Preferences over equality in the presence of costly income sorting

Gilat Levy and Ronny Razin, LSE[1]

Abstract: We analyze preferences over redistribution in societies with costly (positive) sorting according to income. We identify a new motivation for redistribution, where individuals support taxation in order to reduce the incentives to sort. We characterize a simple condition over income distributions which implies that even relatively rich voters -with income above the mean- will prefer full equality (and thus no sorting) to societies with costly sorting. We show that the condition is satisfied for relatively equal income distributions. We also relate the condition to several statistical properties which are satisfied by a large family of distribution functions.

1 Introduction

The presence of income sorting or stratification in society has received plenty of attention in the economics and sociology literature.[2] Relocating to a leafy suburb, sending your child to a private school, or engaging in conspicuous consumption of sports car, jewelry or designer clothes, have all been mentioned as ways in which people try to guarantee that they mix, interact, or match with those with the same or higher income than theirs.[3]

When individuals participate in such costly sorting, what are their preferences over redistribution? Beyond being a traditional tool for creating equality, income redistribution will potentially decrease the incentive to sort as it might decrease the benefit of mixing with other rich individuals. In this paper we explore how costly income sorting shapes individual and political preferences over redistribution.

To analyze this question, we introduce a simple model in which individuals differ in their income. We assume that the utility of an individual exhibits complementarities in his disposable income and that of those he interacts with. We consider incentive compatible partitions of

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[2]See for example Benabou (1996), Fernandez and Rogerson (2001), Kremer (1997) and Wilson (1987).

[3]The literature on conspicuous consumption includes contributions by Liebenstien (1950), Bagwell and Bernheim (1996), Pesendorfer (1995) and Heffetz (2011). Glazer and Konrad (1996) consider signalling of wealth via charitable donation which exhibits positive externalities. Moav and Neeman (2012) analyze the trade-off between conspicuous consumption and human capital as signals for unobserved income.

society into "clubs", where all individuals in the same club pay the same costly signal and interact only with each other. This framework can be seen as a reduced form of several economic environments:

Example (i): The education market: The literature on sorting in children's education (see for example Epple and Romano 1998 and Fernandez and Rogerson 2003) typically assumes a single crossing condition -i.e., that richer individuals care more about the education of their child. If there are peer effects, i.e., complementarities in the ability of pupils, or if education is financed locally with school quality determined by a majority vote in the community, then agents will sort into schools or neighborhoods according to income. Our model can be viewed as a reduced form of these models. The costly signals can then be entry fees to private schools or land and house prices in a wealthy suburb (where children would attend the state school);[4] in both cases these costs imply that the child mixes with children of relatively rich individuals.[5]

Example (ii): The marriage market: Another example explored in the literature is that of the marriage market. Pesendorfer (1995) describes a "dating" market where individuals of different types, be it their education, entertainment skills, or human capital are matched with one another. The utility from matching is supermodular, which induces high types to distinguish themselves by acquiring the newest fashion design. As typically human capital and education attainment are correlated with income, our model is a reduced form for this matching environment as well; the different signals would be the different fashion labels that would allow individuals to identify one another.[6]

In environments such as the ones described above, would individuals prefer to live in an equal society -which will reduce the incentive to sort- or in an unequal society where one can mix with the rich but has to pay a cost for doing so? We focus on the income distribution

[4] See Bradford and Kelejian (1973) who show empirically that the decision of the middle classes to live in the suburbs depend (negatively) on the share of the poor in the city.

[5] In tertiary education, income might have a more direct complementarity when one considers networks and potential for future investment and work opportunities. A recent study by Cohen and Malloy (2010) on alumni relations finds that U.S. mutual fund portfolio managers placed larger concentrated bets on companies to which they were connected through an education network, and that the fund managers performed significantly better on those connected positions to the tune of around 8%. These college network effects imply complementarities in knowledge, human capital, and connections, all correlated with and enabled by income.

[6] More generally, in marriage models, where an agent with income x is matched with another agent with income y, the surplus $s(x, y)$ is considered to be a function $H(x + y)$ which, due to transferrable utility, is convex and thus induces positive assortative matching (see Becker 1973, and Lam 1998 who shows how positive sorting arises on wage incomes).

as the main parameter determining such preferences. One intuition would be that income distributions characterized by high income inequality might push the middle classes to advocate more redistribution as it will soften the pressures to engage in costly signalling. On the other hand, another intuition is that it might induce the middle classes to be more concerned about the incomes of the wealthier groups they wish to mingle with, and therefore not support redistribution.[7]

In our main result we show that it is the latter intuition which holds. In particular, we identify a necessary and sufficient condition (Condition 1) over income distributions which implies that all individuals up to the mean (and possibly some above) prefer full equality to *any* incentive compatible partition of society and *any* linear tax level. We show that Condition 1 is satisfied for relatively equal societies. However, we show that if a society is sufficiently unequal, this condition will be violated and there will be incentive compatible partitions of society for which some individuals below the mean would oppose redistribution. High inequality implies that the middle class can, by sorting, avoid a large mass of very poor individuals, while keeping the cost of sorting relatively low.[8]

We show that functions with familiar properties satisfy Condition 1. Specifically, Condition 1 is satisfied by all functions which are *new better than used in expectations* (NBUE)[9], where NBUE is satisfied by functions with increasing hazard rate (and thus all log-concave density functions). Intuitively, these densities have tails which are not too "thick" and are thus relatively equal. We also show that full redistribution is efficient (in a utilitarian sense) compared to any partition into clubs if and only if the distribution function is NBUE. This implies that whenever full redistribution is efficient, it is also supported by a large coalition, but moreover, that it may be supported by such a coalition even if it is not efficient, i.e., when Condition 1 is satisfied but the income distribution is not NBUE.

In the classical work of Meltzer and Richards (1981), an individual favours taxation if (and only if) her income is below the mean income. While the empirical literature supports a positive relation between income and preferences over taxation, a familiar puzzle is the observation that many voters with income below the mean vote for parties on the right who traditionally

[7] Naturally, for individuals with income below the mean, there is also the standard motivation to support redistribution to simply increase their own income.

[8] Indeed India is one example of a society with a large fraction of the very poor, coupled with low income tax rates and a large degree of income sorting, as manifested for example in the marriage market. See Banerjee et al (2010) who measure the effects of castes (often correlated with income) as well as costly signals (such as education) on the marriage market.

[9] In reliability theory, NBUE describes the stochastic life span of a device which is less reliable with time.

oppose further taxation.[10] The opposite happens as well; De la O and Rodden (2008) use the Eurobarometers and World Values Survey data to show that on average well over 40% of the wealthiest individuals vote for parties of the left in Europe. Moreover, some evidence also indicates that voters in more equal societies are more positive towards further taxation and transfers, while voters in relatively unequal societies have less positive attitudes towards taxation.[11]

Our paper ties together these two empirical observations, as in the model it is in sufficiently equal (unequal) societies where one might find rich (poor) agents voting to the left (right). There is a large literature in Political Economy explaining one or both of the above empirical observations, and we contribute to this literature by identifying an explanation that is based on the effects that redistribution has on the patterns of costly sorting in societies.

Individuals in our model care about their disposable income and -indirectly- about the distribution of income, as it affects the sorting partitions. Our model can then also shed light on recent empirical findings on inequality and happiness, which show that happiness can decrease even when everyone's income had increased, if inequality increases as well.[12] In the standard approach (e.g., Melzer and Richards 1981) when utility is proportional to disposable income this cannot arise. One explanation that has been put forward in this literature is that agents have direct preferences over income inequality. In our model such preferences arise endogenously, and indeed, it is easy to find examples in our model in which the income of all individual increases along with inequality, while the utility of a sizable fraction of the population decreases as a result of the changes in the cost and benefit of sorting.

We discuss the relation to the theoretical literature in the next section. Section 3 presents the model. In Section 4 we derive our main result in a simple environment in which we compare full redistribution to a society with at most two clubs and no taxation. We generalize these results to any incentive compatible partition and any linear tax in Section 5, where we also discuss more general utility functions. In Section 6, we discuss the implications of our results to income distribution functions that have been used to fit the data.

[10] See for example Frank (2004). Gelman et al (2007) show that the positive relation between income and voting right is strong in poor American states and weak in rich states.

[11] See Perotti (1996) and Kerr (2011).

[12] A recent example is Oishi, Kesebir, Diener (2011). See also Alesina, Di Tella and MacCulloch (2004).

2 Related literature

Previous literature in Political Economy explaining why the poor might vote right (or why the rich might vote left), and why preferences for redistribution are stronger in equal societies, can in general be split into dynamic and static models.[13]

Within the dynamic literature, Piketty (1995) and Benabou and Tirole (2004) show how different beliefs, i.e., whether success is a function of luck or effort, could induce multiple equilibria, one with a large welfare state and low effort and one with a small government and high effort.[14] Benabou and Ok (2002) show how a future redistribution of a concave (convex) function of the current income distribution will, by Jensen's inequality, induce those below (above) the mean to vote against (in favour) redistribution. Galor and Zeira (1993) show how credit constraints and education externalities imply that middle income voters prefer a more equal society, as this will allow the poor to gain higher education levels. Benabou (2000) analyzes a dynamic model in which redistributive policies might also have a positive effect on ex-ante welfare. He shows that the relationship between income inequality and the demand for redistribution is U-shaped. Our analysis -albeit static- indicates a similar U-shaped relation. While in Benabou (2000) this arises from the interplay between the incentives of the poor to increase their income and the efficiency of redistribution, in our analysis it arises from the interplay between the same former effect and the effect of redistribution on the cost and benefit of sorting. In terms of predictions, the main difference is that the decreasing part of the U-shaped relation can arise in our analysis even if redistribution is inefficient, as Condition 1 can still be satisfied.

Other related papers have static models that explain why agents vote against their standard economic interest. Some consider a multidimensional policy space (Roemer 1998, Levy 2004, Alesina and La Ferrara 2005) where, for example, poor agents who care about religion might vote for a religious right-wing party, or racist preferences may induce voters to vote for less redistribution if tax revenues will be spent on other groups. Shayo (2009) introduces social group identity and shows that when voters identify with their nation as opposed to their economic class only, the tax rate is lower. The effect of inequality on redistribution however is ambiguous. Our model has a unidimensional heterogeneity among voters and no additional elements in the utility function beyond utility from (matching) income. Within this literature of static explanations related papers are Corneo (2002) and Corneo and Gruner (2000). In the first, individuals care about their rank in society (according to after-tax income) and the level

[13] For a good summary of this literature, see Alesina and Giuliano (2009).

[14] See also Alesina and Angeletos (2005).

of pre-tax equality affects the intensity of the competition for rank. This paper focuses on the efficiency of progressive taxation whereas our analysis focuses on support for redistribution and on linear taxation. In Corneo and Gruner (2000), individuals' consumption levels signal their (pre-tax) wealth, and therefore redistribution reduces the information value of signalling. Our analysis complements this paper by focusing on the signaling of after-tax income.

Beyond the literature on the political economy of taxation, our paper is also related to the literature on sorting in the tradition of Tiebout models, where agents who have different preferences over the provision of public goods sort themselves into different communities.[15] Within the sorting literature several papers consider the effect of redistributive policies. Fernandez and Rogerson (2003) consider provision of quality of schooling and analyze different equalizing policies which target the finance of education. Epple and Romano (1998) model the supply side, i.e., the market for private schools, and show how more wealthy and able agents are screened into better quality schools. In this environment, they consider the policy of school vouchers and show that it is mainly high ability and high income types who benefit from the introduction of vouchers to private schools.

Tournaments have been analyzed as another form of sorting; Fernandez and Gali (1997) show that with credit constraints, markets perform less well than tournaments at sorting individuals according to ability. Hopkins and Korneiko (2011) explore. in the context of a tournament, the effect of equality in the distribution of rewards vis a vis an equality in the distribution of income. They show that the latter induces effort whereas the former hampers it.

Finally, our model is related to recent literature on the cost of signalling. Hoppe, Moldovanu and Sela (2009) consider a model in which individuals signal their attributes. Their model is an incomplete information model with two-sided heterogeneity, finite types and perfect signalling. We discuss the relation of our results to theirs in more detail in Section 5. Several other papers focus on coarse matching, for example Hoppe, Moldovanu and Ozdenoren (2011) and McAfee (2002), and show the conditions under which coarse matching provides sufficiently high surplus compared with random or perfect matching.[16]

3 The model

The population is composed of agents who differ in their income, x, which is distributed according to some distribution $F(x)$ and density $f(x)$, strictly positive on some $[0, \nu]$, $0 < \nu \leq \infty$. Let μ (m) denote the mean (median) of the distribution, with $m \leq \mu$.

[15] For an example of this approach see Fernandez and Rogerson (2001).

[16] See also Rege (2003).

We assume that when an individual with disposable income x interacts with an individual with disposable income y, as in the marriage market, or belongs to a club in which the average income is y, as in the case of peer or network effects in education, he receives a utility xy. The assumption of supermodularity is important as it creates the incentive to (positively) sort. Our results could be adjusted to other supermodular functions as we discuss in Section 5.

We incorporate in this environment a set of costly signals (such as private schools with different fees) that will enable sorting. Thus when some individuals use a costly signal they will interact randomly with, and only with, other individuals who use the same signal. When an agent with income x_i uses a signal that costs b, his utility will therefore be

$$x_i E[x_j | j \in X_b] - b$$

where X_b is the set of other agents who use the same signal.[17] In some applications, the signal might provide an intrinsic utility on top of the sorting value, e.g., private schools might provide, aside from peer effects, better education. With some monotonicity condition, this can be accommodated in the model.

By single crossing, if some agent with x_i prefers to use a signal with cost $b > b'$, all agents with $x > x_i$ will prefer b over b'. We will therefore focus on monotone sorting, i.e., with connected intervals. We will abstract away from the supply side, i.e., how the signals or their costs are being determined.[18] But when agents choose optimally which signal to use, no matter how the supply side arises, the costs of the signals have to satisfy some incentive compatibility constraints:

Definition 1: *An incentive compatible partition is a vector* $\mathbf{x} = (x_0, x_1, ...x_{n-1}, x_n)$ *with* $x_0 = 0$*,* $x_n = \nu$ *and* $x_i < x_{i+1}$*, such that all agents with type* $x \in [x_i, x_{i+1})$ *for* $i = 0, 1, ..., n-1$ *pay* b_i *and interact with agents in* $[x_i, x_{i+1})$ *only,*[19] *with*

$$\begin{aligned} b_0 &= 0 \\ b_i - b_{i-1} &= x_i(E[x_j | x_j \in [x_i, x_{i+1}]] - E[x_j | x_j \in [x_{i-1}, x_i]]) \geq 0 \end{aligned}$$

In such an incentive compatible partition, the prices are such that for all i, the agent in x_i is indifferent between joining the club below her and the club above her. By single crossing,

[17] The quasi-linear nature of the utility function is simple to use but is not necessary for our results; our main result can be extended to the case in which the utility of an agent with income x_i who mixes in the same "club" with the population whose average income is x_j is $(x_i - b)(E(x_j) - b)$ instead.

[18] For such analysis see Damiano and Li (2007) and Rayo (2005).

[19] For completeness, when $i = n - 1$, the last interval is closed from above as well, i.e., $[x_{n-1}, x_n]$.

all other agents act optimally by joining the club they belong to, according to the partition. For simplicity and without loss of generality, we are restricting the price of joining the lowest club in the partition to zero. Henceforth, when we say a partition or a sorting environment, we mean an incentive compatible partition. For expositional purposes, we will present in Section 4 all the main results for the case of sorting with at most two clubs, i.e., where the incentive-compatibility partition is $\mathbf{x} = (0, \hat{x}, \nu)$. These results generalize to any incentive compatible partition as we show in Section 5.

Our key assumption is that what matters for the utility from matching is (at least to some degree) the absolute, disposable, income. This will imply that when income inequality is reduced, so are the incentives to sort or the willingness to pay for sorting. In particular, with full redistribution, the income of all is the same, at μ, and sorting cannot arise.[20] Note that the utility from matching in such an equal society would be μ^2.

Our main analysis focuses on deriving a simple condition such that if satisfied, all agents up to the mean (and possibly some above) prefer full redistribution (henceforth FR) to *any* incentive compatible partition with sorting. Thus, our approach is to find conditions that will apply to all partitions, rather than focusing a particular one. This allows us to pursue results in environments in which there are typically multiple equilibria, or in environments in which we, the modelers, do not have a precise grasp of the supply side of the sorting market.[21]

While we abstract away from a specific political model, we will show that preferences over FR are characterized by a cutoff and all voters with income up to that cutoff will support redistribution. The larger is the coalition supporting FR, the more likely is FR to be politically implemented; thus the preferences we characterize -where a coalition of more than 50% of all agents up to at least the mean support FR- can be manifested as the political outcome of many political models. For example, it would arise in a two-candidate competition, any political model that supports the median voter results or some supermajority rules, as well as some environments which allow for lobbying or noise voters.[22]

4 Preferences over redistribution

In this section, for expositional purposes, we focus on a comparison between a society with FR and a society with a simple incentive compatible partition of the form $\mathbf{x} = (0, \hat{x}, \nu)$, where

[20] Formally, under FR, in any incentive compatible partition it has to be that $b_i = 0$ for all i.

[21] A different approach is taken by Moav and Neeman (2012) who focus on a refinement of equilibria.

[22] Note that we do not consider the preferences of the firms or organizations that provide signals; to maintain the political model one can assume that they compose a negligible part of the population.

$\hat{x} \in [0, \nu]$. In the next section we will generalize all the results below to any incentive compatible partition and also allow for linear taxes.

We now characterize a simple necessary and sufficient condition on the distribution function, which will imply that a coalition of all agents up to the mean (and some above) will support FR over any society with sorting. As the mean and those above him do not enjoy redistribution *per se*, this will allow us to identify a motivation for redistribution for relatively rich agents, which arises due to sorting only.

Note that the utility from FR is μ^2 for all agents; the income of each agent will be μ and thus the utility from a match is μ^2. We now construct the utility from $\mathbf{x} = (0, \hat{x}, \nu)$ or in short the cutoff $\hat{x}$. Suppose that all agents above $\hat{x}$ pay $b(\hat{x})$ and all below pay nothing. The type at the cutoff $\hat{x}$ will be indifferent between paying the cost of sorting and gaining $\hat{x}E[x_j|x_j > \hat{x}]$, vs. not paying and gaining a utility of $\hat{x}E[x_j|x_j < \hat{x}]$, where

$$\begin{aligned} \underline{E}_{\hat{x}} &\equiv E[x|x \leq \hat{x}] = \frac{\int_0^{\hat{x}} x f(x)dx}{F(\hat{x})}, \\ \bar{E}_{\hat{x}} &\equiv E[x|x \geq \hat{x}] = \frac{\int_{\hat{x}}^{\upsilon} x f(x)dx}{1 - F(\hat{x})}. \end{aligned}$$

In an incentive compatible environment, the price of the signal must satisfy:

$$b(\hat{x}) = \hat{x}(\bar{E}_{\hat{x}} - \underline{E}_{\hat{x}})$$

The expected utility of an individual $x < \hat{x}$ is therefore $x\underline{E}_{\hat{x}}$ and the expected utility of an individual $x > \hat{x}$ can be written as $x\bar{E}_{\hat{x}} - b(\hat{x}) = x\bar{E}_{\hat{x}} - \hat{x}(\bar{E}_{\hat{x}} - \underline{E}_{\hat{x}})$ or:

$$(x - \hat{x})\bar{E}_{\hat{x}} + \hat{x}\underline{E}_{\hat{x}} \tag{1}$$

Expected utility from using the signal can be interpreted as the utility of the cutoff type, plus an information rent component that depends on the distance from the cutoff. This utility is increasing and convex in the income x; the slope for $x < \hat{x}$ is $\underline{E}_{\hat{x}}$ and the slope for $x > \hat{x}$, is $\bar{E}_{\hat{x}}$. This implies:

Lemma 1 *The utility from sorting with any $\hat{x}$ is increasing and convex in x; as the utility from FR is equal to all, then whenever a voter with income x' prefers FR, then all voters with $x < x'$ do so as well.*

Note that if $\hat{x} = 0$, then $b(\hat{x}) = 0$, which is equivalent to having no club at all so that the whole population matches randomly, each gaining a utility of $x\mu$. This implies that preferences over redistribution would be standard: all agents up to the mean would support redistribution, and all agents above the mean would be against it. However, when $\hat{x} > 0$, both the cost of the club and the benefit of the club increase. It is obvious that if $\mu < \hat{x}$ then the mean and in fact all those with $x < \hat{x}$, prefer FR to sorting, as then both their own and their match's income would be higher. It is therefore left to consider clubs in which $\mu > \hat{x}$ which we now consider.

4.1 Sorting vs. equality: Condition 1

Note that the mean prefers FR to any club $\hat{x} < \mu$ iff

$$(\mu - \hat{x})\bar{E}_{\hat{x}} + \hat{x}\underline{E}_{\hat{x}} \leq \mu^2$$

Divide by μ to get

$$(1 - \frac{\hat{x}}{\mu})\bar{E}_{\hat{x}} + \frac{\hat{x}}{\mu}\underline{E}_{\hat{x}} \leq \mu$$

As

$$\mu = (1 - F(\hat{x}))\bar{E}_{\hat{x}} + F(\hat{x})\underline{E}_{\hat{x}}, \tag{2}$$

then FR is preferred to coarse sorting for any cutoff $\hat{x}$ iff:

$$\frac{x}{\mu} \geq F(x) \text{ for all } x < \mu \tag{Condition 1}$$

We then have:

Proposition 1: *The mean (and all below) prefers FR to any cutoff $\hat{x}$ iff $F(x)$ satisfies $\frac{x}{\mu} \geq F(x)$ for all $x < \mu$.*

Note that when $\frac{\hat{x}}{\mu} > F(\hat{x})$ for some $\hat{x} < \mu$, then the mean will strictly prefer FR to the environment with $\hat{x}$ and by continuity some agents with $x > \mu$ will do so as well. Thus, a coalition which is larger than all those up to the mean, including relatively rich agents, will support FR. On the other hand, when this condition fails, this implies that there exists a cutoff $\hat{x}$ for which the mean and some individuals poorer than the mean, prefer sorting to FR.

The condition is simple and intuitive. When $\hat{x}$ is large enough and close to μ, then $\frac{\hat{x}}{\mu} > F(\hat{x})$, as $\frac{\hat{x}}{\mu}$ is close to one whereas $F(\hat{x}) < 1$. Intuitively, all the rent is extracted from the type in the cutoff (whose utility is equal to that of the marginal voter who is not in the club). When the mean is too close to the cutoff, he would then prefer FR. When the club is relatively inclusive though, and $\hat{x}$ is small, it may be hard to satisfy Condition 1. Specifically, when $\hat{x}$ is small, it may be possible to maintain a low price for the club (as the price is in the order of $\hat{x}$). Moreover if $F(\hat{x})$ is high for a small $\hat{x}$, there are many, very poor, individuals. Belonging to a club allows then the mean to stay away from a large constituency of these very poor individuals. In other words, $\bar{E}_{\hat{x}}$ -the benefit from sorting- is relatively high. Condition 1 insures then that this will not happen by keeping $\frac{x}{F(x)}$ sufficiently large.

In Section 5 we generalize the analysis and show that Condition 1 is necessary and sufficient also when considering any incentive compatibility partition, as well as such a partition with an interior (linear) tax and redistribution scheme. Generalizing Condition 1 to allow for some taxation under sorting is trivial. Generalizing it to any partition with more than one signal does not follow immediately however. In particular, whenever $\frac{x}{F(x)}$ is increasing, adding more signals below some cutoff $\hat{x} < \mu$ reduces the signalling cost for all types $x > \hat{x}$ and thus improves the utility from sorting. Still, we are able to show that Condition 1 is necessary and sufficient for all partitions; the intuition is that Condition 1 insures that the mean prefers FR both to a partition $[0, x_1, \upsilon]$ and to a partition $[0, x_2, \upsilon]$, for $\mu > x_2 > x_1$, which together imply that the mean would also prefer it to a partition $[0, x_1, x_2, \upsilon]$.

We next discuss the relation of Condition 1 to inequality and then some familiar properties of distribution functions which ensure that Condition 1 is satisfied.

4.1.1 Condition 1 and inequality

From the intuition above, we can see that Condition 1 can be violated when there is a large share of very poor agents (a large $F(x)$ for a small x), which is typically associated with a high level of inequality. A sufficiently concave function with a high $f(x)$ for small x will therefore violate Condition 1. However, a more equal income distribution, with sufficiently low $f(x)$ for small x, would render Condition 1 viable. To see the intuition, consider the almost fully equal distribution, with almost all weight on μ. In that case, for any club, the benefit from being in the club is associating with a type of average income close to μ (as in FR), while the cost is strictly positive as it is in the order of $\hat{x}(\mu - \underline{E}_{\hat{x}}) \geq \hat{x}(\mu - \hat{x}) > 0$. Thus FR is preferred and Condition 1 is satisfied. We illustrate this idea with some examples below:

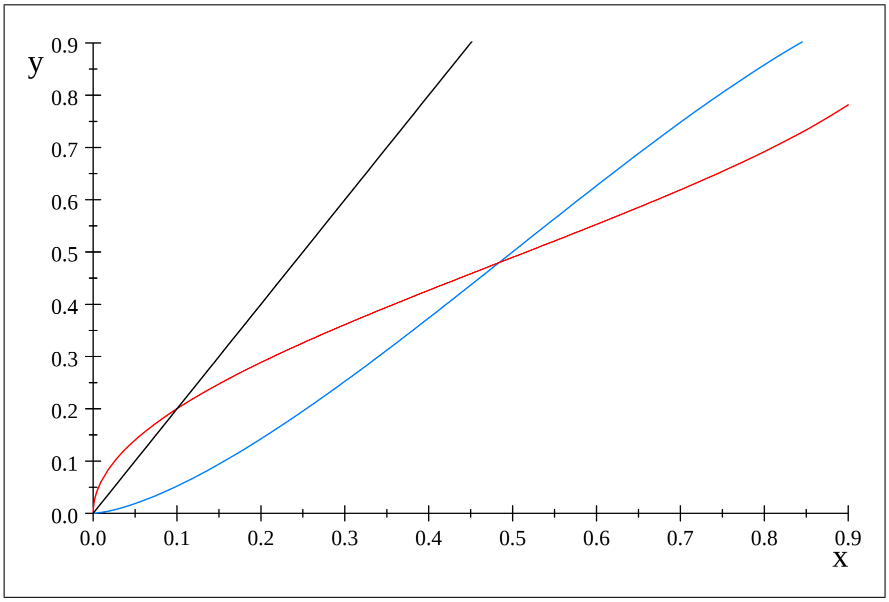

Figure 1: The straight line coresponds to $\frac{x}{\mu}$. If $F(x)$ is sufficiently equal, then it is completely below $\frac{x}{\mu}$ (the blue curve), whereas if it is too concave, or in other words there is a large share of the very poor, it is above $\frac{x}{\mu}$ for small values of x (the red curve).

We now make this relation between Condition 1 and equality more precise. In particular, we show that whenever Condition 1 is satisfied by some $F(x)$, then it is also satisfied by $G(x)$, if G belongs to a set of mean-preserving contractions of F.

We say that G is a *monotone* mean-preserving contraction of F if to obtain G, for all values smaller than μ, weight always shifts upwards to higher values, still below μ (naturally some weight shifting must occur also above μ to preserve the mean and the second-order stochastic dominance of G, but we can be agnostic about their exact nature). Formally, G has to be a mean-preserving contraction of F satisfying: (i) $F(\mu) = G(\mu)$, (ii) for any interval $Y = [y_1, y_2] \subset [0, \mu]$ for which $\int_Y g(x)dx < \int_Y f(x)dx$, then there exists an interval $Y' = [y_1', y_2'] \subset [0, \mu]$ such that $y_1' \geq y_1$ and $y_2' \geq y_2$ and $\int_{Y'}(g(x) - f(x))dx = \int_Y (f(x) - g(x))dx$.[23] We then have:

Proposition 2: *(i) Suppose that $F(x)$ satisfies Condition 1. Then all $G(x)$ obtained from $F(x)$ by some monotone mean-preserving contraction also satisfy Condition 1.*[24] *(ii) Suppose that $F(x)$ does not satisfy Condition 1. Then there exists a monotone mean-preserving contraction of $F(x)$ that would satisfy Condition 1.*

[23] It is easy to find such a mean-preserving contraction.

[24] It is possible to construct non-monotone mean preserving contractions (for example, with smaller weight on low and high values below the mean, and higher on intermediate values below the mean) in a way that would violate Condition 1.

Proof: (i) Note that $G(\mu) = F(\mu)$ and that $G(x) \leq F(x)$ for any $x < \mu$ by the definition of a monotone mean-preserving contraction. Thus $G(x) \leq F(x) \leq \frac{x}{\mu}$ and $G(x)$ satisfies Condition 1. (ii) One way to do so would be to shift (almost) all weight from $[0, \zeta\mu]$ to $[\zeta\mu, \mu]$ (and a corresponding change above μ), where $\zeta = F(\mu)$. Condition 1 is satisfied then for all $x > \zeta\mu$ (as then $\frac{x}{\mu} > 1 > F(x)$), as well as for $x < \zeta\mu$ for which $F(x) \to 0$.||

Condition 1 is then more likely to be satisfied when $F(x)$ is more equal in the monotone mean-preserving contraction sense. Note that with more general utility functions, such as $h(x)g(y)$, a condition similar to Condition 1 can be constructed and a similar relation between the Condition and inequality can be derived, as in Proposition 2 (see Section 5).

4.1.2 Condition 1 and statistical properties of distributions

We now continue to explore Condition 1. Below we show that functions with the familiar property of increasing failure or hazard rate (IFR) satisfy the condition. In fact, Condition 1 will be satisfied with a strict inequality for any IFR distribution. Intuitively, these distributions do not provide sufficient benefits from matching with the rich as the tail on high income falls too quickly.

However, we can also relate Condition 1 to a weaker property, called NBUE. In reliability theory, a distribution F is said to be *new better than used in expectations*, in short NBUE, if it describes the stochastic life span of a device which is less reliable with time. Formally,

Definition 2: *A distribution function satisfies NBUE iff* $\bar{E}_x - x \leq \mu$ *for all* x.

Proposition 3: *Any NBUE function satisfies condition 1.*

Proof: Assume that $\bar{E}_x - x \leq \mu$ for any x. Using (2) we have that

$$\begin{aligned} \mu &= F(x)\underline{E}_x + (1 - F(x))\bar{E}_x \leq F(x)\underline{E}_x + (1 - F(x))(x + \mu) \Leftrightarrow \\ F(x)\mu &\leq F(x)\underline{E}_x + (1 - F(x))x \Leftrightarrow \mu \leq \frac{x}{F(x)} + (\underline{E}_x - x) \Rightarrow \\ \mu &< \frac{x}{F(x)} \text{ for any } x > 0 \text{ as } \underline{E}_x < x. || \end{aligned}$$

Note that NBUE is a weaker condition than Condition 1, and thus there will be functions satisfying Condition 1 which are not NBUE. It is easy to establish that a function with IFR, which implies that the survival rate $1 - F$ is log-concave, also satisfies NBUE. The Proposition below (essentially a corollary to Proposition 3 and results from the statistical literature) lists properties of distribution functions which are stronger than NBUE and hence functions with these properties satisfy Condition 1:

Proposition 4:

(i) Suppose that f satisfies decreasing mean residual life, i.e., $\bar{E}_{\hat{x}}[x] - \hat{x}$ decreases in $\hat{x}$ or in other words $\int_x^\infty (1 - F(v))dv$ is log-concave; it then satisfies Condition 1.

(ii) Suppose that f has increasing failure rates or in other words that $1 - F$ is log-concave; it then satisfies Condition 1.

(iii) Suppose that f is log concave; it then satisfies Condition 1.

Proof: To see (i), note that $\bar{E}_{\hat{x}}[x] - \hat{x} = \mu$ for $\hat{x} = 0$. Decreasing mean residual life (DMRL) implies then that $\bar{E}_{\hat{x}}[x] - \hat{x} < \mu$, and thus NBUE is satisfied which by Proposition 3 implies that Condition 1 is satisfied. It is then easy to see (ii) and (iii) (this is based on Bagnoli and Bergstrom 2005 and Barlow and Proschan 1966): (ii) If f has IFR then $1 - F$ is log concave, which also implies that $\int_x^\infty (1 - F(v))dv$ is log-concave, which is identical to DMRL and thus by (i) it satisfies Condition 1. (iii) If f is log-concave then also $1 - F$ is log concave (and hence IFR) which then implies (ii) and thus Condition 1 is satisfied.||

Log-concavity, of either f, its survival/reliability function $1 - F$, or the integral of the reliability $\int_x^\infty (1 - F(v))dv$, are all stronger properties than Condition 1 and are easy to verify. They are satisfied for example by the uniform, normal, logistic and exponential functions, as well as for the Power, Weibull, Gamma, and Beta functions with parameters greater than one. Intuitively, it implies that the density does not increase too fast and thus prevents $\frac{x}{F(x)}$ from being too low, or that the density on the tails is not too "thick", implying also a relatively equal distribution as discussed above.

4.2 Sorting vs. equality: efficiency

We now explore for which distribution functions it is efficient -in a utilitarian sense- to have FR compared with sorting. While sorting is always beneficial when the utility from a match is supermodular, it is also costly.[25] Note that F is *new worse than used in expectations* (NWUE) iff $\mu + \hat{x} \leq \bar{E}_{\hat{x}}$ for any $\hat{x}$. We then have:

Proposition 5: *FR is more (less) efficient than any club $\hat{x}$ iff F is NBUE (NWUE).*

[25] We perceive the costs of sorting to be either deadweight loss, or benefit only a negligible proportion of society, which is the case in which the suppliers of the signals are highly concentrated.

Proof: Average utility from sorting for some $\hat{x}$ can be written as:

$$\begin{aligned} U(\hat{x}) &= \int_0^{\hat{x}} x\underline{E}_{\hat{x}} f(x)dx + \int_{\hat{x}}^{\nu} (\hat{x}\underline{E}_{\hat{x}} + x\bar{E}_{\hat{x}} - \hat{x}\underline{E}_{\hat{x}}) f(x)dx \\ &= F(\hat{x})\underline{E}_{\hat{x}}^2 + (1-F(\hat{x}))\hat{x}\underline{E}_{\hat{x}} - (1-F(\hat{x}))\hat{x}\bar{E}_{\hat{x}} + (1-F(\hat{x}))\bar{E}_{\hat{x}}^2 \\ &= (\underline{E}_{\hat{x}} - \bar{E}_{\hat{x}})(F(\hat{x})(\underline{E}_{\hat{x}} + \bar{E}_{\hat{x}} - \hat{x}) + \hat{x}) + \bar{E}_{\hat{x}}^2 \end{aligned}$$

The average utility from FR is:

$$\begin{aligned} U(FR) &= \mu^2 \\ &= \mu(F(\hat{x})\underline{E}_{\hat{x}} + (1-F(\hat{x}))\bar{E}_{\hat{x}}) \\ &= \mu(F(\hat{x})(\underline{E}_{\hat{x}} - \bar{E}_{\hat{x}}) + \bar{E}_{\hat{x}}) \end{aligned}$$

Let $\Delta = U(\hat{x}) - U(FR)$. Then:

$$\begin{aligned} \Delta &= (\underline{E}_{\hat{x}} - \bar{E}_{\hat{x}})(F(\hat{x})(\underline{E}_{\hat{x}} + \bar{E}_{\hat{x}} - \hat{x}) + \hat{x}) + \bar{E}_{\hat{x}}^2 - \mu(F(\hat{x})(\underline{E}_{\hat{x}} - \bar{E}_{\hat{x}}) + \bar{E}_{\hat{x}}) \\ &= (\underline{E}_{\hat{x}} - \bar{E}_{\hat{x}})(F(\hat{x})(\underline{E}_{\hat{x}} + \bar{E}_{\hat{x}} - \hat{x} - \mu) + \hat{x}) + \bar{E}_{\hat{x}}(\bar{E}_{\hat{x}} - \mu) \\ &= (\underline{E}_{\hat{x}} - \bar{E}_{\hat{x}})(F(\hat{x})(\underline{E}_{\hat{x}} + \bar{E}_{\hat{x}} - \hat{x} - \mu) + \hat{x}) + \bar{E}_{\hat{x}}F(\hat{x})(\bar{E}_{\hat{x}} - \underline{E}_{\hat{x}}) \\ &= (\underline{E}_{\hat{x}} - \bar{E}_{\hat{x}})(F(\hat{x})(\underline{E}_{\hat{x}} - \hat{x} - \mu) + \hat{x}) \\ &= (\underline{E}_{\hat{x}} - \bar{E}_{\hat{x}})(1-F(\hat{x}))(\mu + \hat{x} - \bar{E}_{\hat{x}}), \end{aligned}$$

and thus $\Delta < 0$ ($\Delta > 0$) for any $\hat{x}$ iff $\mu + \hat{x} - \bar{E}_{\hat{x}} > 0$ ($\mu + \hat{x} - \bar{E}_{\hat{x}} < 0$) for any $\hat{x}$ which is the NBUE (NWUE) property.||

To see the intuition for the efficiency result, note that positive assortative matching outweighs the cost when variability in the distribution is sufficiently high (in which cases random matching results in significant losses). Hall and Wellner (1984) showed that any NBUE function has a coefficient of variation $CV(x) = \frac{\sqrt{Var(x)}}{E(x)} \leq 1$, whereas for any NWUE, $CV(x) \geq 1$. Thus, under NBUE, the variability of the income distribution is too small and sorting is inefficient.[26]

4.3 Efficiency and political outcomes

We can now use the results in 4.1 and 4.2 to relate political support and efficiency. Specifically, we have the following Corollary for Propositions 1, 3 and 5:

[26] For the case of perfect continuous signalling, Hoppe, Moldovanu and Sela (2009) show that $CV(x) \geq (\leq) 1$ is a sufficient and necessary condition for sorting to be efficient (not efficient) compared with random matching. For their discrete model which has incomplete information on a discrete set of types but perfect signalling, a necessary and sufficient condition for efficiency (inefficiency) of signalling is for the function to have decreasing (increasing) failure rate.

Corollary 1: *If $F(x)$ is such that FR is more efficient relative to any club $\hat{x}$ then a large coalition of all up to at least the mean will support FR.*

Note however that by Proposition 3, NBUE implies Condition 1 but not the other way around. Thus, even if sorting is efficient for some club in the utilitarian sense, it could still be the case that a large coalition up to the mean will support it:

Corollary 2: *Suppose that $F(x)$ is such that for some $\hat{x} > 0$, $0 < \bar{E}_{\hat{x}} - \hat{x} - \mu < \frac{F(\hat{x})}{1-F(\hat{x})}(\hat{x} - \underline{E}_{\hat{x}})$. While in this case sorting with $\hat{x}$ is efficient, a coalition of all agents up to at least the mean will support FR instead.*

While we have derived Corollaries 1 and 2 using three separate Propositions, note that by Lemma 1, the utility from signalling is strictly convex in the income x. This implies that

$$U_{\mu}(\hat{x}) < \int_0^{\nu} U_x(\hat{x}) dF \tag{3}$$

and thus if $\int_0^{\nu} U_{\hat{x}}(x) dF < U(FR)$, all up to at least the mean will support FR and that this will be the case even if $\int_0^{\nu} U_{\hat{x}}(x) dF > U(FR)$ as long as the efficiency of sorting is not too large, given the slackness in (3). Propositions 5 identifies for which functions $\int_0^{\nu} U_{\hat{x}}(x) dF < U(FR)$ for any $\hat{x}$, and Corollary 2 relies on Proposition 3 to quantify the inefficiency of FR compared with some $\hat{x}$ while it is still acceptable by the mean.

As a political outcome is typically deemed to be more successful when a larger coalition supports it, our next question is whether political behavior is locally aligned with efficiency. That is, if $\hat{x}$ changes and as a result FR becomes more efficient relative to the club, is FR supported by a larger coalition? We can then show:

Proposition 6: *Assume that F is concave and satisfies Condition 1. For small enough $\hat{x}$, an increase in $\hat{x}$ decreases the efficiency of the club (relative to FR) and increases the size of the coalition supporting FR.*

Proof: Recall that:

$$\Delta = U(\hat{x}) - U(FR) = -(\bar{E}_{\hat{x}} - \underline{E}_{\hat{x}})(\hat{x} + \mu - \bar{E}_{\hat{x}})$$

and thus

$$d\Delta = -(d\bar{E}_{\hat{x}} - d\underline{E}_{\hat{x}})(\hat{x} + \mu - \bar{E}_{\hat{x}}) - (\bar{E}_{\hat{x}} - \underline{E}_{\hat{x}})(1 - d\bar{E}_{\hat{x}})$$

Note that if F is concave and satisfies Condition 1, then:

$$d\Delta_{\hat{x} \to 0} < 0$$

This is because: (i) $d\bar{E}_{\hat{x}} - d\underline{E}_{\hat{x}} > 0$ when f is decreasing as shown in Jewitt (2004); (ii) as F satisfies Condition 1 and is concave, it has to be that $d\bar{E}_{\hat{x}} < 1$. To see why, note that when F is concave, it satisfies Condition 1 iff for $\hat{x} \to 0$, $\frac{\partial}{\partial \hat{x}} \frac{\hat{x}}{\mu} > \frac{\partial F(\hat{x})}{\partial \hat{x}}$, as the derivative of $F(x)$ is decreasing while that of $\frac{x}{\mu}$ is fixed. This implies that $\frac{1}{\mu} > f(0)$. This in turn implies that $d\bar{E}_{\hat{x}} = (\bar{E}_{\hat{x}} - \hat{x})\frac{f(\hat{x})}{1-F(\hat{x})} \to_{\hat{x}\to 0} \mu f(0) < 1$.

Now consider the voter who is indifferent between FR and some club $\hat{x}$, some $z > \mu$. The voter $z(\hat{x})$ satisfies:

$$
\begin{aligned}
z(\hat{x})\bar{E}_{\hat{x}} - \hat{x}(\bar{E}_{\hat{x}} - \underline{E}_{\hat{x}}) &= \mu^2 \\
z(\hat{x}) &= \frac{\mu^2 + x(\bar{E}_{\hat{x}} - \underline{E}_{\hat{x}})}{\bar{E}_{\hat{x}}} \\
\frac{dz(\hat{x})}{d\hat{x}} &= \frac{((\bar{E}_{\hat{x}} - \underline{E}_{\hat{x}}) + \hat{x}(d\bar{E}_{\hat{x}} - d\underline{E}_{\hat{x}}))\bar{E}_{\hat{x}} - d\bar{E}_{\hat{x}}(\mu^2 + \hat{x}(\bar{E}_{\hat{x}} - \underline{E}_{\hat{x}}))}{\bar{E}_{\hat{x}}^2}
\end{aligned}
$$

Its sign equals

$$
\begin{aligned}
& d\bar{E}_{\hat{x}}(-\mu^2 - \hat{x}(\bar{E}_{\hat{x}} - \underline{E}_{\hat{x}}) + \hat{x}\bar{E}_{\hat{x}}) - d\underline{E}_{\hat{x}}\hat{x}\bar{E}_{\hat{x}} + \bar{E}_{\hat{x}}(\bar{E}_{\hat{x}} - \underline{E}_{\hat{x}}) \\
= \; & -\mu^2 d\bar{E}_{\hat{x}} + \hat{x}(d\bar{E}_{\hat{x}}\underline{E}_{\hat{x}} - d\underline{E}_{\hat{x}}\bar{E}_{\hat{x}}) + \bar{E}_{\hat{x}}(\bar{E}_{\hat{x}} - \underline{E}_{\hat{x}}) \\
> \; & -\mu^2 d\bar{E}_{\hat{x}} + \hat{x}(d\bar{E}_{\hat{x}}\underline{E}_{\hat{x}} - d\bar{E}_{\hat{x}}\bar{E}_{\hat{x}}) + \bar{E}_{\hat{x}}(\bar{E}_{\hat{x}} - \underline{E}_{\hat{x}}) = \\
& d\bar{E}_{\hat{x}}(-\mu^2 + \hat{x}(\underline{E}_{\hat{x}} - \bar{E}_{\hat{x}})) + \bar{E}_{\hat{x}}(\bar{E}_{\hat{x}} - \underline{E}_{\hat{x}})
\end{aligned}
$$

where the inequality follows from $d\bar{E}_{\hat{x}} > d\underline{E}_{\hat{x}} > 0$. We now take limits as $\hat{x} \to 0$:

$$
d\bar{E}_{\hat{x}}(-\mu^2 + \hat{x}(\underline{E}_{\hat{x}} - \bar{E}_{\hat{x}})) + \bar{E}_{\hat{x}}(\bar{E}_{\hat{x}} - \underline{E}_{\hat{x}}) \to_{\hat{x}\to 0} \mu^2(1 - d\bar{E}_{\hat{x}}) > 0
$$

and thus the size of the coalition increases and is therefore aligned with efficiency.||

4.4 Sorting vs. equality: the preferences of poorer agents

We now look at smaller, majoritarian, coalitions which includes agents only up to the median. When we had considered the preferences of the mean, this had allowed us to identify the non-standard incentives for redistribution, as from the point of view of their own income, those from the mean and up lose from redistribution. Moreover, it had allowed us to see when relatively rich voters support redistribution and when a large coalition can arise to support such policy.

Assuming that the median is poorer than the mean, as is typically the case, whenever the mean supports FR, so does the median. But for the median voter (or all below the mean), there are also income incentives for redistribution which Condition 1 does not take into account. We now focus on the median voter to combine sorting and standard income motivations for redistribution. We show that these additional income incentives imply that whenever the income distribution is sufficiently *unequal*, the median (and all those below) would favour FR:

Proposition 7: *The median (and all below) prefer FR to any partition if* $m < \frac{1}{2}\mu$.

Proof: Note that $m\bar{E}_m$ is the highest utility the median can get in all clubs as $\bar{E}_m$ is the highest expected type he could match with in a club he belongs to, and we are excluding the cost of the match. Note though that when $m < \frac{1}{2}\mu$, we have that:

$$m\bar{E}_m = m\frac{\int_m^\infty xf(x)dx}{1-F(m)} = 2m\int_m^\infty xf(x)dx < \mu^2$$

as $\mu = \int_0^\infty xf(x)dx > \int_m^\infty xf(x)dx.||$

The condition holds for sufficiently unequal distributions with half the population concentrated on relatively low incomes compared with the mean; the Proposition adds then a counterpart to Condition 1. As sorting benefits arise through income complementarities, if the distribution is too unequal and the income of the median is simply too low, no sorting benefits will allow the median to prefer sorting to FR. Moreover, if $m < \frac{1}{2}\mu$ is satisfied for some $F(x)$, it will also be satisfied any $G(x)$ which is a monotone mean-preserving spread of F, i.e., when weight is transferred from high values in $[0, \mu]$ to low values in $[0, \mu]$.[27] Thus, the more unequal is the distribution in this second-order stochastic sense the more likely is the condition to hold.

Together, Propositions 1 and 7 imply that from the point of view of the median, either relatively equal or relatively unequal distributions would yield preferences for FR (as Proposition 1 provides a sufficient condition for the median). It thus generates some form of a U-shaped relation with respect to preferences of the majority for full redistribution. When the distribution is relatively equal, preferences for redistribution grow with equality as Propositions 1 and 2 illustrate. On the other hand, when the distribution is relatively unequal, pressure for redistribution grows with higher inequality, as Proposition 7 illustrates.

Remark 1: Note that for all distributions with decreasing failure rates (DFR), then $m \leq \mu \ln 2 \approx 0.69\mu$, and thus redistribution will be favoured in a large family of DFR distributions by the median and those below (and in particular those that are relatively more concave or more unequal). This arises as all DFR's with the same mean as some Exponential, are more variable -i.e., stochastically dominated in a second-order sense- than the Exponential one, which satisfies $m = \mu \ln 2$.[28] Thus, together with Proposition 4, both IFR functions and a

[27] And similarly weight shifts on values above μ to maintain the mean and the second order stochastic dominance of F.

[28] Specifically, by Theorems 4.4 and 4.7 in Barlow and Proschan (1965), $F(x) \geq 1 - e^{\frac{-x}{\mu}}$ for all $x < \mu$ if $F(x)$ is DFR which implies that the median is lower in the DFR distribution.

large family of DFR functions will imply support for FR.

4.5 Sorting: An "ends against the middle" coalition

We conclude this Section with a very different political economy question. So far, we have considered government intervention only in the form of redistribution. This has led to monotone coalitions, characterized by a cutoff, where all voters below this cutoff advocate redistribution.

One other possible intervention for the government is to introduce taxes or subsidies in the housing or education markets; these will not only generate revenues from sorting, but will also affect the price and composition of sorting. For example, a tax on luxury goods or private schools might increase the exclusiveness of sorting.

To shed some light on this, we ask whether agents will prefer their club to be more or less inclusive. In other words, conditional on sorting, what form would voters prefer it to be.

For the poor voters who are not in the club, the higher is $\hat{x}$ the higher is the average income of those left to interact with them. For those in the club, the derivative of the utility from sorting is (for some type x) is:

$$(\bar{E}_{\hat{x}} - \hat{x})((x - \hat{x})\frac{f(\hat{x})}{1 - F(\hat{x})} - 1) + (\hat{x} - \underline{E}_{\hat{x}})(\hat{x}\frac{f(\hat{x})}{F(\hat{x})} - 1) \tag{4}$$

An increase in $\hat{x}$ directly increases $\bar{E}_{\hat{x}}$, $\underline{E}_{\hat{x}}$, and the price. What is clear from (4) is that once some x prefers an increase in $\hat{x}$, then all those above prefer an increase in $\hat{x}$ as well. This reveals a possible "ends against the middle" coalition for small local changes.

Proposition 8: *A coalition to increase $\hat{x}$ will always consist of agents below $\hat{x}$ and sometimes consists of all agents from some $x > \hat{x}$ and above.*

Moreover, it is also easy to find parameters for income distributions for which an "ends against the middle" majority coalition can arise to successfully increase the exclusiveness of the club.

5 Generalizing the results

In this Section we generalize our results. First we show that Condition 1 is sufficient for a coalition of all agents up to the mean to prefer FR compared with any incentive compatible partition, and any linear tax. We then generalize our efficiency results and finally we provide some results on general utility functions.

5.1 General incentive compatibility partitions and linear taxes

We first extend Proposition 1 to any incentive compatible partition $\mathbf{x} = (x_0, x_1, ...x_{n-1}, x_n)$ and to any linear tax $t > 0$, i.e., when the disposable income of an agent of type x is $x^t = (1-t)x + t\mu$. We can then show:

Proposition 9: *(i) The mean and all below prefer FR to any incentive compatible partition* $\mathbf{x}$ *and any* $t \in [0, 1]$ *iff* $F(x)$ *satisfies Condition 1. (ii) When* t *is sufficiently large, the mean and all below prefer FR to any incentive compatible partition* $\mathbf{x}$*.*[29]

Note that when a tax $t > 0$ is in place, then the relevant income distribution becomes $F^t(x) = F(\frac{x-t\mu}{1-t})$, with $F^0(x) = F(x)$. In the proof we show that for any t, the mean prefers FR to any incentive compatible partition x iff $F^t(x)$ satisfies Condition 1. Note also that $F^t(x)$ is essentially a monotone mean-preserving contraction of F,[30] and thus if F satisfies Condition 1, so does $F^t(x)$. Thus, the necessary condition for $t = 0$ is also sufficient for any $t > 0$, implying that the mean prefers FR to any partition and any t iff $F(x)$ satisfies Condition 1. Moreover, when t is sufficiently high, Condition 1 is satisfied by F^t, as then income equality is high enough. Similarly, Condition 1 is necessary for a partition with one cutoff and turns out to be sufficient for any other partition with more than one cutoff.

Next we turn to generalizing Proposition 5, which contrasts the efficiency of sorting and FR. We have a similar generalization to the above, and in particular, when t is high enough, FR is always efficient:

Proposition 10: *(i) FR is more efficient than any incentive compatible partition and any* $t \in [0, 1]$ *iff* F *is NBUE, whereas for any* t*, it is less efficient than any incentive compatible partition iff* F^t *is NWUE. (ii) When* t *is large enough, FR is more efficient than any incentive compatible partition.*

Proof: Define

$$\bar{E}_i^t \equiv E[x_j^t | x_j \geq x_i] = (1-t)\bar{E}_i + t\mu.$$

Note that

$$\mu + x_i^t - \bar{E}_i^t > 0 \Leftrightarrow \bar{E}_i < \frac{\mu}{1-t} + x_i$$

[29] The proof is in the appendix.

[30] In our main model we have considered only densities with full support while F^t is not full support, but this is not important for the gist of our analysis.

and so if F is NBUE, then also F^t is NBUE for any $t > 0$. In the appendix we show that $\Delta = U(\mathbf{x}) - U(FR)$ can be written as:

$$\Delta = \sum_{i=1}^{n-1} (E_{i-1}^t - E_i^t)(1 - F(x_i))(\mu + x_i^t - \bar{E}_i^t)$$

Given the above, NBUE (NWUE) of F^t is therefore necessary and sufficient for FR to be efficient (inefficient) compared with any partition, given some t. However, as $\mu + x_i^t - \bar{E}_i^t > 0 \Leftrightarrow \bar{E}_i < \frac{\mu}{1-t} + x_i$, if F is NBUE then it also holds for F^t and in other words FR is more efficient ($\Delta < 0$) than any partition and any $t \in [0, 1]$ iff F is NBUE. (ii) Note that for a high enough t, $\mu + x_i^t - \bar{E}_i^t > 0$ for all x_i^t, implying that high enough equality is associated with the efficiency of FR compared with any partition and the (high enough) tax rate.||

5.2 More general utility functions

We now generalize our results to a larger set of utility functions. Let $\Phi(x, y)$ be the benefit of an individual with income x from membership in a club composed of other individuals with average income y. We assume that $\Phi_1, \Phi_2 > 0$ and for assortative matching that $\Phi_{12} > 0$.

In what follows we restrict attention to simple partitions with the cutoff $\hat{x}$. As we do above, we are interested in a condition under which the individual with average income prefers FR to sorting for any $\hat{x}$ (we focus on the interesting case in which $\hat{x} < \mu$, as otherwise $\Phi(\mu, \underline{E}_{\hat{x}}) < \Phi(\mu, \mu)$). We therefore need:

$$\Phi(\mu, \bar{E}_{\hat{x}}) - \Phi(\hat{x}, \bar{E}_{\hat{x}}) + \Phi(\hat{x}, \underline{E}_{\hat{x}}) < \Phi(\mu, \mu) \text{ for all } \hat{x} < \mu$$

which is satisfied if:

$$\Phi(\mu, \bar{E}_{\hat{x}}) - \Phi(\mu, \mu) < \Phi(\hat{x}, \bar{E}_{\hat{x}}) - \Phi(\hat{x}, \underline{E}_{\hat{x}}) \text{ for all } \hat{x} < \mu \qquad \text{(Condition 2)}$$

We first illustrate that also in this level of generality there is a sense in which more equality implies that Condition 2 is easier to satisfy. Consider an income distribution $F(.)$. For any $\alpha \in (0, 1)$ define F^α as the income distribution with $F^\alpha(x) = (1 - \alpha)F(x) + \alpha\delta_\mu(x)$, where $\delta_\mu(x)$ is the degenerate distribution that has all mass on η, i.e. $\delta_\mu(x) = 0$ if $x < \mu$ and equals 1 otherwise. The property of supermodularity, $\Phi_{12} > 0$, and $\Phi_2 > 0$ will then be sufficient to guarantee that:

Lemma 2 *If F satisfies Condition 2 then for any $\alpha \in (0, 1)$, F^α satisfies condition 2.*

Proof of Lemma 2: Let $\underline{E}_{\hat{x}}^G$ and $\bar{E}_{\hat{x}}^G$ denote the relevant expressions $\underline{E}_{\hat{x}}$ and $\bar{E}_{\hat{x}}$ under distribution G. Note that for any $\hat{x} < \mu$, $\underline{E}_{\hat{x}}^{F^\alpha} = \underline{E}_{\hat{x}}^F$ as the density, conditional on $[0, \hat{x}]$ is the same under both distributions. Note further that the expectation of F^α is μ. Finally note that $\bar{E}_{\hat{x}}^{F^\alpha} \leq \bar{E}_{\hat{x}}^{F}$ as all we did is convexify the conditional distribution with one that has a lower expectation. By $\Phi_{12} > 0$ and $\Phi_2 > 0$ and for any $\hat{x}$, the LHS of Condition 2 has decreased more than the RHS.||

We now further explore Condition 2. In particular we want to analyze its relation to Condition 1. In the next two results, we show that a sufficient degree of concavity and a relatively weak supermodularity, imply that Condition 1 is sufficient for Condition 2:[31]

Lemma 3 *Suppose that* $\Phi_{22}(x,y) \leq 0$ *and that* $\frac{\Phi_2(x,y)}{\Phi_{12}(x,y)} \geq x$ *for all* x *and* y*. Then Condition 1 implies condition 2.*

EXAMPLE 1 Suppose that $\Phi(x,y) = (xy+1)^\beta$, in this case,

$$\begin{aligned} \frac{\Phi_2(x,y)}{\Phi_{12}(x,y)} &= \frac{x(xy+1)}{(xy+1)+y(\beta-1)x} \geq x \Leftrightarrow \beta \leq 1; \text{ and} \\ \Phi_2(x,y) &\leq 0 \Leftrightarrow \beta \leq 1 \end{aligned}$$

As a further illustration of the sufficiency of Condition 1 when Φ satisfies some concavity, let us consider a more specific form of complementarities, namely that,

$$\Phi(x,y) = h(x)g(y) + f(x) + l(y).$$

Note that to guarantee incentive to sort, $h' > 0$ and $g' > 0$ implying that Condition 2 becomes,

$$\begin{aligned} \Phi(\mu, \bar{E}_{\hat{x}}) - \Phi(\mu,\mu) &< \Phi(\hat{x}, \bar{E}_{\hat{x}}) - \Phi(\hat{x}, \underline{E}_{\hat{x}}) \Leftrightarrow \\ \frac{h(\hat{x})}{h(\mu)} &> \frac{g(\bar{E}_{\hat{x}}) - g(\mu)}{g(\bar{E}_{\hat{x}}) - g(\underline{E}_{\hat{x}})}, \end{aligned}$$

where by the Mean Value Theorem, this is equivalent to:

$$\frac{h(\hat{x})}{h(\mu)} > F(\hat{x})(\frac{g'(y' \in (\mu, \bar{E}_{\hat{x}}))}{g'(y'' \in (\underline{E}_{\hat{x}}, \bar{E}_{\hat{x}}))})$$

Lemma 4: *Suppose that* $h(0) = 0$*. (i) If* h *and* g *are concave then Condition 1 implies Condition 2. (ii) If* h *and* g *are convex then Condition 2 implies condition 1.*

Proof: If g is concave (convex), then $\frac{g'(y' \in (\mu, \bar{E}_x))}{g''(y' \in (\underline{E}_x, \bar{E}_x))} < (>) 1$. If h is concave (convex), $\frac{h(x)}{h(\mu)} > (<) \frac{x}{y}$.||

EXAMPLE 2: Assume that $\Phi(x,y) = x^\alpha y^\beta$. (i) Whenever $\alpha, \beta \leq 1$, Condition 1 implies Condition 2 and thus when Condition 1 is satisfied, the mean and all below to prefer FR to any partition with one club. (ii) Whenever $\alpha, \beta \geq 1$, Condition 2 implies Condition 1. Therefore, in this case, the set of distributions for which the mean and all below to prefer FR to any partition with one club shrinks.

[31] The proof of Lemma 3 is in the appendix.

6 Discussion: some empirically estimated income distributions

Our analysis had identified a simple necessary and sufficient condition for at least a majoritarian coalition to prefer FR. We now discuss whether this condition is satisfied for income distributions which are often used in the literature.

For the US in the 1960's, Salem and Mount (1974) have advocated a version of the Gamma distribution which is IFR, i.e., with a shape parameter estimated to be around two.[32] For these distributions the higher is the shape parameter, the lower is the Gini coefficient and hence Condition 1 is satisfied for the sufficiently equal Gamma and Weibull distributions.

Other distributions which are typically considered in the literature are Pareto (which is DFR, i.e., decreasing failure rates) and the Lognormal (which is first IFR and then DFR). Singh and Maddala (1976) claim that income distributions should be DFR at least for high enough income, as the ability to make more money should increase with one's income, once some threshold is reached.[33]

It is easy to compute Condition 1 for Pareto distributions on $[1,\infty)$ and to see that it is satisfied for all such distribution with a sufficiently high shape parameter α, $\alpha \geq 1.5$. The higher is the shape parameter α, the lower is the Gini coefficient (which equals $\frac{1}{2\alpha-1}$), and thus we find that Condition 1 is satisfied for the more equal Pareto distributions.[34] For lower shape parameters, $\alpha \in (1,2]$, when the Gini coefficient is high, the Pareto distribution satisfies $m < \frac{1}{2}\mu$, and thus the condition identified in Proposition 7 is satisfied for the more unequal Pareto distributions.

The lognormal distribution is characterized by two parameters, $\tilde{\mu}$ (log-scale) and σ (the shape). The Gini coefficient is $2\Phi(\sigma/\sqrt{2}) - 1$ where $\Phi(x)$ is the standard normal distribution, and thus a lower σ is associated with a lower Gini. In this family of distributions we can show that Condition 1 is satisfied as long as σ is sufficiently low, $\sigma \leq 1.1$, and irrespective of $\tilde{\mu}$,[35] whereas the condition specified in Proposition 7 holds for all, more unequal, Lognormal

[32] The distribution is $f(x) = \frac{\lambda^\alpha}{A(\alpha)} x^{\alpha-1} e^{-\lambda x}$ on $[0,\infty]$ for $A(\alpha) = \int_0^\infty e^{-u} u^{\alpha-1} du.$ For this distribution the median is $\frac{3\alpha-1}{3\lambda}$, $\frac{1}{\sqrt{\alpha}}$ is the parameter of skewness, and the mean is $\frac{\alpha}{\lambda}$. For the decades of the 60's, their estimate of α is around 2 and λ is around $\frac{3}{10^4}$.

[33] Singh and Maddala (1976) fit the data to some mixture of Pareto and Weibull, with an increasing *proportional* hazard rate ($x\frac{f(x)}{1-F(x)}$) which then converges to become constant. We note that Cramer (1978) advocates caution with respect to interpreting failure rates properties with regard to static distributions of income (where such properties should relate to time or age).

[34] Atkinson, Piketty and Saez (2011) and Diamond and Saez (2011) provide evidence that the top tail of income distributions follows a Pareto distribution. See also Cowell (2011).

[35] One example for the estimation of σ is the estimation of the distribution of earnings of UK full time male manual workers (see Cowell 2011) with an estimated $\sigma^2 = 0.13$ well below the cutoff above. See also Pinkovskiy

functions with σ sufficiently high, $\sigma > 1.174$. If one assumes in addition that $\tilde{\mu} > 0$ (as in typical income distributions), then the condition in Proposition 7 holds also for all $\sigma \in [1.1, 1.1774]$.

7 Appendix

Proof of Proposition 9: As we deal with general partitions, define

$$E_i \equiv E[x_j | x_j \in [x_i, x_{i+1}]].$$

and analogously

$$E_i^t \equiv E[x_j^t | x_j \in [x_{i-1}, x_i]] = (1-t)E_i + t\mu.$$

(i) We provide a direct proof for all partitions and t. We have already considered the case of one signal or a partition with $n = 2$. Note that if we start from some positive level of taxation t, the condition becomes $\frac{x^t}{\mu} \geq F(x)$ for all $x < \mu$, for which Condition 1 is sufficient. The necessary part of the Proposition follows then from this case for $t = 0$.

We now show sufficiency using an induction on the number of elements in the partition. Suppose that the Proposition is true for any partition with $j = k - 1$. Consider all partitions with $j = k$.

Note that if $\mu < x_1$, then the utility of the mean is like in a partition with $j = 2$ and the same x_1, and so Condition 1 applies. If $x_1 < \mu < x_2$, consider his utility from a partition with $j = 3$ and the same x_1, x_2, which is the same again. Thus if $x_{i-3} < \mu < x_{i-2}$ for $i \leq k$, his utility from the partition is the same as the utility from a partition with $j = i$ and the same $x_0, x_1, ..., x_{i-2}$ which by the induction hypothesis proves the result. Now assume that $x_{k-2} < \mu < x_{k-1}$. The mean's expected utility can be written as:

$$x_1^t E_0^t + (x_2 - x_1)(1-t)E_1^t + ... + (x_{k-2} - x_{k-3})(1-t)E_{k-3}^t + (\mu - x_{k-2})(1-t)E_{k-2}^t)$$

which is strictly lower than the utility from a partition with $j = k-1$ and the same $x_0, x_1, ..., x_{k-2}$ in which case the last expectations are replaced by $\bar{E}_{x_{k-2}}$ and the rest is the same.

Finally consider the case of $\mu > x_{k-1}$. We first divide both sides by μ and then use Condition 1 repetitively:

$$\begin{aligned}
\frac{x_1^t}{\mu}E_0^t + \frac{x_2^t - x_1^t}{\mu}E_1^t + ... + \frac{x_{k-1}^t - x_{k-2}^t}{\mu}E_{k-2}^t + (1 - \frac{x_{k-1}^t}{\mu})E_{k-1}^t &= \\
\frac{x_1^t}{\mu}(E_0^t - E_1^t) + ... + \frac{x_{k-1}^t}{\mu}(E_{k-2}^t - E_{k-1}^t) + E_{k-1}^t &\leq \\
F(x_1)(E_0^t - E_1^t) + ... + F(x_{k-1})(E_{k-2}^t - E_{k-1}^t) + E_{k-1}^t &= \\
F(x_1)E_0^t + (F(x_2) - F(x_1))E_1^t + ...(F(x_{k-1}) - F(x_{k-2}))E_{k-2}^t + (1 - F(x_{k-1}))E_{k-1}^t &= \mu
\end{aligned}$$

and Sala-i-martin (2009).

where the inequalities follow from Condition 1 as the difference in the expectations terms is negative.

(ii) As we illustrate in the proof above, fixing t, the necessary and sufficient condition for FR to be preferred by the mean to any partition is Condition 1(t) which states that $\frac{x^t}{\mu} \geq \mu$ for any $x < \mu$, for which Condition 1 is sufficient. But for a high enough t, Condition 1(t) would hold for any $F(x)$ (as it becomes sufficiently equal). For example, for all $t > F(\mu)$, $\frac{x^t}{\mu} \geq \frac{F(\mu)\mu}{\mu} > F(x)$ for any $x < \mu$.||

Proof of Proposition 10: The utility of an individual with after tax income x^t from sorting is $x^t E_0^t$ if $x \in [0, x_1]$ and $x^t E_k^t - \sum_{i=1}^k x_i^t (E_i^t - E_{i-1}^t)$ if if $x \in [x_k, x_{k+1}]$ for $k = 1, ..., n$. Integrating over all types x, we get:

$$
\begin{aligned}
U(\mathbf{x}) &= F(x_1)(E_0^t)^2 + \sum_{i=1}^{n-1}(F(x_{i+1}) - F(x_i))(E_i^t)^2 - \sum_{i=1}^{n-1}(1 - F(x_i))x_i^t(E_i^t - E_{i-1}^t) \\
&= \sum_{i=1}^{n-1} F(x_i)((E_{i-1}^t)^2 - (E_i^t)^2) + (E_{n-1}^t)^2 - \sum_{i=1}^{n-1}(1 - F(x_i))x_i^t(E_i^t - E_{i-1}^t) \\
&= \sum_{i=1}^{n-1} F(x_i)(E_{i-1}^t - E_i^t)(E_{i-1}^t + E_i^t) + (E_{n-1}^t)^2 - \sum_{i=1}^{n-1}(1 - F(x_i))x_i^t(E_i^t - E_{i-1}^t) \\
&= \sum_{i=1}^{n-1}(E_{i-1}^t - E_i^t)[F(x_i)(E_{i-1}^t + E_i^t) + (1 - F(x_i))x_i^t] + (E_{n-1}^t)^2
\end{aligned}
$$

whereas the average utility from FR is:

$$
\begin{aligned}
& \mu(F(x_1)E_0^t + \sum_{i=1}^{n-1}(F(x_{i+1}) - F(x_i))E_i^t) \\
= \; & \mu(\sum_{i=1}^{n-1} F(x_i)(E_{i-1}^t - E_i^t) + E_{n-1}^t)
\end{aligned}
$$

The difference $\Delta = U(\mathbf{x}) - U(FR) =$

$$
\begin{aligned}
& \sum_{i=1}^{n-1}(E_{i-1}^t - E_i^t)[F(x_i)(E_{i-1}^t + E_i^t) + (1 - F(x_i))x_i^t] + (E_{n-1}^t)^2 \\
& -\mu(\sum_{i=1}^{n-1} F(x_i)(E_i^t - E_{i+1}^t) + E_{n-1}^t) \\
= \; & \sum_{i=1}^{n-1}(E_{i-1}^t - E_i^t)[F(x_i)(E_{i-1}^t + E_i^t - \mu) + (1 - F(x_i))x_i^t] + E_{n-1}^t(E_{n-1}^t - \mu)
\end{aligned}
$$

Note that

$$\begin{aligned} E_{n-1}^t - \mu &= E_{n-1}^t - \sum_{i=1}^{n-1} F(x_i)(E_{i-1}^t - E_i^t) - E_{n-1}^t \\ &= -\sum_{i=1}^{n-1} F(x_i)(E_{i-1}^t - E_i^t) \end{aligned}$$

Therefore:

$$\begin{aligned} \Delta &= \sum_{i=1}^{n-1}(E_{i-1}^t - E_i^t)[F(x_i)(E_{i-1}^t + E_i^t - \mu) + (1-F(x_i))x_i^t] \\ &\quad -E_{n-1}^t \sum_{i=1}^{n-1} F(x_i)(E_{i-1}^t - E_i^t) \\ &= \sum_{i=1}^{n-1}(E_{i-1}^t - E_i^t)[F(x_i)(E_{i-1}^t + E_i^t - E_{n-1}^t - \mu) + (1-F(x_i))x_i^t] \end{aligned}$$

We now add and subtract $\sum_{j=i+1}^{n-1} E_j^t$ in the summation, with the convention that if $i+1 > n-1$ these expressions are zero,

$$\begin{aligned} \Delta &= \\ &\sum_{i=1}^{n-1}(E_{i-1}^t - E_i^t)[F(x_i)(E_{i-1}^t + E_i^t - E_{n-1}^t + \sum_{j=i+1}^{n-1} E_j^t - \sum_{j=i+2}^{n-1} E_j^t - \mu) + (1-F(x_i))x_i^t] \\ &= \sum_{i=1}^{n-1}(E_{i-1}^t - E_i^t)[F(x_i)(E_{i-1}^t + \sum_{j=i}^{n-2}(E_j^t - E_{j+1}^t) - \mu) + (1-F(x_i))x_i^t] \end{aligned}$$

We now move the expressions $(E_j^t - E_{j+1}^t)F(x_i)(E_{i-1}^t - E_i^t)$ for any i up to their relevant position, $j+1$, in the summation,

$$\Delta = \sum_{i=1}^{n-1}(E_{i-1}^t - E_i^t)[F(x_1)E_0^t + \sum_{j=1}^{i}(F(x_{j+1}) - F(x_j))E_j^t - F(x_i)\mu + (1-F(x_i))x_i^t]$$

Note that, $F(x_1)E_0^t + \sum_{j=1}^{i}(F(x_{j+1}) - F(x_j))E_j^t - F(x_i)\mu = (1-F(x_i))(\mu - \bar{E}_i^t)$ and so we have,

$$\Delta = \sum_{i=1}^{n-1}(E_{i-1}^t - E_i^t)(1-F(x_i))(\mu + x_i^t - \bar{E}_i^t),$$

and the rest is shown in the main text.||

Proof of Lemma 3: By the mean value theorem,

$$\begin{aligned} \Phi(\mu, \bar{E}_x) - \Phi(\mu, \mu) &< \Phi(x, \bar{E}_x) + \Phi(x, \underline{E}_x) \Leftrightarrow \\ \frac{\Phi_2(x, y' \in (\underline{E}_x, \bar{E}_x))}{\Phi_2(\mu, y'' \in (\mu, \bar{E}_x))} &> \frac{\bar{E}_x - \mu}{\bar{E}_x - \underline{E}_x} = F(x) \text{ where} \\ \Phi_2(x, y' &\in (\underline{E}_x, \bar{E}_x))(\bar{E}_x - \underline{E}_x) = \Phi(x, \bar{E}_x) - \Phi(x, \underline{E}_x) \\ \Phi_2(\mu, y'' &\in (\mu, \bar{E}_x))(\bar{E}_x - \mu) = \Phi(\mu, \bar{E}_x) - \Phi(\mu, \mu) \end{aligned}$$

We show that under the two conditions $\frac{\Phi_2(x,y'\in(\underline{E}_x,\bar{E}_x))}{\Phi_2(\mu,y''\in(\mu,\bar{E}_x))} \geq \frac{x}{\mu}$, or equivalently that:

$$\frac{\Phi_2(x,y'\in(\underline{E}_x,\bar{E}_x))}{x} \geq \frac{\Phi_2(\mu,y''\in(\mu,\bar{E}_x))}{\mu}$$

Note however that

$$\frac{\Phi_2(x,y'\in(\underline{E}_x,\bar{E}_x))}{x} \geq \frac{\Phi_2(\mu,y'\in(\underline{E}_x,\bar{E}_x))}{\mu} \geq \frac{\Phi_2(\mu,y''\in(\mu,\bar{E}_x))}{\mu}$$

where concavity in second element will imply the second inequality, and for the first inequality, a sufficient condition is that $\frac{\Phi_2(x,y'\in(\underline{E}_x,\bar{E}_x))}{x}$ is decreasing in x, i.e., if $\frac{\Phi_2(x,y)}{\Phi_{12}(x,y)} \geq x.||$

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