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Redistribution in the Open Economy:

A Political Economy Approach

By

Vincent Anesi and Udo Kreickemeier

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The Authors

Vincent Anesi is a Lecturer in the School of Economics at the University of Nottingham. Udo Kreickemeier is Professor of International Economics at the University of Tubingen.

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Abstract

This paper develops a two-country model of international trade in which citizens who are heterogeneous with respect to their factor endowments vote over tariffs and income tax rates. In the politico-economic equilibrium, each country chooses its national policies by majority voting, taking the policy choice of the other country as given. By incorporating both income and trade taxes in a unified international-trade framework, we uncover the interplay between majority voting over these two instruments at the domestic level and strategic interdependencies between countries' trade policies. Our main result is that greater inequality can be conducive to more redistribution via income taxation, more protectionist policies in capital-abundant countries, and less protectionist policies in labour-abundant countries. The model can accommodate the predictions of recent empirical studies on the relationship between inequality, protectionism, and redistribution.

JEL classification: D31, D72, F13, F59

Keywords: International trade, majority voting, inequality, income taxation, tariffs.

Outline

Non-Technical Summary

The politico-economic analysis of the link between inequality and redistribution is well established in both the field of international trade and the field of public economics, but both literatures have so far developed quite separately from each other. Following the classic paper by Mayer (1984), trade economists have focused on tariffs as the main instrument to redistribute income between domestic citizens in the open economy. On the other hand, contributions in the field of public economics have focused on economies that are closed to international trade, and have employed income taxes as the preferred means to redistribute income. In this paper we develop a political economy model of redistribution in an open economy, in which both tariffs and income tax rates are determined by majority vote. We go on to argue that our novel approach is well suited to accommodate empirical evidence that has been influential in both the international trade and the public economics analysis of the inequality-redistribution link.

We introduce a framework that allows for the joint determination of trade taxes and income taxes. In line with the existing literature on inequality and redistribution we identify income taxes as the key redistributive instrument, but acknowledge that trade taxes have an impact on the primary (pre-tax) distribution of income. The Meltzer-Richard framework (1981) is cast into a simple neoclassical two-country trade model with two sectors, and labour and capital as the two sector-specific factors of production. Countries differ in their relative factor endowments, and in equilibrium the labour abundant country exports the labour intensive good. Countries also differ in the degree of domestic inequality, as measured by distribution of capital across individuals in each country. Policy spillovers arise since the relative world market price is jointly determined by the tariffs in both countries, and the relative world market price affects capital income in the two countries.

A political equilibrium is defined as a situation in which each country chooses, given the trade policy adopted by the other country, its majority-preferred policy. Three main positive results emerge from the analysis of political equilibria. Under basic conditions — inequality in capital endowments and excess demands at a zero price are both relatively large — that receive strong empirical support, greater inequality has
the following consequences:

(i) Redistribution through income taxes declines.
(ii) The capital-abundant country becomes more protectionist.
(iii) The labour-abundant country becomes less protectionist.

These results are in accordance with recent empirical studies on the relationship between inequality, protectionism, and redistribution.

The impact of inequality on redistributive and trade policies hinges on the relative potency of two effects: a domestic-politics effect and an international-trade effect. The former corresponds to the direct impact of inequality on each country's majority-preferred domestic policy. The latter describes how changes in inequality affect countries' strategic behaviour in the international-trade game, and therefore the resulting equilibrium policies. Our analysis of political equilibria reveals that these two effect work in opposite directions: while domestic politics alone would yield counterfactual equilibrium predictions, strategic interdependencies through international trade reverse the latter to yield the above results.

1 Introduction

The politico-economic analysis of the link between inequality and redistribution is well-established in both the field of international trade and the field of public economics, but both literatures have so far developed quite separately from each other. Following the classic paper by Mayer (1984), trade economists have focused on tariffs as the main instrument to redistribute income between domestic citizens in the open economy. On the other hand, contributions in the field of public economics have focused on economies that are closed to international trade, and have employed income taxes as the preferred means to redistribute income. In this paper we develop a political economy model of redistribution in an open economy, in which both tariffs and income tax rates are determined by majority vote. We go on to argue that our novel approach is well suited to accommodate empirical evidence that has been influential in both the international trade and the public economics analysis of the inequality-redistribution link.

Trade theory's take on this question has typically come in the form of analysing the relationship between inequality in factor endowments and the level of protection, with Mayer (1984) being the first to analyse the endogenous determination of tariffs in a direct democracy. He finds that in a standard Heckscher-Ohlin trade model the trade policy bias introduced by majority voting relative to the social optimum depends on the trade pattern of the country: A less equal distribution of capital ownership biases import taxes towards trade protection if the country imports the labour intensive good, while it biases the trade policy towards trade promotion if the country imports the capital intensive good. The intuition for this is simple: The median voter has less capital than the economy average, and hence has an incentive to shift the income distribution in favour of labour. With tariffs as the only policy instrument, this requires increasing the domestic relative price of the labour intensive good, which is exactly what is achieved by the trade policies chosen by the median voter in equilibrium. Dutt and Mitra (2002, 2006) subject the Mayer-Heckscher-Ohlin model to empirical scrutiny, and find support for the mechanism put forward in it. In the same vein, Mayda and Rodrik (2005) find that individual's attitudes towards trade vary with their level of human capital in a way predicted by the Mayer-Heckscher-Ohlin

model.

The political-economy literature in public economics that discusses the relationship between income inequality and redistribution dates back to the seminal work of Romer (1975), Roberts (1977), and Meltzer and Richard (1981). The latter point to pre-tax inequality — the difference between mean and median incomes — as the major determinant of income redistribution: greater inequality translates into a median voter who is poorer relative to the mean income, and therefore raises the median voter's support for redistributive policies that reduce the gap between rich and poor. Though intuitively quite amenable, this "Meltzer-Richard paradigm of redistribution" is inconsistent with empirical evidence. Paraphrasing Bénabou (2000), "redistribution is often correlated with income inequality in just the opposite way than predicted by standard politico-economic theory: among industrial democracies the more unequal ones tend to redistribute less, not more."

The political-economy literature has devoted much attention in recent years to this puzzling observation. The explanations it provides fall into three broad classes. The first identifies situations in which higher inequality increases the cost of redistributive policies to the decisive voter (see for instance Saint-Paul, 2001). The second shows that, when both redistributive and insurance motives influence voters' preference for government redistribution, political support for the latter may decrease with inequality (Bénabou, 2000, and Moene and Wallerstein, 2001). The third puts emphasis on non-economic factors that influence citizens' preferences for income redistribution — like for instance social competition in Corneo and Grüner (2000), or social perceptions regarding the fairness of market outcomes in Alesina and Angeletos (2005).[1] Our aim is to develop and explore another and quite different explanation, one that emphasizes the role of *policy spillovers* between countries that are linked through international trade.

To this end, in this paper we introduce a framework that allows for the joint determination of trade taxes and income taxes. In line with the existing literature on inequality and redistribution we identify income taxes as the key redistributive instrument, but acknowl-

[1] We also refer the reader to Corneo and Grüner (2002), and Alesina and La Ferrara (2005) for recent empirical studies of the determinants of preferences for redistribution.

edge that trade taxes have an impact on the primary (pre-tax) distribution of income. The Meltzer-Richard framework is cast into a simple neoclassical two-country trade model with two sectors, and labour and capital as the two sector-specific factors of production. Countries differ in their relative factor endowments, and in equilibrium the labour abundant country exports the labour intensive good. Countries also differ in the degree of domestic inequality, as measured by distribution of capital across individuals in each country. Policy spillovers arise since the relative world market price is jointly determined by the tariffs in both countries, and the relative world market price affects capital income in the two countries.

In this economic environment, the collective-choice framework we use is as follows. Each country is assumed to choose its policy vector with majority rule, which maps the country's capital endowment (or wealth) distribution into an aggregate preference relation over the set of feasible policies. Since voters' preferences over domestic policies depend on the other country's trade policy, this is used to define each country's "best-response function" in the international-trade game played by the two countries. In this paper, a political equilibrium is therefore a situation in which each country chooses, given the trade policy adopted by the other country, its majority-preferred policy.

Three main positive results emerge from the analysis of political equilibria. Under basic conditions — inequality in capital endowments and excess demands at a zero price are both relatively large — that receive strong empirical support, greater inequality has the following consequences:

(i) Redistribution through income taxes declines.

(ii) The capital-abundant country becomes more protectionist.

(iii) The labour-abundant country becomes less protectionist.

Result (i) is in accordance with the evidence from the public economics literature cited above, while results (ii) and (iii) are in accordance with the evidence from the trade literature.

The impact of inequality on redistributive and trade policies hinges on the relative potency of two effects: a *domestic-politics effect* and an *international-trade effect*. The former corresponds to the impact of inequality on each country's majority-preferred domestic policy, holding the other country's trade policy constant at its equilibrium level. The latter describes how changes in inequality affect countries' strategic behavior in the international-trade game, and therefore the resulting equilibrium policies. Our analysis of political equilibria reveals that these two effect work in opposite directions: while domestic politics alone would yield counterfactual equilibrium predictions, strategic interdependencies through international trade reverse the latter to yield the above results.

In his excellent survey of the literature on the political economy of trade policy Rodrik (1995) emphasizes the challenge facing economic theorists to explain why trade policy is chosen in equilibrium if other policies, which are more efficient for redistributing income, are available.[2] There are only a few theoretical contributions along these lines, and all of those achieve this by highlighting some form of asymmetry between tariffs and the alternative instruments that may make tariffs an equilibrium choice despite their inefficiency.[3] In the present paper, this asymmetry is with respect to the ability of both instruments to affect relative prices, which in our setup exists for tariffs but not for the comprehensive income tax. Hence in our two-country model there is an incentive for strategic use of tariffs that does not exist for income taxes.

The paper is structured as follows. The model is described in Section 2. In Section 3, we perform some comparative statics exercises on each country's majority-winning policy. Section 4 contains the main results of the paper, and Section 5 concludes.

[2]The point is nicely illustrated by the well-known remark: "Saying that trade policy exists because it serves to transfer income to favored groups is a bit like saying Sir Edmund Hillary climbed Mt. Everest because he wanted to get some mountain air" (Rodrik, 1995, p. 1470).

[3]In Mayer and Riezman (1989, 1990) voters are heterogeneous in dimensions other than factor endowments, and the relevance of these heterogeneities for tariffs and income taxes, respectively, may lead to the presence of tariffs in equilibrium. In the models by Rodrik (1986), Mitra (2000) and Glazer and Ranjan (2007) tariffs may be chosen in equilibrium since their use goes hand in hand with a lower total volume of redistribution, which in turn has a positive effect on the total excess burden in the economy.

2 The Model

2.1 The Economic Environment

Consider a competitive world economy with two countries, indexed by $i = A, B$, each populated by a mass-one continuum of individuals, who are all endowed with L units of labour, but differ in their capital endowment (wealth): An individual of "type" e living in country i has a capital endowment $\bar{y}_i + e$. The countries are identical in all respects, except in the level and distribution of capital endowments. Let e_i denote the median type in country i, while the average type is normalized to zero in both countries. We assume throughout that country A has a higher capital endowment: $\bar{y}_A > \bar{y}_B$.

Country i has two sectors, each producing a single consumption good. Sector 1 produces a numeraire good from labour alone with a constant input-output coefficient equal to unity. The wage rate is therefore equal to one if sector 1 is active. Sector 2 produces a nonnumeraire good from capital alone with a constant input-output coefficient equal to unity. The capital income for a type-e individual is consequently $p_i(\bar{y}_i + e)$, where p_i is the price of good 2 in country i.

In both countries, an individual's utility is given by $u - V$, where u represents the utility from private consumption, and V represents the disutility from labour supply. The function u is quasilinear in the consumption of the numeraire good, so that utility from consumption of a type-e individual living in country i is of the form $I_e^i + S(p_i)$, where I_e^i — which will be fully detailed below — is the individual's income net of taxes and transfers, and $S(p_i)$ is the individual's consumer surplus. In order to ease explicit analysis, we follow the previous literature – as Grossman and Helpman (2005), Laussel and Riezman (2005), and Bond and Park (2002) for instance – and assume a linear demand function for the non-numeraire good: $-S'(p_i) \equiv x(p_i) = \alpha - p_i$, where $\alpha > \bar{y}_A$. Furthermore V is assumed quadratic: the utility cost of providing ℓ units of labor is $\ell^2/2$.

We assume that the income of all individuals is large enough for them to consume strictly positive amounts of both goods. This implies, in combination with our above assumption that countries have the same population size, that both will consume the same

amount of good 2 in a free trade equilibrium. On the other hand, the supply of good 2 is higher in capital abundant country A, which therefore exports good 2 under free trade.

Policy is chosen by majority rule in each country i. It has two components. First, the government runs a redistributive policy by means of a linear income tax with tax rate τ_i accompanied by a lump sum transfer $T_i \geq 0$, which is the same for all individuals in country i. Thus, the disposable income of an individual of type e is

$$I_e^i = (1 - \tau_i) \left[p_i \left(\bar{y}_i + e \right) + \ell \left(\tau_i \right) \right] + T_i, \tag{1}$$

where $\ell(\tau_i) \equiv (1 - \tau_i) = \arg\max_\ell (1 - \tau_i)\ell - \ell^2/2$ is individual labour supply, and it is assumed that L is sufficiently large as to be non-binding. Second, the government levies a trade tax t_i on good 2.[4] Let p^* stand for the world price of good 2. We then have $p^* = p_A + t_A = p_B - t_B$. We denote the net import volume of good 2 in country i by $m_i(p_i) \equiv x(p_i) - \bar{y}_i$. The government budget constraint can then be written as

$$\tau_i \left[p_i \bar{y}_i + \ell \left(\tau_i \right) \right] - \iota(i) t_i m_i(p_i) = T_i, \tag{2}$$

with $\iota(i)$ being an indicator variable that equals 1 for $i = A$, and -1 for $i = B$. Henceforth, we refer to a policy as a vector (τ_i, t_i), with T_i being determined as a residual.

Goods market equilibrium requires that export supply of good 2 by country A equals import demand of good 2 by country B, at these countries' respective domestic prices:

$$m_A \left(p_A \right) + m_B \left(p_B \right) = 0, \tag{3}$$

where we know that $p_A = p^* - t_A$ and $p_B = p^* + t_B$. Equation (3) implicitly defines the world-market price function $p^* \left(\mathbf{t} \right)$, with $\mathbf{t} \equiv (t_A, t_B)$. Simple calculations show that the world market price and domestic prices are given by:

$$\begin{aligned} p^*(\mathbf{t}) &= \frac{2\alpha + t_A - t_B - (\bar{y}_A + \bar{y}_B)}{2} \\ p_i(\mathbf{t}) &= \frac{2\alpha - \iota(i) \left(t_A + t_B \right) - (\bar{y}_A + \bar{y}_B)}{2} \end{aligned} \tag{4}$$

It is easily checked that $\iota(i) \partial p^* / \partial t_i > 0$, and $\iota(i) \partial p_i / \partial t_i = \iota(i) \partial p_i / \partial t_j < 0$.

[4] We do not constrain t_i to be positive. Our assumption that the numeraire is untaxed does not imply a loss of generality, due to the Lerner Symmetry Theorem.

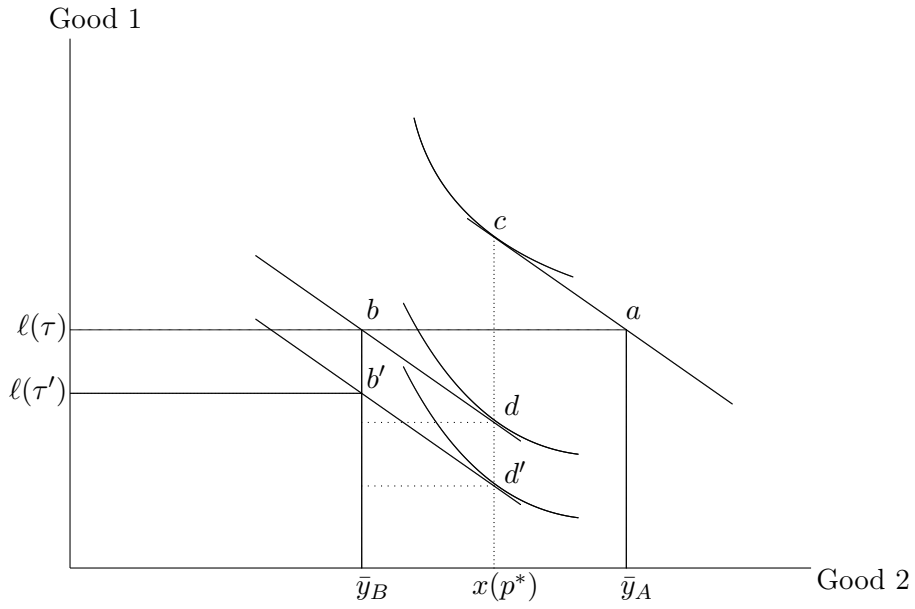

Figure 1: Free trade equilibrium

Crucially, eqs. (4) show that relative goods prices are independent of income tax rates τ_A and τ_B. Figure 1 shows the reason for this, focusing for simplicity on the case of free trade. Consider first the case where both countries have the same income tax rate τ. Country A produces at a and consumes at c, country B produces at b and consumes at d. Relative price p^* adjusts to clear the world market for goods 1 and 2. Now, consider an increase in the income tax rate in country A, from τ to τ'. Output and demand for good 1 in country A fall by the same amount (to b' and d', respectively), thereby leaving the market clearing relative goods price unchanged.

We are now in a position to define individuals' policy preferences. Combining equations (1) and (2), we can write the policy preferences of an individual of type e living in country i, given that trade tax t_j is adopted by country j, as

$$v_i\left(\mathbf{t},\tau_i,e\right) \equiv p_i\left(\mathbf{t}\right)\left[\bar{y}_i+\left(1-\tau_i\right)e\right]+\ell\left(\tau_i\right)-\frac{\ell\left(\tau_i\right)^2}{2}-\iota(i)t_i m_i\left(p_i\left(\mathbf{t}\right)\right)+S\left(p_i\left(\mathbf{t}\right)\right)\ . \quad (5)$$

It is easily checked that the indirect utility function (5) is of the general form $A_i(\mathbf{t},\tau_i)+eB_i(\mathbf{t},\tau_i)$, and hence it represents *intermediate preferences* as defined by Grandmont

(1978).[5] With intermediate preferences, the existence of a median voter is ensured even in the presence of a multidimensional policy space. The issue is explored further in Section 3 below.

Throughout the analysis, we will maintain the following assumption:

Assumption 1 For each $i = A, B$, $-\sqrt{3} < e_i < 0$.

The first inequality ensures that $v_i(\cdot, \cdot, t_j, e_i)$ is strictly concave for any t_j and e_i. The second inequality says, in accordance with empirical observation, that the average type is wealthier than the the median type.

2.2 Collective Choice

Each country collectively chooses a domestic policy by majority rule *taking the choice of the other country as given.* Thus, policies are chosen cooperatively within countries but non-cooperatively across countries. Furthermore, equation (5) makes apparent that the utility of a citizen of country i depends not only on the domestic policy (τ_i, t_i) but also on the trade policy t_j adopted by country j. It is independent on τ_j since, as shown above, in our setup changes in τ_j have no effect on the relative goods price. Citizens' preferences over domestic policies, and therefore the majority-preferred policy — or "Condorcet winner" — in country i, will consequently be affected by the policy choice of country j, thus generating strategic interdependence among the countries. In such a context, the appropriate political equilibrium concept to study is that of a group Nash equilibrium (Duggan, 2001), namely a pair of country policies such that each country, given the other country's policy, is choosing a Condorcet winner.

A *political equilibrium* is thus defined as a vector $(\tau_A^*, t_A^*, \tau_B^*, t_B^*)$ that satisfies the following conditions:

- (τ_A^*, t_A^*) is a Condorcet winner in country A given that country B's import tax is t_B^*;
- (τ_B^*, t_B^*) is a Condorcet winner in country B given that country A's export tax is t_A^*.

[5] For a textbook treatment of intermediate preferences, see Persson and Tabellini (2000, ch. 2.2.2).

Put differently, a political equilibrium is a Nash equilibrium of a non-cooperative game in which players' — or countries' — best-response functions result from majority voting over domestic policy vectors. Characterizing these best-response functions occupies the section to follow.

3 Domestic Politics

We start the analysis by focusing on domestic politics, postponing the study of political equilibria until the next section. That is, we first study the determination of the Condorcet winner in a given country, keeping fixed the policies prevailing in the other country. This characterization of countries' "best-response functions" will prepare the ground for the more complicated analysis of political equilibria.

Our analysis of Condorcet winners is divided into two subsections. We begin by explaining the main factors that determine Condorcet winners. Then, we establish useful comparative-statics results on the effects of changes in income inequality and foreign trade policy.

3.1 Condorcet Winners

The first issue is the existence of a Condorcet winner. A famed result of voting theory indeed states that Condorcet winners generically fail to exist in models with multidimensional policy spaces. However, using Assumption 1 as well as the observation that individuals in our model have intermediate preferences, represented by indirect utility function (5), we immediately obtain the following: *There exists a unique Condorcet winner in each country* i, $i = A, B$, *which coincides with the ideal policy of the voter of type* e_i *for any* t_j, $j \neq i$. Of particular interest is this: Although foreign trade policies influence the preferred domestic policy vector of the domestic median voter, they do not change his identity. That is, the Condorcet winner is always the ideal policy of the median type e_i. Our next step is therefore to characterize the solution to the following problem:

$$(\mathcal{P}_i) : \max_{(\tau_i, t_i)} v_i(\tau_i, t_i, t_j, e_i) \tag{6}$$

Assuming interior solutions, the policy (τ_i, t_i) that maximizes the median voter's utility in each country must satisfy the following first-order conditions:

$$-p_i e_i + \tau_i \ell' = 0 \qquad i = A, B \tag{7}$$

$$-m_i \frac{\partial p^*}{\partial t_i} - \iota(i) t_i m_i' \frac{\partial p_i}{\partial t_i} + (1 - \tau_i)\, e_i \frac{\partial p_i}{\partial t_i} = 0 \qquad i = A, B \tag{8}$$

Eqs. (7) show that the utility maximising tax rate τ_i in each country equalises the marginal benefit that the median voter gets from increased redistribution, $-p_i e_i$, to the marginal welfare cost of increasing the tax rate, $-\tau_i \ell'(\tau_i)$. With e_i and ℓ' both negative, the optimal tax rate must be strictly positive.

Similarly, eqs. (8) give the condition for the optimal trade tax in each country. The first two terms side are familiar from the standard optimum tariff formula, as they give the positive terms of trade gain for the country from increasing the trade tax (first term) and the negative tariff revenue effect from increasing the trade tax (second term), respectively. The third term shows the *pre-tax distribution effect*, known in principle from the Mayer (1984) model: the welfare of a median voter with below-average capital endowment is negatively affected by an increase in the price for the capital intensive good, ceteris paribus. Hence the pre-tax distribution effect is positive for capital-abundant country A, where an increase in the trade tax lowers the relative price of the capital intensive good, and negative for capital-scarce country B, where the opposite is true. Eqs. (8) show that the existence of a positive income tax τ_i serves to mitigate the pre-tax distribution effect, but that it does not eliminate it. We therefore find that the result pointed out by Dutt and Mitra (2002) in the case of the Mayer model holds as well in our framework with a second policy instrument: Political economy effects bias the trade policy towards more protectionism in capital abundant countries and towards less protectionism in capital-scarce countries, ceteris paribus.

First-order conditions (7) and (8) give for each country i the *constrained optimal tax* $\widetilde{\tau}_i(t_i, e_i, t_j)$ and the *constrained optimal tariff* $\widetilde{t}_i(\tau_i, e_i, t_j)$, respectively. It is easily checked that for country A both first order conditions are downward sloping in $\tau_i - t_i$ space, while for country B they are upward sloping in $\tau_i - t_i$ space.

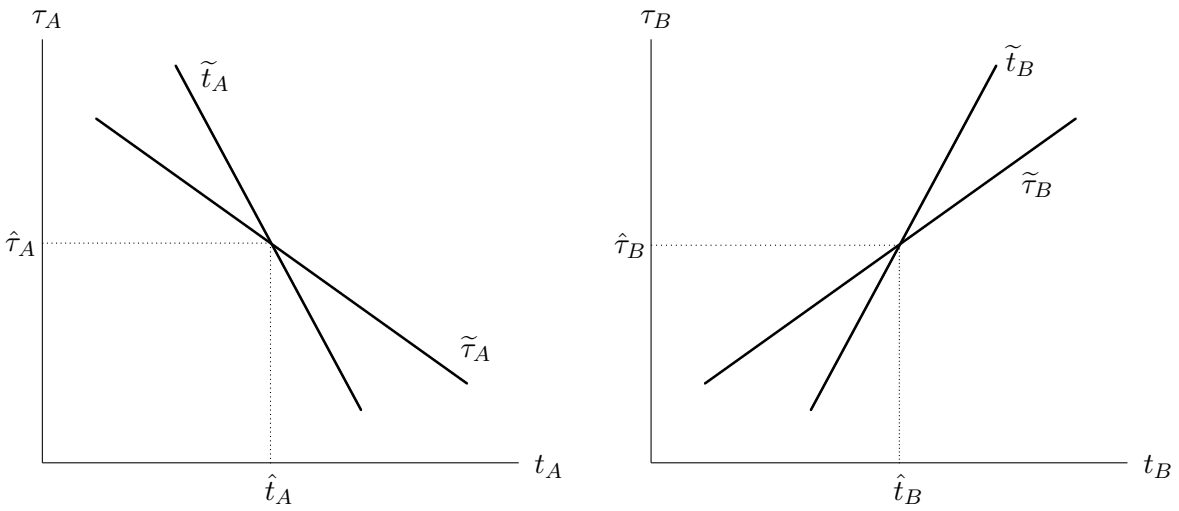

Figure 2: Condorcet Winners

The slopes of the respective loci are explained as follows. In the case of the constrained optimal income tax $\widetilde{\tau}_i(t_i, \cdot)$, both a decrease in the export tax t_A or an increase in the import tax t_B increase the respective domestic relative price of the capital intensive good, thereby increasing the marginal benefit that the median voter gets from redistribution. In order to restore the constrained optimum, the marginal welfare cost of the tax has to increase, which is brought about by an increase in τ_i, $i = A, B$. In the case of the constrained optimal tariff $\widetilde{t}_i(\tau_i, \cdot)$, increasing τ_i reduces in absolute size the marginal effect that a tariff change has on the median voter's transfer income. In country A this marginal effect is positive, while it is negative in country B. The reduction of a positive marginal effect in country A requires that the net effect of the tariff on the terms of trade and the goods market distortion becomes less negative. This is achieved by reducing t_A. The opposite adjustment is required in country B: The reduction of a negative marginal effect in absolute size requires that the net effect of the tariff on the terms of trade and the goods market distortion becomes less positive. This in turn requires an increase in t_B. Using our parametrisations, explicit expressions for the constrained optimal taxes can be derived to

give:

$$\widetilde{t}_i(\tau_i,\cdot) = -\frac{1}{3}\big\{\iota(i)\big[\bar{y}_i - \bar{y}_j + 2e_i(1-\tau_i)\big] + t_j\big\} \tag{9}$$

$$\widetilde{\tau}_i(t_i,\cdot) = -\frac{e_i}{2}\big[2\alpha - (\bar{y}_i + \bar{y}_j) - \iota(i)(t_i + t_j)\big] \tag{10}$$

The graphical representations of $\tilde{\tau}_i(t_i)$ and $\tilde{t}_i(\tau_i)$ are given by the solid curves in figure 2, where the relative slopes follow from assumption 1.

The intersection of the respective loci gives the Condorcet winners $\hat{\tau}_i(e_i, t_j)$ and $\hat{t}_i(e_i, t_j)$ for each country as a function of their respective median voter's capital endowment and the other country's trade policy.

3.2 Comparative Statics

Before determining equilibrium policies in the open-economy, as an intermediate step we examine how the national Condorcet winners are affected by exogenous changes in t_j and e_i, respectively. It is clear from the previous section that these effects in turn are jointly determined by the effects that these changes have on constrained optimal trade and income taxes, respectively.

The effects of an exogenous change in foreign trade policy is summarised in the following lemma:

Lemma 1. *An increase in the trade tax t_j leads to*

(i) a reduction in the optimal income tax rate $\hat{\tau}_i$ for the capital abundant country ($i = A$),

(ii) an increase in the optimal income tax rate $\hat{\tau}_i$ for the labour abundant country ($i = B$),

(iii) an increase in the optimal tariff $\hat{t}_i$ if and only if the median voter's capital endowment e_i is below the threshold level $e = -1$.

Proof. See the appendix. □

An intuitive understanding of the lemma can be gained with the help of eqs. (9) and (10) as well as Figure 3. A change in foreign trade policy affects national Condorcet winners $\hat{\tau}_i$ and $\hat{t}_i$ via both its effect on the constrained optimal tariff and its effect on

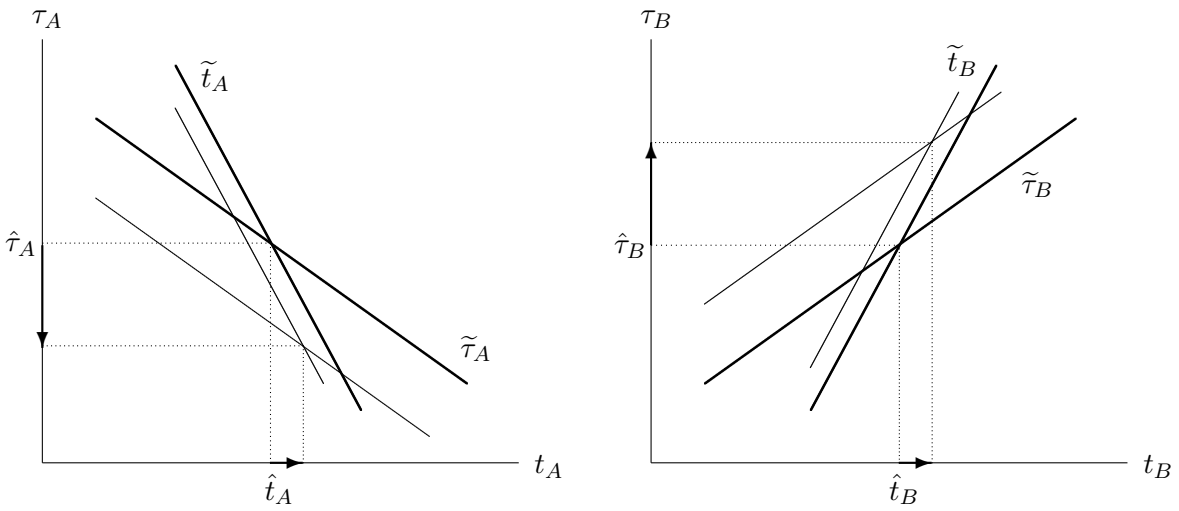

Figure 3: Domestic Politics Effects of Increasing t_j

the constrained optimal income tax. From (9), the constrained optimal tariff $\tilde{t}_i$ in both countries decreases with an increase in the respective other country's tariff, and hence both $\tilde{t}_A$ and $\tilde{t}_B$ shift to the left. Furthermore, from (10), the constrained optimal income tax $\widetilde{\tau}_i$ decreases in country B but increases in country A. Lemma 1 shows that the resulting effect on $\hat{\tau}_i$ is unambiguous, while the effect on $\hat{t}_i$ depends on the relative endowment of the median voter. With a poor median voter, characterised by capital endowment $e_i < -1$, $\hat{t}_i$ is increasing in t_j, and hence the tariffs in the two countries are strategic complements. This is the case depicted in figure 3, and the one we will be focusing on below.

As a second comparative statics exercise, consider a rise in income inequality as measured by the distance between the average and median endowments, $-e_i$. A decrease in e_i has the usual effect of increasing the preferred income tax rate of the median voter, ceteris paribus, as shown in eq. (10). This is reflected in figure 4 by an upward shift in both $\widetilde{\tau}_A$ and $\widetilde{\tau}_B$. Furthermore, with a poorer median voter (i.e. a lower value for e_i) the absolute size of the pre-tax distribution effect increases. As a consequence the preferred tariff of the median voter increases in country A and decreases in country B (compare eq. (9)), ceteris paribus, thereby changing the pre-tax income distribution towards labour in both

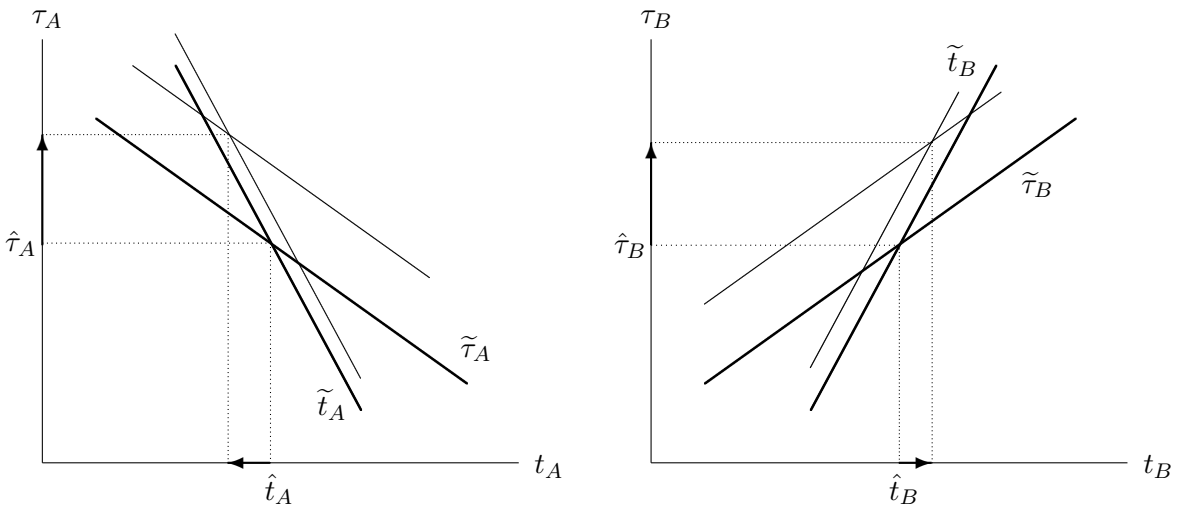

Figure 4: Domestic Politics Effects of Decreasing e_i

countries. In figure 4, $\widetilde{t}_A$ shifts to the right, while $\widetilde{t}_B$ shifts to the left. The effect of the decrease in e_i on the Condorcet winner $(\hat{t}_i, \hat{\tau}_i)$ in each country is unclear in general, and it depends on the slopes of the constrained optimal policy loci, as well as on the extent to which these loci shift as a consequence of the decrease in e_i.

The case presented in figure 4, in which the optimal income tax rate in both countries goes up, while the optimal tariff decreases in country A and increases in country B is therefore just illustrative. It is however shown in Proposition 3 below that the case presented here is indeed the outcome if (i) we start from a political equilibrium, as defined above, and (ii) the median voters of both countries are sufficiently poor (relative to the mean-income citizen). We consider this our *benchmark scenario*. In this scenario, more inequality leads to more redistribution via the income tax system, while the redistribution of the pre-tax income through tariffs is reduced. While plausible, this outcome is problematic in the face of the empirical evidence cited above: The Meltzer-Richard paradigm for income tax rates still holds in this scenario, while the effect of inequality on tariffs is exactly opposite to the standard result from the Mayer model, for which Dutt and Mitra (2002) find empirical support. We now turn to the strategic interaction between the policies in the two coun-

tries, which was hitherto neglected. In particular, we are interested to see whether – and under what conditions – the comparative static results for the full political equilibrium are compatible with the empirical evidence on the relationship between income inequality and equilibrium policy outcomes.

4 International Politics

We now turn to the analysis of the full equilibrium of our model. Section 4.1 starts with an intuitive account of how the domestic politics (DP) comparative static effects are related to the international politics (IP) effects, where the latter take into account the strategic interdependency between the trade policies of the two countries. A formal analysis follows in section 4.2.

4.1 General Intuitions

We begin the analysis of political equilibria with an intuitive presentation of some key mechanisms. By definition, a political equilibrium $\{(\tau_i^*(e_i, e_j), t_i^*(e_i, e_j))\}_{i=A,B}$ must satisfy the following conditions:

$$\tau_i^*(e_i, e_j) \equiv \hat{\tau}_i\left(t_j^*(e_j, e_i), e_i\right), \tag{11}$$

$$t_i^*(e_i, e_j) \equiv \hat{t}_i\left(t_j^*(e_j, e_i), e_i\right), \tag{12}$$

for every $i = A, B$, $j \neq i$. The above identities allow us to relate the domestic politics effect of a change in inequality on income tax rate and tariff rate to the overall change in these variables in the political equilibrium.

To this end we differentiate (12) with respect to e_i and obtain

$$\frac{\partial t_i^*}{\partial e_i} = \frac{\partial \hat{t}_i}{\partial e_i} + \frac{\partial \hat{t}_i}{\partial t_j}\frac{\partial t_j^*}{\partial e_i}. \tag{13}$$

We can substitute for $\partial t_j^*/\partial e_i$ by differentiating (12) with respect to e_j and exchanging labels i and j. We finally get

$$\frac{\partial t_i^*}{\partial e_i} = \Phi\frac{\partial \hat{t}_i}{\partial e_i}, \tag{14}$$

with

$$\Phi \equiv \left[1 - \frac{\partial \hat{t}_i}{\partial t_j}\frac{\partial \hat{t}_j}{\partial t_i}\right]^{-1}$$

as the *international trade multiplier*, linking the domestic and international politics effects of a change in the income of the median voter. Since we consider the case where tariffs are strategic complements, Φ is either positive *and* greater than one or negative, implying that the domestic politics effect $\partial \hat{t}_i/\partial e_i$ is either augmented or reversed in the full equilibrium.

To gain a better understanding of the mechanisms at play, consider the example described by Figure 5. The two thick lines $\hat{t}_A$ and $\hat{t}_B$ depict the Condorcet winners in the two countries as a function of the respective other country's tariff. As drawn, $\hat{t}_B$ cuts $\hat{t}_A$ from below, and it is easily checked that this is the case if and only if Φ is negative.[6] This result is assured if the median voter in both countries is sufficiently poor. By definition, the intersection of the two loci determines the equilibrium trade policy vector (t_A^*, t_B^*). Assume now that the endowment level e_A decreases, and consider the benchmark scenario from section 3.2, i.e. the case where $\hat{t}_A$ is increasing in the median voter's endowment everywhere. The $\hat{t}_A$ locus shifts to the left, and its new position is represented by the thin line in Figure 5. The arrows show the changes in the equilibrium tariffs, and one can see that both tariffs are higher in the new equilibrium.

Thus, this example describes a situation in which the strategic interdependencies generated by international trade reverse the effect of inequality in country A on its own tariff rate. This is brought about by the increase in country B's tariff, which can formally be derived by differentiating (12) with respect to e_j, and exchanging labels i and j. We get, using (14),

$$\frac{\partial t_j^*}{\partial e_i} = \frac{\partial \hat{t}_j}{\partial t_i}\left(\Phi \frac{\partial \hat{t}_i}{\partial e_i}\right). \tag{15}$$

The effect of a change on the median voter's income on the income tax rate in the international politics equilibrium is found by differentiating (11) with respect to e_i. We obtain

$$\frac{\partial \tau_i^*}{\partial e_i} = \frac{\partial \hat{\tau}_i}{\partial e_i} + \frac{\partial \hat{\tau}_i}{\partial t_j}\frac{\partial \hat{t}_j}{\partial t_i}\left(\Phi \frac{\partial \hat{t}_i}{\partial e_i}\right), \tag{16}$$

[6] Formally, we have $0 < (\partial \hat{t}_A/\partial t_B)^{-1} < (\partial \hat{t}_B/\partial t_A)$, or $(\partial \hat{t}_A/\partial t_B)(\partial \hat{t}_B/\partial t_A) > 1$.

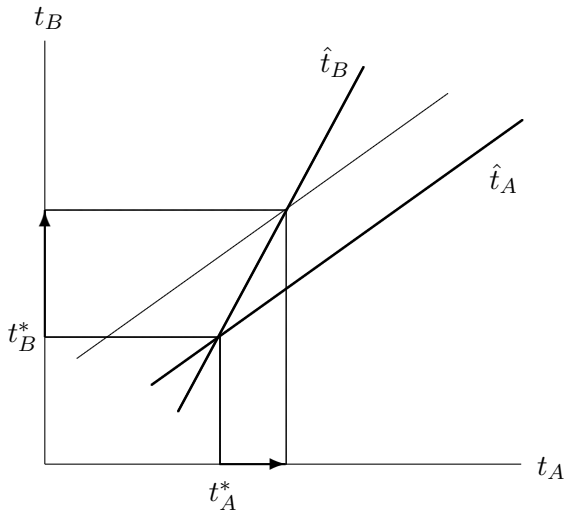

Figure 5: International Politics Effect of Decreasing e_A

where (15) has been used to substitute for $\partial t_j^*/\partial e_i$. As the IP tariff rate, the IP tax rate depends on e_i both directly and via the tariff rate of the other country. A marginal change in e_i has therefore a direct effect on the equilibrium tax rate, which is represented by the first term on the right-hand side of the above equation. But a marginal change in e_i has also an indirect effect on $\hat{\tau}_i$, for it affects $\hat{t}_i(\cdot, e_i)$, namely the best-response function of country i's government (or median voter) in the tariff game played by both countries' governments. This then results in a change in the equilibrium value of t_j, which in turn affects country i's equilibrium tax rate. The second term in (16) represents this "international-trade effect." It is easily checked that in the case where the international trade multiplier Φ is negative the international trade effect on the tax rate in both countries works against the direct domestic politics effect identified in the previous section.

To be sure, this is just an illustration at this stage of how the presence of strategic policy interaction between the two countries may have the potential to reverse the domestic politics effect on the tax rate, and bring the overall effect in accordance with the stylised facts. Next we turn to a formal analysis of this issue, which will allow us to actually sign the effects of a change in e_i on the policy variables.

4.2 Formal Analysis

In order to derive our results formally, we need to make the assumption that at a zero price for the capital intensive good the import demand for it would be large in both countries:

Assumption 2 For each $i = A, B$, $m_i(0) > \sqrt{3}/2$.

Using this assumption, the following establishes the main results of the paper:

Proposition 1. *Let* $\{(\tau_i^*(\cdot), t_i^*(\cdot))\}_{i=A,B}$ *be a political equilibrium. Then, a decrease in* e_i *leads to*

(i) a reduction in the equilibrium income tax rate τ_i^**,*

(ii) an increase in the equilibrium tariff t_i^* *for* $i = A$*,*

(iii) a reduction in the equilibrium tariff t_i^* *for* $i = B$*,*

whenever e_j *is below some threshold* $\tilde{e}_j > -\sqrt{3}$*.*

Proof. See the appendix. □

An immediate implication of Proposition 1 is the following: If inequality is sufficiently large in both trading economies, a further increase in inequality reduces domestic redistribution through income taxes. Furthermore, the increase in inequality makes the capital abundant country more protectionist and the labour abundant country less protectionist.

Part (i) of the proposition stands in sharp contrast to the Meltzer-Richard paradigm of redistribution, according to which greater inequality is unambiguously correlated with a higher income tax. Meltzer and Richard (1981) consider a closed economy in which citizens vote over a single policy dimension. Our model shows that, when there are international policy spillovers and citizens vote over both domestic redistribution and international trade policies, income taxation may fall as inequality rises. In the extended model we thus obtain a theoretical prediction that corresponds better to the empirical evidence mentioned in the introduction. Parts (ii) and (iii) in principle do replicate the result from the standard Mayer (1984) model, which has been put forward by Dutt and Mitra (2002). The mechanism by

which this result comes about is very different to the Mayer model, however. In particular, with the income tax as a second instrument at the disposal of the median voter in our setup, strategic interaction between the two countries' median voters is essential to replicate the Mayer result.

The role of strategic interaction is confirmed by looking at the effect that increased inequality in one country has on the equilibrium tariff chosen by the trading partner:

Proposition 2. *A decrease in e_i leads to*

(i) an increase in the equilibrium tariff t_j^* for $i = A$,

(ii) a reduction in the equilibrium tariff t_j^* for $i = B$,

whenever e_j is below some threshold $\hat{e}_j > -\sqrt{3}$.

Proof. See the appendix. □

Propositions 1 and 2 together show that for a sufficiently high level of initial inequality equilibrium tariffs in both countries change in the same direction if inequality in one of the countries grows further. A graphical illustration of this case is given by the example in Subsection 4.1 above.

One more way of showing the importance of strategic trade policy setting is to look at the counterfactual: Suppose we start out in a political equilibrium and analyse the effect of increased domestic inequality for a given value of the other country's tariff. Formally, this means looking at how the Condorcet winners $\hat{\tau}_i(t_j, e_i)$ and $\hat{t}_i(t_j, e_i)$ change with a decrease in e_i, while holding t_j constant at its pre-change equilibrium level. We can show the following:

Proposition 3. *Suppose we start off in a political equilibrium $\{(\tau_i^*(\cdot), t_i^*(\cdot))\}_{i=A,B}$. Then, a decrease in e_i leads to*

(i) an increase in the Condorcet income tax rate $\hat{\tau}_i$,

(ii) a decrease in the Condorcet tariff $\hat{t}_i$ for $i = A$,

(iii) an increase in the Condorcet tariff $\hat{t}_i$ *for* $i = B$,

whenever the maximum of e_i *and* e_j *is below some threshold* $\hat{e} > -\sqrt{3}$.

Proof. See the appendix. □

Hence, were there no strategic interaction between countries trade policy choices, in the case of a poor median voter considered throughout our model would generate predictions for the income tax rate similar to those in Meltzer and Richard (1981). Put differently, the addition of the trade policy dimension to their original model is not sufficient to reverse their counterfactual conclusions about the relationship between inequality and income taxation. On the other hand, looking at Proposition 3 through the lens of the Mayer (1984) model, the addition of a second instrument as such *does* reverse the prediction of the model emphasized by Dutt and Mitra (2002): a poorer median voter now chooses less redistribution through tariffs. The strategic interdependency of both countries' trade policies is therefore decisive in bringing about our key result in Proposition 1 that is compatible with the evidence on inequality, redistribution, and protection.

5 Conclusion

The relationship between inequality, protectionism, and income redistribution is a complex one. In this paper, we develop a model that starts from the primitive of countries' income distributions and builds up a structure tractable enough to capture the predictions of recent empirical exercises on this relationship. Our analysis rests on two premises: (i) income and trade taxes are both redistributive instruments that interact with each other, and (ii) international trade generates international policy spillovers. We construct a framework that incorporates these two ingredients, and study the effect of income inequality on aggregate political outcomes in this context. Consistent with empirical evidence, the main predictions of the model are that greater inequality is conducive to more redistribution via income taxation, more protectionist policies in capital-abundant countries, and less protectionist policies in labour-abundant countries. These results are established under the condition that inequality is relatively important in each country. There is now an abundant literature

showing that inequality measures vary greatly across time and place. While there is no consensus on how to measure inequality (see Cowell, 2000), all indicators display significant levels of inequality in both developing and developed countries.[7]

The impact of inequality on redistribution and protectionism has already received much attention in the previous literature. But the principal contribution of the present paper is to throw light on new channels through which income inequality impacts countries' redistributive and trade policies: two-dimensional majority voting at the domestic level on the one hand, and strategic interdependencies between countries' trade policies on the other hand. The analysis shows how these domestic-politics and international-trade effects interact to yield the above-mentioned predictions.

Appendix

Proof of Lemma 1

For each $i = A, B$, the pair $\left(\hat{\tau}_i, \hat{t}_i\right)$ is implicitly defined by the system of equations (7) and (8). Solving this system of equations and rearranging terms yields:

$$\hat{\tau}_i\left(t_j, e_i\right) = \frac{e_i\left(2\bar{y}_i + \bar{y}_j - 3\alpha - e_i + \iota(i)t_j\right)}{3 - e_i^2}\ , \tag{17}$$

$$\hat{t}_i\left(t_j, e_i\right) = \iota(i)\frac{\left(1 - e_i^2\right)\left(2\alpha - \bar{y}_i - \bar{y}_j - \iota(i)t_j\right) + 2\left(\bar{y}_i - e_i - \alpha\right)}{3 - e_i^2}\ . \tag{18}$$

A brief inspection of equation (17) above reveals that $\frac{\partial\hat{\tau}_i(t_j,e_i)}{\partial t_j}$ is nonnegative if and only if

$$\iota(i)\frac{e_i}{3 - e_i^2} \geq 0.$$

By Assumption 1, $e_i < 0$ and $3 - e_i^2 > 0$. This proves parts (i) and (ii) of the lemma.

Part (iii) is proved in like manner: Simple differentiation shows that

$$\frac{\partial\hat{t}_i\left(t_j, e_i\right)}{\partial t_j} = \frac{e_i^2 - 1}{3 - e_i^2}\ . \tag{19}$$

As $e_i^2 < 3$, the above derivative is nonnegative if and only if $e_i \leq -1$.

[7] Income inequality measures for a large number of countries can be found in United Nations (2007, pp. 281-284).

Proof of Proposition 1

By definition, $\{(\tau_i^*(e_i,e_j),t_i^*(e_i,e_j))\}_{i=A,B}$ solves the system of first-order conditions (7) and (8) for both countries simultaneously. Tedious computations reveal that the unique solution of this system of four equations and four unknowns is

$$\tau_i^*(e_i,e_j) = -\frac{e_i\left[\left(2-e_j^2\right)(2\alpha-\bar{y}_i-\bar{y}_j)+e_i-e_j-(\bar{y}_i-\bar{y}_j)\right]}{4-\left(e_A^2+e_B^2\right)}, \tag{20}$$

and

$$\begin{aligned} t_i^*(e_i,e_j) =& \frac{\iota(i)}{4-e_A^2-e_B^2}\left\{\left(3-e_j^2\right)(\bar{y}_i-e_i)+\left(1-e_i^2\right)(\bar{y}_j-e_j)-\alpha\left(4-e_A^2-e_B^2\right)\right. \\ &\left.+(2\alpha-\bar{y}_i-\bar{y}_j)\left[2-2e_i^2-e_j^2\left(1-e_i^2\right)\right]\right\}, \end{aligned} \tag{21}$$

for each $i=A,B$.

To prove the first claim in Proposition 1, we differentiate (20) and rearrange terms so as to obtain

$$\begin{aligned} \left[4-\left(e_A^2+e_B^2\right)\right]^2\frac{\partial\tau_i^*(e_i,e_j)}{\partial e_i} =& \left[e_j+\bar{y}_i-\bar{y}_j-\left(2-e_j^2\right)(2\alpha-\bar{y}_i-\bar{y}_j)\right] \\ &\times\left[4+\left(e_A^2+e_B^2\right)\right]-2e_i\left(4-e_j^2\right). \end{aligned}$$

Thus, τ_i^* is increasing in e_i if and only if

$$e_j+\bar{y}_i-\bar{y}_j+\left(e_j^2-2\right)[m_i(0)+m_j(0)] \geq \frac{2e_i\left(4-e_j^2\right)}{4+e_A^2+e_B^2}. \tag{22}$$

Denote by $f(e_j)$ and $g(e_j,e_i)$ the left- and right-hand sides of the above inequality, respectively. Then, note that

$$\lim_{e_j\to-\sqrt{3}} f(e_j) = 2m_j(0)-\sqrt{3} > 0 = \sup_{e_j,e_i} g(e_j,e_i),$$

where the inequality comes from Assumption 2. By continuity, therefore, there exists $\tilde{e}_j^1\in(-\sqrt{3},0)$ such that (22) holds with a strict inequality for any $e_i\in(-\sqrt{3},0)$ whenever $e_j\in\left(-\sqrt{3},\tilde{e}_j^1\right)$. This proves part (i).

We now turn to the proof of parts (ii) and (iii). Differentiating (21) and rearranging terms yields

$$\iota(i)\frac{\left(4-e_A^2-e_B^2\right)^2}{3-e_j^2}\frac{\partial t_i^*\left(e_i,e_j\right)}{\partial e_i} =2e_i\left[\bar{y}_i-\bar{y}_j+\left(m_i(0)+m_j(0)\right)\left(e_j^2-2\right)\right] - 4+e_j^2-e_i\left(e_i-2e_j\right) \ .$$

Hence, $\iota(i)\frac{\partial t_i^*}{\partial e_i}<0$ if and only if

$$\left[\bar{y}_i-\bar{y}_j+\left(m_i(0)+m_j(0)\right)\left(e_j^2-2\right)\right] > \frac{4-e_j^2+e_i\left(e_i-2e_j\right)}{2e_i} \ . \tag{23}$$

Let $l(e_j)$ and $h(e_j,e_i)$ stand for the left- and right-hand sides of the above inequality, respectively. Thus, we have

$$\frac{\partial h(e_j,e_i)}{\partial e_i}=\frac{e_i^2+e_j^2-4}{2e_i^2}\geq 0 \Leftrightarrow e_i\leq -\sqrt{4-e_j^2},$$

and therefore

$$\arg\max_{e_i\in\left(-\sqrt{3},0\right)} h(e_j,e_i) = -\min\left\{\sqrt{4-e_j^2},\sqrt{3}\right\}.$$

This implies that

$$\lim_{e_j\to-\sqrt{3}}\left[\max_{e_i\in\left(-\sqrt{3},0\right)} h\left(e_j,e_i\right)\right]=\sqrt{3}-1<2m_j(0)=\lim_{e_j\to-\sqrt{3}} l\left(e_j\right).$$

By continuity, this in turn implies that there exists a sufficiently small ε such that $l\left(e_j\right)>\sup_{e_i\in\left(-\sqrt{3},0\right)} h\left(e_j,e_i\right)$ whenever $e_j\in\left(-\sqrt{3},\varepsilon-\sqrt{3}\right)$. Setting $\tilde{e}_j^2=\varepsilon-\sqrt{3}$, we thus obtain inequality (23) for all $e_j\leq\tilde{e}_j^2$.

To complete the proof of the proposition, define $\tilde{e}_j\equiv\min\left\{\tilde{e}_j^1,\tilde{e}_j^2\right\}$.

Proof of Proposition 2

The t_j^* function is obtained by substituting j to i and i to j in (21). Then, differentiating this function with respect to e_i and rearranging terms yields:

$$\left(4-e_i^2-e_j^2\right)^2\frac{\partial t_j^*\left(e_j,e_i\right)}{\partial e_i} =\iota(i)\left(1-e_j^2\right)\left\{e_i\left[e_i-2e_j+2\left(m_i(0)+m_j(0)\right)\left(2-e_j^2\right)\right.\right. \left.\left.-2\left(\bar{y}_i-\bar{y}_j\right)\right]+4-e_j^2\right\} \ .$$

Suppose $e_j < -1$. Hence, $\iota(i)\frac{\partial t_j^*}{\partial e_i} \leq 0$ if and only if

$$-e_i\left[e_i - 2e_j + 2\left(m_i(0) + m_j(0)\right)\left(2 - e_j^2\right) - 2\left(\bar{y}_i - \bar{y}_j\right)\right] \leq 4 - e_j^2.$$

Assumption 2 – namely $m_j(0) > \sqrt{3}/2$ – guarantees that the above condition holds with a strict inequality for any $e_i \in \left(-\sqrt{3}, 0\right)$ if $e_j \to -\sqrt{3}$. By continuity, therefore, there exists a sufficiently small $\epsilon < \sqrt{3}-1$ such that this is also true for any $e_j \in \left(-\sqrt{3}, \epsilon - \sqrt{3}\right)$. Setting $\hat{e}_j \equiv \epsilon - \sqrt{3}$, we obtain the proposition.

Proof of Proposition 3

Differentiating $\hat{\tau}_i\left(t_j^*, e_i\right)$ (see equation (17) above) with respect to e_i, we can see that

$$\frac{\partial \hat{\tau}_i\left(t_j^*, e_i\right)}{\partial e_i} \geq 0 \text{ if and only if } \iota(i)t_j^* \geq 2m_i(0) + m_j(0) + \frac{6e_i}{3 + e_i^2} \equiv \beta_i(e_i).$$

Moreover, inspection of (21) reveals that

$$\lim_{e_i \to -\sqrt{3}} t_j^*\left(e_j, e_i\right) = -\iota(j)\left[2m_i(0) + m_j(0) - \sqrt{3}\right].$$

As a consequence,

$$\lim_{e_i \to -\sqrt{3}}\left[\iota(i)t_j^*\left(e_j, e_i\right)\right] = 2m_i(0) + m_j(0) - \sqrt{3} = \lim_{e_i \to -\sqrt{3}} \beta_i\left(e_i\right), \tag{24}$$

for any e_j.

Let

$$\gamma_i(e_i) \equiv \max_{e_j \in \left[-\sqrt{3}, \hat{e}_j\right]}\left\{\iota(i)t_j^*\left(e_j, e_i\right)\right\}.$$

It results from (24) that $\gamma_i(-\sqrt{3}) = \beta_i(-\sqrt{3})$. We know from Proposition 2 that $\iota(i)t_j^*\left(e_j, e_i\right)$ is strictly decreasing in e_i when $e_j \in \left(-\sqrt{3}, \hat{e}_j\right)$. This implies that γ_i is a decreasing function and, since β_i is strictly increasing over $(-\sqrt{3}, 0)$, that

$$\iota(i)t_j^*\left(e_j, e_i\right) \leq \gamma_i(e_i) < \beta_i(e_i)$$

whenever $e_j \in \left(-\sqrt{3}, \hat{e}_j\right)$. This proves the first part of the proposition.

We know from equation (14) that

$$\frac{\partial \hat{t}_i(t_j^*, e_i)}{\partial e_i} = \frac{\partial t_i^*(e_i, e_j)}{\partial e_i}\left[1 - \frac{\partial \hat{t}_i(t_j^*, e_i)}{\partial t_j}\frac{\partial \hat{t}_j\,(t_i^*, e_j)}{\partial t_i}\right] .$$

From Proposition 1, $\iota(i)\frac{\partial t_i^*(e_i,e_j)}{\partial e_i}$ whenever $e_j < \tilde{e}_j$. Moreover, inspection of (19) reveals that, for each i and j with $i \neq j$, $\frac{\partial \hat{t}_i(t_j^*,e_i)}{\partial t_j} > 1$ when $e_i < -\sqrt{2}$. Hence,

$$\iota(i)\left.\frac{\partial \hat{t}_i\,(t_j, e_i)}{\partial e_i}\right|_{(t_j,e_i)=\left(t_j^*(\bar{e}_j,\bar{e}_i),\bar{e}_i\right)} > 0$$

whenever $(\bar{e}_i, \bar{e}_j) \in \left(-\sqrt{3}, \breve{e}\right)^2$, where $\breve{e} \equiv \min\left\{\tilde{e}_A, \tilde{e}_B, -\sqrt{2}\right\}$. Thus, setting $\hat{e} \equiv \min\left\{\hat{e}_A, \hat{e}_B, \breve{e}\right\}$ completes the proof of Proposition 3.

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