

Optimal Wealth Inequality in the Economy with Heterogenous Workers and Interdependent Preferences^{*}

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Abstract

I analyze an optimal wealth distribution in a two-person two-good model with heterogenous workers and asymmetric social interactions where only one (social) individual derives positive or negative utility from the leisure of the other (non-social) individual. I show that in most cases at the social optimum there is a considerable wealth dispersion which arises either due to the differences in ability or interdependent preferences or both. A calibrated model with the quasi-linear utility function not only moderately well approximates magnitudes of wealth, earnings, and total income inequalities, but also matches the relative structure of the distributions in the US.

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1. Introduction

Analysis of economic inequality has been the focus of economic research ever since the data on personal incomes became available. Due to natural differences in ability the dispersion of earnings is generally accepted as a natural state of the market economy. However, the distribution of wealth has sometimes been the focus of normative discussions because it relates to issues of equal opportunity, discrimination, and social class stratification. Moreover, economic theory holds that there is a fundamental trade-off between equity and efficiency). The implication is that richer societies must pay in terms of welfare due to inequality because equality is regarded as the most socially desirable outcome.¹ This paper proposes that wealth equality optimizes social welfare only in special cases. Therefore, I study an existence of optimal wealth distribution that maximizes social welfare, conditional on the dispersion of wages (which proxy for ability) and level of social interactions in a society. The result implies that policy makers may first need to determine a socially optimal level of wealth inequality in order to impose an effective redistributive policy because it is not obvious why the equality of wealth, earnings, or total income is the best choice for a society. For example, government may find it beneficial to accept and promote high earnings inequality when it helps to outweigh wealth inequality and reduce inequality of utility and total income.

Wealth inequality, defined as non-labor part of income, is an important component of income inequality and there are consistent patterns across many countries suggesting that inequality of wealth is relatively stable and high (Davies and Shorrocks 2000). Earnings, defined as labor income, are usually distributed less unequally than wealth; however, more developed societies tend to have higher dispersion of earnings due to higher rewards to ability. Income, defined as the sum of wealth and earnings, is usually much less unequally distributed, mostly due to the smoothing effect of earnings (wealthy individuals work less). Such patterns of wealth, earnings,

and income inequalities can be generated in various economic models. Mookherjee and Ray (2003) show that under very weak assumptions in a dynamic model of dynasties there will be inequality in incomes at the steady state. Castaneda et al. (forthcoming) manages to mimic closely US wealth, earnings, and income distributions in a dynamic model with identical altruistic households who face uninsured idiosyncratic shocks to their endowments of efficiency labor units and who go through the retirement stage.

Evaluation of inequality has its efficiency and welfare aspects. Studies usually point to the efficiency-equity trade-off: higher growth or lower deadweight loss, but lower social welfare. From the efficiency viewpoint, inequality of wealth can potentially generate capital accumulation necessary for growth, or wage inequality may induce high-ability individuals to invest in time-consuming human capital accumulation so that they can recover forgone earnings. Therefore Burtless (2003) claims that a certain level of inequality may promote economic growth and he argues that because US imposes fewer restrictions on economic agents and provides less help to disadvantaged people the government does not have to sacrifice efficiency in order to achieve economic equality. Sell and Blumle (1998) formalize the argument and derive an optimal inequality for the highest economic growth. Furthermore, Scully (2003) provides estimates of growth-maximizing levels of inequality. Ray and Ueda (1996) show that the inefficiency can be decreased if we consider a less egalitarian social welfare function in the economy in which the social planner distributes goods produced by individuals and bases his decisions on their contributions. In a more microeconomic approach Neal and Rosen (2000), who review theories of earnings inequality, show that without inequality workers would not invest in human capital, and thus growth might be lower. Along those lines, Benabou (2002) shows that inequality generated by investment in education increases economic growth. Therefore, Welch (1999) argues that in many situations wage inequality is beneficial for better allocation of resources and human capital accumulation. He argues that higher inequality can increase welfare because the dispersion of

incomes can offer increased opportunities for specialization and better coordination of skills and activities. Welch admits that the benefits of more unequal distribution can be appreciated only as long as low-wage workers do not view the income distribution as unfair and there are opportunities for upward mobility. The above evidence suggests that inequality may in many circumstances be beneficial for the economy. Thus, if we can find an optimal, or at least socially acceptable level of income inequality, then society may benefit more from the government policies that foster economic growth and investment in human capital than from policies that attempt to provide more equity in the economy.

An evaluation of economic inequality from the welfare perspective usually boils down to assuming a social welfare function that satisfies certain properties and then deriving appropriate indexes of inequality. In most circumstances a higher income inequality is classified as lower welfare (Atkinson and Bourguignon, 2000) and researchers go to great extends to compare stochastic distributions. However, there are also studies suggesting that objective measures of inequality (like a Gini coefficient) are not adequate for evaluating well-being. Moyes (2003) shows that when the principle of minimal equal sacrifice is applied to make incomes more equal the goal of the policy should be to decrease the relative inequality, not absolute inequality. Lambert et al. (2003) hypothesize that there is a 'natural level' of subjective inequality equal between countries, as measured by the Atkinson index. Therefore, observed differences in objective inequality as measured, for example, by the Gini coefficient are due to differences in inequality aversion between countries, whereas the income distributions may actually be perceived as having the same level of inequality between societies. Confirming a subjective-based evaluation of inequality there is evidence that Americans may not object to high inequality to the extent that Europeans do, even if in Europe the objective inequality is lower (Alesina, Di Tella, and MacCulloch, 2001). In fact, even though there is a consensus among citizens of many countries about the need for the redistributive role of the government, there is no general

acceptance of the idea of income equality (Levison et al., 2003). One explanation for this result may be that income mobility matters for welfare evaluation, not income inequality (Alesina and La Ferrara, 2001). Formalization of the argument lets Creedy and Wilhelm (2002) show how different mobility patterns may affect the evaluation of inequality, and sometimes the offsetting mobility can decrease long-run inequality even though short-run inequality may increase. Authors suggest a direct use of social welfare measure (not through derived indexes) to properly evaluate changes in inequality because higher inequality may be desirable if it brings more mobility. Gottschalk and Spolaore (2002) apply a similar framework to indirectly evaluate inequality by incorporating different patterns for mobility. They find that when aversion to inequality is the only consideration, the U.S. gains more from mobility than does Germany.

Besides the discussion on how to properly evaluate the impact of income inequality on welfare, Podder (1998) argues that the level of inequality, however measured, may not be a good measure of social welfare. He suggests that well-being should be evaluated from the perspective of the degree of social discontent, represented by the level of social envy, which is a non-monotonic function of inequality. The approach has merit; Brams and Fishburn (2000) show that envy-free allocations are feasible and Nishimura (2003) proposes a taxation scheme that reduces envy. Chakravarty and Moyes (2003) analyze income taxes from the perspective of utility (social deprivation), not income distribution, and find that certain classes of utility functions ensure that progressive taxation always implies an improvement in the distribution of well-being as measured by the amount of reduction in deprivation felt in society. Therefore, interdependence of preferences and cross-evaluations between consumers in the economy is a critical part of evaluating income distribution from the welfare perspective. In fact, Bernheim and Stark (1988) show that an altruism, a form of social interaction, affects the utility possibility frontier in a non-trivial way and may even cause inefficiency. The intuition is that the individual who behaves in a way that harms others' welfare affects other individuals and thus others also react negatively.

Along the same lines, Kooreman and Schoonbeek (forthcoming) argue that conspicuous consumption has a negative effect on social welfare and that the market equilibrium represented by the Nash equilibrium can produce suboptimal outcomes. Therefore, in order to evaluate a particular income distribution many authors argue not only that the level of objective and subjective inequality should be considered but that other non-market effects should also be introduced, including social interactions. This reasoning suggests that, due to various distortions to the assumption of homogeneous population, there is a possibility that incomes will be unequal at the social optimum.

The notion that at the social welfare optimum identical households within a city should not be treated equally, except in special cases, was first introduced by Mirrlees (1972). The intuition of that result stems from the fact that there are different resource costs of making households at different locations in a city equally well off. In the context of the distribution of welfare in cities, White (1981) confirms the result and argues that when there are differing transportation costs then equal households in cities will not be treated equally (in terms of welfare) at the social optimum because of differing costs to make different households better off (the social planner needs to give more money to households for whom he can more efficiently improve welfare). In a slightly different context, Pestieau et al. (2002) shows that when individuals have different risk aversion levels there may be a tendency for an unequal income in order to maximize social welfare. Kreider (2003) argues similarly and shows that when incomes are uncertain the optimal redistribution may be to take income away from individuals suffering negative income shock even if the redistributive policy causes their utility to fall even further. Besides results obtained in various economic models, the subjective evidence suggests that in fact inequality may be good for the economy in the same way that the natural level of unemployment is (Alesina and La Ferrara, 2001). Therefore, the goal of the researcher should be to determine the welfare maximizing dispersion of incomes.

In this paper I extend the literature on evaluation of economic inequality. In addition to modeling heterogeneous agents in terms of wage distribution, I introduce social interactions (SI) as one of the factors that may affect welfare evaluations. For simplicity I use a quasi-linear utility function and assume an economy with two heterogeneous (in ability) workers and two goods. One individual is social and either cares for the other person's leisure (eg., a parent cares for children's vacation time, or a spouse cares for the free time of his mate because that improves the family welfare), or is envious of the other's leisure (eg. workers envy the free time of non-workers who can support themselves with their wealth). Therefore, my setup is very similar to the models used in the family studies, with the distinction that individuals are independent workers and respond only to each other's choices, but not to utilities (see a comprehensive review in Bergstrom, 1997).²

The results suggest that when workers have different wages it is optimal to redistribute wealth from high-wage workers to low-wage workers; overall the utility inequality increases, but the total income inequality remains the same (increased earnings inequality has a compensating effect). When workers have the same wages but one individual is social, the optimal wealth distribution suggests taking wealth away from the individual who derives more utility when given the same resources (with negative SI - from the non-social individual, with positive SI - from the social individual). Inequality of utility decreases relative to the case of perfect equality, with social individual always having more utility (regardless of whether it is positive or negative). The intuition of the findings is similar to other studies on optimal inequality where it is best to redistribute income to individuals for whom it is easier to increase welfare (in my case, low-wage workers who have a low price of leisure, non-social individuals who have a positive effect on other workers, and negatively social individuals for whom it is easier to reduce negative utility).

I analyze two cases where wage heterogeneity and social interactions counteract (the low-wage individual is positively social and the high-wage individual is negatively social). I

show that under special conditions it is possible that at the social optimum there is wealth equality. However, the outcome does not guarantee earnings or total income equality, and therefore any combination of simultaneous wealth, earnings, or income equality at the social optimum should be regarded as a very special case. The results imply that when the society has interdependent preferences, individuals may potentially not only accept a relatively high level of wealth inequality but also that under optimal wealth inequality there is an order-preserving reduction in inequality of utility.

I calibrate parameters for the quasi-linear utility function using estimated parameters for the Stone-Geary utility function. If the model is correct (because it moderately well approximates not only wealth, earnings, and total income inequality but also the relative structure of the distributions), the simulation results suggest that half of the population is positively social and has lower wages. Therefore, if the US were at the optimum level of the wealth distribution, with about 67 percent of wealth belonging to the top 50 percent of the low-wage, social workers [*(in possession by social individual)*], and we decided to completely reduce the wealth inequality to zero, there would be a potential welfare loss of about 0.029 percent.

2. Model

I assume a two-worker two-good economy where each worker has the same individual preferences for consumption and leisure. Heterogeneity of agents is introduced by the differences in wages; half the population can be classified as high-wage workers and the other half can be viewed as low-wage workers. Although the assumption is a great simplification of reality, we can think of it in very simple terms: part of the population that goes to college vs. others. In fact, a dummy variable indicating some university education is commonly used in labor economics studies because it avoids problems with potentially endogenous years of schooling being introduced into the estimating equation.

Social interactions are introduced to the first individual's preference similarly to the approach in Brock and Durlauf (2001). In addition to the individual utility, the worker has a social part in his total utility, which represents the fact that he cares for the other person's choice of leisure. The simple setup assumes that half the population is social and the other half is selfish (non-social). Interestingly, this assumption may not be far from the reality. Falk and Fischbacher (2002) set up a direct experiment which helped them identify around 44% of individuals as selfish and 42% as reciprocal. It is a powerful result because it may help to explain experimental results that are otherwise difficult to explain within the framework of the classical economic theory that rational individuals make decisions independent of his or her environment (eg. dictator games) (Fehr and Schmidt, 1999). Also, a model of Castaneda et al. (forthcoming) successfully mimics US wealth distribution partially because it introduces altruism into the framework. Thus, the very simple view of the world implied by my model that half of the population is social may mean that at any given time there are two generations of equal number in the society, selfish young and altruistic old. For example, oftentimes the older generation sacrifices its free time to take care for grandchildren so that their children can have more free time.

In the following setup the social planner redistributes total wealth (Y) between two workers in order to maximize social welfare (W) subject to the social constraint, where each worker individually maximizes his utility subject to the individual budget constraint. Therefore, the approach is different from the standard general equilibrium analysis where the social planner maximizes social welfare by choosing particular combinations of consumption and leisure for each individual and where wealth is treated as an exogenous endowment. Formally, the model can be represented as

$$\begin{aligned} \max_{Y_1, Y_2} W &= W(V_1(c_1^*, l_1^*; \beta, S(l_2^*; \delta)), V_2(c_2^*, l_2^*; \beta)) \\ \text{st. } Y &= Y_1 + Y_2 \quad \text{social wealth constraint,} \end{aligned} \tag{1}$$

where subscripts index the worker, c is consumption of the generic good, l is leisure, $(\)^*$

indicates the utility maximizing choice for each individual of consumption and leisure, Y is non-labor income, S is social utility (which represents social interactions), V stands for total individual utility, W is the social welfare function (SWF), and β, δ are parameters. The social planner chooses a combination of wealth (Y_1, Y_2) that maximizes social welfare (W) subject to the individual maximization conditions and the social constraint.

The social maximization condition requires that the social welfare function is tangent to the budget constraint. Therefore the SWF marginal rate of substitution should equal minus the slope of the utility possibility frontier

$$\frac{W_{V_1}}{W_{V_2}} = -\frac{dV_1}{dV_2}, \quad (2)$$

where W_{V_1} and W_{V_2} represent marginal social utilities with respect to individual utilities. Because the distribution is done with respect to wealth, there is no clear relation of the ratio in (2) to a particular wealth distribution, and therefore we want to restate the condition in the wealth space as

$$\frac{W_{Y_1}}{W_{Y_2}} = -\frac{dY_1}{dY_2} = 1 \quad (3)$$

because the budget constraint is a straight line with the slope of negative one. By representing the SWF in (1) as an indirect social welfare function in w and Y , and considering that condition (3) must be satisfied for the solution of the optimization problem (Y_1^*, Y_2^*) , given $(w_1, w_2, \beta, \delta)$, we have

$$\frac{W_{V_1} \frac{\partial V_1(w_1, Y_1^*)}{\partial Y}}{W_{V_2} \frac{\partial V_2(w_2, Y_2^*)}{\partial Y} + W_{V_1} \frac{\partial V_1}{\partial S} \frac{\partial S(w_2, Y_2^*)}{\partial Y}} = 1. \quad (4)$$

Notice that due to social interactions the marginal utility of wealth for the second individual is altered by $W_{V_1} \frac{\partial V_1}{\partial S} \frac{\partial S(w_2, Y_2^*)}{\partial Y}$ because the leisure of the second worker affects the first worker's utility.

Now for the moment suppose that there are no social interactions, and thus

$W_{V_1} \frac{\partial V_1}{\partial S} \frac{\partial S(w_2, Y_2^*)}{\partial Y} = 0$. For the social optimum to be at equal wealth distribution, that is $Y_1^* = Y_2^*$, either the wages have to be the same ($w_1 = w_2$), or else there is no income effect due to a change in wages ($dY/dw = 0$). Both assumptions are special cases and therefore in general the wage heterogeneity should result in unequal optimal distribution of wealth. By the same token when there are social interactions, let us suppose that wages are equal ($w_1 = w_2$), and formula (4) holds only when $\frac{\partial S(w_2, Y_2^*)}{\partial Y} = 0$. The effect of income on social utility is zero only when the second worker's demand for leisure is not affected by income (dl_2^*/dY), which again is a very special case. Therefore, in general social interactions should produce unequal wealth distribution. The interesting feature of my modeling strategy is that both heterogeneity of wages and social interactions can be incorporated and when the effects counteract each other, even though the possibility of such a coincidence in particular wage distribution and social interactions pattern is low, it is possible that at the optimum there is an equal wealth distribution.

One could potentially perform comparative statics using total differential of the first order conditions for (1), and obtain dY_1/dw_1 , dY_1/dw_2 , $dY_2/d\delta$, dY_2/dw_2 , dY_2/dw_1 , $dY_2/d\delta$. However, not only are the derivatives not very informative about relative changes to optimal wealth distribution, but there are also there difficulties with analyzing the changes due to uncertain signs of $\partial V_1/\partial Y_1 \partial w_1$, $\partial V_2/\partial Y_2 \partial w_2$, $\partial S/\partial Y_2 \partial w_2$, and $\partial S/\partial Y_2 \partial \delta$ (derivations omitted). Therefore unless a researcher makes certain assumptions about particular marginal effects, analytical comparative statics is not very useful. As a result, I decide to select a functional form, calibrate the parameters of the individual utility function, and perform simulations in order to obtain results of the numerical comparative statics.

In order to analyze what exactly happens to the wealth distribution and obtain a close form solution, I need to assume particular functional forms for the individual utility function, social

utility, and social welfare function. Social welfare function is assumed to be utilitarian. I acknowledge the fact that the utilitarian social welfare function does not satisfy the condition of independence of utility units in the axiomatic bargaining approach (as for example, the general utilitarian $W = u_1 u_2$ does; MasCollé et al. 1997, p. 841). However, because I model exactly the same workers with the same parameters to compare their utilities, the utility units are by construction the same and the analytical setup mitigates the consequences of violating the condition of independence. Also, a utilitarian utility function treats every individual as equal, and such a value judgement allows for the greatest inequality of utility but the smallest inequality of wealth. The utilitarian social planner has no aversion to utility inequality, i.e. a utilitarian SWF is neutral towards inequality in the distribution of utility. Therefore, there is no incentive to redistribute wealth on the basis of utility inequality, but only on the basis of maximization of social welfare. In a certain sense a utilitarian SWF should be the most wealth equalizing and the most utility unequalizing choice. Thus I believe that my results, which show significant wealth inequality at the optimum, are stronger with a utilitarian SWF than any other SWF, such as a Bergstrom-Samuelson class of quasi-linear social welfare functions. I also avoid the difficulty of making particular value judgements when assigning social weights to individuals.

The individual and social utility are represented by a simple quasi-linear functional form, for convenience and analytical tractability. For example, there are other attractive utility functions, like Stone-Geary, which is probably the most often used in studies on interactions (Gaertner 1974, Pollak 1976, Pollak and Wales 1992, Kapteyn et al. 1997, Soetevent and Kooreman 2002, Kooreman and Schoonbeek (forthcoming)). However, because the utility possibility frontier is a straight line in the case of Stone-Geary a utilitarian social welfare function, which is also a straight line, may not be a realistic choice as we shall obtain either a corner solution or an infinite number of solutions.³ Therefore, one would need to choose a strictly concave social welfare function and make a normative judgement about the weights given to the individual utilities.

Moreover, in non-additive cases of individual utility most often the derived demands are interdependent. Therefore one needs to treat the demands as best response functions and compute a Nash equilibrium as the market equilibrium. When the Nash equilibrium does not coincide with Pareto efficient allocation a researcher has the dilemma of choosing a benchmark result: Nash or Pareto efficient or equal wealth distribution. To avoid the dilemma, one may choose a utility function that is non-linear but the social interactions are introduced linearly. In the maximization problem the interdependence terms will cancel out and do not appear in the demands. However, any such case may prove analytically intractable. A quasi-linear utility avoids all those difficulties and still provides a sufficient level of complexity in order model the economy.

Finally, note that in the following I use wealth and non-labor income as equivalent terms though in practice these two are different sources of income. Wealth is a sum of non-labor income discounted by the interest rate: $(\text{non-labor income})/r$. Therefore I implicitly assume that $r = 0$ in my static model. There are only two periods and therefore all sources of income become stocks.

2.1 Basic setup with heterogenous agents

I begin with the baseline case without social interactions. Suppose there are two workers in the economy with different wages, who face the same budget constraint, and thus their optimization problem becomes:

$$\max_{c_i, l_i} u_i = \beta_c \sqrt{c_i} + \beta_l \sqrt{l_i} \quad (5)$$

$$\text{st. } c_i + w_i l_i = w_i T + Y_i, \quad (6)$$

where i indexes the individual ($i = 1, 2$), c is consumption of the generic good, l is leisure, T is total available time, w is the wage rate (price of consumption is 1 and is taken as numeraire), Y is non-labor income, and β_c, β_l are parameters. Note that $(T - l)$ represents labor supply and $w(T - l)$ is total earnings. The particular form of the utility function in (5) has the property that even though it is quasi-linear the production possibility frontier is still convex.

The demands for both individuals are the same:

$$c_i = (w_i T + Y_i) P_{c_i} \quad (7)$$

$$l_i = (w_i T + Y_i) P_{l_i}, \quad (8)$$

where $P_{c_i} = 1/(1 + \beta_l^2/(\beta_c^2 w_i))$, $P_{l_i} = 1/(w_i(1 + (\beta_c^2 w_i)/\beta_l^2))$, and the resulting indirect utility function is:

$$V_i = \beta_c \sqrt{(w_i T + Y_i) P_{c_i}} + \beta_l \sqrt{(w_i T + Y_i) P_{l_i}}. \quad (9)$$

Therefore, by solving for Y_i and using the condition that the total distribution of non-labor income is constrained by $Y = Y_1 + Y_2$, the utility possibility frontier (UPF) for different distributions of wealth is:

$$s_1 V_1^2 + s_2 V_2^2 = Y + w_1 T + w_2 T, \quad (10)$$

where $s_1 = 1/(\beta_c \sqrt{P_{c_1}} + \beta_l \sqrt{P_{l_1}})^2$, $s_2 = 1/(\beta_c \sqrt{P_{c_2}} + \beta_l \sqrt{P_{l_2}})^2$. Notice that the UPF is convex and when $w_1 = w_2 = w$ it is symmetric around the 45 degree line. Differences in wages have two effects: (i) the shift of the entire UPF outward (it can be called the potential income effect as the right hand side of (6) changes), and (ii) the slope of UPF changes because the coefficients s_i change (it can be called a substitution effect as, due to the change of the price for leisure, the marginal individual utilities of SWF change).

The goal of the analysis is to distribute the total wealth between two individuals in order to maximize social welfare, assuming there are no efficiency costs associated with undertaking the redistribution. Because I use the utilitarian social welfare function, the problem for the benevolent planner becomes:

$$\max_{Y_1, Y_2} W = u_1 + u_2 \quad (11)$$

$$\text{st. } Y = Y_1 + Y_2. \quad (12)$$

Notice that because the utility possibility frontier is convex and a linear social welfare function is quasi-concave, there is going to be only one level of distribution for Y_1 and Y_2 at the

social maximum. When $w_1 = w_2$, each individual gets an equal share of wealth ($Y_1 = Y_2 = Y/2$) because of the symmetry of the demands (the result can be obtained from the computations below by setting $w_1 = w_2 = w$ and $\delta = 0$, and therefore the derivations are omitted). However, when wages are different the solution is not symmetric because the UPF is changing shape and there is going to be wealth inequality at the optimum.

2.2 Asymmetric social interactions

I introduce asymmetric additive social interactions into the model, meaning only one individual responds to the behavior of the other individual. Therefore suppose

$$\begin{aligned} u_1 &= \beta_c \sqrt{c_1} + \beta_l \sqrt{l_1} + \delta_l \sqrt{l_2} \\ u_2 &= \beta_c \sqrt{c_2} + \beta_l \sqrt{l_2}, \end{aligned} \tag{13}$$

where δ_l represents the parameter of social interactions. Of course, I could introduce a more general model with δ_j being individual/good-specific. In that framework my setup would reflect choosing particular parameters so that $\delta_{ji} \neq 0$, where j represents a good and i represents index for an individual. However, I believe that discussing interactions in only one good and in one individual is sufficient to draw conclusions that reflect more general models. Notice that when $\delta_l > 0$ we can think about the altruistic behavior of the first individual with respect to the second (eg. a spouse cares for the partner's rest or parents care for leisure of their offspring), but when $\delta_l < 0$ we can think about envious behavior (eg. in the family setting, siblings may feel rivalry over how much attention they are given from their parents because attention translates into higher levels of quality for leisure time). Therefore the approach is quite flexible and the model can in fact generate almost any pattern of wealth, earnings, and income distribution.

The introduction of social interactions in (13) helps to avoid the problem of a concave utility possibility set that is usually encountered when there are externalities or public goods (Baumol and Oates 1988, Bergstrom 1997). Also, because of the particular form of the individual utility

for the social worker, the demands are the same as in the case of no interactions (because social utility is introduced additively and does not depend on the individual choice of the social individual). However, the indirect utility function for the social individual becomes:

$$V_1 = \sqrt{(w_1 T + Y_1)} \left(\beta_c \sqrt{P_{c_1}} + \beta_l \sqrt{P_{l_1}} \right) + \delta_l \sqrt{(w_1 T + Y_2) P_{l_2}}. \quad (14)$$

After solving for Y_1 and Y_2 in terms of the indirect utility functions V_1 and V_2 , plugging in Y_1 and Y_2 into the social budget constraint ($Y = Y_1 + Y_2$), the UPF becomes:

$$s_1^2 \left(V_1 - s_2 \delta_l \sqrt{P_{l_2}} V_2 \right)^2 + s_2^2 V_2^2 = Y + w_1 T + w_2 T, \quad (15)$$

where $s_1 = 1 / \left(\beta_c \sqrt{P_{c_1}} + \beta_l \sqrt{P_{l_1}} \right)$ and $s_2 = 1 / \left(\beta_c \sqrt{P_{c_2}} + \beta_l \sqrt{P_{l_2}} \right)$.

Without social interactions, when $\delta_l = 0$, I get the UPF without interactions, equation (6). When there are positive interactions ($\delta_l > 0$) the UPF is shifted rightward (toward the utility of the social individual (1)) by the amount $s_2 \delta_l \sqrt{P_{l_2}} V_2$, which represents the compensation that the social individual gets from interdependence. The magnitude of the rightward shift is increasing in V_2 . Therefore, the social individual has the highest social utility when all the resources are devoted to the non-social individual and V_2 is at the maximum level.

The problem for the benevolent planner is to maximize social welfare subject to the social constraint defined in the same way as before by (11) and (12). However, because the shape of the UPF changes, the optimal levels for Y_1 and Y_2 are not equal anymore and the solution is not symmetric. The optimal allocation of wealth becomes:

$$Y_1 = \frac{Y - P^2 w_1 T + w_2 T}{(P^2 + 1)} \quad (16)$$

$$Y_2 = P^2 w_1 T - w_2 T + P^2 \frac{Y - P^2 w_1 T + w_2 T}{(P^2 + 1)}, \quad (17)$$

where $P = \left(\beta_c \sqrt{P_{c_2}} + (\beta_l + \delta_l) \sqrt{P_{l_2}} \right) / \left(\beta_c \sqrt{P_{c_1}} + \beta_l \sqrt{P_{l_1}} \right)$. By setting $\delta_l = 0$ I get the baseline case with $Y_1 = Y_2 = \frac{Y}{2}$. Because I assume $\delta \neq 0$ I know that in general $Y_1 \neq Y_2$ and therefore the

optimal wealth distribution generates some sort of wealth inequality. For example, when $\delta_l \geq 0$ and $w_1 = w_2$ (which implies that $P_{c_1} = P_{c_2}$ and $P_{l_1} = P_{l_2}$) I know that $P > 1$. Therefore, when both individuals have the same wage rate then the non-social individual always receives more wealth to compensate for his lack of social component in the utility. However, when wages are different the analysis has to be done for each case separately.

3. Numerical results

So far I have shown that if the wages for individuals differ or when social interactions are present in the society and interdependence is introduced in the asymmetric way (only part of the population responds to other consumers' demands), the utility possibility frontier changes shape and the optimal level of wealth distribution is not symmetric. In the following section I calibrate the parameters of the utility function in (5), introduce both heterogenous wages and social interactions (as in (13)), and compute the potential optimal distributions of wealth, earnings, and income.

3.1. Calibration

The demands derived from the utility function in (5) are highly non-linear both in the variables and the parameters, and I am not aware of any attempt to estimate either the consumption or leisure demand functions presented in (7) and (8). Therefore, I decide to calibrate parameters of the utility functions in (5) by fitting another utility function with relatively well-known parameter values. I use the parameters estimated in Grodner and Kniesner (2003), who analyze the Stone-Geary utility function of the form:

$$u_{SG} = \theta \ln(\gamma_h - h_i) + (1 - \theta) \ln(c_i - \gamma_c) \quad (18)$$

where h_i represents hours worked for consumer i , c represents consumption, γ_h is the maximum possible number of hours worked, γ_c is the minimum necessary consumption, and θ is the parameter representing the percent of income spent on leisure (I assume that $0 < \theta < 1$). Grodner

and Kniesner (2003) report all parameters estimated from the macro-economic data used in Abbott and Ashenfelter (1976) and they provide summary statistics that are important in fitting the utility functions. Therefore I use $\theta = 0.113$, $\gamma_h = 2465$, $\gamma_c = \$636$, average hours worked is $\bar{h} = 2172$, average non-labor income is $\bar{Y} = \$733$, average hourly wage rate $\bar{w} = \$0.77$, and from the budget constraint I can obtain potential average consumption for the representative consumer as $\bar{c} = \bar{w}\bar{h} + \bar{Y} = 0.77 * 2172 + 733 = 2405$ (all values are in 1967 dollars because this is the base year for the data used in the estimation). I also assume total available hours in a year as $T = 16\text{hours} * 7\text{days} * 52\text{weeks} = 5824$ hours per year, which implies that $\bar{l} = 3652$.

I can transform (18) into:

$$u_{SG} = \theta \ln(l_i - (T - \gamma_h)) + (1 - \theta) \ln(c_i - \gamma_c) \quad (19)$$

because hours worked can be expressed as $h_i = T - l_i$. Therefore, utility functions in (5) and (19) have the same arguments, l_i and c_i , and both utility functions can be represented in the same argument space. Because I know the parameters of the utility function in (19), the purpose of the present exercise is to find such parameters for the utility function in (5) so that it is tangent to the utility in (19) at the particular point (I pick mean values for l_i and c_i).

The process of fitting the utility in (5) to the utility in (19) is done by taking the total differential of both (5) and (19), assuming that $du = 0$, so that we move along the same utility level curve, and then by comparing equivalent parameters in the linear approximations (see computations in appendix).

The parameters of the utility function (5) in terms of the parameters of the utility function (19) are:

$$\beta_c = \frac{2(1 - \theta) \sqrt{c_i}}{(c_i - \gamma_c)}, \quad \beta_l = \frac{2\theta \sqrt{l_i}}{l_i - (T - \gamma_h)}. \quad (20)$$

At the point $c_i = 2405$, $l_i = 3652$, $Y_i = 733$ (mean values of the data) I get $\beta_c = 0.0492$ and $\beta_l = 0.0466$. Therefore, the utility curves (5) and (19) are tangent to each other at the utility

maximization point and subject to exactly the same budget constraint. I present the idea of fitting utilities and how well they match on Graph 1A. We can see that the quasi-linear utility function is not flexible enough to well approximate the Stone-Geary utility function on the whole argument space. However, in the neighborhood of the optimal point (mean value) the error is not very large. I pick various levels of $\delta_l = \{-0.01, \dots, 0, \dots, 0.01\}$ corresponding to negative interactions (envy), no interactions, and positive interactions (altruism).⁴

3.2. Discussion

I begin the discussion of optimal wealth distribution with the case of no wage heterogeneity and no interactions, where both individuals have the same demand functions, represented by (7) and (8). The optimal level of distributing total wealth is to give each individual a half of total wealth because of symmetry of demands and utilitarian social welfare function. The outcome is Pareto optimal as it is determined by the tangency point of the utility possibility frontier and the utilitarian social welfare function. It is also a Nash equilibrium outcome determined by the market where each consumer's demands are unaffected by the interdependence.⁵ Thus the optimum is symmetric with $(c_i = 2408, l_i = 3649)$ at fixed wage $w_i = 0.77$, and individual wealth $Y_i = 733$. From (5) I can compute the individual utility for each individual as $u_i = 5.2289$ and therefore the total welfare becomes $W = 10.4578$.

In order to discuss the distributive effects of optimal wealth inequality in tables 1-3 I present the results of ratios of wealth, earnings, income (wealth+earnings), and utilities between agents 1 and 2. Each ratio is the relative proportion of each quantity for individual 1 in terms of number of units that individual 2 has. Notice that for each table parameters for the second individual are always fixed. However characteristics of the first individual change (eg. low-wage/high-wage, or positively social/negatively social). The left panel always assumes equal wealth distribution, the right panel represents the effect of optimal wealth distribution given by (16) and (17), and the last column presents the welfare loss caused by a redistribution that completely reduces wealth

inequality to zero.⁶ In the case of no wage differences and no social interactions there is neither wealth, nor earnings, nor income, nor utility inequality; I call it a baseline case. In Graph 1 I present the utility possibility frontier, which is symmetric for equal wages.

In the following I use the baseline situation as a starting point, meaning I take total wealth as a sum of non-labor incomes from each consumer, $2 * 733 = 1466$, and the focus is on how to optimally distribute the total wealth $Y = 1466$ between two individuals under various scenarios. I first introduce wage heterogeneity, then I add interactions into one individual's utility function, and finally I introduce both wage heterogeneity and social interactions at the same time.

3.2.1. Heterogenous agents

I introduce agent heterogeneity by letting one agent's wage change and holding the other worker's wage constant at the mean value. The results of the simulation are presented in table 1. The wage for agent 2 is always 0.77 whereas the wage for agent 1 is changing and ranges from 0.65 to 0.90. The baseline case of no wage heterogeneity, where both workers have equal wages of 0.77, is represented in row 4 of table 1. As expected, the optimal wealth distribution results in equal shares for each individual. There is neither wealth, nor earnings, nor income, nor utility inequality (all ratios are 1).

Now suppose worker 1 has a lower wage: first three rows of table 1. As the wage decreases for low-wage worker (1) (high-wage worker's (2) wage is held constant at 0.77), under equal wealth distribution (left panel) the low-wage worker (1) has less earnings due to lower wage, and as a result lower income. Further suppose that there is a benevolent planner who decides to redistribute wealth so that the two-person society achieves the social optimum. The right panel of table 1 presents the results, which show that under heterogenous wages it is optimal to redistribute wealth from the high-wage worker to the low-wage worker, and both individuals have the same total income because of the compensating effect of earnings. Under the optimal wealth redistribution there is higher utility inequality than in the case of wealth equality, and utility

dispersion increases with higher relative differences in wages. Notice that after redistribution the low-wage individual (1) has less earnings and the decrease is compensated by higher wealth, but he is better off because he works less, consumes less (Table A1), and has higher utility than before redistribution. Clearly, the high-wage worker (2) is paying for the welfare of the low-wage individual (1).

I demonstrate the changes to the optimum on Graph 1. The social welfare function is a straight line with equal weights for each individual. However, UPF is changing shape because the first individual has lower wage (.75) and the second individual has a higher wage (0.8702). We can see that the UPF tilts; on the one hand low low-wage worker has lower potential earnings and thus the UPF shifts inwards, but on the other hand because leisure is cheaper for the low-wage worker (1) he can derive more utility from his total income. The effects are evident in the formula for the UPF (10), where we can see that w_1 affects both the slope of UPF and the potential level of total income that is to be distributed (total wealth plus earnings of each individual). As a result of the change in shape of the UPF that favors the low-wage individual, we can see that after the redistribution he has more utility, at the expense of the high-wage individual's wealth.

The result which suggests that it is optimal to redistribute wealth to low-wage workers is almost the same as the conclusion in Mirrless (1972), White (1981), and Kreider (2003) who showed that it is optimal to invest in groups of individuals for whom it is easier to increase welfare, even if the disadvantaged group is going to have less utility than before a negative shock. In my case the high-wage worker works more because he can more efficiently generate earnings (more earnings with the same amount of time used) and therefore he is induced to work more to compensate for wealth that is taken away from him. On the other hand, the total welfare increases because the low-wage worker has a lower cost of leisure and the wealth transfer lures him away from work.

Notice that, at optimum with higher wealth inequality there is also higher earnings inequality.

Therefore, some policies to reduce earnings inequality without reduction of wealth inequality may not only be suboptimal but may actually decrease welfare. On the other hand, a the redistributive policy that affects wealth may be much more effective than a policy affecting earnings or total income because it is not only an almost efficiency-loss-free way of redistribution (no efficiency loss resulting from taxing high-wage workers and generating work disincentives for them), but also the economy achieves perfect total income equality by workers endogenously selecting the numbers of hours worked. An interesting conclusion of this part of the analysis is that high-wage individuals will not be taxed for their wages but for their wealth because it is wealth we want to redistribute to maximize income. In this model, when evaluating inequality it is the structure of inequalities that matter the most, and not necessarily their absolute levels.

Because the redistribution always makes the low-wage individual "rich" and the high-wage individual worse off, together with the increase of order-reversing utility inequality, the redistributive policy that optimizes social welfare may not be socially acceptable. Therefore, I now turn to the case where one individual derives positive or negative utility from the other individual's leisure, but not vice versa (one individual is social and the other is non-social), and I examine the consequences of the redistribution.

3.2.2. Social interactions

In equation (13) I introduce interaction into the utility function of the first individual by assuming that the second individual's leisure affects the well-being of the first individual. The parameter that represents interdependence, δ_l , can be either positive or negative, meaning that the social individual (1) can be either altruistic toward the non-social individual's (2) leisure or envious. I present the results of the simulation with asymmetric social interaction in Table 2 where δ_l ranges from -0.01 to 0.01, with the point of no interactions in between ($\delta_l = 0$). The first individual is always the social individual and individual 2 is non-social. Both workers have the same fixed wage rate at 0.77 and the social planner distributes total non-labor income, which is

fixed at 1466. First note that for $\delta_l = 0$ I obtain the baseline case with no interactions where there is no wealth, earnings, or income inequality at the social optimum.

Suppose that $\delta_l > 0$ (first three rows of table 2), meaning the social individual (1) has positive interactions. With equal distribution of wealth (left panel) both individuals make exactly the same choices of consumption and leisure as in the baseline case (wages and wealth are the same) but the social individual derives much more utility and total social welfare increases. As the interactions increase inequality of utility increases; the social individual (1) has even more of utility that comes from the social component. When the social planner decides to redistribute wealth (right panel) the strategy is to take wealth away from the social individual (1) who has more utility and distribute it to the non-social individual (2). Similarly to the case of heterogenous agents, the individual with less wealth, works more, and thus has more earnings (social individual). However, the compensation of earnings for lost wealth is not enough to bring total income (sum wealth and earnings) to equality. Notice that besides having less wealth, social individual has still more utility than the non-social individual and, as opposed to the case of wage heterogeneity, optimal redistribution always decreases utility inequality.

By the same token, when $\delta_l < 0$ (last three rows of table 2), social worker (1) experiences negative utility from higher leisure of the non-social individual (2) (negative social interactions). The optimal wealth distribution suggests redistributing wealth from the non-social individual to the negatively social individual. As a result wealth, earnings, and income inequality increase but inequality of utility decreases and the negatively social individual always has more utility.

I present the effect of social interactions on the UPF in graph 2, with the first individual having positive social interactions. Due to interdependence the UPF shifts to the right (toward more utility for social individual (1)), which means that for any utility level of the non-social individual (2) the social individual (1) has higher utility due to the social component in his utility. Also notice that the social individual (1) never has zero utility (the UPF is discontinuous and

starts at some point to the right, not at zero) because even if he has no wealth he always derives some positive utility from the other individual's leisure.⁷ The dynamics to reach the new social optimum start with the equality of wealth, where the utility level for the social individual (1) shifts parallel to the right without any change to the utility level of the non-social individual (2) (a move from the cross to the triangle sign on graph 2). In the second stage, when the social planner strives to achieve the social maximum by finding the tangency between the UPF and the social welfare function, the social individual has less wealth and thus has a bit less utility to the benefit of the second individual who has more wealth and utility than before redistribution (a move from the triangle to the square on graph 2).

Again, the intuition of the redistribution is similar to the logic used by White (1981) and Kreider (2003) where it is optimal to transfer more wealth from the individual whose utility it is easier to increase. In the case of positive spillover, the social individual (1) has less wealth because the decrease in his wealth is compensated by the non-social individual (2) having more leisure, and also the non-social individual's (2) utility increase; therefore it is cheaper to make the non-social individual (2) have more utility. When one individual negatively responds to the leisure time of the other individual it is best to take wealth away from the non-social individual (2) because the social individual's (1) utility increases not only because of higher wealth but also due to lower negative social utility; therefore it is cheaper to make the negatively social individual (1) increase his utility. Note that in the presence of social interactions the redistribution not only brings the social maximum, but in contrast to the case of heterogeneous workers, the redistribution reduces inequality of utility with the social individual always having higher utility. Looking at the wealth changes from the ethical point of view, the redistribution from the positively social individual to the non-social may be well accepted (it is done in practice in the form of foundations and other non-profit organizations), but the redistribution from the non-social individual to the envious individual may create some controversy.

To sum up the last two sections, I observe that under optimal wealth distribution the wealth is distributed from the individual who gets more utility, given that both individuals have the same wealth and wages. Therefore, wealth should be taken away from the high-wage individual, the positive social interaction individual, and the non-social individual (when the other worker has negative interactions). Notice that the effect of high wage roughly corresponds to the effect of positive interactions which creates a similar order of inequalities at the optimum: the high-wage/social individual has much less wealth (wealth has the highest inequality), earns more to compensate for lost wealth (earnings has the second highest inequality), and has less total income (income has the mildest inequality). Also, the structure of inequalities is similar (both the high-wage and positively social individuals have less wealth and more earnings), but the consumption/leisure pattern is different (in table 1A and table 2A low-wage has less consumption and more leisure, but the positively social individual has less of both consumption and leisure). Notice that the order of inequalities (wealth/earnings/income) is observed in the real data, suggesting that the model generates reasonable distributions.

3.2.3. Heterogenous agents and social interactions

So far I have analyzed independently what happens to the optimal wealth distribution when there are either a wage heterogeneity or asymmetric social interactions (only one individual is social). I showed that at the social optimum wealth is redistributed from a high-wage worker to a low-wage worker, and from a positively social to a non-social individual (or from non-social to negatively social). Next, I examine the case where the low-wage worker is social, and I expect that counteracting forces may result in the equality of wealth at the socially optimal distribution (low-wage increases wealth but being positively social decreases wealth). I also focus on the mirror case where the high-wage worker has negative social interactions.

Suppose that the non-social worker (2) is a high-wage worker with the wage rate of 0.8702, whereas the positively social individual (1) with $\delta_l = 0.01$ is a low-wage worker with

$w_1 < 0.8702$. I present simulation results in table 3.1; the first six rows represent the case of the positively social worker (1) having a low wage. Similar to the finding in table 1, as the wage for the social worker (1) decreases, the optimal wealth distribution suggests giving him more wealth. However, notice that income inequality does not change. It is completely determined by the assumed level of social interactions, and is at the ratio level 0.813 regardless of the variations in wage differences.

When the low-wage, positively social worker (1) has a wage level close to the non-social worker's wage level, the optimal wealth distribution suggests that he will have less wealth than the non-social individual (2). As the wage for the low-wage, positively social individual (1) decreases, the optimal wealth distribution suggests giving more and more wealth to the low-wage, social individual (1). Ultimately, at the wage equal to 0.75 there is no wealth inequality at the social optimum; at that point the force of low wage (contributes to more wealth for the low-wage worker) and the force of positive social interactions (the social individual needs to sacrifice more wealth) completely counteract each other. Even though it is some sort of a point of balance, where utility inequality is at the same level as when there is no redistribution (but still there is no equality of utility), at the optimal redistribution there still exist earnings and total income inequalities, with the low-wage worker (1) having less earnings and total income but higher utility. I observe that depending on how low or high (relative to wage 0.75) the wage is for the low-wage worker (1), at the social optimum the utility inequality decreases when the low-wage worker has a wage between 0.750 and 0.8702, but increases when the lower-wage worker has a wage rate below 0.75. This observation confirms the fact that, for the former range, the effect of the social interactions dominates the effect of low wage and thus he has less wealth, whereas for the latter range the effect of low wage is dominant over the effect of social interactions and thus he has more wealth. Note that there is also potentially a point of no earnings inequality at the social optimum, when the first individual has the wage between 0.80 and 0.85. However, again it

does not result in wealth equality and does not affect distribution of total income under the optimum. Equality of total income is only at the social maximum when there are no social interactions, and generally, simultaneous equality of any of two pairs between wealth, earnings, and income inequalities should be regarded as very special cases.

I also present the changes to the utility possibility frontier in graph 3. The first UPF is for equal wages, no social interactions, where the optimal wealth inequality is to distribute total wealth evenly between two workers. In the next step I introduce heterogeneity of wage so that the low-wage worker (1) has a wage equal to 0.75 and the high-wage worker (2) has a wage of 0.8702. There are two effects of heterogeneous wages: (i) the UPF shifts slightly outward because of potential income increases due to higher wage, and the slope of the UPF becomes flatter because leisure is cheaper for the low-wage individual (1) but more expensive for the high-wage worker (2). In the final step I introduce social interactions to the low-wage worker's (1) utility with $\delta_l = 0.01$, and thus the low-wage individual gains utility from the second individual's leisure. We can see that the UPF shifts to the right and counteracts the slope flattening due to heterogeneous wages. Therefore at the optimum there is equal distribution of wealth even though the ratio of utilities is slightly different than in the baseline case. Numerically the change in the maximum distribution of wealth is represented by movement from equal distribution (4th row in table 1) to another equal wealth distribution with counteracting wage heterogeneity and positive social interactions effects (3rd row in table 3.1.).

Note that when positively social worker (1) has a wage rate of 0.77 and the non-social individual (2) has a wage of 0.8702 (row two, table 3.1), welfare evaluation comparing the equal and optimal wealth distributions may be somewhat surprising. For example, under the optimal wealth distribution the social individual (1) has to sacrifice wealth for the benefit of the non-social individual (2), and therefore he has less earnings (due to a lower wage), less total income (both wealth and earnings are lower), less leisure (he needs to work more to compensate

for lost wealth), and has lower consumption (because of lower income). All the indicators would suggest that the low-wage, positively social worker (1) is greatly exploited and his welfare has been compromised. However, notice that under both the equal and optimal wealth distributions social individual is still better off in the society (he has higher individual utility). This observation underlines the need to analyze inequalities together (wealth, earnings, and total income) and calls for an introduction of social interaction in the model of income distribution because it is possible that there are circumstances of "unfair" redistribution that may not only be acceptable but even desirable for society. Along the same lines, we can argue that if the population has a particular structure of preferences and wage/ability distribution, then the society may accept high levels of inequality for various income sources, which is important for redistributive policies. In some cases a policy maker may not have to sacrifice efficiency for equity, and this result may hint why Americans have much higher acceptance of inequality even though it is at much higher levels than in many other developed countries. Even more so, the efficiency-equality trade-off may have a different meaning in my model. It is not only hard to decide whether we should focus on the equality of incomes or utility, but also whether a society might necessarily desire equity of any source of income.

In table 3.2 I also present a similar case, which guarantees that at the social optimum there is equal distribution of wealth, and the high-wage worker has negative social interactions (1) with $\delta_l = -0.01$. This situation is similar to the case of low-wage worker being positively social. There is a wage rate combination that guarantees that at the maximum social welfare there is no wealth inequality.

Because I calibrated parameters from the US economy, even though there are many misspecification errors, I attempt to assess whether the model predicts an observed distribution of wealth, earnings, and total income. First, it is widely reported that in the US wealth inequality is relatively higher than earnings inequality, which in turn is higher than the total income dispersion.

Notice that the model predicts in most cases exactly such a pattern, with low-wealth individuals working more than high-wealth individuals, and thus reducing the total income inequality. Second, when I use calculations by Rodriguez et al. (2002), sorted by wealth, the ratios of the 5th quintile to all four quintiles together are for wealth 4.4645, for earnings 0.73913, and for income 0.92678 (table 7). Notice that the numbers in table 3.1, column 2, with a wealth ratio of 2.073, an earnings ratio of 0.546, and an income ratio of 0.813 are not very far off. Therefore, I believe that the model performs relatively well considering various simplifications, possible misspecification, and measurement errors due first to the estimation of parameters and then to the calibration process. In fact, for the second case of the negatively social individual having a high wage (table 3.2, the wage for the social worker (1) equals 0.7 and the wage for the non-social worker is 0.66319), the ratios for wealth, earnings, and income inequalities are also relatively close: 3.963, 0.767, and 1.301.

Moreover, if I relax the assumption that I deal with two equal size populations and I assume that a particular proportion of low-wage workers (0.70) and high-wage workers (0.8702) generates an average wage rate of 0.77, I get a population size of the low-wage workers around 60 percent. The proportion of low-wealth workers is far from 80 percent observed for the first four quintiles in the US economy, but the model still generates the correct pattern. Therefore, the model suggests that if the US economy is at the optimum levels of wealth inequality, there may be a high population of low-wage, positively social individuals and a smaller population of high-wage, non-social individuals. Further, if we decide to distribute wealth equally in the population starting from the case of optimal wealth distribution, there is a small welfare loss of only about 0.029 percent (although this number may be highly underestimated because of different measurement errors and the choice of the particular utility functions).

Notice that the model can give an alternative explanation to changes in the distributions of US sources of income in the last 30 years. Higher wage dispersion could generate both higher

dispersion of wealth and earnings at the new optimum. Stronger social interactions, due to decreasing communications costs (digital technology, internet), could increase the level total income inequality.

4. Conclusion

I have presented a model with two heterogeneous individuals deriving utility from consumption and leisure where one of the individuals derives utility from the other's leisure (asymmetric interactions). The presence of a high level of wage dispersion suggests a higher wealth inequality and also higher earnings inequality at the social optimum, so that both distributions have compensating effects that result in equality of total income. When there is interdependence of preferences the inequality of wealth is not only an optimal outcome but is also desirable because under most conditions it increases social welfare and reduces inequality of utility. The case of wealth equality at the social optimum occurs only when agents are homogenous and do not interact, or when the effect of wage differences is exactly offset by a particular form of social interactions. Therefore, in most cases wealth inequality is the social welfare optimizing outcome, together with earnings and income inequality.

Notice that wealth equality that brings the economy to the social optimum is a very special case in my model. Thus, researchers studying the welfare effects of inequality may need to investigate not only the level of inequality of income but also the structure of inequalities (wealth, earnings, and total income), and how wage differences and potential social interactions affect workers' evaluation of the wealth, earnings, and income distributions. There may also be a need for more flexible measures of inequality, as the classical measures like the Gini and Atkinson coefficients may not necessarily be relevant.⁸

These results suggest that, from the policy perspective, wealth redistribution may be more effective to maximize social welfare than policies affecting earnings distribution because earnings

inequality is endogenous to the model and has a compensating effect for differences in wealth. However, when wealth redistribution is not feasible to the extent needed, the government may want to focus on decreasing wage inequality. In particular, when there is a significant dislike in society toward inequality of utility, the lower wage dispersion not only decreases differences in utility, but also the social planner needs to perform less drastic wealth redistribution to reach the social optimum. In addition, from the efficiency standpoint, investment in education may probably be the best way to implement policy to reduce wage dispersion by increasing wages for low ability individuals. Not only can any high-wage individuals efficiently allocate their human capital and work an optimal number of hours, but such a solution is also probably the most socially acceptable.

From the exercise shown in this paper I do not argue that wealth inequality is always beneficial for a society with unequal wages and social interactions. However, I point out the very real possibility of wealth and income inequalities that maximize welfare. For example, social interactions can potentially mitigate the adverse effects of inequality on social welfare and thus, in some circumstances, optimal inequality creates an outcome that is not only desirable from the perspective of social welfare, but is also acceptable because it reduces inequality of utility. In the presence of social interactions the redistribution is always from high-utility individuals to low-utility individuals. Therefore, it is most likely that the society will not only be willing to perform the redistribution, but also will regard such a redistribution as fair.⁹ Of course, for any sensible policy based on my analysis it is critical to identify correctly high utility individuals (these may be either social or non-social) and that may prove a formidable task.

I acknowledge that this study has many limitations and even though the calibrated model performs moderately well to approximate US inequalities, there are many potential improvements that can give more insightful results. One extension to the present project is to pick a more flexible utility function and use more precisely calibrated structural parameters. In particular a

very attractive alternative is Linear Expenditure System with interactions which had gotten much attention and there are already estimates for both structural parameters and levels of interactions. However, the researcher may need to choose carefully the social welfare function because the utility possibility frontier in the case of the Stone-Geary utility is linear. In fact, choosing a different social welfare function, not utilitarian, may be a useful extension and provide additional insights. One may just note that probably any type of strictly concave social welfare function would create higher wealth inequalities at the social optimum than the utilitarian case because the utilitarian SWF is the most wealth equalizing. Another line of future research may focus on the source of a more realistic social interactions effect. Some may argue that people do not envy or support other's free time but they rather respond to other's consumption choices because they are easier to observe. Therefore, a group of individuals can have positive or negative interactions, which can be in leisure or consumption or both. For example, it is sensible to suppose that high-wage workers are envious of time because their leisure is expensive but they are altruistic toward their consumption which is plentiful. On the other hand, low-wage workers may have positive interactions toward leisure but they may be envious about the consumption of high-wage individuals because they can generate less income with their lower wage. A more involved but realistic extension is to model a different social interactions effect, say conformity, which is related to the notion of social norms, although there may be strong analytical hurdles to overcome. In the culmination, one may attempt to model both spillover-like and conformity-like interdependence together. However, again, the model will probably be very difficult to work with analytically.

Endnotes:

- ¹ Most literature on economic inequality focuses on measuring inequality and comparing two unequal distributions to determine which is more unequal, implicitly assuming that equal distribution of incomes is the welfare maximizing outcome.
- ² In contrast to studies on the distribution of income within the family, I do not assume a public good in the household due to the benefit of living together. Rather, I assume an externality related to one consumer's behavior, which affects the other consumer. I also do not suppose that individuals can observe each other's utilities but only the choices. Moreover, the maximization is not with the respect to the distribution of goods but rather with wealth; individuals receive certain resources and they maximize their individual utilities and have individual demands. In such a setup my model is almost the same as approaches used in studies of the Rotten Kid Theorem (Becker, 1981).
- ³ Notice that in the paper by Kooreman and Shoonbeek (forthcoming) there may be a corner solution because the authors assume a utilitarian utility function that is a straight line, a Stone-Geary utility function that generates a linear utility possibility frontier, and preferences are symmetric across consumers. The convexity of the utility possibility frontier is guaranteed by varying levels of social interactions.
- ⁴ Grodner and Kniesner (2003) analyze a Stone-Geary utility function with interactions, and perhaps I could fit the parameter that represents social interactions in their model (α) with the parameter representing interdependence used in this paper (δ_i). However, because the quasi-linear utility function is not flexible enough to fit Stone-Geary utility function with interactions when interdependence is strong, I decided to use interaction levels that are specific for a quasi-linear utility.
- ⁵ Notice that in general the Nash equilibrium determined by the market forces does not have to coincide with the Pareto optimal allocation. I obtain the correspondence of demands in the present paper because of a particular form for the quasi-linear utility function.
- ⁶ I acknowledge that in fact the government has many instruments available and thus there are many different channels through which it can affect total income inequality (affecting the wealth inequality may not be the critical concern). However, because earnings inequality has such a profound effect on total inequality and is really endogenous to the model, it is much easier to focus on wealth inequality because it is the only exogenous variable in the model that the government can potentially control. Therefore, the discussion in this paper can be viewed as if the government attempts to give equal chances to individuals and reduce inequality of opportunity. It can also be viewed as if the government has an equal size pool of money to distribute in the society, which I call total wealth, and tries to find the optimal way to distribute it.
- ⁷ A potentially appropriate example is war. People who go to war know full well that their probability of dying increases and thus we can assume that the individual utility from their actions is zero because soldiers do not derive any positive utility from fighting that ultimately brings them death. However, the fact that they die for a greater cause may be enough extra/social utility that motivates them to go to the battlefield and sacrifice their lives. (here we can translate leisure as the freedom of the soldier's relatives)

- ⁸ The most obvious difficulty of using objective inequality measures like the Gini coefficient is that incomes have to be sorted from smallest to largest in order to compute the measure of dispersion. When, for example, the same ordering that is used to compute wealth inequality is applied to compute earnings inequality, the Gini coefficient does not have a good interpretation and its value can actually be negative or more than one. Also note that a very popular welfare-based inequality index, called after the authors Atkinson-Kolm (Atkinson 1971), is based on the presumption that at the perfect equality of income, welfare is maximized. When the social optimum is not at the equality of incomes the Atkinson index can in fact be negative.
- ⁹ The idea of fairness used here is only loosely related to the fairness defined in the social choice literature, where fair or envy-free distribution means that at optimum neither individual envies the other for having his or her allocation bundle.

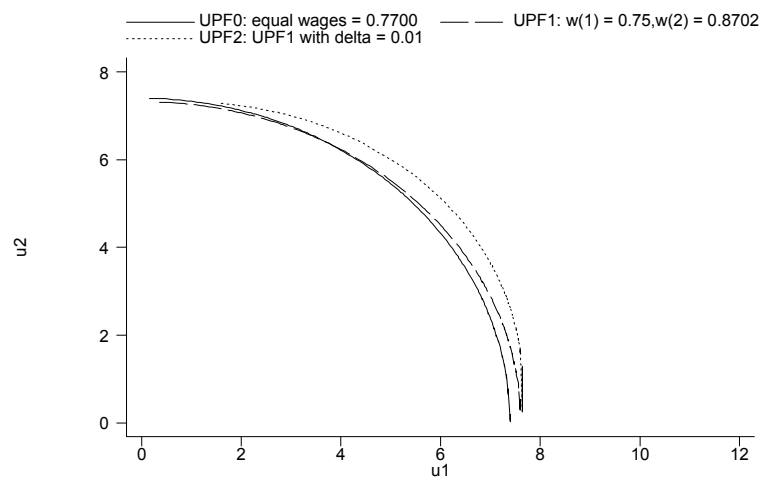
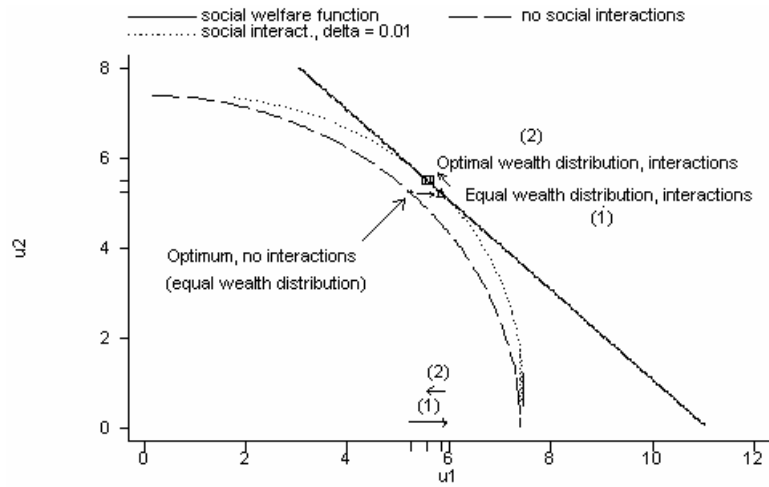
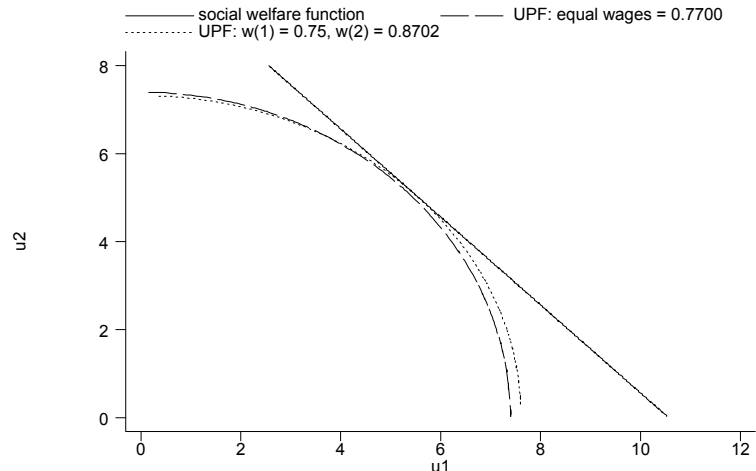


Table 1. Effect of heterogenous wage on the optimal distribution of wealth.

(total wealth always equals 1466, **wage for worker 2 is 0.77**, and ratios indicate how much more (or less) the worker 1 has relative to worker 2)

	Equal wealth distribution				Optimal wealth distribution				% welfare loss due to equality
	Wealth 1	Earnings 1	Income 1	Utility 1	Wealth 1	Earnings 1	Income 1	Utility 1	
	/ Wealth 2	/Earnings 2	/Income 2	/Utility 2	/ Wealth 2	/Earnings 2	/Income 2	/Utility 2	
0.6500	1.000	0.695	0.788	0.976	8.578	0.416	1.000	1.099	-0.178%
0.7000	1.000	0.820	0.875	0.986	2.686	0.639	1.000	1.054	-0.056%
0.7500	1.000	0.948	0.964	0.996	1.298	0.890	1.000	1.014	-0.004%
0.7700	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000%
0.8000	1.000	1.079	1.055	1.006	0.676	1.177	1.000	0.980	-0.009%
0.8500	1.000	1.212	1.147	1.017	0.324	1.509	1.000	0.949	-0.059%
0.9000	1.000	1.347	1.242	1.028	0.096	1.897	1.000	0.922	-0.146%

Table 2. Effect of social interactions in worker 1 on the optimal distribution of wealth.

(total wealth always equals 1466, wage for both workers is 0.77, and ratios indicate how much more (or less) the worker 1 has relative to worker 2)

	Equal wealth distribution				Optimal wealth distribution				% welfare loss due to equality
	Wealth 1	Earnings 1	Income 1	Utility 1	Wealth 1	Earnings 1	Income 1	Utility 1	
	/ Wealth 2	/Earnings 2	/Income 2	/Utility 2	/ Wealth 2	/Earnings 2	/Income 2	/Utility 2	
-0.0100	1.000	1.000	1.000	0.884	14.314	0.660	1.278	1.015	-0.187%
-0.0050	1.000	1.000	1.000	0.942	2.466	0.819	1.126	1.004	-0.044%
-0.0010	1.000	1.000	1.000	0.988	1.180	0.962	1.024	1.000	-0.002%
0.0000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000%
0.0010	1.000	1.000	1.000	1.012	0.849	1.039	0.977	1.000	-0.002%
0.0050	1.000	1.000	1.000	1.058	0.429	1.208	0.894	1.003	-0.039%
0.0100	1.000	1.000	1.000	1.116	0.127	1.447	0.804	1.012	-0.149%
0.0120	1.000	1.000	1.000	1.139	0.042	1.553	0.771	1.017	-0.209%

Table 3.1. Effect of heterogenous wage and social interactions in worker 1 on the optimal distribution of wealth.

Positively social individual is a low wage worker (delta = 0.01, wage for non-social worker [2] = 0.8702)

	Equal wealth distribution				Optimal wealth distribution				% welfare loss due to equality
	Wealth 1	Earnings 1	Income 1	Utility 1	Wealth 1	Earnings 1	Income 1	Utility 1	
	/ Wealth 2	/Earnings 2	/Income 2	/Utility 2	/ Wealth 2	/Earnings 2	/Income 2	/Utility 2	
0.6500	1.000	0.549	0.665	1.064	5.793	0.362	0.813	1.166	-0.126%
0.7000	1.000	0.647	0.738	1.074	2.073	0.546	0.813	1.122	-0.029%
0.7500	1.000	0.749	0.813	1.084	1.000	0.749	0.813	1.084	0.000%
0.7700	1.000	0.790	0.844	1.088	0.758	0.835	0.813	1.070	-0.004%
0.8000	1.000	0.852	0.890	1.094	0.489	0.973	0.813	1.051	-0.025%
0.8500	1.000	0.957	0.968	1.105	0.190	1.224	0.813	1.022	-0.095%
0.9000	1.000	1.064	1.048	1.115	-0.007	1.507	0.813	0.996	-0.200%

Table 3.2. Effect of heterogenous wage and social interactions in worker 1 on the optimal distribution of wealth.

Negatively social individual is a high wage worker (delta = -0.01, wage for non-social worker [2] = 0.66319)

	Equal wealth distribution				Optimal wealth distribution				% welfare loss due to equality
	Wealth 1	Earnings 1	Income 1	Utility 1	Wealth 1	Earnings 1	Income 1	Utility 1	
	/ Wealth 2	/Earnings 2	/Income 2	/Utility 2	/ Wealth 2	/Earnings 2	/Income 2	/Utility 2	
0.6500	1.000	0.955	0.972	0.874	19.423	0.488	1.301	1.031	-0.265%
0.7000	1.000	1.127	1.079	0.884	3.963	0.767	1.301	0.983	-0.109%
0.7500	1.000	1.303	1.189	0.894	1.843	1.094	1.301	0.941	-0.025%
0.7700	1.000	1.374	1.234	0.899	1.431	1.241	1.301	0.926	-0.009%
0.8000	1.000	1.483	1.301	0.905	1.000	1.483	1.301	0.905	0.000%
0.8500	1.000	1.666	1.416	0.916	0.547	1.955	1.301	0.873	-0.022%
0.9000	1.000	1.852	1.532	0.927	0.263	2.540	1.301	0.845	-0.082%

APPENDIX. Calibration

Suppose we know the parameters of the Stone-Geary utility function:

$$u_{SG} = \theta \ln(\gamma_h - h_i) + (1 - \theta) \ln(c_i - \gamma_c)$$

which can be transformed into

$$\begin{aligned} u_{SG} &= \theta \ln(\gamma_h - (T - l_i)) + (1 - \theta) \ln(c_i - \gamma_c) \\ &= \theta \ln(l_i - (T - \gamma_h)) + (1 - \theta) \ln(c_i - \gamma_c) \end{aligned}$$

I want to match the parameters at mean values with:

$$u_{QL} = \beta_c \sqrt{c_i} + \beta_l \sqrt{l_i}$$

where u_{QL} stands for the quasi-linear utility as opposed to Stone-Geary utility u_{SG} .

Thus, I want to fit three known parameters ($\theta, \gamma_h, \gamma_c$) into two unknown parameters (β_c, β_l) of a different utility function. I take the total differential of both utility functions:

$$\begin{aligned} du_{SG} &= \frac{(1 - \theta)}{(c_i - \gamma_c)} dc_i + \frac{\theta}{l_i - (T - \gamma_h)} dl_i \\ du_{QL} &= \beta_c \frac{1}{2\sqrt{c_i}} dc_i + \beta_l \frac{1}{2\sqrt{l_i}} dl_i \end{aligned}$$

Now suppose there is no change in utility, just the movement along the utility curves, meaning du_{SG} and du_{QL} are zero. At the particular point (ex. mean values) the two utility curves are tangent when the coefficients on differentials are the same. Therefore,

$$\begin{aligned} \frac{(1 - \theta)}{(c_i - \gamma_c)} &= \beta_c \frac{1}{2\sqrt{c_i}} \\ \frac{\theta}{l_i - (T - \gamma_h)} &= \beta_l \frac{1}{2\sqrt{l_i}} \end{aligned}$$

and the solution is:

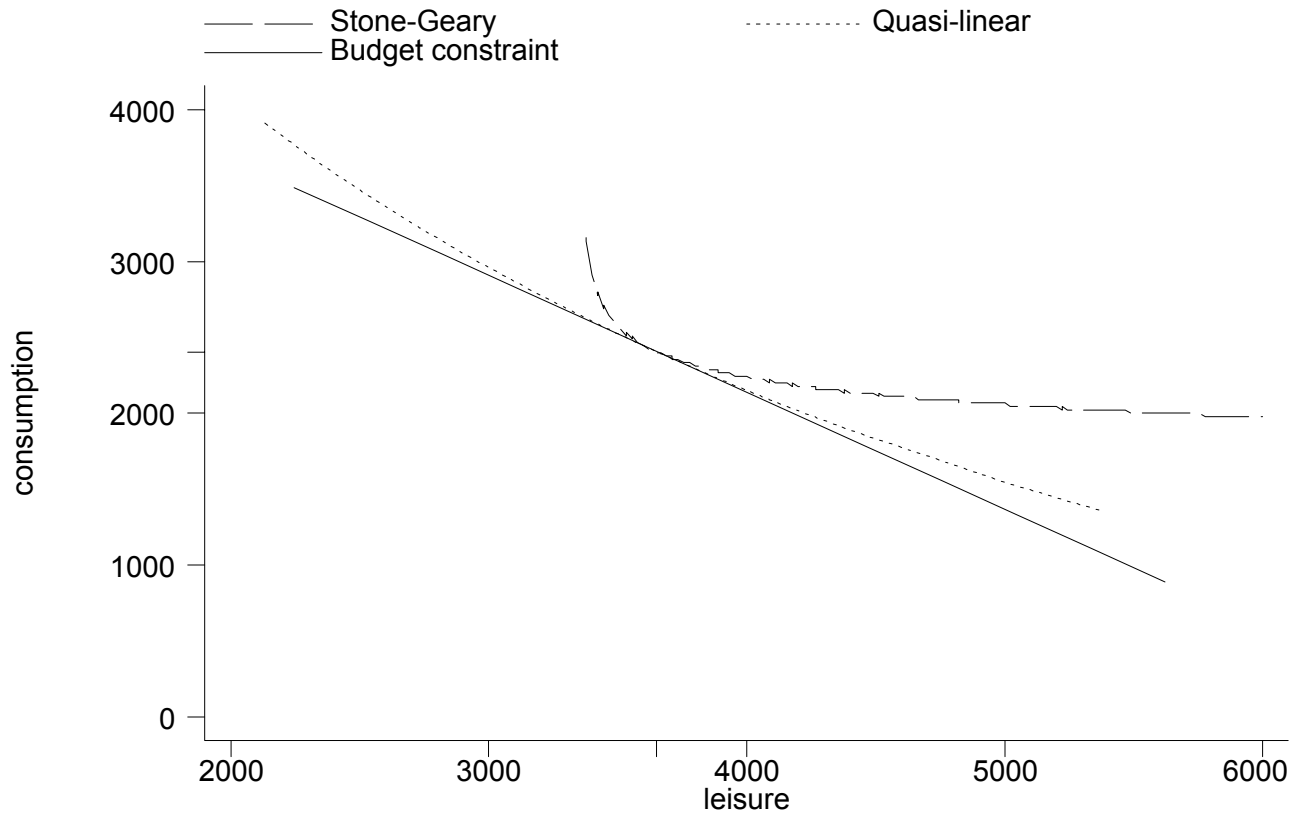
$$\begin{aligned} \beta_c &= \frac{2(1 - \theta) \sqrt{c_i}}{(c_i - \gamma_c)} \\ \beta_l &= \frac{2\theta \sqrt{l_i}}{l_i - (T - \gamma_h)} \end{aligned}$$

I have the following parameter values: $\theta = 0.113$, $\gamma_h = 2465$, $\gamma_c = \$636$, and I want to fit utility in (9) to the utility in (15) at the mean values of annual hours worked $\bar{h} = 2172$, non-labor income $\bar{Y} = \$733$, and hourly wage rate $\bar{w} = \$0.77$; from the budget constraint I obtain potential average consumption for the representative consumer as

$\bar{c} = \bar{w}\bar{h} + \bar{Y} = 0.77 * 2172 + 733 = 2405$, and average leisure is $\bar{l} = 3652$ because I assume $T = 16\text{hours} * 7\text{days} * 52\text{weeks} = 5824$ hours per year, which implies that $T - l_i = h_i \Rightarrow 5824 - l_i = 2172 \Rightarrow l_i = 3652$. Thus

$$\beta_c = \frac{2(1 - \theta) \sqrt{c_i}}{(c_i - \gamma_c)} \Rightarrow \beta_c = \frac{2(1 - 0.113) \sqrt{2405}}{(2405 - 636)} = 0.0492$$

$$\beta_l = \frac{2\theta \sqrt{l_i}}{l_i - (T - \gamma_h)} \Rightarrow \beta_l = \frac{2 * 0.113 \sqrt{3652}}{3652 - (5824 - 2465)} = 0.0466$$



Graph A1. Fit of Quasi-linear to Stone-Geary utility function.

Table A1. Effect of heterogenous wages on leisure and consumption demands under optimal wealth distribution.
(wage for worker 2 is 0.77)

		Equal wealth distribution				Optimal wealth distribution			
		Worker 1		Worker 2		Worker 1		Worker 2	
		Consumption	Leisure	Consumption	Leisure	Consumption	Leisure	Consumption	Leisure
Wage for worker 1	0.6500	1897	4033	2408	3649	2140	4551	2140	3243
	0.7000	2106	3862	2408	3649	2253	4131	2253	3414
	0.7500	2321	3707	2408	3649	2364	3776	2364	3582
	0.7700	2408	3649	2408	3649	2408	3649	2408	3649
	0.8000	2540	3565	2408	3649	2473	3472	2473	3748
	0.8500	2763	3436	2408	3649	2581	3209	2581	3911
	0.9000	2990	3316	2408	3649	2687	2980	2687	4072

Table A2. Effect of social interactions on leisure and consumption demands under optimal wealth distribution.
(wage for both workers is 0.77)

		Equal wealth distribution				Optimal wealth distribution			
		Worker 1 – social		Worker 2 – non-social		Worker 1 – social		Worker 2 – non-social	
		Consumption	Leisure	Consumption	Leisure	Consumption	Leisure	Consumption	Leisure
Delta for worker 1	-0.0100	2408	3649	2408	3649	2702	4094	2114	3203
	-0.0050	2408	3649	2408	3649	2551	3865	2265	3432
	-0.0010	2408	3649	2408	3649	2436	3691	2380	3606
	0.0000	2408	3649	2408	3649	2408	3649	2408	3649
	0.0010	2408	3649	2408	3649	2380	3606	2380	3606
	0.0050	2408	3649	2408	3649	2273	3444	2543	3853
	0.0100	2408	3649	2408	3649	2146	3251	2670	4046
	0.0120	2408	3649	2408	3649	2097	3178	2719	4120

Table A3.1. Effect of heterogenous wage and social interactions on leisure and consumption demands under optimal wealth distribution.
(delta for worker 1 is 0.01 (**worker 1 is positively social**), wage for worker 2 is 0.8702)

		Equal wealth distribution				Optimal wealth distribution			
		Worker 1 – social		Worker 2 – non-social		Worker 1 – social		Worker 2 – non-social	
		Consumption	Leisure	Consumption	Leisure	Consumption	Leisure	Consumption	Leisure
Wage for worker 1	0.6500	1897	4033	2854	3386	2114	4495	2600	3084
	0.7000	2106	3862	2854	3386	2219	4067	2728	3237
	0.7500	2321	3707	2854	3386	2321	3707	2854	3386
	0.7700	2408	3649	2854	3386	2361	3578	2904	3445
	0.8000	2540	3565	2854	3386	2422	3399	2978	3533
	0.8500	2763	3436	2854	3386	2521	3134	3100	3677
	0.9000	2990	3316	2854	3386	2618	2904	3220	3820

Table A3.2. Effect of heterogenous wage and social interactions on leisure and consumption demands under optimal wealth distribution.
(delta for worker 1 is -0.01 (**worker 1 is negatively social**), wage for worker 2 is 0.66319)

		Equal wealth distribution				Optimal wealth distribution			
		Worker 1 – social		Worker 2 – non-social		Worker 1 – social		Worker 2 – non-social	
		Consumption	Leisure	Consumption	Leisure	Consumption	Leisure	Consumption	Leisure
Wage for worker 1	0.6500	1897	4033	1952	3986	2174	4624	1671	3413
	0.7000	2106	3862	1952	3986	2298	4213	1766	3607
	0.7500	2321	3707	1952	3986	2420	3865	1859	3798
	0.7700	2408	3649	1952	3986	2468	3740	1896	3874
	0.8000	2540	3565	1952	3986	2540	3565	1952	3986
	0.8500	2763	3436	1952	3986	2659	3306	2043	4173
	0.9000	2990	3316	1952	3986	2776	3079	2133	4357

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