CESifo WORKING PAPERS

11060
2024

April 2024

Levelling the Global Playing Field through Optimal Non-Discriminatory Corporate Taxes and Subsidies

Antonella Nocco, Gianmarco Ottaviano, Matteo Salto, Atsushi Tadokoro

CESifo

Impressum:

CESifo Working Papers
ISSN 2364-1428 (electronic version)
Publisher and distributor: Munich Society for the Promotion of Economic Research - CESifo GmbH
The international platform of Ludwigs-Maximilians University's Center for Economic Studies and the ifo Institute
Poschingerstr. 5, 81679 Munich, Germany
Telephone +49 (0)89 2180-2740, Telefax +49 (0)89 2180-17845, email office@cesifo.de
Editor: Clemens Fuest
https://www.cesifo.org/en/wp
An electronic version of the paper may be downloaded
· from the SSRN website: www.SSRN.com
· from the RePEc website: www.RePEc.org
· from the CESifo website: https://www.cesifo.org/en/wp

CESifo *Working Paper No. 11060*

Levelling the Global Playing Field through Optimal Non-Discriminatory Corporate Taxes and Subsidies

Abstract

Due to markup distortions, in international trade models with monopolistic competition and heterogeneous firms the market equilibrium is inefficient unless demand exhibits constant elasticity of substitution. When it does not, global welfare maximization generally requires policy intervention that is firm specific, and consequently of limited practical relevance due to its information requirements, discriminatory nature and susceptibility to rent seeking. We assess whether there are particular conditions under which countries can coordinate on the common use of policy tools that are not firm-specific but still maximize global welfare. We show that a demand system implying constant absolute pass-through from marginal cost to price is both necessary and sufficient for the existence of welfare-maximizing nondiscriminatory policies that can level the global playing field with a one-size-fits-all approach for all firms selling in a given market, eventually complemented by a global tax rate on corporate profits.

JEL-Codes: D400, D600, F100, L000, L100.

Keywords: international trade policy, firm heterogeneity, monopolistic competition, multilateralism, level playing field.

Antonella Nocco
Department of Economics
Università del Salento
Lecce / Italy
antonella.nocco@unisalento.it

Gianmarco Ottaviano
Department of Economics
Bocconi University
Milan / Italy
gianmarco.ottaviano@unibocconi.it

Matteo Salto
European Commission
Brussels / Belgium
matteo.salto@ec.europa.eu

Atsushi Tadokoro
Graduate School of Economics
Kyoto University / Japan
takokoro.atsushi.6c@kyoto-u.ac.jp

March 2024
For useful comments and discussions we are grateful to Pasquale Commendatore, Shunsuke Maeda, Marc Melitz, Monika Mrazova, Marcelo Olarreaga, Mikhail Oshmakashvili, Frederic Robert-Nicoud and Davide Suverato as well as seminar participants at various conferences and workshops. This project has received funding from the European Research Council (ERC) under the European Union's Horizon 2020 research and innovation programme (grant agreement n◦ 789049-MIMAT-ERC-2017-ADG). The views expressed here are those of the authors and do not represent in any manner the EU Commission.

1 Introduction

International trade models with monopolistic competition and heterogeneous firms have disconcerting implications for policy intervention that seeks to maximize global welfare through taxes and subsidies. Despite firms exerting market power, when the demand system exhibits constant elasticity of substitution (which is the customary assumption), the within-industry market allocation is unconstrained efficient and thus does not require any intervention. In contrast, when the demand system exhibits variable elasticity of substitution, the within-industry market allocation is inefficient and thus does require policy intervention to achieve the social optimum. However, in general the taxes and subsidies needed have to be firm-specific, and consequently are of limited practical relevance due to the sheer amount of information required to design them, their discriminatory nature, and their susceptibility to firms' opportunistic rent-seeking.

It is, therefore, of both conceptual and practical importance to assess whether there are particular conditions under which taxes and subsidies may exist that achieve the social optimum with variable demand elasticity without being firm-specific. The present paper shows that a demand system with constant absolute pass-through is both a necessary and a sufficient condition for such taxes and subsidies to exist in a monopolistically competitive model with heterogenous firms and an arbitrary number of countries that differ in terms of market size, state of technology and geographical position in the international trade network.

The starting point of the analysis is the observation that the hands-off policy prescription under constant elasticity of substitution (CES) is associated with several intertwined implications. To see this, let us introduce some definitions. We call 'absolute markup' the difference between a firms' profit-maximizing price and its marginal cost, and 'relative markup' the ratio of the profit-maximizing price to the marginal cost. We then use 'absolute pass-through' to refer to the derivative of the profit-maximizing price to the marginal cost, and 'relative pass-through' to refer to the corresponding percentage change, that is, the derivative of the logarithm of the profit-maximizing price to the logarithm of the marginal cost. Under CES, the relative markup, the absolute pass-through and the relative pass-through are all constant and common across firms. Only the absolute markup varies and increases as the marginal cost increases, which implies that in equilibrium it is larger for less productive firms as these have higher marginal cost. In addition, both the absolute and the relative pass-throughs are also constant and common across firms. However, while the former is larger than one, the latter is equal to one (which is what the literature refers to as 'complete pass-through').

The CES setup prescribes obvious, though degenerate, non-discriminatory welfare maximizing intervention as the policy maker is required to do the same, namely nothing, with respect to all firms. Which of the foregoing CES implications should be retained if one wanted to understand under which conditions non-degenerate non-discriminatory welfare maximizing policy intervention can still be prescribed without CES demand?

To address this question, we introduce a new family of utility functions that lead to demand functions with variable elasticity of substitution (VES) supporting constant absolute pass-through while dispensing with all other CES implications. We use this family to discuss the properties associated with a demand system exhibiting constant absolute pass-through, and then to develop a graphical proof that constant absolute pass-through is both necessary and sufficient to support non-degenerate non-discriminatory welfare maximizing policy intervention beyond and above the specific family of demand functions we have introduced. Nevertheless, this family allows us to contribute a closed-form exact characterization of the tools needed within national policy makers' budget constraints, and to relate them to the various dimensions of heterogeneity across countries affecting national gains and losses from global coordination.

Making the empirically relevant assumption that the own-price elasticity of demand decreases with quantity (a.k.a. Marshall's second law of demand), the key source of distortion in the model is firms' heterogeneous market power, as a result of which more productive firms, which are bigger due to lower marginal cost, charge higher relative markups, and are thus not big enough from a social optimum point of view. Vice versa, less productive firms, which are smaller due to higher marginal cost, charge lower relative markups and are thus not small enough. The fact that more productive firms restrain their output below the socially optimal level also implies that there are too many firms as the smallest ones should not be active at all. In other words, the within-industry market allocation is distorted both at the intensive and extensive firm margins.

In this setup, the non-discriminatory policy tools that can achieve the social optimum consist of a common global ad valorem sales tax and a set of destination-specific subsidies per unit sold. The global tax is needed to implement the optimal distribution of output across firms, and thus redresses the intensive margin misallocation. The local subsidies are needed to deliver the welfare maximizing number of firms, and thus deals with the extensive margin misallocation. Hence, it is possible for international trade agreements to coordinate on non-discriminatory policies that level the playing field with an appropriate one-size-fits-all approach for all firms selling in a given market, eventually complemented by a global tax rate on corporate profits. This type of measures is in line with the principle of the Most Favoured Nations (MFN) clause (Art. 1 GATT-WTO), as they have a non-discriminatory nature and guarantee the same treatment to all member countries.

The reason why the aforementioned combination of policy tools is optimal is that the magnitude of the price impact of the ad valorem sales tax depends on each firm's productivity, with more productive firms featuring a smaller price increase. Although this non-uniform price increase raises the markup level of all firms, it can eliminate the markup differences across firms by disproportionately raising the markups of less productive firms. This induces a shift in demand towards more productive firms and delivers the socially optimal relative firm output by making all firms price at a common constant markup over marginal cost.

On the other hand, by decreasing firms' prices and markups uniformly in any given destination, the additional introduction of the per-unit subsidies leads firms to operate at their socially optimal output levels by inducing them to price at marginal cost.

All this happens because, with constant absolute pass-through, the profit maximizing price is an affine linear function of such cost with slope and intercept that are the same for all firms. In turn, being equal to marginal cost, the welfare maximizing price is a linear function of such cost with no intercept and slope equal to one. Non-firm-specific tools can then be used to neutralize the intercept and adjust the slope of the profit maximizing price so that it matches the welfare maximizing one. This explains why affine linearity is both necessary and sufficient for taxes and subsidies to exist that achieve the social optimum with variable demand elasticity without being firm-specific.

With this general result on absolute pass-through and the exact implementation of globally welfare-maximizing policy intervention for our family of utility functions, we contribute to several research lines in the existing literature.

Assumptions about the structure of preferences and demand are of fundamental importance for comparative statics in industrial organization, international trade, public economics and several other applied fields (Mrazova and Neary, 2017). A crucial example concerns the pass-through from marginal cost to price as the latter responds to changes in the former quite independently of the demand elasticity unless this is constant. This result is well-known since Bulow and Pfleiderer (1983), who introduced a class of constant absolute pass-through demand functions that is strictly related to ours, the main difference being that we allow for cross substitutability between firms' product. With reference to taxation, Weyl and Fabinger (2013) show that the degree of pass-through can be taken as a unifying principle to extend five principles of tax incidence under perfect competition to a general model of imperfect competition. In particular, they show that the welfare effects of price discrimination are largely determined by comparing incidence properties in the two markets separated by discrimination, and that a wide range of effects in oligopoly theory often depend on the comparison of pass-through or incidence to simple thresholds. We contribute to this line of research by establishing, in a monopolistically competitive setup, the importance of the notion of absolute pass-through for assessing the possibility of international coordination on non-discriminatory policies that maximize global welfare.

The result that constant absolute pass-through is important is inspired by the finding of Tadokoro (2024) that, in the closed economy of Melitz and Ottaviano (2008), the social optimum can be achieved not only using firm-specific taxes and subsidies as in Nocco, Ottaviano and Salto (2014), but also with common taxes and subsidies. This is due to the fact that their demand system arises as a special case of the one we use when the constant absolute pass-through equals to fifty percent. The result is also inspired by Melitz, Oshmakashvili, Ottaviano and Suverato (2024) who show that, for a closed economic with general additive separable utility, necessity and sufficiency of affine linear pricing and thus constant absolute pass-through can be readily proved analytically. Differently from these works, we provide a graphical argument that constant absolute pass-through is necessary and sufficient also in an open economy consisting of several asymmetric countries. However, we do not take on the additional challenge of identifying a broader class of utility function delivering constant absolute pass-through as Melitz, Oshmakashvili, Ottaviano and Suverato (2024) do.

Trade models of international taxation with monopolistic competition often assume CES demand. Ossa (2011) analyzes international import tariff competition and coordination in a two-country economy with homogeneous firms motivated by the firm delocation effect of taxation identified by Venables (1987) within Krugman's (1980) model. Two main results stand out. Each country has a unilateral incentive to raise its import tariff at the expense of the other country to attract firms within its national borders, resulting in inefficiently high Nash import tariffs. Moreover, both countries can improve their welfare through a coordinated policy of reciprocal tariff reduction from the Nash tariffs.[1] Within the same framework, Campolmi, Fadinger and Forlati (2014) analyze international

[1]In the case of Cournot competition, Venables (1985) shows that, starting with global free trade, each country has a unilateral incentive to introduce import tariffs or export subsidies at the expense of the other country. In the symmetric Nash equilibrium of this model considered by Bagwell and Staiger (2012), if policymakers have access to both import and export instruments, export taxes are used in addition to import tariffs, and countries can mutually gain by symmetrically reducing import tariffs or export taxes from their levels at the Nash equilibrium.

tax competition and coordination between two symmetric countries when governments have access to both trade and domestic policy instruments (import and export tariffs as well as wage taxes and subsidies). They show that the joint social optimum can be achieved through a coordinated policy that uses domestic instruments (wage subsidies) rather than trade policy tools, or uses trade policy tools but offsets their distortions with the domestic instruments. Campolmi, Fadinger and Forlati (2021) allow for firm heterogeneity and consider different trade agreements when relative markups are constant within industries but vary between them. They conclude that, under a 'shallow' trade agreement that bans trade policies but imposes no restrictions on domestic policies, the level of wage subsidies in both countries becomes inefficiently low and can even turn into wage taxes, implying that a 'deep' trade agreement that coordinates both trade and domestic policies is needed to achieve the social optimum. While this holds also in our setup, our emphasis is on within-industry misallocation, which they do not have due to CES demand, and how to deal with it without firm-specific tools.

With VES demand and constant absolute pass-through à la Melitz and Ottaviano (2008), Bagwell and Lee (2020) consider both coordinated and non-coordinated import and export policies in a symmetric two-country setup. They show that the total tariffs (the net tariff level imposed when exporting from one country to the other) in the symmetric Nash equilibrium are inefficiently high, and that countries can mutually gain by symmetrically reducing the total tariffs from their level at the Nash equilibrium. They also show that the efficient total tariff level that maximizes joint welfare level could be positive, negative, or zero depending on a simple relationship among parameters. Based on the same model, Nocco, Ottaviano and Salto (2019) extend Nocco, Ottaviano and Salto (2014) from a closed to an open economy with an arbitrary number of asymmetric countries and show how the social optimum can be achieved through firm-specific taxes and subsidies that take also the characteristics of origin and destination countries into account. With respect to them, we focus on policy intervention that is not firm-specific within a more general demand system that reveals the importance of constant absolute pass-through.

Finally, our work speaks to recent studies on the effects of a global minimum tax on the profits of multinational firms. In these studies, multinational firms located in high-tax countries ('non-havens') have an incentive to shift their (fixed) profits to low-tax countries ('havens') to avoid tax payments, but this profit shifting incurs some costs. The global minimum tax raises the corporate tax rate in havens, reducing profit shifting and affecting the tax rate in non-havens too. With two countries, Hebous and Keen (2022) show that the non-haven raises its tax rate in response to the introduction of the global minimum tax, and that not only the non-haven but also the haven can benefit from the tax. With an arbitrary number of haven and non-haven countries, Johannesen (2022) finds that whether countries benefit from the global minimum tax depends on the level of the tax, and that a global minimum tax at a low rate may be detrimental to non-havens. Janeba and Schjelderup (2022) analyze the impact of the introduction of the global minimum tax on tax revenues in a three-country setup with a haven and two non-havens that seek to maximize their own tax revenues. Allowing for endogenous location choices by multinational firms, they show that, when the costs of profit shifting are low, the global minimum tax tends to raise tax rates in non-havens and tax revenues in both non-havens and havens. Janeba and Schjelderup (2022) also show that, when the level of corporate tax in non-havens is fixed but lump-sum subsidies are available to non-havens, the introduction of the global minimum tax intensifies subsidy competition between non-havens to increase their tax base by attracting multinational firms, which results in unchanged net tax revenues in non-havens. Hence, they conclude that a global minimum tax agreement should be discussed including its impact on competition via other policy instruments. This need to coordinate trade and domestic policies, which echoes Nocco, Ottaviano and Salto (2019) and Campolmi, Fadinger and Forlati (2021), is also a conclusion of the present analysis despite a very different framework. For further comparison, we devote particular attention to analyzing how a global corporate tax rate on profits should be set to enhance global welfare in our model.

The rest of the paper is organized as follows. Section 2 presents the global economy consisting of potentially asymmetric countries. After introducing the demand system, it derives the market equilibrium and the first best optimum. Section 3 describes the general properties of optimal non-discriminatory multilateral policies that can be used to decentralized the global optimum by leveling the playing field through destination specific per-unit subsidies. Section 4 and Section 5 deal with the implications of specific sets of taxes used to finance optimal non-discriminatory subsidies, and deepen the analysis of welfare-maximizing global corporate tax rate on profits. However, once taxes are nondiscriminatorily set across the world to decentralize the efficient outcome, there is still an issue in terms of redistribution of resources because taxes on production and corporate profits can be collected in different ways. Thus, Section 6 analyzes which countries benefit more from taxes collected by the origin country than by the destination country. Section 7 concludes.

2 The Global Economy

Consider M countries, indexed by $l = 1, \ldots, M$, that constitute the world economy. Each country l is populated by L_l consumers, each endowed with $\overline{q}_{0l}^{\varepsilon}$ units of a traditional good 0, and inelastically supplying one unit of labor in the domestic labor market. Workers are also consumers, and this implies that L_l also defines the 'market size' of country l.

Consumers across the world share the same preferences that are defined over the 'traditional' homogeneous good 0 and a continuum of varieties of a horizontally differentiated 'modern' good indexed by $i \in \Omega_l$, where Ω_l denotes the set of the continuum of varieties. Specifically, consumers in country l have the following quasi-linear utility function

$$U_l = q_{0l}^{\varepsilon} + \alpha \int_{i\in\Omega_l} q_l^{\varepsilon}(i)\, di - \frac{1}{1-\delta}\gamma \int_{i\in\Omega_l} \left(q_l^{\varepsilon}(i)\right)^{1-\delta} di - \frac{1}{1-\delta}\eta \left(\int_{i\in\Omega_l} q_l^{\varepsilon}(i)\, di\right)^{1-\delta}, \tag{1}$$

where q_{0l}^{ε} and $q_l^{\varepsilon}(i)$, respectively, represent the individual consumption of the traditional good and of variety i of the differentiated good. To ensure that the consumption of the traditional good is positive, its individual endowment is assumed to be sufficiently large. The sub-utility for the modern varieties combines a binomial component (with coefficients $\alpha \geq 0$ and $\eta \geq 0$) whereby only total consumption matters, with a CES component (with coefficient $-\gamma/(1-\delta)$) through which also the dispersion of total consumption across varieties matters. While the importance of the CES component is regulated by γ, the 'love of variety' it embeds is measured by δ. Varieties are perfect substitutes in two extreme situations: when γ goes to zero, there is no CES component; when δ goes to zero, the CES component's elasticity of substitution $(1/\delta)$ limits infinity. Special cases include the CES sub-utility of Krugman (1980) for $\alpha = \eta = 0$, $\gamma < 0$ and $0 < \delta < 1$, and the quadratic sub-utility of Melitz and Ottaviano (2008) for $\alpha > 0$, $\eta > 0$, $\delta = -1$ and $\gamma > 0$. While these are the most popular cases in models of monopolistic competition with heterogeneous firms, henceforth we will focus on the more flexible mixture with $\alpha > 0$, $\eta > 0$, $\delta < 0$ and $\gamma > 0$.[2]

Labor is the sole productive factor and its endowment is assumed to be large enough to sustain production of both goods. The supply of the traditional good takes place under constant returns to scale, with one unit of labor required to produce one unit of output. As for the modern good, its production in country l takes place only after a requirement of $f_l > 0$ units of labor has been sunk in that country to develop the corresponding blueprint. Then, the actual production of each variety requires c units of labor per unit of output randomly drawn from a country-specific continuous distribution with cumulative density function

$$G_l(c) = \left(\frac{c}{c_{M,l}}\right)^k, \; c \in [0, c_{M,l}], \tag{2}$$

where $c_{M,l}$ represents the maximum value of c that can be drawn in country l, and $k \geq 1$ denotes the shape parameter of the Pareto distribution (2). Larger k shift the density towards the right tail of the distribution towards the upper bound $c_{M,l}$.[3] Considering two countries h and l characterized by different upper bounds $c_{M,h}$ and $c_{M,l}$, the fact that the unit labor requirement for the homogeneous good equals 1 in both countries implies that country l has a stochastic comparative advantage in the modern good with respect to country h whenever $c_{M,h}/c_{M,l} > 1$ holds. The advantage increases with k as larger k reduces the probability that varieties randomly chosen in the two countries are produced with the same unit input requirements.

While exchanges of the traditional good are frictionless both within and between countries, those of the modern good face international 'iceberg frictions'. Specifically, $\tau_{hl} \geq 1$ units have to be shipped from country h to country l for one unit to arrive at destination, with $\tau_{hl} = 1$ for $h = l$. These frictions are not due to trade policy barriers, and merely describe the impact of geography and transport technologies. Hence, $\tau_{hl}c$ is the 'delivered' unit labor requirement of a variety with unit labor requirement c shipped from h to l.[4]

2.1 Market Structure and Equilibrium

In this section we describe the market equilibrium, which requires that all markets clear with all consumers maximizing their utility subject to their respective budget constraints, and all firms maximizing their profits subject to their technological constraints (for both production and trade). While perfect competition is the market structure characterizing the traditional good sector and the labor

[2] These restrictions on the parameters' space are required to ensure that: (i) profit-maximizing quantities and markups as well as maximized profit are non-negative; (ii) the SOC for profit maximization as well as the conditions for convergence of the integrals determining the number of sellers and the cutoffs are satisfied.

[3] When $k = 1$, the distribution is uniform on its support $[0, c_{M,l}]$, and the density becomes more skewed towards the upper bound of the support when k increases, becoming degenerate at $c_{M,l}$ when k is infinitely large in the limit.

[4] For $\alpha = \eta = 0$, $\gamma < 0$ and $\delta > 0$, the existence of a market equilibrium with endogenous firm selection would require the introduction of fixed production and export costs as in Melitz (2003). Moreover, due to quasi-linear utility, it would also require the introduction of an additional parameter regulating the substitutability of the CES bundle of modern varieties with the traditional good as in Bagwell and Lee (2018).

market, monopolistic competition prevails in the market of modern differentiated varieties. The traditional good is chosen as the numeraire of the model and this assumption, together with those of perfect competition for its market structure and of frictionless international shipments, ensures that both its price and the wage of workers are equal to one in all countries. Thus, the presence of the freely traded 'outside good' generates a perfectly elastic labor supply curve, and it allows to identify the effects of trade policies on firm location (Ossa, 2011). Given the unitary wage, the unit input requirement c corresponds to the marginal cost of production for the varieties for which it is drawn and, in general, the 'delivered' marginal cost to l of a variety produced in h at marginal cost c is equal to $\tau_{hl}c > c$.

Maximization of utility (1) subject to the budget constraint

$$q_{0l}^{\varepsilon} + \int_{i \in \Omega_l} p_l(i)\, q_l^{\varepsilon}(i)\, di = w_l + \overline{q}_{0l}^{\varepsilon} = 1 + \overline{q}_{0l}^{\varepsilon},$$

yields individual inverse demand curve in country l for variety i

$$p_l(i) = \alpha - \gamma \left(q_l^{\varepsilon}(i)\right)^{-\delta} - \eta \left(Q_l^{\varepsilon}\right)^{-\delta}, \tag{3}$$

for $q_l^{\varepsilon}(i) \geq 0$, with $p_l(i)$ denoting the price of variety i and $Q_l^{\varepsilon} = \int_{i \in \Omega^l} q_l^{\varepsilon}(i)\, di$ expressing the total individual demand of the differentiated varieties in country l. Then, once defined the total consumption of modern varieties in l as $Q_l \equiv L_l Q_l^{\varepsilon}$, (3) implies that the choke price that drives demand to zero is $p_l^{\max} \equiv \alpha - \eta \left(Q_l/L_l\right)^{-\delta}$. Using this expression, (3) can be rewritten and aggregated across consumers to obtain the aggregate demand of variety i in country l

$$q_l(i) = L_l \left(\frac{p_l^{\max} - p_l(i)}{\gamma}\right)^{-\frac{1}{\delta}} \qquad \forall i \in \Omega_{*,l},$$

where $\Omega_{*,l}$ is the largest subset of Ω_l such that demand in l is positive for variety i, and $p_l^{\max} \leq \alpha$ is the price at which demand for a variety in l is driven to zero.

The national markets of the differentiated varieties are 'segmented' due to international trade frictions and, therefore, firms maximize their profits market by market. Moreoever, as there are no scope economies, each variety is produced by one firm only. Denoting by $q_{hl}(c)$ the profit maximizing quantity delivered to country l by a firm producing in country h at marginal cost c, its value is given by

$$q_{hl}^{m}(c) = \frac{L_l}{\gamma^{-\frac{1}{\delta}} \left(1-\delta\right)^{-\frac{1}{\delta}}} \left(c_{ll}^{m} - \tau_{hl}c\right)^{-\frac{1}{\delta}}, \tag{4}$$

where 'm' labels equilibrium variables and $c_{ll}^{m} = p_l^{\max}$ with $\tau_{hl}c \leq c_{ll}^{m}$ is the 'domestic cutoff' in country l below which the delivered marginal cost must fall for the delivered quantity be positive. Equivalently,

$$c_{hl}^{m} = c_{ll}^{m}/\tau_{hl}, \tag{5}$$

is the 'export cutoff' in country h below which the marginal cost in country h must fall for the delivered quantity to country l to be positive. Given $\tau_{hl} > 1$, (5) implies that marginal exporters from h to l have lower marginal cost than marginal domestic sellers ($c_{hl}^{m} < c_{ll}^{m}$).

The delivered price for quantity (4) evaluates to

$$p_{hl}^m(c) = \frac{-\delta}{1-\delta}c_{ll}^m + \frac{1}{1-\delta}\tau_{hl}c, \tag{6}$$

with corresponding markup $\mu_{hl}^m(c)$ and maximized profit $\pi_{hl}^m(c)$ respectively given by

$$\mu_{hl}^m(c) = \frac{-\delta}{1-\delta}(c_{ll}^m - \tau_{hl}c) \quad \text{and} \quad \pi_{hl}^m(c) = \mu_{hl}^m(c)q_{hl}^m(c). \tag{7}$$

Results in expressions (4)-(7) show that more productive firms producing in country h and selling to country l are characterized by lower production cost c, set smaller prices $p_{hl}^m(c)$ than higher cost firms and sell larger quantities $q_{hl}^m(c)$. This, combined with the fact that they are able to impose a larger markup $\mu_{hl}^m(c)$, allows them to obtain higher profits $\pi_{hl}^m(c)$.

Free entry requires expected profits to be zero in equilibrium

$$\sum_{l=1}^{M}\left[\int_0^{c_{hl}^m}\pi_{hl}^m(c)dG_h(c)\right] = f_h, \tag{8}$$

that is

$$\sum_{l=1}^{M}\left[(\tau_{hl})^{-k}L_l\left(c_{ll}^m\right)^{k+1-\frac{1}{\delta}}\right] = (1-\delta)^{-\frac{1}{\delta}}\frac{\frac{1-\delta}{-\delta}\gamma^{-\frac{1}{\delta}}\left(c_{M,h}\right)^k f_h}{kB\left(2-\frac{1}{\delta},k\right)}$$

where $B(.,.)$ is the Beta function.[5] Together with (4), (5) and (7), (8) defines a system of M equations in M unknown cutoffs that can be solved to obtain the equilibrium domestic cutoff

$$c_{ll}^m = \left\{(1-\delta)^{-\frac{1}{\delta}}\frac{(1-\delta)\gamma^{-\frac{1}{\delta}}}{-\delta kB\left(2-\frac{1}{\delta},k\right)L_l}\frac{\sum\limits_{h=1}^{M}\left[f_h\left(c_{M,h}\right)^k|C_{hl}|\right]}{|P|}\right\}^{\frac{1}{k+1-\frac{1}{\delta}}}, \tag{9}$$

where $|P|$ is the determinant of the geographical 'ease-of-shipment' matrix P with element $\rho_{hl} = (\tau_{hl})^{-k}$ ranging from 0 when international frictions are prohibitively high to 1 when they are null, and $|C_{hl}|$ is the cofactor of element ρ_{hl}.[6] The term $f_l\left(c_{M,l}\right)^k$ represents the 'state of technology' available in country l and $\sum\limits_{h=1}^{M}\left[f_h\left(c_{M,h}\right)^k|C_{hl}|\right]/|P|$ in (9) is an inverse index of 'supply access' measuring how difficult it is for consumers in l to source cheap varieties from other countries. The value of the index depends on how far from country l are countries characterized by a good state of technology. According to (9), the domestic cutoff c_{ll}^m decreases with 'market size' L_l and 'supply access'.

Following Nocco, Ottaviano and Salto (2019), we define as advantaged (disadvantaged) countries those economies characterized by larger (smaller) market size, better (worse) state of technology in terms of lower (higher) innovation and production costs, and better (worse) geography in terms of less (more) remoteness from other countries.

[5]See Appendix A for a detailed derivation.

[6]Henceforth, we focus on cases in which all countries have firms producing in the modern sector, which requires $\sum\limits_{h=1}^{M}\left[f_h\left(c_{M,h}\right)^k|C_{hl}|\right]/|P| > 0$ to hold for $l = 1,\ldots,M$.

Once determined all the cutoffs c_{ll}^m, all other endogenous variables of the model can be readily derived. In particular, the number of sellers that defines the 'product range' N_l^m is derived making use of $c_{ll}^m = p_l^{\max}$, $c_{hl}^m = c_{ll}^m/\tau_{hl}$ from (5), $p_l^{\max} \equiv \alpha - \eta\left(Q_l/L_l\right)^{-\delta}$, (2) and (4) to obtain

$$N_l^m = \frac{(1-\delta)^{-\frac{1}{\delta}}}{kB\left(1-\frac{1}{\delta},k\right)}\left(\frac{\gamma}{\eta}\right)^{-\frac{1}{\delta}}\left(\frac{\alpha - c_{ll}^m}{c_{ll}^m}\right)^{-\frac{1}{\delta}} \tag{10}$$

for $l = 1,\ldots,M$.[7]

The total number of sellers in country l is given by the sum of all producers that are able to sell to l

$$N_l^m = \sum_{h=1}^{M} N_{hl}^m,$$

where N_{hl}^m is the number of sellers from country h to country l, and it corresponds to the share of entrants in country h with marginal cost lower than the cutoff c_{hl}, that is $N_{hl} = N_{E,h}G_h(c_{hl})$. Relying on this expression together with (2) and (5), the equilibrium number of sellers can then be rewritten as $N_l^m = \sum_{h=1}^{M} \rho_{hl} N_{E,h}\left(c_{ll}^m/c_{M,h}\right)^k$, which, combined with (10) gives, for $l = 1,\ldots,M$, a system of M linear equations that solves for the equilibrium number of entrants

$$N_{E,l}^m = \frac{\frac{(1-\delta)^{-\frac{1}{\delta}}}{kB\left(1-\frac{1}{\delta},k\right)}\left(\frac{\gamma}{\eta}\right)^{-\frac{1}{\delta}}\left(c_{M,l}\right)^k \sum\limits_{h=1}^{M}\left[\left(\alpha - c_{hh}^m\right)^{-\frac{1}{\delta}}\left(c_{hh}^m\right)^{-\left(k-\frac{1}{\delta}\right)}\left|C_{lh}\right|\right]}{|P|}. \tag{11}$$

The equilibrium number of producers is given by $N_{P,l}^m = N_{E,l}^m\left(c_{ll}^m/c_{M,l}\right)^k$.

Finally, indirect utility can be written as

$$U_l^m = 1 + \overline{q}_{0l}^{\varepsilon} + \frac{-\delta}{1-\delta}\frac{1}{\eta^{-\frac{1}{\delta}}}\left(\alpha - c_{ll}^m\right)^{-\frac{1}{\delta}}\left(\alpha - \frac{k+1}{k+1-\frac{1}{\delta}}c_{ll}^m\right). \tag{12}$$

2.2 Global Optimum and Market Failures

The optimal outcome is obtained by maximizing world welfare subject to labor (L_l) and traditional good endowments for each country l ($\overline{q}_{0l} = \overline{q}_{0l}^{\varepsilon}L_l$), trade frictions, and technological constraints represented by production functions for all types of goods. The planner takes into account that the unit labor requirement c for each variety produced of the differentiated good is the realization of a random draw from the distribution $G_l(c)$, which requires first the allocation of f_l units of labor to the design of that specific variety by each of the entrants $N_{E,l}$ in country l. Thus, the planner chooses the number of varieties $N_{E,l}$ to be designed in each country l, which implies choosing how much labor $f_l N_{E,l}$ should be allocated to the design of varieties. After drawing the unit labor requirement c for each designed variety, the planner decides how much output $q_{hl}(c) \geq 0$ of each designed variety has to be produced and shipped between any country pair according to the value of c.

[7] See Appendix A for a detailed derivation.

Specifically, the planner maximizes global welfare

$$\max_{\{q_{0l},N_{E,l},q_{lh}(c)\}|_{l=1}^{M}} W=\sum_{l=1}^{M}U_lL_l,$$

subject to the resource constraint for each country $l=1,\ldots,M$, that is given by

$$(q_{0l}-\overline{q}_{0l})+f_lN_{E,l}+N_{E,l}\sum_{h=1}^{M}\left[\int_0^{c_{M,l}}\tau_{lh}cq_{lh}(c)dG_l(c)\right]=L_l$$

for $l=1,\ldots,M$ and with $\tau_{ll}=1$. In the resource constraint, the left hand side represents how the available resources of labor L_l in each country l are allocated, that is to produce the numeraire good, to design modern differentiated varieties and to produce those selected by the planner for each country h, including l, taking the distribution of c and iceberg frictions τ_{lh} as given. To obtain U_lL_l, the planner considers that expressions $\int_{i\in\Omega_l} q_l\,(i)\,di$ and $\int_{i\in\Omega_l}(q_l\,(i))^{1-\delta}\,di$ in (1), can be, respectively, rewritten as $\sum_{h=1}^{M}N_{E,h}\int_0^{c_{M,h}}q_{hl}(c)dG_h(c)$ and $\sum_{h=1}^{M}N_{E,h}\int_0^{c_{M,h}}\left[q_{hl}(c)\right]^{1-\delta}dG_h(c)$.

Let superscript o denote the optimal values. The first order conditions for $q_{hl}(c)$ in the planner's maximization problem yield the delivered quantity

$$q_{hl}^{o}(c)=\frac{L_l}{\gamma^{-\frac{1}{\delta}}}\left(c_{ll}^{o}-\tau_{hl}c\right)^{-\frac{1}{\delta}} \tag{13}$$

for $c\le c_{ll}^{o}/\tau_{hl}$, where $c_{ll}^{o}\equiv\alpha-\eta\left(\frac{Q_l^o}{L_l}\right)^{-\delta}$ and $Q_l^o=\sum_{h=1}^{M}\left(N_{E,h}\int_0^{c_{hl}^o}q_{hl}^o(c)dG_h(c)\right)$. From (13), the 'export cutoff' defined by $q_{hl}^o(c_{hl}^o)=0$ is expressed as $c_{hl}^o=c_{ll}^o/\tau_{hl}$. Optimal quantities $q_{hl}^o(c)$ in (13) are associated with the 'shadow price' and 'shadow markup', respectively, given by[8]

$$p_{hl}^o(c)=\tau_{hl}c\quad\text{and}\quad\mu_{hl}^o(c)=0.$$

Instead, the first order conditions of the planner's problem with respect to $N_{E,h}$ require that

$$\sum_{l=1}^{M}\left[(\tau_{hl})^{-k}L_l\left(c_{ll}^o\right)^{k+1-\frac{1}{\delta}}\right]=\frac{\frac{1-\delta}{-\delta}\gamma^{-\frac{1}{\delta}}\left(c_{M,h}\right)^k f_h}{kB\left(2-\frac{1}{\delta},k\right)} \tag{14}$$

for $h=1,....,M$, generating a system of M equations that can be solved for the M optimal domestic cutoffs

$$c_{ll}^o=\left\{\frac{1-\delta}{-\delta}\frac{\gamma^{-\frac{1}{\delta}}}{kB(2-\frac{1}{\delta},k)L_l}\frac{\sum_{h=1}^{M}\left[f_h\left(c_{M,h}\right)^k|C_{hl}|\right]}{|P|}\right\}^{\frac{1}{k+1-\frac{1}{\delta}}} \tag{15}$$

for $l=1,\ldots,M$. We thus have

$$c_{ll}^o=\left[(1-\delta)^{-\frac{1}{\delta}}\right]^{-\frac{1}{k+1-\frac{1}{\delta}}}c_{ll}^m.$$

[8]Using the definition of the cutoff $c_{ll}^o\equiv\alpha-\eta\left(\frac{Q_l^o}{L_l}\right)^{-\delta}$ into (13) and substituting it into the inverse demand in (3), $p_{hl}\,(c)=\alpha-\gamma\,(q_{hl}(c)/L_l)^{-\delta}-\eta\,(Q_l/L_l)^{-\delta}$, we get $p_{hl}^o\,(c)=\tau_{hl}c$. This implies that optimal quantities clear the market in a decentralized outcome only if the market price is equal to the marginal delivered cost.

The optimal number of varieties sold in each country l , that is N_l^o, is obtained from the definition of the cutoff $c_{ll}^o = \alpha - \eta \left(\frac{Q_l^o}{L_l}\right)^{-\delta}$, the relation between the cutoff for marginal firms producing in different countries and selling in l, that is $c_{hl}^o = c_{ll}^o/\tau_{hl}$, and the definition of Q_l^o together with (2) and (13) to get

$$N_l^o = \frac{1}{kB\left(1 - \frac{1}{\delta}, k\right)} \left(\frac{\gamma}{\eta}\right)^{-\frac{1}{\delta}} \left(\frac{\alpha - c_{ll}^o}{c_{ll}^o}\right)^{-\frac{1}{\delta}} \tag{16}$$

for $l = 1, \ldots, M$. Moreover, given that $N_l^o = \sum\limits_{h=1}^{M} N_{hl}^o$, with N_{hl}^o denoting the optimal number of varieties produced in country h and consumed in country l, the optimal number of varieties consumed in l can also be expressed as $N_l^o = \sum_{h=1}^{M} \rho_{hl} N_{E,h}^o \left(c_{ll}^o/c_{M,h}\right)^k$. This expression combined with (16) gives a system of M linear equations for $l = 1, \ldots, M$, and the resulting system can be solved to find the optimal number of designed varieties

$$N_{E,l}^o = \frac{\frac{1}{kB\left(1-\frac{1}{\delta},k\right)} \left(\frac{\gamma}{\eta}\right)^{-\frac{1}{\delta}} \left(c_{M,l}\right)^k \sum\limits_{h=1}^{M} \left[\left(\alpha - c_{hh}^o\right)^{-\frac{1}{\delta}} \left(c_{hh}^o\right)^{-\left(k-\frac{1}{\delta}\right)} |C_{lh}|\right]}{|P|} \tag{17}$$

with $l = 1, \ldots, M$. Finally, $N_{P,l}^o = N_{E,l}^o \left(c_{ll}^o/c_{M,l}\right)^k$ represents the efficient number of varieties produced in country l.

Taking into account these results, Nocco, Ottaviano and Salto (2019) show that in the market with respect to the optimal outcome: i) too many products are sold to advantaged countries and too few to disadvantage countries (‘inefficient product range’); ii) conditional on range, relatively too many high cost products are sold to any country (‘inefficient product selection’) and that this inefficiency is more severe for disadvantaged countries; iii) conditional on range and selection, the quantities of high cost products sold to any country are too large and those of low cost products are too small (‘inefficient product mix’), and again this inefficiency is more severe for disadvantaged countries. These findings show that there is room for welfare improving multilateral policy intervention that: increases sales of low cost firms to all countries but especially to disadvantaged countries; decreases sales of high cost firms to all countries but, again, especially to disadvantaged countries; reduces firm entry in all countries but especially in disadvantaged ones. Then, in the same work, it is shown that policy tools can be used to decentralize the optimal outcome and they are identified with firm-origin-destination-specific per-unit transfers and origin-specific lump-sum entry taxes. Being different across firms, they are in principle discriminatory in their nature.

The aim of the following sections is to show how the first best outcome can be obtained also by means of non-discriminatory policy measures that can be thought as more likely to be implemented by countries involved in global exchanges. Moreover, the nature of these instruments can be thought as ‘fair’ because they ensure an equal treatment to all firms selling in a specific market contributing to level the playing field in which they compete.

3 Optimal non-discriminatory Multilateral Subsidies

Let us consider how different sets of policy instruments can be used to implement the efficient outcome described in previous section. We focus on specific combinations of these instruments that have a non-discriminatory nature, in the sense they are not firm specific, and 'fair' because they do not alter the playing field for firms selling in a specific country.

3.1 Intensive Margin Misallocation

To this end, we consider how profits realized by a firm producing in country h with unit input requirement c from its sales in country l are affected by the use of discriminatory and non-discriminatory ('level-playing-field') policy tools in the following expression

$$\pi_{hl}(c) = (1 - t_h^\pi)\left[\frac{p_{hl}(c)}{1 + t_l^a} + s_{hl}(c) - (1 + t_h^c)\,\tau_{hl}c\right] q_{hl}(c), \tag{18}$$

where policy tools are given by: the tax rate on corporate profits $t_h^\pi < 1$ common to all firms producing in country h; the ad valorem sales tax (subsidy if negative) rate $t_l^a > -1$ common to all firms selling in the same destination country l; the ad valorem production tax (subsidy if negative) rate $t_h^c > -1$ common to all firms producing in h; and, finally, the per-unit subsidy (tax if negative) $s_{hl}(c)$ for firm producing in h and selling in l with unit labor requirement c. Per-unit transfers $s_{hl}(c)$ are written in this general way for the moment, as they can be potentially firm specific. They are used to correct the intensive margin distortions in all countries by aligning the market price with the marginal delivered cost through eliminating the markup, i.e. $p_{hl}^d(c) = \tau_{hl}c$ where superscript d denotes variables in the decentralized outcome.[9] As shown in Appendix B, this requires setting

$$s_{hl}(c) = \frac{-\delta\tau_{hl}c_{hl}^d + \left[(1 + t_l^a)(1 + t_h^c) - (1 - \delta)\right]\tau_{hl}c}{1 + t_l^a}, \tag{19}$$

where c_{hl}^d is the export cutoff in the decentralized outcome. Expression (19) allows us to state that a combination of policy tools that is non-discriminatory across firms can be used to decentralize the efficient allocation of resources, provided that ad valorem taxes on revenues and on production satisfy the following relationship

$$(1 + t_l^a)(1 + t_h^c) = 1 - \delta. \tag{20}$$

Expression (20) gives the combinations of ad valorem tax rates on sales t_l^a and on production t_h^c for optimal per-unit subsidy $s_{hl}(c) = s_{hl}$ that is not firm specific. To align all market prices with the marginal delivered cost without relying on firm specific subsidies, (20) must hold for $h, l = 1, \ldots, M$, which is equivalent to setting common global ad valorem tax rates on sales (t^a) and production (t^c) such that[10]

$$(1 + t^a)(1 + t^c) = 1 - \delta. \tag{21}$$

[9]This is a necessary condition for optimal quantity $q_{hl}(c)$ in the decentralized outcome (see footnote 8).

[10]For given ad valorem sales tax rate in country l, (20) holds for $h = 1, \ldots, M$ if and only if ad valorem production taxes are commonly set to satisfy $\left(1 + t_l^a\right)(1 + t^c) = 1 - \delta$. This can apply to all l if and only if ad valorem sales taxes are commonly set to $t^a = (-\delta - t^c)/(1 + t^c)$.

Hence, expression (21), together with the relationship between the cutoffs $\tau_{hl}c_{hl}^{d} = c_{ll}^{d}$ derived in Appendix B, implies that to correct the intensive margin distortions in all countries, all firms selling in country l should receive the same destination specific per-unit subsidy $s_{hl} = s_l$ such that

$$s_l = \frac{-\delta}{1+t_l^a}c_{ll}^d = \frac{-\delta}{1-\delta}\left(1+t_h^c\right)c_{ll}^d \tag{22}$$

for $l = 1, \ldots, M$. As will be confirmed below, decentralizing the optimal outcome in Section 2 requires setting c_{ll}^d equal to c_{ll}^o through firm entry and profit adjustments. Hence, the optimal destination specific subsidy (22) eventually depends on c_{ll}^o in (15), which is larger for disadvantaged countries—characterized by smaller market size, worse state of technology in terms of higher innovation and production costs, and worse geography in terms of more remoteness from other countries—implying that the optimal destination specific subsidy is larger for disadvantaged countries. Note that s_l can be equivalently thought as an export ('production') transfer in h for sales to l or an import ('consumption') transfer in l for purchases from h.

These findings make clear that 'fair' competition requires governments to intervene in the economy when firms have market power and that, with this aim in mind, they should coordinate on 'non-discriminatory' policies that level the playing field with an appropriate one-size-fits-all approach for all firms selling in a specific market. Clearly, in the case of $\left(1+t_l^a\right)\left(1+t_h^c\right) \neq 1-\delta$, expression (19) shows that the optimum can be decentralized only by means of subsidies/taxes that are firm-origin-destination specific.[11]

Let us come back to the case that is the focus of this paper, specifically the scenario in which per-unit subsidies given by (22) are non-discriminatory as (21) holds. To gain some more insights on the reasons why the destination specific per-unit subsidy s_l can be used, let us recall that the expression for the market price $p_{hl}(c)$ when no policy instruments are used in (6) is linear in $\tau_{hl}c$, with incomplete and constant pass-through $(1/(1-\delta))$ and vertical intercept $-\delta c_{ll}^m/(1-\delta)$. The use of the destination specific per-unit subsidy s_l that is common, and, therefore, non-discriminatory across all firms selling their products in country l, and of the other policy instruments introduced in this section implies that the general expression for the price paid by consumers becomes[12]

$$p_{hl}^d(c) = \frac{1}{1-\delta}\left(1+t_l^a\right)\left(1+t_h^c\right)\tau_{hl}c + \frac{-\delta}{1-\delta}\left(1+t_l^a\right)\left(1+t_l^c\right)c_{ll}^d - \left(1+t_l^a\right)s_l \tag{23}$$

linear in $\tau_{hl}c$, with vertical intercept $\frac{-\delta}{1-\delta}\left(1+t_l^a\right)\left(1+t_l^c\right)c_{ll}^d - \left(1+t_l^a\right)s_l$. Hence, given that the optimal price curve is $p_{hl}^d(c) = \tau_{hl}c$, to decentralize the optimal outcome: (i) the slope of (23) has to be set

[11] This is the case in Nocco, Ottaviano and Salto (2019), whose results obtain for $\delta = -1$ and $t_h^c = t_l^a = 0$, so that (19) corresponds to the firm-origin-destination-specific transfer

$$s_{hl}(c) = \tau_{hl}\left(c_{hl}^o - c\right) = c_{ll}^o - \tau_{hl}c,$$

where the cutoffs are aligned with their optimal levels by implementing lump-sum entry taxes to adjust firm entry. This rule implies that the optimal per-unit transfer decreases with the marginal cost c; it is positive for $c \in [0, c_{hl}^o)$, zero for $c = c_{hl}^o$, negative ('tax') for $c \in (c_{hl}^o, c_{M,l}]$.

[12] Notice that (23) corresponds to (50) in Appendix B when the common destination specific per-unit subsidy $s_{hl}(c) = s_l$ is used. In this case, (49) in Appendix B can be rewritten as $p_l^{\max}/\left(1+t_l^a\right) = \left(1+t_h^c\right)\tau_{hl}c_{hl}^d - s_l = \left(1+t_l^c\right)c_{ll}^d - s_l$, implying that the general expression for the relation between the export and domestic cutoffs becomes $\left(1+t_h^c\right)\tau_{hl}c_{hl}^d = \left(1+t_l^c\right)c_{ll}^d$.

equal to 1 (i.e. $\left(1+t_l^a\right)\left(1+t_h^c\right)=1-\delta$) by rotating the price curve, which requires (20) to be satisfied; and (ii) the intercept of (23) has to be set equal to 0 (i.e. $\frac{-\delta}{1-\delta}\left(1+t_l^a\right)\left(1+t_l^c\right)c_{ll}^d-\left(1+t_l^a\right)s_l=0$) by shifting downward the price curve, which requires $s_l=\frac{-\delta}{1-\delta}\left(1+t_l^c\right)c_{ll}^d$ to be satisfied. This condition is expressed in (22) with common global ad valorem taxes (21).[13] Consequently, with destination specific subsidy (22) and common global ad valorem taxes (21), the net subsidy received by a firm producing in h from selling one unit of good in l becomes

$$s_l-\frac{t^a}{1+t^a}p_{hl}^d(c)-t^c\tau_{hl}c=\frac{-\delta\left(c_{ll}^d-\tau_{hl}c\right)}{1+t^a}, \tag{24}$$

which shares a similar characteristic with the firm-origin-destination-specific per-unit subsidy presented by Nocco, Ottaviano and Salto (2019), where more productive firms would receive more subsidies.[14]

3.2 Extensive Margin Misallocation

Once the destination specific per-unit subsidies s_l in (22) and common global ad valorem taxes on sales and on production are used, all market prices are aligned with the marginal delivered cost. This implies that the 'intensive margin misallocation' caused by markup pricing is tackled. However, this does not imply that firms' entry decision is optimal and, therefore, the analysis needs to be complemented by the correction of the 'extensive margin misallocation' that deals with the number of firms entering within each country and with selection. To this end, we consider the 'free entry condition' for firms producing in h adapted to introduce a potential lump-sum entry tax per firm entering in market h denoted by T_h^v, that is

$$\sum_{l=1}^{M}\left\{\int_0^{c_{hl}^d}\pi_{hl}^d(c)dG_h(c)\right\}=f_h+T_h^v. \tag{25}$$

The after tax profits (i.e. net of tax on profits) that should be substituted into the free entry condition (25) are those obtained in the non-discriminatory case, where the per-unit subsidies are common for all firms selling in each country. Thus, considering the common per-unit subsidy $s_{hl}(c)=s_l$ offered to all firms selling in l into the general expression for profits (51) derived in Appendix B, yields

$$\pi_{hl}^d(c)=\left(1-t_h^\pi\right)\frac{-\delta}{1-\delta}\left[\frac{1+t_l^a}{(1-\delta)\gamma}\right]^{-\frac{1}{\delta}}L_l\left[\left(1+t_h^c\right)\tau_{hl}\right]^{1-\frac{1}{\delta}}\left(c_{hl}^d-c\right)^{1-\frac{1}{\delta}}. \tag{26}$$

This can be substituted into the free entry condition (25) that, making use of the relation between

[13] Notice that s_l is common for all firms selling in country l given that the ad valorem production tax rate t_h^c has to be common across all countries, and this can apply to all destination countries $l=1,\ldots,M$, given that the ad valorem sales tax rate t_l^a has to be common across all countries (see footnote 10).

[14] see footnote 11.

c_{hl}^d and c_{ll}^d, can be rewritten as follows[15]

$$\sum_{l=1}^{M}\left[(\tau_{hl})^{-k}\left(1+t_l^a\right)^{-\frac{1}{\delta}}\left(1+t_l^c\right)^{k+1-\frac{1}{\delta}}L_l\left(c_{ll}^d\right)^{k+1-\frac{1}{\delta}}\right]=\frac{\frac{1-\delta}{-\delta}\left(1-\delta\right)^{-\frac{1}{\delta}}\left(\gamma\right)^{-\frac{1}{\delta}}\left(c_{M,h}\right)^{k}\left(f_h+T_h^{\upsilon}\right)}{kB\left(2-\frac{1}{\delta},k\right)\left(1-t_h^{\pi}\right)\left(1+t_h^c\right)^{-k}},\quad (27)$$

which holds for $h=1,\ldots,M$, yielding a system of M equations that can be solved using Cramer's rule to find the M equilibrium cutoffs:

$$c_{ll}^d=\left\{\frac{1-\delta}{-\delta}\frac{\left(\gamma\right)^{-\frac{1}{\delta}}}{kB\left(2-\frac{1}{\delta},k\right)L_l}\frac{\left(1-\delta\right)^{-\frac{1}{\delta}}}{\left(1+t_l^a\right)^{-\frac{1}{\delta}}\left(1+t_l^c\right)^{k+1-\frac{1}{\delta}}}\frac{\sum_{h=1}^{M}\left[\frac{\left(f_h+T_h^{\upsilon}\right)\left(c_{M,h}\right)^k}{\left(1-t_h^{\pi}\right)\left(1+t_h^c\right)^{-k}}\left|C_{hl}\right|\right]}{\left|P\right|}\right\}^{\frac{1}{k+1-\frac{1}{\delta}}}. \quad (28)$$

The cutoff c_{ll}^d in (28) is aligned with the optimal cutoff c_{ll}^o in (15) if and only if

$$\frac{\left(1-\delta\right)^{-\frac{1}{\delta}}}{\left(1+t_l^a\right)^{-\frac{1}{\delta}}\left(1+t_l^c\right)^{k+1-\frac{1}{\delta}}}\sum_{h=1}^{M}\left[\frac{\left(f_h+T_h^{\upsilon}\right)\left(c_{M,h}\right)^k}{\left(1-t_h^{\pi}\right)\left(1+t_h^c\right)^{-k}}\left|C_{hl}\right|\right]=\sum_{h=1}^{M}\left[f_h\left(c_{M,h}\right)^k\left|C_{hl}\right|\right]$$

holds. With common global ad valorem taxes on sales and production satisfying (21), this condition can be rewritten as

$$\sum_{h=1}^{M}\left\{\left[\frac{f_h+T_h^{\upsilon}}{\left(1-t_h^{\pi}\right)\left(1+t^c\right)}-f_h\right]\left(c_{M,h}\right)^k\left|C_{hl}\right|\right\}=0.$$

This must hold for $l=1,\ldots,M$, yielding a system of M linear equations in the terms between brackets, which is satisfied for any given geographical matrix P if and only if

$$T_l^{\upsilon}+f_l=\left(1-t_l^{\pi}\right)\left(1+t^c\right)f_l \quad (29)$$

holds for $l=1,\ldots,M$.

In summary, (29) describes the relationship between the lump-sum tax on entry T_l^{υ} and the corporate profit tax rate t_l^{π} that can correct the extensive margin misallocation in all countries when the destination specific per-unit subsidy (s_l) and common global ad valorem taxes on sales (t^a) and on production (t^c) are used to correct the intensive margin misallocation. Several remarks can be made based on these conditions, and will be discussed later. For the moment, let us point out one specific case in which ad valorem production taxes are not used ($t_l^c=0$ for all l). In this case, to correct the intensive margin distortions, ad valorem sales taxes and per-unit destination specific subsidies should be set to levels that satisfy (21) and (22) ($t_l^a=-\delta$ and $s_l=\frac{-\delta}{1-\delta}c_{ll}^d$ for all l), respectively. Then, condition (29), required to correct the extensive margin distortions, is satisfied without using lump-sum entry taxes and corporate profit taxes, that is, $c_{ll}^d=c_{ll}^o$ holds for all l with $T_l^{\upsilon}=t_l^{\pi}=0$ for all l. Consequently, this scenario demonstrates that the common global ad valorem sales tax and the per-unit destination specific subsidies ($t_l^a=-\delta$ and $s_l=\frac{-\delta}{1-\delta}c_{ll}^d$ for all l) can implement the optimum with no need for additional tools targeting entry and profits. This case is summarized in the second

[15] When per-unit subsidies are common to all firms selling in l, the general expression for the relation between c_{hl}^d and c_{ll}^d is given by $\left(1+t_h^c\right)\tau_{hl}c_{hl}^d=\left(1+t_l^c\right)c_{ll}^d$ (see footnote 12).

column of Table 1 and denoted as Case A. More on the other cases will be discussed after describing how the optimal per-unit subsidies can be financed so that the complete policy sets can be analyzed.

3.3 Constant Absolute Pass-Through

Melitz, Oshmakashvili, Ottaviano and Suverato (2024) have shown that, in the case of additive separable utility satisfying certain regularity conditions, the affine linearity of the profit-maximizing price as a function of marginal cost is both necessary and sufficient for the existence of optimal policies that are not firm-specific in a closed economy with no outside good. Tadakoro (2024) has shown that the optimum can be achieved without firm-specific policy tools in a closed-economy version of the present model for $\delta = -1$, corresponding to the non-separable utility of Melitz and Ottaviano (2008). What his analysis misses is the crucial importance of the affine linearity of the pricing equation, in particular of the implied constant absolute pass-through.

We want to argue here that the affine linearity of the profit-maximizing price as a function of marginal cost is both necessary and sufficient for the existence of non-firm-specific tools that can implement the social optimum. Our argument relies on Figure 1, which provides a visualization of the comparison between the market equilibrium and the optimum analogous to Figure 1 in Tadokoro (2024). There are two differences between the two figures. The first is that we do not impose $\delta = -1$; the second is that we consider a national market in open economy where sellers can bring their varieties produced in M heterogeneous countries facing trade frictions.

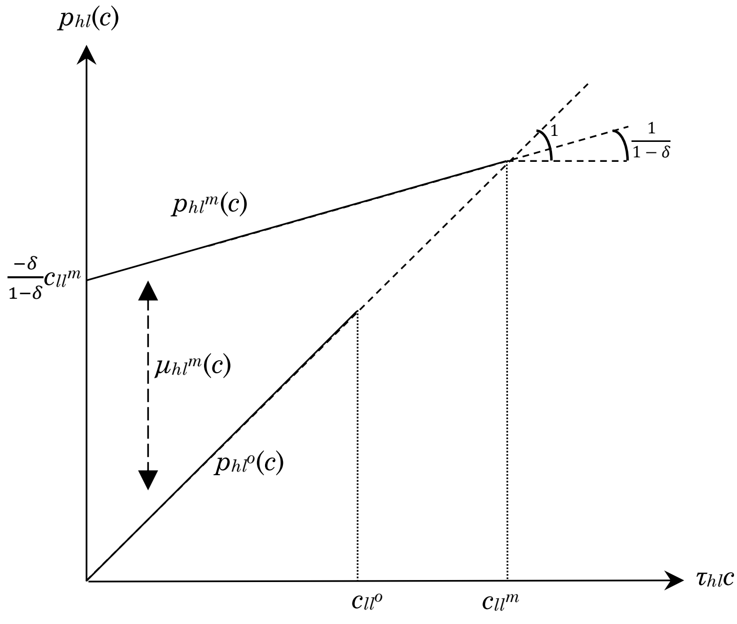

Figure 1: Prices, markups and marginal costs

In the figure, due to marginal cost pricing, the welfare-maximizing price $p^o_{hl}(c)$ is represented by the linear function of the marginal cost with slope equal to 1, truncated at the cutoff c^o_{ll}. Analogously, the profit-maximizing price $p^m_{hl}(c)$ in the market equilibrium corresponds to the affine linear function with vertical intercept $[-\delta/(1-\delta)]c^m_{ll}$ and slope $1/(1-\delta)$, truncated at the cutoff c^m_{ll}. Given that the slope of $p^o_{hl}(c)$ is constant, for non-firm-specific tools to be able to implement the optimum it is necessary that also the slope of $p^m_{hl}(c)$ is constant. Vice versa, if the slope of $p^m_{hl}(c)$ is constant, the results derived on the previous sections show that there exist non-firm-specific tools that can implement the optimum. As constant slope of the pricing equation implies constant absolute pass-through and vice versa, constant absolute pass-through is a necessary and sufficient condition for the existence of optimal non-firm-specific policy tools as in Melitz, Oshmakashvili, Ottaviano and Suverato (2024).

4 Financing Optimal non-discriminatory Subsidies

In general, when the optimal outcome is decentralized by means of non-discriminatory destination specific subsidies s_l, the total amount of the total expenditure on 'destination specific subsidies' (DSS) for all firms selling in country l is given by[16]

$$DSS_l = s_l \frac{L_l \left(\alpha - c^o_{ll}\right)^{-\frac{1}{\delta}}}{\eta^{-\frac{1}{\delta}}}, \tag{30}$$

where c^o_{ll} corresponds to the optimal domestic cutoff in country l as defined in expression (15).[17]

Then, aggregating over all countries, $\sum_{l=1}^{M} DSS_l$ is the 'global' destination specific per-unit subsidies expenditure, which needs to be financed, and the global budget constraint can be written as follows

$$\sum_{l=1}^{M} \left(L_l T^{\varepsilon}_l + N^o_{E,l} T^{\upsilon}_l + PT_l + ST_l + \Pi T_l\right) = \sum_{l=1}^{M} DSS_l. \tag{31}$$

The left hand side is obtained by adding up the following five components for all M countries: lump-sum taxes on consumers in country l ($L_l T^{\varepsilon}_l$), lump-sum entry taxes in l ($N^o_{E,l} T^{\upsilon}_l$), ad valorem 'production taxes' on production in l (PT_l), ad valorem 'sales taxes' on global sales in l (ST_l) and 'profit taxes' paid by all firms producing in l (ΠT_l). Notice that T^{ε}_l denotes the individual lump-sum tax on a consumer in l, while T^{υ}_l represents the lump-sum entry tax for each variety designed in l, with a negative value corresponding to a lump-sum entry subsidy.

It can be readily shown that to decentralize the optimal outcome, total ad valorem production

[16] Total expenditure on destination specific per-unit subsidies for firms selling in country l from all countries is given by

$$DSS_l = \sum_{h=1}^{M} \left(s_l N^o_{hl} \int_0^{c^o_{hl}} q^o_{hl}\left(c\right) \frac{dG_h(c)}{G_h(c^o_{hl})} \right).$$

Using (2), (13), (16), $c^o_{hl} = c^o_{ll}/\tau_{hl}$ and $N^o_l = \sum_{h=1}^{M} N^o_{hl}$, the expression for DSS_l can be written as in the text.

[17] Sets of policy tools satisfying (21), (22) and (29) can implement the optimum, ensuring that each variable in the decentralized outcome is aligned with its optimal level. Notice that general expressions for policy variables described in the following are implicitly assumed to satisfy these conditions.

taxes on production in country l are given by[18]

$$PT_l = t_l^c k f_l N_{E,l}^o, \tag{32}$$

while total ad valorem sales taxes on global sales in country l are given by[19]

$$ST_l = \frac{t_l^a}{1+t_l^a} \frac{k}{k+1-\frac{1}{\delta}} \frac{L_l c_{ll}^o \left(\alpha - c_{ll}^o\right)^{-\frac{1}{\delta}}}{\eta^{-\frac{1}{\delta}}}. \tag{33}$$

Taxes on corporate profits are collected in the origin (source) country. Total corporate profit taxes on all firms producing in country l can be expressed as[20]

$$\Pi T_l = t_l^\pi \left(1 + t_l^c\right) f_l N_{E,l}^o. \tag{34}$$

Lump-sum taxes on consumers are obtained taking into account that they are used with all, or part of all other taxes computed above to finance the total global per-unit subsidies for all firms selling in all countries. Specifically, the global budget constraint in (31) has to be satisfied in equilibrium. Assuming for the moment that the taxes and subsidies described above (i.e. DSS_l, $N_{E,l}^o T_l^v$, PT_l, ST_l and ΠT_l) are collected or provided by country l, we finally derive the lump-sum tax on consumers required for country l. Substituting the expressions for its components derived above, the global budget constraint in (31) is satisfied when

$$\begin{aligned} T_l^\varepsilon &= \left(s_l - \frac{t_l^a}{1+t_l^a} \frac{k c_{ll}^o}{k+1-\frac{1}{\delta}}\right) \frac{\left(\alpha - c_{ll}^o\right)^{-\frac{1}{\delta}}}{\eta^{-\frac{1}{\delta}}} - \left[t_l^c f_l k + t_l^\pi \left(1+t_l^c\right) f_l + T_l^v\right] \frac{N_{E,l}^o}{L_l} \\ &= \left(1 + t^c \left(k+1\right)\right) \frac{c_{ll}^o \left(\alpha - c_{ll}^o\right)^{-\frac{1}{\delta}}}{\left(k+1-\frac{1}{\delta}\right) \eta^{-\frac{1}{\delta}}} - t^c \left(k+1\right) \frac{f_l N_{E,l}^o}{L_l} \end{aligned} \tag{35}$$

[18] Total ad valorem production taxes paid by all firms producing in country l and selling to all countries are given by

$$PT_l = \sum_{h=1}^{M} \left(t_l^c N_{lh}^o \int_0^{c_{lh}^o} \tau_{lh} c q_{lh}^o(c) \frac{dG_l(c)}{G_l(c_{lh}^o)} \right).$$

Making use of (2), (13), (14), $c_{lh}^o = c_{hh}^o / \tau_{lh}$ and $N_{lh}^o = N_{E,l}^o G_l(c_{lh}^o)$, PT_l can be written as in the text.

[19] For a good produced by a firm in h and sold in l, consumers pay $p_{hl}(c)$ per unit, of which $\frac{t_l^a}{1+t_l^a} p_{hl}(c)$ is collected as sales tax and the firm receives $\frac{1}{1+t_l^a} p_{hl}(c)$. Noting that $p_{hl}^d(c) = p_{hl}^o(c) = \tau_{hl} c$ in a decentralized outcome, total ad valorem sales taxes for sales in l by all firms producing in all countries are given by

$$ST_l = \sum_{h=1}^{M} \left(\frac{t_l^a}{1+t_l^a} N_{hl}^o \int_0^{c_{hl}^o} p_{hl}^o(c) \, q_{hl}^o(c) \frac{dG_h(c)}{G_h(c_{hl}^o)} \right).$$

By (2), (13), (16), $c_{hl}^o = c_{ll}^o / \tau_{hl}$ and $N_l^o = \sum_{h=1}^{M} N_{hl}^o$, ST_l can be written as in the text.

[20] In a decentralized outcome, profit taxes paid by a firm producing in l with unit input requirement c from its sales in h are given by $\frac{t_l^\pi}{1-t_l^\pi} \pi_{lh}^d(c)$. Total profit taxes on all firms producing in l and selling to all countries $h = 1, \ldots, M$ are given by

$$\Pi T_l = \sum_{h=1}^{M} \left(\frac{t_l^\pi}{1-t_l^\pi} N_{lh}^o \int_0^{c_{lh}^o} \pi_{lh}^d(c) \frac{dG_l(c)}{G_l(c_{lh}^o)} \right).$$

By (2), (14), (20), (26), $c_{lh}^o = c_{hh}^o / \tau_{lh}$ and $N_{lh}^o = N_{E,l}^o G_l(c_{lh}^o)$, ΠT_l can be written as in the text.

holds for $l = 1, \ldots, M$, where, at the second line, (21), (22) and (29) are used to rewrite t_l^a, s_l and T_l^{υ}, respectively.[21]

5 Sets of Optimal Policy Tools

We have so far identified a set of six policy variables in each country $\{s_l, t_l^a, t_l^c, t_l^{\pi}, T_l^{\upsilon}, T_l^{\varepsilon}\}_{l=1}^M$ that can be used to decentralize the optimal outcome: the destination specific subsidy, the three tax rates on sales, production and corporate profits, and the two lump-sum taxes on firms (entry) and on consumers. The decentralization of the efficient outcome can be achieved if these policy tools satisfy the following conditions:

1. expression (21) that defines the necessary condition for the application of non-discriminatory per-unit subsidies across all firms selling in any given destination;
2. expression (22) for $l = 1, \ldots, M$ that defines the optimal destination specific per-unit subsidies to correct the intensive margin distortions;
3. expression (29) for $l = 1, \ldots, M$ that gives the conditions to correct the extensive margin distortions through aligning the market cutoff and entry with their optimal levels;
4. expression (35) for $l = 1, \ldots, M$ that defines the values of lump-sum taxes on consumers that ensure the complete financing of global subsidies once the other taxes have been set.

Hereafter, we focus on the specific case of a common global corporate tax rate (i.e. $t_l^{\pi} = t^{\pi}$ for $l = 1, \ldots, M$) to understand if a common global corporate tax can be included in a set of policy tools designed to harness market power to implement the optimal outcome. Thus, we have a system of $1 + 3M$ equations with $3 + 3M$ unknowns (i.e. three common global tax rates t^a, t^c and t^{π} as well as s_l, T_l^{υ} and T_l^{ε} for each country), implying two degrees of freedom. This allows for two policy variables to be freely set.

First of all, for the sake of designing an easier multilateral coordination, in what follows we introduce specific optimal multilateral policies for which lump-sum entry taxes are not available/used ($T_l^{\upsilon} = 0$ for $l = 1, \ldots, M$). In this context, to implement the optimum with fewer policy instruments, we particularly focus on two scenarios in which only one of the two ad valorem taxes is applied: Case A in which ad valorem production taxes are not available/used ($t^c = 0$) and Case B in which ad valorem sales taxes are not available/used ($t^a = 0$). These cases allow us to understand how common global corporate tax t^{π} should be incorporated into the optimal non-discriminatory multilateral policies. Subsequently, we will consider another potential situation, denoted as Case C, to explore the implications for the general case in which lump-sum entry taxes are not available/used to decentralize the optimal outcome. Table 1 summarizes the different sets of policy tools used in all these cases where lump-sum entry taxes are not used. The implementation of lump-sum entry taxes will be discussed in the next section.

[21] Recall that the destination specific per-unit subsidy in (22) can be applied to correct the intensive margin distortions in conjunction with common global ad valorem taxes on sales and production satisfying (21) (see footnote 10). Expression (29) represents the condition to correct the extensive margin distortions with this destination specific per-unit subsidy.

Table 1. Sets of Policy Tools with a Common Global Corporate Tax Rate t^{π}

	Case A	Case B	Case C
s_l	$\frac{-\delta}{1-\delta}c_{ll}^{o}$	$-\delta c_{ll}^{o}$	$\frac{-\delta}{(1-\delta)(1-t^{\pi})}c_{ll}^{o}$
t^a	$-\delta$	0	$-\delta-(1-\delta)\,t^{\pi}$
t^c	0	$-\delta$	$\frac{t^{\pi}}{1-t^{\pi}}$
t^{π}	0	$\frac{-\delta}{1-\delta}$	t^{π}
T_h^{υ}	0	0	0
T_l^{ε}	$\frac{c_{ll}^{o}(\alpha-c_{ll}^{o})^{-\frac{1}{\delta}}}{\left(k+1-\frac{1}{\delta}\right)\eta^{-\frac{1}{\delta}}}$	$-\delta\left[\frac{c_{ll}^{o}(\alpha-c_{ll}^{o})^{-\frac{1}{\delta}}}{\eta^{-\frac{1}{\delta}}}-\frac{(k+1)f_l N_{E,l}^{o}}{L_l}\right]$	$\frac{t^{\pi}k+1}{1-t^{\pi}}\frac{c_{ll}^{o}(\alpha-c_{ll}^{o})^{-\frac{1}{\delta}}}{\left(k+1-\frac{1}{\delta}\right)\eta^{-\frac{1}{\delta}}}-\frac{t^{\pi}}{1-t^{\pi}}\frac{(k+1)f_l N_{E,l}^{o}}{L_l}$

Note. Case C is adaptable for any common global corporate tax/subsidy rate $t^{\pi}<1$

5.1 Uniform ad Valorem Sales Taxes (Case A)

Let us start to analyze the optimal multilateral policies for which ad valorem production taxes t_l^c and lump-sum entry taxes T_l^{υ} are not available/used in all countries. In this scenario, the first degree of freedom is used to set $t^c=0$. Then, expression (21) requires the common global ad valorem sales tax rate to be $t^a=-\delta$, enabling the implementation of non-discriminatory per-unit subsidies (22) designed to correct the intensive margin distortions by aligning the market price with the marginal delivered cost, that is $s_l=-\delta c_{ll}^{o}/\left(1-\delta\right)$. Notice that s_l is higher in disadvantaged countries, as they are characterized by larger c_{ll}^{o}.

With the specific combination of $t^c=0$, $t^a=-\delta$ and $s_l=-\delta c_{ll}^{o}/\left(1-\delta\right)$, expression (29) implies any combination of a lump-sum entry tax and common global corporate tax to correct the extensive margin distortions, that is

$$T_l^{\upsilon}+f_l t^{\pi}=0 \tag{36}$$

for $l=1.\ldots,M$. The second degree of freedom is used to set $T_l^{\upsilon}=0$ for any one country l. Then, expression (36) requires the common global corporate tax rate to be $t^{\pi}=0$, indicating that lump-sum entry taxes must be set to zero in all countries to correct the extensive margin distortions.

Hence, in Case A, the common global ad valorem sales tax $t^a=-\delta$ and the destination specific per-unit subsidy $s_l=-\delta c_{ll}^{o}/\left(1-\delta\right)$ are already sufficient to implement the optimum with no need for additional tools targeting entry and profits. This means that tackling the intensive margin misallocation through the per-unit transfers does not backfire in terms of extensive margin misallocation.[22] In this specific case, financing non-discriminatory per-unit subsidies to decentralize

[22]This is not what happens in Nocco, Ottaviano and Salto (2019) where, instead, the firm-origin-destination-specific per-unit transfer would lead to too much entry, requiring an optimal lump-sum entry tax that is origin specific to align the market cutoff and entry with their optimal levels. In Case A, from (24), the net subsidy received by a firm producing in h from selling one unit of good in l is given by $\left(c_{ll}^{o}-\tau_{hl}c\right)/2$ for $\delta=-1$, which is half of the level in their firm-origin-destination-specific per-unit subsidy (see footnote 11) and does not generate an excess entry.

the optimal outcome requires lump-sum taxes on consumers that, from (35), evaluate to

$$T_l^{\varepsilon} = \frac{c_{ll}^o \left(\alpha - c_{ll}^o\right)^{-\frac{1}{\delta}}}{\left(k + 1 - \frac{1}{\delta}\right) \eta^{-\frac{1}{\delta}}}.$$

The policy tools used for optimal multilateral policy in Case A are summarized in Table 1. The table shows that Case A is the most straightforward multilateral coordination scheme as it necessitates only three policy tools. Considering that the current global minimum tax rate on corporate profits stands at 15% (i.e. $t^{\pi} = 0.15$), it is crucial to sufficiently reduce the tax rate (to zero) to make the multilateral coordination scheme in Case A feasible. Note that with the global minimum tax rate $t^{\pi} = 0.15$, expression (36) implies that origin-specific lump-sum entry subsidies ($T_h^{\upsilon} = -0.15 f_h$ for $h = 1, \ldots, M$) are additionally required to implement the optimum (when $t^c = 0$).

5.2 Uniform ad Valorem Production Taxes (Case B)

Let us now consider another case in which, instead of ad valorem sales taxes t_l^a, ad valorem production taxes t_l^c are used for multilateral coordination. Thus, in Case B the first degree of freedom is used to set $t^a = 0$, requiring the common global ad valorem production tax rate to be $t^c = -\delta$ by (21). Then, non-discriminatory per-unit subsidies $s_l = -\delta c_{ll}^o$ derived from (22) can be used to correct the intensive margin distortions. The subsidy levels are larger than those in Case A, and analogously larger for disadvantaged countries as they have a higher value of c_{ll}^o.

From (29), to correct the extensive margin distortions with the specific combination of $t^a = 0$, $t^c = -\delta$ and $s_l = -\delta c_{ll}^o$, a lump-sum entry tax and common global corporate tax must satisfy

$$T_l^{\upsilon} = \left(-\delta - t^{\pi} \left(1 - \delta\right)\right) f_l \tag{37}$$

for $l = 1, \ldots, M$. As in Case A, we set $T_l^{\upsilon} = 0$ for any one country l as the second degree of freedom, which requires the common global corporate tax rate to be $t^{\pi} = -\delta/(1-\delta)$, and thereby other countries must set their lump-sum entry tax levels to zero as well. The lump-sum taxes on consumers required to finance subsidies are obtained from (35) and presented in Table 1.

Compared to Case A, the multilateral coordination scheme in Case B requires an extra policy tool to implement the optimum. Intuitively, this is because a higher level of per-unit subsidies than in Case A (necessary to address the intensive margin distortions) leads to an excess entry that must be corrected by implementing an additional policy tool targeting entry and/or profits.[23] The common global corporate tax $t^{\pi} = -\delta/(1-\delta)$ fulfills this role and is thus part of the multilateral coordination scheme in Case B designed to implement the optimal outcome.

Before moving on to Case C, it is worth noting the usefulness of introducing common global wage tax, which we have not considered so far. As labor is the only factor of production in our framework, the ad valorem production tax t^c can be viewed as a wage tax on firms' marginal delivered

[23] In Case B, from (24), the net subsidy received by a firm producing in h from selling one unit of good in l is given by $-\delta\left(c_{ll}^o - \tau_{hl} c\right)$, which is higher than that in Case A, represented by $-\delta\left(c_{ll}^o - \tau_{hl} c\right)/\left(1-\delta\right)$, resulting in too much entry.

cost. Specifically, in the expression for profits (18), $t^c w\tau_{hl} c q_{hl}(c)$ represents taxes levied on wage payments to labor assigned by a firm producing in h to produce for sale in l (where w is wage and the choice of numeraire implies $w = 1$). Following this interpretation, if we set $T_h^v = t^c w f_h$, then, from the free entry condition (25), T_h^v can be viewed as wage taxes paid by each entrant in h for its wage payments to f_h units of labor assigned to development. Hence, with this modification, t^c represents the common global wage tax rate. Substituting $T_l^v = t^c f_l$ into (37) yields $t^c = -\delta - t^\pi (1 - \delta)$, which holds for $t^\pi = 0$ as we set $t^c = -\delta$ in Case B. This implies that the common global wage tax $t^c = -\delta$ and the destination specific per-unit subsidy $s_l = -\delta c_{ll}^o$ can implement the optimum with no need for additional tools targeting entry and profits. Consequently, three policy instruments, including the lump-sum taxes on consumers, are sufficient to achieve a desired multilateral coordination, as in Case A. Meanwhile, the lump-sum taxes on consumers under the optimal policy with the common global wage tax are consistent with Case B reported in Table 1, which are different from those in Case A.[24] As will be shown in the next section, this difference implies the welfare implications of optimal multilateral policies that depend on the coordination scheme adopted.

5.3 General Case Without Lump-Sum Entry Taxes (Case C)

Given that we have shown above (Cases A and B) that lump-sum entry taxes/subsidies T_l^v are not necessary to decentralize the optimal outcome, we analyze in this subsection the general case in which lump-sum entry taxes/subsidies are not available/used. As in the two cases above, we set $T_l^v = 0$ for all countries. Then, another policy tool can be freely set. To see how other policy tools are adequately applied in response to an arbitrary common global corporate tax rate, we express these measures in terms of t^π.

Firstly, with $T_l^v = 0$ for all l, expression (29) implies

$$t^c = \frac{t^\pi}{1 - t^\pi}. \tag{38}$$

Then, substituting this into (21) and (22) respectively yields

$$t^a = -\delta - (1 - \delta)t^\pi \quad \text{and} \quad s_l = \frac{-\delta}{(1 - \delta)(1 - t^\pi)} c_{ll}^o. \tag{39}$$

Expressions (38) and (39) represent the combination of s_l, t^a and t^c to implement the optimum for any given common global corporate tax rate t^π. In other words, the optimal outcome can be decentralized by choosing one of the combinations of s_l, t^a and t^c that correct the intensive margin distortions so that a given common global corporate tax rate just corrects the extensive margin distortions. Specifically, with a higher common global corporate tax rate t^π, the efficient outcome can be achieved by implementing higher common global ad valorem production tax rate t^c, higher levels of destination-specific subsidy s_l, and lower common global ad valorem sales tax rate t^a. Accordingly, the level of lump-sum taxes on consumers also changes. Using (38) and (39), lump-sum taxes on consumers (35)

[24] Even when we set $T_h^v = t^c f_h$, the lump-sum taxes on consumers in l can be expressed as (35). Then, substituting $t^c = -\delta$ into (35) yields the expression for T_l^ε in Case B of Table I. Note that wage taxes are collected in origin (source) countries.

are expressed as

$$T_l^{\varepsilon} = \frac{1}{1-t^{\pi}}\left[\left(t^{\pi}k+1\right)\frac{c_{ll}^{o}\left(\alpha-c_{ll}^{o}\right)^{-\frac{1}{\delta}}}{\left(k+1-\frac{1}{\delta}\right)\eta^{-\frac{1}{\delta}}} - t^{\pi}\left(k+1\right)\frac{N_{E,l}^{o}f_l}{L_l}\right]. \tag{40}$$

Table 1 summarizes three different multilateral coordination schemes for which lump-sum entry taxes are not used. Notice that Case C corresponds to Case A when $t^{\pi} = 0$ and to Case B when $t^{\pi} = -\delta/\left(1-\delta\right)$. The results reported in the table demonstrate that the optimum can be implemented under any common global corporate tax rate by making use of either one or both of the two ad valorem taxes designed to correct the intensive margin distortions. Specifically, if the common global corporate tax rate can be reduced sufficiently (to zero), the ad valorem sales tax t^a becomes effectively used, resulting in the optimal outcome with three policy tools (Case A). Conversely, if the common global corporate tax rate can be increased sufficiently (to $-\delta/\left(1-\delta\right)$), the ad valorem production tax t^c is effectively used, enabling the optimal outcome to be decentralized with four policy tools (Case B). In Case B, the common global corporate tax is integrated into the multilateral coordination scheme to address the extensive margin distortions. In cases where neither scenario applies, i.e., when the corporate tax rate falls within the range between these two extremes, both ad valorem sales and production taxes are used to adjust as if the common global corporate tax were used to eliminate the extensive margin distortions at the specified rate (Case C).[25] In this scenario, five policy tools are used to implement the optimum.

Finally, let us point out that to implement the suggested policies or to simulate them in a quantitative model one would need to have information not only on the parameters that describe the state of development of the technology within each country, its geographical characteristics and market size, but also information on the parameters describing consumers' preferences. The determination of all the first best combinations of policy tools requires the computation of both the optimal cutoff (needed to compute the destination specific production subsidy), and the lump-sum tax on consumers for each country. Hence, the less information demanding (in terms of the parameters of the model that one needs to know) combination of those reported in Table 1 is that defined as Case A. This combination requires destination specific subsidies and lump-sum taxes on consumers, with the addition of the reported other listed taxes. Case A is the less information demanding case because it can be computed making use of the product $f_l\left(c_{M,l}\right)^k$ that defines the state of technology in country l, without needing to disentangle the value of f_l from that of the upper value of the cost parameter $\left(c_{M,l}\right)^k$.[26] Specifically, the value of the product $f_l\left(c_{M,l}\right)^k$ could be retrieved along the lines suggested by Corcos et al. (2011). Moreover, to retrieve the values related to the freeness matrix in our framework, one should consider that they require only data on geographical distance and natural barriers to trade, as international frictions describe the impact of geography and transport technologies and are not due to trade policy barriers.

[25] Note that Case C can be applied at any common global corporate tax rate $t^{\pi} < 1$. From (38) and (39), if $t^{\pi} \in \left(\frac{-\delta}{1-\delta}, 1\right)$, an ad valorem sales subsidy $t^a < 0$, along with an ad valorem production tax $t^c > 0$ and per-unit subsidies $s_l > 0$, is used to implement the optimum. For a common global corporate subsidy $t^{\pi} < 0$, an ad valorem production subsidy $t^c < 0$, together with an ad valorem sales tax $t^a > 0$ and per-unit subsidies $s_l > 0$, is used.

[26] The other combinations in Table I would require to disentangle these values also in order to compute $N_{E,l}^{o}$.

6 Welfare

In pursuing the desirable form of multilateral coordination from the global welfare perspective, various approaches may be considered. Depending on the adopted multilateral coordination scheme, the allocation of tax revenues and subsidy payments to each country will vary, which ultimately influences welfare of each country. While addressing this complex scenario is conceivable through the introduction of international lump-sum transfers, practical challenges may impede their implementation. In the face of such difficulties, it becomes essential to explore desirable multilateral coordination schemes within the constraints of limited policy instruments. With these in mind, we identify how the multilateral coordination schemes adopted have different impacts on welfare of each country.

In order to perform a more general analysis, we notice that, from (21), (22), and (29), indirect utility of country l can be written as

$$U_l = 1 + \overline{q}_{0l}^{\varepsilon} - T_l^{\varepsilon} + \frac{-\delta}{1-\delta} \frac{1}{\eta^{-\frac{1}{\delta}}} \left(\alpha - c_{ll}^o\right)^{-\frac{1}{\delta}} \left(\alpha - \frac{k}{k+1-\frac{1}{\delta}} c_{ll}^o\right), \tag{41}$$

where T_l^{ε} is determined by the budget constraint of a government in country l, that is by

$$L_l T_l^{\varepsilon} = DSS_l - N_{E,l}^o T_l^{\upsilon} - PT_l - ST_l - \Pi T_l. \tag{42}$$

Thus, changes in multilateral coordination schemes would affect the level of lump-sum taxes on consumers necessary for each country to finance subsidies, thereby influencing the welfare level of each country.

Continuing from the previous section, we assume that all countries set common global corporate tax rate t^{π} and that the first best optimum is decentralized with (21), (22) and (29). In addition, the geographical 'ease-of-shipment' M-by-M matrix $P = (\rho_{hl})$ is assumed to satisfy inequality (55) in Appendix C. As shown in the Appendix, this assumption ensures its determinant and corresponding cofactors to be $|P| > 0$, $|C_{hh}| > 0$ and $|C_{lh}| \leq 0$ for $h, l = 1, \ldots, M$ with $h \neq l$. While these signs are guaranteed in a three-country economy ($M = 3$) by simply assuming triangle inequality (56), this is not the case for $M \geq 4$, potentially leading to economically unrealistic scenarios (see Appendix C.1).

6.1 Changes in Common Global Corporate Tax Rate

We first investigate the welfare impact of changes in common global corporate tax rate t^{π} incorporated into non-discriminatory multilateral policies. Assuming $T_l^{\upsilon} = 0$ for $l = 1, \ldots, M$, this corresponds to Case C in Section 5.3. Thus, with a higher common global corporate tax rate t^{π}, the optimal multinational policy can be sustained by adjusting s_l, t^c and t^a according to (38) and (39). Specifically, this involves a corresponding increase in destination-specific subsidies s_l and common global ad valorem production tax rate t^c as well as a corresponding decrease in common global ad valorem sales tax rate t^a. These changes also alter the level of lump-sum taxes on consumers in (40), which affects the welfare level of each country. Substituting (40) into (41) and differentiating it with respect to t^{π}, we obtain

$$\frac{dU_l}{dt^\pi} = \frac{k+1}{(1-t^\pi)^2}\left[-\frac{(\alpha - c_{ll}^o)^{-\frac{1}{\delta}}(c_{ll}^o)^{k+1-\frac{1}{\delta}}}{\left(k+1-\frac{1}{\delta}\right)\eta^{-\frac{1}{\delta}}(c_{ll}^o)^{k-\frac{1}{\delta}}} + \frac{N_{E,l}^o f_l}{L_l}\right] \tag{43}$$

$$= \frac{k+1}{(1-t^\pi)^2}\frac{\gamma^{-\frac{1}{\delta}}\sum_{h\neq l}^{M}\left[-f_h\left(c_{M,h}\right)^k \frac{(\alpha-c_{ll}^o)^{-\frac{1}{\delta}}}{(c_{ll}^o)^{k-\frac{1}{\delta}}}|C_{hl}| + f_l\left(c_{M,l}\right)^k \frac{(\alpha-c_{hh}^o)^{-\frac{1}{\delta}}}{(c_{hh}^o)^{k-\frac{1}{\delta}}}|C_{lh}|\right]}{\eta^{-\frac{1}{\delta}}L_l k B\left(1-\frac{1}{\delta},k\right)|P|}, \tag{44}$$

where (15) and (17) are used at the second line to rewrite $(c_{ll}^o)^{k+1-\frac{1}{\delta}}$ and $N_{E,l}^o$. As shown in Appendix C, our assumption on matrix P ensures $|C_{hl}| \leq 0$ to hold for $h, l = 1, \ldots, M$ with $h \neq l$, implying that the first and second terms in the square brackets in (44) are positive (non-negative) and negative (non-positive), respectively. The welfare effect of an increase in t^π on country l tends to be positive if the country has relatively lower cutoff c_{ll}^o compared to other countries, as it facilitates positive sign in the square brackets. Moreover, the sign in the square brackets is more likely to be positive when $c_{M,l}$ and f_l are small or $c_{M,h}$ and f_h are large, both of which make c_{ll}^o lower and c_{hh}^o higher.[27] Finally, lower (negatively larger) $|C_{hl}|$ or higher (negatively smaller) $|C_{lh}|$ also facilitates making (44) positive. The former implies lower c_{ll}^o and the latter implies higher c_{hh}^o.[28] Hence, the sign of (44) is likely to be positive (negative) if country l is an advantaged (a disadvantaged) country characterized by lower (higher) c_{ll}^o.

This finding highlights that adopting a higher common global corporate tax rate within the multilateral coordination scheme benefits advantaged countries while causing detriment to disadvantaged ones. Given that Case C is equivalent to Case A in Section 5.1 when $t^\pi = 0$, Case A is the multilateral coordination scheme with the least impact of such higher corporate tax rates on welfare. Substituting $t^\pi = 0$ into (40) and using it to rewrite (41), the welfare level of country l in Case A is expressed as

$$U_l = 1 + \overline{q}_{0l}^\varepsilon + \frac{-\delta}{1-\delta}\frac{1}{\eta^{-\frac{1}{\delta}}}(\alpha - c_{ll}^o)^{1-\frac{1}{\delta}}, \tag{45}$$

which is higher than its welfare level at the market equilibrium given by (12). We regard the multilateral coordination scheme in Case A as a benchmark, where the optimal multilateral policy unambiguously raises welfare of all countries. Since the welfare level is higher for advantaged countries in the benchmark case, the introduction and subsequent increase of a common global corporate tax further widens the welfare gap through international transfers from disadvantaged to advantaged countries resulting from changes in multilateral coordination schemes. Consequently, for common global corporate tax rate in the range of $t^\pi \in [0, -\delta/(1-\delta)]$, the welfare gap is smallest for Case A ($t^\pi = 0$), largest for Case B ($t^\pi = -\delta/(1-\delta)$), and Case C ($0 < t^\pi < -\delta/(1-\delta)$) falls between them.[29] Fur-

[27] From the expression for c_{ll}^o in (15), it is clear that c_{ll}^o is lower for smaller $f_l\left(c_{M,l}\right)^k$ (since $|C_{ll}| > 0$) or for larger $f_h\left(c_{M,h}\right)^k$ (since $|C_{hl}| \leq 0$). Analogously, c_{hh}^o, derived by interchanging notations l and h in (15), is higher for smaller $f_l\left(c_{M,l}\right)^k$ (since $|C_{lh}| \leq 0$) or for larger $f_h\left(c_{M,h}\right)^k$ (since $|C_{hh}| > 0$).

[28] Expressions for c_{ll}^o in (15) and for c_{hh}^o derived from (15) reveal that lower $|C_{hl}| \leq 0$ reduces c_{ll}^o and has no effect on c_{hh}^o, while higher $|C_{lh}| \leq 0$ raises c_{hh}^o and has no effect on c_{ll}^o.

[29] As noted in footnote 25, the optimal outcome can be decentralized with any common global corporate tax rate $t^\pi < 1$. When $t^\pi > -\delta/(1-\delta)$, the welfare gap is more severe than in Case B. Conversely, when $t^\pi < 0$ (i.e. common global corporate subsidy), this multilateral coordination scheme generates transfers from advantaged to disadvantaged countries relative to the benchmark case.

thermore, as mentioned in Section 5.2, a multilateral coordination scheme involving common global wage tax requires lump-sum taxes on consumers for each country at the same level as in Case B, meaning that the welfare level of each country is also consistent with Case B. Therefore, while this scheme can easily implement the optimum with three policy instruments (i.e. common global wage tax, destination specific subsidy and lump-sum tax on consumer) as in Case A, the welfare outcomes are contrary to those observed in Case A in terms of welfare disparities.

The variation in these welfare outcomes based on the adopted scheme is associated with whether the respective taxes/subsidies incorporated into the multilateral coordination scheme are collected/provided by origin or destination country. In the benchmark case, taxes/subsidies are collected/provided by destination countries (i.e. in Case A, both common global ad valorem sales tax and destination specific subsidy are collected or provided by destination countries). The additional incorporation of common global corporate tax, which is collected in the origin country, into the scheme generates international transfers from disadvantaged to advantaged countries relative to the benchmark outcome.[30] Similarly, a scheme using common global wage tax collected in the origin country instead of common global sales tax used in Case A also generates international transfers towards advantaged countries relative to the benchmark outcome.

6.2 Lump-sum Entry Subsidy

In the remainder of this paper, we explore ways to reduce the international tax revenue transfers generated by incorporating a positive common global corporate tax rate into the scheme. First of all, if lump-sum entry subsidies ($T_l^v < 0$) are available, they can be used to fully offset those transfers. As shown in Appendix D, for given positive common global corporate tax rate t^π, the introduction or increase of entry subsidies within multilateral coordination schemes generates international transfers from advantaged to disadvantaged countries, where advantaged (disadvantaged) countries are those with a positive (negative) sign in (44). Making use of this characteristic, if lump-sum entry subsidies are set to $T_l^v = -t^\pi f_l < 0$, expression (29) implies $t^c = 0$ for correcting the extensive margin distortions. Then, from (21) and (22), $t^a = -\delta$ and $s_l = -\delta c_{ll}^o / (1 - \delta)$ are required to address the intensive margin distortions. In this multilateral coordination scheme, the lump-sum taxes on consumers in (35) becomes the same level as those in the benchmark case (Case A), implying that the welfare outcome is also consistent with that in the benchmark.

Therefore, implementing lump-sum entry subsidies can be used to fully offset international transfers generated by a positive common global corporate tax rate. In contrast to the case of taxation, incorporating subsidies provided by the origin country into multilateral coordination schemes results in international transfers from advantaged to disadvantaged countries.

[30]As explained below, this transfer is also triggered by the introduction or increase of a common global ad valorem production tax collected in the origin country, where its introduction or increase is required to maintain the optimal multilateral policies in response to the introduction or increase of a common global corporate tax.

6.3 Corporate Tax Collection Country

Next, let us consider an alternative scenario where corporate profit taxes are collected in the destination country. This scenario could apply, for example, when a firm sets export prices to transfer the profits resulting from sales in a foreign country to its affiliates located in that country. To distinguish the two scenarios for corporate profit tax collection countries, we refine our notation and redetermine total corporate profit taxes collected in the origin (source) country l in expression (34) as ΠTO_l, and define total corporate profit taxes collected in the destination country l as ΠTD_l, which is given by[31]

$$\Pi TD_l = t^\pi (1 + t^c) \frac{L_l c_{ll}^o (\alpha - c_{ll}^o)^{-\frac{1}{\delta}}}{\left(k + 1 - \frac{1}{\delta}\right) \eta^{-\frac{1}{\delta}}}.$$

Using this expression, together with (29), (30), (32) and (33), the budget constraint for country l in (42) yields

$$T_l^\varepsilon = [1 + t^c (k+1) - t^\pi (1 + t^c)] \frac{c_{ll}^o (\alpha - c_{ll}^o)^{-\frac{1}{\delta}}}{\left(k + 1 - \frac{1}{\delta}\right) \eta^{-\frac{1}{\delta}}} - [t^c(k+1) - t^\pi(1+t^c)] \frac{f_l N_{E,l}^o}{L_l}. \tag{46}$$

Thus, (35) and (46) represent the general expressions for lump-sum taxes on consumers when corporate profit taxes are collected in the origin and destination countries, respectively. From these two expressions and (41), the welfare changes resulting from switching corporate profit tax collecting countries are expressed as

$$U_l|_{\Pi T_l = \Pi TD_l} - U_l|_{\Pi T_l = \Pi TO_l} = -t^\pi (1 + t^c) \left[-\frac{c_{ll}^o (\alpha - c_{ll}^o)^{-\frac{1}{\delta}}}{\left(k + 1 - \frac{1}{\delta}\right) \eta^{-\frac{1}{\delta}}} + \frac{f_l N_{E,l}^o}{L_l} \right],$$

which is positive (negative) for disadvantaged (advantaged) countries as the terms in the square brackets correspond to those in (43). Therefore, switching the collection of corporate profit taxes from origin to destination countries is an effective way to limit international transfers resulting from a positive common global corporate tax rate within multilateral coordination schemes.

In the specific case where lump-sum entry taxes are not available/used ($T_l^v = 0$), adopting a higher t^π within this multilateral coordination scheme leads to an increase (a decrease) in the welfare level of advantaged (disadvantaged) countries which have positive (negative) sign in (44) (see Appendix D). Since the scheme with $t^\pi = 0$ and $T_l^v = 0$ is exactly the benchmark case (Case A), this result implies that even if the scheme is changed so that corporate taxes are collected in the destination country, international transfers towards advantaged countries would still persist (for a positive common global corporate tax rate) relative to the benchmark. This result is due to the fact that multilateral coordination schemes with a common global corporate tax require the use of a common global ad valorem production tax: expression (29) implies that t^c must be positive to

[31] Total profit taxes on all firms selling in l from all countries $h = 1, \ldots, M$ are given by

$$\Pi TD_l = \sum_{h=1}^{M} \left(\frac{t^\pi}{1 - t^\pi} N_{hl}^o \int_0^{c_{hl}^o} \pi_{hl}^d(c) \frac{dG_h(c)}{G_h(c_{hl}^o)} \right).$$

By (2), (16), (21), (26), $c_{hl}^o = c_{ll}^o / \tau_{hl}$ and $N_l^o = \sum_{h=1}^{M} N_{hl}^o$, ΠTD_l can be written as in the text.

correct the extensive margin distortions for $t^{\pi} > 0$ and $T_l^{v} = 0$. A higher common global corporate tax rate requires a corresponding higher common global ad valorem production tax rate, and this production tax is collected in the origin country. Consequently, a higher common global corporate tax rate within the multilateral coordination scheme results in more international transfers towards advantaged countries relative to the benchmark outcome.[32]

6.4 From Import to Export Subsidies

Finally, we consider a scenario where subsidies are provided by the origin country. So far, destination specific subsidy s_l has been regarded as an import ('consumption') subsidy, but here, we consider it as an export ('production') subsidy and compare the two cases. Similarly to the previous subsection, we refine our notation and redetermine total import subsidies provided by the destination country l in (30) as $DSSD_l$ and define total export subsidies provided by the origin country l as $DSSO_l$, which is given by[33]

$$DSSO_l = (1 + t^c) \frac{-\delta \left(k + 1 - \frac{1}{\delta}\right)}{1 - \delta} f_l N_{E,l}^o.$$

Using this expression, together with (29), (32), (33) and (34), into (42), the general expression for lump-sum taxes on consumers when export subsidies are applied is

$$T_l^{\varepsilon} = -\frac{-\delta - t^c}{1 - \delta} k \frac{c_{ll}^o \left(\alpha - c_{ll}^o\right)^{-\frac{1}{\delta}}}{\left(k + 1 - \frac{1}{\delta}\right) \eta^{-\frac{1}{\delta}}} - \left[t^c (k+1) - (1 + t^c) \frac{-\delta \left(k + 1 - \frac{1}{\delta}\right)}{1 - \delta}\right] \frac{f_l N_{E,l}^o}{L_l}, \tag{47}$$

Substituting (35) and (47) into (41) and comparing the results, the welfare changes resulting from switching from import to export subsidies are expressed as

$$U_l|_{DSS_l = DSSO_l} - U_l|_{DSS_l = DSSD_l} = -(1 + t^c) \frac{-\delta \left(k + 1 - \frac{1}{\delta}\right)}{1 - \delta} \left[-\frac{c_{ll}^o \left(\alpha - c_{ll}^o\right)^{-\frac{1}{\delta}}}{\left(k + 1 - \frac{1}{\delta}\right) \eta^{-\frac{1}{\delta}}} + \frac{f_l N_{E,l}^o}{L_l}\right].$$

This expression is positive (negative) for disadvantaged (advantaged) countries as the terms in the square brackets correspond to those in (43). Hence, switching from import to export subsidies is also an effective way to cease international transfers towards advantaged countries resulting from a positive common global corporate tax rate within multilateral coordination schemes.

As shown in Appendix D, when lump-sum entry taxes are not available/used, adopting a higher t^{π} within this multilateral coordination scheme leads to international transfers towards advantaged countries, and the welfare level of each country corresponds to that in the benchmark outcome for $t^{\pi} = \frac{-\delta\left(k+1-\frac{1}{\delta}\right)}{(1-\delta)(k+1)} > \frac{-\delta}{1-\delta}$. Hence, when the global corporate tax rate is not sufficiently high, switching

[32] If ad valorem production taxes are also collected in the destination country and $T_l^{v} = 0$, then the welfare level of each country is consistent with the benchmark outcome in (45) for any common global corporate tax rate.

[33] Total expenditure on destination specific subsidies for firms producing in country l is given by

$$DSSO_l = \sum_{h=1}^{M} \left(s_h N_{lh}^o \int_0^{c_{lh}^o} q_{lh}^o (c) \frac{dG_l(c)}{G_l(c_{lh}^o)} \right).$$

Using (2), (13), (14), (22), $c_{lh}^o = c_{hh}^o / \tau_{lh}$ and $N_{lh}^o = N_{E,l}^o G_l(c_{lh}^o)$, the expression for $DSSO_l$ can be written as in the text.

from import to export subsidies leads to international transfers from advantaged to disadvantaged countries relative to the benchmark outcome.

7 Conclusion

Due to markup distortions, in international trade models with monopolistic competition and heterogeneous firms the market equilibrium is inefficient unless demand exhibits constant elasticity of substitution. When it does not, global welfare maximization generally requires policy intervention that is firm specific, and consequently of limited practical relevance due to its information requirements, discriminatory nature and susceptibility to rent seeking. We have assessed whether there are particular conditions under which countries can coordinate on the common use of policy tools that are not firm-specific but still maximize global welfare. We have shown that a demand system implying constant absolute pass-through from marginal cost to price is both necessary and sufficient for the existence of welfare-maximizing non-discriminatory policies that level the global playing field with an appropriate one-size-fits-all approach for all firms selling in a given market, eventually complemented by a global tax rate on corporate profits.

The optimal set of nondiscrimatory policies involves a common global sales tax and destination specific per-unit production subsidies, or alternatively, a common global production tax and destination specific per-unit production subsidies complemented by an appropriate combination of additional tools targeting entry or profits (i.e. a global common corporate tax rate on profits associated with an origin-specific entry subsidy/tax). Coordination on a common global tax rate on corporate profits might contribute to correct inefficiencies due to firms' market power if combined with other suitable policy tools. Being non-discriminatory, it may also make multilateral coordination easier. To this end can also contribute the fact that the sets of non-discriminatory policy tools we have identified are in line with the Most Favoured Nation clause (Art. 1 GATT-WTO), which does not require reciprocity, as it states that all members should be guaranteed the same treatment by each country member.

With respect to laissez-faire, optimal multilateral policy is not necessarily Pareto improving as it may, for instance, make advantaged countries better off and disadvantaged countries worse off, implying that adopting an appropriate multilateral coordination scheme is needed. Disadvantaged countries benefit more from adopting multilateral coordination schemes that involve: a lower common global corporate tax rate; a common global corporate tax collected in destination countries rather than in origin countries; and export subsidies rather than import subsidies.

References

[1] Bagwell, K., and S.H. Lee (2018). Trade policy under monopolistic competition with heterogeneous firms and quasi-linear CES preferences, mimeo.

[2] Bagwell, K., and S.H. Lee (2020). Trade policy under monopolistic competition with firm selection, *Journal of International Economics* 127, 103379.

[3] Bagwell, K., and R.W. Staiger (2012). The economics of trade agreements in the linear Cournot delocation model. *Journal of International Economics* 88, 32–46.

[4] Campolmi, A., H. Fadinger, and C. Forlati (2014). Trade policy: home market effect versus terms-of-trade externality. *Journal of International Economics* 93, 92–107.

[5] Campolmi, A., H. Fadinger, and C. Forlati (2021). Trade and domestic policies under monopolistic competition. CEPR Discussion Paper N. 13219.

[6] Corcos, G., M. Del Gatto, G. Mion, and G., Ottaviano (2011). Productivity and firm selection: quantifying the 'new' gains from trade. *Economic Journal* 122, 754–798.

[7] Hebous, S., and M. Keen (2022). Pareto-improving minimum corporate taxation. CESifo Working Paper n. 9633.

[8] Janeba, E., and G. Schjelderup (2022). The global minimum tax raises more revenues than you think, or much less. CESifo Working Paper n. 10318.

[9] Johannesen, N. (2022). The global minimum tax. *Journal of Public Economics* 212.

[10] Johnson, C. R. and R. L. Smith (1999). Path product matrices, *Linear and Multilinear Algebra* 46 (3). 177–191.

[11] Krugman, P. (1980). Scale economies, product differentiation, and the pattern of trade. *American Economic Review* 70 (5), 950–959.

[12] Melitz M.J. (2003). Market size, trade, and productivity, *Econometrica* 71, 1695–1725.

[13] Melitz M.J. and G.I.P. Ottaviano (2008). Market size, trade, and productivity, *Review of Economic Studies* 75, 295–316.

[14] Melitz M.J., G.I.P. Ottaviano, M. Oshmakashvili and D. Suverato (2024). Markup distortions and optimal non-discriminatory industrial policy, mimeo.

[15] Nocco, A., G.I.P. Ottaviano and M. Salto (2014). Monopolistic competition and optimum product selection, *American Economic Review* 104, 304–309.

[16] Nocco, A., G.I.P. Ottaviano and M. Salto (2019). Geography, Competition, and Optimal Multilateral Trade Policy, *Journal of International Economics* 120, 145–161.

[17] Ossa, R. (2011). A "new trade" theory of GATT/WTO negotiations, *Journal of Political Economy* 119, 122–152.

[18] Tadokoro, A. (2024). Optimal policy against distortions caused by monopolistic competition and variable markup pricing, *Economics Letters*, forthcoming.

[19] Venables. A. (1985). Trade and trade policy with imperfect competition: the case of identical products and free entry. *Journal of International Economics* 19, 1–19.

[20] Venables. A. (1987). Trade and trade policy with differentiated products: a Chamberlinian-Ricardian model. *Economic Journal* 97, 700–717.

[21] Zhu, Y., C.Y. Zhang and J. Liu (2011). Path product and inverse M-matrices. *Electronic Journal of Linear Algebra* 22, 644–652.

Appendix

A Equilibrium domestic cutoff and number of sellers

Making use of (2), (4), (5) and (7), expression (8) can be written as

$$\frac{-\delta}{1-\delta}\frac{1}{\gamma^{-\frac{1}{\delta}}(1-\delta)^{-\frac{1}{\delta}}}\frac{k}{(c_{M,h})^k}\sum_{l=1}^{M}\left[L_l\int_0^{c_{ll}^m/\tau_{hl}}(c_{ll}^m-\tau_{hl}c)^{1-\frac{1}{\delta}}c^{k-1}dc\right]=f_h.$$

To solve the integral, we change the integrating variable as $t=\tau_{hl}c/c_{ll}^m$. Then, the above expression can be rewritten as

$$\frac{-\delta}{1-\delta}\frac{1}{\gamma^{-\frac{1}{\delta}}(1-\delta)^{-\frac{1}{\delta}}}\frac{k}{(c_{M,h})^k}\left(\int_0^1(1-t)^{1-\frac{1}{\delta}}t^{k-1}dt\right)\sum_{l=1}^{M}\left[L_l(\tau_{hl})^{-k}(c_{ll}^m)^{k+1-\frac{1}{\delta}}\right]=f_h,$$

which includes an integral with known solution

$$\int_0^1(1-t)^{1-\frac{1}{\delta}}t^{k-1}dt=\frac{\Gamma\left(2-\frac{1}{\delta}\right)\Gamma(k)}{\Gamma\left(2-\frac{1}{\delta}+k\right)}=B\left(2-\frac{1}{\delta},k\right),$$

where $\Gamma(.)$ and $B(.,.)$ are the Gamma and Beta functions respectively. Thus, the free entry condition for country h can be expressed as

$$\sum_{l=1}^{M}\left[(\tau_{hl})^{-k}L_l(c_{ll}^m)^{k+1-\frac{1}{\delta}}\right]=(1-\delta)^{-\frac{1}{\delta}}\frac{\frac{1-\delta}{-\delta}\gamma^{-\frac{1}{\delta}}(c_{M,h})^k f_h}{kB\left(2-\frac{1}{\delta},k\right)},$$

which holds for $h=1,\ldots,M$, yielding a system of M equations that can be solved using Cramer's rule to find the M equilibrium cutoffs given by (9).

Once determined all the cutoffs c_{ll}^m, the number of sellers, N_l^m, can be derived. Using (2), (4) and (5) into the definition of Q_l^m, we get

$$\begin{aligned}
Q_l^m &= \sum_{h=1}^{M} N_{hl}^m \int_0^{c_{hl}^m} q_{hl}^m(c) \frac{dG_h(c)}{G_h(c_{hl}^m)} \\
&= \frac{L_l}{\gamma^{-\frac{1}{\delta}} (1-\delta)^{-\frac{1}{\delta}}} \sum_{h=1}^{M} N_{hl}^m \frac{1}{G_h(c_{hl}^m)} \frac{k}{(c_{M,h})^k} \int_0^{c_{hl}^m} (c_{ll}^m - \tau_{hl} c)^{-\frac{1}{\delta}} c^{k-1} dc \\
&= \frac{L_l}{\gamma^{-\frac{1}{\delta}} (1-\delta)^{-\frac{1}{\delta}}} k (c_{ll}^m)^{-k} \sum_{h=1}^{M} N_{hl}^m (\tau_{hl})^k \int_0^{c_{ll}^m/\tau_{hl}} (c_{ll}^m - \tau_{hl} c)^{-\frac{1}{\delta}} c^{k-1} dc.
\end{aligned}$$

Then, we change the integrating variable as $t = \tau_{hl} c / c_{ll}^m$ to obtain

$$Q_l^m = \frac{L_l k (c_{ll}^m)^{-\frac{1}{\delta}} B\left(1 - \frac{1}{\delta}, k\right)}{\gamma^{-\frac{1}{\delta}} (1-\delta)^{-\frac{1}{\delta}}} N_l^m,$$

where $N_l^m = \sum_{h=1}^M N_{hl}^m$ and $B\left(1 - \frac{1}{\delta}, k\right) = \int_0^1 (1-t)^{-\frac{1}{\delta}} t^{k-1} dt$. Making use of this expression and $c_{ll}^m = p_l^{\max}$ into the definition of the choke price, $p_l^{\max} = \alpha - \eta \left(Q_l^m / L_l\right)^{-\delta}$, we can derive the number of sellers N_l^m given by (10).

B Destination Specific Subsidies

The inverse demand in (3) can be rewritten as[34]

$$p_{hl}(c) = p_l^{\max} - \gamma \left(\frac{q_{hl}(c)}{L_l}\right)^{-\delta},$$

and this expression can be used to rewrite profits obtained from sales in l of a good produced in h with unit labor requirement c in (18) as follows

$$\pi_{hl}(c) = (1 - t_h^{\pi}) \left[\frac{p_l^{\max}}{1 + t_l^a} - \frac{1}{1 + t_l^a} \frac{\gamma}{L_l^{-\delta}} (q_{hl}(c))^{-\delta} + s_{hl}(c) - (1 + t_h^c) \tau_{hl} c\right] q_{hl}(c).$$

The first order condition for profit maximization with respect to $q_{hl}(c)$ gives

$$q_{hl}(c) = L_l \left[\frac{1 + t_l^a}{(1-\delta)\gamma}\right]^{-\frac{1}{\delta}} \left[\frac{p_l^{\max}}{1 + t_l^a} + s_{hl}(c) - (1 + t_h^c) \tau_{hl} c\right]^{-\frac{1}{\delta}} \tag{48}$$

showing that, given $p_l^{\max}$, the policy tools t_l^a, $s_{hl}(c)$ and t_h^c can be used to increase or decrease firm sales in l.

[34] Denoting $N_{E,h}$ the mass of entrants in country h, the total quantity of modern good sold in country l is

$$Q_l \equiv \sum_{h=1}^{M} \left(N_{E,h} \int_0^{c_{hl}} q_{hl}(c) dG_h(c)\right).$$

Then, since $Q_l = L_l Q_l^{\varepsilon}$, (3) implies that the cutoff price is such that $p_l^{\max} = \alpha - \eta \left(\frac{Q_l}{L_l}\right)^{-\delta}$.

Denoting with c_{hl}^d the highest cost parameter in the case of the decentralized outcome, the choke price is such that $q_{hl}(c)$ in (48) is non-negative, with the maximum price that can be set in country l given by

$$p_l^{\max} = (1+t_l^a)\left[(1+t_h^c)\,\tau_{hl}c_{hl}^d - s_{hl}(c_{hl}^d)\right]. \tag{49}$$

For a given set of policy tools, expression (49) can be used to rewrite the profit maximizing quantity in (48) as

$$q_{hl}(c) = L_l\left[\frac{1+t_l^a}{(1-\delta)\,\gamma}\right]^{-\frac{1}{\delta}}\left\{\left[(1+t_h^c)\,\tau_{hl}c_{hl}^d - s_{hl}(c_{hl}^d)\right] - \left[(1+t_h^c)\,\tau_{hl}c - s_{hl}(c)\right]\right\}^{-\frac{1}{\delta}}$$

with the corresponding price evaluating to

$$p_{hl}^d(c) = \frac{1+t_l^a}{1-\delta}\left\{-\delta\left[(1+t_h^c)\,\tau_{hl}c_{hl}^d - s_{hl}(c_{hl}^d)\right] + \left[(1+t_h^c)\,\tau_{hl}c - s_{hl}(c)\right]\right\}. \tag{50}$$

Making use of these results, profits from sales in l of a firm producing in h can be rewritten as

$$\pi_{hl}(c) = L_l\,(1-t_h^\pi)\,\frac{-\delta}{1-\delta}\left[\frac{1+t_l^a}{(1-\delta)\,\gamma}\right]^{-\frac{1}{\delta}}\left\{\left[(1+t_h^c)\,\tau_{hl}c_{hl}^d - s_{hl}(c_{hl}^d)\right] - \left[(1+t_h^c)\,\tau_{hl}c - s_{hl}(c)\right]\right\}^{1-\frac{1}{\delta}}. \tag{51}$$

Per-unit transfers $s_{hl}(c)$ are needed to decentralize the optimum outcome and they are used in order to align the market price in (50) with the marginal delivered cost by eliminating the markup, that is $p_{hl}^d(c) = \tau_{hl}c$, which requires setting

$$s_{hl}(c) = \delta s_{hl}(c_{hl}^d) + (1+t_h^c)\,\tau_{hl}\left[-\delta c_{hl}^d + \frac{t_h^c + \delta + t_l^a\,(1+t_h^c)}{(1+t_h^c)\,(1+t_l^a)}c\right]. \tag{52}$$

From (52), the per-unit subsidy for marginal firms producing in h and selling in l (with $c = c_{hl}^d$) is

$$s_{hl}(c_{hl}^d) = \frac{t_h^c + t_l^a\,(1+t_h^c)}{(1+t_l^a)}c_{hl}^d\tau_{hl},$$

and it can be used, to rewrite the expression (52) for the per-unit as follows

$$s_{hl}(c) = \frac{-\delta\tau_{hl}c_{hl}^d + \left[t_h^c + \delta + t_l^a\,(1+t_h^c)\right]\tau_{hl}c}{1+t_l^a}. \tag{53}$$

Expression (53) shows that the optimal per-unit transfer is firm specific, unless

$$t_h^c + \delta + t_l^a\,(1+t_h^c) = 0$$

$$\Leftrightarrow t_l^a = \frac{-\delta - t_h^c}{1+t_h^c} \Leftrightarrow 1 + t_l^a = \frac{1-\delta}{1+t_h^c}$$

that corresponds to expression (20) in the paper. This expression gives the combinations of ad valorem sales tax rates t_l^a and ad valorem tax rate on production t_h^c that yield optimal subsidies that are not firm specific, and it implies the common per-unit subsidy in (19) that should be given to firm selling in country l in order to decentralize the first best outcome when $c_{hl}^d = c_{hl}^o$ is

$$s_{hl}^d = \frac{-\delta}{1+t_l^a}\tau_{hl}c_{hl}^d.$$

Substituting this subsidy into (49) yields

$$p_l^{\max} = \tau_{hl}c_{hl}^d = c_{ll}^d,$$

and, therefore, the per-unit subsidy common to all firms selling in l can be rewritten as:

$$s_l = s_{hl}^d = \frac{-\delta}{1+t_l^a}c_{ll}^d = \frac{-\delta}{\frac{1-\delta}{1+t_h^c}}c_{ll}^d = \frac{-\delta}{1-\delta}\left(1+t_h^c\right)c_{ll}^d$$

where the last expression is obtained making use of

$$t_l^a = \frac{-\delta - t_h^c}{1+t_h^c}$$

from (20).

C Geographical Matrix P

Here, we provide a sufficient condition for the geographical 'ease-of-shipment' M-by-M matrix $P = (\rho_{hl})$ to satisfy

$$|P| > 0, \quad |C_{ll}| > 0, \quad |C_{lh}| \leq 0 \tag{54}$$

for $h, l = 1, 2, \ldots, M$ and $h \neq l$. For $M = 3$, the triangle inequality ensures (54) to hold, but it does not for $M \geq 4$.

Let $P[a_h; a_l]$ denote the submatrix of P lying in rows a_h and columns a_l, where a_h and a_l are subsets of $\{1, 2, \ldots, M\}$. For example, if $a_h = \{1, 3\}$ and $a_l = \{2, 3, 5\}$ for $M \geq 5$, then $P[a_h; a_l]$ is given by

$$P[a_h; a_l] = P[\{1,3\}; \{2,3,5\}] = \begin{pmatrix} \rho_{12} & \rho_{13} & \rho_{15} \\ \rho_{32} & \rho_{33} & \rho_{35} \end{pmatrix}.$$

If $a_h = a_l$, then we denote the principal submatrix $P[a_h; a_h]$ by $P[a_h]$. Then, as will be shown below, matrix P satisfies (54) if, for all $a_n \subseteq \{1, 2, \ldots, M\} \setminus \{h, l\}$ and $h, l \in \{1, 2, \ldots, M\}$, we have

$$P[\{h\}; a_n] \left(P[a_n]\right)^{-1} P[a_n; \{l\}] \leq \rho_{hl} \tag{55}$$

with strict inequalities for $h = l$.[35] Note that inequalities (55) correspond to the triangle inequality when a_n is singleton: when $a_n = \{n\}$ with $n \in \{1, 2, \ldots, M\} \setminus \{h, l\}$, we have

$$\rho_{hn} \left(\rho_{nn}\right)^{-1} \rho_{nl} = \rho_{hn}\rho_{nl} \leq \rho_{hl} \tag{56}$$

[35] Matrices satisfying this inequality are a special case of the strict block path product (SBPP) matrices proposed by Johnson and Smith (1999).

with strict inequalities when $h = l$. Thus, inequalities (55) include the triangle inequality (56). Although the class of matrices satisfying (55) coincides with the class of matrices satisfying (56) for $M \leq 3$, these classes are different for $M \geq 4$.

To confirm that the inequality (55) ensures $|P| > 0$ and $|C_{ll}| > 0$ to hold, we first show that inequalities (55) for $h = l$ are necessary and sufficient conditions for all principal submatrices of P, including matrix P itself, to have positive determinants by induction on k. Consider a principal submatrix of P of order k ($\leq M$), a k-by-k matrix formed by selecting the same set of k rows and columns from P. Let ω_i denote the i-th row and column of the selected k rows and columns such that $\omega_1 < \omega_2 < \ldots < \omega_k$. For example, if a submatrix of P of order $k = 3$ is formed by selecting the second, fourth, and fifth rows and columns of matrix P, then $\omega_1 = 2$, $\omega_2 = 4$, and $\omega_3 = 5$. Defining subset a_k of $\{1, 2, \ldots, M\}$ as $a_k = \{\omega_1, \omega_2, \ldots, \omega_k\}$, we can express a principal submatrix of P of order k as

$$P[a_k] = \begin{pmatrix} \rho_{\omega_1\omega_1} & \rho_{\omega_1\omega_2} & \cdots & \rho_{\omega_1\omega_k} \\ \rho_{\omega_2\omega_1} & \rho_{\omega_2\omega_2} & \cdots & \rho_{\omega_2\omega_k} \\ \vdots & \vdots & \ddots & \vdots \\ \rho_{\omega_k\omega_1} & \rho_{\omega_k\omega_2} & \cdots & \rho_{\omega_k\omega_k} \end{pmatrix},$$

where $P[a_k] = P[a_k; a_k]$. Let $a_{k-1,i}$ denote the subset of a_k with $k-1$ elements such that $a_{k-1,i} = a_k \setminus \{\omega_i\}$ with $i = 1, 2, \ldots, k$. Then, a principal submatrix of P of order $k-1$ formed by deleting the i-th row and column from $P[a_k]$ can be expressed as

$$P[a_{k-1,i}] = \begin{pmatrix} \rho_{\omega_1\omega_1} & \cdots & \rho_{\omega_1\omega_{i-1}} & \rho_{\omega_1\omega_{i+1}} & \cdots & \rho_{\omega_1\omega_k} \\ \vdots & & \vdots & \vdots & & \vdots \\ \rho_{\omega_{i-1}\omega_1} & \cdots & \rho_{\omega_{i-1}\omega_{i-1}} & \rho_{\omega_{i-1}\omega_{i+1}} & \cdots & \rho_{\omega_{i-1}\omega_k} \\ \rho_{\omega_{i+1}\omega_1} & \cdots & \rho_{\omega_{i+1}\omega_{i-1}} & \rho_{\omega_{i+1}\omega_{i+1}} & \cdots & \rho_{\omega_{i+1}\omega_k} \\ \vdots & & \vdots & \vdots & & \vdots \\ \rho_{\omega_k\omega_1} & \cdots & \rho_{\omega_k\omega_{i-1}} & \rho_{\omega_k\omega_{i+1}} & \cdots & \rho_{\omega_k\omega_k} \end{pmatrix},$$

where $P[a_{k-1,i}] = P[a_{k-1,i}; a_{k-1,i}]$. Using this expression, the principal minor of P of order k can be expressed in the form of the determinant of a partitioned matrix as follows

$$|P[a_k]| = (-1)^{2(i-1)} \begin{vmatrix} \rho_{\omega_i\omega_i} & P[\{\omega_i\}; a_{k-1,i}] \\ P[a_{k-1,i}; \{\omega_i\}] & P[a_{k-1,i}] \end{vmatrix},$$

where we interchange row and column ω_i of matrix $P[a_k]$ with the previous row and column $i-1$ times, respectively. Then, using Schur's formula, the principal minor of P of order k can be expressed as

$$|P[a_k]| = \left\{\rho_{\omega_i\omega_i} - P[\{\omega_i\}; a_{k-1,i}]\,(P[a_{k-1,i}])^{-1}\,P[a_{k-1,i}; \{\omega_i\}]\right\}|P[a_{k-1,i}]| \tag{57}$$

for all a_k and $i = 1, 2, \ldots, k$. Expression (57) represents the relationship between any principal minor of order k and a principal minor of order $k-1$ formed by deleting any i-th row and column from it. Suppose that all principal minors of P of order $k-1$ are positive: $|P[a_{k-1,i}]| > 0$ for all a_k and $i = 1, 2, \ldots, k$, i.e. for all $a_{k-1,i}$ (all subsets consisting of $k-1$ elements from $\{1, 2, \ldots, M\}$). Then, all principal minors of P of order k are positive (i.e., $|P[a_k]| > 0$ holds for all a_k) if and only if the term in the curly brackets in (57) is positive for all $a_{k-1,i}$ and $\omega_i \in \{1, 2, \ldots, M\} \setminus a_{k-1,i}$. We rewrite this necessary and sufficient condition for all principal minors of P of order k to be positive under those of order $k-1$ being positive as

$$\rho_{hh} - P[\{h\}; a_n(k-1)] \left(P[a_n(k-1)]\right)^{-1} P[a_n(k-1); \{h\}] > 0 \tag{58}$$

for all $a_n(k-1)$ and $h \in \{1, 2, \ldots, M\} \setminus a_n(k-1)$, where $a_n(k)$ denote a set $a_n \subseteq \{1, 2, \ldots, M\}$ consisting of k elements. Since all principal minors of order 1 are positive at 1, all principal minors of order 2 are positive if and only if (58) holds for $k = 2$ (which is equivalent to the triangle inequality (56) for $h = l$). Then, all principal minors of orders 2 and 3 are positive if and only if (58) holds for $k = 2, 3$. Proceeding in this way, we can check that all principal minors of P, including the determinant of matrix P itself, are positive if and only if (58) holds for $k = 2, 3, \ldots, M$, and this condition is equivalent to inequalities (55) for $h = l$. Therefore, inequalities (55) for $h = l$ are necessary and sufficient conditions for all principal minors of P to be positive. This implies that if P satisfies (55) for $h = l$, then we have $|P| > 0$ and $|C_{ll}| = (-1)^{l+l} |P(\{l\}; \{l\})| > 0$ for $l = 1, \ldots, M$, where $P(a_h; a_l)$ represents the submatrix obtained from P by deleting rows a_h and columns a_l, and thus $|P(\{l\}; \{l\})|$ is a principal minor of order $M-1$.

Next, we show that inequalities (55) ensure $|C_{lh}| \leq 0$ to hold for $h \neq l$ following Theorem 3.12 in Johnson and Smith (1999). Assume $h < l$ without loss of generality and define subset of $\{1, 2, \ldots, M\}$ with $M-2$ elements as $a_n(M-2) = \{1, 2, \ldots, M\} \setminus \{h, l\}$. Then, a (l, h) cofactor of matrix P, $|C_{lh}|$, can be expressed as

$$\begin{aligned}
|C_{lh}| &= (-1)^{l+h} |P(\{l\}; \{h\})| \\
&= (-1)^{l+h}(-1)^{h-1}(-1)^{l-2} \begin{vmatrix} \rho_{hl} & P[\{h\}; a_n(M-2)] \\ P[a_n(M-2); \{l\}] & P(\{h, l\}; \{h, l\}) \end{vmatrix} \\
&= - \begin{vmatrix} \rho_{hl} & P[\{h\}; a_n(M-2)] \\ P[a_n(M-2); \{l\}] & P[a_n(M-2)] \end{vmatrix} \\
&= - \left\{ \rho_{hl} - P[\{h\}; a_n(M-2)] \left(P[a_n(M-2)]\right)^{-1} P[a_n(M-2); \{l\}] \right\} |P[a_n(M-2)]|,
\end{aligned} \tag{59}$$

where, at the second line, we interchange row h with the previous row $h-1$ times and column l with the previous column $l-2$ times for matrix $P(\{l\}; \{h\})$, respectively, and we use Schur's formula at the fourth line. Note that even assuming $l < h$, we can express $|C_{lh}|$ as (59). If matrix P satisfies inequalities (55) for $h = l$, then all principal minors of matrix P are positive, implying that all principal minors of P of order $M-2$ are positive: $|P[a_n(M-2)]| > 0$. In this case, all (l, h) cofactors of matrix P are non-positive if and only if the term in the curly brackets in (59) is non-negative for all $a_n(M-2)$, and this condition is equivalent to inequalities (55) for $a_n = a_n(M-2)$ (all cases where a_n has $M-2$ elements) with $h \neq l$. Therefore, if P satisfies (55), then we have $|C_{lh}| \leq 0$ for $h, l = 1, \ldots, M$ with $h \neq l$. Note that inequalities (55) for $a_n = a_n(k-2)$ with $h \neq l$ are equivalent to necessary and sufficient conditions for all (l, h) cofactors of principal submatrices of P of order k to be non-positive under inequalities (55) being satisfied for $h = l$. The triangle inequality (56) is the

$k = 3$ case of these conditions.

In summary, assuming matrix P satisfying inequalities (55) ensures (54) to hold. Inequalities (55) for $h = l$ are necessary and sufficient conditions for all principal submatrices of P to have positive determinants (and thus positive (l, l) cofactors). Under (55) being satisfied for $h = l$, inequalities (55) for $h \neq l$ are necessary and sufficient conditions for all principal submatrices of P to have non-positive (l, h) cofactors. Therefore, inequalities (55) represent necessary and sufficient conditions for all principal submatrices of P to have positive determinants, positive (l, l) cofactors, and non-positive (l, h) cofactors for all h, l and $h \neq l$.

C.1 Triangle Inequality and Examples

As explained above, the inequalities (55) ensure that a M-by-M matrix P satisfies (54). We then consider the matrices satisfying the triangle inequality (56) and show that such matrices could no longer be characterized by (54) for $M \geq 4$.

We first check matrix P with $M = 3$. It is straightforward to show that $|C_{ll}| = 1 - \rho_{hn}\rho_{nh} > 0$ holds for $l, n, h = 1, 2, 3$ with $l \neq h$, $h \neq n$ and $n \neq l$, where $|C_{ll}|$ corresponds to the determinant of 2-by-2 matrix P which is positive by $\rho_{hl} < 1$ for $l \neq h$. Then, from (59), $|C_{lh}| \leq 0$ holds if and only if $\rho_{hl} - \rho_{hn}\rho_{nl} \geq 0$, and this is equivalent to the triangle inequality (56). Finally, $|P| > 0$ holds if and only if (58) holds for $k = 3$, and this condition is equivalent to

$$\begin{aligned} & 1 + \rho_{12}\rho_{23}\rho_{31} + \rho_{13}\rho_{32}\rho_{21} - \rho_{12}\rho_{21} - \rho_{23}\rho_{32} - \rho_{13}\rho_{31} \\ = \; & (1 - \rho_{12}\rho_{21})(1 - \rho_{23}\rho_{32}) - \left(\frac{\rho_{21}\rho_{13}}{\rho_{23}} - \rho_{12}\rho_{21}\right)\left(\frac{\rho_{23}\rho_{31}}{\rho_{21}} - \rho_{23}\rho_{32}\right) > 0. \end{aligned}$$

As shown by Johnson and Smith (1999) in their Theorem 3.2, the triangle inequality ensures this condition to hold because $\rho_{12}\rho_{21} \leq \rho_{21}\rho_{13}/\rho_{23} \leq 1$, $\rho_{23}\rho_{32} \leq \rho_{23}\rho_{31}/\rho_{21} \leq 1$, and $(\rho_{21}\rho_{13}/\rho_{23})(\rho_{23}\rho_{31}/\rho_{21}) = \rho_{13}\rho_{31} < 1$ (i.e., $\rho_{21}\rho_{13}/\rho_{23}$ and $\rho_{23}\rho_{31}/\rho_{21}$ cannot both equal 1).

For $M \geq 4$, the triangle inequality does not ensure $|C_{lh}| \leq 0$ to hold. For $M = 4$, we have $|C_{ll}| > 0$ for all l as the determinant of 3-by-3 matrix P satisfying the triangle inequality is positive. In addition, Zhu, Zhang, and Liu (2011) show in their Theorem 2.15 that the triangle inequality ensures $|P| > 0$ to hold for $M = 4$. Meanwhile, $|C_{lh}|$ is not necessarily non-negative as shown in the following example:

$$P = \begin{pmatrix} 1 & 0.7 & 0.8 & 0.8 \\ 0.7 & 1 & 0.8 & 0.8 \\ 0.8 & 0.8 & 1 & 0.8 \\ 0.8 & 0.8 & 0.8 & 1 \end{pmatrix} \tag{60}$$

which satisfies the triangle inequality since $\rho_{hn}\rho_{nl} < 0.7 \leq \rho_{hl}$ for $l, n, h = 1, 2, 3, 4$ with $h, l \neq n$. For this example matrix (60), we have $|P| = 0.03 > 0$, $|C_{11}| = |C_{22}| = 0.104 > 0$, $|C_{33}| = |C_{44}| = 0.126 > 0$ and

$$|C_{lh}| = \begin{cases} 0.004 & > 0 \quad l, h = 1, 2 \\ -0.024 & < 0 \quad l, h = 3, 4 \\ -0.048 & < 0 \quad \text{otherwise} \end{cases} \tag{61}$$

for $h \neq l$. Thus, the triangle inequality does not guarantee $|C_{lh}| \leq 0$ for $M \geq 4$.

For $M \geq 5$, the triangle inequality no longer necessarily ensures $|P| > 0$ to hold. For $M = 5$, the triangle inequality guarantees $|C_{ll}| > 0$ for all l as the determinant of 4-by-4 matrix P satisfying the triangle inequality is positive, whereas it does not ensure $|P| > 0$ as well as $|C_{lh}| \leq 0$ to hold as shown in the following example:

$$P = \begin{pmatrix} 1 & 0.65 & 0.65 & 0.8 & 0.8 \\ 0.65 & 1 & 0.65 & 0.8 & 0.8 \\ 0.65 & 0.65 & 1 & 0.8 & 0.8 \\ 0.8 & 0.8 & 0.8 & 1 & 0.65 \\ 0.8 & 0.8 & 0.8 & 0.65 & 1 \end{pmatrix} \tag{62}$$

which satisfies the triangle inequality. For this matrix P, we have $|P| \approx -0.00193 < 0$, $|C_{11}| = |C_{22}| = |C_{33}| \approx 0.01990 > 0$, $|C_{44}| = |C_{55}| \approx 0.04655 > 0$, and

$$|C_{lh}| \approx \begin{cases} 0.02542 & > 0 \quad l, h = 1, 2, 3 \\ 0.05206 & > 0 \quad l, h = 4, 5 \\ -0.03430 & < 0 \quad \text{otherwise} \end{cases}$$

for $h \neq l$. Thus, the triangle inequality does not guarantee $|P| > 0$ for $M \geq 5$, implying that $|C_{ll}| > 0$ is also not guaranteed to hold for $M \geq 6$.

Therefore, the triangle inequality no longer necessarily ensures $|C_{lh}| \leq 0$ for $M \geq 4$, $|P| > 0$ for $M \geq 5$, and $|C_{ll}| > 0$ for $M \geq 6$ to hold. Finally, to interpret the situations in which matrix P does not satisfy (54) as in example matrices (60) and (62), consider the effect of an increase in market size of a country on the number of entrants in each country.[36] Differentiating (11) with respect to L_h, we have

$$\frac{dN_{E,l}^m}{dL_h} = \frac{(1-\delta)^{-\frac{1}{\delta}} \left(\frac{\gamma}{\eta}\right)^{-\frac{1}{\delta}} (c_{M,l})^k}{kB\left(1-\frac{1}{\delta}, k\right)|P|} \frac{(\alpha - c_{hh}^m)^{-\frac{1}{\delta}-1}\left(\left(k-\frac{1}{\delta}\right)\alpha - kc_{hh}^m\right)}{(c_{hh}^m)^{k+1-\frac{1}{\delta}}} \left(-\frac{dc_{hh}^m}{dL_h}\right)|C_{lh}|, \tag{63}$$

where, from (9),

$$\frac{dc_{ll}^m}{dL_h} = \begin{cases} -\frac{c_{ll}^m}{\left(k+1-\frac{1}{\delta}\right)L_l} < 0 & l = h \\ 0 & l \neq h \end{cases}. \tag{64}$$

Thus, from (63) and (64), we have

$$\frac{dN_{E,l}^m}{dL_h} \begin{cases} > 0 & |C_{lh}| / |P| > 0 \\ \leq 0 & |C_{lh}| / |P| \leq 0 \end{cases}. \tag{65}$$

As explained above, for $M = 3$, the triangle inequality ensures $|C_{ll}| / |P| > 0$ and $|C_{lh}| / |P| \leq 0$

[36]Note that to focus on cases in which all countries have operating firms in the modern sector, we assume parameters such that $c_{ll}^m > 0$ and $N_{E,l}^m > 0$ hold for all l in equilibrium. From (9) and (11) this requires

$$\sum_{h=1}^{M} \left[f_h (c_{M,h})^k |C_{hl}|\right] / |P| > 0 \quad \text{and} \quad (c_{M,l})^k \sum_{h=1}^{M} \left[(\alpha - c_{hh}^m)^{-\frac{1}{\delta}} (c_{hh}^m)^{-\left(k-\frac{1}{\delta}\right)} |C_{lh}|\right] / |P| > 0$$

to hold for all l.

to hold for $l \neq h$, which, together with (65), implies that an increase in market size in a country increases the number of entrants in that country and decreases that in other countries. This feature continues to hold even for $M \geq 4$ if matrix P satisfies (55) as it ensures (54).

When $M = 4$ and matrix P is given by example matrix (60), which satisfies the triangle inequality but not the inequalities (55), then $|C_{ll}| \,/\, |P| > 0$ holds, meaning that an increase in market size in a country increases the number of entrants in that country as in a three-country economy. Meanwhile, from (61), (65), and $|P| > 0$, an increase in market size in either country 1 or 2 also increases the number of entrants in the other country ($|C_{21}| \,/\, |P| = |C_{12}| \,/\, |P| > 0$). Intuitively, an increase in market size in country 1 encourages more firms to enter that country, which decreases the number of entrants in countries 3 and 4 due to an increased level of import competition from country 1 ($|C_{31}| \,/\, |P| = |C_{41}| \,/\, |P| < 0$ from (61)). Country 2 is also affected, but this impact is limited because of the relatively high cost of exports from country 1 (i.e. $\rho_{12} = 0.7 < \rho_{13} = \rho_{14} = 0.8$). Rather, the number of entrants in country 2 eventually increases through a reduced level of import competition from countries 3 and 4 where the number of entrants decreases. As a result, an increase in market size in country 1 increases the number of entrants in countries 1 and 2 and decreases that in countries 3 and 4, and we have similar results for an increase in market size in country 2. An increase in market size in country 3 (or 4) encourages firms to enter the country and decreases the number of entrants in all other countries as in the $M = 3$ case. Matrix P satisfying the inequalities (55) does not include a matrix that represents the situation shown in this example where the number of entrants in a country increases as market size in another country increases.

When $M = 5$ and matrix P is given by example matrix (62), then $|C_{ll}| \,/\, |P| < 0$ holds for all l, which, together with (65), shows that an increase in market size in any country decreases the number of entrants in that country. Thus, for $M \geq 5$, since matrix P satisfying the triangle inequality can have opposite sign for $|P|$ and $|C_{ll}|$, it includes a matrix representing economically unrealistic situation in which the number of entrants in a country decreases as its market size increases. We can omit such situations by considering the class of matrix P that satisfies (55) (for $h = l$) as it ensures $|P| > 0$ and $|C_{ll}| > 0$ to hold.

D Changes in Multilateral Coordination Schemes

If one policy variable is changed, each policy variable must be adjusted to maintain optimal multilateral policies. Specifically, totally differentiating (29) yields

$$dT_l^{\upsilon} + (1 + t^c) f_l dt^{\pi} - (1 - t^{\pi}) f_l dt^c = 0, \tag{66}$$

which represents the relationship between changes in policy variables to maintain the optimal extensive margin allocation. Similarly, totally differentiating (21) and (22), we respectively obtain

$$(1 + t^c) dt^a + (1 + t^a) dt^c = 0 \quad \text{and} \quad ds_l = \frac{-\delta}{1 - \delta} c_{ll}^o dt^c \tag{67}$$

which are required to maintain the optimal intensive margin allocation (i.e., all market prices aligned with the marginal delivered cost). In the following, each policy variable is assumed to change according to these rules.

D.1 Lump-sum Entry Subsidy

First, we check the welfare impact of changes in lump-sum entry taxes/subsidies (dT_l^υ) holding common global corporate tax rate constant ($dt^\pi = 0$). Substituting (35) into (41) and differentiating it with respect to T_l^υ, we get

$$\frac{dU_l}{dT_l^\upsilon} = \frac{k+1}{(1-t^\pi)\, f_l}\left[-\frac{c_{ll}^o\,(\alpha - c_{ll}^o)^{-\frac{1}{\delta}}}{\left(k+1-\frac{1}{\delta}\right)\eta^{-\frac{1}{\delta}}} + \frac{N_{E,l}^o f_l}{L_l}\right],$$

where, from (66), $dt^\pi = 0$ implies $dt^c = dT_l^\upsilon/(1-t^\pi)f_l$. Therefore, an increase in lump-sum entry subsidies or a decrease in lump-sum entry taxes, $dT_l^\upsilon < 0$, results in an increase (a decrease) in the welfare level of country l if the term in the square brackets is negative (positive). As the term corresponds to (43) and is likely to be negative (positive) if country l is a disadvantaged (an advantaged) country, a decrease in T_l^υ leads to international transfers from advantaged to disadvantaged countries.

D.2 Corporate Profit Tax Collected in Destination Countries

Assume that T_l^υ is constant (or not used) for all l. Substituting (46) into (41) and differentiating it with respect to t^π, we get

$$\frac{dU_l}{dt^\pi} = \frac{(1+t^c)k}{1-t^\pi}\left[-\frac{c_{ll}^o\,(\alpha - c_{ll}^o)^{-\frac{1}{\delta}}}{\left(k+1-\frac{1}{\delta}\right)\eta^{-\frac{1}{\delta}}} + \frac{N_{E,l}^o f_l}{L_l}\right],$$

where, from (66), $dT_l^\upsilon = 0$ implies $dt^c = (1+t^c)dt^\pi/(1-t^\pi)$. As the terms in the square brackets correspond to those in (43), an increase in a common global corporate tax increases (decreases) the welfare level of advantaged (disadvantaged) countries.

D.3 Export Subsidy

Assume that T_l^υ is constant (or not used) for all l. Substituting (47) into (41) and differentiating it with respect to t^π, we get

$$\frac{dU_l}{dt^\pi} = \frac{k(1+t^c)}{(1-\delta)(1-t^\pi)}\left[-\frac{c_{ll}^o\,(\alpha - c_{ll}^o)^{-\frac{1}{\delta}}}{\left(k+1-\frac{1}{\delta}\right)\eta^{-\frac{1}{\delta}}} + \frac{N_{E,l}^o f_l}{L_l}\right],$$

where, from (66), $dT_l^\upsilon = 0$ implies $dt^c = (1+t^c)dt^\pi/(1-t^\pi)$. As the terms in the square brackets coincide with those in (43), an increase in a common global corporate tax increases (decreases) the welfare level of advantaged (disadvantaged) countries.

In the specific case of $T_l^\upsilon = 0$ for all l, expression (29) implies $t^c = t^\pi/(1-t^\pi)$. Substituting this into (47) yields

$$T_l^\varepsilon = \frac{\left(t^\pi - \frac{-\delta}{1-\delta}\right)k}{1-t^\pi}\frac{c_{ll}^o\,(\alpha - c_{ll}^o)^{-\frac{1}{\delta}}}{\left(k+1-\frac{1}{\delta}\right)\eta^{-\frac{1}{\delta}}} + \frac{-\delta\left(k+1-\frac{1}{\delta}\right)-(1-\delta)\,(k+1)t^\pi}{(1-\delta)\,(1-t^\pi)}\frac{f_l N_{E,l}^o}{L_l}.$$

As shown in Section 5.1, the lump-sum taxes on consumers in the benchmark case (Case A) are given by $T_l^{\varepsilon} = \frac{c_{ll}^o(\alpha - c_{ll}^o)^{-\frac{1}{\delta}}}{\left(k+1-\frac{1}{\delta}\right)\eta^{-\frac{1}{\delta}}}$. Thus, the common global corporate tax rate at which the welfare level of each country coincides with the benchmark outcome is

$$
\begin{aligned}
& \frac{\left(t^{\pi} - \frac{-\delta}{1-\delta}\right)k}{1-t^{\pi}} \frac{c_{ll}^o\left(\alpha - c_{ll}^o\right)^{-\frac{1}{\delta}}}{\left(k+1-\frac{1}{\delta}\right)\eta^{-\frac{1}{\delta}}} + \frac{-\delta\left(k+1-\frac{1}{\delta}\right) - (1-\delta)(k+1)t^{\pi}}{(1-\delta)(1-t^{\pi})} \frac{f_l N_{E,l}^o}{L_l} = \frac{c_{ll}^o\left(\alpha - c_{ll}^o\right)^{-\frac{1}{\delta}}}{\left(k+1-\frac{1}{\delta}\right)\eta^{-\frac{1}{\delta}}} \\
\Leftrightarrow \quad & \frac{-\delta\left(k+1-\frac{1}{\delta}\right) - (1-\delta)(k+1)t^{\pi}}{(1-\delta)(1-t^{\pi})} \left[-\frac{c_{ll}^o\left(\alpha - c_{ll}^o\right)^{-\frac{1}{\delta}}}{\left(k+1-\frac{1}{\delta}\right)\eta^{-\frac{1}{\delta}}} + \frac{f_l N_{E,l}^o}{L_l} \right] = 0 \\
\Leftrightarrow \quad & t^{\pi} = \frac{-\delta}{1-\delta} \frac{k+1-\frac{1}{\delta}}{k+1}.
\end{aligned}
$$