Home Production and the Optimal Rate of Unemployment Insurance *

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December, 2013

Abstract

In this paper, we incorporate home production into a quantitative model of unemployment and show that realistic levels of home production have a significant impact on the optimal unemployment insurance rate. Motivated by recently documented empirical facts, we augment an incomplete markets model of unemployment with a home production technology, which allows unemployed workers to use their extra non-market time as partial insurance against the drop in income due to unemployment. Depending on the definition of home production, we find that the optimal replacement rate is between 47% and 63% of wages, which is significantly lower than the no home production model's optimal replacement rate of 74%. The calculated range of the optimal rate is also close to the estimated rates in practice. The fact that home production makes a significant difference in the optimal unemployment insurance rate is robust to a variety of parameterizations.

*An older version of this paper was a part of Temel Taskin's Ph.D. thesis at the University of Rochester and circulated with title "Unemployment Insurance and Home Production". The authors would like to thank Mark Aguiar, Árpád Ábrahám, Mark Bils, Yongsung Chang, Gregorio Caetano, and the seminar and conference participants at the University of Rochester, European University Institute, Central European University, Izmir Economy University, Middle East Technical University, Central Bank of Turkey, Bilkent University, SED Meeting in Montreal, Midwest Macro Meeting at Michigan State University, Canadian Economic Association Meeting in Quebec City, Max Weber-Lustrum Conference in Florence, the ASSET Conference in Evora, Swiss Society of Economics and Statistics Meeting in Zurich for helpful discussions. All errors are ours and comments are very welcome. The views expressed here are those of the authors and do not reflect those of the Central Bank of Turkey.

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J.E.L. Classification: D13, E21, J65.
Keywords: Unemployment insurance, home production, incomplete markets, self-insurance.

1 Introduction

In this paper, we study the optimal rate of unemployment insurance in an economy where individuals do home production as well as market production. If there were complete private insurance against unemployment shocks, then government-provided unemployment insurance would be unnecessary. Therefore, it is important to account for the amount of self-insurance of unemployed workers when designing unemployment insurance programs. We consider home production as a self-insurance mechanism and study the role of home production in determining the optimal unemployment insurance rate. The results suggest that the optimal replacement rate in the presence of home production lies in between 47% and 63% of wages, which is significantly lower than that of the no-home production case of 74%. The computed range of optimal rate is also close to the estimated rates in practice for the United States.

Before we pursue a quantitative analysis of optimal replacement rate (benefits/wages) we provide empirical evidence on the relationship between employment status and time spent for home production using the American Time Use Survey (ATUS). We find that unemployed do about 12 hours/week more home production than that of employed.[1] We interpret this difference as a self-insurance mechanism against the loss of earnings during unemployment spell and account for this fact when we compute the optimal replacement rate.

To formalize the idea of self-insurance through home production, we augment an incomplete markets model of unemployment with a home production technology, which al-

[1] Burda and Hamermesh (2010) provide similar evidence.

lows unemployed workers to use their extra non-market time as partial insurance against the drop in income due to unemployment. The model features a heterogeneous agent framework due to idiosyncratic employment shocks. Government provides unemployment insurance as a constant fraction of lost earnings during the unemployment spell, which is the current design of policy implemented in the United States. It is financed through proportional income taxation. Along with government-provided unemployment insurance, individuals can partially self-insure by increasing home production during unemployment spells and/or accumulating savings.

The role of home production in determining the optimal rate of unemployment insurance is quantified by solving the model twice: once with home production and once without home production. By introducing home production into the model, we differentiate consumption from expenditure, which is not an accurate measure of actual consumption.[2] Due to the nature of the unemployment shocks, the budget and time constraints of individuals change during unemployment spells. They have looser time constraints and tighter budget constraints, and their optimal behavior adjusts accordingly. In equilibrium, individuals do more home production during unemployment spells, which provides smoother consumption in comparison with the case in which there is no home production. Eventually, the optimal rate of unemployment insurance turns out to be significantly smaller due to the additional self-insurance through home production. This result is robust to a variety of parameterizations.

The paper contributes to the quantitative unemployment insurance literature by computing the optimal rate of unemployment insurance in an economy where individuals do home production as well as market production. In general, incomplete asset market models - including the quantitative models of unemployment insurance - ignore the partial insurance role of home production and how it varies with employment status.[3] However,

[2] Aguiar and Hurst (2005, 2007)

[3] For examples of quantitative models on unemployment insurance see: Hansen and İmrohoroğlu

the recent empirical literature provides evidence that home production is quantitatively important in time-use surveys.[4] In particular, the unemployed allocate their non-market time differently, and this is important for policy analysis.[5] Therefore, our paper closes the gap between the home production literature and unemployment insurance literature.

The rest of the paper is organized as follows. Section 2 summarizes the related literature. Section 3 presents some interesting facts about employment status and home production. Section 4 describes the model in which we analyze the optimal unemployment insurance. Section 5 presents the quantitative results. Finally, Section 6 concludes.

2 Related Literature

Our paper stands between two bodies of research: first one is the quantitative unemployment insurance literature, and the other is the recent empirical literature on home production. Many papers, including Hansen and İmrohoroğlu (1992), Davidson and Woodbury (1997), Acemoglu and Shimer (2000), and Chetty (2008), look for the optimal rate of unemployment insurance conditioning on a certain type of policy as we do in this paper. Our paper differs from those studies in the sense that we consider home production as well as market production in the model economy.

There is a large literature on the optimal profile of unemployment insurance payments over the unemployment spell. The results vary. Some of the studies (Shavell and Weiss 1979, Hopenhayn and Nicolini 1997, Wang and Williamson 2002, Alvarez and Sanchez 2010) claim that the optimal profile of payments should be decreasing over the unemployment spell. Other papers (Kocherlakota 2004, Hagedorn et al. 2005, Shimer and Werning 2008) support flat or increasing payments over the unemployment spell. In

(1992), Hopenhayn and Nicolini (1997), Acemoglu and Shimer (2000). See Heathcote et al. (2009) for a survey on the partial insurance mechanisms in incomplete markets.

[4]Aguiar and Hurst (2007)

[5]Burda and Hamermesh (2010), and Guler and Taskin (2013)

this paper, we abstract from the problem of optimal design. Instead, we focus on the current design in practice in the United States and look for the optimal rate of insurance conditional on the design in practice.

On the other hand, because of the recent availability of time-use surveys, the number of studies emphasizing the role of home production has increased substantially. In particular, using time-use data from some developed countries, including the U.S., Burda and Hamermesh (2010) document that time spent on home production increases significantly due to unemployment. Guler and Taskin (2013) provide empirical evidence on the negative correlation between time spent for home production and level of unemployment benefits using American Time Use Survey and state level unemployment benefits data. Moreover, Aguiar and Hurst (2007) estimate parameters of a home production function for the U.S. by using two micro data sets.

Moreover, the home production approach has been employed to explain various puzzles in macroeconomics. Aguiar and Hurst (2005) explain the retirement puzzle using a home production approach, where home production has a consumption-smoothing role. Chang and Hornstein (2007) employ home production in a business cycle model to better understand aggregate fluctuations in labor supply and the small correlation between employment and wages. Benhabib et al. (1991), Greenwood and Hercowitz (1991), Canova and Ubide (1998), and Chang (2000) are other examples. In contrast, motivated by recent empirical facts, we employ home production as a self-insurance mechanism in a quantitative unemployment insurance model.

Table 1: Summary Statistics (ATUS, 2003-2008)

	Home production (narrow)	Home production (broad)	%
Full Sample	13.14	22.48	100
Unemployed	18.95	30.29	5
Employed	11.13	19.49	65
Full-time employed	10.24	17.81	49
Not-in-labor force	20.05	32.92	30
Single	10.40	16.81	42
Married	14.58	25.45	58
Female	16.38	28.42	52
Male	9.80	16.33	48

Note: Unmarried couples are included in the "married" sample.

3 Data

In this section, we provide complementary results to the recent empirical literature on home production.[6] In particular, we document the relationship between employment status and home production using the American Time Use Survey (ATUS). It is a repeated cross-sectional data set which is a supplement to the Current Population Survey (CPS). It has been conducted since 2003, and it is nationally representative. We use 2003-2008 samples, which were obtained from the Bureau of Labor Statistics web page.[7] The survey collects information through time-use diaries from individuals. It measures time spent on a rich set of activities, including personal care, household activities, work-related activities, education, socializing, leisure, traveling and volunteer activities.[8] The unit of time is minutes per day, and we convert it to hours per week by multiplying by 7/60. Also, the survey provides detailed information about the employment status and demographic characteristics of individuals.

The type of activities considered in the benchmark definition of home production are

[6] See Burda and Hamermesh (2010), Aguiar et al. (2013), Guler and Taskin (2013) for a discussion on the interaction between employment status and home production.

[7] http://www.bls.gov/tus/

[8] For a detailed description and a guide to the potential uses of the data, see Hamermesh et al. (2005).

Table 2: Home Production and Unemployment in ATUS

	Home production (narrow)	Home production
Unemployed	8.924***	12.038***
	(0.511)	(0.489)
# of Obs.	53016	53016
R^2	0.081	0.122

Robust and clustered standard errors in parentheses
*** $p < 0.001$

time spent on housework, home and vehicle maintenance, consumer purchases, gardening, pet care, child care and adult care, and travel related to these activities.[9] A narrower definition of home production excludes the time spent for caring for household members (child care and adult care).

Table 1 presents the average time spent for home production with respect to demographic features of individuals. As shown in the table, there is a significant difference between home production of unemployed and employed. We test whether this is still true when we account for observable differences between these two groups using the following equation:[10]

$$HP_i = \beta_0 + X_i\beta + U_i\phi + D_i\gamma + \epsilon_i \tag{1}$$

where HP_i is the weekly hours spent on home production, U_i is employment status (1 if individual is unemployed, 0 otherwise), D_i is a set of dummy variables for each state and year, X_i is a set of explanatory variables including age, square of age, education, square of education, interaction of age and education, race, gender, family size, and spouse employment status for individual i.

Table 2 presents the increase in home production at unemployment spells. There is an increase of 12 hours/week in time spent for home production. It increases by 8.9

[9] A full description of activities and their codes are provided online on the web page of the Bureau of Labor Statistics: http://www.bls.gov/tus/lexiconnoex0308.pdf.

[10] Since we focus on the use of extra time when individuals move from employment to unemployment, we restrict the sample to individuals in the labor force between the ages of 20-65.

hours/week when we consider a narrower definition of home production which excludes time spent for child care and adult care. These empirical results are also in line with that of Aguiar et al. (2013), and Burda and Hamermesh (2010).

Our empirical exercise suggests that individuals do not completely substitute leisure for the decline in working hours (on average 40 hours/week) during unemployment spells. Instead, some part of the decline in working hours is substituted with an increase in home production. We interpret this as a consumption insurance during unemployment spells against the loss of earnings and compute the optimal rate of unemployment insurance in an environment where we account for this fact.

4 Model

We augment an incomplete markets model of unemployment with a home production technology, which allows unemployed workers to use their extra non-market time as partial insurance against the drop in income due to unemployment. We aim to understand the role of home production in determining optimal unemployment insurance policy. The asset markets are incomplete because there is only a storage technology for agents. Unemployment insurance is financed through a proportional income tax. There is a continuum of ex-ante identical individuals, and ex-post heterogeneity in the economy arises due to idiosyncratic employment opportunities. We explain each component of the model in detail in the following subsections.

4.1 Employment Process

Individuals receive shocks to employment status every period. It follows a two-state Markov chain. The transition probabilities are defined as $\chi(i, j) = P(e' = j|e = i)$, where $i, j \in \{0, 1\}$. For example, given that the individual did not get an offer in the last period, the probability of getting an offer in the current period is equal to $P(e' = 1|e = 0) = \chi(0, 1)$. Each employed individual earns the same wage rate denoted with y.

4.2 Household Preferences and Constraints

Agents utilize consumption of composite good and leisure. They maximize lifetime utility by making saving/spending decision, and time allocation decision constraint by a budget constraint and a time constraint:

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

where $u(\cdot)$ is a period utility function, β is a time discount factor, c_t is composite good consumption, and l_t is time devoted for leisure.

The utility function is assumed to be a Constant Relative Risk Aversion (CRRA) form with a relative risk aversion parameter of σ, and the combination of composite consumption good and leisure is formed as a Cobb-Douglas function:

$$u(c, l) = \frac{(c^{1-\phi}\, l^{\phi})^{1-\sigma}}{1-\sigma}$$

where ϕ represents the relative importance of composite consumption good in utility.

The composite consumption good is assumed to be a combination of market goods and home goods. Market goods are purchased directly from the market, and home goods are produced at home instead. The composite good is assumed to be a Dixit-Stiglitz aggregation of these two goods:

$$c = g(c_m, c_h) = [\alpha c_m^{(s-1)/s} + (1-\alpha) c_h^{(s-1)/s}]^{s/(s-1)} \tag{2}$$

where c_m is market consumption good, α is the share of market consumption good in the composite good, c_h is home good which is assumed to be equal to time devoted for home production (h), and s is the elasticity of substitution between market and home consumption goods.

Agents have a time constraint in each period, which depends on the employment shock in the present period:

$$h_t + l_t + n(e) = 1 \tag{3}$$

where h_t is time spent on home production, l_t is leisure and $n(e)$ is labor supply. If an agent is unemployed, then $n(e) = 0$. If she is employed, then $n(e) = \bar{n}$, i.e. the labor supply is inelastic and provided in the extensive margin:

$$n(e) = 0 \qquad \text{if unemployed } (e = 0) \tag{4}$$

$$n(e) = \bar{n} \qquad \text{if employed } (e = 1) \tag{5}$$

Therefore, unemployed agents have looser time constraints in comparison with that of employed agents.

The asset markets are assumed to be incomplete, where agents can partially insure themselves through a storage technology (non-interest bearing asset) which evolves as follows:

$$c_{m,t} + a_{t+1} = a_t + y_t^d(e) \tag{6}$$

where $c_{m,t}$ is the consumption of market goods, and a_{t+1} is the amount of wealth carried to the next period. Disposable income (y_t^d) depends on the employment status and receipt of unemployment benefits which is explained in the next section.

4.3 Unemployment Insurance, Taxation and Disposable Income

An unemployed agent is eligible for unemployment benefits. Employed individuals are not qualified for unemployment benefits. The benefits are provided as a certain faction, θ (replacement rate), of the lost after-tax earnings. The unemployment benefits are financed through a proportional income tax, denoted by τ. These taxes are levied both from employed and unemployed individuals.[11] The unemployment benefit system, proportional taxes and the employment process lead to the following disposable income schedule for the individuals:

$$y_t^d = (1-\tau)\theta y \qquad \text{if unemployed } (e=0) \tag{7}$$

$$y_t^d = (1-\tau)y \qquad \text{if employed } (e=1) \tag{8}$$

where, e represents employment opportunity, y_t^d represents disposable income, y represents economy-wide before-tax income, and τ represents proportional tax. There is only one type of income (y) and it is normalized to 1.

4.4 Recursive Formulations

In this section, we formulate the problem of individuals in recursive form to solve for the equilibrium numerically. The state of an individual at any point in time can be summarized by his/her wealth level, a, and employment status, e. Then, we can write the recursive formulation of an individual with the current state vector (a, e) as follows:

$$V(a,e) = \max_{c,c_m,c_h,a',h,l} \{u(c,l) + \beta E_e' V(a',e')\} \tag{9}$$

[11] This is equivalent to assume taxes are only levied from employed individuals by readjusting the replacement rate θ.

subject to

$$c = g(c_m, c_h)$$

$$c_m + a' = y^d(e)$$

$$c_h = h$$

$$h + l + n(e) = 1$$

Equations 4, 5, 7 and 8

$$c \geq 0, c_m \geq 0, c_h \geq 0, a' \geq 0, h \geq 0, l \geq 0$$

where E is the expectation operator over the employment status.

4.5 Equilibrium

We define a *stationary equilibrium* as a set of a value function $v(\omega)$, decision rules for composite consumption good $c(\omega)$, market good consumption $c_m(\omega)$, home good consumption $c_h(\omega)$, wealth $a'(\omega)$, home production time $h(\omega)$, leisure $l(\omega)$, tax rate τ, and an invariant measure $\lambda(\omega)$ with $\omega \equiv (a, e) \in \Omega \equiv (A \times E)$[12] representing the state variable of the individuals such that;

- Given the tax rate τ, the decision rules (c, c_m, a', h, l) solve the individual's problem defined in equation (9), and v is the associated value function
- the government budget is balanced:

$$\sum_a \lambda(a, 0)(1 - \tau)\theta y = \sum_a \lambda(a, 1)\tau y \tag{10}$$

[12] $A \equiv [\underline{a}, \bar{a}]$ with $\underline{a}$ is the borrowing limit and $\bar{a}$ is the maximum asset. And $E \equiv \{0, 1\}$

- and the time-invariant distribution solves:

$$\lambda(\omega') = \sum_{e} \sum_{a \in \Theta} \chi(e, e')\lambda(\omega) \tag{11}$$

where $\omega' \equiv (a', e')$ and $\Theta \equiv \{a : a' = a'(a, e)\}$.

Among the equilibrium conditions, equation (10) equates the taxes collected from employed agents to the unemployment benefits paid to the unemployed agents. Equation (11) ensures that the distribution of the population is stationary.

4.6 Calibration

We calibrate the model to match U.S. data. We set a model period to six weeks which is in line with the unemployment insurance literature.[13] The employment-unemployment shocks follow a two state Markov process. We follow Hansen and İmrohoroğlu (1992) in using a transition matrix of employment opportunities with the following probabilities, which matches the average rate and duration of unemployment in the United States:

$$\begin{bmatrix} .9681 & .0319 \\ .5 & .5 \end{bmatrix}$$

With the above transition matrix, agents receive employment opportunities 94% of the time, and the average duration of time without employment opportunities is 12 weeks.

We have a constant labor supply of employed workers denoted with $\bar{n}$, which equals 0.36. This value is obtained by dividing 40 hours of working time per week by the 112

[13] Most of the studies are quarterly or six-week periods in this literature. However, there are exceptions such as Acemoglu and Shimer (2000), Shimer and Werning (2008) which use weekly periods.

Table 3: Parameters of the Benchmark Economy.

Parameter		Value
β	Time discount factor	.995
σ	Relative risk aversion	2.50
ϕ	Weight of leisure in utility	.67
$\bar{n}$	Constant labor supply	.36
θ	Benchmark unemployment benefit	.40
$\chi(0,0)$	Unemployment/employment transition	.50
$\chi(1,1)$	Employment/employment transition	.9681
s	Elasticity of substitution b/w market goods and HP	1.32
α	Share of market goods in composite good	.53

hours of total available time per week.[14]

We set the value of the discount factor parameter, β, to .995, which is standard for monthly and quarterly models. It returns a plausible value for the average wealth/income ratio of the unemployed workers in the model. Empirical studies report this ratio to be near 0. The model returns a value around 0.05.[15]

We choose a benchmark value for σ in order to have results comparable to those in the aforementioned related studies in the unemployment insurance literature. The acceptable range for σ is 1.5 to 10 in the business cycle literature, and unemployment insurance studies usually set it between 0.5 to 4.[16] In the benchmark case, we pick 2.50 for σ and present results for other values as well.

The share of consumption in the utility function is denoted with ϕ. We follow Kydland and Prescott (1991) for the benchmark value of this parameter (.33), which is standard in the business cycle literature.[17] We repeat the quantitative exercises with other values

[14]We assume 8 hours per day is spent for sleeping and exclude it from total available time.

[15]See Table 1B in Engen and Gruber (2001).

[16]For example, the value of σ is 1 in Shavell and Weiss (1979), 0.5 Hopenhayn and Nicolini (1997), 2.5 in Hansen and İmrohoroğlu (1992), 2 in Alvarez-Parra and Sanchez (2010), and 4 in Acemoglu and Shimer (2000).

[17]Also, Jacobs (2007) estimates a range of 0.37 to 0.32 for the value of ρ using the PSID data set.

of this parameter and present results in section 5.3.

The elasticity of substitution between market goods consumption, c_m, and home goods consumption, c_h, is an important parameter in the model as it emphasizes the role of home production. The share of market consumption good, which is denoted with α, in the consumption aggregator function is also determinant in time spent for home production. These two parameters are calibrated to match two targets, namely average time devoted to home production by employed and unemployed agents. According to the broad (narrow) definition, unemployed spend 30.29 (18.95) hours/week and employed spend 17.81 (10.24) hours/week for home production in data.[18,19] In the benchmark model we target the moments using the narrow definition for the sake of being conservative in estimating the role of home production. The model is able to generate exactly the same moments using .53 for α and 1.32 for e.[20] We also performed a sensitivity check using a narrower definition of home production which excludes time spent for child care and adult care. The results are presented in Section 5.3.

To have a benchmark model, we need to choose a value for the average replacement rate (θ). There are empirical studies on the average replacement rate in the United States. Gruber (1997) finds an average replacement rate of about 40%. Clark and Summers (1982) estimate an average replacement rate of around 65%. We set benchmark value of θ to .40, because replacement rates have decreased over time in the United States, and Gruber's work provides a more up-to-date estimate. The benchmark model parameters are reported in Table 3.

[18]We use American Time Use Survey to calculate average time spent on home production by unemployed. See Section 3 for details.

[19]In the benchmark model, we target the full-time employed's time spent for home production because we do not have partial employment in our model. See Table 1 for details.

[20]In their benchmark cases, Canova and Ubide (1998) and Benhabib et al. (1991) use 5 for the value of e, Greenwood et al.(1991) and Parente et al. (2000) use 3 and 2.5 correspondingly. Since there is no consensus on the value of this parameter, usually any value between 1 and ∞ (perfect substitution case) is considered acceptable.

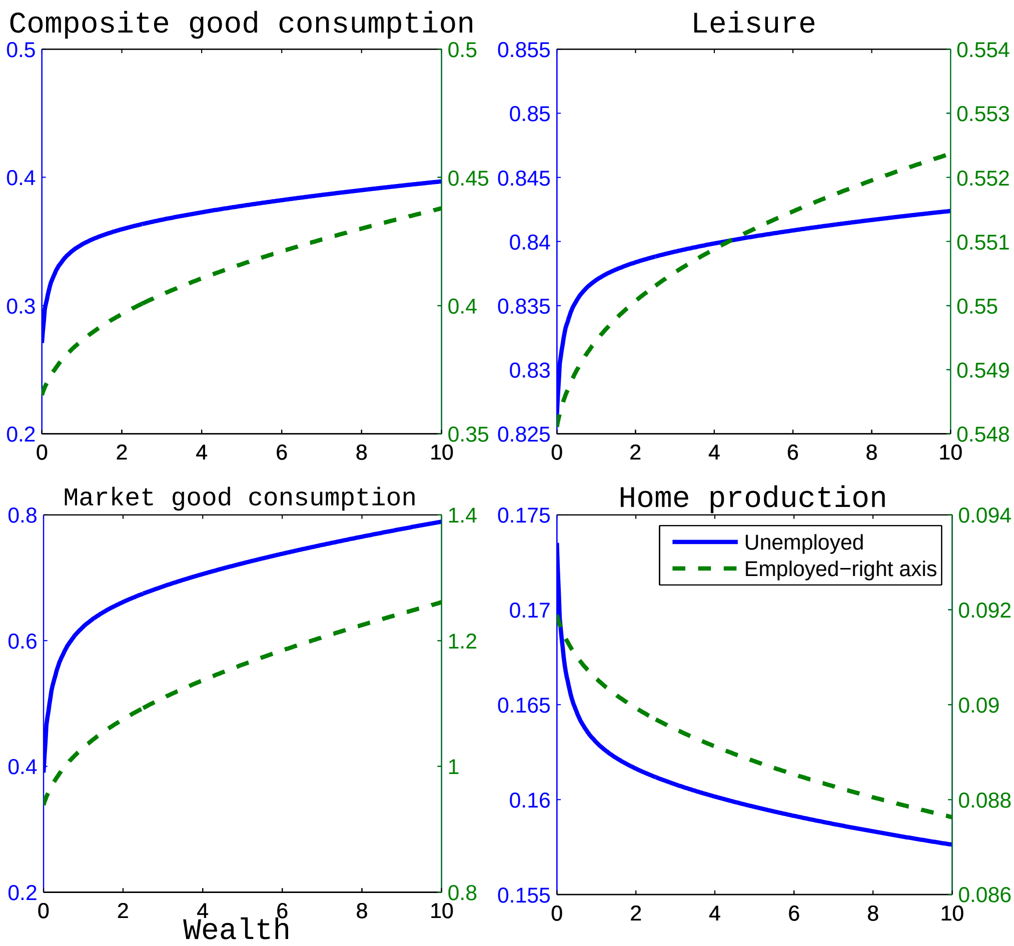

Figure 1: Decision rules.

5 Quantitative Results

We solve the model computationally and find the optimal rate of unemployment insurance in several cases. In the quantitative exercises, we aim to find the role of home production in determining the optimal rate of unemployment insurance. In doing so, we solve the model twice: once with home production and once with no home production.

In general, our results imply that optimal unemployment insurance levels are smaller when we allow for self-insurance through home production. In the following subsections, we quantify the role of home production in determining the optimal unemployment

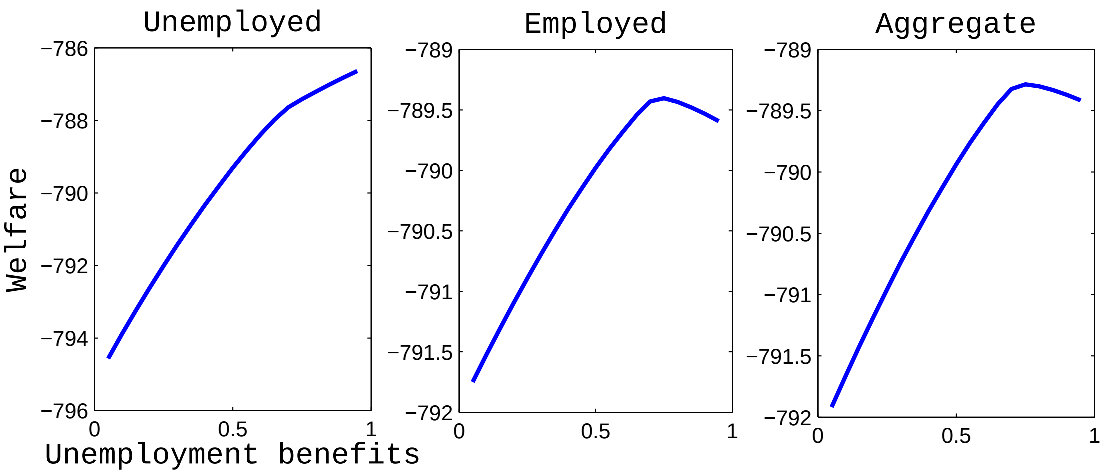

Figure 2: Unemployment benefits versus aggregate welfare: no home production case.

insurance policy using various parameter values.

5.1 An Illustration

We use the benchmark economy as an example to illustrate the behavior of agents. Figure 1 shows the equilibrium home production decision rule of agents. Both employed and unemployed agents decrease the amount of home production as their wealth increase. Agents want to increase the consumption of both leisure and composite good as a result of an increase in wealth since both are normal goods (Figure 1). On the one hand, an increase in leisure (l) implies a decrease in home production (h). On the other hand an increase in composite good requires an increase in market goods and/or home goods. Increasing consumption of home goods requires a decrease in leisure, therefore it is more costly in comparison with that of market good. Combining this additional cost with the substitutability between market goods and home goods in the benchmark model ($e = 2.11$, Table 1) lead agents to substitute towards market goods and decrease home production (Figure 1) in response to an increase in wealth.[21]

[21]See Guler and Taskin (2013) for a theoretical discussion on the correlation between wealth and home production.

5.2 Optimal Rate of Unemployment Insurance

In this subsection, we aim to quantify the role of home production in determining the optimal rate of unemployment insurance. In order to do that, we solve the model twice: once with no home production and once with home production.

No-home production case

In this case, where agents are not allowed to do home production, composite good is assumed to be equal to the consumption of market goods. Using the benchmark parameterization, the optimal rate of unemployment insurance is computed as 74% of lost earnings in this case (Figure 2).

In order to explore the dynamics behind the optimal rate of unemployment insurance, we analyze the impact of marginal increments in unemployment benefits on the welfare of employed and unemployed separately.

An increase in unemployment benefits always improves the welfare of unemployed due to additional income at unemployment spells providing better consumption smoothing (Figures 2,3).

Welfare of employed agents illustrates a hump-shape figure with respect to unemployment benefits. It increases up to a threshold level, and decreases after then. On the one hand, incremental unemployment benefits increase the welfare of employed through their continuation value (welfare of unemployed). On the other hand, it reduces welfare of employed because benefits are funded through income tax. The first effect dominates up to the threshold and the second one dominates after then. This is reflected as a hump-shape in Figure 2 (welfare of employed). Saving behavior of agents also determinant in this threshold because marginal benefit of incremental unemployment insurance depends on savings which is an additional insurance channel. When agents save sufficiently high,

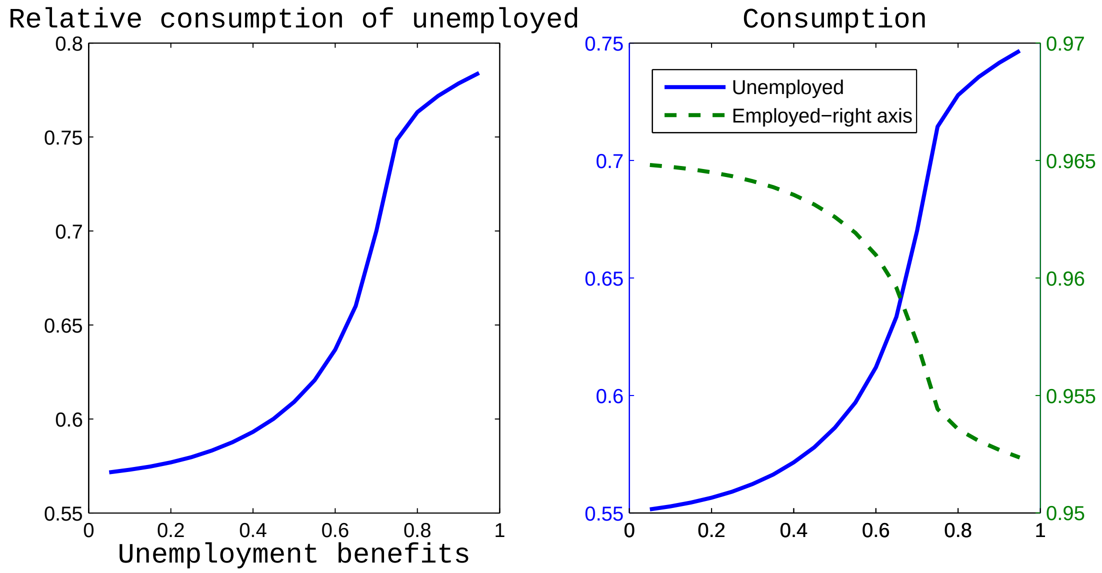

Figure 3: Unemployment benefits versus consumption: no home production case.

the improvement through continuation value declines and first effect dominates (Figure 4)[22]

Home production case

In this case, we let agents to do home production as well as market production in the model economy. Therefore, composite good is assumed to be a combination of home production and market goods in this case. The optimal rate of unemployment insurance is found to be 63% of lost earnings when we use benchmark parameters (Figure 5).

The difference between the two cases relies on the additional insurance channel through home production. This is reflected as a significant improvement in relative consumption of unemployed in the case of home production (Figure 3,6).

[22] Saving behavior of agents illustrate an interesting pattern when replacement rate is higher than 70%. In this case, unemployed agents save more than employed. This happens due to the fact that composite consumption is a combination of leisure and consumption good. When replacement rate is high, consumption good is very well insured against unemployment shocks for employed agents. Therefore, the gap between employed and unemployed agents' consumption is small in this case. However, for an unemployed agent, the risk of reduced leisure is not covered against an employment shock. As a result, unemployed agent saves more than employed in order to smooth the composite consumption between

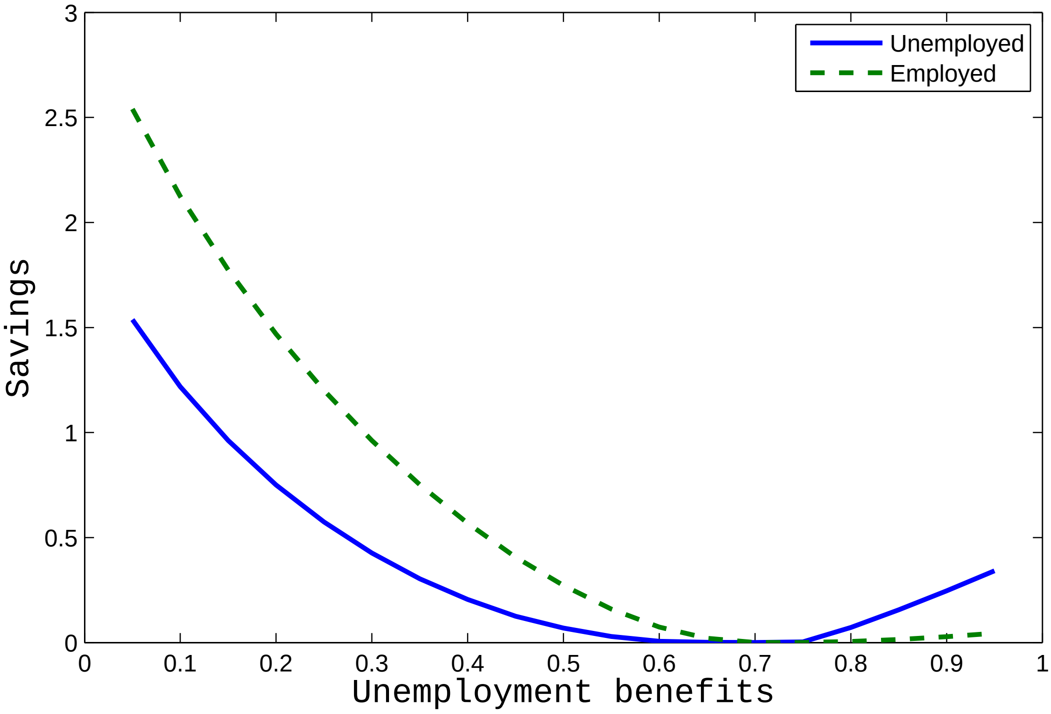

Figure 4: Unemployment benefits versus saving: no home production case.

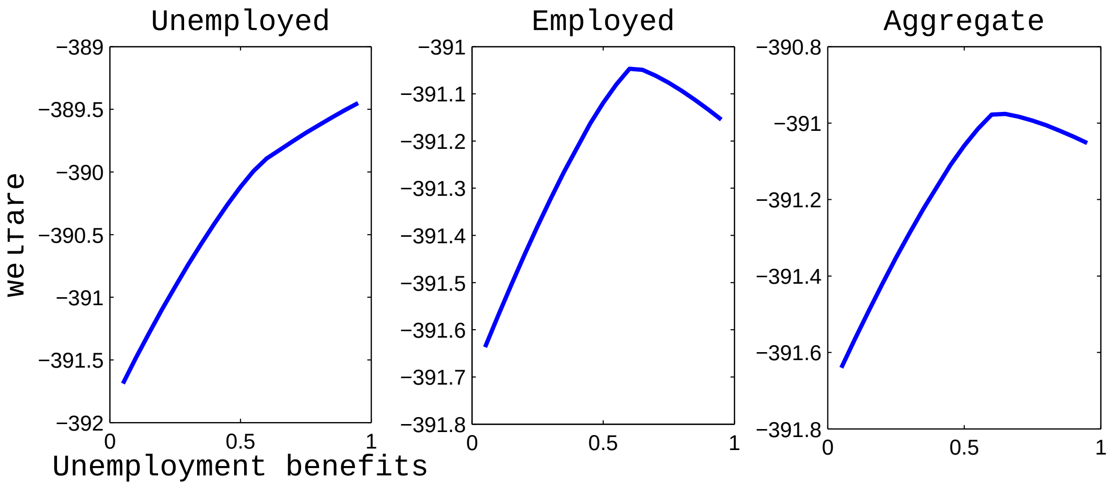

Figure 5: Unemployment benefits versus welfare: home production case.

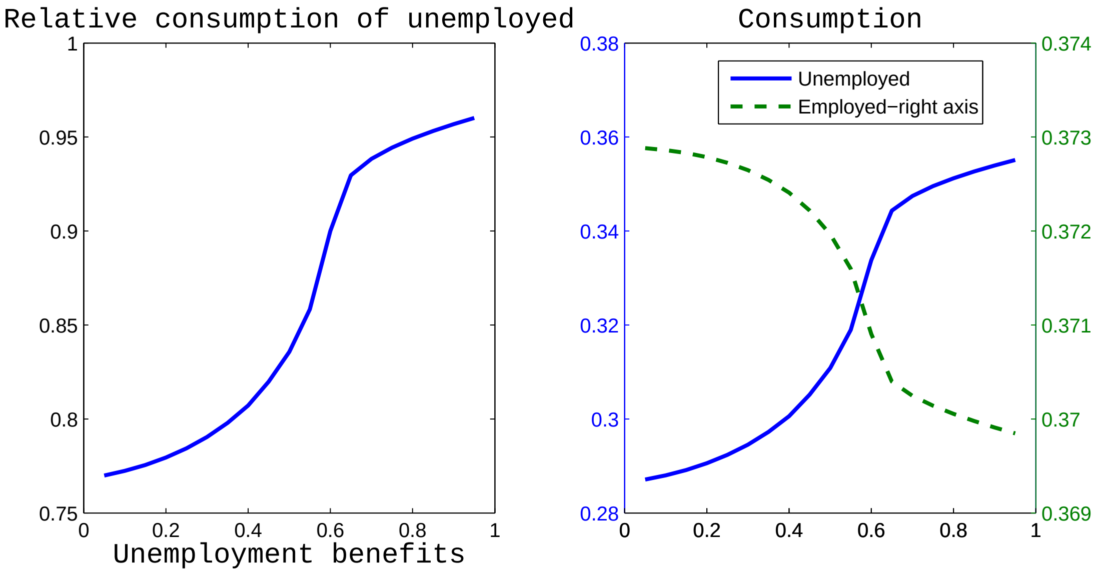

Figure 6: Unemployment benefits versus relative consumption of unemployed: home production case.

The mechanism in no-home production case works in this case as well. In particular, an increase in unemployment benefits always improves the welfare of unemployed due to additional income at unemployment spells providing better consumption smoothing (Figure 5).

Congruous to the no-home production case, welfare of employed agents increases up to a threshold level, and decreases after then. On the one hand, incremental unemployment benefits increase the welfare of employed through their continuation value (welfare of unemployed). On the other hand, it reduces welfare of employed because benefits are funded through income tax. The first effect dominates up to the threshold and the second one dominates after then. However, in this case, home production provides an additional insurance channel, as well as savings, and this additional insurance channel further decreases the marginal benefit through continuation value of employed agents. Eventually, the threshold level of unemployment benefits ends up with a lower value in home-production case. Similar to the case of no-home production, average savings are

the two states.

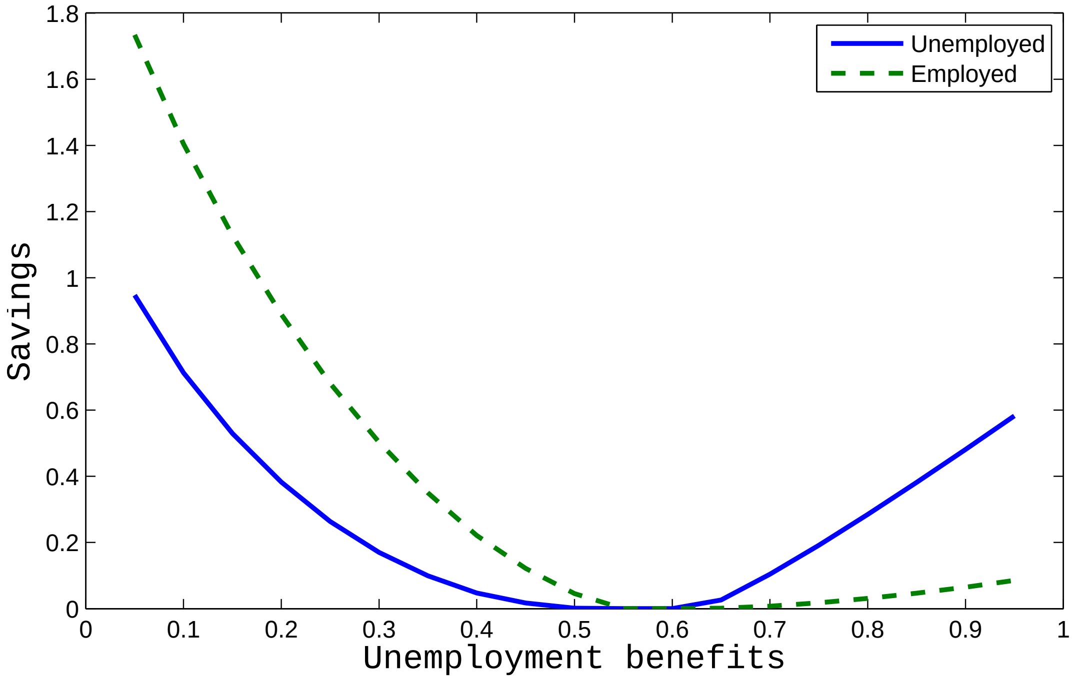

Figure 7: Unemployment benefits versus saving: home production case.

responsive to the amount of unemployment benefits. This is affecting the optimal rate of unemployment insurance because savings provide an additional insurance channel for agents (Figure 7).

The relative consumption of unemployed in home production case is significantly higher than that of no-home production case (Figure 3,6). The underlying mechanism relies on the response of market good consumption and home production to the increments in unemployment benefits. As discussed in Section 5.1, agents are supposed to increase their market good consumption and decrease their home production in response to an increase in their disposable income. An increase in unemployment benefits increases the disposable income of unemployed and decreases that of employed due to the fact that increased unemployment benefits require higher income taxes. As an immediate consequence, unemployed increase their market good consumption and decrease their home production, and employed do the opposite when unemployment benefits are

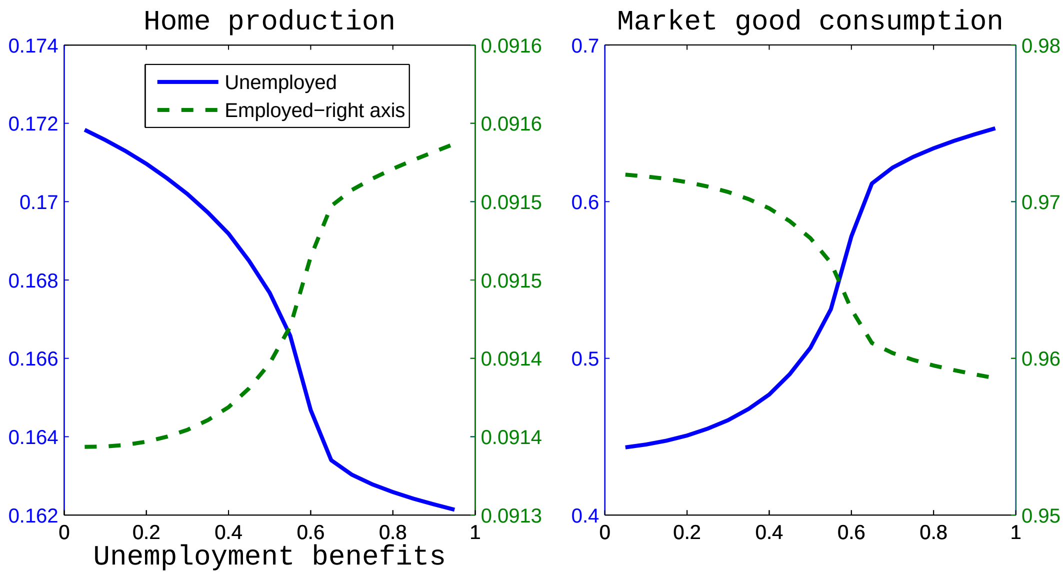

Figure 8: Unemployment benefits versus home production and market good consumption.

increased (Figure 8).

As a consequence of the underlying additional insurance channel through home production, the optimal rate of unemployment insurance is found to be significantly smaller (63%) in comparison with the case where we close this channel (74%). In the next section, we repeat the quantitative exercises with a variety of parameters to check robustness of this result.

5.3 Sensitivity Checks

In this section, we repeat the quantitative experiment with various values of parameters σ and ϕ. We keep the rest of the parameters at their benchmark value except α and e which determine the average time spent for home production. For each value of σ and ϕ, we recalibrate α and e to match unemployed and employed agents' average time devoted for home production. Moreover, we repeated the quantitative exercises with targeting two broader definitions of home production and present the results in Table 4.

Table 4: Sensitivity Checks

	Risk aversion (σ)					Value of leisure (ϕ)						Home production		
	1.5	2	2.5	3	4	.20	.25	.33	.40	.50	.60	HP1	HP2	HP3
θ, HP	.79	.69	.63	.57	.50	.31	.50	.63	.70	.78	.83	.63	.57	.47
θ, no HP	.88	.81	.74	.70	.64	.66	.71	.74	.78	.83	.87	.74	.74	.74
Dif.	.09	.12	.11	.13	.14	.35	.21	.11	.08	.05	.05	.11	.17	.27

Notes: This table shows the summary of our sensitivity checks. HP1 and HP3 denote the narrow and broad definition of home production, respectively. HP2 is the average of the two.

Relative risk aversion

The relative risk aversion parameter affects the decisions of agents in both home production and no home production economies. Optimal θ changes significantly with respect to σ in both economies. The mechanism works through savings. In both economies, agents save more to smooth their consumption as they get more risk averse. Therefore unemployment benefits become less necessary in comparison with the lower risk aversion case. As expected, optimal θ falls in both cases. However, the difference between the two cases is robust, as home production always provides an additional insurance channel in the second economy (Table 4).

The value of leisure

The value of leisure is an important parameter in both economies because it affect the relative value of consumption and the opportunity cost of home production. For smaller values of ϕ, the importance of leisure in utility increase, and that of consumption decrease. Recall that unemployment benefit is valuable for agents because it provides consumption smoothing. Therefore, as we decrease ϕ, the role of unemployment insurance decreases in both economies. As a consequence, the optimal θ declines in both economies. Again, the difference in optimal θ between the two economies is robust due to the additional insurance through home production (Table 4).

Time spent for home production

In this section, we calculate the optimal rate of unemployment insurance using two broader definitions of home production. First, we include the time spent for child care and adult care to the definition of home production. This definition results in 30.29 hours/week for unemployed and 17.81 hours/week for employed. The optimal rate of unemployment insurance decreases to 47% in this case. We also take the average of the two definitions which results in 24.62 hours/week for unemployed and 14.03 hours/week for employed. The optimal rate of unemployment insurance is computed as 57% in this case. The rate of optimal unemployment insurance decreases as the average time spent for home production increases due to the fact that the increase in home production improves the amount of self-insurance through home production. The improvement in self-insurance eventually leaves less room for public insurance through unemployment benefits.

6 Conclusion

In this paper, we perform a quantitative analysis of optimal unemployment insurance, where we incorporate self-insurance through home production and savings. Depending on the definition of home production, we find that the optimal replacement rate is between 47% and 63% of wages, which is 11 to 27 percentage points lower than the no home production model's optimal replacement rate of 74%. The presence of home production decreases the optimal replacement rate, and this result is robust under various parameterizations. The reason behind this result is the nature of the unemployment shock. During unemployment spells, individuals have tighter constraints while purchasing market goods and services and looser time constraints, and they respond by increasing their home production against unemployment shocks. Since consumption is a function of home goods and market goods, in the presence of home production, unemployed individuals enjoy smoother consumption levels in comparison with the no-home production case. Eventually, that lowers the optimal replacement rate significantly.

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Table 5: Optimal rate of unemployment insurance

θ	τ	$\bar{v}$	$\bar{v}_u$	$\bar{v}_e$	$\bar{a}$	$\bar{a}_u$	$\bar{a}_e$	$\bar{c}$	$\bar{c}_u$	$\bar{c}_e$
0.05	0.003	-3099.97	-3110.33	-3099.31	2.48	1.54	2.54	0.94	0.552	0.965
0.10	0.006	-3098.99	-3107.68	-3098.44	2.07	1.22	2.12	0.94	0.553	0.965
0.15	0.009	-3098.04	-3105.14	-3097.58	1.72	0.96	1.77	0.94	0.554	0.965
0.20	0.013	-3097.12	-3102.70	-3096.76	1.42	0.75	1.47	0.94	0.557	0.964
0.25	0.016	-3096.21	-3100.33	-3095.95	1.16	0.57	1.20	0.94	0.559	0.964
0.30	0.019	-3095.35	-3098.05	-3095.18	0.93	0.43	0.96	0.94	0.562	0.964
0.35	0.022	-3094.53	-3095.87	-3094.44	0.72	0.30	0.75	0.94	0.566	0.964
0.40	0.025	-3093.71	-3093.73	-3093.71	0.55	0.20	0.57	0.94	0.572	0.964
0.45	0.028	-3092.97	-3091.73	-3093.05	0.39	0.12	0.41	0.94	0.578	0.963
0.50	0.031	-3092.22	-3089.76	-3092.38	0.26	0.07	0.27	0.94	0.587	0.963
0.55	0.034	-3091.56	-3087.94	-3091.79	0.15	0.03	0.16	0.94	0.597	0.962
0.60	0.037	-3090.91	-3086.19	-3091.21	0.07	0.01	0.07	0.94	0.612	0.961
0.65	0.040	-3090.32	-3084.60	-3090.68	0.02	0.00	0.02	0.94	0.633	0.960
0.70	0.043	-3089.82	-3083.25	-3090.23	0.00	0.00	0.00	0.94	0.670	0.957
0.75	0.046	-3089.66	-3082.37	-3090.13	0.00	0.00	0.00	0.94	0.714	0.954
0.80	0.049	-3089.74	-3081.56	-3090.26	0.01	0.07	0.00	0.94	0.728	0.954
0.85	0.051	-3089.86	-3080.78	-3090.44	0.02	0.15	0.01	0.94	0.736	0.953
0.90	0.054	-3090.01	-3080.03	-3090.65	0.04	0.25	0.03	0.94	0.742	0.953
0.95	0.057	-3090.19	-3079.32	-3090.88	0.06	0.34	0.04	0.94	0.747	0.952

Notes: This table shows the summary of our quantitative results on the optimal unemployment insurance policy: no-home production case. The notations θ, τ, v, a, and c represent replacement rate, tax rate, welfare, saving, and consumption respectively. The subscripts u, and e represent unemployed and employed respectively. Lastly, $\bar{x}$ represents the mean of x.

7 Tables

Table 6: Optimal rate of unemployment insurance: home production case

θ	τ	$\bar{v}$	$\bar{v}_u$	$\bar{v}_e$	$\bar{h}$	$\bar{h}_u$	$\bar{h}_e$
0.05	0.003	-391.64	-391.69	-391.64	0.0962	0.172	0.0914
0.1	0.006	-391.56	-391.48	-391.57	0.0962	0.172	0.0914
0.15	0.009	-391.49	-391.29	-391.50	0.0962	0.171	0.0914
0.2	0.013	-391.42	-391.10	-391.44	0.0962	0.171	0.0914
0.25	0.016	-391.35	-390.92	-391.38	0.0962	0.171	0.0914
0.3	0.019	-391.29	-390.74	-391.32	0.0961	0.170	0.0914
0.35	0.022	-391.22	-390.57	-391.27	0.0961	0.170	0.0914
0.4	0.025	-391.17	-390.41	-391.21	0.0961	0.169	0.0914
0.45	0.028	-391.11	-390.26	-391.16	0.0961	0.168	0.0914
0.5	0.031	-391.06	-390.12	-391.12	0.0960	0.168	0.0914
0.55	0.034	-391.01	-389.99	-391.08	0.0960	0.167	0.0915
0.6	0.037	-390.98	-389.89	-391.05	0.0959	0.165	0.0915
0.65	0.040	-390.98	-389.82	-391.05	0.0959	0.163	0.0915
0.7	0.043	-390.98	-389.76	-391.06	0.0958	0.163	0.0916
0.75	0.046	-390.99	-389.69	-391.08	0.0958	0.163	0.0916
0.8	0.049	-391.01	-389.63	-391.09	0.0958	0.163	0.0916
0.85	0.051	-391.02	-389.56	-391.11	0.0958	0.162	0.0916
0.9	0.054	-391.04	-389.51	-391.13	0.0958	0.162	0.0916
0.95	0.057	-391.05	-389.45	-391.15	0.0958	0.162	0.0916

θ	$\bar{a}$	$\bar{a}_u$	$\bar{a}_e$	$\bar{c_m}$	$\bar{c_{mu}}$	$\bar{c_{me}}$	$\bar{c}$	$\bar{c}_u$	$\bar{c}_e$
0.05	1.69	0.95	1.73	0.94	0.44	0.97	0.368	0.29	0.373
0.1	1.36	0.71	1.40	0.94	0.44	0.97	0.368	0.29	0.373
0.15	1.09	0.53	1.13	0.94	0.45	0.97	0.368	0.29	0.373
0.2	0.86	0.38	0.89	0.94	0.45	0.97	0.368	0.29	0.373
0.25	0.66	0.26	0.68	0.94	0.46	0.97	0.368	0.29	0.373
0.3	0.48	0.17	0.50	0.94	0.46	0.97	0.368	0.29	0.373
0.35	0.34	0.10	0.35	0.94	0.47	0.97	0.368	0.30	0.373
0.4	0.21	0.05	0.22	0.94	0.48	0.97	0.368	0.30	0.372
0.45	0.12	0.02	0.12	0.94	0.49	0.97	0.368	0.31	0.372
0.5	0.04	0.00	0.05	0.94	0.51	0.97	0.368	0.31	0.372
0.55	0.00	0.00	0.00	0.94	0.53	0.97	0.368	0.32	0.372
0.6	0.00	0.00	0.00	0.94	0.58	0.96	0.369	0.33	0.371
0.65	0.00	0.03	0.00	0.94	0.61	0.96	0.369	0.34	0.370
0.7	0.01	0.10	0.01	0.94	0.62	0.96	0.369	0.35	0.370
0.75	0.03	0.19	0.02	0.94	0.63	0.96	0.369	0.35	0.370
0.8	0.05	0.28	0.03	0.94	0.63	0.96	0.369	0.35	0.370
0.85	0.07	0.38	0.05	0.94	0.64	0.96	0.369	0.35	0.370
0.9	0.09	0.48	0.06	0.94	0.64	0.96	0.369	0.35	0.370
0.95	0.12	0.58	0.09	0.94	0.65	0.96	0.369	0.36	0.370

Notes: This table shows the summary of our quantitative results on the optimal unemployment insurance policy: home production case. The notations θ, τ, v, h, a, c_m, and c represent replacement rate, tax rate, welfare, home production, saving, market good consumption, and composite good consumption respectively. The subscripts u, and e represent unemployed and employed respectively. Lastly, $\bar{x}$ represents the mean of x.