CESifo *Working Paper Series*

PARETO EFFICIENCY IN INTERNATIONAL TAXATION

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Working Paper No. 371

November 2000

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* We thank Bernd Genser and participants at the International Conference on Public Economic Theory (Tuscaloosa), the International Institute of Public Finance meetings (Moscow) and seminars at Harvard/MIT, Michigan, Vanderbilt and the IMF for helpful comments. The authors are solely responsible for any errors or omissions. Views are not necessarily those of the International Monetary Fund.

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Abstract

This paper addresses a key but neglected task in the theory of international taxation, lent increased urgency by growing awareness of the potential gains from tax coordination: the characterization of Pareto-efficient international tax regimes. It shows that the Diamond-Mirrlees theorem on the desirability of production efficiency, which underlies the key tenets of policy advice in international taxation – the desirability of destination basis for commodity taxation, of the residence principle for capital income taxation, and of free trade – is rendered inherently inapplicable to problems of international tax design by the distinctness of national budget constraints that is of the essence in thinking about international taxation. Conditions are established – relating to the availability of explicit or implicit devices for reallocating tax revenues across countries – under which production efficiency is nevertheless desirable, and a general characterization developed of the precise ways in which Pareto-efficient international taxation may require violation of established tenets.

JEL Classification: H0, F0

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1 Introduction

A key task in the theory of public finance is to characterize the set of Pareto-efficient tax structures. Starting with the analysis of Pareto-efficient commodity taxation by Harris (1979) and continuing through a wide range of papers inspired by Stiglitz' (1982) treatment of non-linear taxation, this task has received considerable attention in the context of closed economies comprising several distinct types of person. Yet the international form of this general task—characterizing the set of tax-spending policies that are Pareto-efficient in terms of countries' distinct national interests—appears not to have been addressed. This is especially striking given both the evident practical importance of understanding the conditions that must be satisfied for international tax arrangements to be Pareto efficient and the rapid growth of policy and analytical interest in this area over the last decade or so. Indeed the literature appears to have arrived at some articles of faith as to proper practice in international taxation without even considering whether or not they are consistent with the minimal requirement of Pareto efficiency. The purpose in this paper is to first argue that there is indeed a fundamental intellectual gap to be filled in developing principles for Pareto efficiency in international taxation, and then to go some way towards doing so.

The strange neglect of this issue[1] may reflect a view that the fundamental lessons of many-person tax theory—including in particular the Diamond-Mirrlees theorem on the desirability of production efficiency, which will be a particular concern here—can be translated directly into many-country contexts by the simple device of thinking of countries as people. But that is not so. There is a fundamental difference between tax design in a many-country world and in a single country. In the latter case, there is naturally only a single government budget constraint to consider. In many-country settings, in contrast, each government will have its own distinct revenue constraint: that, indeed, is close to being a definition of an independent sovereign state. Of course some countries do in practice make unrequited transfers to others; and there are others within which the revenue constraint of general government is less than fully consolidated as between, for instance, central and lower-level jurisdictions.

While it thus somewhat overstates matters to think of each country as having a single budget constraint entirely independent of those faced by other countries, such a view

[1] Exceptions—from which this paper arises—are Wildasin (1977) and Keen and Smith (1996). Ebrill and Slutsky (1989, 1990) address some issues of regulatory design in hierarchical industrial structures that have similarities with the question addressed here. They examine, for instance, the implications for optimal policy of there being distinct revenue constraints for distinct regulated sectors, which has an obvious analogy with the distinctness of national revenue constraints stressed here. The two settings and concerns are otherwise fundamentally dissimilar, but there is an interesting resonance between their results and some of those here. The importance of budget constraints in the analysis of distortionary taxation and public-sector pricing is emphasized in the title of Boiteux's classic (1956) paper on the subject; our analysis, which focuses on the multiple budget constraints of different countries, has parallel implications for public-sector pricing by multiple public-sector enterprises. (For the reasons noted below, the issues arising from the multiplicity of revenue constraints for public enterprises are perhaps less acute than in the international context, but further exploration of this topic in future research would be desirable.) More recently, the importance of the distinctness of national budget constraints has been recognized by Blackorby and Brett (1999) and Kotsogiannis and Makris (1999).

clearly captures an important aspect of international tax matters: the countries of the world do not pool their tax revenue.

The implications for tax analysis of this obvious observation are profound. Consider, in particular the classic Diamond-Mirrlees theorem (Diamond and Mirrlees (1971), Theorem 4): that any Pareto efficient tax structure is characterized by production efficiency so long as any pure profits are taxed at 100 percent and there are no restrictions on the distorting tax instruments that can be deployed. This has proved one of the most powerful results of optimal tax theory.[2] But the proof of the theorem presumes there to be only a single government budget constraint. Thus, the Diamond-Mirrlees (DM) theorem simply does not apply in international settings.[3]

This has potentially profound implications. Consider, for instance, what are perhaps the three central tenets in the normative theory of international taxation:

- The destination principle for commodity taxation (according to which commodities are taxed according to where they are consumed) is superior to the origin principle (under which they are taxed according to where produced)
- The residence principle for capital income taxation (under which taxation is by the country in which the investor resides) is preferable to the source principle (taxation by the country in which the income arises); and
- Free trade is better than restricted trade.

Of course it is well-known that these are not universal truths. There are many circumstances in which one or all of these claims is incorrect. Origin taxation can be superior to destination, for instance, if taxes are set non-cooperatively (Lockwood, 1993) or in the presence of imperfect competition (Keen and Lahiri, 1996); an element of source taxation may be desirable when rents cannot be fully taxed (Huizinga-Neilsen (1997), Keen and Piekkola (1997)); and there are familiar arguments that can, in principle, be used to justify protectionist trade policies—administrative constraints on the ability of governments to collect taxes on domestic transactions (see Devarajan *et al.* 1996), second-best environmental-policy considerations, or market imperfections or externalities, (*e.g.*, Adam Smith's infant industry argument or its modern descendants) can all provide at least a theoretical rationale for trade interventions. Nevertheless, these three tenets are widely accepted as central benchmarks by which much policy advice in the area of international taxation is framed: the perceived preferability of destination taxation, for example, has been a powerful consideration in the policy advice given to the CIS countries and in discussions of the definitive VAT regime for the European

[2]For example, it has provided much of the intellectual basis for replacing the cascading turnover taxes previously found in many developing and transition economies by the VAT, which, in particular, does not tax intermediate transactions.

[3]The setting of the DM theorem also precludes an important feature of reality in international taxation by presuming that all consumers face the same prices, a point stressed by Homburg (1998). But in this respect the problem of international tax design is evidently *less* constrained than the regular DM one, so that one would not on this account expect the desirability of production efficiency to be over-turned; and Proposition 2(a) below verifies that it is not.

Union. And much discussion of capital income tax coordination begins with the view that the issue has substance only because residence taxation is administratively infeasible (Tanzi (1995)). But the interest the profession attaches to these 'exceptions to the rule' testifies to the central role played by these basic tenets of international taxation.

The important and troubling common feature of these tenets, for present purposes, is that such intellectual appeal as they possess seems—especially in the first two cases—to derive largely from the view, sometimes made explicit,[4] that they are essentially just applications of the DM theorem. The destination principle, for instance, treats all firms equally, irrespective of their location, and so will ensure (in a competitive market, and in the absence of other distortions) that all firms have the same marginal cost of production in equilibrium, and hence that the global allocation of production is efficient. Under the origin principle, in contrast, arbitrage by consumers will ensure that consumer prices are equated across countries (so that there is consumption efficiency); but then firms in different locations will face different net prices if they face different origin-based taxes, and the allocation of production will be inefficient. Very similar arguments apply to the comparison between residence and source taxes: under the latter, consumers in all countries will require the same net of return on their investments, so that pre-tax rates will differ across countries in the presence of unequal source-based taxes; residence taxation, in contrast, leaves intertemporal consumer prices differing across countries, but pre-tax returns equated. And free trade ensures production efficiency—in the absence of origin-based taxes—by ensuring that producers in all countries face the same prices.[5]

Appealing as these arguments appear to be, the distinctness of national revenue constraints that is of the essence in the international context means that the DM theorem cannot be used to provide formal justification for them.[6] This observation thus removes what appears to be a central intellectual underpinning of these ideas: contrary to apparently widespread belief, none of them can be rationalized by appealing to the Diamond-Mirrlees theorem. Consequently, none is as trustworthy as has been widely believed.

The task of characterizing Pareto efficient international tax structures thus remains both open and pressing. Does production efficiency continue to be desirable even when distinct countries face distinct revenue constraints? If not, what features do Pareto efficient structures possess? Are there any general principles for international tax design better founded than the three tenets above but equally practicable for guiding policy formation? These are the questions to which the remainder of the paper is addressed.

Section 2 below presents a theoretical framework within which the problem of Pareto-

[4]See, for example, Keen (1993) and Giovannini (1989).

[5]The link between free trade and the production efficiency theorem is well-known: see DM (pp. 25–26) and many others, *e.g.*, Dasgupta and Stiglitz (1974), and Stern (1987).

[6]Of course the conditions of the DM theorem are far from trivial even in a closed economy (and indeed the counterexamples to the tenets cited above all involve some violation of those conditions). The problem raised here, however, is of a quite different kind: it is that the economic environment presumed in the proof of the DM theorem is inherently inapposite in international settings.

efficient taxation in an international setting can be investigated. This framework is essentially the Arrow-Debreu model of competitive general equilibrium, used by Diamond and Mirrlees, recast in an international context. Section 3 presents the principal results and—harder—develops the intuition behind them. Section 4 discusses the implications of the analysis for policy and for future research, and Section 5 concludes.

2 The model

The framework within which we address the issues raised in the Introduction is an essentially standard competitive trade model, augmented to allow countries to deploy both destination-based commodity taxes and tariffs, and—crucially—to recognize distinct revenue constraints for the distinct countries. This provides a very general setting; we shall spell out, in particular, the way in which it encompasses all three of the central specific questions of principle referred to above.

The world consists of S countries. In each there are $L \equiv T + N$ commodities: the first T are tradable, the rest—including, in particular, internationally immobile factors like labor, as well as non-traded consumption goods like housing—are not. There is in each country s a single representative consumer with preferences described by an expenditure function $e^s(q^s, g^s, u^s)$ defined over the L-vector[7] of consumer prices q^s, an L-vector of publicly provided goods g^s and utility u^s.[8] Consumer prices are partitioned in obvious notation between those relating to tradables and non-tradables as $q^s \equiv (q_T^{s\prime}, q_N^{s\prime})'$. Since the focus of interest is efficiency in relation to internationally mobile goods and factors, and without loss of generality, there is assumed to be production efficiency within countries.[9] The production technology in each country can therefore be described by a profit function $\pi^s(p^s)$ defined on the L-vector of producer prices $p^{s\prime} \equiv (p_T^{s\prime}, p_N^{s\prime})'$. For the same reason, we abstract from issues related to public production by supposing that the public provision $g^s \equiv (g_T^s, g_N^s)$ simply arises from public purchases of that amount.[10] Commodity taxes (on a destination basis) in country s are $t^s \equiv q^s - p^s$. World prices of the T tradable goods, which are of course common to all countries, are given by the T-vector ω. Tariffs are $\tau^s \equiv p_T^s - \omega$. Thus $\tau_i^s > 0$ means an import tariff if i is imported, and an export subsidy if it is exported. Note too—a point of some importance for later intuition—that while world prices ω are something

[7]All vectors are column vectors, and a prime indicates transposition. Superscripts refer to countries.

[8]The assumption of a representative household in each country means that none of our results hinge on the unavailability of policy instruments to achieve desired distributions of income within countries. The immobility of labor is implicit in this assumption, a restriction which substantially simplifies the model but which does not affect the substance of our analysis.

[9]As shown in Wildasin (1977), the standard DM argument applies to the private and public production sectors *within* countries: an optimal tax structure entails no taxation of intermediate good transactions among private-sector producers within countries, and public-sector production in each country should use local producer prices as shadow values. Hence, for our purposes, there is no loss of generality in aggregating the entire production sector in each country.

[10]The utility function is thus defined over *inputs* to the public-sector production process; the technology through which these inputs produce public goods and services valued by the consumer is thus subsumed within the form of the expenditure function.

of a fiction in the sense that no private agent may trade at them, they do matter for the revenues that national governments collect.

To isolate the implications for the desirability of production efficiency of the distinct source of failure of the DM theorem emphasized above—the distinct national revenue constraints—we assume throughout that all other conditions of that theorem are satisfied. Pure profits are thus assumed to be taxed at 100 percent. Consumers then have no lump sum income, so that in equilibrium

$$e^s(q^s, g^s, u^s) = 0, \quad s = 1, ..., S \tag{1}$$

while the revenue constraint in each country requires that

$$(\omega, p_N^s).'g^s = \pi^s(p^s) + (q^s - p^s).'e_q^s(q^s, g^s, u^s) + (p_T^s - \omega).'\{e_T^s(q^s, g^s, u^s) - \pi_T^s(p^s)\} + \omega.'\alpha^s \tag{2}$$

where $e_T^s \equiv \partial e^s/\partial q_T$, $\pi_T \equiv \partial \pi^s/\partial p_T$ (a notational convention for price derivatives that we shall use throughout) and α^s denotes a T-vector of unrequited transfers that country s makes to the rest of the world, with $\sum_s \alpha^s = 0_T$, where 0_k denotes the k-vector of zeros. These lump-sum international transfers are introduced mainly as an expositional device: the case of primary interest is that in which all α^s are zero.

Market-clearing for tradables requires that

$$\sum_{s=1}^{S} \{e_T^s(q^s, g^s, u^s) + g_T^s - \pi_T^s(p^s)\} = 0_T \tag{3}$$

and for non-tradables that

$$e_N^s(q^s, g^s, u^s) + g_N^s - \pi_N^s(p^s) = 0_N, \quad s = 1, ..., S\ . \tag{4}$$

The system comprising (1)–(4) is homogeneous of degree zero in each of the q^s, each of the p^s and in ω. Without loss of generality, we therefore take the first tradable as a numeraire commodity, bearing no tax or tariff in any country: that is, in obvious notation, $q_1^s = p_1^s = \omega_1 = 1$, $\forall i$. To simplify matters still further, we assume that in each country income effects attach only to, that the government only purchases, and that transfers only occur in, good 1.[11] To remove a further inessential complication, we suppose too that the provision of public goods does not affect the compensated demands for any good other than the numeraire (see Wildasin (1979)). The typical government's revenue constraint (2) thus reduces to[12]

$$g^s = \pi^s(p^s) + (q^s - p^s).'e_q^s(q^s) + (p_T^s - \omega).'\{e_T^s(q^s) - \pi_T^s(p^s)\} + \alpha^s \tag{5}$$

[11] Attaching all income effects to the numeraire also enables us to preclude transfer-type considerations associated with income effects that would otherwise obscure the main argument. Thus, in particular, the results to follow do not derive from the effects of the international distribution of income on the equilibrium world price structure that have featured prominently in the long debate over the "transfer problem" in international economics (see Bhagwati *et al.* (1983) for discussion and further references).

[12] We abuse the notation slightly by henceforth using q and p to refer to the $L-1$ non-numeraire goods and by interpreting α^s as a scalar relating to transfers of good 1.

and, using Walras' Law to drop the market-clearing condition for good 1, (3) is replaced by

$$\sum_{s=1}^{S}\{e_T^s(q^s) - \pi_T^s(p^s)\} = 0_{T-1} \ . \tag{6}$$

Equilibrium is thus described by the system (1), (4), (5) and (6).

This framework is very general–sufficiently so, in particular, to encompass all three sets of issues raised in the Introduction. Destination-based commodity taxes and tariffs appear directly as t and τ respectively; origin-based taxes appear implicitly, being equivalent to destination-based consumption taxes and export taxes/import subsidies levied at the same rate.[13] Issues of capital income taxation can be addressed by interpreting one of the traded goods—or several, in a model of sector-specific types of capital—as mobile capital, used only as an intermediate good and with the cost of capital in s given by the corresponding element(s) of p^s; residence-based taxes on capital income are then reflected in the discount factor embedded in the intertemporal price structure within q^s.

The analysis proceeds by first perturbing the equilibrium conditions and then applying a theorem of the alternative to characterize Pareto efficient structures.

For the perturbation, setting $e_u^s = 1$ for all s (without loss of generality) one finds from (1) that

$$du^s = -e_q^s.'dq^s - e_g^s dg^s \ . \tag{7}$$

Perturbing (5) and substituting for dg^s, using (4), substitution into (7) gives

$$du^s = a_q^s.'dq^s + a_p^s.'dp^s + e_g^s m^{s\prime}.d\omega + e_g^s d\alpha^s \tag{8}$$

where $m^s \equiv e_T^s - \pi_T^s$ denotes the $(T-1)$-vector of imports of country s,

$$\begin{aligned} a_q^s &\equiv -[e_q^s + e_g^s(e_q^s + t^s.'e_{qq}^s + \tau^s.'e_{Tq}^s)] &(9)\\ a_p^s &\equiv e_g^s\tau^s.'\Pi_{Tp}^s &(10)\end{aligned}$$

and we partition the $(L-1)\times(L-1)$ matrix of compensated price effects as

$$e_{qq}^s \equiv \begin{bmatrix} e_{Tq}^s \\ e_{Nq}^s \end{bmatrix} \tag{11}$$

where e_{Tq} is $(T-1)\times(L-1)$. Perturbing (6) and (4) and stacking the result with (8), one arrives at the system

$$J_u.du = J_q.dq + J_p.dp + J_\omega.d\omega + J_\alpha.d\alpha \tag{12}$$

where, denoting by I_k the k-dimensional identity matrix and by $0_{a,b}$ the $a\times b$ matrix of zeros,

$$J_u \equiv \begin{bmatrix} I_S \\ 0_{T-1+SN,S} \end{bmatrix} \qquad du \equiv \begin{bmatrix} du^1 \\ du^2 \\ \vdots \\ du^S \end{bmatrix} \tag{13}$$

[13] More precisely, the model developed in the text is equivalent—including in terms of the revenue raised, as is apparent from (5)—to one in which there are no destination-based commodity taxes, but tariffs of $\tau + t$ are combined with a production subsidy (negative origin-based tax) of $-t$.

$$J_q \equiv \begin{bmatrix} a_1^{q\prime} & 0 & ... & 0 \\ 0 & a_2^{q\prime} & ... & 0 \\ 0 & 0 & \ddots & 0 \\ 0 & 0 & ... & a_S^{q\prime} \\ e_{Tq}^1 & e_{Tq}^2 & ... & e_{Tq}^S \\ e_{Nq}^1 & 0 & ... & 0 \\ 0 & e_{Nq}^2 & ... & 0 \\ 0 & 0 & \ddots & 0 \\ 0 & 0 & ... & e_{Nq}^S \end{bmatrix} \qquad dq \equiv \begin{bmatrix} dq^1 \\ dq^2 \\ \vdots \\ dq^S \end{bmatrix} \tag{14}$$

$$J_p \equiv \begin{bmatrix} a_1^{p\prime} & 0 & ... & 0 \\ 0 & a_2^{p\prime} & ... & 0 \\ 0 & 0 & \ddots & 0 \\ 0 & 0 & ... & a_S^{p\prime} \\ -\pi_{Tp}^1 & -\pi_{Tp}^2 & ... & -\pi_{Tp}^S \\ -\pi_{Np}^1 & 0 & ... & 0 \\ 0 & -\pi_{Np}^2 & ... & 0 \\ 0 & 0 & \ddots & 0 \\ 0 & 0 & ... & -\pi_{Np}^S \end{bmatrix} \qquad dp \equiv \begin{bmatrix} dp^1 \\ dp^2 \\ \vdots \\ dp^S \end{bmatrix} \tag{15}$$

$$J_\omega \equiv \begin{bmatrix} e_g^1 & 0 & ... & 0 \\ 0 & e_g^2 & ... & 0 \\ 0 & 0 & \ddots & 0 \\ 0 & 0 & ... & e_g^S \\ & 0_{T-1+S(1+N)} & & \end{bmatrix} M' \qquad d\omega \equiv \begin{bmatrix} d\omega_2 \\ d\omega_3 \\ \vdots \\ d\omega_T \end{bmatrix} \tag{16}$$

$$J_\alpha = \begin{bmatrix} e_g^1 & 0 & ... & 0 \\ 0 & e_g^2 & ... & 0 \\ 0 & 0 & \ddots & 0 \\ 0 & 0 & ... & e_g^S \end{bmatrix} \begin{bmatrix} -1 & -1 & ... & -1 \\ & I_{S-1} & & \end{bmatrix} \qquad d\alpha \equiv \begin{bmatrix} d\alpha^2 \\ d\alpha^3 \\ \vdots \\ d\alpha^S \end{bmatrix} \tag{17}$$

where we have also defined the $(T-1) \times S$ matrix of net import vectors

$$M \equiv \left[e_T^1 - \pi_T^1, e^2 - \pi_T^2, ..., e_T^S - \pi_T^S \right] \ . \tag{18}$$

By Motzkin's theorem of the alternative,[14] an initial equilibrium is either Pareto inefficient in the weak sense that[15] $du > 0_S$ for some perturbation $(dq, dp, d\omega, d\alpha)$ satisfying (12) or there exists some $(T-1+S(1+N))$-vector y such that $y.'J_u << 0$ and $y'.J_k = 0$ for each of the matrices J_k, $k = q, p, \omega$ and, when transfers are allowed, for $k = \alpha$. It helps interpretation to partition $y = (z', x', x^{1\prime}, ..., x^{S\prime})'$ where z is an S-vector, x a $(T-1)$-vector and the x^s are all N-vectors. Note then (using the definition of J_u) that one implication of the latter alternative is that $z << 0$, the weights $-z^s > 0$ then bearing interpretation as the implicit weights in a social welfare function $-\Sigma_s z^s u^s$ that is maximized by the Pareto efficient allocation being characterized.

[14]Mangasarian (1994), p. 34.

[15]The notation $k >> 0$ means that all elements of the vector k are strictly positive, $k > 0$ that all are non-negative and at least one strictly positive.

3 Pareto efficient international tax structures

This section seeks to characterize Pareto efficient international tax structures. Given the central importance that the Diamond-Mirrlees theorem has come to have in policy design and evaluation, we focus in particular on the question of whether or not Pareto efficient international taxation requires production efficiency in the use and production of mobile goods and factors: that is, on whether Pareto efficiency requires $p_T^s = p_T$ in all countries. Except where indicated, we assume—in order to capture the distinctness of national budget constraints that motivates the analysis—that the lump sum transfers α^s cannot be deployed: the instruments at the planner's disposal are thus q, p, and ω.

We start with a fairly bald statement of the formal results themselves (relegating proofs to the Appendix), and then turn to the more difficult task of developing the economic intuition underlying them.

3.1 Results

The following establishes two key features of any Pareto efficient allocation:

PROPOSITION 1: *At any Pareto efficient allocation, in every country s:*
(a) (Ramsey rule) $t^{s}.'e^s_{qq} = \theta^s e^{s\prime}_q$, *where* $\theta^s \equiv -(1+e^s_g)/e^s_g$; *and*
(b) (Collinearity of tariff vectors) $\tau^s = \lambda^s \tau$, *with* $\lambda^s \equiv (1/z^s e^s_g) > 0$.

Proof: See Appendix A.

The interpretation of Proposition 1 is straightforward. Part (a) calls for destination-based consumption taxes to be set in accordance with the Ramsey rule, whose optimality in closed economies is familiar.[16] This will typically require, of course, that consumer prices vary across countries.

Part (b) of the proposition is more striking. Remember that producers in country s face prices $p^s = \omega + \tau^s$. It follows that production will be efficient if and only if the tariff vectors τ^s are the same for all countries. Since there is in general no reason to suppose that $\tau = 0$, nor that $z^s e^s_g$ takes the same value for all s, the implication is that production efficiency is typically *not* a requirement for Pareto efficiency. Instead, producer prices for tradable goods p_T^s must generally differ across countries.

Notice, even more intriguingly, that any production inefficiency takes a very particular form: the tariff vectors of the various countries are collinear at any Pareto efficient allocation. That is, all countries set the same *relative* tariff rates, differing only in the *level* at which tariffs are set.

Proposition 1 is derived under the assumption that lump-sum international transfers

[16] Note that the absence of supply responses from the rule in (a) reflects the assumed taxation of pure profits at 100 percent (see Dasgupta and Stiglitz (1972) and Auerbach (1985)).

are not possible. If such transfers can be used, however, any Pareto-efficient structure of fiscal policies will require production efficiency. The same is *sometimes* true even in the absence of lump-sum transfers:

PROPOSITION 2: *All Pareto efficient allocations are characterized by production efficiency if either:*

(a) International lump sum transfers can be deployed; or

(b) The matrix of net import vectors M (defined in (18) above) has maximal column rank.

Proof: See Appendix B.

Proposition 2 does not, of course, imply that there exist Pareto efficient allocations marked by production inefficiency, merely that such allocations can exist only if conditions (a) or (b) fail. It can be shown by example, however, that there do exist such allocations:[17] that is, the possibility that Pareto efficiency in international taxation will entail production inefficiency is a real one.

3.2 Intuition

To explain the economic meaning and intuition behind these results, it is helpful to begin by considering part (a) of Proposition 2. Formally, this result is a trivial extension of the Diamond-Mirrlees theorem. When lump-sum transfers among countries are feasible, their separate government budget constraints are, in effect, merged into a single global government budget constraint. In this case, the only difference between the optimal taxation problem with many countries that we analyze here and the standard DM optimal tax model is that, in the international tax version of the problem, consumers in different countries may potentially face different prices, corresponding to their respective national tax systems, whereas in the traditional model all consumers face the same taxes. Thus it is possible to select different tax structures for different consumers in the international context; and, in general, the optimal tax structure may well involve higher taxes on traded goods in some countries as compared with others. (For example, if the demand for a traded good such as wine is more inelastic in Germany than in the US, the tax structure that produces equal percentage reductions in demand for all commodities would (other things the same) entail heavier taxation of wine in Germany than in the US.) Aside from this distinction, however, the international taxation problem is fundamentally no different from the standard DM problem when lump sum transfers between countries are possible. In this case, intuition suggests, and Proposition 2(a) confirms, that international trade should not be the subject of fiscal interventions like tariffs or subsidies since these would distort the global pattern of production in an inefficient fashion.

At first sight, part (b) of Proposition 2 appears to bear little relation to part (a).

[17] Any such example is bound to be cumbersome–part (b) of Proposition 2 means that the simplest will have at least three countries–so that details are omitted. An example is available on request.

The rank condition in part (b) is simply that the net import vectors have as much linear independence as possible (given that market-clearing requires them to add to zero). This in turn requires that M have at least as many rows as it has column rank, and hence that $T \geq S$. Very loosely speaking (in taking maximal rank for granted), production efficiency is desirable if there are at least as many tradable goods as there are countries. To take one simple case, consider a world with just two countries. The possibility of international trade presupposes the existence of at least two traded goods and perhaps more. By Proposition 2(b), production efficiency must therefore characterize the Pareto-efficient tax structure in a two-country world, even if lump-sum international transfers are not possible.

To see the connection between parts (a) and (b) of Proposition 2, it is only necessary to note that trade policy—taxes and subsidies on trade flows—can effectively transfer fiscal resources among countries in a lump-sum fashion, provided that there are at least as many traded goods as countries and that the import/export vectors of all countries are linearly independent. This is easiest to see in the case of two countries and two traded goods. Suppose initially that there are no trade interventions at all, so that the global pattern of production is efficient. Suppose that country A imports the non-numeraire traded good 2 and let it impose an import tariff $\tau_2^A > 0$ while country B imposes a subsidy of exactly equal magnitude on its exports of good 2, setting $\tau_2^B = \tau_2^A > 0$. The effect of these trade policies is to transfer net fiscal resources from country 2 to country 1, with no departure from globally-efficient production.[18] In other words, *offsetting* taxes and subsidies on internationally-traded goods shift fiscal revenues among countries but do not distort production. These flows could go in any desired direction; for example, if country A subsidizes its imports of good 2 (*i.e.*, it sets $\tau_2^A < 0$) and country B imposes a tax on its exports of good 2 (*i.e.*, sets $\tau_2^B = \tau_2^A < 0$), transfers would flow from country A to country B, again without disturbing production efficiency. Clearly, then, in the case of two countries with two traded goods, the ability to undertake direct lump sum international transfers is superfluous: any desired transfers between the two countries can just as well be achieved by the use of offsetting trade policies, in which the country that collects a tax gains revenue at the expense of the country that pays a subsidy.

The equivalence between trade interventions and lump-sum transfers obviously continues to hold if there are two countries and three or more traded goods; in this case, tariffs/subsidies for all but one traded good can be set equal to zero, while instituting offsetting taxes/subsidies on the remaining traded good. If there are three or more countries and if the number of traded goods is at least as large as the number of countries, and if the net import vectors are linearly independent, then controlling the tariffs and subsidies of each country appropriately provides enough degrees of freedom to achieve any desired pattern of international fiscal transfers. More formally, note from (5) that a perturbation of world prices $d\omega$, holding constant all consumer and producer prices—and hence also all relevant behavioral decisions—implies an effective

[18]Keeping the other assumptions of this example unchanged, suppose that good 2 were chosen as numeraire. In this case, country A is the exporter of the non-numeraire good. An export tax imposed in country A, accompanied by an equal import subsidy in country B, would again transfer fiscal resources from country B to country A without disturbing production efficiency.

pattern of international transfers given by the S-vector $d\alpha^* = M.'d\omega$, with (denoting the vector of ones by ι) the market-clearing condition (6) implying $\iota.'d\alpha^* = 0$. If M has its maximal possible column rank of $S-1$ then by manipulating world prices it is therefore possible to achieve any *de facto* pattern of international lump-sum redistribution that might be required.[19] With non-distorting redistribution possible by this indirect route, the potential rationale for using distorting tariffs to redistribute tax revenues across countries vanishes. Production efficiency is again desirable.

Once the equivalence is established between trade interventions (in the case $T \geq S$) and lump-sum transfers, the intuition behind Proposition 2 becomes apparent. What, then, of the case for production inefficiency if the conditions of Proposition 2 are not satisfied? This takes us back to Proposition 1 and the general characterization provided there that is valid for any number of goods and countries. Proposition 1(a)—the Ramsey rule—is evident enough. To see the economics of Proposition 1(b), it proves easiest to think of policy as maximizing the social welfare function -$\Sigma z^s u^s$, where z is as in the alternative.

According to Proposition 1(b), any trade interventions that occur with Pareto-efficient policies will leave global production efficiency undisturbed, provided that $z^s e_g^s$, which is strictly positive, takes the same value for all countries s. With z_s interpreted as the social weight attached to the welfare of country s, this term can be thought of as the shadow value of fiscal resources in country s: the lower the value of tax revenue in country s, the lower will be the (absolute value of) the marginal valuation of public spending, $-e_g$, weighted by the multiplier z^s. Note further that[20]

$$\sum_s z^s e_g^s \tau^s.'m^s = 0 \tag{19}$$

so that countries' tariff revenues sum to zero when weighted by the terms $z^s e_g^s$. Intuitively, tariffs are being used to redistribute revenues from countries which are disfavored in the Pareto efficient allocation—in the sense that their $z^s e_g^s$ is low—to those that are favored. For the former, $z^s e_g^s \tau^s.'m^s$ would be negative, while the shadow-value-weighted net tariff revenue for the latter would be positive. Part (b) of Proposition 1 indicates that, relative to a situation in which all countries set equal and offsetting tariffs and export subsidies of (so that production is efficient), a country that is disfavored in the Pareto efficient allocation (*i.e.*, one that is 'fiscally rich,' in the sense of having a low shadow value of government revenue) subsidizes imports or exports more heavily, while a 'fiscally poor' country (*i.e.*, one with a high shadow value of revenue) taxes imports or exports more lightly.

As we have already seen, these fiscal interventions in the markets for imports and exports need not necessarily lead to production inefficiency—not if the number of traded goods is larger than the number of countries. But suppose the contrary; for example, let there be three countries and two traded goods, such that countries A and

[19] In a similar spirit, Turunen-Red and Woodland (1996, Theorem 2) show that adjustment of tariffs/subsidies on traded goods can be used to redistribute the efficiency gains from reforms of quotas on traded goods.

[20] This follows from the condition of the alternative that $y.'J_\omega = 0$. For this implies that $\sum_s z^s e_g^s m^s = 0_{T-1}$; premultiplying by τ and using Proposition 1(b) gives (19) .

B import commodity 2, which is exported by country C. Suppose, further, an initial situation in which country A is very 'fiscally poor' in the sense that government revenue there is highly valued (the value of $z^A e_g^A$ is very high), that the other importing country, B, has a lower shadow value of government revenue (the value of $z^B e_g^B$ is not so high), and that the shadow value of government revenue in the exporting country C (the value of $z^C e_g^C$ is low) is low. If lump-sum international transfers were possible, Pareto-efficient taxation would require that country C transfer fiscal resources to country A; depending on the exact shadow values, country B might also receive some transfers from country C or perhaps it would pay some transfers to country A. If such lump-sum transfers are not possible, what sorts of trade interventions might achieve similar results?

Following the logic of the two-country case, the "fiscally rich" or "disfavored" country C could subsidize its exports of good 2 so as to transfer fiscal resources abroad. If both countries A and B were to impose offsetting import tariffs, they would then both be the beneficiaries of fiscal transfers from country C and production efficiency would be preserved. However, these policies are ineffective in targeting transfers from country C, with a low shadow value of revenue, to country A, the country with the highest shadow value, since some of the subsidy paid by country C accrues to the government of country B. Indeed, according to Proposition 1(b), country B, with its lower shadow value of government revenue, should impose a higher tariff on imports than country A. This would have the effects of increasing the volume of trade and the volume of fiscal transfers between country C and country A and of reducing the volume of trade and transfers between C and B, thus directing country B's subsidies more effectively toward the "favored" country A. While differentiating the tariff rates of countries A and B serves this useful purpose, note that it also results in production inefficiency: the producer price of good 2 will be higher in the country (B) with the higher tariff, as compared with the other countries. This is the source of the production inefficiency in the general case: the production efficiency is a price worth paying to achieve a desired redistribution of tax revenue .

It now remains only to explain the collinearity between tariff vectors that Proposition 1(b) shows to be required for Pareto efficient international taxation. For this, imagine a small change in consumer prices q in countries A and B which has the sole effect of increasing A's imports of good j by an amount $dm_j^A > 0$ whilst reducing B's imports of j by the same amount, $dm_j^B = -dm_j^A$. World prices and producer prices in all countries remain unchanged; consumer prices have changed only in countries A and B, and as an envelope property the changes there have negligible welfare effects. Thus the only welfare effects are those arising from the impact on tariff revenues in A and B. These give a net welfare gain of $(z^B e_g^B \tau_j^B - z^A e_g^A \tau_j^A) dm_j^A$, so that at an optimum it must be the case that

$$\frac{\tau_j^A}{\tau_j^B} = \frac{z^B e_g^B}{z^A e_g^A} \; . \tag{20}$$

But this same argument can be applied to any good k, and to any pair of countries, so that (20) implies

$$\frac{\tau_j^A}{\tau_k^A} = \frac{\tau_j^B}{\tau_k^B}, \quad \forall j, k, A, B \tag{21}$$

which gives the collinearity of tariff vectors. Loosely speaking, tariffs and subsidies on traded goods serve as devices for transferring revenues between countries. Effective deployment of these instruments requires simply scaling up or down a common vector of tariffs: from the perspective of reallocating tax revenues, there is no point in varying tariff rates across countries in light of heterogeneities in their preferences or production patterns.

4 Implications

The central implication of the results above is that the principles at the heart of most policy advice on international tax design are generally not appropriate: there are circumstances in which one must depart from production inefficiency if one is to attain a preferred point on the world's second-best utility possibility frontier, or to ensure a Pareto gain from a desirable reform of domestic taxation within one country. More precisely, Proposition 1 gives a conceptually simple scheme for attaining Pareto efficiency in international taxation: moving around the world's second-best utility possibility frontier requires that commodity taxes be set at all times according to the Ramsey rule and that inter-jurisdictional transfers be made by rescaling the tariff vector that each country deploys. Thus production efficiency loses its primacy in international settings. It might conceivably have been optimal, for instance, to retain production efficiency but move around the utility possibility frontier by restructuring commodity taxes so as to trigger redistribution through changes in world prices; but, in general, it is not. Even when all other conditions of the DM theorem are met, the distinctness of national budget constraints—unless it can be overcome by inter-jurisdictional transfers, explicit or implicit (as described in Proposition 2)—means that in international settings production efficiency ceases to be a prerequisite for Pareto efficient taxation.

The reason why tariffs—which in this discussion should be thought of as simply a surrogate for production inefficiencies more generally—may have a role to play in bringing about Pareto improvements is not hard to discern. Consider some initial equilibrium in which commodity taxes in at least one country depart from the Ramsey rule. Reforming commodity taxes so as to respect the Ramsey rule may change world prices in such a way that some countries lose from the reform unless they receive some form of compensation: and tariffs provide precisely the means to provide such compensation. Indeed the key to understanding the results above on the circumstances in which production inefficiency may be desirable and the form it may then take has been precisely to recognize the role that tariff structures play in redistributing global tax revenues across countries.

Of course distorting tariffs are an inefficient way of redistributing revenue across countries, so that—even if one takes the view that nations will find ways of achieving all potential Pareto gains—these results do not necessarily provide a rationale for their deployment in practice: if some redistribution of revenues is needed to ensure Pareto gains from beneficial reforms, would one not expect to see such redistribution achieved by lump sum rather than distorting means? Part of the answer is surely that lump-sum redistribution between countries suffers many of the difficulties of asymmetric information associated with lump-sum redistribution between individuals that give rise to the traditional optimal tax problem. But part of the answer is also that some such redistribution does in fact occur between countries.

Unrequited aid—whether in the form of bilateral foreign aid or in the form of transfers brought about by multilateral agencies such as the World Bank—is one example of such transfers, but perhaps not the most important. In the treatment of multinational enterprises, the foreign tax credit offered by many developed countries serves precisely to redistribute revenue from the treasury of the home country to that of the host country. In the US, in particular, the opportunity to claim a credit against taxes due on income repatriated to the US for taxes paid in the host country on income derived there[21] has long been a central feature in the taxation of foreign-source income. The foreign income tax credit protects subsidiaries of US firms and other US taxpayers from taxes imposed in foreign countries and provides US firms with an incentive to invest wherever the before-tax rate of return on capital is highest. Advocates of the foreign income tax credit see this as one of its important virtues because it promotes a productively-efficient international allocation of capital. At the same time, the foreign tax credit is often criticized from the viewpoint of US domestic policy interests because it in effect allows foreign treasuries to collect source-based capital income taxes at the expense of the US Treasury: every dollar's worth of creditable foreign taxes reduces the flow of revenue to the US government by one dollar. Indeed it is a central concern of corporate tax design in almost all developing countries to ensure that the taxes they impose on the subsidiaries of US multinationals are in a form and at a level that ensure full creditability against US taxes, and so extract the largest possible subsidy from the US.

Thus the foreign tax credit is, in effect, a means of reallocating revenue across countries without distorting the international allocation of capital. It is not, however, an especially well-targeted means of reallocating revenue, since it extends to investments in rich countries as much as to those in poorer ones. But there also exists a further feature of many tax credit systems—though not that of the US—which in effect reallocates revenue in a way better targeted upon poorer countries but also more likely to distort investment decision. This is the practice of 'tax-sparing,' by which countries offering foreign tax credits agree to disregard the reduction in host country tax liabilities implied by investment incentives offered there (such as tax holidays), the point being that such reductions in host country liability would otherwise be exactly undone by an increased home tax liability. Tax sparing is thus, in effect, a device whereby the home country finances a subsidy to inward investments offered by the host county: it is thus an international redistribution of revenues which, since the subsidy encourages inward investment,[22] distorts location decisions. The use of tax sparing might thus be rationalized along the same lines as the distorting tariffs encountered in the analysis above.

This is not to suggest that such institutions as the foreign tax credit and tax sparing—

[21]Broadly speaking, foreign taxes on the income of foreign subsidiaries is creditable up to the amount of the US corporation income tax that would otherwise be payable on that income.

[22]Hines (1998) finds evidence that tax sparing does indeed affect investment decisions.

let alone tariffs—should be seen as means that nations have found to put themselves at a preferred point on the world's utility possibility frontier: there is clearly much more to them than that. The point is simply that they may indeed have such a role when direct sharing of tax revenues is difficult; and that even when they distort, these devices may have a role to play in fully coordinated outcomes.

These observations have implications too for the internal organization of federations. They point, in particular, to a close link between the extent of horizontal transfers across the constituent states of federation—serving to consolidate their otherwise distinct revenue constraints into one—and the desirability of internal arrangements conducive to production efficiency in the allocation of the federation's resources. Where horizontal transfers are weak or non-existent, Pareto-efficiency within the federation may, for example, require the states to adopt measures, such as taxes on trade between them, that actually interfere with the functioning of the internal market. Conversely, enforcing the three tenets within federations which—as in the European Union—have only nascent internal redistribution can actually leave all member states worse off than they need be.

The results here also have implications for the proper modeling of international tax issues. Public finance theorists, like trade theorists, make much use of two-country models. Proposition 2 warns, however, that these models are inherently and seriously misleading: for since trade balance requires that there then be at least two traded goods, production inefficiency will always be desirable in such settings. To avoid prejudging the desirability of the three tenets one thus needs a model with at least three countries. Dimensionality matters for optimal international tax design.[23] Indeed it is the need to think beyond the usual 2×2 framework that makes interpreting some of the results here so hard.[24] Coming to terms with this complexity is, unfortunately, essential if one is to build a coherent framework for international tax analysis.

5 Summary and conclusion

The preceding analysis has shown that Pareto-efficient taxation in an international context may require production inefficiency; that is, tariffs and other policies that distort world production patterns may actually make all countries better off. This means that the three principles of international taxation identified at the outset are not, in general, valid guides to optimal policy. Source-based capital taxes, origin-based consumption taxes, and subsidies and tariffs on international trade flows, even though they may distort production, can nonetheless be Pareto-improving. Of course, these results in no way suggest that policies that depart in arbitrary ways from traditional principles are Pareto-improving, and one must beware the danger that—as Edgeworth

[23] The dimensionality issue here (concerning numbers of countries and goods) is entirely distinct from that associated with factor price equalization (concerning numbers of factors and goods).

[24] The simplest case in which the result on the collinearity of tariff vectors has force, for instance, is that in which there are three goods and four countries: at least three goods are needed because, by normalization, good 1 bears no tariff and collinearity of the tariff on a single good is vacuous; and then with less than four countries, Proposition 2(b) implies that tariffs are the same in all countries.

(1908, p. 555) feared in respect of Bickerdike's (1906) discovery of the optimal tariff—these arguments might afford "... unscrupulous advocates of vulgar Protection a peculiarly specious pretext for introducing the thin end of the fiscal wedge." Indeed, the analysis identifies several important cases where policies that cause production inefficiency are definitely *not* Pareto-efficient.

The key consideration behind the potential for mutual benefit from production inefficiency is the existence of multiple government budget constraints, implying a potential gain from transferring revenues, directly or indirectly, among countries. When this can be done directly, through lump-sum intergovernmental transfers, the separate budget constraints facing different governments are, in effect, merged, and the standard production-efficiency theorem applies. Even if direct intergovernmental transfers are not possible, an appropriately-designed system of trade interventions, generally involving offsetting taxes and subsidies in different countries, may achieve the desired intergovernmental redistribution of resources without distorting production efficiency. For this purpose, it is necessary that there be sufficient degrees of freedom: specifically, at least as many traded commodities as there are countries. Outside these cases, however, pursuit of conventional wisdom in designing international tax arrangements may leave all countries worse off than they need be.

Appendices

A. Proof of Proposition 1

Supposing the initial allocation to be Pareto efficient, the condition $y.'J_u << 0_S$ implies, as noted in the text, that $z \equiv (z^s) << 0$. The conditions $y.'J_q = 0$ and $y.'J_p = 0$ further imply respectively that

$$z^s a_q^{s\prime} + x^{s*}.'e_{qq}^s = 0 \text{ , } s = 1, ..., S \tag{A.1}$$

and

$$z^s a_p^{s\prime} - x^{s*}.'\pi_{pp}^s = 0 \text{ , } s = 1, ..., S \tag{A.2}$$

where $x^{s*} \equiv (x', x^{s\prime})'$. Using the definition in (10), (A.2) gives

$$x_s^* = z^s e_g^s \tau^s.'\pi_{Tp}^s(\pi_{pp}^s)^{-1}. \tag{A.3}$$

Using in (A.1) both (A.3) and the definition of a_q^s in (9) one finds

$$\begin{aligned} e_q^{s\prime} + e_g^s(e_q^{s\prime} + t^s.'e_{qq}^s) &= e_g^s \tau^s.'[\pi_{Tp}^s(\pi_{pp}^s)^{-1}e_{qq}^s - e_{Tq}^s] & \text{(A.4)} \\ &= 0 & \text{(A.5)} \end{aligned}$$

the second step following on noting that the partitioned form in (11) implies that

$$\pi_{Tp}^s(\pi_{pp}^s)^{-1}e_{qq}^s = [I_{T-1}|0_{T-1,N}]e_{qq}^s = e_{Tq}^s \text{ .} \tag{A.6}$$

Part (a) follows from (A.5). Part (b) follows on using (A.6) to write (A.3) as $(x', x^{s\prime})' = z^s e_g^s \tau^s.'[I_{T-1}|0_{T-1,N}]$.

B. Proof of Proposition 2

From part (a) of Proposition 1, it suffices to show that $z^s e_g^s = \kappa$, independent of s, if the alternative holds.

Case (a): When explicit lump sum taxes can be deployed, the alternative requires that $y.'J_\alpha = 0$. From the definition in (17), this implies that $[z^1 e_g^1 - z^2 e_g^2, ..., z^1 e_g^1 - z^S e_g^S] = 0'_{S-1}$, and the conclusion follows.

Case (b): Amongst the conditions for the alternative is that $y.'J_\omega = 0$. Recalling the definition in (16), this in turn implies that

$$M.v = 0_{T-1} \tag{B.1}$$

where $v \equiv [z_1 e_g^1, ..., z_S e_g^S]'$. Recall too from (6) that market-clearing implies $M.\iota_S = 0'_{T-1}$, so that M has column rank of no more than $S - 1$. If it has precisely that rank, then v must be collinear with i, and the result follows.

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