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Redistributing the Gains from Trade through Non-linear Lump-sum Transfers

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Abstract

I examine lump-sum transfer rules to redistribute the gains from free trade under incomplete information, where the government does not know the characteristics of individuals. By considering transfer rules that make the amount of transfer dependent on transactions of individuals under autarky, I show that there is no incentive-compatible and budget-balancing transfer rule to redistribute the gains from free trade successfully, if the discount factor is sufficiently large. Also, the paper examines whether the amount of transfer should be dependent on transactions under autarky or transactions under free trade, and shows that the former is better when the discount factor is small or the government has enough budget for redistribution.

Key word: Gains from trade, Redistribution, Incomplete information
JEL Classifications: D82, F10, H20

Contents

Introduction

It is well known that free trade creates winners and losers. However, with an appropriate lump-sum transfer, Pareto improvement can be achieved as a country moves from autarky to free trade, as shown by Kemp (1962), Kemp and Wan (1972), and Grandmont and McFadden (1972), among others.(1) Essentially, the idea of Pareto-improving lump-sum transfers is to let what each individual consumed under autarky affordable under free trade, too.(2)

Later, Dixit and Norman (1986) pointed out practical diffculties of implementing such lump-sum transfers. In implementing a lump-sum transfer to make everyone better off after free trade, the government has to figure out not only who are taxed and who are subsidized, but also how much is taxed or subsidized for each individual. To do so, the government needs to collect information about the characteristics of individuals. Moreover, when asked by the government, each individual may not reveal his characteristics that the government is going to use to calculate the amount of transfer. As Dixit and Norman (1986) write, individuals have an incentive to manipulate their behavior "so as to mislead the planner about these characteristics and secure a larger net transfer."

How do they manipulate their behavior? Does that manipulation matter?(3) Wong (1997) studied these questions in a general setting, and argued that ma-

(1) These studies work on models of perfect competition. Under imperfect competition such as oligopoly, whether there are gains from free trade is less unambiguous. See, for example, Dong and Yuan (2010) and Kemp (2010).

(2) Using such lump-sum transfers has been one of the standard techniques to make welfare comparison. For textbook treatment, see Wong (1995; pp. 354-361).

(3) Che and Facchini (2007) studied this kind of manipulation in a context of market liberalization, while we study the manipulation in the context of trade liberalization.

nipulation does not matter if the autarkic price does not change by such manipulation. Recently, however, examining the same question in a simpler setting of a two-goods exchange economy with quasi-linear utility, Ichino (2012) showed that due to consumers' manipulation the autarkic price changes to the directions unfavorable to those who lose by free trade. As a result, a lump-sum transfer rule that allows everyone to consume under free trade what they used to consume under autarky becomes ineffective in redistributing the gains from free trade. Moreover, in Ichino (2012) it is shown that any transfer rules that are linearly dependent on autarkic consumption cannot achieve Pareto gains from trade.

In this paper, we consider a more general class of lump-sum transfer rules, including transfer rules non-linearly dependent on autarkic consumption, and explore if there exist any transfer rules that can successfully redistribute the gains from free trade to everyone. For this purpose, we apply a contract-theory technique used by Feenstra and Lewis (1991) (hereafter, we refer it as FL (1991)). As explained above, since the government does not have complete information on individuals' characteristics, it has to "ask" the individuals to reveal such information in order to calculate the amount of transfer. Then, under such a circumstance, individuals have an incentive to manipulate their behavior, or misreport their characteristics if doing so increases the amount of transfer to be received. To prevent manipulation or misreporting, the government has to design a transfer rule that induces truth telling. We therefore formulate a welfare-maximization problem in which transfer rules should satisfy the incentive compatible constraint as well as the government budget constraint and the everyone-is-made-better-off constraint.

By solving the welfare maximization problem, we first point out that if transfer rules are to relate the amount of transfer to the amount of consumption under autarky, then the autarkic consumption should be distorted to prevent manipulation or misreporting of the individuals. Then, we show that there is no incentive-compatible and budget-balancing transfer rules to achieve Pareto gains from free trade if the discount factor is sufficiently large. Intuitively, this is because the amount of subsidies given to losers of free trade has to be large enough to compensate him not only for his loss from free trade but also for the loss from distorted consumption under autarky. At the same time, the amount of taxes collected from the gainers of free trade is limited because of distorted consumption.

Also, we compare the outcome of our model with the outcome of FL (1991). As mentioned above, in this paper, we consider transfer rules dependent on the consumption under autarky. On the other hand, in FL (1991), transfer rules are dependent on the consumption under free trade. By comparing the resulting welfare of our model and FL (1991)'s, we show that the former gives a higher welfare than the latter when the discount factor is small or the government has enough budget for redistribution.

I The model

We consider an exchange economy with two goods, good x and good y, where good y is the numeraire. In this economy, there is a continuum of individuals with the population normalized to one. The individuals are assumed identical, except the endowment of good x. With ω denoting the endowment of good x, the individuals in the economy are indexed by ω. For simplicity, assume that ω is uniformly distributed over the range of $[0, 1]$. The utility function of an individual having ω units of the endowment of good x is given by

$$u(x+\omega)+y+\bar{y}$$

where x and y denote excess demand of good x and y respectively, and $\bar{y}$ is the endowment of good y (which is the same for everyone). To have explicit solution, we assume that the sub-utility function $u(\cdot)$ quadratic:

$$u(x+\omega)=k+a(x+\omega)-\frac{b}{2}(x+\omega)^2.$$

where $k \geq 0$, $a>0$, $b>0$.

In this model, we have two periods: in period 0, the economy is under autarky; in period 1, the economy is under free trade. The utility maximization problem of an individual is given by

$$\max_x U(x, p, \omega)=u(x+\omega)-px+\bar{y}$$

since the budget constraint $px+y \leq 0$ is always binding. The first-order condition is $u'(x+\omega)=p$, from which the excess demand function $x(p, \omega)=(a-p)/b-\omega$ is derived. Then, the autarkic equilibrium price p^a is determined from the market-clearing condition $\int_0^1 x(p, \omega)d\omega=0$. Since $\int_0^1 \omega d\omega=1/2$, solving this condition gives $p^a=(2a-b)/2$. Let $x^a(\omega) \equiv x(p^a, \omega)$ denote the excess demand (or, we call it "transaction") of individual ω in the autarkic equilibrium, and define the indirect utility of individual ω in the autarkic equilibrium $U^a(\omega) \equiv U(x^a(\omega), p^a, \omega)$.

In period 1, when the economy allows free trade, the price of good x is equal to the world price p^* (we assume that the economy is small). Then, transaction of individual ω in the free-trade equilibrium is given by $x^*(\omega) \equiv (a-p^*)/b-\omega$, and the indirect utility in the free-trade equilibrium by $U^*(\omega) \equiv U(x^*(\omega), p^*, \omega)$. We assume that $p^*<p^a$: the world price of good x is smaller than the autarky price.(4) By this assumption, $x^*(\omega)>x^a(\omega)$.

In aggregate, there are gains from free trade[5]:

$$\int_0^1 U^*(\omega)d\omega - \int_0^1 U^a(\omega)d\omega$$

$$= \int_0^1 [U(x^*, p^*) - U(x^a, p^*)]d\omega + \int_0^1 [U(x^a, p^*) - U(x^a, p^a)]d\omega$$

$$= \int_0^1 [U(x^*, p^*) - U(x^a, p^*)]d\omega + (p^a - p^*)\int_0^1 x^a d\omega > 0$$

since the first term is positive (given p^*, the utility-maximizing transaction is x^*) and the second term is zero because $\int_0^1 x^a d\omega = 0$.

However, the gains from trade do not fall equally to everyone. Buyers of good x under autarky gain from free trade:

$$U^*(\omega) - U^a(\omega) = [U(x^*, p^*) - U(x^a, p^*)] + [U(x^a, p^*) - U(x^a, p^a)]$$
$$= [U(x^*, p^*) - U(x^a, p^*)] + (p^a - p^*)x^a > 0$$

since $x^a > 0$. On the other hand, the sellers of good x under free trade lose from free trade:

$$U^*(\omega) - U^a(\omega) = [U(x^*, p^*) - U(x^*, p^a)] + [U(x^*, p^a) - U(x^a, p^a)]$$
$$= (p^a - p^*)x^* + [U(x^*, p^a) - U(x^a, p^a)] < 0.$$

provided that $x^* < 0$.

Ⅱ Lump-sum transfers under incomplete information

In order to redistribute the gains from trade, the government can give the follow-

(4) For the parameters of the utility function and the world price, we impose the following restriction: (i) $2a > b$. This is to make the autarkic price positive. (ii) $p^* < (2a - b)/2$. This is from the assumption of $p^* < p^a$. (iii) $(a - p^*)/b < 1$. This is to make some individuals still sellers of good x under free trade.

(5) Here, to simplify the notation, we use expressions such as $U(x^a, p^a)$ to mean $U(x^a(\omega), p^a, \omega)$, by suppressing ω. Hereafter, if there is likely no confusion, we write $U(x, p)$ to denote $U(x(\omega), p, \omega)$.

ing lump-sum transfer $z^a(\omega)=-(p^a-p^*)x^a(\omega)$ to individual ω in period 1 (note that $z^a(\omega)>0$ is a subsidy and $z^a(\omega)<0$ is a tax). By this transfer, the budget constraint of individual ω in period 1 becomes $p^*x+y \leq -(p^a-p^*)x^a(\omega)$. It is easy to show that this transfer makes what each individual consumed under autarky affordable under free trade as well:

$$p^*x+y\leq-(p^a-p^*)x^a(\omega) \Leftrightarrow p^*x+y\leq p^*x^a(\omega)-p^ax^a(\omega)$$

Therefore, everyone gets better off by free trade. That is, $U^*(\omega)+z^a(\omega) > U^a(\omega)$ for all ω. In addition, with this lump-sum transfer, the government budget is balanced since $\int_0^1 z^a(\omega)d\omega=-(p^a-p^*)\int_0^1 x^a(\omega)d\omega=0$.

The discussion above that the free trade policy with the lump-sum transfer $z^a(\omega)$ makes everyone better off, however, depends on an implicit assumption that the government can figure out what $z^a(\omega)$'s are. For the government to calculate $z^a(\omega)$, it has to know each individual's endowment. But this is not likely the case. Without knowing the endowment of each individual, the government is not able to calculate $x^a(\omega)$, and thus cannot figure out $z^a(\omega)$. Then, the only way for the government to find the amount of lump-sum transfer for each individual is to *observe* his transaction in period 0 (under autarky). However, if each individual knows that the government is going to observe his transaction in period 0 to determine the amount of transfer for him, then he may want to change, or "manipulate" his period-0 transaction in order to get larger transfer in period 1. So, here is the question: Is it possible to achieve Pareto gains from free trade through lump-sum transfers even when the government does not have complete information on the characteristics of the individuals and thus there can be manipulation of transaction?

To answer the question formally, let us now clarify the setting. As mentioned earlier, in the following analysis we suppose that the government does not know endowment of each individual; the government just observes transaction of each individual in period 0 (under autarky). In period 0, all individuals know that free trade will be allowed in period 1. They also know that a lump-sum transfer $z(x)$ will be given in period 1. Here, note that the transfer depends on x, the observed transaction of an individual in period 0.

In this setting, the utility maximization problem of an individual should be an intertemporal one, namely,

$$\max_{x,x^1} U(x, p, \omega) + \delta z(x) + \delta U(x^1, p^*, \omega) \tag{1}$$

where x and x^1 are respectively the period-0 and the period-1 transaction of good x, p is the prevailing price in period 0, and δ is a discount factor $0 \leq \delta \leq 1$ (we assume everyone has the same discount factor). By inspection of the maximization problem (1), it is obvious that $x^1 = x^*$: the transaction under free trade is the same as the one we saw in the previous section. But the transaction under autarky is now different from x^a because of the dependence of the lump-sum transfer on x. Thus, the autarkic equilibrium price, too, can be different from p^a. We say that a lump-sum transfer rule $z(x)$ can achieve Pareto gains from free trade if the following inequality holds for all ω:

$$\max_{x} [U(x, p, \omega) + \delta z(x)] + \delta U^*(\omega) \geq (1+\delta) U^a(\omega).$$

Ichino (2012) examined the case of $z(x) = -(p - p^*)x$, the lump-sum transfer rule to make sure that all individuals can consume under free trade what they used to consume under autarky, and found that due to transaction manipulation Pareto gains from trade cannot be achieved by this transfer rule. Moreover, in Ichino (2012) it is shown that any transfer rules that are linear in x cannot achieve Pareto gains from trade.

In this paper, we consider a more general class of lump-sum transfers, including transfer rules non-linearly dependent on x, and explore if there are any transfer rules that can successfully distribute the gains from free trade to everyone. For this purpose, we apply a contract-theory technique used by FL (1991), where the endowment of good x is taken as a "type" of an individual not known to the government, and the government is going to solve a welfare-maximization problem to derive a menu $\{x(\omega), z(\omega)\}$ i.e., a pair of transaction and transfer.

Ⅲ Welfare-maximizing transfers

3.1 Welfare maximization problem

Given a menu $\{x(\omega), z(\omega)\}$ for $0 \leq \omega \leq 1$, if an individual whose endowment is ω picks a particular pair $\{x(\omega'), z(\omega')\}$, his intertemporal utility is

$$U(x(\omega'), p, \omega) + \delta z(\omega') + \delta U^*(\omega).$$

By the revelation principle, without loss of generality we can confine the set of pairs $\{x(\omega), z(\omega)\}$ to be considered to those satisfying the following incentive compatibility (IC) constraints:

$$U(x(\omega), p, \omega) + \delta z(\omega) \geq U(x(\omega'), p, \omega) + \delta z(\omega') \text{ for all } \omega, \omega'. \quad (2)$$

In addition to the IC constraints, a transaction-transfer menu $\{x(\omega), z(\omega)\}$ has to be designed so as to make everyone better off by free trade. That is, the inequality

$$U(x(\omega), p, \omega) + \delta z(\omega) \geq U^a(\omega) + \delta(U^a(\omega) - U^*(\omega)) \text{ for all } \omega \quad (3)$$

has to be satisfied. This is analogous to the individual rationality (IR) constraint in a standard contract-theory model. So, in the paper we refer this as the IR constraint.

Third, transfers should satisfy the government's budget (GB) constraint:

$$\int_0^1 z(\omega)d\omega \leq B \tag{4}$$

where $B \geq 0$ is some amount of budget the government can use for transfer policy.

Finally, the market-clearing condition

$$\int_0^1 x(\omega)d\omega = 0 \tag{5}$$

determines the period-0 equilibrium price p.

The welfare maximization problem of the government is set as follows:

$$\max_{x(\omega),z(\omega)} \int_0^1 [U(x(\omega), p, \omega) + \delta z(\omega)]d\omega + \delta B - \int_0^1 \delta z(\omega)d\omega \tag{6}$$

s.t. (2), (3), (4), and (5),

where the objective function is the sum of the individual's utility and the government surplus.

Problem (6) is a natural extension of Ichino (2012). However, here we do not solve problem (6). Instead, we solve a somewhat different problem defined below.

$$\max_{x(\omega),z(\omega)} \int_0^1 [U(x(\omega), p^a, \omega) + \delta z(\omega)]d\omega$$
$$+ \delta B - \int_0^1 [\delta z(\omega) - (p^a - p^*)x(\omega)]d\omega \tag{7}$$

s.t. $U(x(\omega), p^a, \omega) + \delta z(\omega) \geq U(x(\omega'), p^a, \omega) + \delta z(\omega')$ for all ω, ω',

$U(x(\omega), p^a, \omega) + \delta z(\omega) \geq U^a(\omega) + \delta(U^a(\omega) - U^*(\omega))$ for all ω.

$$\int_0^1 \delta z(\omega)d\omega - \int_0^1 (p^a - p^*)x(\omega)d\omega \leq \delta B.$$

The welfare maximization problem (7) is different from problem (6) in how the period-0 price is determined. In problem (6), the period-0 price p is determined by the autarkic market-clearing condition $\int_0^1 x(\omega)d\omega=0$. Therefore, the autarkic equilibrium price may be different from p^a, depending on the shape of $x(\omega)$. On the other hand, in problem (7), the period-0 price is supported by the government at p^a, the autarkic equilibrium price under the complete information case. To support the price at p^a, the government impose an import tariff (if $x(\omega)>0$) or an export subsidy (if $x(\omega)<0$) with the size of (p^a-p^*). That is why we have a term $-\int_0^1 (p^a-p^*)x(\omega)d\omega$ in the government's budget constraint. Simply put, in problem (6) autarky is maintained by prohibition of international trade, while autarky is maintained by a prohibitive tariff (or export subsidy) in problem (7). Below, we present an outline of solving problem (7). Problem (6) is solved in a similar fashion since it has the same structure as problem (7). Later, we explain why we focus on problem (7) instead of problem (6).

To make expressions simpler, by abusing notation a little bit, we define $U(\omega)\equiv U(x(\omega), p^a, \omega)+\delta z(\omega)$. As explained by FL (1991), the IC constraints of problem (7) is equivalent to (i) $U'(\omega)=u'(x(\omega)+\omega)$ and (ii) $x(\omega)$ is nonincreasing. By using condition (i) for the IC constraint, we can construct the following constrained Hamiltonian by treating $x(\omega)$ and $z(\omega)$ as control variables and $U(\omega)$ as a state variable:

$$\begin{aligned} H= & [U(\omega)+\delta B-\delta z(\omega)+(p^a-p^*)x(\omega)] \\ & +\gamma(\omega)u'(x(\omega)+\omega) \\ & +\mu(\omega)(U(\omega)-U^a(\omega)-\delta(U^a(\omega)-U^*(\omega))) \\ & +\rho(\omega)(U(x(\omega),\ p^a,\ \omega)+\delta z(\omega)-U(\omega)) \\ & +\lambda(\delta B-\delta z(\omega)+(p^a-p^*)x(\omega)), \end{aligned} \tag{8}$$

where the second line is condition (i) of the IC constraint, and gives the equation of motion for $U(\omega)$ (we confirm that condition (ii) of the IC constraint is satisfied after having derived a solution). The third line is the IR constraint, the fourth line defines $U(\omega)$, and the fifth line is the GB constraint. The maximum principle requires that

$$H_x = (p^a - p^*) + \gamma(\omega)u'' + \rho(\omega)(u'(x(\omega)+\omega) - p^a) + \lambda(p^a - p^*) = 0, \tag{9a}$$

$$H_z = -\delta + \rho(\omega)\delta - \lambda\delta = 0, \tag{9b}$$

$$-H_U = -1 - \mu(\omega) + \rho(\omega) = \gamma'(\omega), \tag{9c}$$

and the transversality conditions are

$$\gamma(0)[U(0) - U^a(0) - \delta(U^a(0) - U^*(0))] = 0, \text{ and}$$

$$\gamma(1)[U(1) - U^a(1) - \delta(U^a(1) - U^*(1))] = 0.$$

We let $\{x^0(\omega), z^0(\omega)\}$ denote the solution, and $U^0(\omega)$ a utility level achieved by the solution. Here, we present an outline of deriving the solution. For the detail, see the appendix.

From (9b), $\rho(\omega) = 1 + \lambda$ is derived. Substituting this into (9c) gives $\gamma(\omega) = \gamma(0) - \int_0^\omega \mu(t)dt + \lambda\omega$. Then, applying these expressions to (9a), we can derive a equation determining the transaction schedule $x^0(\omega)$

$$u'(x^0(\omega)+\omega) - p^* = -\frac{\gamma(0) - \int_0^\omega \mu(t)dt + \lambda\omega}{1+\lambda}u'', \tag{10}$$

For the time being, assume that the IR constraint is binding only at $\omega = 1$ (Later, we explain it is actually the case when the government's budget B is large enough). Then, $\gamma(0) = 0$ by the transversality condition and $\int_0^\omega \mu(t)dt = 0$ since the IR constraint is not binding for all $\omega < 1$. Thus, (10) is simplified to

$$u'(x^0(\omega)+\omega) - p^* = -u''m\omega$$

where $m=\lambda/(1+\lambda)$. Solving for x^0, the following expression

$$x^0(\omega)=x^n(\omega)\equiv\frac{a-p^*}{b}-(m+1)\omega \tag{11}$$

is derived. Here, we have defined $x^n(\omega)$ as a solution when the IR constraint is not binding for all $\omega<1$ (the superscript n for "not binding"). Since the multiplier $\lambda\geq 0$, $x^n(\omega)$ is decreasing in ω, satisfying condition (ii) of the IC constraint. Once $x^n(\omega)$ is derived, from the IC constraint, and from the IR constraint binding at $\omega=1$, the period-0 utility is determined as follows:

$$U^0(\omega)=U^n(\omega)\equiv U^a(1)+\delta(U^a(1)-U^*(1))-\int_\omega^1 u'(x^n(t)+t)dt.$$

We can interpret $U^0(\omega)$ as a "target level of utility" to be achieved, with a transfer $z(\omega)$. On the other hand, without transfer, the period-0 utility of individual ω is $U(x^n(\omega), p^a, \omega)$. The transfer schedule is thus determined so as to fill the gap between the target level and the without-transfer level:

$$\delta z^0(\omega)=\delta z^n(\omega)\equiv U^n(\omega)-U(x^n(\omega), p^a, \omega). \tag{12}$$

Then, we can calculate the GB constraint

$$\int_0^1 \delta z^n(\omega)d\omega-\int_0^1 (p^a-p^*)x^n(\omega)d\omega=\delta B,$$

and from this we can determine m. This completes the solution.

Now, we explain why we solved problem (7) instead of problem (6). Lemma 1 shows that what is achieved by solving problem (6) is achievable by problem (7).

Lemma 1 *Consider a solution $\{\hat{x}(\omega), \hat{z}(\omega)\}$ of problem (6) and the welfare level achieved by the solution. There exists some $z(\omega)$ by which the same welfare level and the same $\hat{x}(\omega)$ is implemented such that $\{\hat{x}(\omega), z(\omega)\}$ satisfies the constraints of problem (7).*

Proof. Consider a solution $\{\hat{x}(\omega), \hat{z}(\omega)\}$ of problem (6). In problem (6), the utility level of individual ω is equal to $U^a(1)+\delta(U^a(1)-U^*(1)) -\int_\omega^1 u'(\hat{x}(t)+t)dt$. To achieve this target level, the transfer schedule $\hat{z}(\omega)$ is calculated as follows:

$$\delta\hat{z}(\omega)=U^a(1)+\delta(U^a(1)-U^*(1)) -\int_\omega^1 u'(\hat{x}(t)+t)dt-U(\hat{x}(\omega), p, \omega).$$

With the same $\hat{x}(\omega)$, the same target level of utility can be achieved in problem (7) by the following transfer schedule $\delta z(\omega)$.

$$\delta\hat{z}(\omega)=U^a(1)+\delta(U^a(1)-U^*(1)) -\int_\omega^1 u'(\hat{x}(t)+t)dt-U(\hat{x}(\omega), p^a, \omega).$$

Since $\int_0^1 \hat{x}(\omega)d\omega=0$ by the market clearing condition in problem (6), the aggregate transfers are the same for $\hat{z}(\omega)$ and $z(\omega)$, and the tariff revenue in problem (7) is zero.

Therefore, $\int_0^1 \delta\hat{z}(\omega)d\omega=\int_0^1 \delta z(\omega)d\omega-\int_0^1 (p^a-p^*)\hat{x}(\omega)d\omega$. ■

3.2 Characterization of the solution

Now we characterize the solution $\{x^0(\omega), z^0(\omega)\}$ as follows, noticing that the solution depends on the size of the government's budget B.

When B is large and the GB constraint is not binding, the solution is trivial. Since $m=\lambda/(1+\lambda)=0$ if the GB constraint is not binding, from (11) we see that $x^0(\omega)=(a-p^*)/b-\omega=x^*(\omega)$. That is, the government can achieve the most efficient outcome by letting everyone consume good x of the amount under the free trade. However, as the individuals consume $x^*(\omega)+\omega$ when facing p^a, their period-0 utility without transfer is $U(x^*(\omega), p^a, \omega)$, which is less than

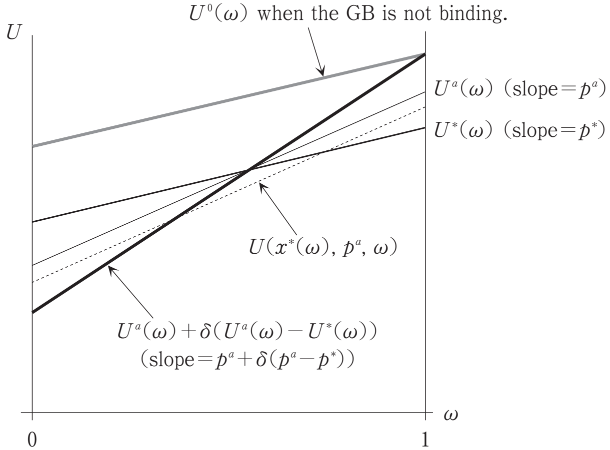

Figure 1: $U^0(\omega)$ when the GB constraint is not binding

$U^a(\omega)$. Since $U^a(\omega)<U^a(\omega)+\delta(U^a(\omega)-U^*(\omega))$ for large ω, the government has to give a positive transfer to those individuals to satisfy the IR constraint (see Figure 1). In particular, individuals with $\omega=1$ need to be compensated at least by $U^a(1)+\delta(U^a(1)-U^*(1))-U(x^*(1), p^a, 1)$ in order for the IR constraint to be satisfied. Suppose that the government gives the individuals with $\omega=1$ exactly this amount of transfer so that the IR constraint is just binding at $\omega=1$. Then, the IC constraint requires that the target level of utility $U^0(\omega)$ has a slope of $u'(x^*(\omega)+\omega)=p^*$ since everyone consumes $x^*(\omega)+\omega$. Namely, $U^0(\omega)$ has to be a parallel upward shift of $U^*(\omega)$ by the amount of $(1+\delta)(U^a(1)-U^a(1))$. By this construction, for all ω the target level of utility is above the utility without transfer. Therefore, the government has to give positive transfers to everyone to achieve the target level of utility. The sum of the transfers is

$$\int_0^1 \delta z^0(\omega)d\omega = \int_0^1 U^*(\omega)d\omega + (1+\delta)(U^a(1) - U^*(1))$$
$$- \int_0^1 U(x^*(\omega), p^a, \omega)d\omega.$$

On the other hand, because $x^*(\omega) > x^a(\omega)$, in aggregate there is imports of good x so that the government earns a tariff revenue $\int_0^1 (p^a - p^*)x^*(\omega)$. Thus, the overall government expenditure needed to implement the transaction-transfer schedule is

$$\int_0^1 \delta z^0(\omega)d\omega - \int_0^1 (p^a - p^*)x^*(\omega)$$
$$= \int_0^1 U^*(\omega)d\omega + (1+\delta)(U^a(1) - U^*(1))$$
$$- \int_0^1 U(x^*, p^a)d\omega - \int_0^1 (p^a - p^*)x^*(\omega)$$
$$= (1+\delta)(U^a(1) - U^*(1)).$$

So, when $\delta B = (1+\delta)(U^a(1) - U^*(1))$, the government has just enough budget to implement $x^*(\omega)$ with the IR constraint binding only at $w = 1$. In other words, when the government has a large enough budget such that $\delta B \geq (1+\delta)(U^a(1) - U^*(1))$, the most efficient transaction $x^*(\omega)$ is implemented, with the GB constraint not binding.

As δB falls below $(1+\delta)(U^a(1) - U^*(1))$, letting everyone consume $x^*(\omega) + \omega$ is no longer compatible with the IR constraint. To satisfy the IR constraint with the smaller amount of the budget available to the government, now the transfer has to be made smaller for the individuals with low ω (since they are the ones who gain from free trade, there is room to shave the transfer for them). Then, with smaller transfer for low ω, if $x^0(\omega) = x^*(\omega)$ were offered, the individuals with low ω would have an incentive to pretend that his ω is higher than what actually is in order to get a large transfer. To prevent it, transaction schedule $x(\omega)$ has to be distorted in such a way that consumption $x(\omega)+\omega$ is no longer the same for everyone but smaller for high ω. This is seen by equation (11): consumption $x^0(\omega)+\omega$ is equal to $x^n(\omega)+\omega$, which is distorted from $x^*(\omega)+\omega$ by $m\omega$.

Put differently, we can explain the following trade-offs of distorting consumption. Take a particular individual with $0<\omega\leq 1$. As consumption is distorted to be smaller than the free trade level, his period-0 utility without transfer is decreased. This makes a transfer needed to be given to this particular individual larger. However, such a distortion steepens the slope of the target utility $u'(x^n(\omega)+\omega)$, which lowers the target utility level of the *all* individuals below ω. This makes transfers needed to be given to those individuals smaller. In aggregate, the latter effect outweighs the former effect, and thus the government expenditure for transfers is made smaller by such distortion. In particular, for the individuals with large ω, the latter effect is dominating. This is why distortion is large for large ω, as illustrated in Figure 4. The target utility level is depicted in Figure 2. It is now steeper than the one when the GB constraint is not binding, but the IR constraint is still binding only at $\omega=1$.

As the government budget gets more stringent, consumption of good x is more distorted and the slope of the target level utility gets steeper. Eventually, the target utility becomes as steep as the right hand side (RHS) of the IR constraint at $\omega=1$. Then, consumption of good x cannot be lowered without violating the IR constraint for high ω. In this case, the IR constraint becomes binding not only at $\omega=1$ but also for large ω such that $\tilde{\omega}\leq\omega<1$, where $\tilde{\omega}$ is a threshold value. Namely, for $\tilde{\omega}\leq\omega<1$, the transaction schedule is chosen so as to make the target utility as steep as the RHS of the IR constraint: $u'(x(\omega)+\omega)=p^a+\delta(p^a-p^*)$ (see Figure 3). Letting $x^b(\omega)$ (b for "binding") denote the

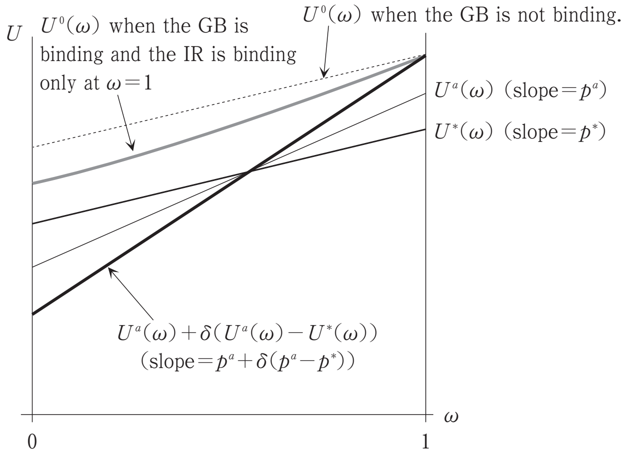

Figure 2: $U^0(\omega)$ when the GB constraint is binding and the IR constraint is binding only at $\omega=1$

transaction schedule satisfying this equality, we have

$$x^b(\omega)=\frac{a-p^a}{b}-\frac{\delta(p^a-p^*)}{b}-\omega \text{ for } \tilde{\omega}\leq\omega<1. \tag{13}$$

Since the target utility is $U^a(\omega)+\delta(U^a(\omega)-U^*(\omega))$, the transaction schedule for $\tilde{\omega}\leq\omega<1$ is given by

$$\delta z^b(\omega)\equiv U^a(\omega)+\delta(U^a(\omega)-U^*(\omega))-U(x^b(\omega), p^a, \omega). \tag{14}$$

On the other hand, for $0\leq\omega<\tilde{\omega}$, the transaction schedule is the same as (11), while the target utility is modified to $U^a(\tilde{\omega})+\delta(U^a(\tilde{\omega})-U^*(\tilde{\omega}))-\int_{\omega}^{\tilde{\omega}}u'(x^n(t)+t)dt$. Threfore, the transaction schedule for $0\leq\omega<\tilde{\omega}$ is

$$\delta\tilde{z}^n(\omega)\equiv U^a(\tilde{\omega})+\delta(U^a(\tilde{\omega})-U^*(\tilde{\omega}))$$
$$-\int_{\omega}^{\tilde{\omega}}u'(x^n(t)+t)dt-U(x^n(\omega), p^a, \omega). \tag{15}$$

The threshold value $\tilde{\omega}$ is determined by equating $x^n(\omega)$ and $x^b(\omega)$. That is,

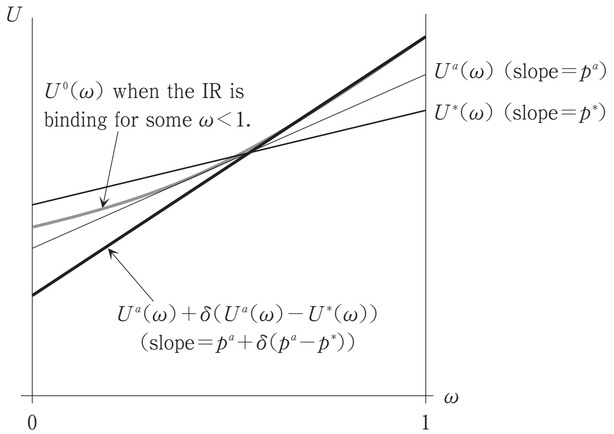

Figure 3: $U^0(\omega)$ when the IR constraint is binding for some $\omega<1$

$\tilde{\omega}$ solves the equality

$$\frac{a-p^*}{b}-(m+1)\tilde{\omega}=\frac{a-p^a}{b}-\frac{\delta(p^a-p^*)}{b}-\tilde{\omega}, \tag{16}$$

that is,

$$\tilde{\omega}=(1+\delta)(p^a-p^*)/bm. \tag{17}$$

The more stringent the government budget constraint becomes, m rises, and $\tilde{\omega}$ falls, meaning that the more individuals are made just indifferent between autarky and free trade. Then, naturally, the following question arises. No matter how small the budget B is, say, even when $B=0$, can some individuals be made *strictly* better off by free trade? Proposition 1 claims that the answer is no: when $B=0$, the gains from free trade can be distributed to make someone strictly better off and no one worse off only when δ is sufficiently small. If δ is large enough and B is small enough, there is no solution to problem (7). See Figure 6 for a graphical presentation.

Proposition 1 *There is a value $\bar{\delta}\in(0, 1)$ such that for $\delta\leq\bar{\delta}$ problem (7) has*

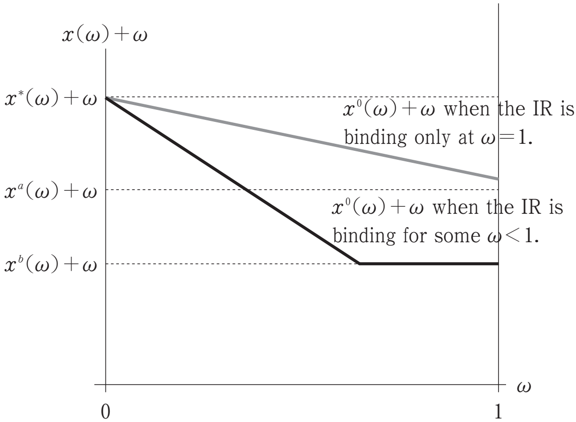

Figure 4: Consumption of good *x*

a solution for any $B \geq 0$. *On the other hand, for* $\delta > \bar{\delta}$, *there is threshold function* $\bar{B}(\delta)>0$ *such that* $\bar{B}'(\delta)>0$ *and for* $B<\bar{B}(\delta)$ *problem (7) has no solution.*

The proof is given in the appendix. Here, we provide intuitive explanation in the following three steps.

First, we show that in problem (7), even when making everyone just indifferent between autarky and free trade, the government needs positive budget. With the transactiontransfer pair $\{x^b(\omega), z^b(\omega)\}$ for all ω, the government expenditure for individual ω is written as

$$\delta z^b(\omega)-(p^a-p^*)x^b(\omega)=U^a(\omega)+\delta(U^a(\omega)-U^*(\omega))-U(x^b, p^*)$$

Adding and subtracting $U^*(\omega)$, we have

$$\begin{aligned}&\delta z^b(\omega)-(p^a-p^*)x^b(\omega)\\&=(1+\delta)(U^a(\omega)-U^*(\omega))+(U^*(\omega)-U(x^b, p^*))\end{aligned}$$

The first term is negative when it is aggregated, while the second term is positive since $U^*(\omega)=U(x^*, p^*)$. By decomposing the first term by adding and subtracting $U(x^a, p^*)$, we have

$$\begin{aligned}
&\delta z^b(\omega)-(p^a-p^*)x^b(\omega)\\
&=(1+\delta)(U^a(\omega)-U(x^a,p^*)+U(x^a,p^*)-U^*(\omega))\\
&\quad+(U^*(\omega)-U(x^b,p))\\
&=-(1+\delta)(p^a-p^*)x^a-(1+\delta)(U(x^*,p^*)-U(x^a,p^*))\\
&\quad+(U(x^*,p^*)-U(x^b,p^*)). \qquad (18)
\end{aligned}$$

The first term disappears when aggregated over $0 \leq \omega \leq 1$. The second term is negative: it represents, in terms of per capita, the gains from free trade allowed in the both periods (with the negative sign in front of it). By giving everyone the IR-binding level of utility instead of the free-trade level of utility, the government can collect this amount of tax revenue. The third term is positive, which is interpreted as the loss of the individuals induced to consume a distortedly small amount of $x^b+\omega$ due to the IC constraint, instead of consuming the free trade level of $x^*+\omega$. So, the government has to compensate this loss to the individuals.

Graphically (see Figure 5), the third term is a big triangle representing the change in the consumer surplus by consuming $x^*+\omega$ at p^* rather than consuming $x^b+\omega$ at p^*. For the second term, $(U^*(\omega)-U(x^a, p^*))$ is a small triangle representing the change in the consumer surplus by consuming $x^*+\omega$ at p^* rather than $x^a+\omega$ at p^*. Multiplied by $(1+\delta)$, it becomes the second term. Since $(x^*+\omega)-(x^b+\omega)=(1+\delta)((x^*+\omega)-(x^a+\omega))$, the big triangle representing the third term is always larger than the triangles representing the second term. Therefore, expression (18) is positive, meaning that it requires positive government budget to make everyone just indifferent between autarky and free trade (i.e., making the IR constraint binding for all ω).

Of course, making the IR constraint binding for all ω may not minimize the government expenditure. In fact, starting from the IR constraint binding for eve-

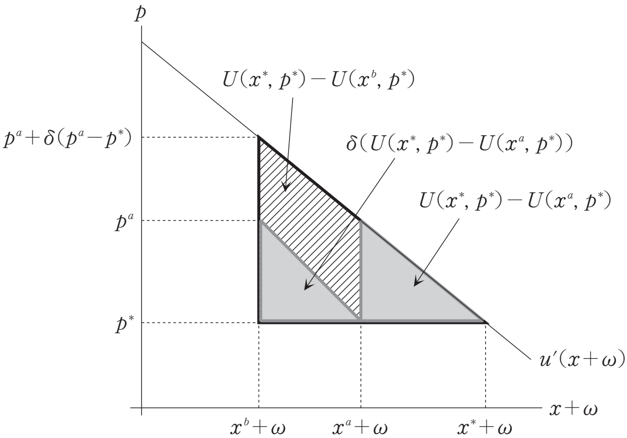

Figure 5: Intuition for Proposition 1

ryone (i.e., starting from $\tilde{\omega}=0$), the government can improve its budget by giving someone strictly positive gains from trade (i.e., by increasing $\tilde{\omega}$). So, second, we explain this. Take a particular individual with ω very small. As $\tilde{\omega}$ increases from zero so that his ω becomes below $\tilde{\omega}$, his consumption is now less distorted, and thus his utility level without transfer increases. By this, the government can collect more taxes from him (or needs to give less subsidy to him), with the government expenditure getting smaller. On the other hand, however, an increase in $\tilde{\omega}$ raises his target utility level. This happens because due to the less distorted (increased) consumption, the slope of the target utility of, not only him, but also all individuals between his ω and $\tilde{\omega}$, gets flatter. By this, the government can collect less taxes from him (or needs to give more subsidy to him), with the government expenditure getting larger. Since the latter effect is small when $\hat{\omega}$ is small, the former effect is dominating so that the government expenditure falls by an increase in $\tilde{\omega}$ from $\tilde{\omega}=0$. Eventually, however, as $\tilde{\omega}$ is increased sufficiently large, the government expenditure hits the bottom, since the latter effect is getting bigger and comes to outweigh the former.

Third, we explain that (18) is large when δ is large. This is seen by inspecting Figure 5. When δ is large, the distance between $p^a+\delta(p^a-p^*)$ and p^a is large, and so is the distance between $x^a+\omega$ and $x^b+\omega$. Therefore, the area of the big triangle not covered by the small triangles gets larger. This means that (18) is large. Then, although the government expenditure decreases as $\tilde{\omega}$ increases, the lowest government expenditure is still positive if δ is large. So, when B is smaller than the lowest government expenditure, the government cannot implement the transfer policy to redistribute the gains from free trade.

3.3 Should the transfers be dependent on transactions under autarky or under free trade?

So far, we have considered transfer rules under which the amount of transfer is dependent on the transaction made in period 0. That is, the government offers a transaction-transfer menu $\{x^0(\omega), z^0(\omega)\}$, where $x^0(\omega)$ is the transaction in period 0 and $z^0(\omega)$ is the transfer given in period 1. In our analysis, the resulting intertemporal utility can be written as

$$U(x^0(\omega), p^a, \omega)+\delta z^0(\omega)+\delta U^*(\omega). \tag{19}$$

On the other hand, in order to redistribute the gains from free trade, we could consider transfer rules dependent on transactions made in period 1. Namely, the government could offer a transaction-transfer menu $\{x^1(\omega), z^1(\omega)\}$, where $x^1(\omega)$ is the transaction in period 1 and $z^1(w)$ is the transfer given in period 1. In fact, this transfer rule is the one studied by FL (1991). Formally, a menu $\{x^1(\omega), z^1(\omega)\}$ is a solution to the welfare-maximization problem formulated as follows:

$$\max_{x(\omega),z(\omega)} \int_0^1 [U(x(\omega), p^*, \omega) + z(\omega)] d\omega + B - \int_0^1 z(\omega) d\omega \qquad (20)$$

$$\text{s.t } U(x(\omega), p^*, \omega) + z(\omega) \geq U(x(\omega'), p^*, \omega) + z(\omega') \text{ for all } \omega, \omega',$$

$$U(x(\omega), p^*, \omega) + z(\omega) \geq U^a(\omega) \text{ for all } \omega.$$

$$\int_0^1 z(\omega) d\omega \leq B.$$

The solution to this problem, denoted by $\{x^1(\omega), z^1(\omega)\}$, is qualitatively similar to $\{x^0(\omega), z^0(\omega)\}$ the solution to problem (7) we derived in the previous section. Namely, when B is sufficiently large, the GB constraint is not binding and the transaction schedule is effcient: $x^1(\omega) = x^*(\omega)$. As B falls, the GB constraint becomes binding and the transaction is distorted so that consumption is smaller for large ω, while the IR constraint is binding only at $\omega = 1$. Then, as B falls further, eventually the IR becomes binding for some $\omega < 1$. However, different from problem (7), there is always a solution to problem (20), as shown by FL (1991). This is because, in problem (20), making the IR constraint binding for all ω (that is, forcing everyone consume $x^a + \omega$) can be implemented by a balanced budget (i.e., with $B = 0$). Therefore, starting from the IR binding for everyone, the government can let some individuals with small ω consume more than $x^a + \omega$ to make them strictly better off by trade, and still the GB constraint is satisfied even when $B = 0$ (See Proposition 4 of FL (1991)).

By the transfer rule $\{x^1(\omega), z^1(\omega)\}$, the intertemporal utility is given by

$$U^a(\omega) + \delta z^1(\omega) + \delta U(x^1(\omega), p^*, \omega). \qquad (21)$$

Comparing (19) and (21), we can see that in (19) the government does not intervene transactions in period 1, leaving the period-1 utility $U^*(\omega)$ intact, while in (21) the government does not intervene transactions in period 0 with leaving the period-0 utility $U^a(\omega)$ intact. Then, we ask the following question: by which transfer rules can the welfare be made higher? In other words, to redistribute the gains from free trade to everyone with satisfying the IC constraint, which is less harmful, distorting period-0 transactions, or distorting period-1 transactions? The proposition below shows that the answer depends on the size of B. If the government has a large budget for transfer, the former is better, and if it has a small budget, the latter is better.

Proposition 2 *If $\delta B \geq (1+\delta)(U^a(1)-U^*(1))$, the transfer rule dependent on transactions in period 0 gives higher welfare than the transfer rule dependent on transactions in period 1. If $B < \overline{B}(\delta)$, the transfer rule dependent on transactions in period 1 gives higher welfare than the transfer rule depending on transactions in period 0.*

Proof. When $\delta B \geq (1+\delta)(U^a(1)-U^*(1))$, the GB constraint is not binding for problem (7) and $x^0 = x^*$. Letting W^0 denote the resulting intertemporal welfare of problem (7),

$$\begin{aligned} W^0 &= \int_0^1 (U(x^0(\omega), p^a, \omega) + \delta z^0(\omega) + \delta U^*(\omega) - \delta z^0(\omega) \\ &\quad + (p^a - p^*) x^0(\omega) + \delta B) d\omega \\ &= \int_0^1 (U^*(\omega) + \delta U^*(\omega) + \delta B) d\omega. \end{aligned}$$

For problem (20), note that the GB constraint is not binding if $B \geq U^a(1) - U^*(1)$ (The reason comes from the same logic discussed in Section 3.2). Therefore, when $\delta B \geq (1+\delta)(U^a(1)-U^*(1))$, the government can implement $x^1 = x^*$. Let W^1 denote the resulting welfare for problem (20). We have

$$\begin{aligned} W^1 &= \int_0^1 (U^a(\omega) + \delta z^1(\omega) + \delta U(x^1(\omega), p^*, \omega) - \delta z_1(\omega) + \delta B) d\omega \\ &= \int_0^1 (U^a(\omega) + \delta U^*(\omega) + \delta B) d\omega. \end{aligned}$$

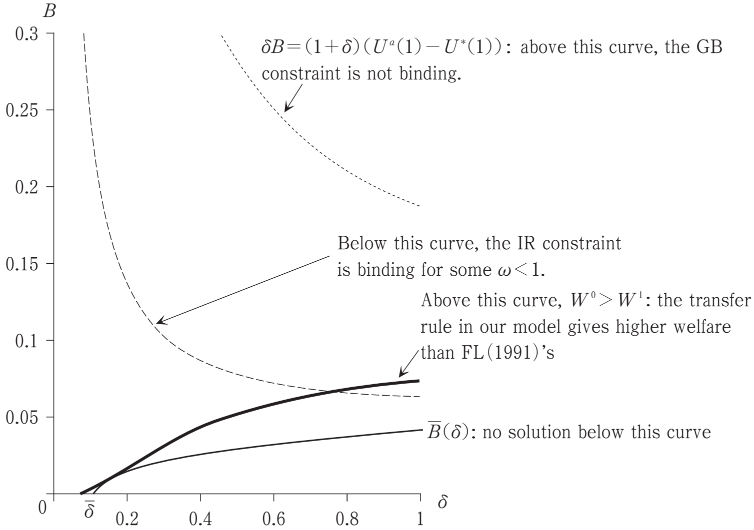

Figure 6: A numerical example: when $a=2$, $b=1$, and $p^*=5/4$

Since $\int_0^1 U^*(\omega)d\omega > \int_0^1 U^a(\omega)d\omega$, it holds that $W^0 > W^1$.

If $B < \overline{B}(\delta)$, there is no solution to problem (7). So, the best thing the government can do is to stay autarky in both periods, thus $W^0 = \int_0^1 (U^a(\omega) + \delta U^a(\omega) + \delta B)d\omega$. On the other hand, for problem (20), the government can give some individuals strictly positive gains from trade. Therefore,

$$W^1 = \int_0^1 (U^a(\omega) + \delta U(x^1(\omega),\ p^*,\ \omega) + \delta B)d\omega$$
$$> \int_0^1 (U^a(\omega) + \delta U^a(\omega) + \delta B)d\omega = W^0.$$

■

Moreover, since W^0 and W^1 are continuous in $B \geq \overline{B}(\delta)$, even when $B < (1+\delta)(U^a(1) - U^*(1))$, as long as B is large enough, W^0 stays above

W^1. This can be seen in Figure 6, where W^0 is higher than W^1 even when B is far below $(1+\delta)(U^a(1)-U^*(1))$.

Concluding remarks

We have considered a two-period model where in period 0 the autarky price is maintained and in period 1 free trade is allowed. To achieve Pareto gains from trade, the government designs a transfer rule to collect taxes from gainers and give subsidies to losers from free trade. By considering transfer rules that make the amount of transfer dependent on transactions in the autarky period, we have shown that there is no incentive compatible transfer rules that successfully redistribute the gains from free trade if the discount factor is sufficiently large or if the government budget available for redistribution is limited. Namely, our finding tells that redistributing the gains from free trade is often very costly under incomplete information; redistribution uses up all gains from free trade and still not able to make everyone better off.

Appendix

A. Solution to problem (7).

(i) When the IR constraint is binding only at $\omega=1$: From equation (11) and (12), the government expenditure is calculated as follows:

$$\int_0^1 \delta z^0(\omega)d\omega-\int_0^1 (p^a-p^*)x^0(\omega)d\omega=(1+\delta)(U^a(1)-U^*(1))-\frac{mb(2-m)}{6}$$

where

$$U^a(1)-U^*(1)=\left(\frac{1}{2}-\frac{(p^a-p^*)}{2b}\right)(p^a-p^*)$$

and $m=\lambda/(1+\lambda)$. The GB constraint is thus

$$(1+\delta)(U^a(1)-U^*(1))-\frac{mb(2-m)}{6}=\delta B.$$

Solving this for m, we get

$$m=\frac{b-\sqrt{b^2-6b((1+\delta)(U^a(1)-U^*(1))-\delta B)}}{b}.$$

Note that m is decreasing in B. So, as B falls, m increases, $x(\omega)$ decreases, and therefore the target utility gets steeper. As B falls enough that the target utility is as steep as the RHS of the IR constraint at $\omega=1$, the IR constraint becomes binding other than $\omega=1$. The border value of B below which this happens is derived by

$$u'(x^0(1)+1)=p^a+\delta(p^a-p^*) \iff p^*+mb=p^a+\delta(p^a-p^*).$$

Solving this for B, wehavethe border value of B:

$$B=\left(1-(2-\delta)\frac{(p^a-p^*)}{b}\right)\frac{(1+\delta)(p^a-p^*)}{6\delta}.$$

From our assumption that $(a-p^a)/b=1/2<(a-p^*)/b<1$, we have $(p^a-p^*)/b<1/2$. So, the B above is always positive, meaning that for any parameter values, if B is small enough, the IR constraint becomes binding for $\tilde{\omega}\leq\omega\leq 1$.

(ii) When the IR constraint is binding for $\tilde{\omega}\leq\omega\leq 1$: For $\tilde{\omega}\leq\omega\leq 1$, the transaction schedule and the transfer schedule are respectively given by equation (13) and (14). For $0\leq\omega<\tilde{\omega}$, since the IR constraint is not binding, and $\gamma(0)=0$ by a transversality condition, the transaction schedule is given by (11), and thus the transfer schedule is by (15). From these, the government expenditure is calculated as

$$\int_{\tilde{\omega}}^{1}(\delta z^b(\omega)-(p^a-p^*)x^b(\omega))d\omega+\int_{0}^{\tilde{\omega}}(\delta\tilde{z}^n(\omega)-(p^a-p^*)x^n(\omega))d\omega$$

$$=(1+\delta)(p^a-p^*)\left(\frac{\tilde{\omega}^2}{2}-\frac{((1+\delta)\tilde{\omega}-\delta)(p^a-p^*)}{2b}\right)-\left(\frac{bm}{3}-\frac{bm^2}{6}\right)\tilde{\omega}^3. \quad (22)$$

The threshold value $\tilde{\omega}$ is determined as follows. For $\tilde{\omega}\leq\omega\leq 1$, $x^b(\omega)$ should satisfy (10):

$$u'(x^b(\omega)+\omega)-p^*=\frac{-\int_{\tilde{\omega}}^{\omega}\mu(t)dt+\lambda\omega}{1+\lambda}b.$$

Here, we used that $\gamma(0)=0$ and $\mu(\omega)=0$ for $0\leq\omega<\tilde{\omega}$. (the IR constraint is not binding for this range of ω). At the same time, by the IC constraint, we have $u'(x^b(\omega)+\omega)=p^a+\delta(p^a-p^*)$. Thus,

$$\int_{\tilde{\omega}}^{\omega}\mu(t)dt=\lambda\omega-(1+\lambda)\frac{(1+\delta)(p^a-p^*)}{b}.$$

Especially, when $\omega=\tilde{\omega}$, it holds that

$$\int_{\tilde{\omega}}^{\tilde{\omega}}\mu(t)dt=m\tilde{\omega}-\frac{(1+\delta)(p^a-p^*)}{b}=0.$$

Therefore, $m=(1+\delta)(p^a-p^*)/b\tilde{\omega}$. Substituting this into (22), and arranging, we have the following GB constraint:

$$\frac{(1+\delta)(p^a-p^*)}{6}\tilde{\omega}^2-\frac{(1+\delta)^2(p^a-p^*)^2}{3b}\tilde{\omega}+\frac{\delta(1+\delta)(p^a-p^*)^2}{2b}=\delta B. \quad (23)$$

This is solved for $\tilde{\omega}$, and then $m=(1+\delta)(p^a-p^*)/b\tilde{\omega}$ is determined.

B. Proof of Proposition 1.

Consider the determinant of the quadratic equation (23). It is nonnegative if

$$B \geq \frac{(1+\delta)(p^a-p^*)^2}{6b\delta}\left(3\delta - \frac{(1+\delta)^2(p^a-p^*)}{b}\right). \tag{24}$$

Define the RHS of (24) as $\overline{B}(\delta)$. If $B<\overline{B}(\delta)$, there is no solution to problem (7). Note that $\overline{B}(\delta)$ is negative if

$$3\delta - \frac{(1+\delta)^2(p^a-p^*)}{b} < 0. \tag{25}$$

Since the inequality (25) holds when $\delta=0$, violated when $\delta=1$, and the LHS of (25) is increasing in δ, there is a unique δ (call it $\bar{\delta}$) below which $\overline{B}(\delta)<0$. Thus, for $\delta \leq \bar{\delta}$, there is a solution to problem (7) for any $B \geq 0$. For $\delta > \bar{\delta}$, $\overline{B}(\delta)>0$ and

$$\overline{B}'(\delta) = \frac{\overline{B}(\delta)}{(1+\delta)} + \frac{(1-\delta)(1+\delta)^2(p^a-p^*)^3}{6b^2\delta^2} > 0.$$

■

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