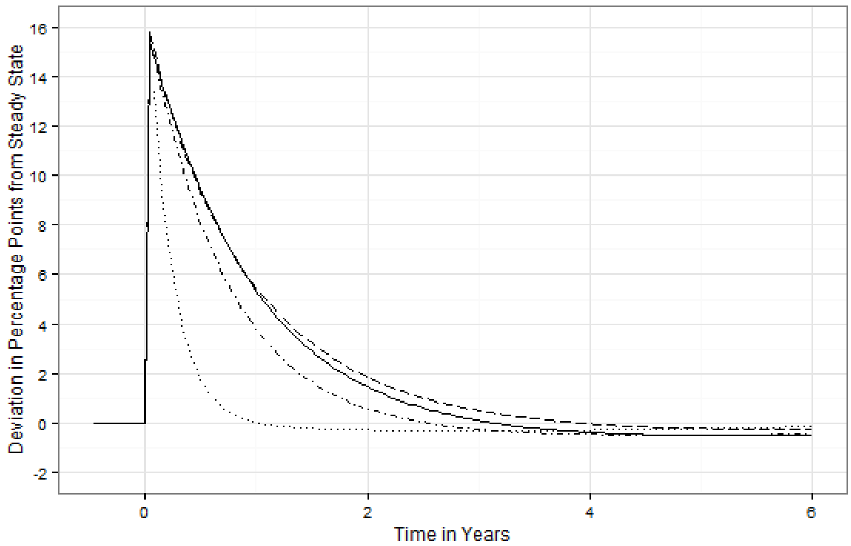


Figure 9.1: Deviation of the total unemployment rate from the steady state due to the transient skill shock. The dotted line is the Laissez-Faire model, the long-dashed is the LS version, the dot-dashed and the solid lines are the low - and 'high z' models.

converge completely to the steady state. When looking at the individual models, the LF economy naturally converge quicker towards the steady state, because these people always search very intensively in case of unemployment, since they now have zero income. It also shows that both the high and 'low z' models actually outperform the LS version, since both of the former models return to the steady state at an earlier point in time than the latter. The 'low z' model crosses the steady state level after approximately 2.5 years, while the 'high z' does so at about 3 years. In comparison, this does not happen until approximately 3.75 years in the LS model. Due to the decreasing absolute value of the slopes, there are, however, not large differences between especially the LS and 'high z' models. The reason for the differences is identified as being a product of the more dispersed population distribution, the existence of state N, the limited duration of UI, and also because the proposed model has a much more inefficient steady state than the LS version as shown in Chapter 7. The two first reasons mean that a smaller part of the laid off agents are subject to the very high reservation wages and very low search intensities, which occur for the highest skilled with previous top level incomes. The third reason leads to a quicker convergence, since part of the UI recipients will lose their benefits and then accept lower wages than before, while also choosing to search more intensively.

The drop in employment also has an impact on the GNP in the economy, since it is only the employed agents who contribute to the GNP statistic. This is presented in Figure 9.2. Here the evolution of

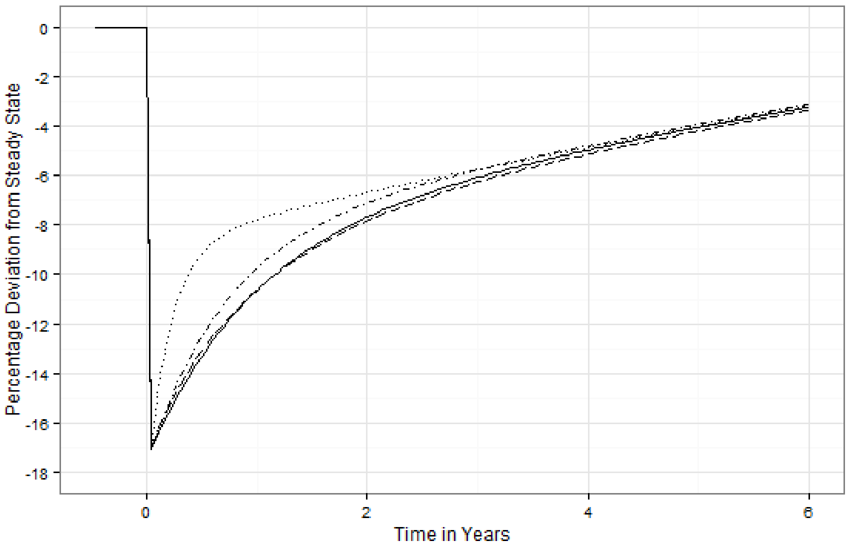


Figure 9.2: Deviation of the GNP from the steady state level due to the transient skill shock. The dotted line is the Laissez-Faire model, the long-dashed is the LS version, the dot-dashed and the solid lines are the low - and 'high z' models.

the economies is not as distinguishable as before. All models see a drop in the GNP of about 17%, before working their way back to the steady state. The 'high z' and the LS versions follow virtually the same trend on the way back to the steady state, while the 'low z' version is initially faster at eradicating the deviation. All models follow the same trend after approximately 4 years.

When examining at the deviations for the average productivity of the employed caused by the shock in Figure 9.3, it can be seen that the shock looks quite different from the other ones. The observed drop is not as sharp as in the other figures; this is happens because in the period of the shock, the statistic does not change, since an equal fraction of each type of worker is fired. This, therefore, has little to no effect on the average productivity of the remaining employed. Afterwards, the graphs start to drop, when the people who have been demoted to the lowest skill now find jobs. Therefore, the reason for the high drop in the LF economy, is that the laid off workers quickly find new jobs, which initially causes a high decrease in average productivity, because a relatively higher fraction are now low skilled. Therefore the less sharp drops in the other economies, come from the relatively slower transition back into employment, compared to the LF economy.

Last are the government finances shown in Figure 9.4, where the increased number of unemployed and the fall in GNP naturally lead to a deficit. Here certain features are evident: First it is clear from the initial deficit, resulting from the shock, that the LS model includes a much lighter public sector as expected due to the lower replacement

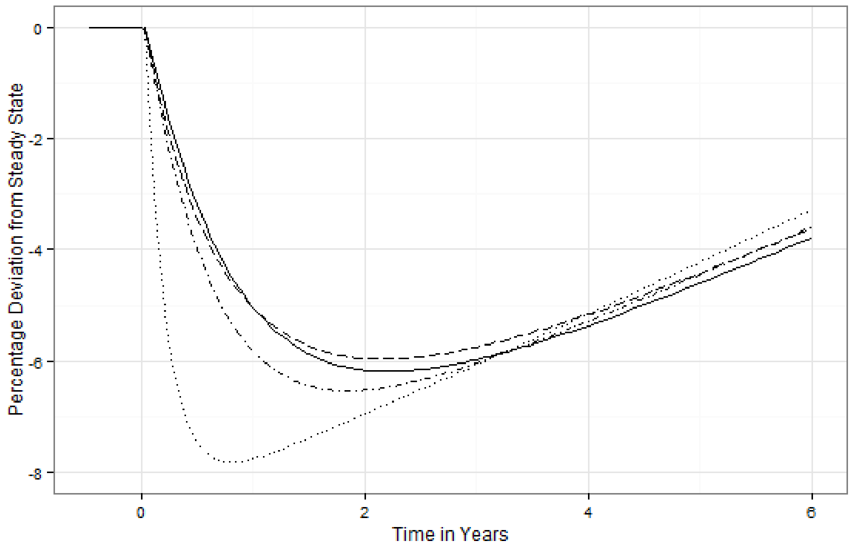


Figure 9.3: Deviation of the average productivity of the employed from the steady state level due to the transient skill shock. The dotted line is the Laissez-Faire model, the long-dashed is the LS version, the dot-dashed and the solid lines are the low - and 'high z' models.

rate. The faster transition into employment in the 'high-' and 'low z' models is seen in the figure in the form of a faster convergence back to the steady state, even though the initial deviation is higher. The specific reasons behind this are the same as for the evolution of the unemployment rate after the shock.

After analyzing this one-time shock in the economy, it does seem possible that the model mimicking the Danish economy will actually perform better in a turbulent environment relative to the original model. The proposed models at least provide a marginally faster convergence towards the steady state results, as presented in Chapter 7. In the following, an extension will be performed which includes more permanent skill shocks in the form of turbulence.

9.2 PERSISTENT TURBULENCE

As was shown above, the proposed economy does seem to function slightly better after a shock to the skill levels compared to the original model. In order to analyze this further, a permanent degree of economic turbulence is introduced, which is specified in the same fashion as in Ljungqvist and Sargent (1998, 2008). The economic turbulence is, in essence, the introduction of losses in human capital and job skills after a layoff, as was empirically found relevant by Jacobsen et al. (1993). It is important to emphasize that the skill losses only occur for people involuntarily becoming unemployed, and therefore not, workers who quit their jobs voluntarily. In den Haan et al. (2001)

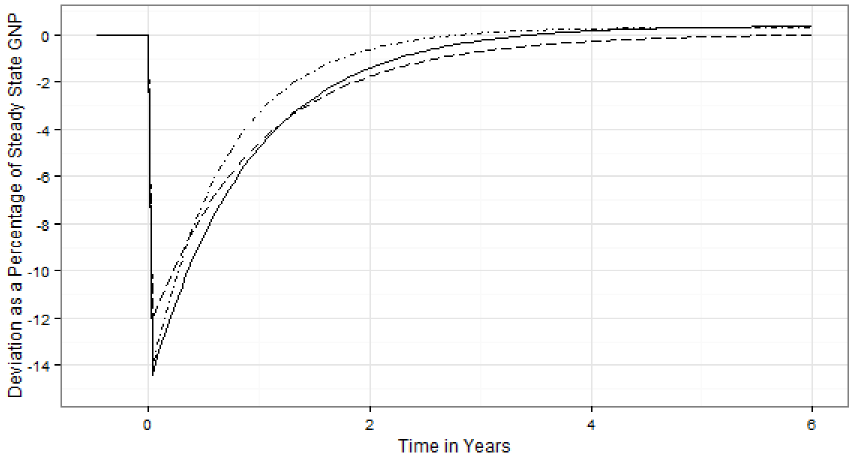


Figure 9.4: Government budget deficit as a percentage of the steady state GNP level due to the transient skill shock. The long-dashed is the LS version, the dot-dashed and the solid lines are the low - and 'high z' models.

the authors disprove the findings of Ljungqvist and Sargent (1998), but do so by assuming that both voluntary and involuntary layoffs lead to skill losses. This in turn means that, especially, high skilled who have transitioned through the skill system, will not quit their jobs since the fear of losing skills will lower their reservation wages. This will therefore depress the voluntary inflow to unemployment. By changing the economic turbulence to only implicate the fired agents, Ljungqvist and Sargent (2004) found similar conclusions as in their original paper. The reasoning for the above is that people who quit their job are confident in their skills and job opportunities, and only quit with a belief that they can use their skills better in another job. Therefore they are not subject to the skill losses.

In terms of the actual specification of the economic turbulence, it arrives as a probability of losing various amounts of skill levels in relation to being fired. All periods after and before the layoff will be governed by the same transition rates as in the model in tranquil times. After a layoff a worker has a positive probability to stay at her current skill level or transitioning down to each single skill level below her. That means that a person with the highest skill level, who has been fired, can end up at every single, different level afterwards, while a worker with the second lowest skill level, can lose a maximum of one level or just stay at her current one. It is assumed that the probability distribution of the skill levels after the layoff is the left half of a normal distribution truncated and centered on the unit interval and with the variance, χ, indexing the level of economic turbulence. Afterwards, this left half is normalized, so it integrates to one, since the sum of the skill level probabilities must sum to one. In simpler terms, this means that the skill level of the agent before the layoff is also the most likely, after the layoff, while the lowest skill level of 1 is also the most unlikely; except in the case where the agent is fired at the lowest level. The variance, or degree of economic turbulence, levels out this distribution, so the probability of transitioning down to the lower skill levels increases with χ.

In Ljungqvist and Sargent (1998, 2008) it was clearly shown that higher economic turbulence, as defined here, would lead to significantly worse steady states for the welfare economy, where especially the various statistics concerning the duration of unemployment saw great increases. In comparison, this development was not observed in the Laissez-Faire economy, where durations actually decreased. These findings were then used to explain the increase in European unemployment in the late 1970s as shown by Ljungqvist and Sargent (1998, Table1, p. 516). In order to challenge these findings, Table 9.1 shows the steady state results when incorporating economic turbulence into the four main models presented in Chapter 7. Three different values of economic turbulence are used, $\chi = \{0.0,\ 0.03,\ 0.04\}$, where it should be noticed that the first value means no turbulence, such that the results are equal to the ones presented in Table 7.1. Aside for the four main models, the simulation for the models with a 70% replacement rate has also been carried out and the results is shown in Table 9.2.

By initially looking at the LS and LF economies, it is clear that the results are a bit less severe than in the original paper, as mentioned in Chapter 6. The development of most statistics and the final conclusion are however the same, where the increasing turbulence actually lowers the unemployment values for the Laissez-Faire economy, while they are exploding in the LS model (welfare state). Along with the higher unemployment statistics, the tax rate must increase in order to finance the additional long-term unemployed, which in turn increases the reservation wage itself. The fraction of unemployed agents does not increase substantially, but the length of the unemployment spells increases drastically. Given the assumption of increased turbulence, this instability of the generous welfare system is then used as an explanation of the higher level of unemployment rates in European countries. The effects on the LS and LF economics are, however, all practically the same, as in the original paper, so now the attention shifts to the evolution of the proposed model under the effect of the same turbulence.

The unemployment rate falls in both proposed models in the first degree of turbulence, before increasing slightly in the following degree. The net effect, however, is a lower unemployment rate in both models. In contrast, the LS model experienced a higher increase, yet still not a truly significant one, so based on this unemployment statistic alone no true conclusions are evident. When looking at the average duration of unemployment a more serious notation appears: Here the LS model increased from a mere 13.46 weeks in a tranquil environment, to 35.92 weeks in the highest degree of turbulence, which

Table 9.1: Steady-state values in various degrees of turbulent environments

$\chi =$	0.00	0.03	0.04
Tax Rate (%)			
High z	7.80	7.16	7.58
Low z	7.15	6.45	6.64
LS Model	2.93	4.25	4.99
Laissez-Faire	0.0	0.0	0.0
Avg. productivity of employed			
High z	1.793	1.622	1.596
Low z	1.787	1.617	1.590
LS Model	1.761	1.607	1.581
Laissez-Faire	1.754	1.600	1.571
Unemployment rate (%)			
High z	9.72	8.63	9.06
Low z	9.17	7.99	8.05
LS Model	7.12	7.12	7.89
Laissez-Faire	6.03	5.64	5.59
Avg. unemployment duration (weeks)			
High z	20.69	22.88	26.15
Low z	20.15	19.86	21.45
LS Model	13.43	23.41	35.92
Laissez-Faire	11.88	10.84	10.92
Unemployed $\geqslant$ 6 months (%)			
High z	27.57	26.64	29.96
Low z	26.51	23.45	25.45
LS Model	11.75	20.87	28.80
Laissez-Faire	8.75	7.02	7.20
Unemployed $\geqslant$ 12 months (%)			
High z	6.41	8.77	11.57
Low z	5.91	6.32	7.83
LS Model	1.26	8.55	16.18
Laissez-Faire	0.60	0.50	0.55
Consumption Value			
High z	1,059.4	968.0	947.7
Low z	1,061.1	971.0	952.7
LS Model	1,066.8	972.7	949.8
Laissez-Faire	1,070.7	980.8	964.0

GNP and average productivity are calculated for 2 weeks. χ is the variance of the distribution of the skill level after an involuntary layoff.

Table 9.2: Steady-state values in various degrees of turbulent environments with 70% replacement rate

$\chi =$	0.00	0.04
Tax Rate (%)		
High z, 70%	3.92	4.31
Low z, 70%	2.85	3.64
LS Model	2.93	4.99
Laissez-Faire	0.0	0.0
Avg. productivity of employed		
High z, 70%	1.781	1.590
Low z, 70%	1.762	1.580
LS Model	1.761	1.581
Laissez-Faire	1.754	1.571
Unemployment rate (%)		
High z, 70%	7.68	6.92
Low z, 70%	6.86	6.41
LS Model	7.12	7.89
Laissez-Faire	6.03	5.59
Avg. unemployment duration (weeks)		
High z, 70%	14.11	15.78
Low z, 70%	13.28	14.94
LS Model	13.46	35.92
Laissez-Faire	11.88	10.92
Unemployed $\geqslant$ 6 months (%)		
High z, 70%	13.38	16.35
Low z, 70%	11.62	14.87
LS Model	11.84	28.80
Laissez-Faire	8.75	7.20
Unemployed $\geqslant$ 12 months (%)		
High z, 70%	1.45	3.58
Low z, 70%	1.12	2.99
LS Model	1.29	16.18
Laissez-Faire	0.60	0.55
Consumption Value		
High z, 70%	$1,069.2$	961.3
Low z, 70%	$1,069.4$	961.5
LS Model	$1,059.0$	949.8
Laissez-Faire	$1,070.7$	964.0

GNP and average productivity are calculated for 2 weeks. χ is the variance of the distribution of the skill level after an involuntary layoff.

is a very significant impact. In contrast, the 'high z' model sees an increase of approximately 6 weeks, while the agents in the 'low z' model only expect 1 additional week of unemployment. The same pattern appears in the statistics for long-term unemployed. Here the LS model observes an exploding amount of such people, who are jobless for more than 6 and 12 months, respectively. For the proposed models, there is a drop in employment spells of more than 6 months in the first degree of turbulence, while it increases in the next. It is however only the 'high z' model that sees additional people with an unemployment duration of more than 6 months.

The rest of the statistics slowly decrease with the increased turbulence, which is expected due to the specification of the turbulence. It should bring about welfare reductions, when the population becomes less skilled and therefore earn lower incomes, as can be seen in the table.

Shifting the attention to the 70% replacement rate in Table 9.2, it shows that much of the same picture appears concerning the results. The negative effects of the turbulence are also countered by the introduced duration policies. In this case, however, the social benefit levels seems to have a very limited effect with similar consumption values and also very similar unemployment statistics. Never the less the results indicate a smaller level, as in the case of the main model. The table also reveals that the replacement rate has a significant effect on the welfare state in turbulent times, since the steady state results show an improved state compared to the economy with a 90% replacement rate. The population has more wealth and shorter periods of unemployment due to the increased incentives from a lower replacement rate.

When looking at the effects of the increased turbulence, it makes sense to first think about the more direct ones first. This new environment introduces the risk of transitioning to a number of different skill levels, compared to staying at the one prior to a layoff, as was the case without turbulence. The direct consequence, everything else equal, that the skill level of the population falls. This is indicated by the average productivity of the employed in Table 9.1, which decreases for all models. In turn, this lowers the potential income for the population, due to this being a product of the wage and skill levels. Therefore it is natural just from this, that the value of consumption drops in the turbulent environment. The more spread out skill distribution also has another effect, which can help explain, why the unemployment rate falls in the proposed model: As argued in Section 7.1, the function for the reservation wage with regard to the current skill level is U-shaped. Therefore, when more people enter the middle levels of the skill grid, due to the risk of losing any number of skills after a layoff, there will be fewer unemployed, since these newly laid off people will have a lower reservation wage than if they did not suffer skill losses. In order to analyze the results further, it is necessary to approach the problem as in Chapter 7 and start with the decision functions. Additionally, the examples and illustrations in the following will be taken from the economy with the high degree of turbulence, $\chi = 0.04$.

9.3 STEADY STATE DECISION RULES IN TURBULENCE

Concerning the choices a worker must make, the turbulence alters one important factor, namely the risk of losing earned skills. As stated earlier, one of the gains from obtaining a job is the increasing skill level through the Markov process. In this new environment, however, the workers understand that even if they become highly skilled through work experiences, there is always a risk that they get fired and experience an adverse skill shock. This effect will, therefore, lower the value of getting a job for people in all skill levels. Clearly this effect has the largest impact on the lower skill levels, since such people have the most to gain from becoming more skillful. The effect is not very large for highly skilled people, since they realize that even with the risk of becoming less desirable after a layoff, the probability of such is only 0.009, which leads to an expected employment spell of approximately 4.3 years. On the other hand, the expected duration of transitioning from the highest skill level to the lowest during unemployment is about 3.8 years. Therefore, even though this new risk is introduced, the workers know that just staying unemployed always has a worse expected outcome on the skill levels, compared to getting a job.

This effect shows itself in the reservation wages, where especially lower skilled unemployed require a higher wage than before, in order to take on the risk created by the turbulence[1]. To illustrate, the workers who previously had the highest level of income, and have now fallen to the lowest skill level, now require a wage level of 0.97, 0.94 and 0.96 for the 'high z', 'low z' and LS economy, respectively. Previously, these levels were at 0.93, 0.91 and 0.91. Universally, it can be stated that the reservation wages in a turbulent environment are higher than, or equal to, the wages in tranquil times. All economies experience increasing reservation wages, and no economy truly differentiates itself from the others in terms of the absolute increases. Therefore, it is decided that a broader analysis is required in order to identify the different paths seen in Table 9.1.

Considering the search intensities for UI recipients, the same story appears: Getting a job, when one is a low skilled individual, is relatively less valuable; so since search is costly, the individual chooses to put less effort into the job finding. Therefore, all of the optimal

1 The graphs containing the decision functions in turbulent times are not depicted, since the general appearance of the graphs does not change.

search intensities are either lower, or equal to, the ones in the tranquil environment. Looking at the same people as above concerning the reservation wage, the ones with high prior income and low skills, the results show that they will only search with very limited intensity. For the 'high z', 'low z' and LS economies, the optimal search for these people are 0.01, 0.04, and 0.02. This is a decrease from 0.06, 0.10, and 0.11. Due to the concavity of the search function, these fairly small changes are actually quite substantial in absolute terms. For the LS version for example, a person in this state goes from having a 52% probability of getting a job offer to only 31%.

When looking closer at the specific group of people as above, it becomes clear that they can actually get more or less stuck in this state. By taking the search function and the normal distribution of wage draws, one can calculate the expected period of unemployment for any agent in this state. Looking at the LS version, the probability of getting an offer for such a person is roughly 31%, and the wage draw for this offer has to be equal to, or above, 0.96. To find a wage of this level, or above, has a probability of approximately 1.78%, which means that the probability of both getting an offer and finding a suitable job is a mere 0.55%. In turn, this is equal to an expected duration of unemployment of about 7 years. This means that the agents, who end up in this state will be experiencing exceedingly long unemployment spells in the LS model. This adverse effect is obviously limited in the 'high-' and 'low z' models, where unemployed agents in this state will lose their UI eligibility after an expected 2 years, where they will change to a state with a lower reservation wage.

9.4 POPULATION DISTRIBUTION

This is also evident, when looking at the population, where the mass of people with skill level $h = 1$ and previous income $I = 2$, increases by 0.74 percentage points in the LS model due to the turbulence. Therefore this group now represents 9.4% of all unemployed, which is substantially higher than the 0.004% in the tranquil environment. In comparison, the same test can be made in the 'high-' and 'low z' models, where the mass of this group increased from 0.005% to 2.4% and from 0.003% to 1.6%, respectively. This suggests that a lot of the adverse effects in the LS model is mainly due to the agents, who get stuck at the lowest skill level, while receiving the highest benefits. It can therefore be explained simply as an incentive problem, which is one of the premier and most common arguments against having a generous welfare state.

Aside from this aspect of the population distribution, another element that can be seen in these distributions, is the direct effect of the stochastic skill losses, as was mentioned earlier in this section. In tranquil times, most people had garnered the highest skill level, with around $71-79\%$ of the population being employed with this level, in the 'high-' and 'low z', and LS models. In the turbulent environment, this fraction has been lowered to $38-41\%$ of the population. The people, who had this level in the tranquil times, are now spread out across the entire skill grid.

To summarize the main findings here, it seems that the LS economy reacts more volatile to the turbulent environment, than the proposed models. The main reasons, identified through the results, are first the relatively lower part of the population stuck in the state with the most disincentives. Second, the extremely high reservation wages for high skilled in the proposed model will be countered by skill losses, which leads to states with lower reservation wages.

10 DISCUSSION

In the previous chapter, the aspect of economic turbulence was introduced, and the steady state results in this new environment were presented.

Before the turbulence was introduced, the proposed models mimicking the Danish economy showed an extremely poor steady state compared to the model by Ljungqvist and Sargent. This was characterized by higher unemployment rates, longer spells, and higher tax rates. By introducing this turbulence, it was seen that while the LS model showed large adverse effects, the statistics concerning the unemployment in the proposed models actually improved for smaller degrees of turbulence. Generally, the LS model seemed to react with a much larger degree of volatility compared to the proposed models, which indicates that in this turbulent setting, the limited duration, and re-entitlement periods actually have the desired effect on the economy.

10.1 HETEROGENEITY

First a discussion of the skill system and the heterogeneity that this produces: It is clear that the introduction of this type of turbulence is only possible with a varying skill level. The main aspect of the system is that this proxy for human capital and job skills, is still a very important element in the shaping of worker incentives. The prospect of accumulating job skills from being employed, and through this to obtain income raises, is the main incentive in the model for obtaining a job. The introduction of turbulence does, however, counteract this positive incentive partly, since the risk of stochastically losing skill levels means that the overall value of a job decreases, and therefore also the incentives. In general, the skill system still appears to be an important factor, when analyzing unemployment benefits, due to the fact that people in the real world are different from each other. The level of heterogeneity is, however, still highly simplified, and it could be considered to change the skill system by splitting up the skill grid into a human capital part and a job skill part, since it can be argued that these two are quite different. This would allow for an extra dimension of heterogeneity, which would be more aligned with reality, in which people have varying skills depending on more than their employment spells. To extend, this would also enable the model to allow for additional kinds of turbulence, that influence the two different skill types independently. Going further down this path, it would then also make sense to differentiate the wage distribution, so it correlates to a certain extend with the level of either human capital or job skills. This would mean that highly capable people do not necessarily search for the same jobs as low skilled people do. These parts were not included in this thesis, since they might alter the effects of the other changes that was made. This must be reserved for future research. To sum up, the results regarding the skill transitions are generally aligned with the theoretical expectations of how this system would affect the economy by influencing the incentives of the workers.

10.2 IMPLICATIONS FOR POLICIES

The different economies tested were subject to various government chosen policies. Different values of replacement rates and low-tier social assistance levels were instated. Additionally the two-tier benefit system was introduced. The replacement rate was found to have a significant and very deciding impact on the level of steady state results. This was evident in the models mimicking the Danish system, where the 90% replacement rate led to a rather inefficient steady state, where agents experienced excessively long unemployment spells, even with the increased turbulence only having limited effects.

Conversely, when inserting a lower replacement rate, the economy improved significantly in terms of unemployment statistics and consumption levels. This shows the importance of this parameter when analyzing welfare states, due to the high degree of sensitivity of the economy. It is, however, not surprising that this parameter plays an incredibly important role, since it was the involuntarily laid off unemployed, receiving UI payment, who were shown to be primarily subjected to the disincentive effects. Therefore, because the replacement rate directly governs these peoples' opportunity costs, they will raise the reservation wage, when the replacement rate increases, since they now can afford to wait for a higher wage offer. A lower rate, on the other hand, will still supply the people with income in case of involuntary layoffs, but also with added incentives to obtain a new job, because the income potential from this is now higher than staying in unemployment.

Another policy parameter was the social assistance level, which was found to have some effects, but was not as influential as the replacement rate. The idea of the second tier benefit level is to ensure that no person is left completely without income at any given point in time. For high replacement rates, the effect from the social assistance level was magnified in turbulent environments, where a decrease of this parameter could lead to welfare improvements, because it enhance the incentives for agents to find a new job. In other environments, the effects are limited, yet the results still point to a lower social assistance level as being beneficial. The level, however, cannot be decreased to zero, since this will cause an inappropriate drop in income which in turn lowers the expected consumption level of the agents. Therefore, there exists a non-zero level that appears optimal, given the other policy parameters. It can therefore be argued that in these economies a lower social assistance level would be beneficial to the welfare state.

Last is the limited duration of UI as well as the re-entitlement period. The inclusion of these policies led to a significantly better steady state compared to an economy without. This lowered the reservation wages and increased the search intensity, because the agents realized that the risk of losing the UI status would lead to certain income loses. The policies also showed promise regarding turbulent environments and skill shocks, because the limited duration eliminates the threat of an unemployed agent being stuck in a position with great disincentives to find a new job. In the most turbulent environment, these policies actually managed to overcome the increased replacement in the 'low z' economy, and outperform the LS model with regard to consumption value. This means that people in this setting, even though the limited duration can be seen as a cutback, actually have more expected wealth than in the model with indefinite UI payments. This all goes in line with previous research on the issue of both the construction of benefits but also on two-tier systems, like Shavell and Weiss (1979), Hopenhayn and Nicolini (1997), and Fredriksson and Holmlund (2001). These papers find that a benefit scheme should decrease over time, and that a two-tier system will always outperform a scheme with indefinite UI payments (when the replacement rates are equal). The re-entitlement period has the effect that employed people with eligibility are willing to work at lower wages than otherwise, due to the fact that they must go through this re-entitlement period, if they quit. This is opposite, yet similar, to the "entitlement effect" proposed by Mortensen (1977), who states that ineligible, unemployed agents are willing to work at lower wages in order to regain eligibility. The reason for the difference here might be due to the stochastic limited duration used in this model, compared to the fixed limited duration utilized in Mortensen's paper. In a fixed duration setting, the hazard rate for an unemployed would likely be an increasing function with regard to time. This happens because, as the prospect of losing UI approaches, the unemployed lowers her reservation wage. This would most likely increase the value of these benefits, since the worker has full knowledge of when she will lose the eligibility.

10.3 IMPLICATIONS FOR THE MODEL

The analysis of the model constructed by Ljungqvist and Sargent brought forth some unfavorable results. It was found that a large dynamic of the model, in turbulent times, was the entrapment of people with high previous incomes, who had now lost all skills due to being fired. This brought on prolonged spells of unemployment and lower general welfare levels, which then led to the adverse results in their original article. In the model proposed in this thesis, the duration of time that people actually can be stuck in these situations was limited, which led the economy to react much less to the negative shocks. This means, in other words, that the results from the original model, regarding the increase in unemployment rates and spells, cannot be fully recreated when removing the assumption of indefinite unemployment insurance durations. Many countries in Europe currently utilize two-tier benefit systems in various forms, which leads to the point that this labor supply analysis does not seem capable of explaining the increase in unemployment anymore. This would only be the case if the economic turbulence had increased continuously and dramatically, while the two-tier systems were implemented in various countries, since a high degree of turbulence will still exacerbate the steady states regarding unemployment. Following Section 4.7, there are a lot of extensions that can be implemented in order to improve the model to make it more realistic, which in turn might lead to a better fit for the empirical data. It is however difficult to truly state which factors should be changed, but this single side labor supply model at least does not seem to fit the purpose of explaining the European unemployment dilemma.

10.4 IMPLICATIONS FOR THE DANISH SYSTEM

The last aspect that has been touched by the thesis is the results concerning the welfare system and state in Denmark. First of all the inclusion of a two-tier system, beginning in the early 1990s leads to a theoretically better welfare state in terms of practically all statistics. This means, in other words, that the decrease in unemployment seen in Figure 3.1 from the early 90s to the late 00s could be partly explained by these introductions. Therefore, the decrease would also be a change in structural/frictional unemployment and not just a random event.

Regarding the replacement rate in the Danish economy, the results point to the optimal rate being lower than the current one, since there were indications of rather significant welfare improvements, when the rate was at 70% compared to being 90%. This would enhance the incentives that unemployed people have in order to secure a faster road back to employment, which in turn would lower unemployment spells and rates, and increase wealth.

I do however identify one major problem in the model regarding the point of a lower replacement rate. This issue concerns the high degree of active labor market policies that is present in the Danish welfare state, and by excluding this, one excludes an important mechanism of decreasing the time spent in unemployment. Recent literature has found evidence that such active labor market policies can be a substitute to having a lower replacement rate such as Andersen and Svarer (2014). Additionally, Keuschnigg and Davoine (2010) argue that active labor market policies are an important and useful tool for especially large welfare states, which could legitimize the high rate in Denmark. Due to the exclusion of such policies, it must be concluded that the analysis regarding replacement rates will be ambiguous with regard to reality.

Last is the social assistance level, which as mentioned had lower impact on the results. As was argued in Section 10.2, the lowering of this policy parameter could lead to welfare improvements. This would especially be the case if the high replacement rate was kept constant, and the environment is assumed to be turbulent. From a worker incentive perspective, the lower level causes agents who have lost their UI eligibility to accept a new job sooner, while still supplying the agent with an income in the case that the agent experiences an unlucky period regarding job offers.

11 CONCLUSION

The preceding chapters have analyzed a welfare state consisting of heterogeneous workers and calibrated to the structure of the Danish unemployment benefit system. More specifically the analysis have challenged the model of Ljungqvist and Sargent (1998) which attempts to explain an increase in European unemployment through the introduction of skill losses from a turbulent environment. Additionally, the structure of the Danish welfare system has been questioned in order to see if improvements can be incorporated. Finally a general analysis regarding the incentives facing heterogeneous agents has been carried out.

In order to answer these questions, the general equilibrium search model developed by Sargent and Ljungqvist has been extended. The original model incorporates a skill system which allow workers to accumulate human capital during employment, while it deteriorates while unemployed, and the skill level determine an agent's income. The extension is the introduction of a two-tier benefit system with a high-paying, income proportional unemployment insurance and a lower-paying flat rate of social assistance. Besides this, a limited unemployment insurance duration and a re-entitlement period for regaining eligibility for the high paying benefits were also introduced. This improves the incentives of the unemployed agents, since they recognize the risk of losing their claim on the insurance, which leads them to lower their reservation wages. In addition, it prevents an unemployed agent from becoming stuck in an unfavorable unemployment state, by eventually securing the transition to the low paying social assistance.

The initial results in tranquil times presented the Danish welfare state as an inefficient system with regard to worker incentives, since the high replacement rate causes unemployed agents to increase their reservation wages. This indicated that efficiency gains were possible by lowering both the replacement rate for unemployment insurance as well as the flat level of social assistance. The introduced duration policies improved the steady state results significantly, since the simulation of the Danish economy without these policies caused the model to diverge. Therefore the decreasing unemployment rate observed in Denmark from the early 1990s can be explained partly by these introductions.

In the same fashion as the original paper, a turbulent economic environment was introduced to cause skill loss after layoffs. The introduction of this environment showed that the conclusions of Ljungqvist and Sargent cannot be fully recreated when allowing for this two-tier benefit structure. The main negative aspect of the original analysis is the extreme disincentives facing some unemployed agents, who thusly become trapped in unemployment after suffering substantial skill loss. By limiting the duration a person can obtain unemployment insurance, it was shown that these negative aspects were counteracted, and this diminished the destructive nature of the turbulence. Concerning the effect of the replacement rate and the social assistance level in the turbulent environment, it was found that the effect of the latter was amplified for the high replacement rate, and as such a smaller second tier benefit level in this situation is preferred. The effect from the replacement rate was similar to that in the tranquil environment, since the higher rate decreased the efficiency of the steady state results drastically compared to the simulation containing a lower replacement rate.

Regarding the element of the different skills that is used in the model, the results point to this being an integral part of studying unemployment benefits, since it induces significant incentives for the agents. This aspect can also help in explaining why some agents decide to become long term unemployed due to a decrease in skill levels that determine the potential income. This decrease causes a disparity between the collected unemployment insurance and the potential income from a new job. The dynamics introduced by this skill system are still important factors when introducing a two-tier benefit scheme, even in the turbulent environments.

A number of points of concern regarding the analysis did present themselves in connection to the limitations of the model. Especially the exclusion of active labor market policies makes the findings regarding welfare gains ambiguous, because these policies have the potential to legitimize a larger welfare state by influencing incentives and by enforcing restrictions. Additionally, it might be beneficial to redo the analysis in a matching framework, where the workers are able to bargain with the production firms in the changing economic environment. Therefore, future research could examine if the conclusions of the analysis are still valid under such extensions.

A
APPENDIX: R CODE - NUMERICAL SOLUTION

Below is the source code, I have written in order to solve the equations numerically. The method used to find the steady states, is value iteration, where the equations are run repeatedly until the values converge. Additionally a number of other statistics are found based on the steady state findings. By splitting up the 9 scripts into ".R" files and putting them in the same folder, it is possible to run the main script and obtain results. The scripts are separated with two dashed lines.

```
# 1_Main_Script_AK.R
# Author : Asbjoern Klein , asbjorn.klein@student.unisg.ch
# Version : 1.0
# Date : May 9, 2014
# This file contains all functions required to compute the steady state results
    for a given economy.
# This script requires the following files in the same folder: "2_Parameters.R",
    "3_Initialize.R", "4_Transition_matrix.R", "5_Value_func_step.R", "6_Pop_
    Distr_step.R", "7_Calculations.R", "8_Transient_shock.R" and "9_Additional_
    Graphs.R".
# Choose an economy and a degree of turbulence, and press ctrl + a, then ctrl +
    enter.
# Then look at the bottom for various graphs.
# The time range or the simulation lies between 1 - 2 hours approximately.

# Check Work directory:
getwd()
# If wrong, then please set work directory
# setwd('C:/...')

# Economy used in computation:
# 1 : Laissez-Faire (no taxes, no benefits)
# 2 : Finite UI duration, High z level (AK model)
# 3 : Infinite UI duration, zero z level (LS model)
# 4 : Finite UI duration, Low z level (AK model)
economy <- "4"

# Degree of persistent 'turbulence'.
# Choose "0.0" or "0.03".
chi <- 0.04

# Packages used in the script:

# Used for Trapz integration approximation function
library(caTools)
# Used for truncated normal distribution
library(truncnorm)
# Used for graphing surface plots
library(rgl)
# Used for graphing 2d plots
library(ggplot2)

# Loads the script steady_param.R with parameters used in the model
source("2_Parameters.R")

# Loads the script steady_init.R with various matrices and vectors are initialised
source("3_Initialize.R")

{print(sprintf('Model economy: %s',name))
 print(sprintf('Replacement rate : %2.0f%%',100*rho))
 print(sprintf('Social Assistance level : %4.2f', z))
```

```
 print(sprintf('Tax Rate : %3.2f%%', 100*tau))
 print(sprintf('Turbulence : %1.2f', chi))}

#---------------------------------------------------------------

# Number of iterations used to find value function steady state
iterations <- 3000
# used for check of convergence.
# iterations <- 200

# Used in estimation of Calculation Status
next_show <- 1

# Loop to calculate the steady state values of the value functions:
for (n_iter in 1 : (iterations - 1)) {
  percentage_iter <- trunc(n_iter/iterations*100)
  if (percentage_iter >= next_show) {
    print(sprintf(' Calculation Status: %4.0f%% ...',percentage_iter))
    next_show <- percentage_iter + 1
  }
  # One iteration of the steady-state calculation is performed
  source("5_Value_func_step.R")
}
# The steady state decision variables are saved depending on chosen economy.
if (LF == 1) {
  w_E_bar_LF <- w_E_bar
  searchint_SA_LF <- searchint_SA
} else if (LF == 0 & LS == 0){
  w_E_bar_AK <- w_E_bar
  w_N_bar_AK <- w_N_bar
  w_UI_bar_AK <- w_UI_bar
  searchint_SA_AK <- searchint_SA
  searchint_UI_AK <- searchint_UI
  tau_AK <- tau
  z_AK <- z
  UI_val_AK <- UI_val
  if (z == W[2]) {
    # Saving the reservation wage for low level z used for graphs:
    w_E_bar_AK_Low <- w_E_bar
    w_N_bar_AK_Low <- w_N_bar
  } else if (z == UI_val[7]) {
    # Saving the reservation wage for low level z used for graphs:
    w_E_bar_AK_High <- w_E_bar
    w_N_bar_AK_High <- w_N_bar
  }
} else if (LS == 1) {
  w_E_bar_LS <- w_E_bar
  w_UI_bar_LS <- w_UI_bar
  searchint_SA_LS <- searchint_SA
  searchint_UI_LS <- searchint_UI
  tau_LS <- tau
  z_LS <- z
  UI_val_LS <- UI_val
}
print(' Calculation Status: 100% ... completed.')

#---------------------------------------------------------------

# Now starts with the calculation of population distributions.
print('Population distribution')

# number of iterations to calculate the steady-state population distributions
distr_iterations <- 2000
# used for check of convergence.
# distr_iterations <- 200

# Used in estimation of Calculation Status
next_show <- 1

# Counts the number of loops elapsed. Used for debugging.
counter <- 1

# Loop to calculate the steady state values of the population distributions:
```

```
source("6_Pop_Distr_step.R")
for (distr_iter in 1 : (distr_iterations - 1)) {
  counter <- counter + 1 # Counts the number of loops elapsed. Used for debugging.
  percentage_iter <- trunc(distr_iter/distr_iterations*100)
  if (percentage_iter >= next_show) {
    print(sprintf(' Calculation Status: %4.0f%% ...',percentage_iter))
    next_show <- percentage_iter + 1
  }
  source("6_Pop_Distr_step.R")
}
# The steady state population distributions are saved depending on chosen economy.
if (LF == 1) {
  u_SA_LF <- u_SA
  e_E_LF <- e_E
} else if (LF == 0 & LS == 0){
  u_SA_AK <- u_SA
  u_UI_AK <- u_UI
  e_E_AK <- e_E
  e_N_AK <- e_N
  w_g_distr_AK <- w_g_distr
} else if (LS == 1) {
  u_SA_LS <- u_SA
  u_UI_LS <- u_UI
  e_E_LS <- e_E
  w_g_distr_LS <- w_g_distr
}
# Sum needs to be 1:
print(sum)
print(' Calculation Status: 100% ... completed.')

# Calculates the relevant statistics from the simulation.
source("7_Calculations.R")

if (chi == 0.00) {
# Calculates developments from a transient shock.
source("8_Transient_shock.R")
}

#-----------------------------------------------------------------

# Prints the statistics results.
{print(sprintf('Tax Rate:............................%2.2f%%',100*tau))
 print(sprintf('Replacement rate:...................%1.0f%%',100*rho))
 print(sprintf('GNP per capita:......................%1.3f', GNP))
 print(sprintf('Avg. productivity of employed:.......%1.3f', avg_prod_emp))
 print(sprintf('Avg. wage of employed:..............%1.3f', avg_wage_emp))
 print(sprintf('Avg. skill level in the population:..%1.3f', avg_skill_pop))
 print(sprintf('Unemployment rate:...................%2.2f%%', 100*u_val))
 print(sprintf('Avg. unemployment duration (weeks):.%2.2f', Exp_Duration_val))
 print(sprintf('Unemployed >= 6$ months:.............%2.2f%%', cont_unemp_13))
 print(sprintf('Unemployed >= 12$ months:............%2.2f%%', cont_unemp_26))
 print(sprintf('Consumption Value:..................%4.1f', Cons_val))}

#-----------------------------------------------------------------

# Graphs.
# Due to the package for the 3D graph, only one graph can be open at a time.
# 3D: Plotting the UI optimal search intensity.
{persp3d(I_grid, h_grid, matrix(s_grid[searchint_UI], nrow = I_ind_max, ncol = h_
      ind_max), nticks = c(5, 6, 6), xlab = "", ylab = "", zlab = "", front="lines",
      back="lines", axes=F, box = F, add = F, aspect = c(1, 1.2, 1), expand = 0,
      draw_front=F, zlim = range(0, w_maxval))
 # Adding gridlines
 grid3d(side = c("x", "y+", "z"), lty = c("2","2","2"), lwd = 1)
 # Adding axes
 axes3d(c('x','y+','z'), nticks = c(6,7,5), labels = T)
 # Adding labels
 mtext3d("Current Skills", edge = 'y+', line = 2, at = NULL, pos = NA)
 mtext3d("Last Earnings", edge = 'x', line = 2.25, at = NULL, pos = NA)
 mtext3d("Search Intensity", edge = 'z', line = 2.5, at = NULL, pos = NA)}
# The following saves a .PNG file of the graph in its current position
# rgl.snapshot("Searchint_UI.png", fmt="png", top=TRUE)
```

```
#---------------------------------------------------------------

# 3D: Plotting the w_UI Reservation wage.
{w_UI_bar_matrix <- t(matrix(w_grid[w_UI_bar], nrow = I_ind_max, ncol = h_ind_max)
    )
 persp3d(h_grid, I_grid, w_UI_bar_matrix, nticks = c(6, 5, 7), front="lines", back="
     lines", xlab = "", ylab = "", zlab = "", labels =F, axes=F, box = F, add = F,
     aspect = c(1.3, 1, 1), expand = 0, draw_front=F, zlim = range(c(0.70,w_
     maxval)), theta=10)
 # Adding gridlines
 grid3d(side = c("x", "y+", "z"), lty = c("2","2","2"), lwd = 0.01)
 # Adding axes
 axes3d(c('x','y+','z'), nticks = c(6,7,5), labels = T)
 # Adding labels
 mtext3d("Current Skills", edge = 'x', line = 2, at = NULL, pos = NA)
 mtext3d("Last Earnings", edge = 'y+', line = 2.25, at = NULL, pos = NA)
 mtext3d("Reservation Wage", edge = 'z', line = 2.5, at = NULL, pos = NA)}
# The following saves a .PNG file of the graph in its current position
# rgl.snapshot("Res_wage_UI.png", fmt="png", top=TRUE)

#---------------------------------------------------------------

# 2D: Plotting the SA optimal search intensity.
# Creating a data frame with the different economy search intensities
{Plot_Search_SA <- data.frame("Current Skills" = h_grid, "Search Intensity" = s_grid[
    searchint_SA])
 # Starting the plot
 ggplot(Plot_Search_SA, aes(x = Current.Skills)) +

   # Adding labels
   labs(x = "Current Skills", y = "Search Intensity") +
   # Redefining scales of the axes.
   ylim(c(0,1)) +
   scale_x_continuous(breaks=seq(from = 1, to = 2, by = 0.1), limits=c(1, 2)) +
   # Adding curves from the different economies
   geom_line(aes(y = Search.Intensity)) +
   theme_bw()}

#---------------------------------------------------------------

# Uncomment to draw additional graphs that takes from multiple economies
# Need to run all four simulations in order to work
# source("9_Additional_Graphs.R")

#---------------------------------------------------------------
#---------------------------------------------------------------

# 2_Parameters.R
# Here the exogenous parameters are loaded. One period is 2 weeks.

# skill levels interval [1:2]
h_minval <- 1
h_maxval <- 2
# Number of skill levels
h_levels <- 21
# defines interval between skill levels
h_step <- (h_maxval - h_minval)/ (h_levels-1)

# wage levels interval [0:1]
w_minval <- 0
w_maxval <- 1
# Number of wage levels
w_levels <- 101
# defines interval between skill levels
w_step <- (w_maxval-w_minval) / (w_levels-1)

# defines mean of wage normal distribution
w_mean <- 0.5
# defines variance of wage normal distribution
w_variance<- 0.1

# Earnings interval [0:2] (product of skill level and wages)
I_minval <- h_minval*w_minval
```

```
I_maxval <- h_maxval*w_maxval
# number of desired UI levels
W_levels <- 15
# defines interval between earning levels for benefits
W_step <- (I_maxval/(W_levels))
# Vector of earning classes used for calculating benefits
W <- c(seq(I_minval, I_maxval, by=W_step))[2:16]

# probability of dying between two consecutive periods
# alpha <- 0.0009
alpha <- 0
# discount rate between two consecutive periods
beta <- 0.9985
# exogenous job separation rate
lambda <- 0.009

# search intensity level interval [0:1] for unemployed workers
s_minval <- 0
s_maxval <- 1
# defines interval between grid points for the search intensity
s_step <- 0.01

# the coefficient, d, in search cost function: c(s) = d*s
c_coeff <- 0.50
# the coefficient, a, in the search function: pi(s) = a*s^b
pi_coeff <- 1.00
# the exponent, b, in the search function: pi(s) = a*s^b
pi_exp <- 0.3

# Transition probability for the unemployed:
mu_u <- 0.2

# Transition probability for the employed:
mu_e <- 0.1

switch(economy,
      "1" = {
        # Laissez-Faire Economy
        name <- "Laissez—Faire Economy"
        # no benefits
        rho <- 0.0
        # Probability of going from unemployment insurance to social assistance (
             Duration of UI)
        gamma <- 0.00
        # Probability of going from employment without UI to employment with UI (
             Duration of work needed for eligibility)
        phi <- 0.00
        # Social Assistance level LS
        z <- 0
        # Binary variable to change the model to Laissez-Faire economy
        LF <- 1
        # Binary variable to change the model to AK economy
        LS <- 0
        # No governemtn in Laissez-Faire, aka. no tax rate
        tau <- 0
        # Arbitrary start value of the value functions
        startval <- 500
      },
      "2" = {
        # 90% Replacement rate, Finite UI duration High z (AK model)
        name <- "Finite UI duration, High SA level (AK model)"
        # Replacement rate LS
        # rho <- 0.7
        # Replacement rate
        rho <- 0.9
        # Probability of going from unemployment insurance to social assistance (
             Duration of UI, 2 years)
        gamma <- 0.0195
        # Probability of going from employment without UI to employment with UI (
             Duration of work needed for eligibility, 1 year)
        phi <- 0.0385
        # UI benefit values
        UI_val <- W * rho
```

```
      # Social Assistance level (High)
      z <- UI_val[7]
      # UI benefit values with minimum of z
      UI_val[which(UI_val<=z)] <- z
      # Binary variable to change the model
      LF <- 0
      # Binary variable to change the model
      LS <- 0
      # Different tax rates for different turbulence degrees
      if (chi == 0) {
        # Optimal value in AK version chi = 0 (0.0780) (High Z) (70% version has 0.0392)
        tau <- 0.0780
      } else if (chi == 0.03) {
        # Optimal value in AK version chi = 0.03 (0.0716) (High Z) (70% version has -)
        tau <- 0.0716
      } else if (chi == 0.04) {
        # Optimal value in AK version chi = 0.04 (0.0758) (High Z) (70% version has -)
        tau <- 0.0758
      }
      # Arbitrary start value of the value functions
      startval <- 500
    },
    "3" = {
      # 70% Replacement rate, Infinite UI duration (LS)
      name <- "Infinite UI duration, zero SA (LS model)"
      # Replacement rate
      rho <- 0.7
      # Replacement rate AK
      # rho <- 0.9
      # Probability of going from unemployment insurance to social assistance (Duration of UI) LS
      gamma <- 0.00
      # Probability of going from employment without UI to employment with UI (Duration of work needed for eligibility) LS
      phi <- 0.00
      # UI benefit values
      UI_val <- W * rho
      # Social Assistance level LS
      z <- 0
      # Binary variable to change the model to AK economy
      LF <- 0
      # Binary variable to change the model to this version, LS model is LS = 1
      LS <- 1
      # Different tax rates for different turbulence degrees
      if (chi == 0) {
        # Optimal value in LS version (0.0293)
        tau <- 0.0293
      } else if (chi == 0.03) {
        # Optimal value in LS version chi = 0.03 (0.0425)
        tau <- 0.0425
      } else if (chi == 0.04) {
        # Optimal value in LS version chi = 0.04 (0.0499)
        tau <- 0.0499
      }
      # Arbitrary start value of the value functions
      startval <- 500
    },
    "4" = {
      # 90% Replacement rate, Finite UI duration Low z (AK model)
      name <- "Finite UI duration, Low SA level (AK model)"
      # Replacement rate LS
      # rho <- 0.7
      # Replacement rate
      rho <- 0.9
      # Probability of going from unemployment insurance to social assistance (Duration of UI, 2 years)
      gamma <- 0.0195
      # Probability of going from employment without UI to employment with UI (Duration of work needed for eligibility, 1 year)
      phi <- 0.0385
```

```
        # UI benefit values
        UI_val <- W * rho
        # Social Assistance level (High)
        # z <- UI_val[7]
        # Social Assistance level (Low)
        z <- W[2]
        # UI benefit values with minimum of z
        UI_val[which(UI_val<=z)] <- z
        # Binary variable to change the model
        LF <- 0
        # Binary variable to change the model
        LS <- 0
        # Different tax rates for different turbulence degrees
        if (chi == 0) {
          # Optimal value in AK version chi = 0 (0.0715) (Low Z) (70% version has 0.0285)
          tau <- 0.0715
        } else if (chi == 0.03) {
          # Optimal value in AK version chi = 0.03 (0.0645) (Low Z) (70% version has -)
          tau <- 0.0645
        } else if (chi == 0.04) {
          # Optimal value in AK version chi = 0.04 (-) (Low Z) (70% version has -)
          tau <- 0.0664
        }
        # Arbitrary start value of the value functions
        startval <- 500
      },
      stop('Please choose economy 1 - 4')
)

#----------------------------------------------------------------
#----------------------------------------------------------------

# 3_Initialize.R
# Here a number of vectors and matrices are initialized based on the parameters chosen.

# creates a grid over the range of possible skill levels
h_grid <- c(seq(h_minval,h_maxval,by=h_step))
# length of grid (no. of skill levels)
h_ind_max <- length(h_grid)

# Used instead of loops at points, the p stands for prime (')
h_index <- 1:h_ind_max
h_index_p <- 1:h_ind_max

# Initializes the standard skill transition matrices
source("4_Transition_matrix.R")

# creates a grid over the range of possible search intensities
s_grid <- c(seq(s_minval,s_maxval,by=s_step))
# length of grid (no. of index points)
s_ind_max <- length(s_grid)

# initializes a wage vector
w_grid <- c(seq(w_minval, w_maxval, by=w_step))
w_ind_max <- length(w_grid)
w_index <- 1:w_ind_max

# Wage vector used for normal distribution
w_step2 <- (w_maxval-w_minval) / (w_levels)
w_grid2 <- c(seq(w_minval, w_maxval, by=w_step2))

# Normal distribution on the wage grid
nu_dens <- dtruncnorm(w_grid2, a=0, b=1, mean = w_mean, sd = (w_variance^0.5)) # density function for truncated normal distribution same for all skill levels
nu_dist <- ptruncnorm(w_grid2, a=0, b=1, mean = w_mean, sd = (w_variance^0.5))[2:102]

# Probabilities for each individual wage rate
w_lag_dist <- array(0, c(w_ind_max))
for (w_ind in 1 : w_ind_max) {
```

```
  if (w_ind == 1) {
    w_lag_dist[w_ind] <- nu_dist[w_ind]
  } else {
    w_lag_dist[w_ind] <- nu_dist[w_ind] - nu_dist[w_ind-1]
  }
}

# I_grid initialized for better overview in the following
I_grid <- W

# Maximum I index pinpointed
I_ind_max <- length(W)
# I index grid
I_index <- 1 : I_ind_max

# initializes wage reservation matrices.

w_N_bar <- matrix(0, ncol = h_ind_max, nrow = 1)

w_E_bar <- matrix(0, ncol = h_ind_max, nrow = 1)

w_UI_bar_val <- array(0, c(I_ind_max, h_ind_max))

w_UI_bar <- array(0, c(I_ind_max, h_ind_max))

# Government threshold vector
w_g <- array(0, c(I_ind_max, h_ind_max))

# Initializes value functions values

V_E <- startval*array(1, c(w_ind_max,h_ind_max))
V_E_value <- array(0, c(s_ind_max,1))

V_N <- startval*array(1, c(w_ind_max,h_ind_max))

V_UI <- startval*array(1, c(I_ind_max,h_ind_max))
V_UI_value <- array(0, c(s_ind_max,1))

V_SA <- startval*array(1, c(h_ind_max, 1))
V_SA_value <- array(0, c(s_ind_max, h_ind_max))

# Initializes array for post wage continuation value of employment
J_E <- startval*array(1, c(w_ind_max,h_ind_max))

# initializes array for post wage continuation value of employment without benefits
J_N <- startval*array(1, c(w_ind_max,h_ind_max))

# Initializes arrays for search intensities
searchint_SA <- array(0, c(h_ind_max))
searchint_UI <- array(0, c(I_ind_max, h_ind_max))

# Initializes matrices for integrals
E_UI_under <- array(0, c(I_ind_max, h_ind_max))
E_UI_over <- array(0, c(I_ind_max, h_ind_max))

E_SA <- array(0, c(h_ind_max, 1))

# Vector with lagged/lower values of I
I_lag <- array(0, c(I_ind_max))
for (I_ind in 1 : I_ind_max) {
  if (I_ind == 1) {
    I_lag[I_ind] <- 0
  } else {
    I_lag[I_ind] <- I_grid[I_ind-1]
  }
}

# Vector with earning levels changed so it works correctly with <= and >= if functions.
I_w_h <- (w_grid[w_index] %*% t(h_grid[h_index]))
for (I_ind in 1 : I_ind_max) {
  for (h_prime in 1 : h_ind_max) {
```

```
    for (w_ind in 1 : w_ind_max) {
      if (abs(I_w_h[w_ind, h_prime] - I_grid[I_ind]) < 0.0000001) {
        I_w_h[w_ind, h_prime] <- I_grid[I_ind]
      }
    }
  }
}

# Population distribution:
# Initializes vectors/matrices for unemployment and employment rates
u_SA <- matrix(0, ncol=h_ind_max, nrow=1)
u_UI <- array(0, c(I_ind_max, h_ind_max))
e_E <- array(0, c(w_ind_max,h_ind_max))
e_N <- array(0, c(w_ind_max,h_ind_max))
# All start at skill level 1 and state SA.
u_SA[1] <- 1

# Initializes an array used for the population distribution for type Unemployed w.
      Unemployment Benefits
MU_L_w <- array(MU_L, c(h_ind_max, h_ind_max, w_ind_max))
MU_L_w <- aperm(MU_L_w, c(3,1,2))

# Initializes a help matrix with wage_index spread out in I_ind_max number of
     columns
w_I_index <- matrix(w_index, nrow = w_ind_max, ncol = I_ind_max)

# Initializes a help matrix with probabilities for wages spread out in I_ind_max
     number of columns
w_I_lag_dist <- matrix(w_lag_dist[w_index], nrow = w_ind_max, ncol = I_ind_max)

# Initializes a matrix with government threshold wages used in population
     distribution calculations
w_g_distr <- array(0, c(I_ind_max, h_ind_max))

for (I_ind in 1 : I_ind_max) {
  for (h_prime in 1 : h_ind_max) {
    w_g_distr_temp <- (UI_val[I_ind] / h_grid[h_prime])
    if (w_g_distr_temp - 1 > 0.0000001) {
      w_g_distr[I_ind, h_prime] <- w_ind_max
    } else if (abs(w_g_distr_temp - w_grid[w_ind_max]) < 0.000001) {
      w_g_distr[I_ind, h_prime] <- w_ind_max-1
    } else {
      w_g_distr[I_ind, h_prime] <- min(which(w_grid - w_g_distr_temp > 0.0000001))
          -1
    }
  }
}

#---------------------------------------------------------------
#---------------------------------------------------------------

# 4.Transition_matrix.R
# Here the skill transition matrices are calculated.

# creates array for transition probabilities for employed
# rows indicate next periods skill level. Columns are this period.
MU_E <- array(0, c(h_ind_max, h_ind_max))

# inserts end probability in the array (highest skilled stays the same)
MU_E[h_ind_max, h_ind_max] <- 1

# inserts probabilities in the array.
for (h_ind in 1 : (h_ind_max-1)) {
  MU_E[h_ind, h_ind] <- (1 - mu_e)
  MU_E[h_ind, h_ind+1] <- mu_e
}

# creates array for transition probabilities for unemployed
# rows indicate next periods skill level. Columns are this period.
MU_U <- array(0, c(h_ind_max, h_ind_max))
# inserts end probability in the array (lowest skilled stays the same)
MU_U[1, 1] <- 1
```

```
# inserts probabilities in the array.
for (h_ind in (1+1) : h_ind_max) {
  MU_U[h_ind, h_ind] <- (1 - mu_u)
  MU_U[h_ind, h_ind-1] <- mu_u
}

# creates array for transition probabilities for newly unemployed
# rows indicate next periods skill level. Columns are this period.
MU_L <- array(0, c(h_ind_max, h_ind_max))

# Inserts absorbing state in the array (lowest skilled stays the same)
MU_L[1, 1] <- 1

# Help multiplier for doubling left half of the distribution
if (chi > 0) {
  Multiplier_dist <- 2
} else if (chi == 0){
  Multiplier_dist <- 1
}

# Filling the MU_L matrix:
for (h_ind in (1+1) : h_ind_max) {
  h_levels3 <- h_ind*2
  h_step3 <- (1 - 0)/ (h_levels3)
  h_grid3 <- c(seq(0,1,by=h_step3))
  h_norm_dist <- Multiplier_dist * ptruncnorm(h_grid3, a=0, b=1, mean = 0.5, sd =
       (chi^0.5))[2:(h_ind+1)]
  h_lag_dist <- array(0, c(h_ind_max))
  for (h_prime in 1 : h_ind) {
    if (h_prime == 1) {
      h_lag_dist[h_prime] <- h_norm_dist[h_prime]
    } else {
      h_lag_dist[h_prime] <- h_norm_dist[h_prime] - h_norm_dist[h_prime-1]
    }
  }
  MU_L[h_ind, ] <- h_lag_dist
}

#-----------------------------------------------------------------
#-----------------------------------------------------------------

# 5.Value_func_step.R
# Here one iteration to calculate the steady state values of the value functions,
      the reservation wages and search intensities is performed.
# The inputs are the values, J_E, J_N, V_N, V_E, V_SA and V_UI, for the economies,
       where they are applicable.

J_E_old <- J_E
if (LS == 0 & LF == 0) { # Not applicable in LF or LS economy
  J_N_old <- J_N
  V_N_old <- V_N
}
V_E_old <- V_E
V_SA_old <- V_SA
if (LF == 0) { # Not applicable in LF economy
  V_UI_old <- V_UI
}

#-----------------------------------------------------------------

# The following is used to find w_E_bar, w_N_bar and the integral from Equation
      (4.5)
if (LS == 1 | LF == 1) { # If LS or Laissez-faire economy, use the first loop (No
      N state)
  S_E <- t(t(J_E_old) - V_SA_old[h_index])
  for (h_ind in 1 : h_ind_max) {
    if (any(S_E[,h_ind]>0) == TRUE & !all(S_E[,h_ind] > 0)) {
      w_E_bar[h_ind] <- min(which(S_E[,h_ind]>0))
    } else if (all(S_E[,h_ind] == 0) | all(S_E[,h_ind] > 0)){
      w_E_bar[h_ind] <- 1
    } else {
      w_E_bar[h_ind] <- w_ind_max
    }
```

```
    E_SA[h_ind] <- sum(w_lag_dist[w_index] * V_E_old[w_index , h_ind])
  }
} else {
  S_E <- t(t(J_E_old) - V_SA_old[h_index])
  S_N <- (t(t(J_N_old) - V_SA_old[h_index]))
  for (h_ind in 1 : h_ind_max) {
    if (any(S_N[,h_ind]>0) == TRUE & !all(S_N[,h_ind] > 0)) {
      w_N_bar[h_ind] <- min(which(S_N[,h_ind]>0))
    } else if (all(S_N[,h_ind] == 0) | all(S_N[,h_ind] > 0)){
      w_N_bar[h_ind] <- 1
    } else {
      w_N_bar[h_ind] <- w_ind_max
    }
    if (any(S_E[,h_ind]>0) == TRUE & !all(S_E[,h_ind] > 0)) {
      w_E_bar[h_ind] <- min(which(S_E[,h_ind]>0))
    } else if (all(S_E[,h_ind] == 0) | all(S_E[,h_ind] > 0)){
      w_E_bar[h_ind] <- 1
    } else {
      w_E_bar[h_ind] <- w_ind_max
    }
    E_SA[h_ind] <- sum(w_lag_dist[w_index] * V_N_old[w_index , h_ind])
  }
}

#-----------------------------------------------------------------

# The following is used to find w_UI_bar_val used later to find w_UI_bar:
if (LF == 0) { # Not applicable in LF economy
  for (I_ind in 1 : I_ind_max) {
    S_UI <- t(t(J_E_old) - V_UI_old[I_ind, h_index])
    for (h_ind in 1 : h_ind_max) {
      if (any(S_UI[,h_ind]>0) == TRUE & !all(S_UI[,h_ind] > 0)) {
        w_UI_bar_val[I_ind, h_ind] <- min(which(S_UI[,h_ind]>0))
      } else if (all(S_UI[,h_ind] == 0) | all(S_UI[,h_ind] > 0)){
        w_UI_bar_val[I_ind, h_ind] <- 1
      } else {
        w_UI_bar_val[I_ind, h_ind] <- w_ind_max
      }
    }
  }
}

#-----------------------------------------------------------------

if (LF == 0) {
  # Estimation of the integrals from Equation (4.4)
  for (I_ind in 1 : I_ind_max) {
    for (h_prime in 1 : h_ind_max) {
      w_over_g <- array(0, c(w_ind_max))
      w_under_g <- array(0, c(w_ind_max))
      w_g_temp <- (UI_val[I_ind] / h_grid[h_prime])
      if (w_g_temp - max(w_grid) > 0.0000001) {
        w_g[I_ind, h_prime] <- w_ind_max
      } else if (abs(w_g_temp - w_grid[w_ind_max]) < 0.000001) {
        w_g[I_ind, h_prime] <- w_ind_max
      } else {
        w_g[I_ind, h_prime] <- min(which(w_grid - w_g_temp > 0.0000001))
      }
      w_over_g <- w_index[w_g[I_ind, h_prime]: w_ind_max]
      w_under_g <- w_index[1: w_g[I_ind, h_prime]-1]
      # h_index indicates the h_prime_prime indices
      E_UI_over[I_ind, h_prime] <- sum(w_lag_dist[w_over_g] * V_E_old[w_over_g, h_
          prime])
      E_UI_under[I_ind, h_prime] <- sum(w_lag_dist[w_under_g] * pmax(J_E_old[w_
          under_g,h_prime], V_UI_old[I_ind, h_prime]))
    }
  }
}

#-----------------------------------------------------------------

# The following is used to estimate the reservation wage for UI recipients
if (LF == 0) {
```

```
  for (I_ind in 1 : I_ind_max) {
    for (h_ind in 1: h_ind_max) {
      if ((w_g[I_ind, h_ind] <= w_UI_bar_val[I_ind, h_ind]) & (w_E_bar[h_ind] <= w_
          g[I_ind, h_ind])) {
        w_UI_bar[I_ind, h_ind] <- w_g[I_ind, h_ind]
      } else if ((w_g[I_ind, h_ind] <= w_UI_bar_val[I_ind, h_ind]) & (w_E_bar[h_ind
          ] > w_g[I_ind, h_ind])) {
        w_UI_bar[I_ind, h_ind] <- w_E_bar[h_ind]
      } else {
        w_UI_bar[I_ind, h_ind] <- w_UI_bar_val[I_ind, h_ind]
      }
    }
  }
}

#-------------------------------------------------------------

# Equation (4.5): Value function for unemployed with no benefits
for (s_ind in 1 : s_ind_max) {
  V_SA_value[s_ind, ] <- - c_coeff*(s_grid[s_ind]) + (1-tau)*z + beta * (1-alpha)
       * MU_U[h_index, h_index_p] %*% ((1 - pi_coeff * s_grid[s_ind]^pi_exp) * V_
       SA_old[h_index_p] + (pi_coeff * s_grid[s_ind]^pi_exp) * E_SA[h_index_p])
}
V_SA <- apply(V_SA_value, 2, max)
searchint_SA <- apply(V_SA_value, 2, which.max)

#-------------------------------------------------------------

# Equation (4.4): Value function for unemployed with benefits
if (LF == 0) { # Not applicable in LF economy
  for (h_ind in 1 : h_ind_max) {
    MU_U_temp <- beta * (1-alpha) * MU_U[h_ind, h_index_p]
    for (I_ind in 1 : I_ind_max) {
      UI_val_temp <- (1-tau) * UI_val[I_ind]
      V_UI_temp <- V_UI_old[I_ind, h_index_p]
      V_SA_temp <- V_SA_old[h_index_p]
      for (s_ind in 1 : s_ind_max) {
        V_UI_value[s_ind] <- - c_coeff*(s_grid[s_ind]) + UI_val_temp + MU_U_temp %*%
             ( (1 - s_grid[s_ind]^pi_exp) * (gamma * V_SA_temp + (1-gamma) * V_UI_
            temp) + s_grid[s_ind]^pi_exp * (gamma * E_SA[h_ind] + (1-gamma) * (E_UI
            _over[I_ind, h_index_p] + E_UI_under[I_ind, h_index_p])))
      }
      V_UI[I_ind, h_ind] <- apply(V_UI_value, 2, max)
      searchint_UI[I_ind, h_ind] <- apply(V_UI_value, 2, which.max)
    }
  }
}

#-------------------------------------------------------------

# Equation (4.3) and (4.7): Value function for employed people not qualifying for
     benefits
if (LS == 0 & LF == 0) {
  for (h_ind in 1 : h_ind_max) {
    MU_E_temp <- (1-lambda) * MU_E[h_ind,h_index]
    MU_L_temp <- lambda * MU_L[h_ind,h_index]
    for (w_ind in 1 : w_ind_max) {
      J_N_value <- beta * (1-alpha) * ( MU_E_temp %*% ( phi * V_E_old[w_ind,h_index
          ] + (1-phi) * V_N_old[w_ind,h_index]) + MU_L_temp %*% V_SA_old[h_index]
          )
      J_N[w_ind,h_ind] <- J_N_value + h_grid[h_ind] * w_grid[w_ind] * (1-tau)
      V_N[w_ind,h_ind] <- max(J_N[w_ind,h_ind], V_SA_old[h_ind])
    }
  }
}

#-------------------------------------------------------------

# Equation (4.2) and (4.6): Value function for employed people
if (LF == 1) { # If Laissez-faire economy 1
  for (h_ind in 1 : h_ind_max) {
    MU_E_temp <- (1-lambda) * MU_E[h_ind,h_index]
    MU_L_temp <- lambda * MU_L[h_ind,h_index]
```

```
    for (w_ind in 1 : w_ind_max) {
      J_E_value <- beta * (1-alpha) * ( MU_E_temp %*% V_E_old[w_ind,h_index] + MU_L_temp %*% V_SA_old[h_index])
      J_E[w_ind,h_ind] <- J_E_value + h_grid[h_ind] * w_grid[w_ind] * (1-tau)
      V_E[w_ind,h_ind] <- max(J_E[w_ind,h_ind], V_SA_old[h_ind])
    }
  }
} else { # If economy 2 or 3 (AK or LS)
  for (h_ind in 1 : h_ind_max) {
    MU_E_temp <- (1-lambda) * MU_E[h_ind,h_index]
    MU_L_temp <- lambda * MU_L[h_ind,h_index]
    for (w_ind in 1 : w_ind_max) {
      J_E_value <- beta * (1-alpha) * ( MU_E_temp %*% V_E_old[w_ind,h_index] + MU_L_temp %*% V_UI_old[min(which(I_grid>=I_w_h[w_ind, h_ind])),h_index])
      J_E[w_ind,h_ind] <- J_E_value + h_grid[h_ind] * w_grid[w_ind] * (1-tau)
      V_E[w_ind,h_ind] <- max(J_E[w_ind,h_ind], V_SA_old[h_ind])
    }
  }
}

#-----------------------------------------------------------------
#-----------------------------------------------------------------

# 6.Pop_Distr_step.R
# Here one iteration to calculate the steady state values of the population distributions is performed.
# The inputs are the values, u_SA, u_UI, e_E and e_N, for the economies, where they are applicable.

u_SA_old <- u_SA
u_UI_old <- u_UI
e_E_old <- e_E
if (LS == 0 & LF == 0) {
  e_N_old <- e_N
}

#-----------------------------------------------------------------

# Equation (5.4): u_SA (Unemployed w. No benefits)
for (h_prime in 1 : h_ind_max) {
  u_SA_temp <- 0
  #-------------------------------------------------------------
  if (LS == 0 & LF == 0) {
    # From u_SA -> u_SA (Unemployed people w/o. benefits who rejected job above government threshold or did not obtain an offer):
    u_SA_temp <- u_SA_temp + sum(MU_U[h_index, h_prime] * u_SA_old[h_index] * ( (1 - pi_coeff * s_grid[searchint_SA[h_index]]^pi_exp) + pi_coeff * s_grid[searchint_SA[h_index]]^pi_exp * sum((w_index < w_N_bar[h_prime]) * w_lag_dist[w_index]) ))
  } else {
    # From u_SA -> u_SA (Unemployed people w/o. benefits who rejected job above government threshold or did not obtain an offer):
    u_SA_temp <- u_SA_temp + sum(MU_U[h_index, h_prime] * u_SA_old[h_index] * ( (1 - pi_coeff * s_grid[searchint_SA[h_index]]^pi_exp) + pi_coeff * s_grid[searchint_SA[h_index]]^pi_exp * sum((w_index < w_E_bar[h_prime]) * w_lag_dist[w_index]) ))
  }
  #-------------------------------------------------------------
  if (LF == 0) {
    # From u_UI -> u_SA (Unemployed people w. benefits who did not obtain a job offer and lost UI status):
    u_SA_temp <- u_SA_temp + sum(MU_U[h_index, h_prime] * apply(u_UI_old[I_index, h_index] * (1 - pi_coeff * s_grid[searchint_UI[I_index, h_index]]^pi_exp) * gamma, 2, sum))
    # From u_UI -> u_SA (Unemployed people w. benefits who rejected job above government threshold):
    u_SA_temp <- u_SA_temp + sum(MU_U[h_index, h_prime] * apply( t(u_UI_old[I_index, h_index] * pi_coeff * s_grid[searchint_UI[I_index, h_index]]^pi_exp) %*% (t(gamma * (w_index < w_N_bar[h_prime]) * (w_I_lag_dist)) + (1- gamma) * t( t( t(w_I_index) > w_g_distr[I_index, h_prime]) * (w_index < w_E_bar[h_prime]) * (w_I_lag_dist) )), 1, sum ) )
  }
  #-------------------------------------------------------------
```

```
    # From e_E -> u_SA (Employed people who quit their job):
    u_SA_temp <- u_SA_temp + sum(t(MU_E[h_index,h_prime] * (1-lambda) * t(e_E_old[w_index,h_index])) * (w_index < w_E_bar[h_prime]))
    if (LF == 1) {
      # From e_E -> u_SA (Employed people who was fired):
      u_SA_temp <- u_SA_temp + sum(MU_L[h_index,h_prime] * lambda * apply(e_E_old[w_index,h_index], 2, sum))
    }
    #-----------------------------------------------------------
    # From e_N -> u_SA
    if (LS == 0 & LF == 0) {
      # From e_N -> u_SA (Employed people who was fired):
      u_SA_temp <- u_SA_temp + sum(MU_L[h_index,h_prime] * lambda * apply(e_N_old[w_index,h_index], 2, sum))
      # From e_N -> u_SA (Employed people who quit their job):
      u_SA_temp <- u_SA_temp + sum(t(MU_E[h_index,h_prime] * (1-lambda) * t(e_N_old[w_index,h_index])) * ( (1-phi) * (w_index < w_N_bar[h_prime]) + phi * (w_index < w_E_bar[h_prime]) ))
    }
    #-----------------------------------------------------------
    # Saving the mass of u_SA with new skill level, h_prime:
    u_SA[h_prime] <- u_SA_temp
  }

  #----------------------------------------------------------------

  # Equation (5.5): u_UI (Unemployed w. Unemployment Benefits)
  if (LF == 0) {
    for (h_prime in 1 : h_ind_max) {
      for (I_ind in 1 : I_ind_max) {
        u_UI_temp <- 0
        #---------------------------------------------------------
        # From e_E -> u_UI (Employed people who was fired):
        if (I_ind == 1) {
          w_h_ind_temp <- (I_grid[I_ind] >= I_w_h[w_index, h_index]) & (I_w_h[w_index, h_index] >= I_lag[I_ind])
        } else {
          w_h_ind_temp <- (I_grid[I_ind] >= I_w_h[w_index, h_index]) & (I_w_h[w_index, h_index] > I_lag[I_ind])
        }
        MU_L_w2 <- MU_L_w[, , h_prime]
        u_UI_temp <- u_UI_temp + sum(MU_L_w2[w_h_ind_temp] * lambda * e_E_old[w_h_ind_temp])
        #---------------------------------------------------------
        # From u_UI -> u_UI (Unemployed people w. benefits who did not receive an offer and retained UI status):
        u_UI_temp <- u_UI_temp + (MU_U[h_index, h_prime] * u_UI_old[I_ind, h_index]) %*% ((1-pi_coeff *s_grid[searchint_UI[I_ind, h_index]]^pi_exp) * (1-gamma))
        # From u_UI -> u_UI (Unemployed people w. benefits who rejected a job below government threshold):
        u_UI_temp <- u_UI_temp + (MU_U[h_index, h_prime] * u_UI_old[I_ind, h_index]) %*% ( (pi_coeff * s_grid[searchint_UI[I_ind, h_index]]^pi_exp) * (1-gamma) * sum(((w_index <= w_g_distr[I_ind, h_prime]) * (w_index < w_UI_bar[I_ind, h_prime])) * (w_lag_dist[w_index])) )
        #---------------------------------------------------------
        # Saving the mass of u_UI with new skill level, h_prime and last income, I_ind:
        u_UI[I_ind, h_prime] <- u_UI_temp
      }
    }
  }

  #----------------------------------------------------------------

  # Equation (5.6): e_E (Employed eligible for UI)
  for (h_prime in 1 : h_ind_max) {
    for (w_prime in 1 : w_ind_max) {
      e_E_temp <- 0
      #---------------------------------------------------------
      # From e_E -> e_E (Employed people who stayed with their jobs):
      e_E_temp <- e_E_temp + sum(MU_E[h_index,h_prime] * e_E_old[w_prime,h_index] * (1-lambda) * (w_prime >= w_E_bar[h_prime]))
```

```r
    #--------------------------------------------------------
    # From e_N -> e_E (Employed people who stayed with their jobs):
    if (LS == 0 & LF == 0) { # Is only included in economy 2
      e_E_temp <- e_E_temp + sum(MU_E[h_index,h_prime] * e_N_old[w_prime,h_index] *
            (1-lambda) * phi * (w_prime >= w_E_bar[h_prime]))
    }
    #--------------------------------------------------------
    # From u_UI -> e_E (Unemployed people w. benefits who accepted an offer):
    if (LF == 0) {
      e_E_temp <- e_E_temp + sum(MU_U[h_index, h_prime] * apply(u_UI_old[I_index, h
           _index] * pi_coeff * s_grid[searchint_UI[I_index, h_index]]^pi_exp * (1-
           gamma) * w_lag_dist[w_prime] * ((w_prime > w_g_distr[I_index, h_prime])
           * (w_prime >= w_E_bar[h_prime]) + (w_prime <= w_g_distr[I_index, h_prime
           ]) * (w_prime >= w_UI_bar[I_index, h_prime])), 2, sum) )
    }
    #--------------------------------------------------------
    if (LS == 1 | LF == 1) {
      # From u_SA -> e_E (Unemployed people w. benefits who accepted an offer):
      e_E_temp <- e_E_temp + sum(MU_U[h_index, h_prime] * u_SA_old[h_index] * pi_
           coeff * s_grid[searchint_SA[h_index]]^pi_exp * (w_prime >= w_E_bar[h_
           prime]) * w_lag_dist[w_prime])
    }
    #--------------------------------------------------------
    # Saving the mass of e_E with new skill level, h_prime and wage, w_prime:
    e_E[w_prime,h_prime] <- e_E_temp
  }
}

#----------------------------------------------------------------

# Equation (5.7): e_N (Employed ineligible for UI)
if (LS == 0 & LF == 0) {
  for (h_prime in 1 : h_ind_max) {
    for (w_prime in 1 : w_ind_max) {
      e_N_temp <- 0
      #--------------------------------------------------------
      # From u_SA -> e_N (Unemployed people w/o. benefits who accepted an offer):
      e_N_temp <- e_N_temp + sum(MU_U[h_index, h_prime] * u_SA_old[h_index] * pi_
           coeff * s_grid[searchint_SA[h_index]]^pi_exp * (w_prime >= w_N_bar[h_
           prime]) * w_lag_dist[w_prime])
      #--------------------------------------------------------
      # From u_UI -> e_N (Unemployed people w. benefits, who lost them and who
           accepted an offer):
      e_N_temp <- e_N_temp + sum(MU_U[h_index, h_prime] * t(u_UI_old[I_index, h_
           index] * pi_coeff * s_grid[searchint_UI[I_index, h_index]]^pi_exp) *
           gamma * w_lag_dist[w_prime] * (w_prime >= w_N_bar[h_prime]))
      #--------------------------------------------------------
      # From e_N -> e_N (Employed people who stayed with their jobs, but did not
           become eligible for UI):
      e_N_temp <- e_N_temp + sum(MU_E[h_index,h_prime] * e_N_old[w_prime,h_index] *
            (1-lambda) * (1-phi) * (w_prime >= w_N_bar[h_prime]))
      #--------------------------------------------------------
      # Saving the mass of e_N with new skill level, h_prime and wage, w_prime:
      e_N[w_prime,h_prime] <- e_N_temp
    }
  }
}

#----------------------------------------------------------------

# Unemployment and Employment rates
# Mass of SA recipients
u_SA_val <- sum(u_SA)
# Mass of UI recipients
u_UI_val <- sum(apply(u_UI, 2, sum))
# Mass employed in state E
e_E_val <- sum(apply(e_E, 2, sum))
# Mass employed in state N
e_N_val <- sum(apply(e_N, 2, sum))
# Employment rate
e_val <- e_E_val + e_N_val
# Unemployment rate
u_val <- u_UI_val + u_SA_val
```

```
u_val <- u_UI_val + u_SA_val
# Should sum to 1
sum <- (u_val+e_val)

#----------------------------------------------------------------
#----------------------------------------------------------------

# 7_Calculations.R
# Here the population distribution results and steady state statistics are
     computed.

if (LF == 1) {

  # Economy 1, LF steady state results:

  # Unemployment and Employment rates
  # Mass of SA recipients
  u_SA_val_LF <- sum(u_SA_LF)
  # Mass employed in state E
  e_E_val_LF <- sum(apply(e_E_LF, 2, sum))
  # Employment rate
  e_val_LF <- e_E_val_LF
  # Unemployment rate
  u_val_LF <- u_SA_val_LF
  u_val <- u_SA_val_LF
  # Should sum to 1
  sum_LF <- (u_val_LF+e_val_LF)

  # Economy statistics:

  # GNP per capita (total earnings of employed people)
  GNP_LF <- sum(e_E_LF * (w_grid %*% t(h_grid)))
  GNP <- sum(e_E_LF * (w_grid %*% t(h_grid)))
  # Average productivity of employed
  avg_prod_emp_LF <- GNP_LF / e_val_LF
  avg_prod_emp <- GNP_LF / e_val_LF
  # Average wage level of the employed
  avg_wage_emp_LF <- (sum(e_E_LF * (w_grid))) / e_val_LF
  avg_wage_emp <- (sum(e_E_LF * (w_grid))) / e_val_LF
  # Average skill level of population
  avg_skill_pop_LF <- sum((apply(e_E_LF, 2, sum) + u_SA_LF) * h_grid)
  avg_skill_pop <- sum((apply(e_E_LF, 2, sum) + u_SA_LF) * h_grid)
  # Value of consumption
  Cons_val_LF <- sum(V_SA * u_SA_LF) + sum(V_E * e_E_LF)
  Cons_val <- sum(V_SA * u_SA_LF) + sum(V_E * e_E_LF)

  # Transformation of e from w to I index.

  e_E_UI_LF <- array(0, c(I_ind_max, h_ind_max))
  for (h_ind in 1 : h_ind_max) {
    for (I_ind in 1 : I_ind_max) {
      if (I_ind == 1) {
        w_h_ind_temp <- (I_grid[I_ind] >= I_w_h[w_index, h_ind]) & (I_w_h[w_index, h
             _ind] >= I_lag[I_ind])
      } else {
        w_h_ind_temp <- (I_grid[I_ind] >= I_w_h[w_index, h_ind]) & (I_w_h[w_index, h
             _ind] > I_lag[I_ind])
      }
      e_E_UI_LF[I_ind, h_ind] <- sum(e_E_LF[w_h_ind_temp, h_ind])
    }
  }

  #------------------------------------------------------------

} else if (LF == 0 & LS == 0) {
  # Economy 2, AK steady state results:

  # Unemployment and Employment rates
  # Mass of SA recipients
  u_SA_val_AK <- sum(u_SA_AK)
  # Mass of UI recipients
  u_UI_val_AK <- sum(apply(u_UI_AK, 2, sum))
  # Mass employed in state E
```

```
e_E_val_AK <- sum(apply(e_E_AK, 2, sum))
# Mass employed in state N
e_N_val_AK <- sum(apply(e_N_AK, 2, sum))
# Employment rate
e_val_AK <- e_E_val_AK + e_N_val_AK
# Unemployment rate
u_val_AK <- u_UI_val_AK + u_SA_val_AK
u_val <- u_UI_val_AK + u_SA_val_AK
# Should sum to 1
sum_AK <- (u_val_AK+e_val_AK)

# Economy statistics:

# GNP per capita (total earnings of employed people)
GNP_AK <- sum(e_E_AK * (w_grid %*% t(h_grid))) + sum(e_N_AK * (w_grid %*% t(h_
    grid)))
GNP <- sum(e_E_AK * (w_grid %*% t(h_grid))) + sum(e_N_AK * (w_grid %*% t(h_grid)
    ))
# Tax revenues to the state
tax_rev_AK <- tau_AK * GNP_AK + tau_AK * (sum(u_SA_AK * z_AK) + sum(u_UI_AK * UI
    _val_AK))
# Unemployment benefits paid out
transfers_AK <- (1-tau_AK) * (sum(u_SA_AK * z_AK) + sum(u_UI_AK * UI_val_AK))
# Government budget
Gov_Fin_AK <- tax_rev_AK - transfers_AK
# Average productivity of employed
avg_prod_emp_AK <- GNP_AK / e_val_AK
avg_prod_emp <- GNP_AK / e_val_AK
# Average wage level of the employed
avg_wage_emp_AK <- (sum(e_E_AK * (w_grid)) + sum(e_N_AK * w_grid)) / e_val_AK
avg_wage_emp <- (sum(e_E_AK * (w_grid)) + sum(e_N_AK * w_grid)) / e_val_AK
# Average skill level of population
avg_skill_pop_AK <- sum((apply(e_E_AK, 2, sum) + apply(e_N_AK, 2, sum) + u_SA_AK
     + apply(u_UI_AK, 2, sum)) * h_grid)
avg_skill_pop <- sum((apply(e_E_AK, 2, sum) + apply(e_N_AK, 2, sum) + u_SA_AK +
    apply(u_UI_AK, 2, sum)) * h_grid)
# Value of consumption
Cons_val_AK <- sum(V_SA * u_SA_AK) + sum(V_E * e_E_AK) + sum(V_UI * u_UI_AK) +
    sum(V_N * e_N_AK)
Cons_val <- sum(V_SA * u_SA_AK) + sum(V_E * e_E_AK) + sum(V_UI * u_UI_AK) + sum(
    V_N * e_N_AK)

# Transformation of e from w to I index.

e_E_UI_AK <- array(0, c(I_ind_max, h_ind_max))
for (h_ind in 1 : h_ind_max) {
  for (I_ind in 1 : I_ind_max) {
    if (I_ind == 1) {
      w_h_ind_temp <- (I_grid[I_ind] >= I_w_h[w_index, h_ind]) & (I_w_h[w_index, h
          _ind] >= I_lag[I_ind])
    } else {
      w_h_ind_temp <- (I_grid[I_ind] >= I_w_h[w_index, h_ind]) & (I_w_h[w_index, h
          _ind] > I_lag[I_ind])
    }
    e_E_UI_AK[I_ind, h_ind] <- sum(e_E_AK[w_h_ind_temp, h_ind])
  }
}

e_N_UI_AK <- array(0, c(I_ind_max, h_ind_max))
for (h_ind in 1 : h_ind_max) {
  for (I_ind in 1 : I_ind_max) {
    if (I_ind == 1) {
      w_h_ind_temp <- (I_grid[I_ind] >= I_w_h[w_index, h_ind]) & (I_w_h[w_index, h
          _ind] >= I_lag[I_ind])
    } else {
      w_h_ind_temp <- (I_grid[I_ind] >= I_w_h[w_index, h_ind]) & (I_w_h[w_index, h
          _ind] > I_lag[I_ind])
    }
    e_N_UI_AK[I_ind, h_ind] <- sum(e_N_AK[w_h_ind_temp, h_ind])
  }
}

#------------------------------------------------------------
```

```
} else if (LS == 1) {

  # Economy 3, LS steady state results:

  # Unemployment and Employment rates
  # Mass of SA recipients
  u_SA_val_LS <- sum(u_SA_LS)
  # Mass of UI recipients
  u_UI_val_LS <- sum(apply(u_UI_LS, 2, sum))
  # Mass employed in state E
  e_E_val_LS <- sum(apply(e_E_LS, 2, sum))
  # Employment rate
  e_val_LS <- e_E_val_LS
  # Unemployment rate
  u_val_LS <- u_UI_val_LS + u_SA_val_LS
  u_val <- u_UI_val_LS + u_SA_val_LS
  # Should sum to 1
  sum_LS <- (u_val_LS+e_val_LS)

  # Economy statistics:

  # GNP per capita (total earnings of employed people)
  GNP_LS <- sum(e_E_LS * (w_grid %*% t(h_grid)))
  GNP <- sum(e_E_LS * (w_grid %*% t(h_grid)))
  # Tax revenues to the state
  tax_rev_LS <- tau_LS * GNP_LS + tau_LS * (sum(u_SA_LS * z_LS) + sum(u_UI_LS * UI_val_LS))
  # Unemployment benefits paid out
  transfers_LS <- (1-tau_LS) * (sum(u_SA_LS * z_LS) + sum(u_UI_LS * UI_val_LS))
  # Government budget
  Gov_Fin_LS <- tax_rev_LS - transfers_LS
  # Average productivity of employed
  avg_prod_emp_LS <- GNP_LS / e_val_LS
  avg_prod_emp <- GNP_LS / e_val_LS
  # Average wage level of the employed
  avg_wage_emp_LS <- (sum(e_E_LS * (w_grid))) / e_val_LS
  avg_wage_emp <- (sum(e_E_LS * (w_grid))) / e_val_LS
  # Average skill level of population
  avg_skill_pop_LS <- sum((apply(e_E_LS, 2, sum) + u_SA_LS + apply(u_UI_LS, 2, sum)) * h_grid)
  avg_skill_pop <- sum((apply(e_E_LS, 2, sum) + u_SA_LS + apply(u_UI_LS, 2, sum)) * h_grid)
  # Value of consumption
  Cons_val_LS <- sum(V_SA * u_SA_LS) + sum(V_E * e_E_LS) + sum(V_UI * u_UI_LS)
  Cons_val <- sum(V_SA * u_SA_LS) + sum(V_E * e_E_LS) + sum(V_UI * u_UI_LS)

  # Transformation of e from w to I index.

  e_E_UI_LS <- array(0, c(I_ind_max, h_ind_max))
  for (h_ind in 1 : h_ind_max) {
    for (I_ind in 1 : I_ind_max) {
      if (I_ind == 1) {
        w_h_ind_temp <- (I_grid[I_ind] >= I_w_h[w_index, h_ind]) & (I_w_h[w_index, h_ind] >= I_lag[I_ind])
      } else {
        w_h_ind_temp <- (I_grid[I_ind] >= I_w_h[w_index, h_ind]) & (I_w_h[w_index, h_ind] > I_lag[I_ind])
      }
      e_E_UI_LS[I_ind, h_ind] <- sum(e_E_LS[w_h_ind_temp, h_ind])
    }
  }

  # End of the if function
}

#-----------------------------------------------------------------

if (LF == 1) {
  # Economy 1 (LF):
  # Calculation of hazard rates of employment over time, after a layoff from employed state E in Economy 1 (LF) with skill level h_haz_ind
```

```
# Function that supplies a vector of hazard rates for different points in time. Inputs are skill level prior to layoff and number of periods
haz_emp_func_LF <- function (h_haz_ind, n) {
  # Number of periods (1 = 2 weeks, 130 = 5 years)
  n_periods <- n
  # Time vector in years
  time_years <- (seq(0, n_periods/26, by = (1/26)))[2:(n_periods+1)]
  # Matrix where hazard rates are inserted as well as expected durations
  haz_emp_LF <- matrix(0, ncol = n_periods, nrow = 3)
  # Vector of mass of unemployed with different skills in SA
  u_SA_haz_LF <- matrix(0, ncol = h_ind_max, nrow = 1)
  # Start with mass of 1 in the chosen skill level
  u_SA_haz_LF[h_haz_ind] <- 1
  # Start with 'survivor' function at 1.
  survivor <- 1
  for (n_per in 1 : n_periods) {
    u_SA_haz_LF_old <- u_SA_haz_LF
    for (h_prime in 1 : h_ind_max) {
      #-----------------------------------------------------------
      u_SA_temp <- 0
      #-----------------------------------------------------------
      # From u_SA -> u_SA (Unemployed people w/o. benefits who rejected job above government threshold or did not obtain an offer):
      u_SA_temp <- u_SA_temp + sum(MU_U[h_index, h_prime] * u_SA_haz_LF_old[h_index] * ( (1 - pi_coeff * s_grid[searchint_SA_LF[h_index]]^pi_exp) + pi_coeff * s_grid[searchint_SA_LF[h_index]]^pi_exp * sum((w_index < w_E_bar_LF[h_prime]) * w_lag_dist[w_index]) ))
      #-----------------------------------------------------------
      u_SA_haz_LF[h_prime] <- u_SA_temp
    }
    haz_emp_LF[1, n_per] <- ((sum(u_SA_haz_LF_old) - sum(u_SA_haz_LF)) / sum(u_SA_haz_LF_old))
    haz_emp_LF[2, n_per] <- n_per * survivor * ((sum(u_SA_haz_LF_old) - sum(u_SA_haz_LF)) / sum(u_SA_haz_LF_old))
    survivor <- survivor * (1-((sum(u_SA_haz_LF_old) - sum(u_SA_haz_LF)) / sum(u_SA_haz_LF_old)))
    haz_emp_LF[3, n_per] <- survivor
  }
  haz_emp_LF <- data.frame("Time in Years" = time_years, "Hazard of Gaining Employment" = c(haz_emp_LF[1, ]), "Sum" = c(haz_emp_LF[2, ]), "Survivor" = c(haz_emp_LF[3, ]))
  return(haz_emp_LF)
}

# Data frame with hazard rates of obtaining a new job used for plotting.
Plot_haz_emp_LF <- haz_emp_func_LF(21, 130)

# Function to calculate the expected duration of unemployment for each skill level, h given a time period, n.

Exp_Duration_LF_func <- function (n_per) {
  sum_temp <- matrix(0, ncol = h_ind_max, nrow = 1)
  for (h_ind in 1 : h_ind_max) {
    sum_temp[h_ind] <- sum(haz_emp_func_LF(h_ind, n_per)$Sum)
  }
  return(sum_temp)
}
Exp_Duration_LF <- Exp_Duration_LF_func(130)

# Calculates the number of week as a weighted average of the unemployment vector:

Exp_Duration_LF_val <- sum(1/sum(u_SA_LF) * u_SA_LF * Exp_Duration_LF) * 2
Exp_Duration_val <- sum(1/sum(u_SA_LF) * u_SA_LF * Exp_Duration_LF) * 2

# Function that calculates the fraction of a mass that is still unemployed after n_per periods.
cont_unemp_LF_func <- function (n_per) {
  sum_temp <- matrix(0, ncol = h_ind_max, nrow = 1)
  for (h_ind in 1 : h_ind_max) {
    sum_temp[h_ind] <- (haz_emp_func_LF(h_ind, n_per)$Survivor[n_per])
  }
  return(sum_temp)
}
```

```
  # Calculates the fractions for 6 months.
  cont_unemp_SA_LF_13 <- cont_unemp_LF_func(13)
  # Weights the above with the steady state results to find the fraction of people
        who have been unemployed for more than 6 months.
  cont_unemp_13_LF <- (sum(cont_unemp_SA_LF_13 * u_SA_LF)) / u_val_LF * 100
  cont_unemp_13 <- (sum(cont_unemp_SA_LF_13 * u_SA_LF)) / u_val_LF * 100

  # Calculates the fractions for 12 months.
  cont_unemp_SA_LF_26 <- cont_unemp_LF_func(26)
  # Weights the above with the steady state results to find the fraction of people
        who have been unemployed for more than 12 months.
  cont_unemp_26_LF <- (sum(cont_unemp_SA_LF_26 * u_SA_LF)) / u_val_LF * 100
  cont_unemp_26 <- (sum(cont_unemp_SA_LF_26 * u_SA_LF)) / u_val_LF * 100

}

#----------------------------------------------------------------

if (LF == 0 & LS == 0) {

  # Economy 2 (AK) State E:
  # Calculation of hazard rates of employment over time, after a layoff from
       employed state E in Economy 2 (AK) with skill level h_haz_ind, last
       earnings I_haz_ind and a binary variable where SA = 1 and UI = 0.

  # Function that supplies a vector of hazard rates for different points in time.
       Inputs are last earnings level index and skill level prior to layoff and
       periods of time
  haz_emp_func_E <- function (I_haz_ind, h_haz_ind, n, SA) {
    # Number of periods (1 = 2 weeks, 130 = 5 years)
    n_periods <- n
    # Time vector in years
    time_years <- (seq(0, n_periods/26, by = (1/26)))[2:(n_periods+1)]
    # Vector where hazard rates are inserted
    haz_emp_E <- matrix(0, ncol = n_periods, nrow = 3)
    # Vector of mass of unemployed with different skills in UI
    u_UI_haz_E <- matrix(0, ncol = h_ind_max, nrow = 1)
    # Vector of mass of unemployed with different skills in SA
    u_SA_haz_E <- matrix(0, ncol = h_ind_max, nrow = 1)
    # Start with mass of 1 in the chosen skill level depending on model
    if (SA == 0) {
      u_UI_haz_E[h_haz_ind] <- 1
    } else if (SA == 1) {
      u_SA_haz_E[h_haz_ind] <- 1
    }
    # Start with 'survivor' function at 1.
    survivor <- 1
    for (n_per in 1 : n_periods) {
      u_UI_haz_E_old <- u_UI_haz_E
      u_SA_haz_E_old <- u_SA_haz_E
      for (h_prime in 1 : h_ind_max) {
        u_UI_temp <- 0
        # From u_UI -> u_UI (Unemployed people w. benefits who did not receive an
             offer):
        u_UI_temp <- u_UI_temp + (MU_U[h_index, h_prime] * u_UI_haz_E_old[h_index])
             %*% ((1-pi_coeff *s_grid[searchint_UI_AK[I_haz_ind, h_index]]^pi_exp) *
              (1-gamma))
        #---------------------------------------------------------
        # From u_UI -> u_UI (Unemployed people w. benefits who rejected a job below
             government threshold):
        u_UI_temp <- u_UI_temp + (MU_U[h_index, h_prime] * u_UI_haz_E_old[h_index])
             %*% ( (pi_coeff * s_grid[searchint_UI_AK[I_haz_ind, h_index]]^pi_exp) *
              (1-gamma) * sum(((w_index <= w_g_distr_AK[I_haz_ind, h_prime]) * (w_
             index < w_UI_bar_AK[I_haz_ind, h_prime])) * (w_lag_dist[w_index])) )
        #---------------------------------------------------------
        u_UI_haz_E[h_prime] <- u_UI_temp
        #---------------------------------------------------------
        u_SA_temp <- 0
        # From u_UI -> u_SA (Unemployed people w. benefits who did not obtain a job
             offer and lost UI status):
```

```
      u_SA_temp <- u_SA_temp + sum(MU_U[h_index, h_prime] * u_UI_haz_E_old[h_index] * (1 - pi_coeff * s_grid[searchint_UI_AK[I_haz_ind, h_index]]^pi_exp) * gamma)
      #--------------------------------------------------------
      # From u_UI -> u_SA (Unemployed people w. benefits who rejected job above government threshold):
      u_SA_temp <- u_SA_temp + (MU_U[h_index, h_prime] * u_UI_haz_E_old[h_index]) %*% (pi_coeff * s_grid[searchint_UI_AK[I_haz_ind, h_index]]^pi_exp * (gamma * sum((w_index < w_N_bar_AK[h_prime]) * (w_lag_dist[w_index])) + (1-gamma) * sum((w_index > w_g_distr_AK[I_haz_ind, h_prime]) * (w_index < w_E_bar_AK[h_prime]) * (w_lag_dist[w_index])) ))
      #--------------------------------------------------------
      # From u_SA -> u_SA (Unemployed people w/o. benefits who rejected job above government threshold or did not obtain an offer):
      u_SA_temp <- u_SA_temp + sum(MU_U[h_index, h_prime] * u_SA_haz_E_old[h_index] * ( (1 - pi_coeff * s_grid[searchint_SA_AK[h_index]]^pi_exp) + pi_coeff * s_grid[searchint_SA_AK[h_index]]^pi_exp * sum((w_index < w_N_bar_AK[h_prime]) * w_lag_dist[w_index]) ))
      #--------------------------------------------------------
      u_SA_haz_E[h_prime] <- u_SA_temp
    }
    haz_emp_E[1, n_per] <- ((sum(u_UI_haz_E_old + u_SA_haz_E_old) - sum(u_UI_haz_E + u_SA_haz_E)) / sum(u_UI_haz_E_old + u_SA_haz_E_old))
    haz_emp_E[2, n_per] <- n_per * survivor * ((sum(u_UI_haz_E_old + u_SA_haz_E_old) - sum(u_UI_haz_E + u_SA_haz_E)) / sum(u_UI_haz_E_old + u_SA_haz_E_old))
    survivor <- survivor * (1-((sum(u_UI_haz_E_old + u_SA_haz_E_old) - sum(u_UI_haz_E + u_SA_haz_E)) / sum(u_UI_haz_E_old + u_SA_haz_E_old)))
    haz_emp_E[3, n_per] <- survivor
  }
  haz_emp_E <- data.frame("Time in Years" = time_years, "Hazard of Gaining Employment" = c(haz_emp_E[1, ]), "Sum" = c(haz_emp_E[2, ]), "Survivor" = c(haz_emp_E[3, ]))
  return(haz_emp_E)
}

# Data frames with hazard rates of obtaining a new job used for plotting.
Plot_haz_emp_E_14 <- haz_emp_func_E(14, 21, 130, 0)
Plot_haz_emp_N <- haz_emp_func_E(1, 21, 130, 1)

# Function to calculate the expected duration of unemployment for each skill level, h given a time period, n.
Exp_Duration_E_func <- function (n_per, SA) {
  if (SA == 1) {
    sum_temp <- matrix(0, ncol = h_ind_max, nrow = 1)
    for (h_ind in 1 : h_ind_max) {
      sum_temp[h_ind] <- sum(haz_emp_func_E(1, h_ind, n_per, SA)$Sum)
    }
  } else if (SA == 0) {
    sum_temp <- matrix(0, ncol = h_ind_max, nrow = I_ind_max)
    for (h_ind in 1 : h_ind_max) {
      for (I_ind in 1 : I_ind_max) {
        sum_temp[I_ind, h_ind] <- sum(haz_emp_func_E(I_ind, h_ind, n_per, SA)$Sum)
      }
    }
  }
  return(sum_temp)
}

Exp_Duration_AK_UI <- Exp_Duration_E_func(260, 0)
Exp_Duration_AK_SA <- Exp_Duration_E_func(260, 1)

# Calculates the number of week as a weighted average of the unemployment matrices.
Exp_Duration_AK_val <- (sum(u_SA_AK * Exp_Duration_AK_SA) + sum(u_UI_AK * Exp_Duration_AK_UI)) / u_val_AK * 2
Exp_Duration_val <- (sum(u_SA_AK * Exp_Duration_AK_SA) + sum(u_UI_AK * Exp_Duration_AK_UI)) / u_val_AK * 2

# Function that calculates the fraction of a mass that is still unemployed after n_per periods.
cont_unemp_AK_func <- function (n_per, SA) {
  if (SA == 1) {
```

```
      sum_temp <- matrix(0, ncol = h_ind_max, nrow = 1)
      for (h_ind in 1 : h_ind_max) {
        sum_temp[h_ind] <- (haz_emp_func_E(1, h_ind, n_per, SA)$Survivor[n_per])
      }
    } else if (SA == 0) {
      sum_temp <- matrix(0, ncol = h_ind_max, nrow = I_ind_max)
      for (h_ind in 1 : h_ind_max) {
        for (I_ind in 1 : I_ind_max) {
          sum_temp[I_ind, h_ind] <- (haz_emp_func_E(I_ind, h_ind, n_per, SA)$
               Survivor[n_per])
        }
      }
    }
    return(sum_temp)
  }

  # Calculates the fractions for 6 months.
  cont_unemp_UI_AK_13 <- cont_unemp_AK_func(13, 0)
  cont_unemp_SA_AK_13 <- cont_unemp_AK_func(13, 1)
  # Weights the above with the steady state results to find the fraction of people
        who have been unemployed for more than 6 months.
  cont_unemp_13_AK <- (sum(cont_unemp_UI_AK_13 * u_UI_AK) + sum(cont_unemp_SA_AK_
       13 * u_SA_AK)) / u_val_AK * 100
  cont_unemp_13 <- (sum(cont_unemp_UI_AK_13 * u_UI_AK) + sum(cont_unemp_SA_AK_13 *
        u_SA_AK)) / u_val_AK * 100
  # Calculates the fractions for 12 months.
  cont_unemp_UI_AK_26 <- cont_unemp_AK_func(26, 0)
  cont_unemp_SA_AK_26 <- cont_unemp_AK_func(26, 1)
  # Weights the above with the steady state results to find the fraction of people
        who have been unemployed for more than 12 months.
  cont_unemp_26_AK <- (sum(cont_unemp_UI_AK_26 * u_UI_AK) + sum(cont_unemp_SA_AK_
       26 * u_SA_AK)) / u_val_AK * 100
  cont_unemp_26 <- (sum(cont_unemp_UI_AK_26 * u_UI_AK) + sum(cont_unemp_SA_AK_26 *
        u_SA_AK)) / u_val_AK * 100

}

#-----------------------------------------------------------------

if (LS == 1) {
  # Economy 3 (LS):
  # Calculation of hazard rates of employment over time, after a layoff from
       employed state in Economy 3 (LS) with skill level h_haz_ind and last
       earnings I_haz_ind

  # Function that supplies a vector of hazard rates for different points in time
  # Inputs are last earnings level index, skill level prior to layoff, periods of
       time and a binary variable, SA, where SA = 1 and UI = 0.
  haz_emp_func_LS <- function (I_haz_ind, h_haz_ind, n, SA) {
    # Number of periods (1 = 2 weeks, 130 = 5 years)
    n_periods <- n
    # Time vector in years
    time_years <- (seq(0, n_periods/26, by = (1/26)))[2:(n_periods+1)]
    # Vector where hazard rates are inserted
    haz_emp_LS <- matrix(0, ncol = n_periods, nrow = 3)
    # Vector of mass of unemployed with different skills in UI
    u_UI_haz_LS <- matrix(0, ncol = h_ind_max, nrow = 1)
    # Vector of mass of unemployed with different skills in SA
    u_SA_haz_LS <- matrix(0, ncol = h_ind_max, nrow = 1)
    # Start with mass of 1 in the chosen skill level depending on model
    if (SA == 0) {
      u_UI_haz_LS[h_haz_ind] <- 1
    } else if (SA == 1) {
      u_SA_haz_LS[h_haz_ind] <- 1
    }
    # Start with 'survivor' function at 1.
    survivor <- 1
    for (n_per in 1 : n_periods) {
      u_UI_haz_LS_old <- u_UI_haz_LS
      u_SA_haz_LS_old <- u_SA_haz_LS
      for (h_prime in 1 : h_ind_max) {
        u_UI_temp <- 0
```

```
      # From u_UI -> u_UI (Unemployed people w. benefits who did not receive an
          offer):
      u_UI_temp <- u_UI_temp + (MU_U[h_index, h_prime] * (1-alpha) * u_UI_haz_LS_
          old[h_index]) %*% (1-pi_coeff *s_grid[searchint_UI_LS[I_haz_ind, h_
          index]]^pi_exp)
      #---------------------------------------------------------
      # From u_UI -> u_UI (Unemployed people w. benefits who rejected a job below
          government threshold):
      u_UI_temp <- u_UI_temp + (MU_U[h_index, h_prime] * (1-alpha) * u_UI_haz_LS_
          old[h_index]) %*% ( (pi_coeff * s_grid[searchint_UI_LS[I_haz_ind, h_
          index]]^pi_exp) * sum(((w_index <= w_g_distr_LS[I_haz_ind, h_prime]) *
          (w_index < w_UI_bar_LS[I_haz_ind, h_prime])) * (w_lag_dist[w_index])) )
      #---------------------------------------------------------
      u_UI_haz_LS[h_prime] <- u_UI_temp
      #---------------------------------------------------------
      u_SA_temp <- 0
      # From u_UI -> u_SA (Unemployed people w. benefits who rejected job above
          government threshold):
      u_SA_temp <- u_SA_temp + (MU_U[h_index, h_prime] * (1-alpha) * u_UI_haz_LS_
          old[h_index]) %*% (s_grid[searchint_UI_LS[I_haz_ind, h_index]]^pi_exp *
           sum((w_index > w_g_distr_LS[I_haz_ind, h_prime]) * (w_index < w_E_bar_
          LS[h_prime]) * (w_lag_dist[w_index]) ) )
      #---------------------------------------------------------
      # From u_SA -> u_SA (Unemployed people w/o. benefits who rejected job above
          government threshold or did not obtain an offer):
      u_SA_temp <- u_SA_temp + sum(MU_U[h_index, h_prime] * (1-alpha) * u_SA_haz_
          LS_old[h_index] * ( (1 - pi_coeff * s_grid[searchint_SA_LS[h_index]]^pi
          _exp) + pi_coeff * s_grid[searchint_SA_LS[h_index]]^pi_exp * sum((w_
          index < w_E_bar_LS[h_prime]) * w_lag_dist[w_index]) ))
      #---------------------------------------------------------
      u_SA_haz_LS[h_prime] <- u_SA_temp
    }
    haz_emp_LS[1, n_per] <- ((sum(u_UI_haz_LS_old + u_SA_haz_LS_old) - sum(u_UI_
        haz_LS + u_SA_haz_LS)) / sum(u_UI_haz_LS_old + u_SA_haz_LS_old))
    haz_emp_LS[2, n_per] <- n_per * survivor * ((sum(u_UI_haz_LS_old + u_SA_haz_
        LS_old) - sum(u_UI_haz_LS + u_SA_haz_LS)) / sum(u_UI_haz_LS_old + u_SA_
        haz_LS_old))
    survivor <- survivor * (1-((sum(u_UI_haz_LS_old + u_SA_haz_LS_old) - sum(u_UI
        _haz_LS + u_SA_haz_LS)) / sum(u_UI_haz_LS_old + u_SA_haz_LS_old)))
    haz_emp_LS[3, n_per] <- survivor
  }
  haz_emp_LS <- data.frame("Time in Years" = time_years, "Hazard of Gaining
      Employment" = c(haz_emp_LS[1, ]), "Sum" = c(haz_emp_LS[2, ]), "Survivor"
      = c(haz_emp_LS[3, ]))
  return(haz_emp_LS)
}

# Data frames with hazard rates of obtaining a new job used for plotting.
Plot_haz_emp_LS_14 <- haz_emp_func_LS(14, 21, 130, 0)

# Function to calculate the expected duration of unemployment for each skill
    level, h given a time period, n.

Exp_Duration_LS_func <- function (n_per, SA) {
  if (SA == 1) {
    sum_temp <- matrix(0, ncol = h_ind_max, nrow = 1)
    for (h_ind in 1 : h_ind_max) {
      sum_temp[h_ind] <- sum(haz_emp_func_LS(1, h_ind, n_per, SA)$Sum)
    }
  } else if (SA == 0) {
    sum_temp <- matrix(0, ncol = h_ind_max, nrow = I_ind_max)
    for (h_ind in 1 : h_ind_max) {
      for (I_ind in 1 : I_ind_max) {
        sum_temp[I_ind, h_ind] <- sum(haz_emp_func_LS(I_ind, h_ind, n_per, SA)$Sum
            )
      }
    }
  }
  return(sum_temp)
}
Exp_Duration_LS_UI <- Exp_Duration_LS_func(260, 0)
Exp_Duration_LS_SA <- Exp_Duration_LS_func(260, 1)
```

```
  # Calculates the number of week as a weighted average of the unemployment matrices.
  Exp_Duration_LS_val <- (sum(u_SA_LS * Exp_Duration_LS_SA) + sum(u_UI_LS * Exp_Duration_LS_UI)) / u_val_LS * 2
  Exp_Duration_val <- (sum(u_SA_LS * Exp_Duration_LS_SA) + sum(u_UI_LS * Exp_Duration_LS_UI)) / u_val_LS * 2

  # Function that calculates the fraction of a mass that is still unemployed after n_per periods.
  cont_unemp_LS_func <- function (n_per, SA) {
    if (SA == 1) {
      sum_temp <- matrix(0, ncol = h_ind_max, nrow = 1)
      for (h_ind in 1 : h_ind_max) {
        sum_temp[h_ind] <- (haz_emp_func_LS(1, h_ind, n_per, SA)$Survivor[n_per])
      }
    } else if (SA == 0) {
      sum_temp <- matrix(0, ncol = h_ind_max, nrow = I_ind_max)
      for (h_ind in 1 : h_ind_max) {
        for (I_ind in 1 : I_ind_max) {
          sum_temp[I_ind, h_ind] <- (haz_emp_func_LS(I_ind, h_ind, n_per, SA)$Survivor[n_per])
        }
      }
    }
    return(sum_temp)
  }

  # Calculates the fractions for 6 months.
  cont_unemp_UI_LS_13 <- cont_unemp_LS_func(13, 0)
  cont_unemp_SA_LS_13 <- cont_unemp_LS_func(13, 1)
  # Weights the above with the steady state results to find the fraction of people who have been unemployed for more than 6 months.
  cont_unemp_LS_13 <- (sum(cont_unemp_UI_LS_13 * u_UI_LS) + sum(cont_unemp_SA_LS_13 * u_SA_LS)) / u_val_LS * 100
  cont_unemp_13 <- (sum(cont_unemp_UI_LS_13 * u_UI_LS) + sum(cont_unemp_SA_LS_13 * u_SA_LS)) / u_val_LS * 100

  # Calculates the fractions for 12 months.
  cont_unemp_UI_LS_26 <- cont_unemp_LS_func(26, 0)
  cont_unemp_SA_LS_26 <- cont_unemp_LS_func(26, 1)
  # Weights the above with the steady state results to find the fraction of people who have been unemployed for more than 12 months.
  cont_unemp_LS_26 <- (sum(cont_unemp_UI_LS_26 * u_UI_LS) + sum(cont_unemp_SA_LS_26 * u_SA_LS)) / u_val_LS * 100
  cont_unemp_26 <- (sum(cont_unemp_UI_LS_26 * u_UI_LS) + sum(cont_unemp_SA_LS_26 * u_SA_LS)) / u_val_LS * 100

}

#-----------------------------------------------------------------
#-----------------------------------------------------------------

# 8_Transient_shock.R
# This script calculates population distributions over time after a one time transient shock

# Transient firing rate
lambda_shock <- 0.18

# creates array for transition probabilities for newly unemployed. Rows indicate next periods skill level. Columns are this period.
MU_L_shock <- array(0, c(h_ind_max, h_ind_max))

# If unemployed this period, all skills are lost
MU_L_shock[, 1] <- 1

# Number of periods to look at (1 = 2 weeks, 130 = 5 years) (plus Âœ year to have prior to period 0)
n_before_shock <- 13
n_after_shock <- 156
n_periods_shock <- n_before_shock + n_after_shock
time_years_shock <- (seq(-n_before_shock/26, n_after_shock/26, by = (1/26)))[1: n_periods_shock+1] # Time vector in years
```

```
# Initializes a matrix with earnings levels spread out on periods
w_times_h <- array((w_grid %*% t(h_grid)), c(w_ind_max, h_ind_max, n_periods_shock
     ))

# Load the relevant steady state population distribution
if (LF == 1) {
  u_SA <- u_SA_LF
  e_E <- e_E_LF
} else if (LF == 0 & LS == 0){
  u_SA <- u_SA_AK
  u_UI <- u_UI_AK
  e_E <- e_E_AK
  e_N <- e_N_AK
  w_g_distr <- w_g_distr_AK
} else if (LS == 1) {
  u_SA <- u_SA_LS
  u_UI <- u_UI_LS
  e_E <- e_E_LS
  w_g_distr <- w_g_distr_LS
}

# Loads the relevant steady state decision results
if (LF == 1) {
  w_E_bar <- w_E_bar_LF
  searchint_SA <- searchint_SA_LF
} else if (LF == 0 & LS == 0){
  w_E_bar <- w_E_bar_AK
  w_N_bar <- w_N_bar_AK
  w_UI_bar <- w_UI_bar_AK
  searchint_SA <- searchint_SA_AK
  searchint_UI <- searchint_UI_AK
  tau <- tau_AK
  z <- z_AK
  UI_val <- UI_val_AK
} else if (LS == 1) {
  w_E_bar <- w_E_bar_LS
  w_UI_bar <- w_UI_bar_LS
  searchint_SA <- searchint_SA_LS
  searchint_UI <- searchint_UI_LS
  tau <- tau_LS
  z <- z_LS
  UI_val <- UI_val_LS
}

# Loads vectors for the results over time
u_val_shock <- matrix(0, nrow = 1, ncol = n_periods_shock)
GNP_shock <- matrix(0, nrow = 1, ncol = n_periods_shock)
avg_prod_emp_shock <- matrix(0, nrow = 1, ncol = n_periods_shock)
gov_fin_shock <- matrix(0, nrow = 1, ncol = n_periods_shock)
u_SA_shock <- matrix(0, ncol=h_ind_max, nrow=n_periods_shock)
if(LF == 0){
  u_UI_shock <- array(0, c(I_ind_max, h_ind_max, n_periods_shock))
}
e_E_shock <- array(0, c(w_ind_max,h_ind_max, n_periods_shock))
if (LF == 0 & LS == 0){
  e_N_shock <- array(0, c(w_ind_max,h_ind_max, n_periods_shock))
}

# Loop that fills response vectors from the shock
for (n_per in 1 : n_periods_shock) {
  if (n_per <= (n_before_shock)) {
    # Save the population distribution results
    u_SA_shock[n_per, ] <- u_SA
    if(LF == 0){
      u_UI_shock[, , n_per] <- u_UI
    }
    e_E_shock[, , n_per] <- e_E
    if (LF == 0 & LS == 0){
      e_N_shock[, , n_per] <- e_N
    }
  } else if (n_per == (n_before_shock+1)) {
    # saves original MU_L and lambda
```

```
  MU_L_save <- MU_L
  lambda_save <- lambda
  # inserts shock values
  MU_L <- MU_L_shock
  lambda <- lambda_shock
  MU_L_w <- array(MU_L, c(h_ind_max, h_ind_max, w_ind_max))
  MU_L_w <- aperm(MU_L_w, c(3,1,2))
  # Runs distribution step script with the shock
  source("6_Pop_Distr_step.R")
  # Save the population distribution results
  u_SA_shock[n_per, ] <- u_SA
  if(LF == 0){
   u_UI_shock[, , n_per] <- u_UI
  }
  e_E_shock[, , n_per] <- e_E
  if (LF == 0 & LS == 0){
   e_N_shock[, , n_per] <- e_N
  }
  # resets MU_L and lambda for the rest of the loop
  MU_L <- MU_L_save
  lambda <- lambda_save
  MU_L_w <- array(MU_L, c(h_ind_max, h_ind_max, w_ind_max))
  MU_L_w <- aperm(MU_L_w, c(3,1,2))
 } else {
  # Runs distribution step script without the shock
  source("6_Pop_Distr_step.R")
  u_SA_shock[n_per, ] <- u_SA
  if(LF == 0){
   u_UI_shock[, , n_per] <- u_UI
  }
  e_E_shock[, , n_per] <- e_E
  if (LF == 0 & LS == 0){
   e_N_shock[, , n_per] <- e_N
  }
 }
}

# Calculating the statistics used for plotting over time

if (LF == 1) {
 # Economy 1, LF steady state results:

 # Unemployment and Employment rates
 # Mass of SA recipients
 u_SA_val_LF_shock <- apply(u_SA_shock, 1, sum)
 # Mass employed in state E
 e_E_val_LF_shock <- apply(e_E_shock, 3, sum)
 # Employment rate
 e_val_LF_shock <- e_E_val_LF_shock
 # Unemployment rate
 u_val_LF_shock <- u_SA_val_LF_shock
 # Should sum to 1
 sum_LF_shock <- (u_val_LF_shock+e_val_LF_shock)

 # Economy statistics:

 # GNP per capita (total earnings of employed people)
 GNP_LF_shock <- apply(e_E_shock * w_times_h, 3, sum)
 # Average productivity of employed
 avg_prod_emp_LF_shock <- GNP_LF_shock / e_val_LF_shock
 # Average skill level of population
 avg_skill_pop_LF_shock <- apply((apply(e_E_shock, c(3, 2), sum) + u_SA_shock) *
     t(array(h_grid, c(h_ind_max, n_periods_shock))), 1, sum)

 # Deviation vectors
 u_val_LF_shock_dev <- (u_val_LF_shock - u_val_LF) * 100
 GNP_LF_shock_dev <- (GNP_LF_shock - GNP_LF) / GNP_LF * 100
 avg_prod_emp_LF_shock_dev <- (avg_prod_emp_LF_shock - avg_prod_emp_LF) / avg_
     prod_emp_LF * 100

 # Creating data frame for plotting
```

```
  trans_shock_LF_plot <- data.frame("Time in Years" = time_years_shock, "Deviation Unemployment rate" = u_val_LF_shock_dev, "Deviation GNP" = GNP_LF_shock_dev, "Deviation Average Productivity" = avg_prod_emp_LF_shock_dev)

  #------------------------------------------------------------

} else if (LF == 0 & LS == 0) {

  # Economy 2, AK steady state results:

  # Unemployment and Employment rates
  # Mass of SA recipients
  u_SA_val_AK_shock <- apply(u_SA_shock, 1, sum)
  # Mass of UI recipients
  u_UI_val_AK_shock <- apply(u_UI_shock, 3, sum)
  # Mass employed in state E
  e_E_val_AK_shock <- apply(e_E_shock, 3, sum)
  # Mass employed in state N
  e_N_val_AK_shock <- apply(e_N_shock, 3, sum)
  # Employment rate
  e_val_AK_shock <- e_E_val_AK_shock + e_N_val_AK_shock
  # Unemployment rate
  u_val_AK_shock <- u_UI_val_AK_shock + u_SA_val_AK_shock
  # Should sum to 1
  sum_AK_shock <- (u_val_AK_shock+e_val_AK_shock)
  # Economy statistics:

  # GNP per capita (total earnings of employed people)
  GNP_AK_shock <- apply(e_E_shock * w_times_h, 3, sum) + apply(e_N_shock * w_times_h, 3, sum)
  # Tax revenues to the state
  tax_rev_AK_shock <- tau_AK * GNP_AK_shock + tau_AK * (apply(u_SA_shock * z_AK, 1, sum) + apply(u_UI_shock * UI_val_AK, 3, sum))
  # Unemployment benefits paid out
  transfers_AK_shock <- (1-tau_AK) * (apply(u_SA_shock * z_AK, 1, sum) + apply(u_UI_shock * UI_val_AK, 3, sum))
  # Government budget
  Gov_Fin_AK_shock <- tax_rev_AK_shock - transfers_AK_shock
  # Average productivity of employed
  avg_prod_emp_AK_shock <- GNP_AK_shock / e_val_AK_shock
  # Average skill level of population
  avg_skill_pop_AK_shock <- apply((apply(e_E_shock, c(3, 2), sum) + apply(e_N_shock, c(3, 2), sum) + u_SA_shock + apply(u_UI_shock, c(3, 2), sum)) * t(array(h_grid, c(h_ind_max, n_periods_shock))), 1, sum)

  # Deviation vectors
  u_val_AK_shock_dev <- (u_val_AK_shock - u_val_AK) * 100
  GNP_AK_shock_dev <- (GNP_AK_shock - GNP_AK) / GNP_AK * 100
  avg_prod_emp_AK_shock_dev <- (avg_prod_emp_AK_shock - avg_prod_emp_AK) / avg_prod_emp_AK * 100
  Gov_Fin_AK_shock_dev <- (Gov_Fin_AK_shock) / GNP_AK * 100

  # Creating data frame for plotting
  if (z == W[2]) {
    trans_shock_AK_Low_plot <- data.frame("Time in Years" = time_years_shock, "Deviation Unemployment rate" = u_val_AK_shock_dev, "Deviation GNP" = GNP_AK_shock_dev, "Deviation Average Productivity" = avg_prod_emp_AK_shock_dev, "Deviation Government Finances" = Gov_Fin_AK_shock_dev)
  } else if (z == UI_val[7]) {
    trans_shock_AK_High_plot <- data.frame("Time in Years" = time_years_shock, "Deviation Unemployment rate" = u_val_AK_shock_dev, "Deviation GNP" = GNP_AK_shock_dev, "Deviation Average Productivity" = avg_prod_emp_AK_shock_dev, "Deviation Government Finances" = Gov_Fin_AK_shock_dev)
  }

  #------------------------------------------------------------

} else if (LS == 1) {

  # Economy 3, LS steady state results:

  # Unemployment and Employment rates
  # Mass of SA recipients
```

```
  u_SA_val_LS_shock <- apply(u_SA_shock, 1, sum)
  # Mass of UI recipients
  u_UI_val_LS_shock <- apply(u_UI_shock, 3, sum)
  # Mass employed in state E
  e_E_val_LS_shock <- apply(e_E_shock, 3, sum)
  # Employment rate
  e_val_LS_shock <- e_E_val_LS_shock
  # Unemployment rate
  u_val_LS_shock <- u_UI_val_LS_shock + u_SA_val_LS_shock
  # Should sum to 1
  sum_LS_shock <- (u_val_LS_shock+e_val_LS_shock)

  # Economy statistics:

  # GNP per capita (total earnings of employed people)
  GNP_LS_shock <- apply(e_E_shock * w_times_h, 3, sum)
  # Tax revenues to the state
  tax_rev_LS_shock <- tau_LS * GNP_LS_shock + tau_LS * (apply(u_SA_shock * z_LS, 1,
      sum) + apply(u_UI_shock * UI_val_LS, 3, sum))
  # Unemployment benefits paid out
  transfers_LS_shock <- (1-tau_LS) * (apply(u_SA_shock * z_LS, 1, sum) + apply(u_
     UI_shock * UI_val_LS, 3, sum))
  # Government budget
  Gov_Fin_LS_shock <- tax_rev_LS_shock - transfers_LS_shock
  # Average productivity of employed
  avg_prod_emp_LS_shock <- GNP_LS_shock / e_val_LS_shock
  # Average skill level of population
  avg_skill_pop_LS_shock <- apply((apply(e_E_shock, c(3, 2), sum) + u_SA_shock +
     apply(u_UI_shock, c(3, 2), sum)) * t(array(h_grid, c(h_ind_max, n_periods_
     shock))), 1, sum)

  # Deviation vectors
  u_val_LS_shock_dev <- (u_val_LS_shock - u_val_LS) * 100
  GNP_LS_shock_dev <- (GNP_LS_shock - GNP_LS) / GNP_LS * 100
  avg_prod_emp_LS_shock_dev <- (avg_prod_emp_LS_shock - avg_prod_emp_LS) / avg_
     prod_emp_LS * 100
  Gov_Fin_LS_shock_dev <- (Gov_Fin_LS_shock) / GNP_LS * 100

  # Creating data frame for plotting
  trans_shock_LS_plot <- data.frame("Time in Years" = time_years_shock, "Deviation
     Unemployment rate" = u_val_LS_shock_dev, "Deviation GNP" = GNP_LS_shock_dev,
      "Deviation Average Productivity" = avg_prod_emp_LS_shock_dev, "Deviation
     Government Finances" = Gov_Fin_LS_shock_dev)
}

# Resetting the population distributions to steady state values.
if (LF == 1) {
  u_SA <- u_SA_LF
  e_E <- e_E_LF
} else if (LF == 0 & LS == 0){
  u_SA <- u_SA_AK
  u_UI <- u_UI_AK
  e_E <- e_E_AK
  e_N <- e_N_AK
  w_g_distr <- w_g_distr_AK
} else if (LS == 1) {
  u_SA <- u_SA_LS
  u_UI <- u_UI_LS
  e_E <- e_E_LS
  w_g_distr <- w_g_distr_LS
}

#-----------------------------------------------------------------
#-----------------------------------------------------------------

# 9_Additional_Graphs.R
# This script draws graphs for Hazard rates and Transient shocks.
# Requires that the four main economies have been run.

#-----------------------------------------------------------------

# Plotting the w_E reservation wage.
# Creating a data frame with the different economy reservation wages
```

```
{Plot_w_E_bar <- data.frame("Current Skills" = h_grid, "Reservation Wage High Z" = w_
      grid[w_E_bar_AK_High], "Reservation Wage Low Z" = w_grid[w_E_bar_AK_Low], "
      Reservation Wage LS" = w_grid[w_E_bar_LS], "Reservation Wage LF" = w_grid[w_E_
      bar_LF])
 # Starting the plot
 ggplot(Plot_w_E_bar, aes(x = Current.Skills)) +
   # Adding labels
   labs(x = "Current Skills", y = "Reservation Wage") +
   # Redefining scales of the axes.
   scale_y_continuous(breaks=seq(from = 0.66, to = 0.84, by = 0.02), limits=c(0.66,
        0.84)) +
   scale_x_continuous(breaks=seq(from = 1, to = 2, by = 0.1), limits=c(1, 2)) +
   # Adding curves from the different economies
   geom_line(aes(y = Reservation.Wage.High.Z), linetype ="longdash") +
   geom_line(aes(y = Reservation.Wage.Low.Z), linetype ="solid") +
   geom_line(aes(y = Reservation.Wage.LS), linetype ="dotted") +
   geom_line(aes(y = Reservation.Wage.LF), linetype ="dotdash")+
   # Changing the theme and background of the plot
   theme_bw()}

#-----------------------------------------------------------------

# Plotting the w_N reservation wage.
# Creating a data frame with the different economy reservation wages
{Plot_w_N_bar <- data.frame("Current Skills" = h_grid, "Reservation Wage High Z" = w_
      grid[w_N_bar_AK_High], "Reservation Wage Low Z" = w_grid[w_N_bar_AK_Low], "
      Reservation Wage LS" = w_grid[w_E_bar_LS], "Reservation Wage LF" = w_grid[w_E_
      bar_LF])
 # Starting the plot
 ggplot(Plot_w_N_bar, aes(x = Current.Skills)) +
   # Adding labels
   labs(x = "Current Skills", y = "Reservation Wage") +
   # Redefining scales of the axes.
   scale_y_continuous(breaks=seq(from = 0.66, to = 0.84, by = 0.02), limits=c(0.66,
        0.84)) +
   scale_x_continuous(breaks=seq(from = 1, to = 2, by = 0.1), limits=c(1, 2)) +
   # Adding curves from the different economies
   geom_line(aes(y = Reservation.Wage.High.Z), linetype ="longdash") +
   geom_line(aes(y = Reservation.Wage.Low.Z), linetype ="solid") +
   geom_line(aes(y = Reservation.Wage.LS), linetype ="dotted") +
   geom_line(aes(y = Reservation.Wage.LF), linetype ="dotdash") +
   # Changing the theme and background of the plot
   theme_bw()}

#-----------------------------------------------------------------

# Plot of hazard rates of obtaining a new job over time for people who are fired.
{ggplot(Plot_haz_emp_N, aes(x = Time.in.Years)) +
   # Adding labels
   labs(x = "Time in Years", y = "Hazard of Gaining Employment") +
   # Changing y axis
   scale_y_continuous(breaks=seq(from = 0.0, to = 0.25, by = 0.05), limits=c(0.0,
       0.25)) +
   # Adding curves from the different economies
   geom_line(aes(y = Hazard.of.Gaining.Employment),linetype="dotdash") +
   geom_line(aes(y = Plot_haz_emp_E_14$Hazard.of.Gaining.Employment),linetype="
       solid") +
   geom_line(aes(y = Plot_haz_emp_LS_14$Hazard.of.Gaining.Employment),linetype="
       longdash") +
   geom_line(aes(y = Plot_haz_emp_LF$Hazard.of.Gaining.Employment),linetype="dotted
       ") +
   # Changing the theme and background of the plot
   theme_bw()}

#-----------------------------------------------------------------

# Graphs for the transient shocks over time

# Plotting deviation of the unemployment rate from steady state in percentage
      points over time.
{ggplot(trans_shock_AK_High_plot, aes(x = Time.in.Years)) +
   # Adding labels
   labs(x = "Time in Years", y = "Deviation in Percentage Points from Steady State") +
```

```r
  # Changing y axis
  scale_y_continuous(breaks=seq(from = -2, to = 16, by = 2), limits=c(-2, 16)) +
  # Adding curves from the different economies
  geom_line(aes(y = Deviation.Unemployment.rate),linetype="solid") +
  geom_line(aes(y = trans_shock_LS_plot$Deviation.Unemployment.rate),linetype="longdash") +
  geom_line(aes(y = trans_shock_LF_plot$Deviation.Unemployment.rate),linetype="dotted") +
  geom_line(aes(y = trans_shock_AK_Low_plot$Deviation.Unemployment.rate),linetype="dotdash") +
  theme_bw()}

# Plotting deviation of GNP from steady state in percentage over time
{ggplot(trans_shock_AK_High_plot, aes(x = Time.in.Years)) +
  # Adding labels
  labs(x = "Time in Years", y = "Percentage Deviation from Steady State") +
  # Changing y axis
  scale_y_continuous(breaks=seq(from = -18, to = 0, by = 2), limits=c(-18, 0)) +
  # Adding curves from the different economies
  geom_line(aes(y = Deviation.GNP),linetype="solid") +
  geom_line(aes(y = trans_shock_LS_plot$Deviation.GNP),linetype="longdash") +
  geom_line(aes(y = trans_shock_LF_plot$Deviation.GNP),linetype="dotted") +
  geom_line(aes(y = trans_shock_AK_Low_plot$Deviation.GNP),linetype="dotdash") +
  theme_bw()}

# Plotting deviation of average productivity for employed from steady state in percentage over time
{ggplot(trans_shock_AK_High_plot, aes(x = Time.in.Years)) +
  # Adding labels
  labs(x = "Time in Years", y = "Percentage Deviation from Steady State") +
  # Changing y axis
  scale_y_continuous(breaks=seq(from = -8, to = 0, by = 2), limits=c(-8, 0)) +
  # Adding curves from the different economies
  geom_line(aes(y = Deviation.Average.Productivity),linetype="solid") +
  geom_line(aes(y = trans_shock_LS_plot$Deviation.Average.Productivity),linetype="longdash") +
  geom_line(aes(y = trans_shock_LF_plot$Deviation.Average.Productivity),linetype="dotted") +
  geom_line(aes(y = trans_shock_AK_Low_plot$Deviation.Average.Productivity),linetype="dotdash") +
  theme_bw()}

# Plotting deviation of government finances from steady state in percentage over time
{ggplot(trans_shock_AK_High_plot, aes(x = Time.in.Years)) +
  # Adding labels
  labs(x = "Time in Years", y = "Deviation as a Percentage of Steady State GNP") +
  # Changing y axis
  scale_y_continuous(breaks=seq(from = -16, to = 0.5, by = 2), limits=c(-15, 0.5)) +
  # Adding curves from the different economies
  geom_line(aes(y = Deviation.Government.Finances),linetype="solid") +
  geom_line(aes(y = trans_shock_LS_plot$Deviation.Government.Finances),linetype="longdash") +
  geom_line(aes(y = trans_shock_AK_Low_plot$Deviation.Government.Finances),linetype="dotdash") +
  theme_bw()}

#----------------------------------------------------------------

# THE END!
```

BIBLIOGRAPHY

Daron Acemoglu and Robert Shimer. Productivity gains from unemployment insurance. *European Economic Review*, 44(7):1195–1224, 2000.

Alfonso Alba, Jose Maria Arranz, and Fernando Munoz-Bullon. Re-employment probabilities of unemployment benefit recipients. *Applied Economics*, 44(28):3645–3664, 2012.

Torben M. Andersen. A flexicurity labour market in the great recession: The case of denmark. *De Economist*, 160(2):117–140, 2012.

Torben M. Andersen and Michael Svarer. Flexicurity–labour market performance in denmark. *CESifo Economic Studies*, 53(3):389–429, 2007.

Torben M. Andersen and Michael Svarer. The role of workfare in striking a balance between incentives and insurance in the labour market. *Economica*, 81(321):86–116, 2014.

Arbejdsmarkedskommissionen. Velfærd kræver arbejde. Technical report, Arbejdsmarkedskommissionen, 2009.

Martin N. Baily. Some aspects of optimal unemployment insurance. *Journal of Public Economics*, 10(3):379–402, 1978.

K. Burdett. Unemployment insurance payments as a search subsidy: a theoretical analysis. *Economic Inquiry*, 17(3):333–343, 1979.

Raj Chetty. Moral hazard versus liquidity and optimal unemployment insurance. *Journal of Political Economy*, 116(2):173–234, 2008.

ThomasF. Crossley and Hamish Low. Borrowing constraints, the cost of precautionary saving and unemployment insurance. *International Tax and Public Finance*, 18(6):658–687, 2011.

Wouter den Haan, Christian Haefke, and Garey Ramey. Shocks and institutions in a job-matching model. CEPR Discussion Paper 2970, 2001.

Henry S. Farber and Robert G. Valletta. Do extended unemployment benefits lengthen unemployment spells? evidence from recent cycles in the u.s. labor market. Working Paper 19048, National Bureau of Economic Research, May 2013. URL `http://www.nber.org/papers/w19048`.

Peter Fredriksson and Bertil Holmlund. Optimal unemployment insurance in search equilibrium. *Journal of Labor Economics*, 19(2):370–399, 2001.

Peter Fredriksson and Bertil Holmlund. Improving incentives in unemployment insurance: a review of recent research. *Journal of Economic Surveys*, 20(3):357–386, 2006.

Peter Gottschalk and Robert Moffitt. The growth of earnings instability in the u.s. labor market. *Brookings Papers on Econ. Activity*, (2): 217–272, 1994.

Jonathan Gruber. The consumption smoothing bene ts of unemployment insurance. *American Economic Review*, 87(1):195–205, 1997.

Robert E. Hall. The importance of lifetime jobs in the u.s. economy. *American Economic Review*, 72(4):716–724, 1982.

Hugo A. Hopenhayn and Juan Pablo Nicolini. Optimal unemployment insurance. *Journal of Political Economy*, 105(2):412–438, 1997.

Hugo A. Hopenhayn and Juan Pablo Nicolini. Optimal unemployment insurance and employment history. *Review of Economic Studies*, 76:1049–1070, 2009.

Louise S. Jacobsen, Robert J. LaLonde, and Daniel G. Sullivan. Earnings losses of displaced workers. *American Economic Review*, 83(4): 685–709, 1993.

Lawrence F. Katz and Bruce D. Meyer. The impact of the potential duration of unemployment benefits on the duration of unemployment. *Journal of Public Economics*, 41(1):45–72, 1990.

Michael P. Keane and Kenneth I. Wolpin. The career decisions of young men. *Journal of Political Economy*, 105(3):473–522, 1997.

Christian Keuschnigg and Thomas Davoine. Flexicurity and job reallocation. Working paper, University of St. Gallen., 2010.

Mark S. Kristoffersen. *Benefit Reentitlement Conditions in Unemployment Insurance Schemes*. PhD thesis, School of Business and Social Sciences, Aarhus University,, 2013. in Essays on Economic Policies over the Business Cycle.

Anne Lauringson. Disincentive effects of unemployment insurance benefits: maximum benefit duration versus benefit level. *Baltic Journal of Economics*, 11(1):25 – 49, 2011.

Lars Ljungqvist and Thomas J. Sargent. The european unemployment dilemma. *Journal of Political Economy*, 106(3):514–550, 1998.

Lars Ljungqvist and Thomas J. Sargent. *Recursive Macroeconomic Theory*. The MIT Press, Cambridge, MA, USA, 1 edition, 2000.

Lars Ljungqvist and Thomas J. Sargent. European unemployment and turbulence revisited. *Journal of the European Economic Association*, 2(2-3):456–468, 2004.

Lars Ljungqvist and Thomas J. Sargent. Understanding european unemployment with matching and search-island models. *Journal of Monetary Economics*, 54(8):2139–2179, 2007.

Lars Ljungqvist and Thomas J. Sargent. Two questions about european unemployment. *Econometrica*, 76(1):1–29, 2008.

Mikkel Mailand. Dagpengesystemet og flexicurity-modellen. Technical report, Department of Sociology, University of Copenhagen, 2010.

J. J. McCall. Economics of information and job search. *The Quarterly Journal of Economics*, 84(1):113–126, 1970.

Robert Moffitt. Unemployment insurance and the distribution of unemployment spells. *Journal of Econometrics*, 28(1):85–101, 1985.

Robert Moffitt and Walter Nicholson. The effect of unemployment insurance on unemployment: The case of federal supplemental benefits. *Review of Economics and Statistics*, 64(1):1–11, 1982.

Dale T. Mortensen. Unemployment insurance and job search decisions. *Industrial and Labor Relations Review*, 30(4):505–517, 1977.

Makoto Nakajima. A quantitative analysis of unemployment benefit extensions. Research Department, Federal Reserve Bank of Philadelphia, Working Paper no. 11-8, 2011.

Nicola Pavoni. Optimal unemployment insurance, with human capital depreciation, and duration dependence. *International Economic Review*, 50(2):323–362, 2009.

Christopher A. Pissarides. *Equilibrium Unemployment Theory*. The MIT Press, Cambridge, Massachusetts, 2 edition, 2000.

Christopher A. Pissarides and Jonathan Wadsworth. On-the-job search: Some empirical evidence from britain. *European Economic Review*, 38(2):385–401, 1994.

Andreas Pollak. Optimal unemployment insurance with heterogeneous agents. *European Economic Review*, 51(8):2029–2053, 2007.

Steven Shavell and Laurence Weiss. The optimal payment of unemployment insurance benefits over time. *Journal of Political Economy*, 87(61):1347–1362, 1979.

Robert Shimer. The cyclical behavior of equilibrium unemployment and vacancies. *American Economic Review*, 95(1):25–49, 2005.

DECLARATION

I hereby declare

- that I have written this thesis without any help from others and without the use of documents and aids other than those stated above,
- that that I have mentioned all the sources used and that I have cited them correctly according to established academic citation rules,
- that the topic or parts of it are not already the object of any work or examination of another course unless this has been explicitly agreed on with the faculty member in advance,
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Copenhagen, August 29, 2014

Asbjørn Klein