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Lerner Symmetry: A Modern Treatment[†]

By ARNAUD COSTINOT AND IVÁN WERNING*

Which policies are protectionist and which ones are not? The Lerner Symmetry Theorem establishes that import tariffs and export taxes are equally protectionist. In this paper we provide a modern treatment of this classical result, highlighting the importance of multinational firms, global imbalances, and imperfect competition. Under perfect competition, the result follows from the separability of consumption and production across countries, ruling out tourism and some forms of multinational firms, but not others. Though we do not require trade balance, the role of initial assets is subtle: our result rules out foreign ownership of domestic assets, but does not constrain domestic ownership of foreign assets. Under imperfect competition, our result effectively rules out all multinational firms. We conclude by discussing the implications for border adjustment taxes. (JEL D41, D43, F13, F14, F23)

When should one country be concerned about changes in its neighbor's tax system? What type of policies should be deemed protectionist and regulated by the World Trade Organization? What type of tax reforms are neutral in a global economy? How do global imbalances and global supply chains affect, if at all, the answers to these questions?

The Lerner Symmetry Theorem (Lerner 1936) provides an important starting point for thinking about these questions. It establishes the equivalence between import tariffs and export taxes, and, in turn, the neutrality of any tax reform that increases both by the same amount.

The result was originally derived in a simple neoclassical economy with two countries, two final goods, no trade costs, and no distortionary taxes. Over the last 80 years, both the world economy and trade theory have changed. Multinational firms, increasing returns, imperfect competition, and trade costs are now part of the workhorse models. The Lerner Symmetry Theorem deserves a modern treatment.

Our goal is to offer a number of generalizations and qualifications of this well-known result. We focus on a general economy, under either perfect or imperfect competition. Under perfect competition, we highlight three conditions. The first one rules

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out some forms of offshoring, such as those considered in Yeaple (2013), but not those in Yi (2003), Grossman and Rossi-Hansberg (2008), Ramondo and Rodríguez-Clare (2013), or Antràs and de Gortari (2017); the second one rules out international tourism and migration; and the third one rules out foreign ownership of domestic assets, but not domestic ownership of foreign assets. The absence of trade imbalances is neither necessary nor sufficient for Lerner Symmetry to hold.

Turning to imperfect competition, we provide a general framework, which nests various market structures, including Bertrand, Cournot, and monopolistic competition. Although neutrality holds in imperfectly competitive models without multinational firms, like Krugman (1980) or Melitz (2003), it may break down in richer models where such firms are present, like Helpman, Melitz, and Yeaple (2004), Tintelnot (2017), or Arkolakis et al. (2018).

We then discuss how the results extend to economies where agents have behavioral biases, production and consumption are subject to externalities, or prices are sticky. Motivated by the influential work of Auerbach and coauthors (see Auerbach et al. 2017 for a recent summary), we also discuss the implications of our results for border adjustment taxes, extending the neutrality results in Meade (1974) and Grossman (1980).¹

Other authors have offered a number of generalizations and qualifications of Lerner's (1936) original theorem. McKinnon (1966) establishes its robustness to trade in intermediate inputs. Eaton et al. (1983) show that it remains valid in the simple monopolistic setting first considered by Ray (1975). Kaempfer and Tower (1982) offer a fairly general version of the result under perfect competition in a two-country environment where all balance of payment debits and credits are taxed and subsidized. Blanchard (2009) shows how the result may break down in the absence of such general taxes when foreigners hold a claim to part of domestic production.

Compared to prior work, we focus on a more general environment that allows us to nest features of modern trade models, such as trade costs and firm heterogeneity; we allow for a rich set of taxes, not only on trade, capturing domestic distortions that lead to production inefficiency; and we explore the nature of multinational production, the composition of foreign asset positions, and the nature of competition. These features allow us to derive new insights into the conditions under which tax reforms are neutral.

I. Economic Environment

We consider a world economy that comprises any number of countries, goods, firms, and households. Goods encompass final goods, intermediate inputs, as well as labor and other primary factors. Firms may produce and sell goods in multiple countries. Likewise, households may, in principle, work and consume in more than one country, allowing us to capture certain forms of migration and tourism. This is achieved by indexing goods by location of production and consumption.

¹ Barbiero et al. (2018) offer an analysis of border adjustment taxes in the context of a dynamic macroeconomic model where neutrality may fail because of nominal stickiness and a monetary policy conducted according to a Taylor rule under a floating exchange rate regime.

In Arrow-Debreu fashion, goods may also be distinguished by date of availability, allowing for intertemporal trade. Within this environment, we allow for a rich set of linear taxes, including distortionary taxes on buyers and sellers, as well as lump-sum transfers to rebate tax revenues.

A. Technology and Preferences

Firms.—Technology for firm f is described by a production set $\Omega(f)$. A production plan consists of an input vector $m(f) \equiv \{m_{ij}^k(f)\}$ and an output vector $y(f) \equiv \{y_{ij}^k(f)\}$. Here $m_{ij}^k(f) \geq 0$ denotes the input of good k in destination country j from origin country i ; similarly, $y_{ij}^k(f) \geq 0$ denotes the output of good k from origin country i to destination country j . Feasible production plans satisfy

$$(m(f), y(f)) \in \Omega(f).$$

The distinction between non-negative input and output vectors contrasts with the standard consolidation into a single net-output vector given by $y - m$. This allows for differential taxation of inputs and outputs across firms and, in turn, production inefficiency. International transport costs, if any, are captured by $\Omega(f)$ requiring different inputs to produce a given good k for different destinations.

Households.—A consumption plan for household h consists of a vector of goods demanded $c(h) \equiv \{c_{ij}^k(h)\}$ and a vector of goods supplied $l(h) \equiv \{l_{ij}^k(h)\}$. Here $c_{ij}^k(h) \geq 0$ denotes the demand for good k from origin country i in destination country j , while $l_{ij}^k(h) \geq 0$ denotes the supply of good k by household h from an origin country i to a destination country j . Consumption plans must lie in a feasible set $\Gamma(h)$. A feasible consumption plan $(c(h), l(h)) \in \Gamma(h)$ delivers utility

$$(1) \quad u(c(h), l(h); h).$$

Just as with production, our notation for consumption distinguishes demand from supply to allow for differential taxation.²

Resource Constraint.—For each good, total supply must equal total demand,

$$(2) \quad \sum_f y(f) + \sum_h l(h) = \sum_h c(h) + \sum_f m(f).$$

B. Prices, Taxes, and Transfers

In the next sections, we analyze general equilibrium models of perfect and imperfect competition. Under both market structures, all economic transactions take place between a buyer and a seller at unit prices that are subject to ad-valorem taxation. Taxes may vary across origin and destination countries, across goods, as well as

²Exogenous government consumption can be introduced as a household for which $\Gamma(h)$ is a singleton.

across firms and households. We refer to a “trade tax” as any tax imposed on a cross-country transaction. Tax revenues are rebated lump-sum to domestic households and foreign governments.

Taxes.—Let $t_{ij}^k(n)$ denote the tax imposed by country j on a buyer n who purchases good k in that country from a seller producing in country i . The buyer n may be either a household, purchasing a final good, or a firm, purchasing intermediate inputs or labor services. Similarly, we let $s_{ij}^k(n)$ denote the subsidy imposed by country i on a seller n who produces good k in that country and sells it in country j . We impose no restriction on the signs of $t_{ij}^k(n)$ and $s_{ij}^k(n)$. If $i \neq j$, then $t_{ij}^k(n) \geq 0$ corresponds to an import tariff, $t_{ij}^k(n) \leq 0$ to an import subsidy. Likewise, if $i \neq j$, then $s_{ij}^k(n) \geq 0$ corresponds to an export subsidy, $s_{ij}^k(n) \leq 0$ to an export tax.³

Profits.—Let $p \equiv \{p_{ij}^k\}$ denote the vector of untaxed prices. For a firm f facing taxes and subsidies, $t(f) \equiv \{t_{ij}^k(f)\}$ and $s(f) \equiv \{s_{ij}^k(f)\}$, profits equal

$$(3) \quad \pi(f) \equiv p(1 + s(f)) \cdot y(f) - p(1 + t(f)) \cdot m(f),$$

where $p(1 + s(f)) \equiv \{p_{ij}^k(1 + s_{ij}^k(f))\}$ and $p(1 + t(f)) \equiv \{p_{ij}^k(1 + t_{ij}^k(f))\}$ refer to the vectors of element-by-element products and the dot product \cdot refers to the inner product of two vectors, e.g., $p(1 + s(f)) \cdot y(f) = \sum_{i,j,k} p_{ij}^k(1 + s_{ij}^k(f))y_{ij}^k(f)$. In what follows, we let $\pi_i(f) \equiv \sum_{j,k} [p_{ij}^k(1 + s_{ij}^k(f))y_{ij}^k(f) - p_{ji}^k(1 + t_{ji}^k(f))m_{ji}^k(f)]$ denote the profits derived from transactions in country i , so that $\pi(f) = \sum_i \pi_i(f)$.

Budget Constraints.—The budget constraint of household h is

$$(4) \quad p(1 + t(h)) \cdot c(h) = p(1 + s(h)) \cdot l(h) + \pi \cdot \theta(h) + \tau(h),$$

where $\pi \equiv \{\pi(f)\}$ is the vector of firms’ profits, $\theta(h) \equiv \{\theta(f, h)\}$ is the vector of firms’ shares or assets held by household h , and $\tau(h)$ is a lump-sum transfer. Endowments of goods are simple firms with production sets given by a singleton. Negative holdings of a simple firm, $\theta(f, h) < 0$, denote initial debt positions.

The government’s budget constraint in country i is

$$(5) \quad \sum_{j,k} p_{ji}^k \left(\sum_h t_{ji}^k(h) c_{ji}^k(h) + \sum_f t_{ji}^k(f) m_{ji}^k(f) \right) + \sum_{j \neq i} T_{ji} \\ = \sum_{j,k} p_{ij}^k \left(\sum_h s_{ij}^k(h) l_{ij}^k(h) + \sum_f s_{ij}^k(f) y_{ij}^k(f) \right) + \sum_{h \in H_i} \tau(h) + \sum_{j \neq i} T_{ij},$$

where H_i is the set of domestic households and T_{ij} is the transfer to country j .

³Our analysis allows for a limited form of nonlinear taxation since the tax depends on whether firms and households are buying or selling. More generally, one can extend our results to economies where taxes also vary with quantities bought or sold. In particular, one can allow nonlinear income taxation, as is standard in the public finance literature.

II. Neutrality Under Perfect Competition

We first establish a general Lerner Symmetry Theorem under perfect competition.

A. Perfect Competition

Equilibrium.—A competitive equilibrium with taxes, $t \equiv \{t_{ij}^k(n)\}$, subsidies, $s \equiv \{s_{ij}^k(n)\}$, and lump-sum transfers, $\tau \equiv \{\tau(h)\}$ and $T \equiv \{T_{ij}\}$, corresponds to quantities $c \equiv \{c(h)\}$, $l \equiv \{l(h)\}$, $m \equiv \{m(f)\}$, $y \equiv \{y(f)\}$, and prices $p \equiv \{p_{ij}^k\}$ such that: (i) $(c(h), l(h)) \in \Gamma(h)$ maximizes (1) subject to (4) taking p , $t(h)$, $s(h)$, and $\tau(h)$ as given; (ii) $(m(f), y(f)) \in \Omega(f)$ maximizes (3) taking p , $t(f)$, and $s(f)$ as given; (iii) the market clearing condition (2) holds; and (iv) government budget constraints (5) hold.

Given (t, s) , let $\mathcal{E}(t, s)$ denote the set of quantities (c, l, m, y) that form an equilibrium, for some $(\tilde{p}, \tilde{\tau}, \tilde{T})$. Similarly, given (t, s, T) , let $\mathcal{E}(t, s, T) \subseteq \mathcal{E}(t, s)$ denote the set of quantities (c, l, m, y) that form an equilibrium for some $(\tilde{p}, \tilde{\tau})$.

Neutrality.—We say that a tax reform from (t, s) to (\tilde{t}, \tilde{s}) is neutral if either $\mathcal{E}(t, s) = \mathcal{E}(\tilde{t}, \tilde{s})$ or $\mathcal{E}(t, s, T) = \mathcal{E}(\tilde{t}, \tilde{s}, T)$. The first notion, $\mathcal{E}(t, s) = \mathcal{E}(\tilde{t}, \tilde{s})$, captures neutrality in that the equilibrium allocations obtainable with taxes and subsidies (t, s) and (\tilde{t}, \tilde{s}) are the same. This notion not only allows for price changes, but also for adjustments in domestic and international transfers. The second notion, $\mathcal{E}(t, s, T) = \mathcal{E}(\tilde{t}, \tilde{s}, T)$, is a stronger form of neutrality that rules out the adjustment of international transfers.

The first neutrality notion provides an important conceptual benchmark. Even if tax reforms in practice are not accompanied by changes in international transfers, establishing $\mathcal{E}(t, s) = \mathcal{E}(\tilde{t}, \tilde{s})$ clarifies that the effects of the reform, if any, are purely distributional and that (t, s) and (\tilde{t}, \tilde{s}) are equally distortionary tax systems. In this sense, they are both equally protectionist from a trade perspective.⁴

Both our neutrality notions allow for the adjustment of domestic lump-sum transfers, a standard assumption in the literature (e.g., Kaempfer and Tower 1982). This guarantees that the budget balance of the government can be mechanically maintained in response to changes in tax revenues.⁵

B. Lerner Symmetry

We focus on a tax reform that involves a subset of trade taxes. Suppose country i_0 changes its trade taxes, from $\{t_{j_0}^k(n), s_{i_0 j}^k(n)\}_{j \neq i_0}$ to $\{\tilde{t}_{j_0}^k(n), \tilde{s}_{i_0 j}^k(n)\}_{j \neq i_0}$. All other taxes are unchanged. Under which conditions is country i_0 's tax reform neutral?

Our first result emphasizes three conditions.

⁴To see this most clearly, consider the special case where $(t, s) = (0, 0)$ so that initial allocations are Pareto efficient by virtue of the First Welfare Theorem. If $\mathcal{E}(0, 0) = \mathcal{E}(\tilde{t}, \tilde{s})$, then equilibrium allocations with (\tilde{t}, \tilde{s}) are also Pareto efficient.

⁵In standard trade and macro models with a representative agent in each country, the mechanical adjustment is the only role played by domestic lump-sum transfers. In richer environments without representative agents, transfers across households may serve to undo the distributional consequences of the tax reform, if any.

CONDITION A1: For any firm f , production sets can be separated into

$$\Omega(f) = \Omega_{i_0}(f) \times \Omega_{-i_0}(f),$$

where $\Omega_{i_0}(f)$ denotes the set of feasible production plans, $\{m_{ji_0}^k(f), y_{i_0j}^k(f)\}$, in country i_0 and $\Omega_{-i_0}(f)$ denotes the set of feasible plans, $\{m_{ji}^k(f), y_{ij}^k(f)\}_{i \neq i_0}$, in other countries.

CONDITION A2: For any household h , consumption sets can be separated into

$$\Gamma(h) = \Gamma_{i_0}(h) \times \Gamma_{-i_0}(h),$$

where $\Gamma_{i_0}(h)$ denotes the set of feasible consumption plans, $\{c_{ji_0}^k(f), l_{i_0j}^k(f)\}$, in country i_0 ; $\Gamma_{-i_0}(h)$ denotes the set of feasible plans, $\{c_{ji}^k(f), l_{ij}^k(f)\}_{i \neq i_0}$, in other countries; and $\Gamma_{i_0}(h)$ and $\Gamma_{-i_0}(h)$ are such that $h \in H_{i_0} \Rightarrow \Gamma_{-i_0}(h) = \{0\}$ and $h \notin H_{i_0} \Rightarrow \Gamma_{i_0}(h) = \{0\}$.

CONDITION A3: For any foreign country $j \neq i_0$, the total value of assets held in country i_0 prior to the tax reform is zero, $\pi_{i_0} \cdot \sum_{h \in H_j} \theta(h) = 0$.

THEOREM 1 (Perfect Competition): Consider a reform of trade taxes in country i_0 satisfying

$$\frac{1 + \tilde{t}_{i_0}^k(n)}{1 + t_{j i_0}^k(n)} = \frac{1 + \tilde{s}_{i_0 j}^k(n)}{1 + s_{i_0 j}^k(n)} = \eta \quad \text{for all } j \neq i_0, k, \text{ and } n,$$

for some $\eta > 0$; all other taxes are unchanged. If A1 and A2 hold, then $\mathcal{E}(t, s) = \mathcal{E}(\tilde{t}, \tilde{s})$; if A1, A2, and A3 hold, then $\mathcal{E}(t, s, T) = \mathcal{E}(\tilde{t}, \tilde{s}, T)$.

Theorem 1 offers a strict generalization of Lerner Symmetry Theorem. In Lerner (1936), country i_0 imports good 1 and exports good 2; the initial tax schedule is an import tariff ($t_{i_0}^1(n) = s_{i_0}^1(n) = t > 0$), with zero taxes in the export sector ($t_{i_0}^2(n) = s_{i_0}^2(n) = 0$); and the new schedule is an export tax ($\tilde{s}_{i_0}^2(n) = \tilde{t}_{i_0}^2(n) = s < 0$), with zero taxes in the import sector ($\tilde{t}_{i_0}^1(n) = \tilde{s}_{i_0}^1(n) = 0$). If $1 + s = 1/(1 + t)$, Theorem 1 implies the neutrality of such a reform and, in turn, the equivalence between import tariffs and export taxes.

The formal proof of Theorem 1, as well as other proofs, can be found in our online Appendix. Neutrality in Theorem 1 rests on a proportional change in after-tax prices for all domestic buyers and sellers, combined with no change in after-tax prices abroad,

$$(6) \quad \frac{\tilde{p}_{ij}^k(1 + \tilde{s}_{ij}^k(n))}{p_{ij}^k(1 + s_{ij}^k(n))} = \frac{\tilde{p}_{ji}^k(1 + \tilde{t}_{ji}^k(n))}{p_{ji}^k(1 + t_{ji}^k(n))} = \begin{cases} \eta & \text{for all } j \text{ and } k, \text{ if } i = i_0 \\ 1 & \text{for all } j \text{ and } k, \text{ if } i \neq i_0 \end{cases}$$

This change is achieved with before-tax prices,

$$(7) \quad \frac{\tilde{p}_{ij}^k}{p_{ij}^k} = \begin{cases} \eta & \text{if } i = j = i_0 \\ 1 & \text{otherwise} \end{cases}$$

Under A1 and A2, condition (6) implies that relevant relative prices for all firms and households are unaffected by the reform. The remaining potential effects are wealth effects that international transfers can counter. Under A3, our second neutrality result guarantees that no adjustment in international transfers is needed.

C. Discussion

Although our result provides sufficient conditions for neutrality, these conditions are critical in the sense that if one relaxes any of A1, A2, or A3, there exist counterexamples to our neutrality conclusions.

The first of our sufficient conditions, A1, implies the separability of a firm's decisions across markets. Although there may be global supply chains—so that a firm from Japan may export intermediate goods to China, combine these goods with Chinese labor to produce final goods, and export those to the United States—it is as if multinational firms behave like a series of independent local firms would, each maximizing local profits $\pi_i(f)$, taking as given the vector of after-tax prices where these activities are located. The perfectly competitive models of offshoring developed by Yi (2003), Grossman and Rossi-Hansberg (2008), Ramondo and Rodríguez-Clare (2013), or Antràs and de Gortari (2017) satisfy A1.

To see what forms of multinational production A1 rules out, consider a multinational with affiliates located in countries i_0 and $i \neq i_0$. The first affiliate can produce good k for country j , whereas the second can produce good k' for country j' . A fixed resource, like CEO time, limits overall production between the two affiliates, as in Yeaple (2013). This leads to the production possibility frontier,

$$(8) \quad G(y_{i_0j}^k(f), y_{ij'}^{k'}(f)) \leq 0$$

for some increasing function G . If after-tax prices adjust according to (6), with $\eta > 1$, profits maximization prompts an expansion of the activities of country i_0 's affiliate and a contraction of the activities of the other affiliate. This is true even if both affiliates are only selling locally ($i_0 = j$ and $i = j'$) and, thus, only subject to (unchanged) local taxes.

The second of our sufficient conditions, A2, is the counterpart of A1 on the household side. It ensures that households only consume and supply goods in their country. This rules out tourism and migration. As shown by (6), after-tax prices rise proportionally in i_0 , but are unchanged abroad. This makes vacationing abroad relatively cheaper and earning a wage abroad less attractive. Condition A2 shuts down the effect of this relative price change.⁶

Turning to the stronger neutrality result, $\mathcal{E}(t, s, T) = \mathcal{E}(\tilde{t}, \tilde{s}, T)$, it is important to note that A3 does not imply balanced trade. Trade imbalances may occur in two ways. First, A3 allows country i_0 to own assets abroad and, thus, to run a trade deficit.

⁶For neutrality to hold in the absence of A2, one needs the tax authorities of country i_0 to tax tourism of domestic households abroad as an import, and subsidize foreigners' tourism at home as an export. Relaxing A1 requires a similar adjustment in the taxes imposed on the activities of affiliates in country $i \neq i_0$; in the example above, $\{y_{ij'}^{k'}(f)\}$ should still be treated as part of country i_0 's exports. This echoes Kaempfer and Tower's (1982) observation that Lerner Symmetry holds if all entries of the balance of payments can be taxed or subsidized.

Neutrality, however, still holds in this case because the increase in tax revenues is exactly counterbalanced by the lower prices on foreign assets held by households from country i_0 . Interestingly, there is an asymmetry between domestic and foreign assets and liabilities. A3 restricts the gross asset position of foreigners in country i_0 to be zero, but does not impose any restriction on the gross asset position of country i_0 in the rest of the world. This asymmetry reflects the fact that the tax reform only raises the value of assets in country i_0 . The absence of foreign asset holdings in country i_0 rules out the need for international transfers.⁷

Second, trade imbalances may occur even if all initial cross-country asset holdings are zero (a strengthening of A3). In our Arrow-Debreu framework, goods may be indexed by time, allowing for intertemporal trade. Accordingly, a country may run deficits and surpluses at different points in time, in spite of trade being balanced in net present value. If so, our stronger notion of neutrality holds because the higher taxes collected when a trade surplus occurs are exactly offset by lower revenues when the trade balance reverses.

III. Neutrality Under Imperfect Competition

We now extend our results to imperfect competition.

A. Imperfect Competition

Equilibrium.—As under perfect competition, an equilibrium requires households to maximize utility subject to budget constraint taking prices and taxes as given (i), markets to clear (iii), and government budget constraints to hold (iv), but it no longer requires firms to be price-takers.

To capture general forms of imperfect competition, we proceed as follows. In place of (ii), each firm f chooses a correspondence $\sigma(f)$ that describes the set of quantities $(y(f), m(f))$ that it is willing to supply and demand at every price vector p . The correspondence $\sigma(f)$ must belong to a feasible set $\Sigma(f)$. For each strategy profile $\sigma \equiv \{\sigma(f)\}$, an auctioneer then selects a price vector $P(\sigma)$ and an allocation $C(\sigma) \equiv \{C(\sigma, h)\}$, $L(\sigma) \equiv \{L(\sigma, h)\}$, $M(\sigma) \equiv \{M(\sigma, f)\}$, and $Y(\sigma) \equiv \{Y(\sigma, f)\}$ such that the equilibrium conditions (i), (iii), and (iv) hold. Firm f solves

$$(9) \quad \max_{\sigma(f) \in \Sigma(f)} P(\sigma)(1 + s(f)) \cdot Y(\sigma, f) - P(\sigma)(1 + t(f)) \cdot M(\sigma, f),$$

taking the correspondences of other firms $\{\sigma(f')\}_{f' \neq f}$ as given.

⁷Blanchard (2009) emphasizes a related dichotomy in a two-country-two-good model where foreign households own domestic firms, but domestic households do not own foreign firms. Lerner Symmetry fails when domestic firms' profits owned by foreigners are valued at local prices, as is natural; it obtains when they are valued at foreign prices, an implausible scenario that implicitly requires a differential tax treatment of domestic firms depending on who owns them. In the natural scenario, because domestic ownership of foreign assets is ruled out, Lerner Symmetry requires trade balance, unlike in our paper.

Strategy Sets.—The feasible set $\Sigma(f)$ reflects the technological constraint $\Omega(f)$ and the strategic nature of competition. On the technological side, $\Sigma(f)$ may allow for entry decisions subject to fixed costs or other forms of increasing returns. On the strategic side, it may, for example, restrict a firm to choose a vertical schedule, i.e., fixed quantities, as under Cournot competition, or it may restrict a firm to choose a horizontal schedule, i.e., fixed prices, as under Bertrand competition. Monopolistic competition with a continuum of firms and goods can be obtained as a limit case.

The only mild restriction that we impose on $\Sigma(f)$ is that it is broad enough to accommodate the type of price changes required for neutrality under perfect competition. Formally, for given $\eta > 0$, let the mapping ρ_η be $\tilde{p} = \rho_\eta(p)$ with \tilde{p} and p satisfying (7). We assume that for any $\eta > 0$, if $\sigma(f) \in \Sigma(f)$, then $\tilde{\sigma}(f) \equiv \sigma(f) \circ \rho_\eta \in \Sigma(f)$.

B. Lerner Symmetry

Under a stronger version of A1, Theorem 1 generalizes to imperfect competition.

CONDITION A1': For any firm f , production sets can be separated into

$$\Omega(f) = \Omega_{i_0}(f) \times \Omega_{-i_0}(f),$$

where $\Omega_{i_0}(f)$ and $\Omega_{-i_0}(f)$ are such that either $\Omega_{-i_0}(f) = \{0\}$ or $\Omega_{i_0}(f) = \{0\}$.

THEOREM 2 (Imperfect Competition): *Consider the tax reform of Theorem 1. If A1' and A2 hold, then $\mathcal{E}(t, s) = \mathcal{E}(\tilde{t}, \tilde{s})$; if A1', A2, and A3 hold, then $\mathcal{E}(t, s, T) = \mathcal{E}(\tilde{t}, \tilde{s}, T)$.*

The proof relies on a similar logic as that of Theorem 1. Let ρ_η^{-1} denote the inverse of the function ρ_η mapping p into \tilde{p} using (7). Under the assumptions of Theorem 2, if σ is an equilibrium for taxes (t, s) —with the auctioneer selecting $P(\sigma')$, $C(\sigma')$, $L(\sigma')$, $M(\sigma')$, and $Y(\sigma')$ for each feasible strategy profile σ' —then $\tilde{\sigma} = \sigma \circ \rho_\eta^{-1}$ is an equilibrium for taxes (\tilde{t}, \tilde{s}) —with the auctioneer selecting $\tilde{P}(\tilde{\sigma}') = \rho_\eta(P(\tilde{\sigma}' \circ \rho_\eta))$, $\tilde{C}(\tilde{\sigma}') = C(\tilde{\sigma}' \circ \rho_\eta)$, $\tilde{L}(\tilde{\sigma}') = L(\tilde{\sigma}' \circ \rho_\eta)$, $\tilde{M}(\tilde{\sigma}') = M(\tilde{\sigma}' \circ \rho_\eta)$, and $\tilde{Y}(\tilde{\sigma}') = Y(\tilde{\sigma}' \circ \rho_\eta)$ for each feasible strategy profile $\tilde{\sigma}'$. Given the new taxes, we therefore obtain equilibrium prices $\tilde{p} = \rho_\eta(p)$ and unchanged quantities, as with perfect competition.⁸

C. Discussion

Compared to A1, which only requires separability, A1' requires that each firm can either produce only in i_0 or only outside of i_0 . Essentially, A1' rules out all multinational firms.

⁸ A similar logic applies to extensive form games together with equilibrium refinements such as subgame perfection. One can accommodate, for example, Stackelberg competition and strategic entry games. One could also extend our results to allow for households who are not price-takers or for transfers to firms that may depend on f and σ , thereby capturing additional forms of regulation and incentive schemes.

To see why A1 is no longer sufficient under imperfect competition, consider an economy in which the same monopolistically competitive firm f chooses how much to produce at two locations, i_0 and $i \neq i_0$, to serve a given destination j . This may reflect a choice between exports and horizontal foreign direct investment (FDI), if $j \in \{i, i_0\}$, as in Helpman, Melitz, and Yeaple (2004), or more general forms of offshoring associated with platform FDI, if $j \notin \{i, i_0\}$, as in Tintelnot (2017) and Arkolakis et al. (2018). Even if A1 holds, the residual demand faced by firm f introduces non-separability between the two output decisions,

$$(10) \quad y_{i_0j}^k(f) + y_{ij}^k(f) \leq D_j^k(p).$$

Equation (10) is analogous to equation (8) in Section III, though the restriction that firm f sells the same good k to the same destination j is now critical (here, $j' = j$ and $k' = k$).

Indeed, let $\hat{\pi}_{i_0j}(f)$ and $\hat{\pi}_{ij}(f)$ denote the profits of firm f if it were to choose production from country i_0 ($y_{ij}^k(f) = 0$) or country i ($y_{i_0i}^k(f) = 0$). Suppose that prior to the tax reform, firm f prefers producing from country i , $\hat{\pi}_{i_0j}(f) < \hat{\pi}_{ij}(f)$. For neutrality to hold under the price adjustment described in (7), the same ranking must hold for the post-reform profits associated with these two activities: $\eta \hat{\pi}_{i_0j}(f)$ and $\hat{\pi}_{ij}(f)$. If η is large enough, however, it will not. For $\eta > 1$, the tax reforms that we consider raise profits for firms producing in country i_0 relative to those producing in country i , thereby incentivizing a firm to move production to i_0 .

IV. Extensions

We next describe how our results extend to environments with behavioral agents, externalities, or nominal rigidities.

Behavioral Agents.—Our results generalize to economies where households are not fully rational, so that consumption choices do not satisfy condition (i). Our proof relies on the fact that budget constraints hold and only relative prices matter—consumption plans are homogeneous of degree zero in after-tax domestic prices. In fact, Lerner Symmetry may even hold without homogeneity if price movements described in (6) are obtained by a change in the nominal exchange rate, with no change in after-tax prices expressed in local currencies, as we discuss further below. Thus households may suffer from some forms of nominal illusion (as in Gabaix 2014).

Externalities.—Our results also easily generalize to perfectly competitive economies with production and consumption externalities. Formally, suppose production sets $\Omega(f)$ and utility functions $u(h)$ depend on the entire allocation (y, m, c, l) . When making decisions, firms and households now choose their own quantities, $(y(f), m(f))$ or $(c(h), l(h))$, taking as given both prices and the other agents' quantities. Because our neutrality results verify quantities to be unchanged, these externalities do not affect the logic of the proof.⁹

⁹Accommodating production externalities with imperfect competition is also possible but requires modifying our general framework, since it is no longer technologically feasible for firms to determine their production plans,

Exchange Rates and Nominal Rigidities.—So far, we have expressed prices in all countries in some common baseline unit of account. Representations in other units of account or currencies require adjustments by the relevant exchange rate. For concreteness, suppose that there are as many currencies as countries, with e_i the exchange rate for currency i relative to the baseline unit of account. Then, e_i/e_j represents the bilateral exchange rate between currencies i and j and $p_{ij}^{k,i} \equiv p_{ij}^k e_i$ gives the before-tax price expressed in units of currency i .

The previous observation has implications for the importance of nominal rigidities. Although we have implicitly focused on full price flexibility, price stickiness in the relevant currency may impede price changes in the short run, as in many macroeconomic models. If both prices and exchange rates are fixed, neutrality no longer holds, a situation referred to as fiscal devaluations (e.g., Keynes 1931). If exchange rates are flexible, however, the simplicity of (7) suggests that the required change in prices may be obtained solely via changes in exchange rates, $\{e_i\}$. Whether this turns out to be the case hinges on the exact nature of nominal rigidities, as we now show.

We introduce nominal rigidities as a constraint on the set of feasible prices. The constraint can be specified in terms of before-tax prices, after-tax prices, or a combination of both. For instance, if all prices are rigid in the origin country's currency before taxes are imposed, then we take $\{\bar{p}_{ij}^{k,i}\}$ as given and consider the set of feasible prices to be $\mathcal{P}(t, s) = \{\{p_{ij}^k\} | \exists \{e_i\} \text{ such that } p_{ij}^k = \bar{p}_{ij}^{k,i}/e_i \text{ for all } i, j, k\}$. Instead, if prices are rigid in the destination country's currency after buyers' taxes are imposed, $\mathcal{P}(t, s) = \{\{p_{ij}^k\} | \exists \{e_i\} \text{ such that } p_{ij}^k(1 + t_{ij}^k(n)) = \bar{p}_{ij}^{k,j}(1 + \bar{t}_{ij}^k(n))/e_j \text{ for all } i, j, k, n\}$. The case of international prices being rigid before taxes in the currency of a dominant country i_D gives $\mathcal{P}(t, s) = \{\{p_{ij}^k\} | \exists \{e_i\} \text{ such that } p_{ij}^k = \bar{p}_{ij}^{k,i_D}/e_{i_D} \text{ for all } i \neq j, k \text{ and } p_{ii}^k = \bar{p}_{ii}^{k,i}/e_i \text{ for all } k\}$.

Our next proposition describes circumstances under which a movement of the exchange rate is sufficient for price adjustments to satisfy (7), as well as counterexamples under which it is not.

PROPOSITION 1: *Consider the tax reform of Theorem 1 with $\eta \neq 1$. Suppose $p \in \mathcal{P}(t, s)$ and \tilde{p} satisfies (7). Then $\tilde{p} \in \mathcal{P}(\tilde{t}, \tilde{s})$ holds if prices are rigid in the origin country's currency after sellers' taxes or the destination country's currency after buyers' taxes, but not if they are rigid before taxes. Likewise, $\tilde{p} \in \mathcal{P}(\tilde{t}, \tilde{s})$ holds if prices are rigid in a dominant currency before taxes and country $i_0 \neq i_D$, but not if $i_0 = i_D$.*

These are subtle considerations that depend not only on the currency of denomination, a point already emphasized by Barbiero et al. (2018), but also on whether prices are rigid before or after taxes, as well as whether the dominant country is the one changing taxes.

$\sigma(f) \in \Sigma(f)$, independently of other firms' plans.

V. Application to Border Adjustment Taxes

We conclude by drawing the connection between Lerner Symmetry and border adjustment taxes. Such taxes are standard in countries with a value-added tax. In the context of profit taxation, a border adjustment tax amounts to a reform that would allow firms to deduct export sales from their profits, while no longer allowing them to deduct import purchases. Such tax proposals have been recently discussed as part of a greater tax reform in the United States (see Weisbach 2017).

Consider the profits of a firm f operating in country i_0 , both before and after border adjustment tax. Suppose profits are subject to an ad-valorem corporate tax, $t_\pi > 0$, as well as perhaps some other taxes. Using our notation, the profits of a firm f operating in country i_0 before border adjustment tax is

$$\pi_{i_0}(f) = (1 - t_\pi) \sum_{j,k} \left[(1 + s_{i_0j}^k(f)) p_{i_0j}^k y_{i_0j}^k(f) - (1 + t_{j i_0}^k(f)) p_{j i_0}^k m_{j i_0}^k(f) \right].$$

After border adjustment tax, this becomes

$$\begin{aligned} \pi_{i_0}(f) = & (1 - t_\pi) \sum_k \left[(1 + s_{i_0 i_0}^k(f)) p_{i_0 i_0}^k y_{i_0 i_0}^k(f) - (1 + t_{i_0 i_0}^k(f)) p_{i_0 i_0}^k m_{i_0 i_0}^k(f) \right] \\ & + \sum_{j \neq i_0, k} \left[(1 + s_{i_0j}^k(f)) p_{i_0j}^k y_{i_0j}^k(f) - (1 + t_{j i_0}^k(f)) p_{j i_0}^k m_{j i_0}^k(f) \right]. \end{aligned}$$

This is equivalent to a uniform change in trade taxes with $\eta = 1/(1 - t_\pi) > 0$. Excluding direct imports and exports by households and assuming all firms importing and exporting from country i_0 are subject to corporate taxation, Theorems 1 and 2 apply.

VI. Concluding Remarks

Which policies are protectionist and which ones are not? Lerner's (1936) original insight, developed in the context of a simple neoclassical economy, is that an export tax and an import tariff are equally protectionist. In this paper we have provided a modern treatment of this classical result and established its robustness and limits along various dimensions.

Although we establish neutrality for fairly general technologies, preferences, and market structures, we do not view the assumptions in Theorems 1 and 2 as trivial. Multinational firms, in particular, account for a significant fraction of international trade. Our analysis suggests that moving from an export tax to an import tariff tends to incentivize these firms to expand domestic activities. In this sense, import tariffs may indeed be more protectionist than export taxes; border adjustment taxes may not be neutral; and the focus of the WTO on import tariffs and export subsidies rather than export taxes and import subsidies may be partly justified.

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