Public insurance of married versus single households in the US: trends and welfare consequences*

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Abstract

Using the March Current Population Survey, I show that over the last two decades, married households in the United States received increasingly more public insurance against labor income risk, whereas the opposite was true for single households. To evaluate the welfare consequences of this trend, I perform a quantitative analysis. As a novel contribution, I expand the standard incomplete markets model à la Aiyagari (1994) to include two groups of households: married and single. The model allows for changes in the marital status of households and accounts for transition dynamics between steady states. I show that the divergent trends in public insurance have a significant detrimental effect on the welfare of both married and single households. Higher public insurance crowds out the private savings of married households, thus decreasing their mean wealth. In the long run, lower wealth decreases mean consumption for married households, driving the decline in their welfare. For singles, transition dynamics play a major role. Although in response to lower public insurance they save more and can afford higher mean consumption in the new steady state, the welfare loss from lower initial consumption after the policy change offsets this welfare gain.

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1 Introduction

In the US, income tax and transfer laws are conditional on the marital status of individuals. This conditionality is due to several reasons. It reflects the preference of the policy makers who want to maintain a balance in the tax treatment of families with different marital status, CBO (1997). Also, some policy makers use tax laws to promote the institution of marriage. For example, one out of four goals of the Temporary Aid to Needy Families (1996) program was to "encourage the formation and maintenance of two-parent families", Kominos (2006)[1]. Furthermore, these tax and transfer policies change over time due to the introduction of new laws. As an example, Table 1 reports the number of income tax bills, in which marital status plays an important role, referred and enacted in the US Senate in the last four (111^{th}-114^{th}) Congress sessions. It shows that in just four sessions only, Congress enacted 18 income tax bills which are conditional on marital status. As tax and transfer policies provide public insurance against labor income risk, their conditionality on marital status and change over time can induce different levels and trends of public insurance received by married and single households. This paper asks two questions: first, is the evolution of public insurance against idiosyncratic labor income risk significantly different for married and single households in the US? If the answer is yes, then what are the quantitative implications for the insurance[2] and welfare of married and single households?

The contribution of this paper is twofold: empirical and quantitative. As an empirical contribution, using the March Current Population Survey dataset, I report how public insurance against labor income risk has changed over time for married and single households. Public insurance is defined as one minus the ratio of after-tax and transfer labor income risk over before-tax and transfer labor income risk. More reduction in after-tax and transfer labor income risk increases public insurance. I show that smoothed trends in public insurance are monotonic over time and married households benefited relative to single households. Over the sample period 1992-2015, married households experienced a 19 percent increase in public insurance whereas single households experienced a 13 percent decrease.

Given this empirical fact, I explore whether this *relative* change in public insurance has significant implications for risk sharing and welfare in the economy. To answer this question, as a quantitative contribution, I expand the standard incomplete markets (SIM) model á la Aiyagari

[1] Temporary Aid to Needy Families was a block grant system under the aegis of the Personal Responsibility and Work Reconciliation Act, 1996.

[2] Insurance in this paper refers to consumption insurance against idiosyncratic labor income risk. Furthermore, insurance and risk sharing are synonymous and will be used interchangeably.

Table 1: Number of income tax bills, conditional on marital status, referred and enacted by US Senate during the last four (111^{th}-114^{th}) Congress sessions.

Purpose of the bill	**Referred**	**Enacted**
Income tax credits	225	6
Income tax deduction	111	2
Tax treatment of families	39	2
Income tax rates	81	6
State and local taxation	18	2

Notes: The source of this data is https://www.govtrack.us/

(1994) to include two groups of households: married and single. The transition between married and single is allowed, and is determined by an exogenous probability. The market is assumed to be exogenously incomplete. Due to market incompleteness, households have a precautionary motive to save, and they do so by using a risk-free non-state-contingent bond. This precautionary saving determines private insurance. Another type of insurance in the model economy is public insurance provided by the government through progressive taxation of labor income. As public insurance affects after-tax and transfer income risk, it also effects the precautionary motive to save, and by extension the amount of savings in the economy. The response of the precautionary motive to save to changes in public insurance will determine the welfare effects, as explained below.

I calibrate the model to the US data. For this I follow the method proposed by Castañeda et al. (2003) which allows me to match the wealth distribution in the US almost perfectly. After calibrating the model I implement the changes in public insurance as found in the data: an increase for married households and a decrease for singles. As there is a one-to-one mapping between public insurance and tax progressivity in the model, an increase (decrease) in public insurance implies an increase (decrease) in tax progressivity for married (single) households. The central result of the paper is that higher public insurance for married households leads to better total insurance but lower welfare for them, whether transition between steady states is taken into account or not. Hence, the model suggests that tax and transfer policies that are supposed to benefit married households can actually deteriorate their welfare. For single households, their total insurance and welfare decrease.

The key to understanding why the increase in total insurance for married households does not translate into higher welfare, lies in the heterogeneous saving response of married and single households. For a moment, consider the changes in total insurance only. When public insurance increases for married households, their precautionary motive to save decreases, leading to a reduction in their savings. This translates into lower private insurance for married households. In other words, public insurance crowds out private insurance. However, as shown by Krueger and Perri (2011) in the framework of the standard incomplete markets model, public insurance compensates more than a one for one decrease in private insurance. In this model also, I observe that total insurance increases for married households. The opposite happens with singles: in response to lower public insurance they save more and experience higher private insurance but lower total insurance.

The heterogeneous saving response also explains the welfare results. The measure of welfare adopted in this paper is the utilitarian welfare. It allows to evaluate the welfare effects of the relative change in public insurance by comparing two economies: one without any change in public insurance and another where married households experience a relative increase in public insurance. This welfare measure gives the percentage change in consumption in the economy without any changes in public insurance which would allow to achieve the same expected utility as observed in the economy where public insurance changes. I find that the change in welfare of married households is -0.4 percent if the transition is not taken into account, and -0.08 percent if the transition between steady states is taken into account. Following Koehne and Kuhn (2015), the welfare metric can be decomposed into (i) an inequality effect [0.2], (ii) an uncertainty effect [-0.16], (iii) a level effect [-0.43] and (iv) a transition effect [0.30]. These effects come into the picture because the decrease in savings and the relative increase in public insurance affects inequality, uncertainty and mean consumption for married households. As public insurance increases, the ex-ante inequality decreases due to better redistribution. Hence, the inequality effect for married households is positive. However, higher public insurance does not reduce consumption uncertainty as much as it would if private savings remained constant. As private savings of married households decrease, consumption uncertainty does not decrease significantly, which yields the negative uncertainty effect. Furthermore, due to the decrease in savings, long-term mean consumption of married households decreases, and this is captured by the negative level effect. The transition effect is strongly positive because, as married households start to dis-save in response to the relative increase in public insurance, they substitute it by more consumption initially. This increase in consumption slowly decreases towards the low-level of consumption in the long run. However, taking the whole transition path into account implies that the initial increase in consumption matters more (due to the discounting of future consumption), making the transition effect positive. In total, the level effect dominates, leading to a decline in the welfare of married households. The opposite logic applies to the change in welfare for single households. When the transition is not taken into account, their welfare effect is 0.46 percent. However, taking transition into account reverses the result: welfare declines by -0.21 percent which again can be decomposed into the inequality effect (-0.28), the uncertainty effect (0.02), the level effect (0.73) and the transition effect (-0.67). One important point to notice here is that the importance of the transition effect differs for the two groups. For married households, the transition effect counteracts the level effect by less as compared to the case of single households.

Having two groups of agents is the assumption that allows for the counter-intuitive welfare results for married households. Providing more public insurance cannot lead to a decrease in welfare in the standard incomplete markets model (Aiyagari (1994)). In that model, a tax and transfer policy change in the standard incomplete markets model applies to all individuals. To understand why these two models offer different predictions for welfare in response to the change in public insurance, consider an economy composed only of married households. When these households experience an increase in public insurance, they decrease their savings. The interest rate increases to clear the market. Hence, the elasticity of the interest rate with respect to the public insurance against the labor income risk is high. As capital income of an individual is the product of the interest rate and savings, the decrease in savings is, to some extent, compensated by the significant increase in the interest rate. Furthermore, the decrease in the interest rate implies a higher wage rate and hence higher labor income. Lower capital income and higher labor income almost offset each other leading to minor changes in mean consumption. Thus the level effect in the standard incomplete markets model is weaker and is dominated by the positive transition effect. In the model presented in this paper, when married households decrease their savings in response to the increase in public insurance, the interest rate does not respond as much as in the standard incomplete markets model. This is because the decrease in savings by married households is counteracted by the increase in savings by singles, leading to the low elasticity of the interest rate. As a consequence, the capital income of married households declines significantly. Also, as the interest rate does not respond too much, this implies an almost stagnant wage rate. This means that married households experience a significant decline in their capital income but almost no change in their labor income. The opposite happens with singles. In short, in the standard incomplete markets model, aggregate variables are more responsive to the change in public insurance. However, in the model presented in this paper, aggregate variables are almost mute with respect to the relative change in public insurance. This difference explains the difference in the welfare results between the standard incomplete markets model and this model.

The last section of the paper shows that the results are qualitatively robust with respect to the calibration methods. Although the calibration method of Castañeda et al. (2003) allows the model to match the wealth distribution, it fails in matching consumption insurance as is found in the data. To make sure that the welfare results are not very sensitive to the calibration method, in Section 6 I implement the calibration method proposed by Krueger and Perri (2006), Broer (2013) in which the model matches the consumption insurance moments very well. Qualitatively, welfare results remain robust to calibration exercises although their magnitudes change.

Related Literature: The idea that taxes can provide insurance has been studied extensively in the macroeconomics literature. Diamond and Mirrlees (1978) derive the optimal policy for insurance against the earnings-ability risk. Varian (1980) assumes that observed income inequality in a society is solely due to the income shocks an individual receives. He derives the optimal re-distributive tax policy based on the trade off between the benefit from providing public insurance and the cost from reduced incentives. Eaton and Rosen (1980) show how re-distributive taxes can provide insurance to individuals who have imperfect information at the time when they choose their labor supply. However these papers left one question on the table: whether public insurance through progressive taxation improves the total insurance or not? Recently Krueger and Perri (2011) provided the results which show that the answer to this question depends upon the underlying frictions due to which markets are incomplete. If market is incomplete for exogenous reasons as in Aiyagari (1994), public insurance crowds out private insurance. However, this crowding out is more than one for one, hence total insurance in the economy increases. Furthermore, this is also welfare improving. Hence improved welfare and total insurance go hand in hand. The most important contribution of this paper is that it shows how relative changes in tax progressivity, where different groups in an economy face different tax progressivity over time, can result in improved total insurance at the cost of reduced welfare.

The method adopted in this paper, evaluating tax and transfers policies by employing dynamic macroeconomic model with heterogeneity, is based on the work by Aiyagari (1995), Ventura (1999), Nishiyama and Smetters (2005), Conesa et al. (2009), Mitman (2016), and among others. The paper which comes closest in the spirit and method adopted in this paper is Guner et al. (2012): it focuses on the effect of the US tax reforms on the labor supply of married and single households. It shows that marital status plays an important role in the determination of extensive margin of labor supply in response to tax reforms.

Note that, although this paper distinguishes individuals and their tax progressivity by marital status, the insight provided by this paper is very general. For example, progressivity of taxes can also be conditional on age of individuals, Heathcote et al. (2014). Hence if different age individuals experience different public insurance/tax progressivity over time this also can lead to reduction in welfare due to heterogeneous response in savings.

The outline of the paper is as follows: Section 2 explains and reports the empirical results related to labor income tax progressivity. Section 3 expands the Aiyagari (1994) model by including two groups of households: married and single. Section 4 describes different calibration methods. Section 5 reports the results when model is calibrated according to Castañeda et al. (2003) method, whereas section 6 reports the results when model is calibrated according to Tauchen (1986) method. Section 7 concludes the paper.

2 Data

I use March Current Population Survey[3] (CPS henceforth) to report the changes in public insurance results. The CPS is the monthly survey of the US households conducted together by the US Census Bureau and Bureau of Labor Statistics. It is the primary source of information regarding the labor force, employment, unemployment and demographic characteristics of the US population. I focus on Annual Social and Economic (ASEC) Supplement which refers to the sample surveyed in March and is known as March CPS. This supplement extends the usual question of other month surveys to include questions on income, taxes, cash and non-cash benefits, migration and work experience[4].

Sample Selection: The sample is restricted to a 24 year period, 1992-2015. I intend to focus on the labor income before and after-tax and transfer at the family level. However, in CPS the basic unit of observation is a housing unit and not the family unit[5]. To overcome this problem, I drop those households in which more than one family is living, making the household and the family unit same. As the focus is on the labor income, the households in which the head's labor income

[3] I use the harmonized micro dataset provided by Integrated Public Use Microdata Series for CPS (IPUMS-CPS, Flood et al. (2015).

[4] Due to the timing of the survey design, the data on employment and income refer to the preceding year whereas the demographic data refer to the year of survey.

[5] In the technical language of CPS, a household is different from the family. A household is a group of persons, related or unrelated living together in a dwelling unit. The family is the group of persons who are related by blood, marriage or adoption and are living together.

is not the main source of income are dropped. Furthermore, the households in which head is below (above) 25 (65) years of age, head is not working full time or worked less than 30 hours per week in last year are dropped. Also to construct the homogeneous dataset, households which are below the poverty line, or have the negative before-tax labor income are also dropped. This procedure gives the sample of 686,423 households in which 242,296 households are single households, and 444,127 households are married with a spouse present. Next, I define the measure of labor income, taxes and transfers taken in this paper.

Measure of labor income: The labor income of the household is the sum of wages and salaries of the head (and spouse if present and working) and the fixed fraction of self-employment farm and non-farm income. The value of fixed fraction is taken from Diáz-Giménez et al. (1997) and set equal to 0.864.

Measure of taxes: There are three types of taxes taken into consideration: federal taxes, state taxes and social security payroll taxes collected under the Federal Insurance Contributions Act (FICA). Note that these numbers are not collected from the survey respondents, as in the harmonized data provided by IPUMS, the amount of taxes were not determined by the direct questioning of respondents. On the contrary, these numbers are generated by the Census Bureau's tax model.

Measure of transfers: The measure of transfers is the sum of child tax credit, additional child tax credit, the dollar value of food stamps and income from (supplemental) social security, welfare, unemployment, retirement and worker compensations. Furthermore, depending upon the status of individual, income from veteran or survivor or disability benefits is added.

All nominal amounts are corrected by adult equivalence scale (Dalaker and Naifeh (1998)) and consumer price index corresponding to the year 1999. It is important to mention here that I follow the path of Krueger and Perri (2006) and use adult equivalence scales and not the method proposed by Aguiar and Hurst (2013). This is because of two reasons. First, Aguiar and Hurst (2013) are concerned with the life-cycle profile of consumption, implying that the age and family size are correlated. As the model presented here is an infinite horizon model, the concern of Aguiar and Hurst (2013) is not of much importance. Second, choice of family size control has more implications for the consumption as compared to the labor income.

Table 8 in appendix reports the sample size, mean of age, labor income before tax, total taxes and transfers over the years for married and single households.

2.1 Public Insurance

Public insurance against idiosyncratic labor income risk reduces the after-tax and transfer income risk. Hence, one way to measure it is by asking how much income risk is reduced by taxes and transfers. For this, I need a measure of before and after-tax and transfer labor income risk. To measure this, I follow the methodology employed by Katz and Autor (1999): decompose the labor income inequality in between and within group inequality. The between-group inequality is attributable to observed characteristics of the individual, for example, education, sex, race, the region of residence, etc. As these characteristics are already known to the individual, the differences arising in labor income due to these characteristics do not come under the purview of the labor income risk. The within-group inequality is the labor income inequality minus the between-group inequality and is the measure of labor income risk[6]. Formally, denoting Y_{it} as the after-tax and transfers[7] log labor income of individual i in period t, X_{it} as the vector of observed individual characteristics, I can write

$$Y_{it} = X_{it}\mathcal{B} + y_{it} \tag{1}$$

where $\mathcal{B}$ is the vector of OLS estimated returns to observable characteristics and y_{it} is the residual. Due to the assumption of orthogonality between the estimated value and the residuals I can write

$$\text{var}(Y_{it}) = \text{var}(X_{it}\mathcal{B}) + \text{var}(y_{it}) \tag{2}$$

In equation (2), $\text{var}(Y_{it})$ is the total labor income inequality whereas $\text{var}(X_{it}\mathcal{B})$ and $\text{var}(y_{it})$ denote the between and within group inequality respectively. As mentioned above, $\text{var}(y_{it})$ is also the measure of labor income risk.

Using these definitions of before and after-tax and transfer income risk, the public insurance can be defined as

$$\mathcal{GI} = 1 - \frac{\text{var}(y_{it})}{\text{var}(\tilde{y}_{it})} \tag{3}$$

where $\text{var}(\tilde{y}_{it})[\text{var}(y_{it})]$ refers to before [after] tax income risk. If $\text{var}(y_{it}) = \text{var}(\tilde{y}_{it})$, then $\mathcal{GI} = 0$,

[6] Note that this is not the ideal definition of income risk, where I would correct for unobserved heterogeneity across individuals by taking individual fixed effects into account. As CPS is not a panel dataset, I cannot take fixed effects into account. However, as the focus is on the trend, I will assume that the role of unobserved heterogeneity in determining the size of within-group inequality did not change over time.

[7] The same argument holds for before-tax and transfer labor income

Table 2: Estimated public insurance.

Sample	**Sample Size**	$\mathbf{var}(\tilde{y}_{it})$	$\mathbf{var}(y_{it})$	$\mathcal{GI} = 1 - \frac{\mathbf{var}(y_{it})}{\mathbf{var}(\tilde{y}_{it})}$
Whole	686423	0.370	0.268	0.275
		(0.001)	(0.001)	
Married	444127	0.307	0.234	0.238
		(0.001)	(0.001)	
Single	242296	0.471	0.322	0.316
		(0.002)	(0.002)	

Note: This table reports the variance of residual income for the whole sample as well as married and single households. The last column reports the measure of public insurance. Standard errors are reported in open brackets below the concerned statistic. Bootstrap procedure with 1000 repetition is used to compute the standard errors.

implying that taxes and transfers do not provide any insurance. However if $\text{var}(y_{it}) = 0$, then taxes and transfers provide full insurance against labor income shocks.

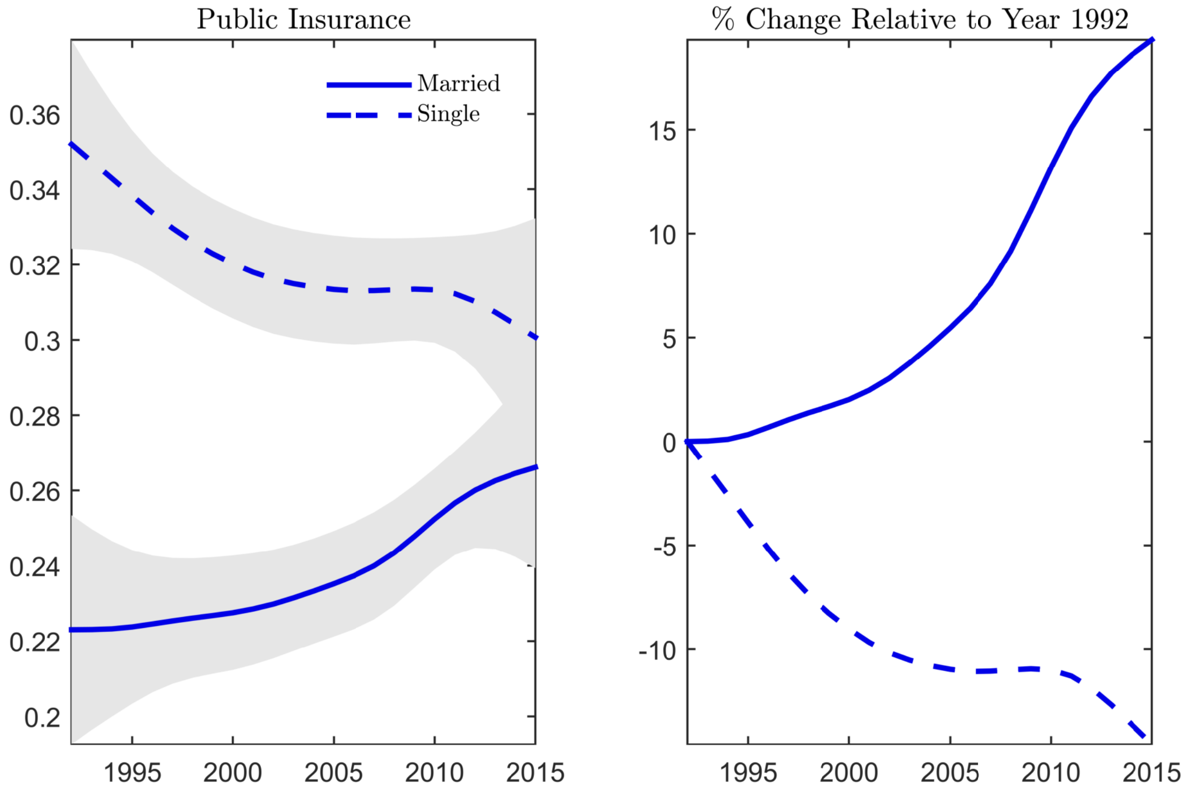
2.2 Empirical Results

In this section, I report the public insurance results based on the method explained above. For this, I proceed in two steps. First, the levels of tax progressivity are reported. In the second step, I report how the levels of tax progressivity changed over time for married and single households.

Level of public insurance: Table 2 report the levels of public insurance for the sample period 1992-2015. Some important points to notice. First, before and after tax labor income risk of single individuals is significantly higher as compared to married households. In the case of before-tax and transfer income risk, singles face 53 percent more income risk whereas in the case of after-tax and transfer, singles have 37 percent more income risk. Second, taxes and transfers indeed reduce the after-tax and transfer labor income risk. For the whole sample, the reduction is about 27 percent. However, the reduction in income risk is more for singles, 32 percent, as compared to married, 24 percent. Hence single households face more income risk, but also receive more public insurance through taxes and transfers.

Trend in public insurance: The discussion till now reveals that the married households receive lower public insurance as compared to the single household. In this section, I show that these levels of public insurance do not remain same over time and follow a systematic trend. More importantly,

Figure 1: Public insurance trend and change, 1992-2015.



Notes: The left panel reports the trends of public insurance against the labor income risk for the married and single households. The shaded region is the 95% confidence interval based on the standard error computed using 1000 bootstrap repetitions. The right panel reports the percentage change in public insurance, with 1992 as the base year.

the trends of public insurance are significantly different for married and single households. Figure 1 plots the public insurance trend for married and single household using the above-mentioned method. The left panel reports the actual trends and the right panel report the percentage change with respect to the base year 1992. The estimated public insurance was smoothed using the Hodrick-Prescott filter (Hodrick and Prescott (1997)) with the smoothing factor 100 (Backus and Kehoe (1992)). The most important conclusion from Figure 1 is that the public insurance received by married and single households follow a different trend. Over the sample period 1992-2015, it increased for married households by 19 percent and decreased for singles by about 13 percent.

Summarizing, the level of public insurance against idiosyncratic labor income risk is not the same for all households and depends on their marital status. Single households have received higher public insurance as compared to the married households. However, over time this difference has decreased, as insurance received by single (married) households decreased (increased). As the presence of public insurance affects the precautionary motive to save and hence affects the private and total insurance, change in public insurance implies a change in total insurance and which can also affect the welfare of the individuals. Furthermore, as different marital status households face different trend in progressivity, this also has a distributional implication within the economy and hence can affect the welfare more. In next section, I develop a two group standard incomplete markets model to quantitatively assess the total insurance and welfare implication of change in public insurance.

3 Model

In this section I extend the standard SIM model, à la Aiyagari (1994) to include two groups of individuals[8], namely married (denoted by m) and singles (denoted by s). The groups are indexed by $j = \{m, s\}$. Individuals in the economy live for infinite time periods. Time is discrete and is denoted by t, starting from $t = 0$. Each group at time t contains a continuum of individuals with measure g_t^j. The measure of all individuals in this economy is equal to one i.e. $g_t^m + g_t^s = 1$. The individuals can transit between the married and single groups with exogenous probabilities[9]. The transition matrix between married and single is given as

$$\mathcal{P} = \begin{bmatrix} \pi_{mm} & \pi_{ms} \\ \pi_{sm} & \pi_{ss} \end{bmatrix} \tag{4}$$

where π_{ij} denotes the probability of transition from state i to j such that $\pi_{mm} + \pi_{ms} = 1$ and $\pi_{sm} + \pi_{ss} = 1$.

The objective of the individual in group j is to maximize the expected lifetime utility, given as,

$$U^j = \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t u(c_t^j) \tag{5}$$

where β is the subjective discount factor, $\mathbb{E}_0$ is the expectation based on the information set[10] at time $t = 0$ and $u(\cdot)$ is the period utility function which is strictly increasing and strictly concave in its argument and satisfies the Inada conditions. I assume that the subjective discount factor and

[8] As the empirical evidence was based on the labor income adjusted by the adult equivalence scale, in the model, individual and household are synonyms.

[9] This is a strong assumption, as individuals explicitly decide to marry and divorce. In future work I intend to include endogenous marriage decision.

[10] The information set contains the transition probability between married and single and vice versa, and also the information about the labor income process, described later.

the period utility function of the individuals do not depend upon the group to which individual belongs. As the utility function is independent of labor supply, I implicitly assume that labor is supplied inelastically.

Market Structure: Individuals in group j can only save in the form of real capital, denoted by a^j. The presence of this non-state-contingent bond allows individuals to smooth consumption across time as well as state. The gross return of this bond is denoted by R. Individuals are also allowed to borrow and the exogenous borrowing limit is denoted by $\underline{a}$.[11]

Labor Endowment Process: In period t, a household in group $j = \{m, s\}$ receives a random labor endowment denoted by $\tilde{l}_t^j$. The set of random labor endowment is time-invariant and finite and is given by an ordered set $\tilde{\mathcal{L}}^j = \{\tilde{l}^{j,1}, \cdots, \tilde{l}^{j,N}\}$. The labor endowment is independent and identically distributed across households and evolves across time according to a first order Markov chain process with transition matrix $\mathcal{P}^j$. The before tax labor income is given by $\tilde{y}^j = w\tilde{l}^j$ where w is the economy wide wage rate. I assume the law of large numbers for each group, implying that the fraction of agents with labor income $\tilde{y}^{j'}$ next period given the labor income $\tilde{y}^j$ in present period is $\pi^j(\tilde{y}^{j'}|\tilde{y}^j)$. Note that the transition probabilities are different for each group, which can be the case if the labor endowment process is different for each group. I assume that the transition probabilities have a unique measure Π^j. The average income in each group is normalized to one i.e. $\sum_{\tilde{y}^j} \Pi^j(\tilde{y}^j)\tilde{y}^j = 1$.

Labor Income Tax: Government provides public insurance through the tax policy denoted by $\tau^j(w\tilde{l}_t^j)$. As the aim is to establish how the ex-ante welfare and the risk allocation gets affected due to the progressive taxes, I assume that tax system is revenue neutral within each group i.e. net revenues generated by the tax system within each group are equal to zero and hence there is no redistribution between the groups[12]. Furthermore I assume a one-parameter family of tax system as in Krueger and Perri (2011) so that in policy experiments the progressivity of tax system can be varied in a transparent way. The tax system for the group j is given by a marginal tax rate τ^j

[11] The borrowing constraint is not indexed by the group. This is because I assume that both married and single households face the same borrowing constraint. If $\underline{a} = 0$ then it implies that no borrowing is allowed and individuals can only save. Furthermore, the lower bound on borrowing can come into existence because of a requirement that individual is always able to pay back her debt. It may also be the case that lower bound is exogenously set.

[12] It is important to note that no redistribution between the groups through tax and transfers does not imply that there is no redistribution between the groups at all. As both groups are interacting the same market and face one same prices, the change in these prices will induce redistribution between the groups.

and a transfer ϕ^j. Since the mean of before tax labor income is normalized to one, this implies the constant transfer $\phi^j = w\tau^j$. Hence the after tax labor income (y^j) is given as

$$y^j = (1 - \tau^j)\tilde{y}^j + w\tau^j \tag{6}$$

Higher τ^j implies more transfer from individuals with high labor income to individuals with low labor income. Hence the higher value of τ^j implies higher extent of public insurance.

Firms: There is a continuum of competitive firms who have access to the constant returns to scale (CRS) production technology, denoted as $Y = Af(K, L)$ where K and L are the total capital and labor inputs respectively, A is the technology parameter and $f(\cdot, \cdot)$ is the production function. The reason for assuming the CRS production function is that then the size of the firms doesn't matter and hence I can assume the existence of a representative firm. Furthermore, production function is strictly increasing and strictly concave in both of its argument i.e $f_K, f_L > 0$ and $f_{KK}, f_{LL} < 0$. Every period capital depreciates at the rate δ. Inputs are rented by the firm in the competitive factor markets.

Aggregate State Variables: In this economy individuals are characterized by the group to which they belong and the pair (a^j, y^j) which I call individual states. The aggregate state of the economy is the distribution of the agents across these states. There are two distributions corresponding to each group, denoted by $\lambda^m(a^m, y^m)$ and $\lambda^s(a^s, y^s)$. These two distributions are the probability measures over the Borel sets of the compact set $S^j = A^j \times Y^j$, and determine the aggregate amount of capital and labor in the economy, which are given as

$$K = \sum_j g^j \int_{S^j} a^j \; d\lambda^j, \quad L = \sum_j g^j \int_{S^j} \tilde{l}^j \; d\lambda^j$$

The gross rental rate of capital and wage rate are $R = 1 + f_K(K, L) - \delta$, $w = f_L(K, L)$ respectively. This implies that the factor prices are the functions of probability measures λ^j i.e. $R = R(\lambda^m, \lambda^s)$ and $w = w(\lambda^m, \lambda^s)$.

Household Problem: The household's problem is to maximize (5) given the sequence of intertemporal budget constraint and the borrowing constraint. The problem for the married individual can be cast in a recursive problem given as,

$$V^m(a^m, y^m; \lambda^m, \lambda^s) = \max_{c^m, a'} \left\{ u(c^m) + \beta \sum_{j=m,s} \pi_{mj} \sum_{y^{j'}} \pi^j(y^{j'}|y^j) V^{j'}(a', y^{j'}; \lambda^{m'}, \lambda^{s'}) \right\} \tag{7}$$

$s.t.$

$$c^m + a' = w(\lambda^m, \lambda^s)[(1 - \tau^m)\tilde{l}^m + \tau^m] + R(\lambda^m, \lambda^s)a^m \tag{8}$$

$$a' \geqslant -\underline{a} \tag{9}$$

The superscript prime denote the next period variables. The problem for the single household can be written in the same way. The equation (7) is the value function of the married individual with initial wealth a^m and labor endowment y^m. Given a^m, y^m and λ^m, λ^s the married individual chooses the present consumption c^m and savings a'. Note that I don't index the savings by the group. This is because next period, the married individual can transit to being single. Two assumptions are made to write the problem in this way. First, if individual transit from married to single and vice versa, the wealth level of the individual does not change. This implies that transition between married and single state do not affect the wealth level. Second, I assume that if the individual transfers from married to single, his associated income process also changes immediately. Another way of saying this is that the transition between the marital status and income process are perfectly correlated. So, if a married individual switches to being single, his income process will be the associated single income process, immediately.

To solve the model, I focus on the stationary recursive competitive equilibrium, defined below.

Definition 1 ***Stationary Recursive Competitive Equilibrium***
A stationary recursive competitive equilibrium consists of the type distribution of individuals $\lambda^m(a^m, y^m)$, $\lambda^s(a^s, y^s)$, the gross rental rate of capital $R(\lambda^m, \lambda^s)$, rental rate of labor $w(\lambda^m, \lambda^s)$, and for each group the value function $V^m(a^m, y^m; \lambda^m, \lambda^s), V^s(a^s, y^s; \lambda^m, \lambda^s)$, optimal policy functions $a'(a^m, y^m; \lambda^m, \lambda^s)$, $a'(a^s, y^s; \lambda^m, \lambda^s)$ $c^j(a^j, y^j; \lambda^m, \lambda^s)$, and the aggregate capital $(K(\lambda^m, \lambda^s))$ and labor $(L(\lambda^m, \lambda^s))$ such that

- *Given prices $R(\lambda^m, \lambda^s)$ and $w(\lambda^m, \lambda^s)$, the policy functions $a'(a^j, y^j; \lambda^m, \lambda^s), c^j(a^j, y^j; \lambda^m, \lambda^s)$ solves the individual's optimization problem (7) and $V^j(a^j, y^j; \lambda^m, \lambda^s)$ are the associated value functions.*
- *Firm maximize the profit*
- *For all $(\mathcal{A}^j, \mathcal{Y}^j)$ the probability measure λ^j are invariant*

$$\lambda^j(\mathcal{A}^j \times \mathcal{Y}^j) = \int_{A^j \times Y^j} Q^j((a^j, y^j), \mathcal{A}^j \times \mathcal{Y}^j) \, \mathrm{d}\, \lambda^j(a^j, y^j) \tag{10}$$

where Q^j is the transition matrix for group j.

- *Capital and labor market clears*

The change in public insurance implies substantial redistribution, both within and between the groups, in the short run. Hence, focusing only on the steady-states can be very misleading. Therefore, this paper explicitly takes transition dynamics into account to compute the welfare and insurance effect of the relative change in public insurance. The definition of recursive competitive equilibrium with transition is given below.

Definition 2 ***Recursive Competitive Equilibrium***
A recursive competitive equilibrium consists of the sequence of the type distribution of individuals $\{\lambda_t^m, \lambda_t^s\}_{t=0}^{\infty}$, the sequence of the gross rental rate of capital $\{R(\lambda_t^m, \lambda_t^s)\}_{t=0}^{\infty}$, the sequence of the rental rate of labor $\{w(\lambda_t^m, \lambda_t^s)\}_{t=0}^{\infty}$, and for each group the sequence of value functions $\{V_t^m(a_t^m, y_t^m; \lambda_t^m, \lambda_t^s)\}_{t=0}^{\infty}$, $\{V_t^s(a_t^s, y_t^s; \lambda_t^m, \lambda_t^s)\}_{t=0}^{\infty}$, the sequence of policy functions $\{c_t^m(a_t^m, y_t^m; \lambda_t^m, \lambda_t^s)\}_{t=0}^{\infty}$, $\{c_t^s(a_t^s, y_t^s; \lambda_t^m, \lambda_t^s)\}_{t=0}^{\infty}$, $\{a_{t+1}(a_t^m, y_t^m; \lambda_t^m, \lambda_t^s)\}_{t=0}^{\infty}$, $\{a_{t+1}(a_t^s, y_t^s; \lambda_t^m, \lambda_t^s)\}_{t=0}^{\infty}$ and the sequence of aggregate capital and labor, $\{K_{t+1}(\lambda_t^m, \lambda_t^s)\}_{t=0}^{\infty}$, $\{L_t(\lambda_t^m, \lambda_t^s)\}_{t=0}^{\infty}$ such that

- *Given prices $R(\lambda_t^m, \lambda_t^s)$ and $w(\lambda_t^m, \lambda_t^s)$, the policy functions $a_{t+1}(a_t^j, y_t^j; \lambda_t^m, \lambda_t^s), c_t^j(a_t^j, y_t^j; \lambda_t^m, \lambda_t^s)$ solves the individual's optimization problem (7) and $V_t^j(a_t^j, y_t^j; \lambda_t^m, \lambda_t^s)$ are the associated value functions.*

- *Firm maximize the profit every period*

- *For all $(\mathcal{A}^j, \mathcal{Y}^j)$ the probability measure λ_t^j and λ_{t+1}^j satisfy*

$$\lambda_{t+1}^j(\mathcal{A}^j \times \mathcal{Y}^j) = \int_{A^j \times Y^j} Q_t^j((a_t^j, y_t^j), \mathcal{A}^j \times \mathcal{Y}^j)\, \mathrm{d}\, \lambda_t^j(a_t^j, y_t^j) \tag{11}$$

  where Q_t^j is the transition matrix for group j at time period t.

- *Capital and labor market clears*

It is important to note that this definition of recursive equilibrium with transition is written under the assumption that the dynamics introduced by the change in tax progressivity are deterministic in nature. This is also the basis of the solution algorithm.

4 Functional Forms and Calibration

To assess the welfare and risk sharing implications of differential change in tax progressivity, the underlying model should quantitatively account for not only the observed earnings and wealth inequality, but also the consumption risk sharing observed in the data. Due to the structure of the standard incomplete markets model, the predictions about the wealth inequality and consumption risk sharing rely on the underlying earnings process. The literature uses two methods predominantly to generate the earnings process. First method is based on Tauchen (1986), Tauchen and Hussey (1991) procedure which generates the symmetric transition matrix for the earnings process. The advantage of using this method is that it can match the consumption risk sharing as observed in the data fairly well, but fails to generate the observed wealth inequality. The second method, proposed by Castañeda et al. (2003), generates the earnings process which can match the observed wealth inequality. However this method fails in matching the observed consumption risk sharing. To solve this dilemma, I report the results for both types of calibration. The major part of the paper will focus on Castañeda et al. (2003) method, which is described below in this section. However the last section will report the results when calibration is based on Tauchen (1986) method of discretization. The conclusion of implementation of both types of calibration is that, qualitatively, results remain the same although the magnitudes change.

Labor income process: The group specific (idiosyncratic) labor productivity levels and the transition matrices $\mathcal{P}^j, j = \{m, s\}$ are chosen to match the US wealth distribution. The labor income process is discretized in three states which implies that there are in total 24 free parameters (18 from income transition matrix and six from income states). However, the weighted labor productivity is normalized to 1 and the rows of the transition matrices add up to one. This reduces the free parameters to 18.

To match the US wealth distribution, I focus on the percentage of wealth owned by the bottom 60 percent and top 40 percent and the Gini index. Based on the Survey of Consumer Finances 1992, The Gini index value is set equal to 0.71 instead of 0.83 as is found in SCF 1992 by Wolff (2011). The lower value of Gini index is obtained after dropping the individuals in top 1 percent of the wealth distribution. The reason behind dropping these individuals is two-fold. First, the primary focus of this paper is on labor income. Alvaredo et al. (2013) and references cited there in emphasize the importance of capital income and not labor income for the households in top 1 percent of wealth distribution. Hence I drop these households. Second reason is based on survey design. SCF employs two methods for random sampling. One method using the area-probability sample identify the households with characteristics that are broadly distributed in the population. This sample is called area-probability sample. Second method is focused on disproportionately including the wealthy families and this sample is called list sample. The response in area probability sample is about 70 percent whereas in list sample response rate is just one third. Furthermore, the response rate of the wealthiest families was only half of that level. This implies, even though SCF focuses on wealthy families to create a complete picture of wealth inequality, very wealthy families response rate distorts this picture. Hence I drop those households.

The (log) labor income is assumed to follow the AR(1) process. The variance of the log labor income process i.e. labor income risk is equal to the group specific after-tax and transfer income risk in the year 1992. This is equal to 0.221 for married group and 0.301 for the single group. I take after-tax and transfer risk because then in the policy experiment I can only focus on the trend of the tax progressivity. There is uncertainty associated with the autocorrelation coefficient of the AR(1) process. Domeij and Heathcote (2004) report that autocorrelation coefficient lies between 0.88 and 0.96. For this paper, I set this coefficient equal to 0.9. The estimated labor income productivity level, transition matrix and stationary distribution for the married and single households are,

$$\tilde{\mathcal{L}}^m = \begin{pmatrix} 0.6581 \\ 0.6719 \\ 1.9068 \end{pmatrix} \qquad \mathcal{P}^m = \begin{pmatrix} 0.9562 & 0.0353 & 0.0086 \\ 0.0731 & 0.8499 & 0.0770 \\ 0.0200 & 0.0602 & 0.9198 \end{pmatrix} \qquad \Pi^m = \begin{pmatrix} 0.5020 \\ 0.2267 \\ 0.2713 \end{pmatrix}$$

$$\tilde{\mathcal{L}}^s = \begin{pmatrix} 0.5512 \\ 0.6325 \\ 1.8443 \end{pmatrix} \qquad \mathcal{P}^s = \begin{pmatrix} 0.9563 & 0.0276 & 0.0160 \\ 0.0539 & 0.8622 & 0.0839 \\ 0.0201 & 0.0591 & 0.9208 \end{pmatrix} \qquad \Pi^s = \begin{pmatrix} 0.4371 \\ 0.2303 \\ 0.3326 \end{pmatrix}$$

Some comments are in order. First, as the number of free parameters are greater than the targeted moments, the calibration process is under-identified. Second, the estimated income processes are different from what is estimated by Castañeda et al. (2003). This is because they calibrate their model without dropping the households in the top 1 percent of the wealth distribution. Third, the estimated income processes for the married and single households are different. This is because of the difference in labor income risk faced by these households.

Functional Forms: The agent's instantaneous utility function is assumed to be of constant relative risk aversion type (CRRA) given as

$$u(c) = \begin{cases} \frac{c^{(1-\sigma)}}{1-\sigma}, & \sigma \neq 1 \\ \log(c), & \sigma = 1 \end{cases}$$

The production function is assumed to be of Cobb Douglas type, given as $F(K, L) = K^{\alpha}L^{1-\alpha}$ where α is the output elasticity of capital.

Model parameters: As the main emphasis of the paper is to show how the more progressive labor income tax affects risk sharing and welfare, it is important that the benchmark economy captures the wealth stock properly. This is because accumulated wealth affects the level of risk sharing. Hence following Kaplan and Violante (2010), I target aggregate wealth to income ratio equal to 2.5. This number is computed from the Survey of Consumer Finances, 1989 and 1992 waves. To calculate this number wealth is defined as the total net worth of an individual and income is pre-tax labor income and capital income. To target this statistic, I set gross interest rate (R) equal to 1.025[13], the depreciation rate of capital (δ) equal to 0.1357 and find the subjective discount factor β which gives aggregate wealth to income ratio equal to 2.5. On average, the single individual's population share in the economy is about 33 percent. So I set the share of married individuals in the economy (g^m) equal to 0.67 and hence $g^s = 0.33$. The borrowing constraint is set exogenously to $a^j = -1, j = \{m, s\}$ i.e. both married and single individuals can borrow up to the average income.

Married single transition probabilities: To calibrate the probability of transition from married to single and vice versa, I use the National Survey of Family Growth 2006-2010 wave, Copen et al. (2012). From this survey, focusing only on white men and women, the probability of remaining married after five years of marriage is 0.8 for women and 0.82 for men. The weighted average is equal to 0.809[14]. Assuming that the survival probability of marriage follows the exponential distribution with parameter λ_{mm}, I can write

$$\exp(-5\lambda_{mm}) = 0.809$$

which implies $\lambda_{mm} = 0.0423$. Hence the probability of remaining married after one year is $\pi_{mm} = \exp(-\lambda_{mm}) = 0.958$ and transition to single is $\pi_{ms} = 1 - \exp(-\lambda_{mm})$. To calibrate the transition probabilities for the single individuals I follow different procedure because it is not straight forward to estimate these probabilities. I ask, given the transition probabilities of the married individuals, which transition probabilities I need for single individuals so that the share of single and married

[13] This is taken from Broer (2013)and is the average ex-ante real interest rate on six-month US Treasury bills between 1998 and 2003.

[14] Sample size of white women is 21,703 and of white men is 17,813

Table 3: Model parameter and target statistics for the benchmark model.

Calibration statistic	**Parameter**	**Value**
Preferences and Technology		
Subjective discount factor	β	0.964
Capital income share	α	0.300
Capital depreciation rate	δ	0.136
Technology parameter	A	1.060
Gross interest rate	R	1.025
CRRA utility parameter	σ	1
Marriage characteristics parameters		
Probability, married to single	π_{ms}	0.042
Probability, single to married	π_{sm}	0.071
Share, married	g^m	0.630
Share, single	g^s	0.370
Exogenous borrowing constraint	$\underline{a}$	1

Target Statistic	**Data**	**Model**
Wealth to income ratio	2.50	2.50
% Wealth, bottom 60%	4.10	5.26
% Wealth, top 40%	95.8	94.7
Wealth Gini	0.71	0.68
Variance labor income, married	0.221	0.221
Variance labor income, single	0.301	0.301
Autocorrelation, labor income	0.900	0.900

Notes: The top table reports the calibrated value of the model parameters. The bottom table reports the targeted statistics, based on the calibration method proposed by Castañeda et al. (2003).

individuals in the economy is equal to g^m and g^s respectively. This procedure gives $\pi_{ss} = 0.929$ and $\pi_{sm} = 0.071$.

Table 3 summarizes the model parameters and the target statistics for the benchmark economy[15].

[15] I do not target the consumption risk sharing measure in this calibration exercise. There are two reasons behind it. First, at this moment, model is calibrated on CPS dataset (variance of income is taken from this dataset) which does not have consumption data. Hence there is no consumption risk sharing statistic which I can target. Second, I cannot use information from the Consumption and Expenditure Survey (CEX) data because of the difference between the CPS and CEX sample survey design.

5 Effects of Change in Tax Progressivity

The objective of this section is to quantify the effect of change in public insurance of married and single households, as documented in Section 2, on consumption risk sharing (or synonymously insurance) and welfare in the economy. As reported in Figure 1, over the sample period 1992-2015, the public insurance against labor income risk increased for married households and decreased for single households. Since there is one-to-one mapping between public insurance and tax progressivity in the present model, this implies tax progressivity increased for married households and decreased for singles. The primary objective of this section is to show that this relative change in tax progressivity has non-trivial consequences for the welfare. The conclusion of the exercise is this: the married households, despite increase in their tax progressivity which reduces their after-tax and transfer labor income risk, suffer a welfare loss, whether transition is taken into account or not. This is despite the increase in insurance achieved by married households. On the other hand, single households experience welfare gain when transition is not taken into account. However, when transition is taken into account, they loose in terms of welfare. For the comparison, if the economy was populated by only married households, then the increase in tax progressivity will result in unambiguous welfare gain.

Section 5.1 describes the insurance and utilitarian welfare measures. Furthermore, utilitarian welfare measure is decomposed into uncertainty effect, inequality effect, level effect and the transition effect.

5.1 Insurance and Welfare Measures

Insurance measure: Following Krueger and Perri (2011) I define the total insurance of group j as one minus the ratio of standard deviation of consumption with respect to pre-tax income:

$$\mathcal{TI}^j = 1 - \frac{\text{var}(c^j)}{\text{var}(\tilde{y}^j)} \tag{12}$$

Intuitively, (12) tells us how much the variability of before-tax and transfer income transfers to consumption. If $\text{var}(c^j) = 0$, this implies $\mathcal{TI}^j = 1$ implying that income shocks are perfectly insured. But if $\text{var}(c^j) = \text{var}(\tilde{y}^j)$ then $\mathcal{TI}^j = 0$ implying that income shocks completely transfer to consumption. I can further decompose the total insurance in public or government insurance

$(\mathcal{GI}^j)$ and private insurance $(\mathcal{PI}^j)$, defined as

$$\mathcal{GI}^j = 1 - \frac{\text{var}(y^j)}{\text{var}(\tilde{y}^j)}, \quad \mathcal{PI}^j = 1 - \frac{\text{var}(c^j)}{\text{var}(y^j)} \tag{13}$$

Given the assumed functional form of tax policy, (6), there is one to one monotonous positive relationship between τ^s and $\mathcal{GI}^j$. Higher τ^j implies higher public insurance.

Welfare measure: I denote the benchmark economy with superscript A and the economy after the policy reform by superscript B. The utilitarian welfare of group $j = \{m, s\}$ in economy A (similarly for economy B) is defined as

$$U^{j,A} = \int_{A^j \times Y^j} \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t u(c_t^j | a_0^j, y_0^j) \, \mathrm{d}\, \lambda^j(a_0^j, y_0^j) \tag{14}$$

For the logarithmic utility function, the utilitarian welfare change for group $j = \{m, s\}$ due to the policy reform, denoted by Δ^j is given as

$$\Delta^j = \exp[(1-\beta)(U^{j,B} - U^{j,A})] - 1$$

where U_B^j is calculated by taking the value function based on the consideration of the transition path, but the stationary distribution of benchmark economy A. The variable Δ^j can be interpreted as the percentage change in consumption in economy A, such that the expected utility in economy A is same as in economy B.

In order to understand the different implications of the policy reform, following Flodén (2001),Benabou (2002) and Koehne and Kuhn (2015), I can decompose Δ^j into welfare components arising from changes in inequality, levels, uncertainty and transition. For an individual in group $j = \{m, s\}$ with initial asset a_0^j and initial labor income y_0^j a certainty equivalent of consumption in economy A can be defined as

$$\frac{u(\bar{c}^{j,A}(a_0^j, y_0^j))}{(1-\beta)} = \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t u(c_t^{j,A}(a_0^j, y_0^j))$$

The mean certainty equivalent of consumption of group j in economy A is denoted by $\bar{C}^{j,A}$ and is defined as

$$\bar{C}^{j,A} = \int \bar{c}^{j,A}(a_0^j, y_0^j) \, \mathrm{d}\, \lambda^{j,A}(a_0^j, y_0^j)$$

whereas the mean consumption of group j in economy A is defined as

$$C^{j,A} = \int c^j(a_0^j, y_0^j)\,\mathrm{d}\,\lambda^{j,A}(a_0^j, y_0^j)$$

As I am interested in determining the welfare effect due to change in inequality and uncertainty, I have to first determine how much the individuals in the economy dislike inequality and uncertainty. For group j in economy A denote the price of inequality by $p_{ineq}^{j,A}$ and the price of uncertainty by $p_{unc}^{j,A}$. The $p_{ineq}^{j,A}$ can be determined by comparing the consumption of single individual with the average consumption. Formally, it is given as

$$u((1 - p_{ineq}^{j,A})\bar{C}^{j,A}) = \int u(\bar{c}^{j,A}(a_0^j, y_0^j))\,\mathrm{d}\,\lambda^{j,A}(a_0^j, y_0^j)$$

Note that the certainty equivalent of consumption and its mean determine the cost of inequality. Using the actual consumption will does not allow to separate the cost of uncertainty from the cost of inequality. The cost of uncertainty for group j in economy A is defined as

$$u((1 - p_{unc}^{j,A})C^{j,A}) = u(\bar{C}^{j,A})$$

In words, the cost of uncertainty quantifies how much individuals are willing to let go of the mean consumption to consume mean certainty equivalent of consumption.

Using these definitions I can define the different components of welfare change. These are given as

$$\begin{aligned}
\Delta_{ineq}^j &= \frac{1 - p_{ineq}^{j,B}}{1 - p_{ineq}^{j,A}} - 1 \\
\Delta_{unc}^j &= \frac{1 - p_{unc}^{j,B}}{1 - p_{unc}^{j,A}} - 1 \\
\Delta_{lev}^j &= \frac{C^{j,B}}{C^{j,A}} - 1 \\
\Delta_{trans}^j &= \exp[(1-\beta)(U^{j,B} - U_{ss}^{j,B})] - 1
\end{aligned}$$

where $U_{ss}^{j,B}$ is the utilitarian welfare of group j under economy B when transition is not taken into account.

Proposition 1 $\quad \Delta^j = (1 + \Delta_{ineq}^j)(1 + \Delta_{unc}^j)(1 + \Delta_{lev}^j)(1 + \Delta_{trans}^j) - 1$

The proof follows from the method proposed by Flodén (2001), Benabou (2002), Domeij and Heathcote (2004) and Koehne and Kuhn (2015). Note that under this particular welfare decomposition,

Table 4: Different welfare measures and their symbols.

Welfare Measures	**Symbol**
Utilitarian welfare, steady state	Δ^j_{ss}
Utilitarian welfare	Δ^j
Inequality effect	Δ^j_{ineq}
Uncertainty effect	Δ^j_{unc}
Level effect	Δ^j_{lev}
Transition effect	Δ^j_{trans}

Note: The table reports the different measures of welfare and their symbols. The superscript j refers to the married (m) and singles (s) group.

all the changes which were not attributed to inequality, uncertainty or level effect is relegated to the transition part. Table 4 summarizes the different welfare measures.

5.2 Results

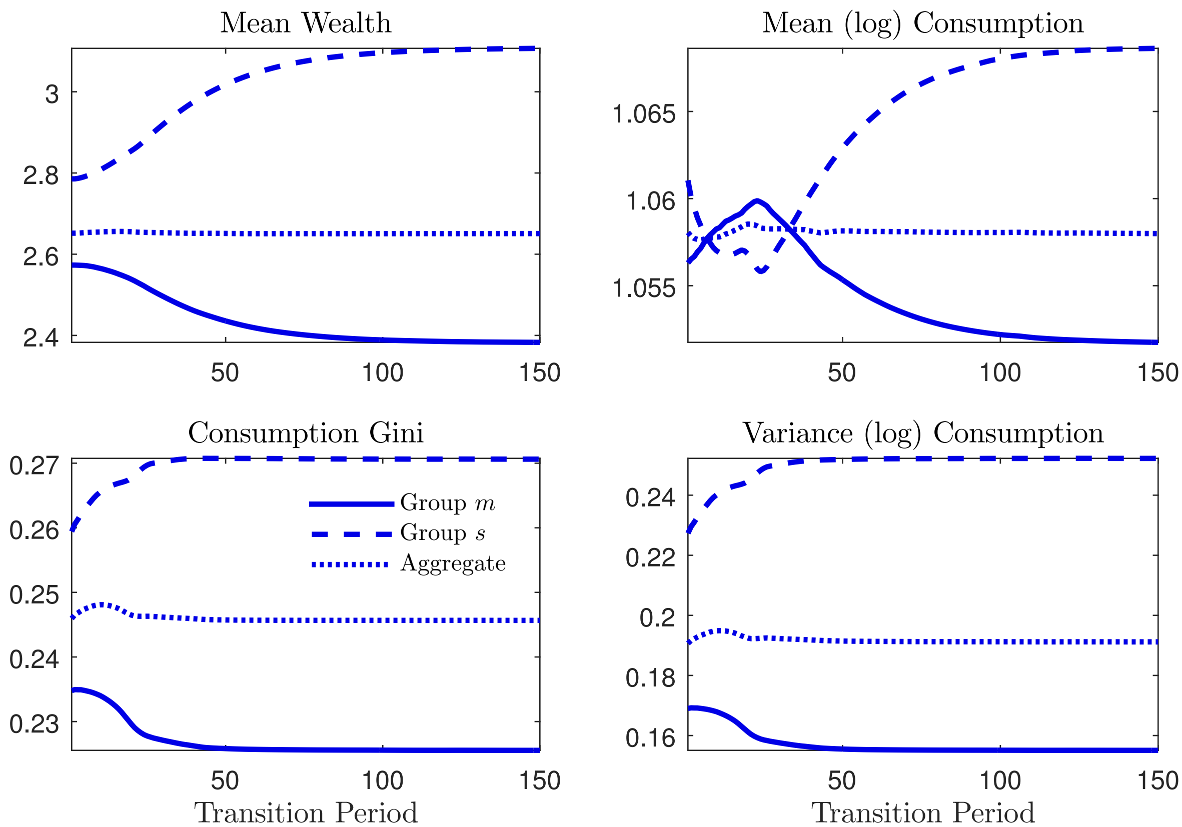
Figure 2 report the evolution of mean savings, mean log(consumption), Gini index of consumption and variance of log(consumption) when individuals in group m and s experience the change in tax progressivity. The reason for reporting these variables is that it allows me to explain the utilitarian welfare change and its components. The top left panel reports the change in group specific mean savings and the aggregate savings in the economy. It can be seen that there is no visible change in the aggregate savings as compared to group specific changes, which are significant. Savings of group m decreased and group s increased.

This is because, as progressivity of labor income taxes increases for group m individuals, it lead to the decrease in precautionary motive to save, leading to the decrease in savings. Opposite happens with group s[16]. The aggregate savings are insignificantly affected due to the opposite behavior of two groups. Due to this change in saving behavior, as group m (s) individuals start to de-cumulate (accumulate) their savings, their initial consumption increases (decreases). However, in long term, as the market clearing interest rate is not much affected, the mean wealth of group m individuals is low as compared to the single individuals. Hence the long term mean consumption of group m (s) individuals is low (high).

Now focusing on the bottom panel of Figure 2, we see that the Gini index and variance of

[16] At this point it is important to realize that, qualitatively, this behavior of group specific and aggregate savings will still hold if only married group experienced increase in tax progressivity, but single household's tax progressivity remain the same. This is because due to the decrease in precautionary savings by married households, aggregate interest rate will rise, implying that single households will start to save more.

Figure 2: Evolution of endogenous variables in response to change in tax progressivity.



Notes: The figure reports the evolution of endogenous variables in response to the change in tax progressivity which mimics the change in public insurance as reported in Figure 1.

log consumption increased for group s and decreased for group m. The variance of consumption increases for group s, because the decrease in tax progressivity leads to the reduction in total insurance. Opposite happens with group m.

Table 5 reports the welfare results of the change in tax progressivity. The second and third column report the result for the group m and s, whereas the last column refers to the one group model. There are some important points to notice. First, in two group model, by comparing the steady state, group m suffered welfare loss whereas group s experience welfare gain. However if the group m experiences the same tax progressivity change in one group model, then there is welfare gain. Second, when transition is taken into account, the utilitarian welfare change for both group is negative. However, the result of one group model is robust to the transition effect and utilitarian welfare change remains positive. These two observations imply that reducing the after-tax and transfer labor income risk of individuals does not necessarily imply that those individuals will

Table 5: Percentage welfare change and decomposition.

Welfare measure	**Two Group Model**		**One Group Model**
	Group m	Group s	
Utilitarian, steady state (Δ^j_{ss})	- 0.38	0.46	0.37
Utilitarian (Δ^j)	-0.08	-0.21	0.19
Inequality (Δ^j_{ineq})	0.20	-0.28	0.12
Uncertainty (Δ^j_{unc})	-0.16	0.02	0.30
Level (Δ^j_{lev})	-0.43	0.73	-0.05
Transition (Δ^j_{trans})	0.30	-0.67	-0.18

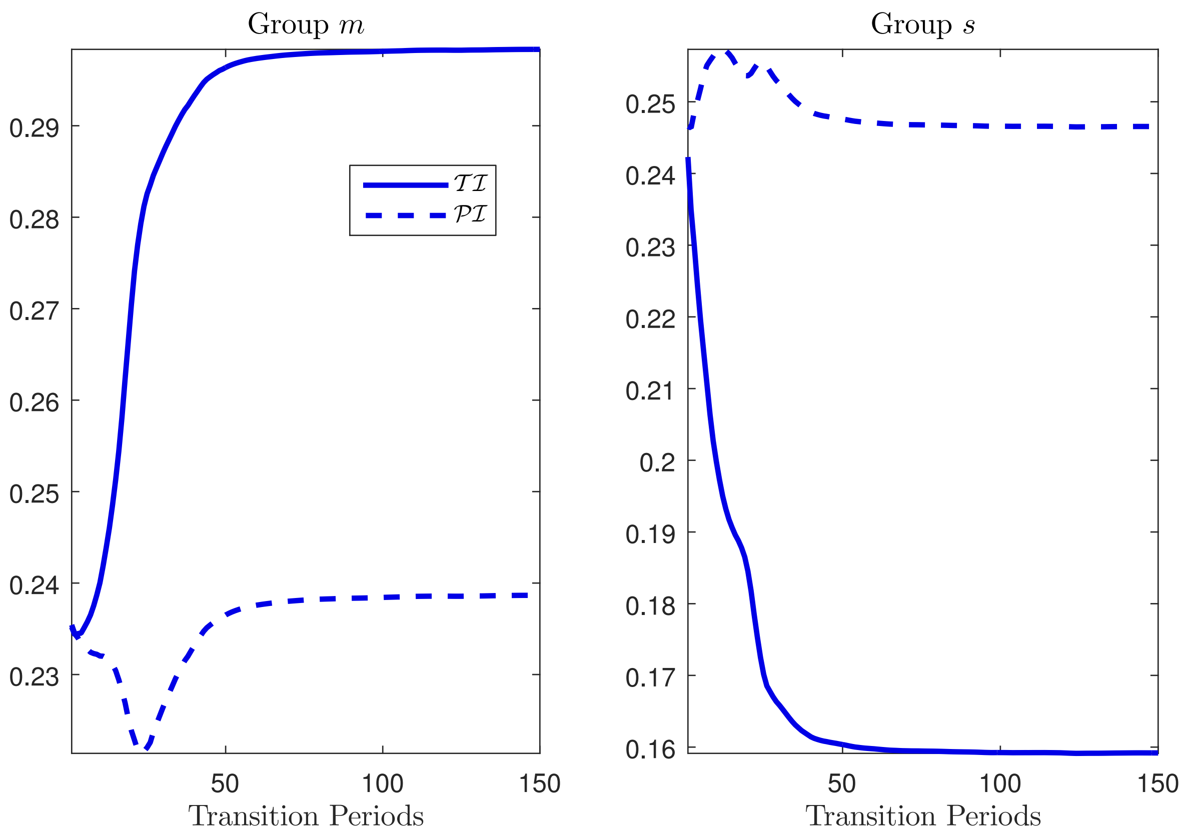
Notes: The table reports the welfare measures for the married and single households in response to the change in tax progressivity which mimics the change in public insurance as reported in Figure 1. The results for one group model is generated by keeping all the parameters in the model same, except for setting the share of married individuals in economy, g^m, equal to one.

be better off. Third, decomposition of welfare change shows that the origin of negative welfare change is different for two groups. For group m, uncertainty and level effect play an important role, whereas for group s it is inequality and transition effect. Below I discuss why these effects behave differently for group m and s.

Inequality effect: The consumption Gini index has increased for group s but decreased for group m. This is because, due to the decrease in tax progressivity, group s individuals started to increase their savings. However, the individuals with history of positive shocks will accumulate disproportionately more wealth as compared to individuals with history of negative shocks, and this translates into higher dispersion in wealth as well as consumption. For the opposite reason, group m experienced decrease in consumption Gini index. As group s becomes more unequal, individuals are ready to pay more price to reduce the inequality, and hence inequality effect for group s is negative.

Uncertainty effect: Variance of log consumption for married households decreased and increased for single households. So it comes as a surprise that uncertainty effect is negative for married households and positive for single households. This welfare effect implies that price of uncertainty has increased for married households. To visualize this, Figure 3 plots the total and private insurance

Figure 3: Public and private insurance measures.



Notes: The figure reports the evolution of total and private insurance in response to the change in tax progressivity which mimics the change in public insurance as reported in Figure 1. The solid (dashed) line refers to total (private) insurance.

of group m and s. More progressive taxes crowd out the private insurance, more than one by one. Hence total insurance increases but private insurance decreases for married households. Opposite is true for the single households. As individuals are concerned with after-tax and transfer income and the extent to which it transfers to the consumption (in other words private insurance), married households are ready to pay higher price to remove the uncertainty. Hence the uncertainty effect is negative for married households. Similar but opposite argument applies to single households.

Level effect: This effect depends upon the mean of consumption in steady states. From Figure 2 we can see that mean consumption of group m is lower in final steady state, while for group s it is higher. Hence level effect is negative for group m but positive for group s.

Transition effect: After level effect, transition effect plays the most important role in the determination of utilitarian welfare. It is positive for group m and negative for group s. The intuition behind it is bit ambiguous. As mentioned in Section 5.1 all the effects which cannot be attributed to the inequality, uncertainty or level affect are summed up in the transition effect. More importantly, except for transition effect, all other welfare effects rely on the comparison of two steady states. However, looking at the change in mean of log consumption over the transition period, it decreased for group s initially but increased for group m. This is because, after the tax progressivity change, group s starts to save more whereas group m started to dis-save. In later periods, group s (m) experienced an increase (decrease) in consumption. Due to the presence of the subjective discount factor, the initial period consumption contributes to the lifetime utility more as compared to later period consumption. Hence transition effect is positive for group m, as their initial mean consumption increased. Opposite is true for group s.

6 Tauchen Calibration

As discussed in Section 4, calibration method of Castañeda et al. (2003) allows me to match the wealth distribution. However it fails in matching the insurance coefficient as it is observed in data. The objective of this section is to check whether the welfare results are robust to the specification in which calibration allows me to match the insurance coefficient.

As CPS does not provide the consumption data, I focus on the Consumption and Expenditure Survey (CEX). For this I use the same sample as used by Broer (2013) and Krueger and Perri (2006). In this sample, the income is supposed to capture the sources of household revenues which are independent of consumption and saving decisions. Hence income is after-tax and transfer labor earnings. The labor earnings is measured as the sum of wages and salaries of households members and the fixed fraction farm and non-farm income. Taxes refer to federal, state and local taxes and contributions to social security whereas transfers refer to welfare, food stamps and unemployment insurance. The measure of consumption refers to the expenditure on non-durable consumption and the flow of services from durable goods.

The measure of insurance, as defined above, is one minus the variance of residual consumption over residual income. I find that the insurance achieved by the married and single households, based on after-tax and transfer labor income, is 0.57 and 0.58 respectively. This value is close to the value found by Broer (2013) which is equal to 0.61, when marital status is not taken into consideration.

Table 6: Labour income calibration according to Tauchen (1986) method and target statistics.

Labour Income Statistic	Symbol	Value
Income persistence, AR(1)	ρ	0.9989
Variance labor income, married	$\text{var}(y_t^m)$	0.34
Co-variance labor income, married	$\text{Cov}(y_t^m, y_{t-1}^m)$	0.22
Variance labor income, single	$\text{var}(y_t^s)$	0.38
Co-variance labor income, single	$\text{Cov}(y_t^s, y_{t-1}^s)$	0.24
Target Statistic	**Data**	**Model**
Wealth to income ratio	2.50	2.50
Insurance, married	0.57	0.45
Insurance, single	0.58	0.45
Wealth Gini	0.71	0.22
% Wealth, bottom 60%	4.10	21.97
% Wealth, top 40%	95.80	78.03

Notes: The table reports the calibration and target statistics for the Tauchen (1986) calibration. The top table reports the calibration of the labor income process based on the Consumption and Expenditure Survey data. The bottom table reports the target statistics.

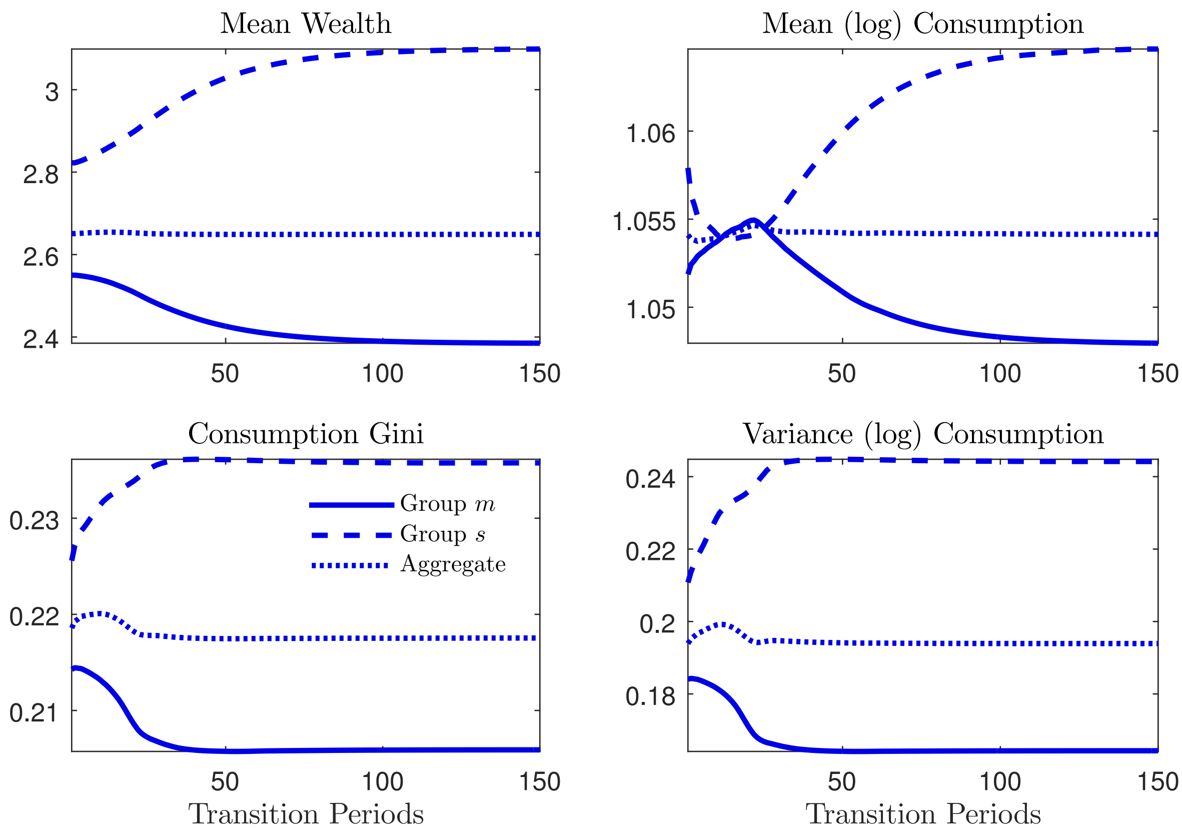
For the discretization of labor income, it is modeled as (I remove the superscript j because the same procedure is followed for married and single group)

$$\log(y_t) = z_t + \epsilon_t, \quad z_t = \rho z_{t-1} + \eta_t \tag{15}$$

where ϵ_t, η_t are independent, serially uncorrelated and normally distributed with mean zero and variances σ_ϵ^2 and σ_η^2 respectively. Following Storesletten et al. (2004) I set $\rho = 0.9989$. Using the CEX sample for the period 1991-2003 I estimate the values of σ_ϵ^2 and σ_η^2 for married and single group. Then using the Tauchen and Hussey (1991) method, the income process is approximated by five persistent and two transitory income states.

Table 6 reports the calibrated labor income and the target statistics. All other calibration parameters are the same as in previous calibration. As predicted, this calibration matches the insurance coefficient and aggregate wealth to income ratio reasonably well, but fails in matching the wealth inequality. From SCF 1992 survey, the bottom 60 percent of the population had 4.1 percent of the total wealth where as the model predicts 21.97 percent. Same mis-prediction holds

Figure 4: Evolution of endogenous variable in response to the change in tax progressivity under Tauchen (1986) calibration.



Notes: The figure reports the evolution of endogenous variables in response to the change in tax progressivity which mimics the change in public insurance as reported in Figure 1. For this figure, the model is calibrated using the Tauchen (1986) method.

for the top 40 percent of the population.

Figure 4 reports the evolution of the variables in response to the same tax progressivity changes as was used for Figure 2. We can see that the change in calibration procedure has no impact on the qualitative evolution of the variables over the transition path. Although the aggregate mean wealth and mean consumption do not respond to the change in tax progressivity, group specific variables exhibit significant heterogeneous behavior. But the magnitude of the changes is different. For the Castañeda et al. (2003) type calibration, mean wealth of group s increased by 11.52 percent, but in present calibration it only increased by 8.18 percent. Does these different magnitudes have implications for the welfare effect?

Table 7 reports the utilitarian welfare change and its decomposition. The most important point to notice is that the welfare effects are qualitatively robust to the change in the calibration

Table 7: Percentage welfare change and decomposition, Tauchen (1986) calibration.

Welfare measure	Group m	Group s
Utilitarian, steady state (Δ^j_{ss})	- 0.23	0.53
Utilitarian (Δ^j)	0.02	-0.11
Inequality (Δ^j_{ineq})	0.14	-0.20
Uncertainty (Δ^j_{unc})	-0.00	0.08
Level (Δ^j_{lev})	-0.37	0.65
Transition (Δ^j_{trans})	0.24	-0.63

Notes: The table reports the welfare measures for the married and single households in response to the change in tax progressivity which mimics the change in public insurance as reported in Figure 1. For this table, the model is calibrated using the Tauchen (1986) method.

and the intuition from the previous calibration follows. However their combination leads to the welfare gain for group m (consumption increases by 0.02 percent) whereas in previous calibration it decreased by 0.08 percent if transition is taken into account. Group s still experiences the decrease in consumption by 0.1 percent as compared to in previous calibration, where its consumption decreased by 0.2 percent. The overall conclusion of this exercise is that under Tauchen calibration, the magnitude of welfare effects are muted, but qualitative effects remain the same.

7 Conclusion

The objective of this paper was two-fold: empirical and quantitative. As an empirical contribution, using the March Current Population Survey dataset I show that the tax and transfer policies have benefited married households more in terms of the public insurance against the labor income risk. Over the sample period 1992-2015, the public insurance received by the married households increased by 19 percent, but the single households experienced a 13 percent decrease. As public insurance effects the saving behavior of individuals, the relative change has an implication for the total insurance and welfare in an economy. Hence, for the quantitative contribution, I expanded the standard incomplete markets model to include two groups of households: married and single. The main contribution was in showing that relatively more public insurance to the married households can increase their total insurance, but decrease their welfare. Hence better insurance and better welfare do not go hand in hand if there is a relative change in public insurance. This counter-intuitive result comes into the picture because, in response to the relative change in public insurance, the married households decrease their savings and the single households increase their savings.

Future directions: To make the exposition simple, this paper made two strong assumptions: first, the labor supply is assumed to be inelastic and second, the decision to remain single or married is determined by the exogenous probability. In future, this paper intends to relax these two assumptions. The second important direction which this paper can take is to understand how the change in tax progressivity affects the within household decision making about the labor supply.

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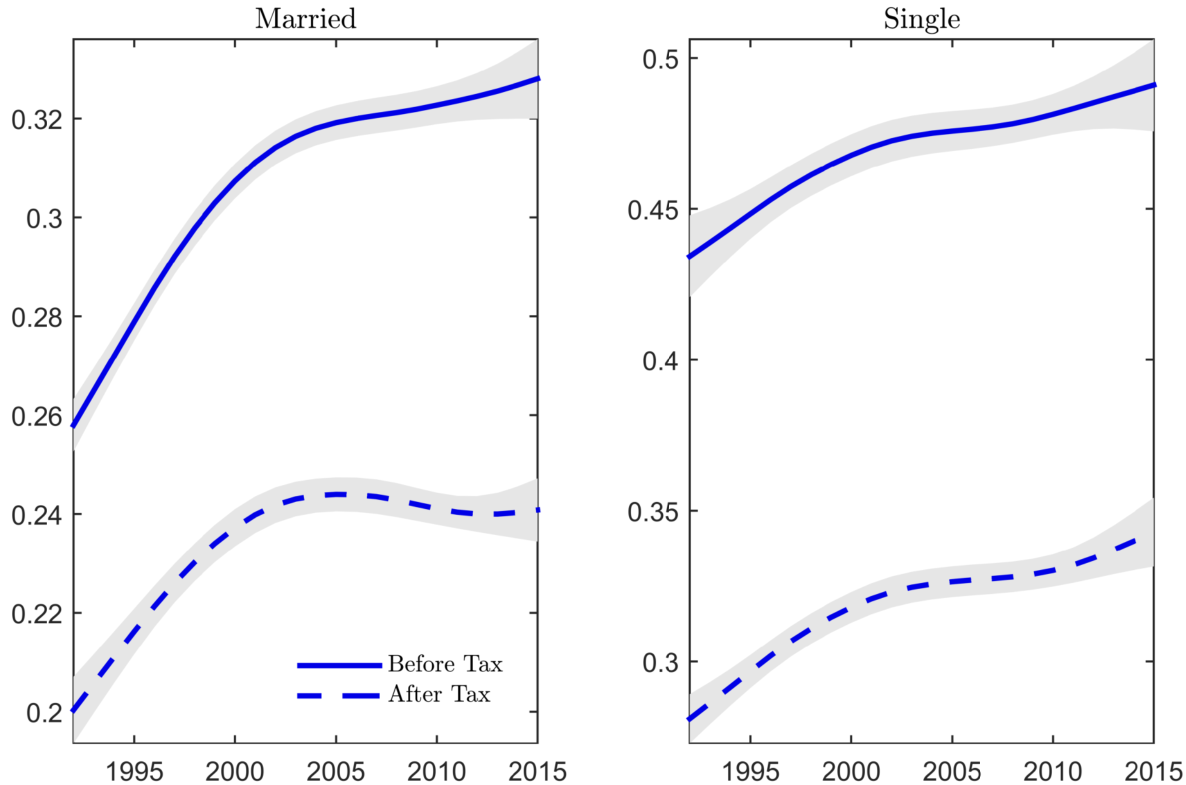
Appendix A: Figures

Figure 5: Before and after-tax and transfer income risk of married and single households.



Note: *The shaded region represent the 95 percent confidence interval computed using 1000 bootstrap samples.*

Figure 5 reports the before and after tax income risk of married and single households over the period 1992-2015. Some important points to notice. Before and after tax income risk of married and single households has increased. However after 2004, the reduction in income risk due to taxes and transfer is very strong for married households. So even though they experienced increase in before-tax and transfer income risk, their after-tax and transfer income risk did not change much.

Appendix B: Tables

Table 8: Group specific mean of age, income, taxes and transfers in CPS 1992-2015 sample.

	Single					Married				
Year	N	Age	Income	Taxes	Transfers	N	Age	Income	Taxes	Transfers
1992	8392	41	28318	7010	932	17828	42	25864	6475	537
1993	8258	42	28140	7021	997	17762	42	26135	6519	615
1994	7839	42	28324	7156	989	16650	42	28797	7152	867
1995	8007	42	29193	7544	945	16501	42	27254	7386	607
1996	7300	42	29934	7398	1016	14384	42	29143	7351	572
1997	7535	42	30966	7877	1013	14506	42	29209	7492	591
1998	7540	42	30721	7876	935	14066	43	30264	7942	554
1999	7812	42	30963	7984	974	14122	43	31299	8290	580
2000	7917	42	31757	8848	912	14020	43	31218	8757	563
2001	11892	42	30472	7782	1084	23229	42	32063	8553	558
2002	12296	43	31596	8120	1085	23005	43	32317	8531	598
2003	12036	43	31357	7398	1107	22430	43	32557	7952	647
2004	11573	43	30921	7161	1090	21890	43	32713	7536	668
2005	11626	43	31057	7465	1190	21132	43	32891	8062	915
2006	11655	44	31402	7721	1143	20798	43	32606	7624	880
2007	11744	44	31679	8079	1092	20807	44	33491	7956	850
2008	11955	44	31918	8268	1066	20462	44	33398	7989	795
2009	11689	44	30994	7595	1036	20472	44	33334	7899	835
2010	11249	44	31686	7813	1297	19536	44	33451	7785	1037
2011	11049	44	31722	8055	1273	18651	44	33002	8092	1007
2012	11050	45	31589	7299	1177	18195	45	33676	7661	948
2013	10890	45	32199	7452	1073	18427	45	33407	7459	872
2014	10776	45	31492	7990	1030	18159	45	34011	8578	827
2015	10710	45	31745	8309	972	17937	45	34444	9353	831
All years	242790	43	30964	7726	1072	444969	43	31701	7864	747

Table 9: Estimated before and after-tax and transfer labor income risk and public insurance for married households.

Year	$\mathbf{var}(\boldsymbol{y_{it}})$	$\mathbf{var}(\boldsymbol{\tilde{y}_{it}})$	$\boldsymbol{\tau^{IR} = 1 - \frac{\mathbf{var}(y_{it})}{\mathbf{var}(\tilde{y}_{it})}}$
1992	0.198	0.262	0.244
1993	0.203	0.270	0.248
1994	0.208	0.262	0.208
1995	0.204	0.260	0.217
1996	0.230	0.304	0.244
1997	0.237	0.314	0.247
1998	0.232	0.311	0.255
1999	0.228	0.301	0.241
2000	0.234	0.297	0.214
2001	0.250	0.332	0.248
2002	0.256	0.325	0.212
2003	0.242	0.325	0.255
2004	0.242	0.321	0.245
2005	0.234	0.319	0.266
2006	0.241	0.319	0.244
2007	0.258	0.325	0.205
2008	0.251	0.308	0.185
2009	0.234	0.310	0.246
2010	0.246	0.338	0.271
2011	0.225	0.327	0.312
2012	0.233	0.326	0.285
2013	0.232	0.318	0.273
2014	0.234	0.321	0.270
2015	0.260	0.344	0.243

Note: *Second (third) column refers to after (before) taxes and transfer income risk.*

Table 10: Estimated before and after-tax and transfer labor income risk and public insurance for single households.

Year	$\mathbf{var}(\boldsymbol{y_{it}})$	$\mathbf{var}(\boldsymbol{\tilde{y}_{it}})$	$\boldsymbol{\tau^{IR} = 1 - \frac{\mathbf{var}(y_{it})}{\mathbf{var}(\tilde{y}_{it})}}$
1992	0.286	0.452	0.367
1993	0.283	0.432	0.344
1994	0.275	0.436	0.368
1995	0.280	0.444	0.368
1996	0.316	0.469	0.327
1997	0.326	0.481	0.322
1998	0.320	0.475	0.327
1999	0.305	0.452	0.324
2000	0.299	0.456	0.345
2001	0.333	0.489	0.319
2002	0.350	0.491	0.288
2003	0.319	0.477	0.332
2004	0.328	0.485	0.324
2005	0.315	0.473	0.334
2006	0.348	0.480	0.276
2007	0.317	0.474	0.331
2008	0.325	0.463	0.298
2009	0.328	0.472	0.305
2010	0.324	0.493	0.343
2011	0.312	0.490	0.364
2012	0.327	0.487	0.328
2013	0.349	0.504	0.308
2014	0.345	0.475	0.274
2015	0.348	0.499	0.301

Note: *Second (third) column refers to after (before) taxes and transfer income risk.*