Economic Isolation, Inequality, and the Suits Index of Progressivity*

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Résumé

Nous présentons une classe de fonctions d’utilité sociale et d’indices d’inégalité qui respectent des axiomes standard de la théorie du bien-être et qui peuvent être reliés intuitivement à des mesures de carence relative et d’isolement économique. Deux classes d’indices de non-proportionnalité et de redistribution du système fiscal découlent de ces mesures. Un cas particulier et très important de ces indices est l’indice de progressivité des taxes de Suits, un indice très répandu pour lequel aucune justification en termes de bien-être social n’avait été proposée auparavant. Nous illustrons l’usage de ces indices à l’aide de micro-données britanniques sur l’impôt sur le revenu des particuliers et sur les cotisations d’assurance sociale.

Mots clés: Progressivité, redistribution, inégalité, isolement économique.

Abstract

We present a class of social evaluation functions and inequality indices that obey standard axioms of welfare economics and that can be intuitively linked to measures of relative deprivation and economic isolation. From this, associated classes of indices of tax departure from proportionality and tax redistribution are derived. A special case of these indices is the popular Suits index of progressivity, for which no social welfare foundation has previously been provided. We illustrate the application of these indices using the British regime of personal income taxes and National Insurance contributions.

Keywords: Progressivity, redistribution, inequality, economic isolation.

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I. Introduction

Imagine society as a large shopping centre in which individuals purchase and consume goods and services in proportion to their respective income. Suppose that, while circulating in the centre, any individual can randomly observe consumption units purchased and the income status of those acquiring the goods and services. Let an interviewer ask a random citizen of the supermarket the following question (Q), for an integer v greater than 1:

> Q: "*Are you poorer than the (v-1) individuals you last observed as consumers?*"

Finally, let the expected income of a citizen who answers yes to that question constitute the level of social welfare[1] W of that society.

W is then symmetric, increasing with proportionate rises in the consumers' incomes, and it obeys the Dalton transfer principle, by which a mean- and rank-preserving transfer from a rich to a poor increases social welfare. Changing the value of v changes our ethical attitude towards inequality and equity[2]. There corresponds to W a unique index of relative inequality, which can also be interpreted as an indicator of economic isolation of the poor and of social cohesion. From W, we can derive a general class of indices of tax departure from proportionality, for which a special case is the well-known Suits (1977) index of progressivity. An intuitive and coherent social welfare interpretation can then be provided for that popular index of progressivity. A transformation of these generalised Suits indices yields the tax redistributive effect, which measures the fall in inequality induced by taxation.

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[1] We use interchangeably the terms "social welfare functions" and "social evaluation functions".

[2] This is in the spirit of Donaldson and Weymark (1980) and Yitzhaki (1983) who present a generalised Gini coefficient that also depends on a parameter of distributional sensitivity. For a clear overview of that literature, see Lambert (1993).

We proceed by presenting in Section II some definitions and the derivation of a class of social evaluation functions and associated indices of inequality. Section III shows how the valuation of social welfare and inequality depends on the parameter v, and how the valuation of each varies when we move from a very unequal to a perfectly equal distribution of income. Sections IV and V derive the associated class of indices of tax departure from proportionality and of tax redistribution. Using these indices, we decompose the change in inequality induced by taxation. Section VI illustrates the use of the indices through an application to personal income taxes and National Insurance Contributions in Britain. Section VII concludes. In line with much of the conventional practice in the theoretical literature on the measurement of progressivity and inequality, we assume throughout that pre-tax incomes are exogenous.

II. Definitions

Let F_X be the distribution of incomes X, with minimum and maximum incomes respectively given by a and z, with z>a≥0. We have that $X(p)=F_X^{-1}(p)$. We can define the Lorenz curve for X as:

$$L_X(p) = \frac{\int_a^y x \, dF_X(x)}{\mu_X}, \text{ with } p = F_X(y) \tag{1}$$

and where μ_X is the mean of X. $L_X(p)$ shows the proportion of total income held by those individuals with X(p) and less in the income distribution. Hence, *1-$L_X(p)$* is the proportion of society's total consumption made by those with incomes greater than X(p). Let

$$K_X(p) = v\,[1 - L_X(p)]^{v-1} \tag{2}$$

with v>1. We can interpret $K_X(p)$ as v times the probability that, in (v-1) random and independent observations of consumption units, the income of all observed consumers exceed X(p). Note that $K_X(p)$ is equivalently the probability that an individual with X(p) answer yes to the question Q posed in the introduction by the social welfare interviewer. Now integrate that probability over all individuals in the distribution; this gives:

$$\omega_X(v) = \int_0^1 K_X(p)dp \ . \qquad \textbf{(3)}$$

$\omega_X(v)$ thus equals v times the population proportion answering yes to question Q. $K_X(p)/\omega_X(v)$ is then the density of individuals with income X(p) conditional to a yes reply to Q. We shall see later that $\omega_X(v)$ enters nicely the inequality index on which the Suits index of progressivity is implicitly based.

Now define the level of social welfare for distribution F_X, $W_X(v)$, as the expected income of an individual replying yes to Q:

$$W_X(v) = \int_0^1 X(p) \ \frac{K_X(p)}{\omega_X(v)} \ dp \ . \qquad \textbf{(4)}$$

We can show that $W_X(v)$ is symmetric, increasing along income rays[3], and quasi-concave in incomes X. It thus belongs to the general class of Schur-concave social welfare functions defined in Dasgupta, Sen and Starret (1973) and for which partial orderings of distributions may be made using the Lorenz criterion. $W_X(v)$ is also homothetic. By Blackorby and Donaldson (1978), we can then define a unique index of relative inequality, $I_X(v)$, corresponding to $W_X(v)$, with

$$I_X \ (v) = \int_0^1 \frac{[\mu_x - X(p)]}{\mu_X} \ \frac{K_X(p)}{\omega_X(v)} \ dp \qquad \textbf{(5)}$$

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[3] This corresponds to the concept of "scale improvement" efficiency defined by Shorrocks (1983). $W_X(v)$ may not be increasing in the income level of any individual since it is not an "individualistic" social welfare function. As Shorrocks (1983,p.12) explains, "if income differences are a source of envy, or are socially divisive for some other reason [e.g., causing relative deprivation or economic isolation, see below], we cannot presume that an increase in the income of one individual will not have repercussions on the welfare levels of others that lead to an overall reduction in welfare. In these circumstances it seems questionable whether it should be treated as axiomatic that an increment to any person’s income necessarily improves the standard of welfare".

and

$$W_X(v) = \mu_X [1 - I_X(v)] . \qquad (6)$$

The index $I_X(v)$ is thus symmetric, scale invariant, and Schur-convex, and it thus obeys the Dalton principle of transfers. Integrating by parts equation (5), we also find:

$$I_X(v) = \int_0^1 [p - L_X(p)] \left[v(v-1) \frac{[1-L_X(p)]^{v-2}}{\omega_X(v)} \frac{X(p)}{\mu_X} \right] dp . \qquad (7)$$

Equations (5) and (7) show that $I_X(v)$ is a subclass of the Mehran (1976) class of linear inequality measures, for which Pfähler (1987) and Duclos (1993) derive general classes of tax progressivity, tax redistribution, and horizontal inequity indices.

III. Parameter Sensitivity

The parameter v in question Q can usefully be seen as a parameter of distributional sensitivity. It is analogous, for instance, to the relative inequality aversion parameter of Atkinson (1970) and to the parameters generalising the Gini coefficients in Donaldson and Weymark (1980), Yitzhaki (1983), and Chakravarty (1988). As v approaches 1, we become less and less concerned about inequality and equity, and we have that

$$\lim_{v \Rightarrow 1} I_X(v) = 0 \quad ; \quad \lim_{v \Rightarrow 1} W_X(v) = \mu_X \qquad (8)$$

Conversely, as v approaches infinity, we become more and more concerned about the welfare of the least well-off members of the society. Recalling that *a* is the minimum income, we note that

$$\lim_{v \Rightarrow \infty} I_X(v) = 1 - \frac{a}{\mu_X} \quad ; \quad \lim_{v \Rightarrow \infty} W_X(v) = a . \qquad (9)$$

Integrating (5) leads to the following useful result:

$$I_X(v) = 1 - \frac{\int K_X(p) L_X(p)\, dp}{\omega_X} = 1 - \frac{1}{\omega_X(v)} . \qquad (10)$$

Using (6), we furthermore have that

$$W_X\ (v) = \frac{\mu_X}{\omega_X(v)}\ . \tag{11}$$

Inspection of (3) and (10) reveals that, for a given μ_X, W_X is large when $L_X(p)$ is close to p, the line of perfect equality. If L(p)=p, for all p between 0 and 1, then $\omega_X(v)=1$ and $W_X(v)=\mu_X$. In conditions of extreme inequality, $I_X(v) = 1\text{-}1/v$ and $W_X\ (v) = \mu_X/v$. We thus note that

$$0 \le I_X(v) \le 1-\frac{1}{v}\quad ,\quad \frac{\mu_X}{v} \le W_X(v) \le \mu_X\ . \tag{12}$$

A simple transformation of (3) indicates that

$$\omega_X(v) = v - \int v \left\{1 - [1 - L_X\ (p)\ ]^{v-1}\right\} dp\ . \tag{13}$$

We can then give the following interpretation to $\omega_X(v)$. Allocate v$ to a random individual on the condition that he must forego this allocation if, in the next (v-1) units of consumption he observes, he comes across someone that is poorer than him. The more equal the distribution of income, the better represented the poor will be, on average, in these observations of consumption. $\omega_X(v)$ is then the expected amount that such an individual will *not* have to forego in his (v-1) observations, and it can therefore be interpreted as an indicator of social incohesion and of economic isolation of the poor. If we believe private charity to be spurred by encounters between the rich and the poor when in the process of consuming goods and services, $1/\omega_X(v)$ can also be seen as an index of the intensity of private charity. By equation (10), social welfare is at its greatest when the consumption interaction between the rich and the poor is maximised. From equation (10), we note that the index of inequality $I_X(v)$ is an increasing function of the ineffective interaction between the poor and the rich in their consumption activities.

IV. Indices of Tax Departure From Proportionality

Now define the tax schedule by T(X), with T(X)≥0, ∀X≥0, and net income N(X) by N(X)=X-T(X). We denote by t the average tax rate:

$$t = \frac{\int_a^z T(x)\ dF_X(x)}{\mu_X}\ . \tag{14}$$

If we define $I_T^*(v)$ as the following weighted average of differences between the level of a poll tax, $t\mu_X$, and actual taxation, T(X),

$$I_T^*(v) = \int_0^1 \left[\frac{t\mu_X - T[X(p)]}{t\mu_X}\right] \frac{K_X(p)}{\omega_X(v)}\ dp \tag{15}$$

we can obtain the following class of v-sensitive indices of the difference between inequality in the distribution of taxes and inequality in the distribution of pre-tax incomes:

$$S(v) = \omega_X(v) \left[\ I_T^*(v) - I_X(v)\ \right] \tag{16}$$

Rearranging, we find

$$S(v) = \int_0^1 \frac{\{tX(p) - T[X(p)]\}}{t\,\mu_X}\ K_X(p)\ dp \tag{17}$$

S(v) is thus a function of weighted distances between proportional and actual taxation. As such, it qualifies as an index of tax departure from proportionality and is homogeneous of degree zero in the tax schedule T(X).

Table 1 gives minimum and maximum values for $I_T^*(v)$ and S(v). These are obtained when all taxes are paid by the poorest and by the richest individual, respectively. They thus correspond to index values for extreme regressivity and extreme progressivity. When T(X) is progressive[4], we can show that $I_T^*(v)>I_X(v)$

[4] A tax system is said to be progressive if the average tax rate increases with the level of pre-tax income [e.g., see Jakobsson (1976)], *viz*, if d[T(X)/X]/dX>0.

and S(v)>0. The intermediate index values that occur for a proportional tax system are also shown.

The Suits (1977) index of progressivity is defined as:

$$2\cdot \int_0^1 \left[L_X(p) - L_T(p)\right] dL_X(p) \tag{18}$$

where $L_T(p)$ is the concentration curve for taxes:

$$L_T(p) = \frac{\int_a^y T(x)\, dF_X(x)}{t\mu_X}, \text{ with } p = F_X(y) . \tag{19}$$

$L_T(p)$ shows the percentage of total taxes paid by individuals with X(p) and less. Graphically, the Suits index measures twice the area between the Lorenz curve $L_X(p)$ and the concentration curve $L_T(p)$ when both of these curves are plotted against $L_X(p)$. For a proportional tax, L_X and L_T coincide and the Suits index equals zero. Integrating by parts equation (17) and using equation (18), we can check that the Suits index is simply S(2). From Table 1, we confirm that the Suits index varies from -1 to 1 between extreme regressivity and extreme progressivity. Since the Gini coefficient of inequality in the distribution of X is defined as

$$G_X = 2\int_0^1 \left[p - L_X(p)\right] dp \tag{20}$$

we can also show that the indices of economic isolation and inequality corresponding to the Suits index of tax departure from proportionality are $\omega_X(2)=1+G_X$ and $I_X(2)= G_X/(1+G_X)$.

The S(v) index for the overall tax system can easily be decomposed as a sum of the indices of component taxes (e.g., indirect taxes, personal income taxes, social insurance contributions). Denote each of M component taxes as T_m, with average tax t_m; the overall tax system equals $\sum_{m=1}^{M} T_m$, with overall average tax rate $t = \sum_{m=1}^{M} t_m$. Let $S_m(v)$ be the generalised Suits index for tax T_m. The index for the overall tax system, S(v), then equals:

$$S(v) = \frac{1}{t} \sum_{m=1}^{M} t_m S_m(v) \quad \textbf{(21)}$$

which is a simple weighted average of the component $S_m(v)$.

V. Indices of Tax Redistribution

The redistributive impact of the tax system, $R(v)=I_X(v)-I_N(v)$, can be expressed as a function of S(v). Assume, for expositional simplicity, that the tax system does not rerank individuals. We can then show that

$$R(v) \equiv I_X(v) - I_N(v) = \frac{t}{(1-t)} \frac{S(v)}{\omega_X(v)} + C(v) \quad \textbf{(22)}$$

where

$$C(v) = \int_0^1 \frac{N[X(p)]}{(1-t)\mu_X} \left[\frac{K_N(v)}{\omega_N(v)} - \frac{K_X(v)}{\omega_X(v)} \right] dp \ . \quad \textbf{(23)}$$

The first term on the right of (22) is a generalisation of an index of the redistributive effect of taxation derived in Pfähler (1983). Once it is normalised by $\omega_X(v)$, this term has the simplicity of multiplying the index S(v) of tax departure from proportionality by t/(1-t), the average rate of taxation expressed as a proportion of net income[5]. The second term on the right of (22) adjusts for changes induced by T(X) to the income distribution of the yes answers to question Q. Under progressive taxation, we expect this second term to be negative since relative gainers under progressive taxation tend on average to be less present in the distribution of the yes answers than if their presence had remained described by K_X/ω_X. If the tax system reranks individuals in the

[5] This feature also links the Gini-based Kakwani (1977) index of tax departure from proportionality and the Reynolds-Smolensky (1977) index of tax redistribution.

dimension of their income and thus causes horizontal inequity[6], this second term C(v) will tend to be even more negative and will therefore further decrease the net redistributive effect predicted by the term containing S(v). In the absence of reranking, we can show[7] that a progressive tax system must generate a fall in inequality, with R(v)>0.

Table 2 summarises the extreme values of $\omega_X(v)$, $I_X(v)$, $I_T^*(v)$, S(v), and R(v) for v approaching 1 and infinity (defined for a>0). For v close to 1, we are insensitive to inequality and we record no progressivity and no redistribution. As v becomes very large, we measure inequality as a decreasing function of the poorest individual's share of total income, we measure tax departure from proportionality as the fraction of the proportional tax which the poorest avoids when he is charged *T(a)* instead of *ta*, and we measure redistribution as the difference between the income share of the poorest under T(a) and his share under proportional taxation.

VI. Illustration

We illustrate the use of the above indices of inequality, progressivity and redistribution through an application to the British tax system. To this end, we make use of the sample of 4471 families that appear in the British Family Expenditure Survey (FES) data between April 8th and October 7th, 1985. The FES is a continuous and reliable enquiry into the socio-economic characteristics of private households in the United Kingdom and is carried out by the Office of Population Censuses and Surveys on behalf of the Department of Employment. Using this source of information, we compute a level of pre-tax income X that

[6] On this, see, for instance, Plotnick (1982) and Duclos (1993).

[7] Using the contributions of Jakobsson (1976) and Fellman (1976).

includes a number of state and social security benefits[8]. We then add to this the regimes of personal income taxes and National Insurance contributions (NIC) that prevailed in 1985 to yield a level of net income N. The marginal tax rates of the 1985 personal income tax regime range from 30% to 60% and apply to incomes net of various personal allowances. NIC consist mainly of a tax of 9% on earned income once a threshold of around 36£ a week is passed; marginal contributions stop when a weekly upper income limit of 265£ is reached. To compare families of different sizes and compositions, we use the equivalence scale implicit in the main social assistance programme, Supplementary Benefit. The variables X, N and T defined above must then be more properly understood as "equivalised" incomes and taxes.

Figure 1 plots the values S(v) of the index of tax departure from proportionality for each of the two taxes, against values[9] of v ranging from 1 to 5. We also show S(v) for the sum of the two taxes, which, as equation (21) indicates, is simply a weighted average of the index for each of the two taxes. Personal income taxes are everywhere deemed farther from proportionality than NIC. Since the average rates of personal income taxation and of NIC are, respectively, 15% and 5.3%, we note from equation (21) that the redistributive role of personal taxation dominates by far the redistributive impact of NIC. Values of S(v) increase for both taxes when v increases, showing that we estimate the tax system to be farther from proportionality as we focus more on the economically more deprived.

Figure 2 exhibits and decomposes the change in inequality when moving from the pre-tax to the post-tax income distribution. As expected, inequality indices $I_X(v)$ and $I_N(v)$ increase with v, moving from 0 to 0.47 for pre-tax income

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[8] We include among these benefits the level of Mortgage Interest Tax Relief. More information on the survey and on the computations summarily described here can be found in Duclos (1992).

[9] Our discussion in much of the text implicitly assumed integer values for v, but the various indices proposed here are in fact defined for any real v greater than 1.

and to 0.42 for post-tax income. From the inequality indices, the index $\omega_X(v)$ [or $\omega_N(v)$] of economic isolation of the poor can easily be calculated since it equals $1/[1-I_X(v)]$. This is shown in Table 3 for pre-tax and post-tax incomes, along with the probability that a rich witness the consumption of a poor when making v-1 observations of consumption units. For v=3, for instance, we have $I_X(v)=0.37$ and $\omega_X(v)=1.58$. A random individual sent with $3 on the condition that he must give up the $3 if he encounters a poorer individual in the next 2 consumption units he observes will, on average, make this encounter with a probability of only 1-1.58/3=0.47, and will therefore keep an expected amount of ω=$1.58. In an equal distribution of income, this expected amount would be of $1, yielding the value of ($1.59-$1)/1.59$ = 0.37 for the inequality index. That is, an equal distribution of income would have made him forego an additional 37% of what he fails to give up because of the economic isolation of the poor. The index of economic isolation increases with v and reaches a maximum at v=5 of 1.88 for pre-tax income and 1.71 for post-tax income. With v=5, the progressivity of taxation increases the average probability of observing the consumption of a poorer person from 63% to 66%.

We also note on Figure 2 that the redistributive effects of taxes, $tS(v)/[(1-t)\omega_X(v)]$, and the net effect, R(v), increase smoothly with v. The correction term C(v) becomes less significant as a proportion of R(v) as v increases. Income taxes and NIC cause a fall in the inequality of pre-tax income of just above 10% for the whole range of v. As a percentage of pre-tax inequality, therefore, the redistributive power of the British system of personal income taxes and NIC does not seem to depend much on the distributional sensitivity parameter v.

VII. Conclusion

We propose a class of social evaluation functions that can be easily and intuitively interpreted as the expected income of someone who finds himself relatively poor as he observes the consumption of (v-1) random dollars. The social evaluation functions and their associated inequality indices obey the principle of transfers and are symmetric. The social evaluation functions are also increasing along rays of income. The index of inequality is an intuitive function of the isolation of the poor from the rich in their economic interactions. From this, we derive associated classes of indices of tax departure from proportionality and of tax redistribution, for which an important special case is the often-used Suits index of progressivity. We are thus able to provide a social welfare and inequality rationale for the use of that index. All indices are explicit functions of a normative parameter v, a feature which stresses the sensitivity of all social welfare, inequality, progressivity and redistribution judgements to normative attitudes. We illustrate the application of the proposed indices using the British regime of personal income taxes and National Insurance contributions. We find, *inter alia*, that the British tax system reduces the income inequality indices by about 10%, with personal income taxation causing most of that redistributive impact. The indices of economic isolation of the poor also fall slightly, and the probability of a rich observing the consumption of a poor rises by between 0.02 and 0.03 for most values of v.

Table 1

	$I_T^*(v)$	S(v)
minimum values (extreme regressivity)	$1-v[1-I_X(v)]$	$1-v$
proportional tax system	$I_X(v)$	0
maximum values (extreme progressivity)	1	1

Table 2

	$\omega_X(v)$	$I_X(v)$	$I_T^*(v)$	S(v)	R(v)
$\lim_{v \to 1}$	1	0	0	0	0
$\lim_{v \to \infty}$	μ_X/a	$1-a/\mu_X$	$1-T(a)/(t\mu_X)$	1-T(a)/(ta)	$\frac{N(a)-(1-t)a}{(1-t)\mu_X}$

Table 3

v	Inequality of pre-tax income $I_X(v)$	Index of economic isolation in pre-tax distribution $\omega_X(v)$	Probabilility of meeting a poor in (v-1) observations of consumption	Inequality of post-tax income $I_N(v)$	Index of economic isolation in post-tax distribution $\omega_N(v)$	Probabilility of meeting a poor in (v-1) observations of consumption
1.0	0.000	1.000	0.000	0.000	1.000	0.000
1.2	0.081	1.088	0.094	0.071	1.077	0.103
1.4	0.141	1.165	0.168	0.126	1.144	0.183
1.6	0.189	1.233	0.229	0.168	1.202	0.249
1.8	0.228	1.295	0.280	0.203	1.254	0.303
2.0	0.260	1.352	0.324	0.231	1.301	0.349
2.2	0.287	1.403	0.362	0.256	1.344	0.389
2.4	0.311	1.451	0.395	0.277	1.383	0.424
2.6	0.332	1.496	0.425	0.295	1.419	0.454
2.8	0.350	1.538	0.451	0.311	1.452	0.481
3.0	0.366	1.577	0.474	0.326	1.483	0.506
3.2	0.381	1.614	0.496	0.339	1.512	0.527
3.4	0.394	1.649	0.515	0.350	1.540	0.547
3.6	0.406	1.683	0.533	0.361	1.565	0.565
3.8	0.417	1.714	0.549	0.371	1.590	0.582
4.0	0.427	1.744	0.564	0.380	1.613	0.597
4.2	0.436	1.773	0.578	0.388	1.635	0.611
4.4	0.445	1.801	0.591	0.396	1.655	0.624
4.6	0.453	1.827	0.603	0.403	1.675	0.636
4.8	0.460	1.853	0.614	0.410	1.694	0.647
5.0	0.467	1.877	0.625	0.416	1.712	0.658

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Figure 1

Generalised Suits Indices

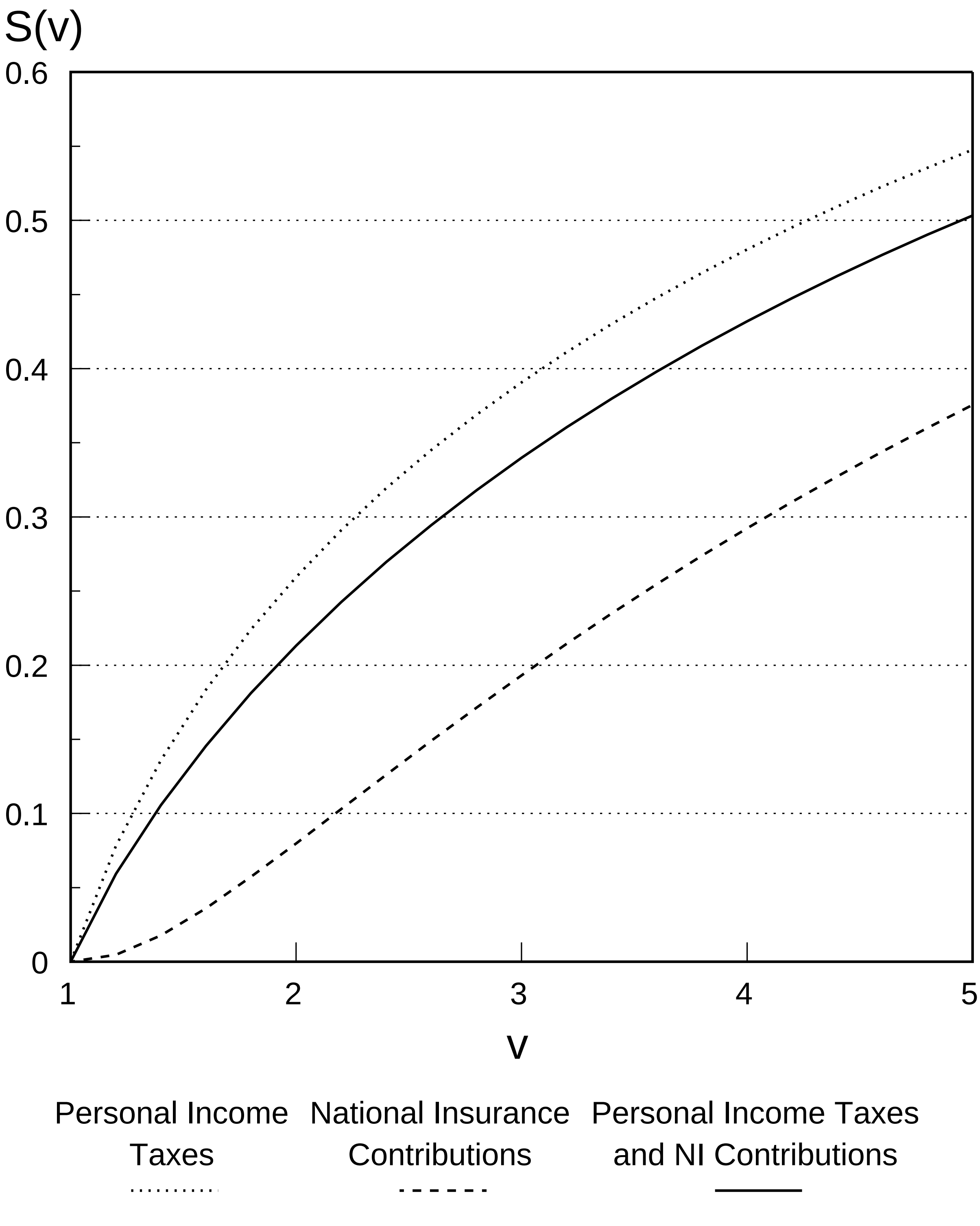

Figure 2

Inequality and Redistribution