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„Suffering from Recessions –
Does Wealth Matter?"

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Abstract

In year 2020, the Corona Pandemic reached Austria and caused the Austrian economy to transit into a severe recession. This thesis now looks at the distribution of welfare losses, measured as reduction in lifetime consumption, from such severe recessions. A simulation exercise using value function iteration, similar to the one by Krueger, Mitman and Perri (2016a) was conducted for the case of Austria. The results show, that households that are poor in wealth suffer more from recessions than rich households. For these wealth-poor households it is especially harmful, if they lose the job in times of recessions. Very rich households on the other hand have accumulated so much wealth that their welfare losses in times of recessions are minimal.

Zusammenfassung

Im Jahr 2020 erreichte die Corona-Pandemie Österreich und stürzte die österreichische Volkswirtschaft in eine schwere Rezession. Das Ziel dieser Masterarbeit ist es, die Verteilung der Wohlfahrtsverluste, gemessen als Reduktionen im lebenslangen Konsum, von solch schweren Rezessionen zu berechnen. Dazu wurde eine Volkswirtschaft simuliert, wobei eine ähnliche Vorgehensweise wie jene von Krueger, Mitman and Perri (2016a) gewählt wurde. Es wurden jedoch entsprechende Anpassungen an die österreichische Volkswirtschaft getroffen. Die Ergebnisse dieser Simulation zeigen, dass Haushalte, die wenig Vermögen besitzen, von Rezessionen schwerer betroffen sind als reiche Haushalte. Besonders schmerzhaft ist es für diese Haushalte, wenn sie in Zeiten einer Rezession den Job verlieren. Sehr vermögende Haushalte haben hingegen genug Vermögen angesammelt und müssen daher nur minimale Wohlfahrtsverluste in Zeiten von Rezessionen hinnehmen.

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Introduction

Research Interest and Research Question

The main interest guiding this Master's thesis is how welfare losses, which occurred due to severe recessions, are distributed among the population, i.e. if all people or households are affected in a similar way. Therefore, heterogeneous households, which differ in income, wealth and employment status are modelled. The welfare losses are described by reductions in lifetime consumption.

So, the strategy applied in this thesis is to compare the simulated value functions of households which differ in wealth and income in situations with and without shocks. There are two types of such shocks, or types of risks, in this model which are the risk that the aggregate economy transits into a severe recession and the risk that the individual household loses the job. Hypothetical situations where households experience shocks and where households do not experience shocks are compared to each other. The difference in lifetime consumption between scenarios with and without shocks are calculated and interpreted as welfare losses if a household lives in a hypothetical world where it experiences shocks compared to the household living in the hypothetical world where it does not experience shocks.

The corresponding research question is: *How are welfare losses due to recessions distributed among households that differ in wealth and income?*

Motivation

The Corona Pandemic hit Austria in year 2020 and caused a severe recession. Many measures were implemented by the government to mitigate the effects of this recession and the related economic downturn on households and companies. But the Corona Crisis is not the first severe recession the Austrian population has faced. Examples of other recessions are the Financial and the Eurozone Crisis.

It is known that households suffer from recessions in terms of welfare but it is not known which types of households suffer most and which types are hardly affected by recessions. This information would be crucial to target policy measure in times of severe recessions. These policy measures are often very costly and often consist of subsidies. There is the criticism that some of these subsidies are just given to every household or firm, no matter whether they are really affected by the crisis. There is even a German word for this procedure which is "Gießkannenprinzip".

This thesis should help to understand which households suffer most from severe recessions which could help to design targeted and efficient policy measures in times of recessions.

Literature Review

Almost all studies that deal with the welfare effects of business cycles refer in the introduction to the famous work by Lucas (1987, cited from Cho, Cooley and Kim, 2015) who found the potential welfare gains of removing business cycles to be very small. Does this mean that we should not care about macroeconomic stabilization policy at all? The answer is clearly no, as Lucas (1987) made some crucial assumptions which heavily influenced the outcomes of his model. Many authors like Tervala (2021), Cho, Cooley and Kim (2015), De Santis (2007), Otrok (2001) and Benartzi and Thaler (1995) have challenged the assumptions made by Lucas (1987) in different ways and came up with very different or very similar results. Another major contribution in the estimation of the welfare costs resulting from business cycles comes from Krusell and Smith (1999). The study was revised in Krusell, Mukoyama et al. (2009) and one adjustment with huge implications for welfare cots was made. As the model, a dynamic equilibrium model, is similar to the one used in this Master's Thesis it is worth looking at it in more detail. Krusell and Smith (1999) estimated a model with heterogeneous consumers who differed in employment status and preferences, or patience levels resulting from discount rates, to be more specific. There are two sources of risk, one is aggregate risk arising from fluctuations in total factor productivity, the other one is idiosyncratic risk arising from preferences and employment status. Krusell and Smith (1999) compare an economy with cycles to one without. For the economy without cycles, they remove aggregate risk by replacing aggregate shocks with their conditional expectation. The main difference between the study by Krusell and Smith (1999) and the one by Krusell, Mukoyama et al. (2009) is the assumption on how the removal of aggregate shocks is connected to idiosyncratic shocks. In Krusell and Smith (1999) it is assumed that idiosyncratic shocks are unaffected by the removal of aggregate shocks, in Krusell, Mukoyama et al. (2009) it is assumed that by the removal of the aggregate shock also the idiosyncratic component is reduced.These assumptions have huge impacts on the welfare results. Krusell and Smith (1999) come up with small costs of business cycles and find some agents to even benefit from cycles, while Krusell, Mukoyama et al. (2009) find large and positive effects of the removal of aggregate risk. One explanation is that in their model, the elimination of aggregate risk reduces idiosyncratic risk by assumption. Storesletten, Telmer and Yaron

(2001) also use a heterogeneous agent model in which the agents face both, aggregate and idiosyncratic risk. They find similarly large average welfare gains of eliminating cycles as Krusell, Mukoyama et al. (2009).

There is also literature, where the theoretical models are applied to calculate the welfare losses of past recessions. Glover et al. (2011) simulate an overlapping generations model to analyse the distribution of welfare losses caused by the Great Recession among households differing by age. Glover et al. (2011) found, that all groups lost welfare due to the Great Recession, but old households are affected more severely as they lost 10 percent of their remaining life-time consumption due to the Great Recession while this loss was 2 percent for young households. A very similar exercise is conducted by Hur (2018), but he allowed households to differ in their portfolio holdings in addition to their age. Portfolio choices are made between risky and risk-free assets. Hur (2018) found that households between the age of 30 and 38 suffered welfare losses equivalent to a reduction in one-period consumption of 24 percent, while these losses amounted to 11 percent for households between the age of 84 and 92, who were affected least. Chatterjee and Corbae (2007) take the highly increased rate of unemployment during the Great Depression between 1930 and 1939 as motivation to ask which fraction of annual consumption a worker would be willing to forego, to avoid events such as the Great Depression. The magnitude of the welfare gains found from eliminating the risk of recessions ranges from 1 to 7 percent of annual consumption per year.

The literature forecasting the welfare implications of the Corona Crisis was, at the time writing this chapter in April 2021, scarce and suffered from the gap between data collection and publication as well as the uncertainty about when we will be able to control the virus. However, a simulation of the welfare effects for Austria was conducted by Fink, Moreau and Rocha-Akis (2020) and for Germany by Bruckmeier et al. (2020) as well as by Beznoska, Niehues and Stockhausen (2020).

Model

The following section is based on the model from Krueger, Mitman and Perri (2016b).

Sources of Risk

Aggregate Risk

Source of aggregate fluctuations are exogenous stochastic movements of total factor productivity. Total factor productivity is denoted by Z, where Z follows a first order Markov process with state space $Z \in \{Z_n, Z_r\}$ and transition matrix $\pi(Z'|Z)$. Z_n should denote Total factor productivity in normal times, while Z_r should denote TFP in times of recessions.

Idiosyncratic risk

In addition to the aggregate risk, the households face two sources of idiosyncratic risk, which are unemployment risk and earnings risk when employed.

Unemployment risk
Households do not value leisure in this model, so they will work full-time if they can, but there is the possibility of unemployment. So, the households are in one out of two possible employment states which are employed or unemployed and will be denoted by $s \in \{e, u\}$. Unemployment risk and therefore also the fraction of the working age population that is unemployed ($\Pi(u)$) depend on the aggregate state of the economy, i.e. in times of recessions, unemployment is higher as in normal times.

Earnings risk
Households face earnings risk when they are employed. This risk is caused by the fact that the households originally differ in productivity. Because of the fact that they differ in productivity, they also differ in earnings, because productivity is one of the components determining earnings, which will be explained later on. For the purpose of simplicity, the earnings process was discretised into seven bins, or seven "earnings states". As these "earnings states" are originally determined by the different productivity levels a

household can show, in the following these states will be referred to as "productivity levels". The distribution of productivity is independent of the aggregate state of the economy and identical for employed and unemployed households.

Summary Risks

To sum up, there are 28 states, a household can be in. This state space is made up by two aggregate states, two employment states and seven productivity levels.

Technology

In this model the aggregate production function is of Cobb-Douglas type and given by

$$Y = ZK^{\alpha}N^{1-\alpha}$$

where K denotes capital which depreciates at a constant rate $\delta \in [0, 1]$ and N denotes labour.

Households

Life Cycle

The economy is populated by a unit mass of potentially infinitely lived households that differ by age. Households can be either of working age (denoted by W), or retired (denoted by R). So there are two types of households $j \in \{W, R\}$. The probability that a working household retires is constant and $1 - \theta \in [0, 1]$ and the probability that a retired household dies is also constant and $1 - \nu \in [0, 1]$. If a retired household dies, a new working age household takes its place.
So, the proportions of working and retired households in a population are

$$\Pi_W = \frac{1 - \theta}{(1 - \theta) + (1 - \nu)}$$

$$\Pi_R = \frac{1 - \nu}{(1 - \theta) + (1 - \nu)}$$

Preferences

The utility function of households is denoted by $u(c)$ and is continuous, strictly increasing, strictly concave and satisfies the Inada conditions. In this model, a logarithmic utility function was chosen and since leisure is not valued, the utility function is given by

$$u(c) = log(c)$$

The discount factor at which households discount future utility is denoted by β and is assumed to be constant.

Earnings

Household's labour income is modelled as a stochastic process. As mentioned before, there is earnings risk when employed. Wages of the households should not be identical and are by calculated as $E = wy$ where w is the aggregate wage per labour efficiency unit and $y \in Y$ is labour productivity, following a first-order Markov chain with transition matrix $\pi(y'|y) > 0$. The distribution $\Pi(y)$ is independent of the state of the economy Z. To sum up, the earnings of a household are determined by an aggregate component w which is the same for all households and a component y that depends on productivity and therefore varies over households.

Savings

In this model, households can save by accumulating capital but cannot borrow. The saving decision is endogenous. Everything that is not consumed in one period is saved. $a \in A$ are the asset holdings of a particular household. At the beginning, households have zero initial wealth. If a household dies, its capital is distributed among the survivors as an extra return on capital $\frac{1}{\nu}$. Working, as well as retired households are able to save in this model. There are two saving motives which are induced by the setup of the model. Households can and will save for retirement and/or for precautionary reasons because they know that the economy could face a recession. Introducing savings helps to generate a more realistic wealth distribution.

Summary Households

The ultimate source of heterogeneity in this model are the different levels of productivity which are randomly assigned at the beginning of the life cycle. Different productivity levels lead to different incomes and therefore different possibilities to save, i.e. high-income households can save more than low-income households.

Government

The Government in this model runs an unemployment insurance and a Pay-As-You-Go pension system.

Unemployment Insurance

The unemployment insurance system is determined by the replacement rate ρ which is chosen and the fact that the budget of the government must be balanced. The replacement rate ρ determines which fraction of the potential earnings of a household is received as benefits in times of unemployment and is given by $\rho = \frac{b}{wy}$ where b denote the unemployment benefits and wy are the potential earnings. Therefore, also the unemployment benefits are partially determined by the productivity of a household.
Households which find themselves in the employment status of unemployment ($s = u$) receive unemployment benefits which are financed by proportional taxes τ_{UE} on labour earnings and unemployment benefits. So households pay this tax even in times when they receive unemployment benefits themselves. If the fraction of unemployed is denoted by $\Pi(u)$ and the distribution of productivity levels over the population is given by $\Pi(y)$, the government's budget constraint for the unemployment insurance system is given by

$$\Pi(u) \sum_y \Pi(y) b = \tau_{UE} \big[\sum_y \Pi(y)[\Pi(u)b + (1 - \Pi(u))wy] \big]$$

The equation for the replacement rate can be rewritten as $b = \rho wy$ and the distribution of productivity is identical for employed and unemployed households. Therefore the budget constraint can be simplified and rewritten to report the tax rate

$$\begin{aligned} \Pi(u)\rho wy &= \tau_{UE}[\Pi(u)\rho wy + (1 - \Pi(u))wy] \\ \Pi(u)\rho wy &= \tau_{UE} wy[\Pi(u)\rho + (1 - \Pi(u))] \\ \Pi(u)\rho &= \tau_{UE}[\Pi(u)\rho + (1 - \Pi(u))] \end{aligned}$$

The tax rate τ_{UE} therefore needs to satisfy

$$\tau_{UE} = \left(\frac{\Pi(u)\rho}{1 - \Pi(u) + \Pi(u)\rho} \right) = \left(\frac{1}{1 + \frac{1-\Pi(u)}{\Pi(u)\rho}} \right)$$

The ratio $\frac{1-\Pi(u)}{\Pi(u)}$ represents the relationship between households in employment and households in unemployment. So, it can be concluded that the tax rate τ_{UE} is higher if the parameter ρ is endogenously chosen to be higher and lower if there are many more households in employment than in unemployment.

Pension System

Retired households receive a transfer which will be denoted by b_R, is independent of past contributions and is financed by a tax on labour earnings. As before, Π_W denotes the fraction of the population of working age and Π_R denotes the retired fraction of the population. To end with a balanced budget, the following equation needs to hold:

$$b_R \Pi_R = \tau_{SS} \Pi_W \left[\sum_y \Pi(y) w y \right]$$

Recursive Competitive Equilibrium

The optimization problem is here stated for working age and retired households separately. I start with the working age households:

$$v_W(s, y, a; Z) = \underset{c, a' \geq 0}{max} \Big\{ u(c) + \beta \sum_{(Z', s', y') \in (Z, S, Y)} \pi(Z'|Z) \pi(s'|s, Z', Z) \pi(y'|y) \times [\theta v_W(s', y', a'; Z') + (1 - \theta) v_R(a'; Z)] \Big\}$$

Subject to

$$c + a' = (1 - \tau_{UE} - \tau_{SS}) w y [1 - (1 - \rho) 1_{s=u}] + (1 + r - \delta) a$$

And the optimization problem for the retired households is the following:

$$v_R(a; Z) = \underset{c, a' \geq 0}{max} \Big\{ u(c) + \nu \beta \sum_{Z' \in Z} \pi(Z'|Z) v_R(a'; Z') \Big\}$$

subject to

$$c + a' = b_R + (1 + r - \delta)a/\nu$$

The state variables according to this definition are asset holdings a, the state of the aggregate economy, i.e. the current TFP Z and for the working household's problem productivity and the employment status.

So, the recursive competitive equilibrium can be, according to Krueger, Mitman and Perri (2016a) defined as given by value and policy functions of working age and retired households, which are denoted by v, c and a' and pricing functions r and w, such that

1. Given the pricing functions r, w and the tax rate τ_{UE} the value function v solves the household Bellman equation and c, a' are the associated policy functions.

2. Factor prices are given by

$$w(Z) = ZF_N(K(Z), N(Z))$$

$$r(Z) = ZF_K(K(Z), N(Z))$$

3. The budget of the government (for the unemployment system) is balanced.

4. Market Clearing (i denoting households)

$$N(Z) = (1 - \Pi(u)) \sum_{y \in Y} y\Pi(y)$$

$$K(Z) = \sum_i a$$

   We need to make sure that the labour and capital markets clear and the goods market will also clear according to Walras law (Walras and Jaffé, 1954).

The calibration process is laid down in the next chapter and the entire Matlab Code can be provided on demand.

Calibration

The model will be calibrated at quarterly levels.

Technology

As suggested by Krueger, Mitman and Perri (2016b), output is produced according to a Cobb-Douglas production function, defined as

$$Y = ZK^{\alpha}N^{1-\alpha}$$

And also according to Krueger, Mitman and Perri (2016b) the parameters are chosen to be $\alpha = 36\%$ and $\delta = 2,5\%$ per quarter.

Aggregate Risk

It is assumed that aggregate risk arises from movements in total factor productivity Z and that this movement is completely driven by exogenous factors. TFP can take one out of two possible values which are denoted by Z_n for normal times and Z_r for times of severe recessions. It should be noted here that this model will only consider severe recessions as recessions. Therefore, a definition for a severe recession needed to be employed. In this study, the economy experiences a severe recession if both of the following conditions are true:

- The growth rate of real GDP compared to the same quarter of the previous year is negative and
- the unemployment rate (national definition) is above 6 percent.

This definition includes both, GDP and unemployment as unemployment rates alone turned out to be an unreliable indicator for a severe recession as they can be also affected by changes in the labour market which are not caused by an economic downturn. One example here is the EU enlargement to the east (Stiglbauer, 2020).
Monthly unemployment rates were provided by the Austrian Labour Market Service (AMS) and used to calculate quarterly rates. Therefore, they are based on the national definition of unemployment referring to all people

who are registered at the Austrian Labour Market Service as unemployed (Knittler, 2017). Real GDP growth rates were obtained from the OECD databank (OECD, 2021).
Applying the definition mentioned above, the Austrian economy experienced three severe recessions in the period ranging from Q1 1961 till Q1 2021. These recession periods are Q4 2008 till Q1 2010 (financial crisis), Q1 2013 till Q2 2013 (Eurozone crisis) and Q1 2020 till Q1 2021 (Corona crisis). There are negative growth rates in earlier periods but the unemployment rates were never high enough to satisfy the conditions for severe recessions.

The goal of this part of the calibration is to find a Markov chain which is given by

$$\pi = \begin{pmatrix} \rho_r & 1-\rho_r \\ 1-\rho_n & \rho_n \end{pmatrix}$$

ρ_r can be interpreted as the probability of experiencing a severe recession in the next period given you are experiencing one in the current period. Therefore, ρ_r is also a measure of the persistence of a recession. In the same manner $1-\rho_r$ can be interpreted as the probability of experiencing normal times in the next period given you are currently living through a recession. The same interpretations hold for the second line of the Markov chain which depicts the probabilities of experiencing a recession or normal times, respectively, in the next period given you are living in normal times in the current period.

In the first step of the calibration ρ_r is chosen in a way that it matches the average length of a recession. Following Krueger, Mitman and Perri (2016b) this average length is given by

$$EL_r = \frac{1}{1-\rho_r}$$

and therefore

$$\rho_r = \frac{EL_r - 1}{EL_r}$$

The average length of a severe recession according to the definition from above is 4.3 quarters and therefore $\rho_r = 0.7692$. Comparing this number, which can be interpreted as the persistence of a recession for Austria with the number Kruger, Mitman and Perri (2016b) came up with for the USA after the Great Recession, recessions in Austria seem to be much less persistent than in the US.

In a second step ρ_n is calculated as suggested by Kruger, Mitman and Perri (2016b). They refer to Π_r as the fraction of time an economy spends in a recessions and find it considering the stationary distribution associated with the Markov chain:

$$\Pi_r = \frac{1 - \rho_n}{2 - \rho_r - \rho_n}$$

and therefore

$$\rho_n = \frac{2\Pi_r - \Pi_r\rho_r - 1}{\Pi_r - 1}$$

Since ρ_r was calculated before and Π_r can be calculated from data to be 5.39 percent, $\rho_n = 0.9868$. The fact, that the Austrian economy was in a severe recession in 5.39 percent of all quarters is consistent with the fact that severe recessions in Austria were found to be less persistent than in the US.

Note that of course

$$\Pi_r + \Pi_n = \Pi_r + \frac{1 - \rho_n}{2 - \rho_r - \rho_n} = 1$$

$1 - \rho_n$ can be calculated as residual and the whole Markov chain for total factor productivity Z is given by:

$$\pi = \begin{pmatrix} 0.7692 & 0.2308 \\ 0.0132 & 0.9868 \end{pmatrix}$$

Finally, the ratio between total factor productivity in normal times and severe recessions $\frac{Z_r}{Z_n}$ needs to be defined. Following Kruegger, Mitman and Perri (2016b) $\frac{Z_r}{Z_n}$ is chosen to target $\frac{Y_r}{Y_n} = 0,93$ which means that GDP Y should be 7 percent lower in times of severe recessions than in normal times. In order to calculate $\frac{Z_r}{Z_n}$, the average unemployment rates in severe recessions and normal times need to be calculated and are found to be $u(Z_r) = 8.42\%$ and $u(Z_n) = 4.94\%$. Setting average labour productivity equal to 1 if employed and equal to 0 if unemployed and taking into account that the capital share is $\alpha = 0.36$, $\frac{Z_r}{Z_n}$ can be calculated in short run (capital stock fixed) to be

$$\frac{Z_r}{Z_n} = \frac{\frac{Y_r}{Y_n}}{\left(\frac{1-u(Z_r)}{1-u(Z_n)}\right)^{0.64}}$$

$$\frac{Z_r}{Z_n} = \frac{0.93}{\left(\frac{0.9158}{0.9506}\right)^{0.64}} = 0.9525$$

Krueger, Mitman and Perri (2016b) argue that the dispersion in total factor productivity is smaller in the long run, as capital is endogenous, i.e. falls in recessions and increases in normal times. Krueger, Mitman and Perri (2016b) adjust their ratio of total factor productivity for that reason. I adjust $\frac{Z_r}{Z_n}$ by the same factor as they do and come up with $\frac{Z_r}{Z_n} = 0.9643$.

If $Z_r\Pi_r + Z_n\Pi_n$ is normalized to 1, $Z_r = 0.9662$ and $Z_n = 1.0019$ can be calculated.

Idiosyncratic Risk

Unemployment Risk

For unemployment risk, four different Markov Chains need to be defined, one for each transition of total factor productivity. This means that there will be one Markov Chain for the transition from normal times to normal times, one for the transition from normal times to severe recessions and so on. In general, following Krueger, Mitman and Perri (2016b) the transition matrices can be written as:

$$\pi(s'|s, Z', Z) = \begin{pmatrix} \pi_{u,u}^{Z,Z'} & \pi_{u,e}^{Z,Z'} \\ \pi_{e,u}^{Z,Z'} & \pi_{e,e}^{Z,Z'} \end{pmatrix}$$

This transition matrix consists of the probabilities of moving from one employment status to another/ remaining in the same employment status given that the economy transits from one state to another/remains in the same state. There are two possible employment states in this model, which are employed (denoted by e) and unemployed (denoted by u). Therefore, $\pi_{u,u}^{Z,Z'}$ describes the probability that an individual that is currently unemployed will also be unemployed in the next period when the economy transits from state Z in the current period to state Z' in the next period. In the same way, $\pi_{u,e}^{Z,Z'}$ can be interpreted as the probability that an individual that is currently unemployed will be employed in the next period when the economy transits from state Z in the current period to state Z' in the next period.

This probability represents the job finding rate in this model.

As suggested by Krueger, Mitman and Perri (2016b), the aggregate unemployment rate is assumed to depend only on the aggregate state of the economy. Therefore, it must hold that $\Pi'_Z(u) = \pi_{u,u}^{Z,Z'} \times \Pi_Z(u) + \pi_{e,u}^{Z,Z'} \times (1 - \Pi_Z(u))$, where $\Pi'_Z(u)$ denotes the fraction of the population that is unemployed if the economy is in state Z', i.e. the unemployment rate if the economy is in state Z'. Since these unemployment rates are known, only the job finding rates $\pi_{u,e}^{Z,Z'}$ for each Z, Z' pair need to be obtained from data to come up with the four transition matrices.

Due to data availability constraints I could not apply the same method as Krueger, Mitman and Perri (2016b) to calculate job finding rates. Instead, I used quarterly data from Eurostat on recent job starters who are defined as people who have started their employment in the last three months before the interview. This data was set in relation to the total number of unemployed in a certain quarter to calculate job finding rates. One drawback is that data on recent job starters is only available from Q1 2006 onwards, but since all the severe recessions according to the definition in the last sub chapter occurred after this time, they are captured by the data. In the end, I only need job finding rates for the transitions of different states of the economy. Therefore, I calculate averages over all periods corresponding to specific transitions. The only exception is the transition from normal times to severe recessions. The data shows here very high job finding rates in the period the transition happens but much lower rates for the subsequent period. This might be due to the fact that firms need some time to react to recessions and employ less labour. Therefore, for each transition from normal times to recessions, an average between the period of the transition and the subsequent period was calculated. In general, the job finding rates that are used to calculate the transition matrices for employment states are averages over all job finding rates that correspond to specific transitions of the state of the economy. Here, also transitions from normal times to normal times or recessions to recessions are included.

In the end, the four following transition matrices are used in the calibration:

- Aggregate economy experiences a severe recession in the current and in the subsequent period (transition from $Z = Z_r$ to $Z = Z_r$)

$$\pi(s'|s, Z'_r, Z_r) = \begin{pmatrix} 0.35281 & 0.64719 \\ 0.05952 & 0.94047 \end{pmatrix}$$

- Aggregate economy experiences normal times in the current and in the subsequent period (transition from $Z = Z_n$ to $Z = Z_n$)

$$\pi(s'|s, Z'_n, Z_n) = \begin{pmatrix} 0.24922 & 0.75077 \\ 0.03904 & 0.96095 \end{pmatrix}$$

- Aggregate economy experiences a severe recession in the current and normal times in the subsequent period (transition from $Z = Z_r$ to $Z = Z_n$)

$$\pi(s'|s, Z'_n, Z_r) = \begin{pmatrix} 0.28037 & 0.71962 \\ 0.02819 & 0.97180 \end{pmatrix}$$

- Aggregate economy experiences normal times in the current and a severe recession in the subsequent period (transition from $Z = Z_n$ to $Z = Z_r$)

$$\pi(s'|s, Z'_r, Z_n) = \begin{pmatrix} 0.28063 & 0.71936 \\ 0.07400 & 0.92599 \end{pmatrix}$$

Most of these transition matrices are intuitive as job finding rates are higher in normal times than in severe recessions. The only problem is that the job finding rates from transiting in and out of a recession are very similar. This is caused by the fact that there are only three severe recessions in my model and the average was therefore only calculated taking into account three or even two numbers as the recession caused by the Corona Crisis is not over by the time writing this thesis.

Earnings Risk

Following for example Meghir and Pistaferri (2004), Krueger, Mitman and Perri (2016b) assume a process with transitory and persistent shocks for log-labor earnings of households and describe it by

$$log(y') = \zeta + \epsilon$$

$$\zeta' = \gamma\zeta + \eta$$

with persistence ζ and persistent and transitory shocks (η, ϵ) with variances $(\sigma_\eta^2, \sigma_\epsilon^2)$. Krueger, Mitman and Perri (2016b) estimate the parameters $(\gamma, \sigma_\eta^2, \sigma_\epsilon^2)$ which characterize the earnings process from data and find them to be $\gamma = 0.9695, \sigma_\eta^2 = 0.0384$ and $\sigma_\epsilon^2 = 0.0522$. In this thesis these parameters are taken from Krueger, Mitman and Perri (2016b) as estimating them from data would go beyond the scope of this thesis. However, including earnings risk is important to generate a disperse wealth distribution.

Household

Life Cycle

In terms of the life cycle, the probabilities of retiring and dying need to be defined, which are denoted by $1 - \theta$ and $1 - \nu$, respectively. As Krueger, Mitman and Perri (2016b) suggest, it is calculated with an expected work life of 40 years, which corresponds to 160 quarters and an expected time in retirement before dying of 15 years, which corresponds to 60 quarters. Therefore, the probabilities $1 - \theta$ and $1 - \nu$ are set to be 1/160 and 1/60 respectively.

Preferences

The utility function used is $u(c) = log(c)$ and therefore a CRRA utility function as suggested by Krueger, Mitman and Perri (2016b). The factor at which future utility is discounted is denoted by β and set equal to 0.9899. This number is also taken from the paper by Krueger, Mitman and Perri (2016b).

Government

As pointed out in the chapter illustrating the model, the government provides unemployment insurance and runs a pension system. These policies are characterized by the replacement rate concerning the unemployment insurance which is set to be 80 percent, 55 percent or 0 percent and the payroll tax on working age households that finances the pension system and is set to be 15.3 percent. Both numbers are as in Krueger, Mitman and Perri (2016b).

Results

The Matlab Code to calculate the policy functions for the Model described before was provided by Dirk Krueger and Kurt Mitman and Fabrizio Perri, who did these calculations in their paper Krueger, Mitman and Perri (2016a) for the financial crises in the US. The Calibration was adjusted as mentioned in the previous chapter for the case of Austria and the Corona Crisis. Since the Code provided by Krueger, Mitman and Perri only calculated policy functions, the value functions and welfare losses that will be reported below were calculated by myself. The whole Code can be provided on demand.

In order to interpret the following results, some important facts should be repeated.

- There is a total of 28 states a household can find itself in. These states are made up of two possible states the aggregate economy can be in, namely normal times or severe recessions, two employment states the household can be in, namely employed or unemployed and seven productivity levels which are assigned randomly to the households.
- Households differ in wealth because they accumulate assets. As the main interest of this paper is to access how households with different levels of wealth perform, all functions will be plotted against assets.
- In addition to the Pension System, the government runs an unemployment insurance system which is characterized by the replacement rate. This replacement rate is set to different levels in the following analysis to access, how changing the replacement rate affects welfare losses from experiencing recessions and job losses. The replacement rates chosen are 80, 55 percent and 0 percent. 80 percent are chosen because this is the value Krueger, Mitman and Perri (2016a) work with and 55 percent is the replacement rate currently in place in Austria. A replacement rate of 0 percent depicts the absence of a unemployment insurance system.

Policy Functions

Analysing the consumption and capital policy functions, some important observations could be made:

- The consumption and capital policy functions are both convex and increasing in assets which is intuitive, as richer people will both, consume and save more.

- Concerning consumption policy functions, it can be observed, that most of the households consume more, if the economy remains in normal times than they do if the economy transits into a recession,regardless of their employment status. Only very wealth-poor households consume more if the economy transits into a recession and they keep the job than they would do if the economy remains in normal times but they lose the job.

- Concerning capital policy functions, it can be observed that households of all wealth levels save more if they are employed, than they would do if they are unemployed, no matter what state the aggregate economy is in. They save most if they are employed and the economy experiences a severe recession. This is due to the fact that they expect the recession to continue if they find themselves in a recession.

The policy functions are depicted in the Appendix.

Value Functions

The two policy functions were used to calculate value functions which were in turn needed to calculate the welfare losses.
The following two graphs show the value functions plotted against aggregate assets for all 28 possible states and a replacement rate set to 80 and 0 percent, respectively. The value function for a replacement rate of 55 percent looks identical to the one with a replacement rate of 80 percent from this perspective. Interpreting value functions, higher values at a given level of aggregate assets are always better because higher values correspond in this setting to higher lifetime utilities, as the objective in this model is to maximize lifetime utility. It can be observed, that some of the value functions in the world without unemployment insurance reach far more into the negative area than in the world with unemployment insurance systems. This is intuitive, as households with low levels of wealth suffer more in certain state combinations if there is no unemployment insurance.
In general, the value functions are concave and increasing.

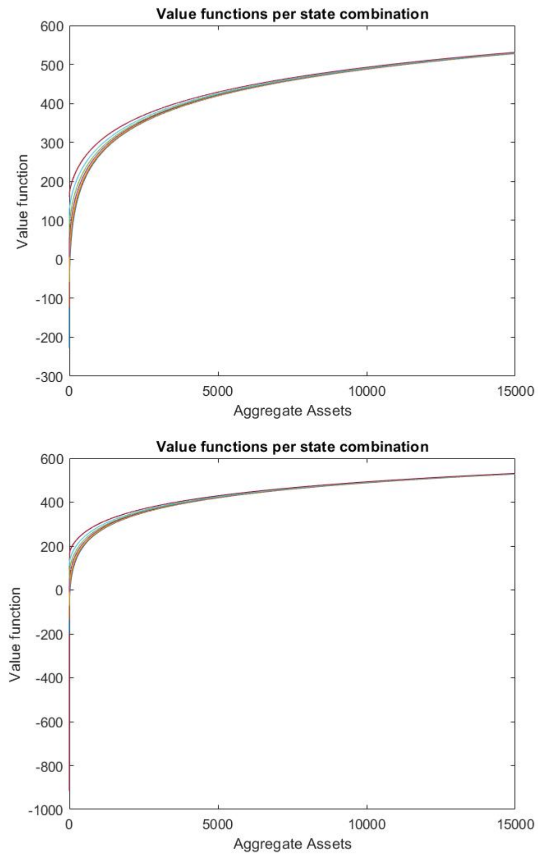

Figure 1: Value Function, All States, Replacement Rates 80 (top) and 0 (bottom) Percent

If we zoom in, it can be observed that the value functions for different productivity levels are stacked over one another. This means households with higher productivity levels will always show higher value functions than households with lower productivity levels, no matter what aggregate state the economy or employment state the household is in. This is true for all replacement rates considered.

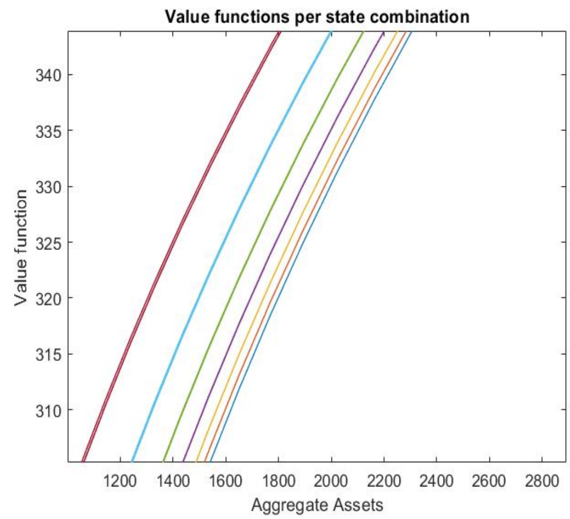

Figure 2: Value Function zoomed in, All States, Replacement Rate 80 Percent

For the following three graphs, the productivity level was fixed at $y = 5$. The graphs therefore do not show value functions for seven productivity levels with four state combinations each, but analyse the value functions for the state combinations belonging to this specific productivity level.

The first graph shows the value functions corresponding to a replacement rate of 80 percent. The differently coloured value functions refer to the following state combinations:

- Blue: The economy transits into a severe recession and the household loses the job.
- Red: The economy transits into a severe recession but the household does not lose the job.
- Yellow: The economy does not transit into a severe recession (remains in normal times) but the household loses the job.
- Purple: The economy does not transit into a severe recession (remains in normal times) and the household does not lose the job.

It is intuitive, that the value function belonging to the state combination *Normal Times, Employed* always leads to the highest values while the policy function belonging to the state combination *Severe Recession, Unemployed* always leads to the lowest values. However, it is of interest, how the value functions for the two remaining combinations of states look like. The graph shows that there is a point where these functions cross each other. So, households holding very low levels of assets, prefer a situation, where the economy transits into a severe recession but they keep the job to a situation where the economy remains in normal times but they lose the job. This relationship changes for households with higher asset levels. It can be concluded, that losing the job is very harmful for low-wealth households while wealth-richer households would prefer losing their job over the economy experiencing a severe recession. As a reminder: these results refer to a world where the replacement rate is set to 80 percent which is very high.

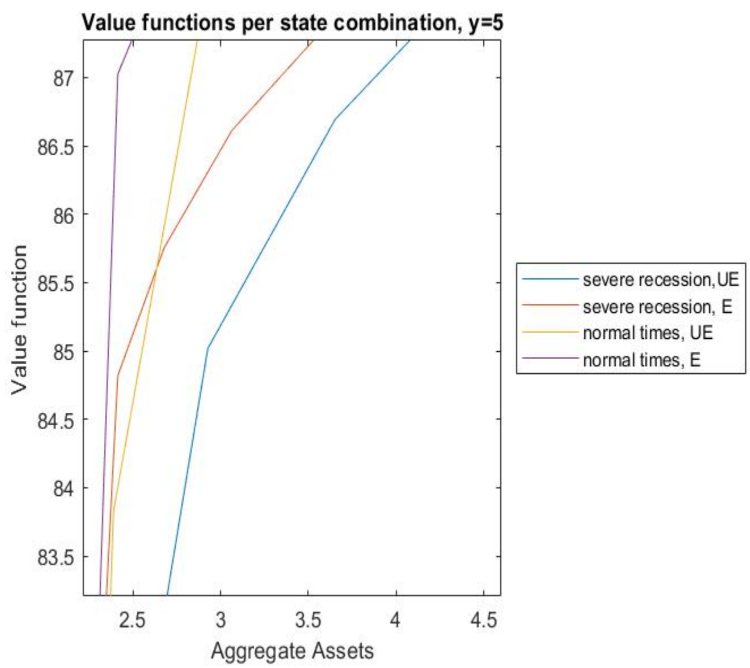

Figure 3: Value Function zoomed in, Productivity Level 5, Replacement Rate 80 Percent

Fixing again the productivity level of $y = 5$ but analysing worlds with replacement rates of 55 and 0 percent, respectively, it can be observed, that the asset level at which the crossing takes place is lowest for the world with a replacement rate of 55 percent and increases for replacement rates of 80 and

0 percent. The crossing can in general be interpreted in the following way: households that are very poor in assets are better off if they find themselves in a world, where the aggregate economy experiences a recession but they keep the job than in a world where the aggregate economy remains in normal times but they lose the job. For wealthier households this relationship is the other way around. The level of wealth where the household would prefer losing the job over the economy transiting into a severe recession varies with replacement rates. This is intuitive as utility in this model only results from consumption and the value functions assign values to the maximized lifetime utilities. However, it is counter-intuitive, that the crossing takes place at a lower asset/wealth level for the world with a replacement rate of 55 percent than for the world with a replacement rate of 80 percent.

Welfare Losses

First, welfare losses need to be defined. In this thesis, welfare losses will only be considered at an individual (household) level rather than on an aggregate level. Welfare losses will be calculated for different transitions, which can be moving from employment to unemployment, or the economy moving from normal times to a severe recession. As before, there are also combinations of these transitions. Transitions between different levels of productivity are not possible in my model.
According to Krueger, Mitman and Perri (2016a), I define the welfare losses as "the permanent percentage increase in consumption that a working age household would require so that its welfare in the transition is the same as the welfare when the transition does not happen (Krueger, Mitman and Perri, 2016a: 23)". In other words that means, that the welfare losses are percentage reductions in lifetime consumption if a transition to a worse state happens.
So, according to Krueger, Mitman and Perri (2016a) the welfare loss (denoted by g) of a transition of the aggregate economy from Z to Z' and the household from s to s' is given by:

$$g_{ss',ZZ'}(y,a) = 100 * \left[exp\left(\left(\frac{(1-\theta\beta)(1-\nu\beta)}{1-\nu\beta+\beta(1-\theta)} \right) \left[v_w(s,y,a;Z) - v_w(s',y,a;Z') \right] \right) - 1 \right]$$

The following graph now illustrates the welfare losses a household experiences if it loses the job and the economy transits into a severe recession by productivity levels. The replacement rate was set to 80 percent for this analysis. It should be mentioned, that the results for very poor households will be biased, as households in my model are allowed to save, but they cannot borrow which they would do in the real world in certain situations. So the very high welfare losses for wealth-poor households, which range up to 90 percent in permanent lifetime consumption should not be analysed in more detail.

Therefore, figure 5 disregards households that are located at the bottom 20 percent of the wealth/asset distribution. Now it can be observed, that the welfare losses from losing the job and the aggregate economy transiting into a recession are higher, the higher the productivity level of a household is. For all productivity levels, it is true that the welfare losses decrease, as the wealth of a household increases. For households located at the bottom of the wealth distribution (remember that the poorest 20 percent were already disregarded from the analysis) the welfare losses range from an almost 6 percent reduction in permanent lifetime consumption for the highest productivity households to an about 1.5 percent reduction in permanent lifetime consumption for the lowest productivity households. Households that are very rich in terms of wealth only experience minimum welfare losses.

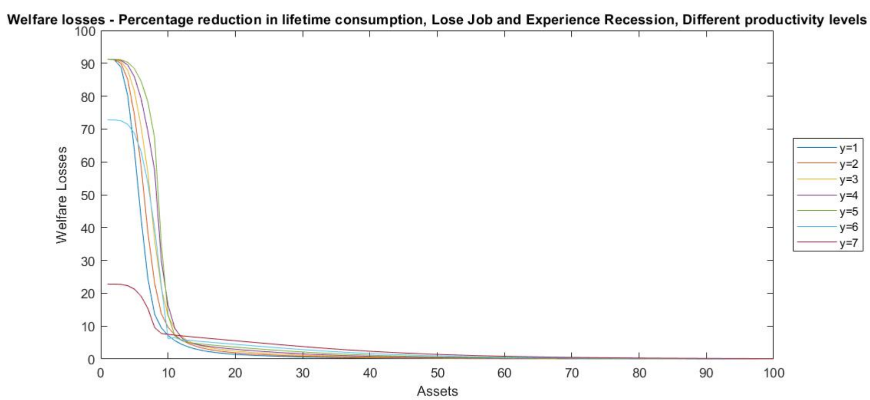

Figure 4: Welfare Losses from losing Job while Economy transits into Recession, All Productivity Levels, Replacement Rate 80 Percent

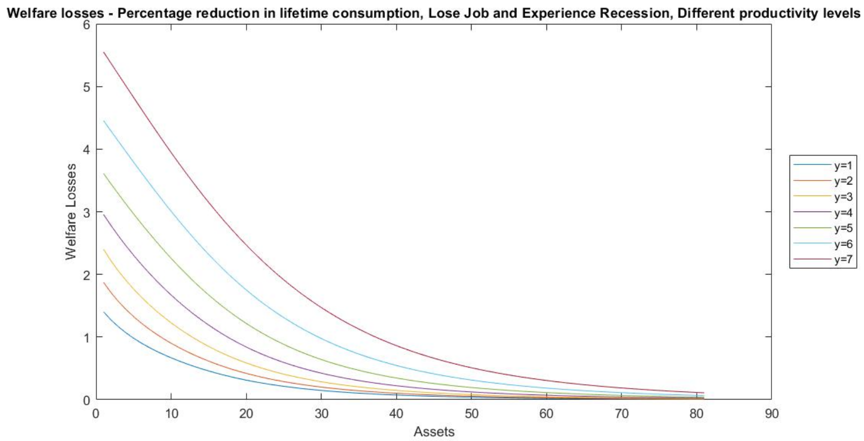

Figure 5: Welfare Losses from losing Job while Economy transits into Recession, Without poorest 20 Percent, All Productivity Levels, Replacement Rate 80 Percent

The previous analysis considered a world where the replacement rate was set to 80 percent. The following two graphs now correspond to the same analysis but a replacement rate of 55 and 0 percent, respectively. Again, the poorest 20 percent are disregarded for the reasons provided above. No matter what replacement rate is in place, the welfare losses at a given level of assets are always highest for households with the highest productivity level and lowest for the households with the lowest productivity level. In addition, it can be observed, that the welfare losses are highest for all productivity levels if the replacement rate is set to 0, so there is in fact no unemployment insurance system. However, the welfare losses are higher for all productivity levels if we consider a world where the replacement is 80 percent than if we consider a world where the replacement rate is 55 percent. This finding is counter-intuitive as one would expect welfare losses from losing the job while the economy transits into a severe recession to be mitigated by the unemployment insurance system and therefore to decrease with the replacement rate. However, this finding corresponds to the finding from the analysis of the value functions.

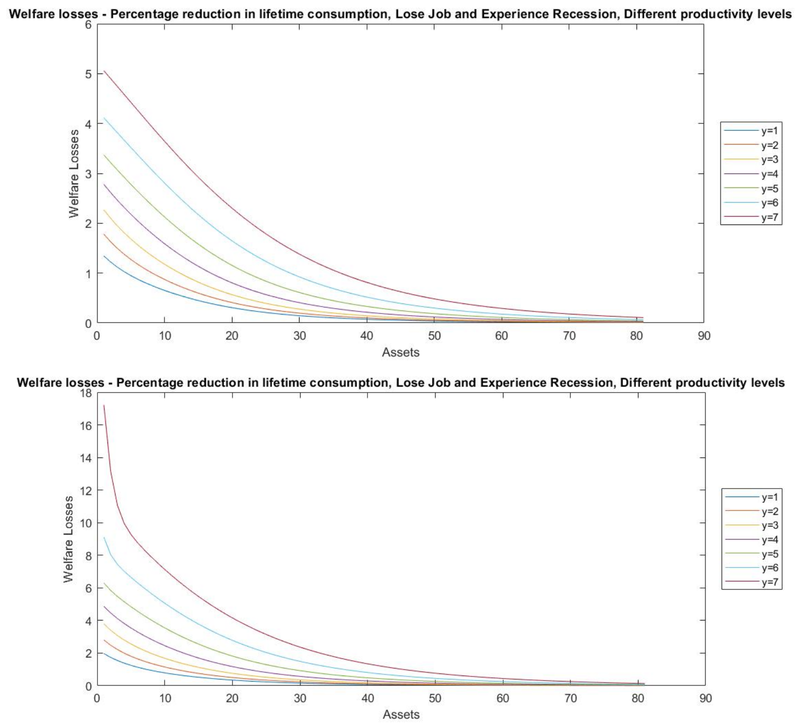

Figure 6: Welfare Losses from losing Job while Economy transits into Recession, Without poorest 20 Percent, All Productivity Levels, Replacement Rate 55 (top) and 0 (bottom) Percent

The following graphs now fix the productivity level and look at the welfare losses from different transitions which are:

- Welfare losses from losing the job while the aggregate economy transits into a severe recession.
- Welfare losses from not losing the job while the aggregate economy transits into a severe recession.
- Welfare losses from losing the job while the aggregate economy remains in normal times, i.e. does not transit into a severe recession.

The analysis is again conducted for the three different replacement rates and always refer to the productivity level $y = 4$ as this is the productivity level in the middle of all levels considered.

It can be observed that the welfare losses for households which are very poor in wealth are extremely high if they lose the job. In the case where no unemployment insurance is in place they are going to infinity for very poor households as they would die in this model if they lose the job and do not hold assets. But, as mentioned before, the magnitude of these welfare losses should not be taken too seriously as in this model it is not possible to borrow, but in the real world households which are losing the job and cannot maintain a certain level of consumption from their saving would borrow.
Nevertheless, I considered it to be important to also show the welfare losses of the very poor households once even though their magnitude is not realistic as the relationship to the welfare losses of the other possible transitions is realistic and should be mentioned. Very wealth-poor households do not suffer from recessions at all if they keep the job. This finding is partly intuitive as these households are not affected by lower interest rates which come with recessions as they do not hold assets.
As we will observe later on for very poor households, scenarios where they lose the job are more harmful than the scenario where they keep the job while the aggregate economy transits into a recession. But this changes after a certain threshold of wealth after which the scenario *Lose Job and Experience Recession* is most harmful in terms of losses of lifetime consumption followed by the scenario *Experience Recession (keep job)* and the scenario *Lose Job (no Recession)*. These findings hold irrespective of the replacement rate considered.

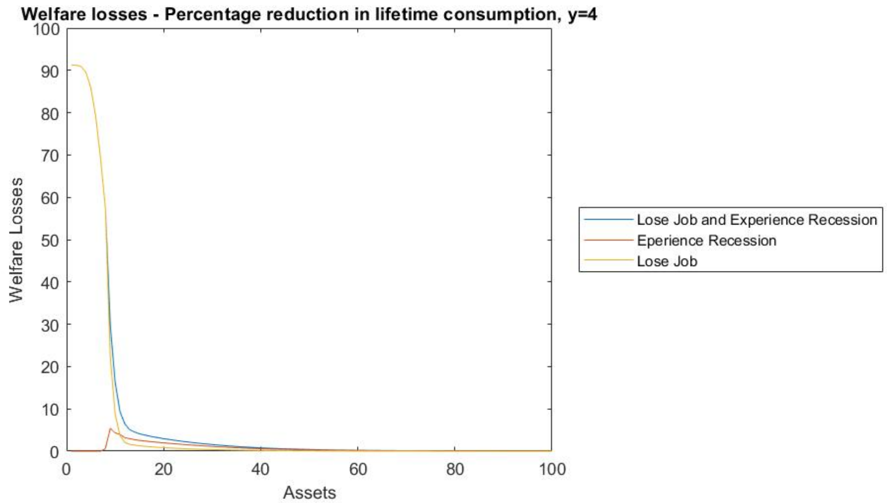

Figure 7: Welfare Losses from different Transitions, Productivity Level 4, Replacement Rate 80 Percent

To be able to make reliable statements about the magnitude of the welfare losses, the following figures show the distribution of welfare losses disregarding households located at the bottom 20 percent of the asset/wealth distribution.

For the worlds, where an unemployment insurance system is in place, transitions of the aggregate economy into a severe recession while the household loses the job are always more harmful than seeing the aggregate economy experiencing a recession while keeping the job and just losing the job while the economy remains in normal times. However, the graph corresponding to a world without an unemployment insurance system looks different. Here, households holding not that much wealth (however located within the upper 80 percent of the wealth distribution) still suffer more of they lose the job and live in normal times than if the aggregate economy experiences a recession while they keep the job up to a certain wealth threshold, as is illustrated in figure 8.

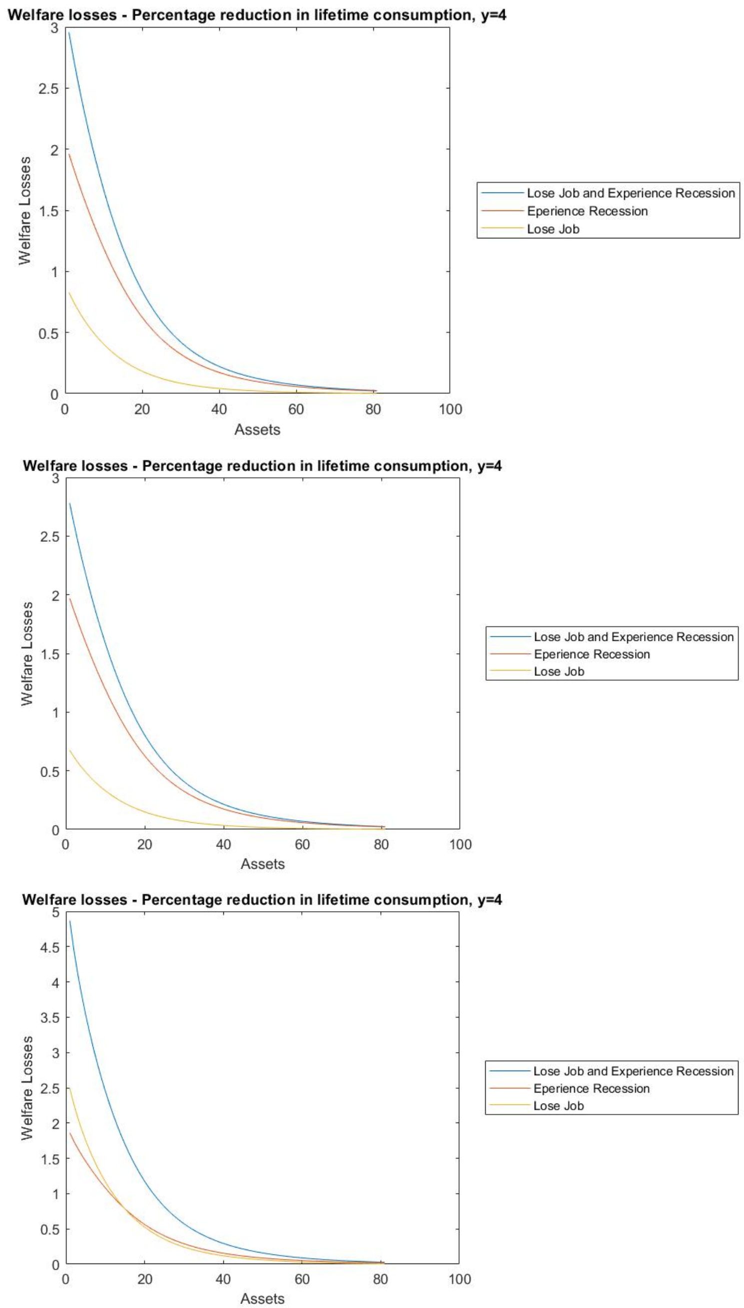

Figure 8: Welfare Losses from different Transitions, Without poorest 20 Percent, Productivity Level 4, Replacement Rates 80 (top), 55 (middle) and 0 (bottom) Percent

The following three graphs quantify the welfare losses for the different transitions which were described above, different replacement rates and households located at different wealth levels. The productivity level was fixed at $y = 4$. The wealth distribution was designed to range from 0 to 100. The following analysis looks at:

- Households located at the bottom of the wealth distribution with an asset level of 15 ($a = 15$).
- Households located in the middle of the wealth distribution with an asset level of 50 ($a = 50$).
- Households located at the top of the wealth distribution with an asset level of 90 ($a = 90$).

It becomes clear right away, that the welfare losses, no matter which transition scenario or replacement rate is considered, are always highest for households located at the bottom of the wealth distribution. They range from 16.17 percent in a world without unemployment insurance and the scenario *Lose Job and Severe Recession* to 1.03 percent in a world with a replacement rate of 55 percent and the scenario *Lose Job (No Recession)*. Welfare losses, which are defined to be reductions in permanent lifetime consumption, are always a lot higher for households located at the bottom of the wealth distribution than for households in the middle or at the top of the wealth distribution. Even though the difference is small, welfare losses are always higher for households located in the middle of than at the top of the wealth distribution, no matter which transition scenario or replacement rate is considered. For households located at the top of the wealth distribution welfare losses are always below 0.1 percent, so these households do not suffer a lot if they lose their job or the economy experiences a severe recession.

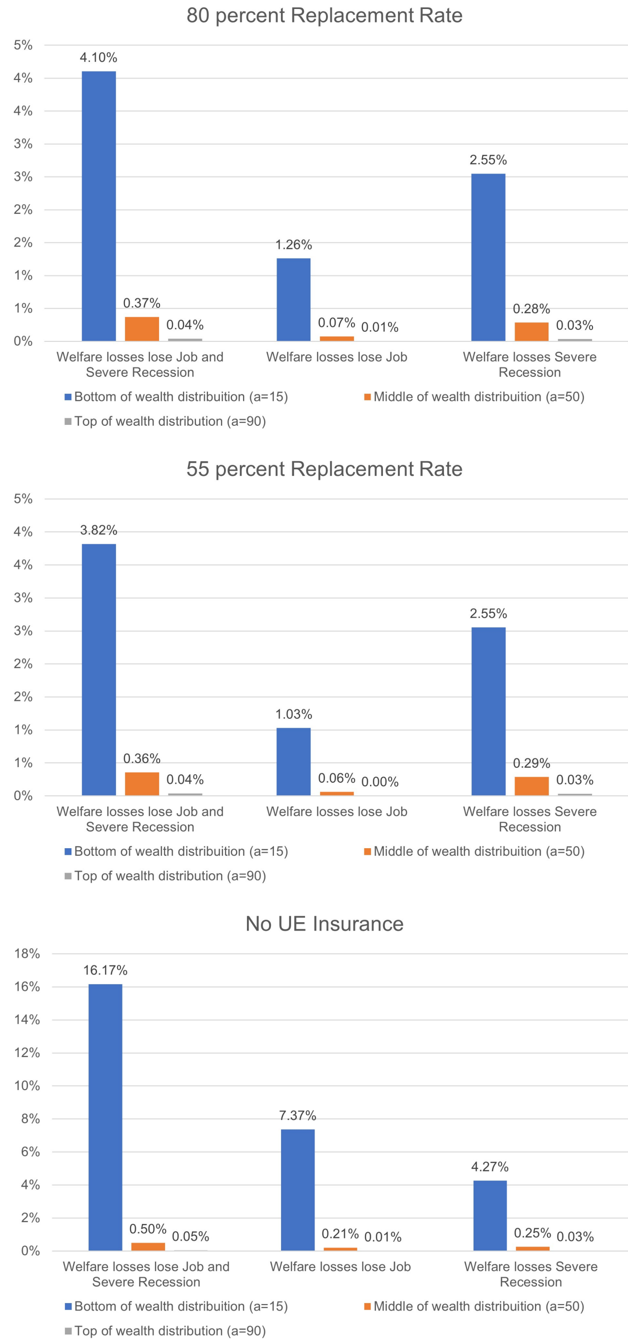

Figure 9: Welfare Losses from different transitions by Wealth level, y=4, Replacement Rate 80 (top), 55 (middle) and 0 (bottom) Percent

Limitations

In this chapter some limitations should be pointed out. The most severe limitations arise from the fact, that the policy functions were obtained using an adjusted version of the code by Krueger, Mitman and Perri (2016a). It would be possible to adjust the model for these shortcomings but this is beyond the scope of a Master's thesis. Krueger, Mitman and Perri (2016a) calculate welfare losses for the US and the financial crisis. They model the US as closed economy which is legitimate. Since their code was used, Austria is also modelled as closed economy which is of course not true. Secondly, Krueger, Mitman and Perri (2016a) model the financial crisis as pure TFP (total factor productivity) shock. This setup was also taken for the model applied here but it can be discussed if the Corona Crisis can be modelled as pure TFP shock. Future models on this questions should include preference shocks as well but also this would go beyond the scope of a Master's thesis. The last possible limitation that should be mentioned here is concerning the calibration. Since only three severe recessions according to the definition given in the calibration part of this thesis could be identified, there are also only three transitions into a recession and two transitions out of a recession (as the Corona Crisis was not over at the time data collection took place). For the calibration of the transition matrix concerning employment transitions, averages of job finding rates at times of transitions were needed. As there are only few transitions, only three relevant recession cycles could be taken into account to calculate averages which could lead to biased or imprecise results.

Conclusion and Policy Implications

Before interpreting the results, the most important findings should be summarized here:

- Concerning consumption policy functions, it can be observed, that most of the households consume more, if the economy remains in normal times than they do if the economy transits into a recession, regardless of their employment status. Only very wealth-poor households consume more if the economy transits into a recession and they keep the job than they would do if the economy remains in normal times but they lose the job.

- Concerning capital policy functions, it can be observed that households of all wealth levels save more if they are employed, than they would do if they are unemployed, no matter what state the aggregate economy is in. They save most if they are employed and the economy experiences a severe recession. This is due to the fact that they expect the recession to continue if they find themselves in a recession.

- Concerning value functions, it can be observed, that very wealth-poor households prefer (in terms of utility) the economy to transit into a severe recession if they keep the job to losing the job while the economy remains in normal times.

- Concerning welfare losses it can be observed, that welfare losses are highest for the households with the highest productivity level. This is due to the fact that they have the highest earnings potentials. Losing the job while the economy experiences a severe recession is always most harmful for all households. Very wealth-poor households do not care so much about the aggregate economy transiting into a recession, but suffer a lot if they lose the job. However, the welfare losses of all households are higher considering a replacement rate of 80 percent than considering a replacement rate of 55 percent, which is counter-intuitive. All in all, for all scenarios and possible transitions, it is true that wealth-poor households suffer a lot more from shocks (aggregate or unemployment) than wealth-rich households.

As the summary before shows, wealthy households can mitigate the effects of a severe recession by themselves as they have accumulated enough capital beforehand. Wealth-poor households on the other hand do not have these possibilities and are hit harder by shocks. An appropriately high replacement rate in the unemployment insurance is also crucial for wealth-poor households that lose the job. However, the replacement rate should not be too high, as a comparison between welfare losses of replacement rates of 80 and 55 percent respectively shows.

It could also be observed, that consumption is lower if the economy transits into a recession, no matter what employment state the households finds itself in. This finding is important, as especially in times of recessions it would be important, that demand is high enough for the economy to overcome the recession.

In terms of policy implications, governments should focus on very poor households and make sure that they do not get unemployed in times of recessions or that the replacement rate is set appropriately. Here, the program of short-time work during the Corona Crisis that was introduced by the Austrian Government to keep companies from laying-off workers should be considered an effective instrument concerning the results of this thesis. Subsidies and lower tax rates in times of the Crisis, i.e. measures from which all households benefited in the same or a similar manner, will not be as effective in reducing welfare losses.

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List of Figures

Appendix

Graphs of Policy Functions

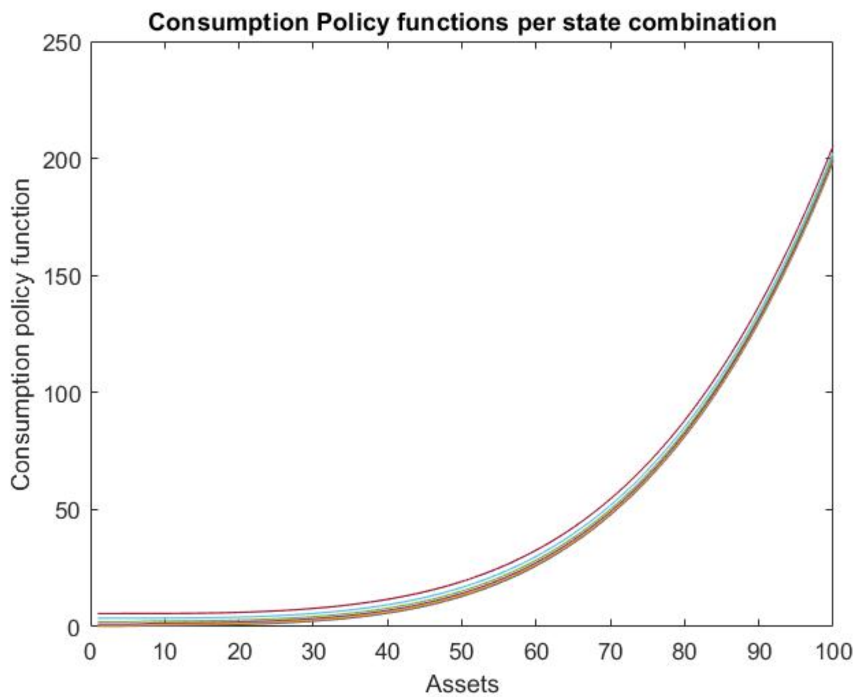

Figure 10: Consumption Policy Function, All States, Replacement Rate 80 Percent

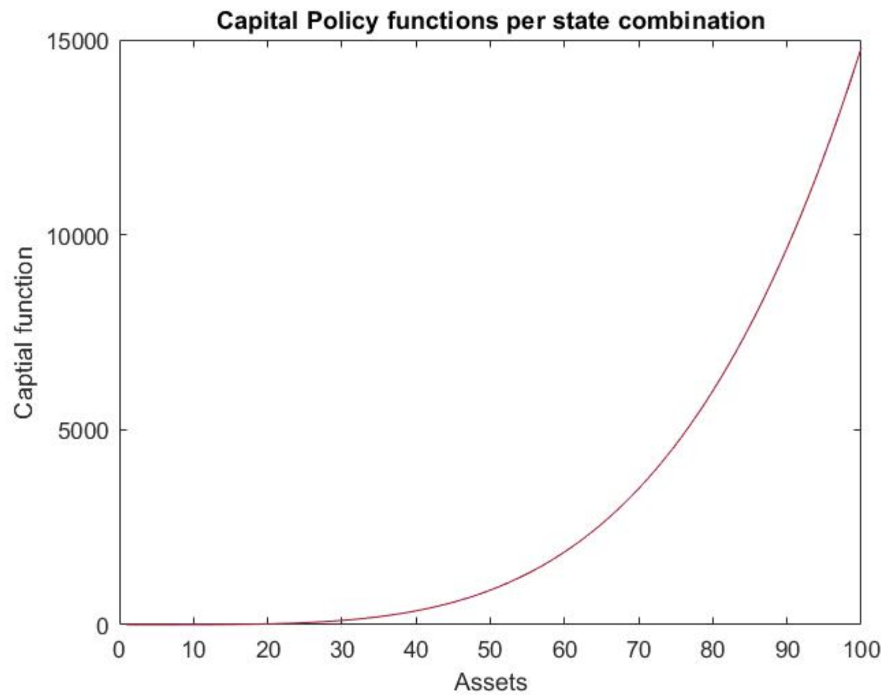

Figure 11: Capital Policy Function, All States, Replacement Rate 80 Percent

Fit of Model

Now, some features of the model will be compared to features from real world data for Austria. As the wealth distribution is crucial for the analysis conducted in this thesis, the features presented will also concern the wealth distribution. Data was obtained from the third wave of the Household Finance and Consumption Survey which was conducted in 2017. This data source was used because it was the only possibility to obtain data on assets/wealth on household level.

The following two graphs show the distribution of assets first generated by the model and then replicated from data. The three richest households were excluded in figure 13 for graphical reasons. It can be observed that both distributions are right skewed. There are many households located at the bottom of the distribution and only some located at the top, both in the model and the data. The distribution generated by the model does not completely match the distribution from data but is very similar which can be seen as an indicator for a good fit of the model.

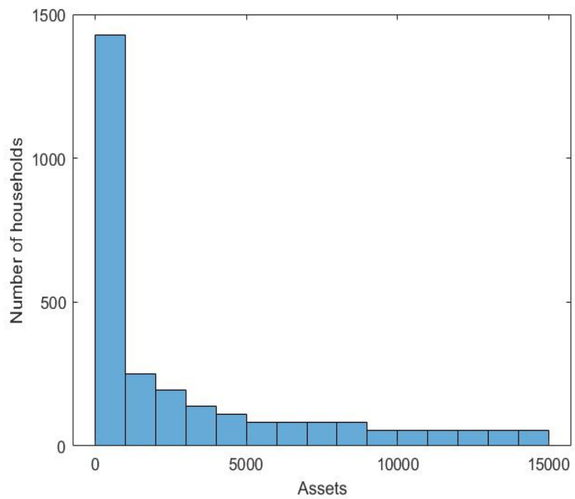

Figure 12: Asset/Wealth Distribution Model

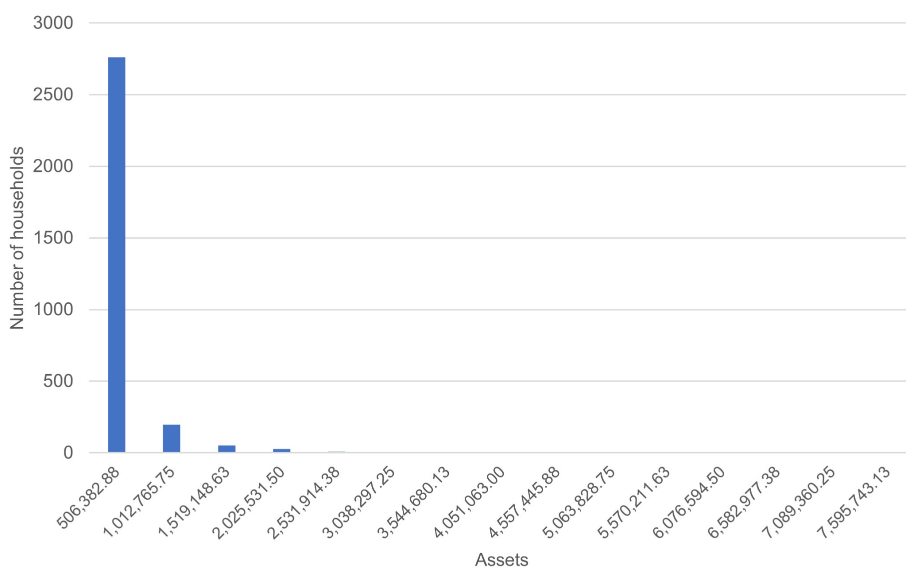

Figure 13: Asset/Wealth Distribution Data, without richest 3 households

In addition to the graphical assessment, GINI coefficients for assets and y ratios were calculated. These y ratios represent the relationship $\frac{y_r}{y_n}$ which was targeted at 0.93 which would correspond to a drop in aggregate output by 7 percent in times of severe recessions compared to normal times. The y ratios generated by the model are in all versions close to the target value. Interestingly, the model in all its versions generates a more unequal wealth distribution than could be found in the data which can be assessed from the fact that the GINI coefficient is higher in the model than the one calculated from data. A possible explanation for this fact is, that the data is survey data and very rich households tend to be underrepresented in survey samples. However, the GINI coefficients of model and data are very similar which is also an indicator for a good fit of the model.

	Gini	y ratio
80 percent	0.765636	0.930344
55 percent	0.765903	0.927398
0 percent	0.749249	0.930969
Data/Target	0.737710	0.93

Figure 14: Comparison Gini Coefficients and y-ratios