Unprotected Resources and Voracious World Markets

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Abstract

The Theory of the Second Best implies that any country with less-than-ideal resources can lose from international trade. Recently it has been suggested this means the South (poor countries) are better off suppressing trade with the North, especially trade in natural resource products, since the North has better developed rights to protect its natural resources. Here we show that the suppression of such trade may also impede the development of property rights in the South, but that even taking this into account, trade liberalization need not improve Southern welfare. We find that within a cone of world prices on the boundary of which lies the South's autarky price vector, welfare losses still occur even when local governments in the South make optimal choices to enclose the hinterlands. Corollary to the losses, the South can gain from tariffs or quotas and, within a proper subset of the cone of loss, can suffer when the prices of its exports rise.

Key Words: International Trade; Property Rights; Natural Resources; Environment; Second Best; Institutional Change; Development

JEL Classification Numbers: F02, F10, F18, K11, O10, O19

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Introduction

North-South trade—by which is meant trade between rich (North) and poor (South) countries—is, by most measures, less free than trade within either set of countries. The most trade-distorting policies in the North, for example, discourage the import of textiles and agricultural commodities, which would rank high among Southern export markets in a world of free trade. Partly as a result, there is less North-South trade compared to North-North trade than simple consideration of comparative advantages would lead one to expect (Helpman 1999). And whatever their intent, the demands in Europe and the United States that environmental and labor standards be used to block imports or foreign direct investment are likely, if accommodated, to increase the bias against North-South trade.

Chichilnisky (1994) has famously argued that this bias may be beneficial, both globally and to the South. The difference between the two sets of nations, she argued, is largely a difference in the efficiency of institutions. In a world where nations are otherwise identical, and otherwise satisfy the conditions for perfectly functioning market systems, she proved that the South ends up exporting the output of its poorly governed activities. More liberal trade thus causes the South increasingly to specialize in those sectors that are most plagued by institutional deficiency. This suggests the South is better off if specialization according to this source of comparative advantage is suppressed. If, as in Chichilnisky's model, the institutional difference driving trade is that natural resources in the South are exploited under open access conditions, then the appropriate intervention reduces export of Southern natural resource products. By extension, the failure of Southern societies to develop effective pollution policies could justify the protection of pollution-intensive industries in the North and barriers to Northern direct investment in the South. [1]

This paper examines a deep objection to that argument—that it treats institutions as though they were social endowments rather than social creations. In reality, of course, the enforcement of property rights or regulations requires resources (Demsetz 1969). Those choosing to allocate resources to enforcement must expect to gain at least as much by doing so as they would if the resources dedicated to enforcement were instead used to produce for markets. The process by which the South loses from trade (outlined below) is driven by an increase in the domestic price of whatever gets harvested from the open access resource, and as that price rises so does the reward to anyone expending the effort to control access. It seems likely that if the response to that incentive is optimal, the classic result that all nations gain from trade will be restored.

We show herein that this is not the case for one important class of property-rights formation systems. Specifically, we assume the act of property-rights formation is locally discrete, meaning a given parcel is either private property or open access; and that it is locally optimal, so that a parcel is private property (in equilibrium) if and only if the rents it generates are greater than the cost of turning it into private property; this process is known as "enclosure"

[1] Chichinisky did not actually prove that the South would lose from trade—only that its problem-ridden sector would grow. She believed she had proven it, but a close reading of the results to which she referred when asserting that the South is worse off actually demonstrated that Southern real income under trade was lower than Northern real income under trade—not lower than Southern real income under autarky. The possibility of actual losses has since been proven in particular contexts in Brander, J. and M. S. Taylor (1997). International Trade Between Consumer and Conservationist Countries, National Bureau of Economic Research Working Paper: 6006**:** 35. and Brander, J. A. and M. S. Taylor (1998). "Open Access Renewable Resources: Trade and Trade Policy in a Two-Country Model." *Journal of International Economics* **44**(2): 181-209. and for the case of all perfectly-competitive small-country worlds in Margolis, M. (2001). "Unprotected Resources and Voracious World Markets." *Economics and Finance*. Laramie, University of Wyoming..

(Cohen and Weitzman 1975).[2] Under these assumptions (and others made for analytical convenience) we show that for any country there exists a range of relative world-market prices (the cone of loss) within which that country will lose from trade. As is the case with property rights exogenous, the cone of loss consists of world prices causing the country to specialize in resource-intensive production, so that in a North-South world it is only the South that can lose.

It is natural to model this sort of property rights formation as the expansion of an ownership frontier through what we call a "hinterland": a set of natural resources that can be exploited independently of one another, and that vary in quality so that some may be worth owning while others are not (assuming property rights are costly to enforce). A hinterland in the usual sense - the land far from the civilization – is one example; quality in that case measures largely the cost of transportation to market centers. More generally, a nation's collection of fisheries, oil pools, or forests is a hinterland, with quality measuring costs of extraction and excellence of output.

To illustrate both the definition and the theory on which we build, consider a large grassland from which the output is wild grain, gathered in baskets. As more gatherers enter this grassland, each finds that she more frequently experiences the frustration of wandering into a region that has recently been harvested, so that harvest-per-gatherer declines as the number of gatherers increases. If the gatherers have no capacity to coordinate their actions, equilibrium occurs when the value of the grain each sells falls to the prevailing wage. If this grassland is small compared to the domestic economy, so that the removal of workers from other sectors does

[2] De Meza, D. and J. Gould (1994). "The Social Efficiency of Private Decisions to Enforce Property Rights." *Journal of Political Economy* **100**(3): 561-580. is the only previous general equilibrium model with the locally optimal enclosure rule of which we are aware. As did we, they built on Cohen, J. S. and M. L. Weitzman (1975). "A Marxian Model of Enclosures." *Journal of Development Economics* (1): 287-336. in which it was shown that even a social-income raising enclosure lowers wages. De Meza and Gould's was a one-country model only, with homogeneous land and the cost of enclosure constant in money rather than (as below) labor, but aside from that the one-country model below is almost the same as theirs. De Meza and Gould showed that the locally optimal enclosure rule does not in general result in the optimal level of enclosure. Instead, too much may be enclosed, as the rewards to enclosure end up including not only the increment it adds to social product, but also a bit redistributed from laborers. This over-enclosure, occurs under autarky in the model of this paper. Because there is not a DMG inefficiency under trade, however, over-enclosure does not play a role in determining whether real income rises with the world price of grain. A full discussion of the DMG behavior of this model can be found in Margolis (2000).

not change the wage then, at this equilibrium, the same national population gets the same income it would if the grassland were removed from the national economy. The rents the grassland could have provided are said, in this, case to have been "dissipated."[3] In our model, this pure, open access is a limiting case.

We depart from that limiting case by assuming hinterland workers can capture some of the dissipated rent through enclosure. A firm could do it, but enclosure is more realistically envisioned as an act of local government, perhaps created for just that purpose (North and Thomas 1973; Umbeck 1981). This renders somewhat artificial our assumption that enclosure decisions are locally optimal, since the systems of property rights created by these local governments are public goods[4]. A public good is more likely to be provided if the benefits from doing so exceed the costs, so the assumption may be thought of as a first approximation, but we have been motivated chiefly by the intuition that, if any assumption about enclosure would restore the classical gains from trade result, this would be the one. It would be of little interest to show that the deficiencies of local decisionmakers add up to a national deficiency. What we find is a national failure being generated by perfect local governments.

That a national deficiency which is itself unrelated to trade can make trade harmful is true quite generally. This follows from the theory of the second best, in which it is shown that a departure from perfectly competitive conditions in any one market renders the allocation of resources in all markets inefficient (Lipsey and Lancaster 1956).[5] Chichilnisky's case against North-South trade can be understood as combining the theory of the second best with the insight that international differences in institutional quality can yield a North-South trade pattern. That is

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[3] Rent dissipation has been thoroughly described by, *inter alia*, Gordon (1954); Hardin (1969); Dasgupta and Heal (1979); and Wenders, J. T. (1987). "On Perfect Rent Dissipation." *American Economic Review* **77**(3): 456-59.

[4] Although mechanisms have been designed that can yield optimal provision of public goods in theory, none is as simple, or as close to anything observed in history, as a competitive market for private goods.

[5] More precisely, R. G. Lipsey and K. Lancaster (1956) show that if there are n different uses among which a nation allocates its resources, there are n-1 independent conditions necessary and sufficient for the allocation to be Pareto efficient. Each of these conditions deals with one pair of resource uses, and states that the marginal rate of substitution between them must equal the marginal rate of transformation. What the theory of the second best says is that if any one of these conditions cannot be fulfilled, the remaining n-2 conditions are, in general, no longer consistent with efficiency.

why her results differ from those of Copeland and Taylor (1994) who explained the same North-South trade patterns on the basis of a model without market failures. In that model, the North is rich because it owns more human capital; because it is rich, it demands more environmental quality, which is achieved through government decision to issue fewer pollution permits; and because permits are scarce in the North, the South specializes in dirty industries. In Copeland and Taylor (1994), losses from trade are not possible.

The application of the theory of the second best to the gains from trade question is, in fact, one of the earliest statements of that theory (Pareto 1909; Bohm 1987) and many of the theoretically valid arguments against free trade are instances of this insight.[6] Our argument goes beyond second-best reasoning, because in our model there is no institutional failure—just a cost to protecting property rights. It seems likely that at least some of the other arguments for trade intervention can also be extended beyond their origins in the second-best world to cases in which the underlying failure can be fixed at cost.

Hotte, Long, et al. (2000) made the only previous attempt to address this phenomenon, and they, too, find an example of "immiserizing trade." Both property rights formation and resource exploitation were treated dynamically in that model, resulting in so rich a set of behaviors that nothing could be demonstrated except by numerical example. Our static model, although less descriptively satisfying, is better suited to illustrate the central intuition and the deep connection to second-best theory, and allows us to prove a more general result—that there must always be a (non-null) cone of loss for any country with unenclosed hinterland.

The remainder of the paper is organized as follows. Section 2 defines a baseline model and presents the benchmark thesis that trade hurts the South under exogenous property rights. Section 3 explores the robustness of this benchmark once we allow property rights to be endogenously selected by the South. Section 4 contains concluding comments.

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[6] See Krishna, P. and A. Panagariya (2000). "A Unification of Second Best Results in International Trade." *Journal of International Economics* **52**(2): 235-57. and Gordon, R. L. (1994). *Regulation and Economic Analysis: A Critique Over Two Centuries, Topics in Regulatory Economics and Policy Series*. Boston and Dordrecht: Kluwer Academic..

The Baseline Model and Comparative Benchmark

The model we use as baseline is a dual[7] to Chichilnisky (1994) and more general in that it allows for any number of traded goods, as long as there are at least two. The level of enclosure is exogenous, and is set higher in the North than in the South. The two sets of nations are otherwise identical. Grain, the output of the hinterland, is used as an input to domestic production. Except for open access on the hinterland, the economy has a complete set of perfectly competitive markets. The allocation of grain among sectors is optimal, as is the allocation of remaining labor after grain is produced. We also brush aside a theoretical curio (Margolis 2001) by assuming grain supply is well-behaved—cheaper grain, or cheaper wages, increases the allocation of labor to the hinterland. This model encompasses a wide variety of institutional failures.[6]

Households have identical and homothetic preferences. Consumers therefore maximize a social utility function identical to the household utility function, subject to the constraint that total spending not exceed social income. We represent this using the dual to the social utility function, the social expenditure function $x(\mathbf{p},u)$, where $\mathbf{p}$ is the vector of consumer goods prices and u the level of social utility; assume $x(\mathbf{p},u)$ is increasing, linearly homogenous and concave in prices and increasing in utility; and the derivative with respect to any given price is the quantity demanded of the corresponding good (Dixit and Norman 1980).

All the outputs are produced by combining two inputs: labor, n, and grain, g. Labor is available in the fixed endowment $\overline{N}$. Grain is an intermediate input, which is produced by applying labor to land. Land itself does not appear as a variable; rather the scarcity of land is represented by diminishing returns in the production of grain. Labor and grain are used to produce a vector of consumer goods $\mathbf{y}$, of the same dimension as $\mathbf{p}$. Define n^G as the labor used to harvest grain, and n^R as the amount remaining for use in the consumer goods sectors.

[7] In general, two models are said to be dual if they are alternative representations of the same process. In economics, it is traditional to refer to models that depart from production functions as "primal" and to alternatives that embed the production function into something else—such as a cost function, or in this case a national revenue function—as the "dual."

The sectors producing **y** are thus allocating n^R and G, which would be called factor endowments if they weren't endogenous. Let $Y(n^R, G)$ be the set output combinations that can be produced from n^R and G. Assuming perfectly competitive markets, firms' output choices maximize the market value of output, $\mathbf{p} \cdot \mathbf{y}$, subject to the condition that **y** can be produced, taking **p** as fixed. The behavior of this set of markets can thus be represented by the national *revenue function*

$$R(\mathbf{p}, n^R, G) = \max_{\mathbf{y}} \{\mathbf{p} \cdot \mathbf{y} : \mathbf{y} \in Y(n^R, G)\}$$

We now adopt a set of assumptions, probably stricter than necessary, that make possible the use of a powerful body of received theory. First, assume all technology is linearly homogeneous and there is no joint production of consumer goods. Then the revenue functions is increasing, concave, and linearly homogeneous in price (**p**) and in the pair (n^R,G); its first derivative with respect to the i^{th} element of **p** is the quantity produced of commodity i; the derivative with respect to n^R is the (demand) wage; and the derivative with respect to G is the (demand) price of grain (Woodland 1982; Dixit and Norman 1980).[7]

Second, assume there are no factor intensity reversals[8] in any technology and that each country produces at least two goods (because there are two factors). Then the prices of labor and grain are functions only of the prices of tradable goods, **p**, and not of the quantities of the inputs or any other endogenous variable (Blackorby, Schworm et al. 1986). Combined with the last of the four envelope results above, this implies the partial derivatives of the revenue function with respect to n^R and G are functions of **p** only, and can be written $R_G(\mathbf{p})$ and $R_n(\mathbf{p})$.

The ratio of those two factor prices determines the allocation of labor between n^G and n^R. Let the production function for grain be $G = F(n^G)$, where F is assumed increasing and strictly concave. If all land were privately held, the amount of grain production is chosen to solve $\max_{n^G} \{R_G(\mathbf{p})F(n^G) - R_n(\mathbf{p})n^G\}$, yielding the first order condition

$$\frac{R_n(\mathbf{p})}{R_G(\mathbf{p})} = F'(n^G) \qquad (1)$$

Rent dissipation occurs when more labor is allocated to the hinterland than the level that satisfies (1). Because marginal product declines, this means that, at a rent dissipating equilibrium, the factor price ratio R_n/R_p is above $F'(n^G)$. We capture this by assuming a function $\Phi(n^G)$ exists that gives, for each level of n^G, the ratio of grain price to wage which results in n^G units of labor on the hinterland.

$$\frac{F(n^G)}{n^G} \geq \Phi(n^G) > F'(n^G) \forall n^G \tag{2}$$

In the case of complete rent dissipation, $\Phi(n^G)$ is the average product curve, which is decreasing in n^G. Assume $\Phi'\left(n^G\right) < 0$ even when rent dissipation is partial. The extent to which institutional conditions allow rents to be dissipated is represented by the size of the gap between Φ and F. The equilibrium condition determining n^G is, by definition,

$$\frac{R_n(\mathbf{p})}{R_G(\mathbf{p})} = \Phi(n^G) \tag{3}$$

Factor price inelasticity implies the left side is constant in n^G, and the right hand side is a decreasing function of n^G, so at most one interior solution exists. With n^G determined by (3), n^R is fully determined by the full employment requirement and G by the production function F.

A country is characterized as a fixed population $\bar{N}$; the tastes of that population, represented in $x(\mathbf{p},u)$; a revenue function R summarizing all technologies in the consumer goods sectors; a function F summarizing grain-production technology and land endowment; and a function Φ which contains the information in F plus a measure of property rights failure. The endogenous variables are the labor allocations n^R and n^G; the grain output G; the consumer goods output vector **y**; the prices of those goods **p**; and the social utility level u. We have shown how all of these are determined except for p and u.

Under free trade, prices are set on world markets, which for a small country renders **p** exogenous. The social utility level is determined by $R(\mathbf{p},n^R,G)=x(\mathbf{p},u^T)$, and is the highest level that can be bought with the social income R. The solution to social utility is unique because R is strictly concave and x is strictly convex (**p** is a bounding hyperplane), which completes the model for an open economy.

Under autarky, the model is completed with the requirement that domestic markets clear $R_{\mathbf{p}}(\mathbf{p}, n^R, G) = x_{\mathbf{p}}(\mathbf{p}, u^A)$. Subscripts still indicate the gradient in price space of the subscripted function, and u^A refers to the particular level of social utility that obtains in autarkic equilibrium. Given there are as many equations as there are consumer goods, this closes the model by determining the equilibrium price vector **p**.

In this framework Margolis (2001) proves the following:

Benchmark theorem: *In a world of otherwise identical countries with exogenously determined property rights, let $\Phi(n^G)$ differ between, but not within two sets of, nations —North and South—such that the $\Phi(n^G)$ function in the South lies everywhere above that in the North. Under free trade*

1) *The North has higher income than the South.*

2) *The North is a net importer of the services of the hinterland, and a net exporter of the services of labor. The South is a net importer of the services of labor, and a net exporter of the services of the hinterland.*

3) *The North always gains from trade.*

4)*The South loses if the world price is within the "cone of loss", which is a convex set of price vectors bounded by a ray through the autarky price vector.*

The benchmark theorem is illustrated in Figure 1 for the case of a two good world, where good one is more grain-intensive than the other (numeraire) good. R gives national income as a function of the price of good one; **x** gives the cost of achieving the autarky utility level. These two are, of course, equal at the autarky price, since the autarky level is the best that can be bought with the autarky income at the autarky price. In a country with no market failures (that is, where $\Phi = F'$) the two curves are tangent at the autarky price. This is because the slope of R is the quantity produced of good one, the slope of **x** is the quantity consumed, and, in autarky, those quantities are equal. This tangency means there is no price for which $\mathbf{x}(p_1)>R(p_1)$.

With rent dissipation on the hinterlands ($\Phi > F'$), the revenue and expenditure curves cross at the autarky price, because the revenue function is flatter. Intuitively, this is because part of the income gain from a price increase is lost to dissipation. A price interval, therefore, exists to the right of the autarky price for which social revenue is insufficient to buy any bundle of goods providing the autarky level of equilibrium. This is the cone of loss (the shaded area in Figure (1), Part 2) of the benchmark theorem establishes that the world price must be to the right of the South's autarky price, so that it may be in the South's cone of loss but never the North's. It is also possible for the world price to be beyond the South's cone of loss, in which case no country loses from trade.

If the world price is within the Southern cone of loss then the South can gain from a positive tariff. In Figure 1, a Southern tariff would be represented as a domestic price somewhat to the left of the world price, since the South imports the numeraire. The optimal tariff for the South will be close to the prohibitive tariff (which makes the domestic price equal to the autarky price) since losses from trade occur in the neighborhood of the autarky price.[8] Note also that, near the right-side boundary of the cone of loss, a small tariff is harmful even though a large one is still good. And in the left-hand region of the cone of loss, a world price change that would be called an "improvement" in the South's terms of trade will actually leave the South worse off. These benchmark results—losses from trade, a positive optimal tariff, and perverse terms of trade impacts—appear in many contexts, and always appear together because all three are aspects of the theory of the second best. Any market failure, in this case open access on the hinterland, creates a region in price space with these characteristics.

If a policymaker under the influence of these benchmark results were to impose a tariff, quota, ban or any other sort of impediment to international trade, it would function by driving down the domestic price of grain. Lower grain price means less potential rent on the hinterland, so less gets dissipated. But a lower grain price is also likely to discourage hinterland residents from investing in the institutional developments required to capture that rent. The second-best solution may thus prevent the implementation of the first best solution. This is the problem to

[8] We do not know whether it is possible for the revenue gained from a small tariff to offset the losses from trade, so we cannot state as proven that the optimal tariff is actually prohibitive.

which we now turn. We will show that when enclosure is endogenous, trade intervention does indeed slow institutional development; but there is still a cone of loss, and thus still prices at which intervention can be justified.

Trade with endogenous property

The One-Country Model

There are two goods. Cloth, the numeraire good, is produced using only labor, assuming a fixed-coefficient production function. Let N_c represent the amount of labor dedicated to cloth production, a_c the amount of labor needed to produce one unit of cloth and C total cloth produced, such that

$$N_c = a_c C \tag{4}$$

Perfect competition for labor implies the unit cost of cloth production must equal its price. Defining w as the wage, this implies

$$w = \frac{1}{a_c} \tag{5}$$

The only factor other than labor is land, which varies systematically in quality. Let $q(\ell)$ denote the quality of the ℓ^{th} parcel of land. For convenience, the size of the parcel is infinitesimal and land is indexed by the real numbers [0,L]. Without loss of generality these are ordered such that $q'(\ell) \leq 0$.

Land and labor are used to produce grain, G. Assume production is multiplicatively separable in land quality and labor, such that the output from parcel ℓ is:

$$g(\ell) = q(\ell)\phi\left[n(\ell)\right] \tag{6}$$

where $n(\ell)$ is labor allocated to production on parcel on ℓ, and $\phi(n)$ is increasing and strictly concave. Total grain output is then

$$G = \int_0^L q(\ell)\phi\left[n(\ell)\right]d\ell \tag{7}$$

Let p be the price of grain. If a parcel is enclosed, its owner maximizes rent, $\rho(\ell)=pg(\ell)-wn(\ell)$, subject to (6). The resulting first order condition gives labor demand, $n^*(\ell)$, that satisfies

$$pq(\ell)\phi'\left[n^*(\ell)\right] = w \tag{8}$$

Equation (8) expresses the familiar condition that the competitive wage equals the value of marginal product.

Any worker is free to produce grain on open land, and to keep an amount of grain proportional to the amount of labor he applies to the parcel. Only enclosure can restrain workers from exploiting the land. This leads to the usual full-rent-dissipation condition for equilibrium of an open access resource, which is that the value of average product equals the wage. Defining $\hat{n}(\ell)$ as the (endogenous) population that fulfills that condition on parcel ℓ

$$pq(\ell)\phi[\hat{n}(\ell)]=w\hat{n}(\ell) \tag{9}$$

Assume the amount of labor required to enclose one parcel is fixed at a level denoted E. Since the aggregate gains from enclosing a parcel are $\rho(\ell)$, the locally optimal enclosure rule is to enclose if and only if $\rho(\ell) > wE$. The following lemma establishes that a marginal parcel, ℓ^*, exists such that land between parcel 0 and ℓ^* is enclosed and land beyond ℓ^* left open.

Lemma 1: $\rho'(\ell)<0$ if $q'(\ell)<0$, and $\rho'(\ell)=0$ if $q'(\ell)=0$. Therefore, there exists an ℓ^* such that $[0,\ell^*]$ is enclosed and $(\ell^*, L]$ is open.

Proof: See appendix.

Assuming an interior ℓ^* and continuity of the quality gradient, the definition of ℓ^* requires[9]

$$\rho(\ell^*) = wE \tag{10}$$

The landlord's first order condition (8)determines the labor density up to ℓ^*. Beyond ℓ^*, the full rent dissipation condition (9) determines labor density. Full employment of labor requires

$$N_C + E\ell^* + \int_0^{\ell^*} n^*(\ell, w, p)d\ell + \int_{\ell^*}^{L} \hat{n}(\ell, w, p)d\ell = \bar{N} \quad (11)$$

spent by landlords in meetings to form local governments.[10] The third term, the integral from zero to ℓ^*, is the workforce employed by those landlords to gather grain; and the integral from ℓ^* to L is the workforce on the open-access land.

Finally, all households in the world possess the same homothetic preferences, which is expressed in the expenditure function

$$x(p, u) = \min(C + pG) \text{ s.t. } U(C, G) \geq u \quad (12)$$

where U(C,G) is the utility function.

Under free trade, (16) through (23) determine G,C,ℓ^*, and the labor gradient $\{n(\ell)\}$on the basis of p, N,a_c, and $\{q(\ell)\}$. In autarky, equilibrium occurs where the grain market clears

$$G = x_p(p^A, u^A) \quad (13)$$

and social income equals expenditure

$$pG + C = x(p^A, u^A) \quad (14)$$

Next we derive the equilibrium conditions that apply for a small country under free trade.

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[9] We have little to say about the corner solutions, in which ℓ^*=0 or ℓ^*=L (the whole land endowment). The former case is pure open access, and thus a parameterization of the model posed in Section 2. The latter is pure private ownership, and hence a parameterization of the standard trade model.

Small Country Equilibrium

Assuming the price is fixed (the small country assumption), equations (4)-(11) jointly determine the supply of cloth and grain (G and C), the enclosure level (ℓ^*), the population gradient ($n(\ell)$), the wage (w) and the rent gradient $\rho(\ell)$. The values of those variable derived with prices exogenous will be denoted by a superscript T, for trade, and constitute predictions for the behavior of the economy under free trade, assuming the country is small and that the world prices fall within its cone of diversification (an interval of p). We first consider the economywide impact of the enclosure decision, and then quantify the impact on that decision of a change in the price of grain. We then bring these calculations together to derive the supply curves for grain and cloth.

How enclosure affects the economy depends on the shift in labor. Enclosing a parcel always means employing fewer farmers and more police. The following lemma establishes that enclosure of the marginal parcel results in a net saving of labor.

> **Lemma 2**: The difference in labor density under ownership regimes, $\hat{n}(\ell) - n^*(\ell)$, is a declining function of ℓ and is greater than E at ℓ^*.

Proof: See Appendix.

Intuitively, enclosure of ℓ^* produces no rent net of enclosure cost, which is what makes it the marginal parcel. If there were no labor savings net of the labor used in enclosure, then the enclosure of the marginal parcel would be a losing proposition, because less output is produced after the parcel is enclosed.

Now consider the impact of price on property rights formation. As long as the economy is not completely specialized in grain production, expression (5) holds, and the nominal wage is constant. Since E is constant by construction, $\rho(l^*)=wE$ only remains true as p changes if

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[10] This is because the enforcement and organizing time add up (by assumption) to E on each parcel, so the total is E times the number of parcels enclosed.

$\frac{d\rho(l^*)}{dp}=0$, which can only be assured by adjustment of l^*. Expanding $\frac{d\rho(l^*)}{dp}=0$ yields

$$\frac{d\rho(l^*)}{dp}=g(l^*)+\left(pq(l^*)\phi'\left[n^*(l^*)\right]-w\right)\frac{dn^*}{dp}$$
$$+\left[pq'(l^*)\phi\left[n^*(l^*)\right]+\left(pq(l^*)\phi'\left[n^*(l^*)\right]-w\right)\frac{dn^*(l^*)}{dl^*}\right]\frac{dl^*}{dp}=0$$

The first term in the expanded derivative is the amount of grain produced on the marginal parcel. The next measures the impact on rent of the labor change on the marginal parcel induced by a price change. Higher p means higher $n^*(l)$ which increases revenue—which is the first term in the coefficient—and cost, which is the second.

The term in square brackets measures the influence of the price-induced shift in l^*. The first term within those brackets measures the revenue change as one moves down the quality gradient; the second measures the indirect impact at l^* on both revenue and cost through the labor market. This term has exactly the same coefficient as the derivatives of $n^*(l)$ with respect to p, and this common term is zero from (9). Thus

$$\frac{d\ell}{dp}=-\frac{g(\ell^*)}{pq'(\ell^*)\phi\left[n^*(\ell^*)\right]}>0 \tag{15}$$

where the sign follows because $g(\ell)$, p and $\phi[n]$ are all positive and $q'(\ell)<0$. This shows that for a small country, an increase in the price of grain causes greater enclosure.

Now consider the endogenous enclosure supply curves. The supply curve for grain has slope

$$\frac{\partial G^T}{\partial p}=$$
$$-\int_0^{\ell^*}\frac{q(\ell)\left[\phi'\left(n^*(\ell)\right)\right]^2}{p\phi''\left(n^*(\ell)\right)}d\ell-\int_{\ell^*}^{L}\frac{\left(q(\ell)\right)^2\phi'\left[\hat{n}(\ell)\right]\phi\left[\hat{n}(\ell)\right]}{pq(\ell)\phi'\left[\hat{n}(\ell)\right]-w}d\ell+\frac{g(\ell^*)q(\ell^*)\left(\phi\left[\hat{n}(\ell^*)\right]-\phi\left[n^*(\ell^*)\right]\right)}{pq'(\ell^*)\phi\left[n^*(\ell^*)\right]} \tag{16}$$

which is calculated by totally differentiating (6)-(11), removing terms made zero by (8)and (9), and rearranging.

The first term on the left-hand side captures the impact of landowner production decisions on supply, and has a positive sign.[11] The second term reflects the impact of laborer decisions to work the open access land, and is negative.[12] The third term shows the impact of the enclosure decision, and is novel. The numerator is total output from the marginal parcel (if enclosed) multiplied by the difference in output on that parcel caused by enclosure. The total output term scales the impact—it is more significant to enclose highly productive land. The denominator is approximately the gradient (slope in ℓ) of the value of output conditional on land being enclosed. The steeper this gradient, the smaller the impact of the whole term, reflecting that less new enclosure follows a price increase if land quality is falling off quickly. Because $\hat{n} > n^*$ and $\phi'(n)>0$, the bracketed difference in the numerator is positive. Every other element of the third term is also positive except $q'(\ell)$. Therefore, the third term is negative.

The negative third term makes the sign of the slope of grain supply ambiguous. Consider a segment of land on which the quality gradient is very flat, indicating that much of the land is of about the same quality. The first two terms in the supply curve slope are unaffected, but the third becomes infinite as $q'(\ell)\to 0$. Hence, the grain supply curve may have downward sloping segments, corresponding to flat quality regions of the gradient.

The slope of the cloth supply curve should be negative in p, since p is the inverse of the price of cloth. Substituting from the total derivative of (8) into that of (5)and setting all differential terms other than dC and dp to zero

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[11] On each enclosed parcel, the slope of the supply curve has the usual form of the squared marginal product over price times the second derivative of the production function (times –1.) These are summed over all enclosed parcels in the first integral. Every element of the integrand is positive except $\phi''[n^*(\ell)]$. The integrand is therefore negative at each ℓ, and the minus sign in front makes the whole term positive.

[12] Here, too, the integrand has the general form of a supply function slope, in this case the supply function of an open access resource with complete rent dissipation: marginal times total product over the difference between the value of marginal product and the value of the outside option (again time –1.) The numerator consists of all positive terms. The denominator is $\partial\rho(\ell)/\partial n(\ell)$ - the derivative with respect to labor of rent on parcel ℓ. By (20), $\partial\rho(\ell)/\partial n(\ell)=0$ at $n^*(\ell)$. Because $\hat{n} > n^*$ (more people work land if access is not controlled) and $\partial^2\rho(\ell)/\partial[n(\ell)]<0$, $\partial\rho(\ell)/\partial n(\ell)<0$ at $\hat{n}$. Each integrand is therefore negative, and so is the integral.

$$\frac{\partial C^T}{\partial p} = w\left[\int_0^{\ell^*} \frac{\phi'\left[n^*(\ell)\right]}{p\phi''\left[n^*(\ell)\right]} d\ell + \int_{\ell^*}^{L} \frac{q(\ell)\phi\left[\hat{n}(\ell)\right]}{pq(\ell)\phi'\left[\hat{n}(\ell)\right] - w} d\ell + \left(\hat{n}(\ell)\text{-}n^*(\ell)\text{-}E\right) \frac{g(\ell^*)}{pq'(\ell^*)\phi\left[\hat{n}(\ell^*)\right]}\right] \quad (17)$$

Everything inside the large square brackets is a shift of labor, multiplied by w. The integrals are shifts into grain production, and are negative. The terms in parentheses, which multiplies the third term, is positive by Lemma 2, so this supply curve, too, is ambiguous.

The World Economy Model

North, South, and the pattern of trade

Consider a world of identical consumers and nations described by the above model. Trade can emerge in such a world if there is any international difference in endowments, N and $\{q(\ell)\}$; in technology, a_c and $\{\phi(n)\}$; or in enclosure cost, E. We focus on the last, which is the only one novel to this model and sufficient to illustrate the points. It should be noted, however, that the traditional Heckshire-Ohline results relating trade flows to endowments, or Ricardo's result relating trade flows to technology, will not always hold. If trade prices wind up in the back-bending segment of the supply curves, a country with more labor than its trading partners could end up exporting grain. But such equilibria are unstable.

Enclosure costs may differ among nations because institutional histories differ—legal precedents, for example, may render the citizens of one nation more confident that the federal authorities will respect local property systems. For another example, if it costs more to patrol a larger area, E is higher in countries with less fertile land, because a larger parcel is required to get the same production function $\phi(n)$. Alternatively, E may be larger because the resource is more difficult to monitor, i.e., an aquifer that bubbles into many surface springs relative to one that rises into few.

Theorem 1 establishes that the differences in enclosure cost are indeed of the North-South type—the North is richer and encloses more land; the South is poorer and encloses less land.

Theorem 1: In a world of otherwise identical countries, let E differ between, but not within, two sets of nations, North and South, such that the $E^S > E^N$. Under free trade, the North has higher income and more land enclosed than the South. (Proof: See Appendix.)

We now show the direction of trade is ascertained by appealing to the general principle of comparative advantage—a good flows into those countries where its relative autarky price is high (Dixit and Norman, 1984). This makes the direction of trade a question for the comparative statics of enclosure costs, E.

We will first show that $\frac{\partial p^A}{\partial \ell^*} > 0$. Recall that autarky equilibrium occurs where the grain market clears and social income equals expenditure. The cloth market clearing condition has nothing interesting to tell us, because demand for a numeraire has no interesting expenditure function interpretation. It is in any case redundant—the emergence of Walras' law. The amount of cloth demanded is social income minus what is spent on grain; with social income as pG+C, this trivially assures C=pG+C-pG. The two conditions above determine the two variables u^A and p^A.

To see what difference these conditions make, it is useful to drop temporarily the enclosure equilibrium condition (10)and to consider the fixed-enclosure grain supply curve, $G^F(p;\ell^*,\{q(\ell)\},N,E)$—that is, the supply curve derived under the assumption that no new property rights are created. The purpose of doing this is to bring together the whole set of factors influencing rent in autarky—which includes domestic demand—into a single rent function comparable to $\rho^T(\ell^*)$. Using the fixed enclosure supply function breaks the slope of grain supply into two parts: the direct impact of price and the enclosure-mediated impact.

$$\frac{\partial G^T}{\partial p} = \frac{\partial G^F}{\partial p} + \frac{\partial G^T}{\partial \ell^*}\frac{\partial \ell^*}{\partial p} \tag{18}$$

Again partitioning (7) at ℓ^* and applying Leibnitz rule gives

$$\frac{\partial G^F}{\partial \ell^*} = q(\ell^*)\left(\phi\left[n^*(\ell^*)\right] - \phi\left[\hat{n}(\ell^*)\right]\right) < 0$$

Differentiating the grain market clearing condition (13) with respect to ℓ^*, using the decomposition of grain supply (18) gives

$$\frac{\partial G^F}{\partial \ell^*} + \frac{\partial G^F}{\partial p}\frac{\partial p^A}{\partial \ell^*} = x_{pp}(p^A, u^A)\frac{\partial p^A}{\partial \ell^*}$$

That is, the direct impact of a change in ℓ^* on grain output, plus the price-mediated impact, must equal the (price-mediated) impact on grain demand. Rearranging,

$$\frac{\partial p^A}{\partial \ell^*} = \frac{\dfrac{\partial G^F}{\partial \ell^*}}{x_{pp}(p^A, u^A) - \dfrac{\partial G^F}{\partial p}} > 0 \tag{19}$$

The sign follows because x_{pp} is the slope of a compensated[13] demand curve, hence negative; the term subtracted from it is positive; and the numerator is negative.

Theorem 2: Under free trade, the North imports grain and the South imports cloth.(Proof: See Appendix.)

The thin, superscripted S curves in Figure 2 are North and South supply curves for grain, G^T, and the D curves are demand (x_p). Southern supply lies to the rights of Northern supply, because grain supply rises as a function E. Because the North is richer, its demand lies to the right of Southern demand. The world price, p^w, is that which equates world supply and demand, the horizontal sums of the national curves. At this price, the North imports G^3-G^1 units of grain, and the South exports G^2-G^0. These two quantities must equal given world supply equals world demand, ($G^1+G^2=G^0+G^3$).

Theorems 1 and 2 show that international differences in the cost of enclosure help explain both the income differences that define the North-South axis, and the resource-intensive nature of Southern exports. These results suggest that the trade pattern findings with exogenous property rights in the baseline case are unchanged when we allow for endogenous enclosure. We now explore whether, as in those models, trade may be harming the South.

Optimality

If price is exogenous, national income is given by

$$R\left(p;\{q(\ell)\},a_c,N,E\right)=pG^T\left(p;\{q(\ell)\},a_c,N,E\right)+C^T\left(p;\{q(\ell)\},a_c,N,E\right)$$

R(p;{q(ℓ)},a_c,N,E)) is the free trade revenue function. We state the optimality results as the derivative of the free trade revenue function with respect to the price of grain, which measures the change in nominal income earned by a nation that begins to export grain at a world price slightly above its autarky price. The change in nominal income necessary to compensate national consumers for that slight price increase is the slope of the expenditure function, which, by the envelope theorem, is the quantity of grain demanded. In the neighborhood of the autarky price, if $R_p > G^A$ (autarky equilibrium grain consumption), a country gains by exporting grain, and loses from importing grain. We now show that unless all land is enclosed, $R_p<G^A$, which implies that, in the neighborhood of the autarky price, exporting grain earns a nation less than the loss to consumers from the higher grain price.

Expanding R_p using the endogenous enclosures supply curve slopes (16) and (17) yields, after a few steps of algebra,

$$\begin{aligned}R_p &= G^T+\int_0^{\ell^*}\frac{\phi'\left[n^*(\ell)\right]}{p\phi''\left[n^*(\ell)\right]}\left\{w-pq(\ell)\phi'\left[n^*(\ell)\right]\right\}d\ell\\&+\int_{\ell^*}^{L}\phi\left[\hat{n}(\ell)\right]q(\ell)\frac{w-pq(\ell)\phi'\left[\hat{n}(\ell)\right]}{pq(\ell)\phi'\left[\hat{n}(\ell)\right]-w}d\ell\\&+\frac{g(\ell^*)q(\ell^*)}{q'(\ell^*)\phi\left[n^*(\ell^*)\right]}\left\{\phi\left[n^*(\ell^*)\right]-\phi\left[\hat{n}(\ell^*)\right]\right\}\end{aligned}\qquad(20)$$

The first integral on the right-hand side captures the impact of a price change on land-owner production decisions. It vanishes, parcel by parcel, because the term in angle brackets is

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[13] It would make more sense to use uncompensated demand here, but what we are calculating is the slope for first order changes. The only feature used here is that demand slopes down, which is true for uncompensated, too, except for Giffen goods. The expenditure function is useful for gains from trade results, and we'd just as soon stick with it rather than add more notation.

zero by (8). This follows because, on enclosed land, the value added by a laborer just equals the value that laborer would add to cloth, so that expansion on this land has no first-order impact on revenue. In the second integral, the ratio is –1, while the remainder of the integrand is g(ℓ). The integral is negative, reflecting the reduced income as labor moves to open land from the cloth sector, where it was more productive.

The contribution of the last term is also unambiguously negative: the part in angle brackets is negative because the open access equilibrium has more labor on the land than the optimum for all prices, and everything in the ratio is positive by construction. This is a result of Lemma 2—all rents from enclosing the marginal parcel are absorbed in the costs of enclosure. Thus, while the sign of R_p is ambiguous, we know that $R_p < G^T$. Intuitively, R_p equals the grain produced on private land minus the grain output lost by diverting workers to enclosure activities on the marginal parcel. This is sufficient to establish the following important result.

Theorem 3: If the difference between autarky prices and the world price is first order small, and ℓ^*<L in the South, then the North gains from trade and the South losses. Proof: For the North, trade is movement to a lower p, for the South to a higher p. For first-order changes in price, the cost of achieving the autarky utility level is measured by the derivative with respect to p of the expenditure function, $x_p(p^A, u^A)$. By the envelope theorem, $x_p(p^A, u^A)$ is grain demand in autarky, so $x_p(p^A, u^A) = G^T(p^A)$ or the grain market doesn't clear. We have just shown that $R(p) < G^T(p)$ for all p within the cone of diversification. Hence, $R(p^A) < x_p(p^A, u^A)$. Thus a move to p slightly above p^A increases the cost of achieving the autarky utility level by more than it increases income, while a slight fall in p reduces the cost of autarky utility by more than it reduces income .

Theorem 3 says the South must lose from trade if the world price is the smallest possible increment above the autarky price.[14] Equally, there must exist an interval (p^A,p^0) such that if the world price is in that interval, the South loses. But the theorem does not establish that the world price will always be within that interval, nor do we believe that it must be. As in Section 2, the second order curvature of the expenditure and revenue functions is such that they bend back towards one another after the intersection at the autarky price, which suggests a finite p^0, and thus the possibility that gains from trade will be restored if the price of grain goes high enough.

Geometrically, this loss is captured in the relative slopes of the revenue and expenditure functions in Figure 3, which is exactly like Figure 1 except that units are now measured in the numeraire (cloth) rather than in the abstraction of dollars. The interpretation is the same: there is a cone of loss bounded by the autarky price. How much harm trade does to the South is measured by x_p-R_p—the faster the gap between expenditure and revenue grows, the more harmful trade.

Conclusions

The idea that the poor suffer from trade with the rich is venerable, going back at least to Marx's model of trade between classes[15] through the import substitution advocates of the post-depression era[16] of whose trade barriers vestiges remain. What we examine here is a rigorous version of a relatively new take on that venerable idea. In this view, the very efficiency of the markets and technologies at the center of the world economy—what we call the North—becomes

[14] What is so special about autarky? If we take the trade-distorted status quo as p^A and change interpretation of all other "autarky" levels accordingly, the expenditure and revenue functions still cross at p^A , but the expenditure function slope is not longer G^T as above; it is instead G^T - grain exports. The revenue slope is unaffected. The question, then is whether, the terms subtracted from G^T in (20) exceed grain exports. It is unlikely that either result obtains in general, because there is no generalization of the relation between slopes of expenditure and revenue functions that exists in autarky for models without market failure – in those models, recall, equality of those slopes is the autarky market clearing condition. Away from the autarky price, the revenue function is steeper than the (equilibrium utility level) expenditure function in the export dimensions, capturing the increase in real income that comes from a terms of trade improvement.

[15] Which was recast as trade between nations by, *inter alia*, Frank, A. G. (1995). The Development of Underdevelopment. *The international political economy and the developing countries. Volume 1*. Baran, P. A. (Ibid.). On the Political Economy of Backwardness.)

[16] See Krueger, A. O. (1997). "Trade Policy and Economic Development: How We Learn." *American Economic Review* **87**(1): 1-22. for an excellent review of this movement.

a threat to the people of the South. The South's failure, for example, to regulate the disposal of mine tailings would loom less large if it did not import from the North the shipping and financial services that make marginal minerals worth pursuing, and export in return a large share of the output. In its broadest form, the question this paper addresses is whether this threat to the unprotected resources of the South can be so grave as to make trade harmful.

The answer is yes, when the South's institutional failure is rent dissipation on the hinterlands—even if exploiters of the hinterland are assumed to enclose parcels whenever the rents justify the costs. We stress, however, that the net loss from trade is only a possible, not a necessary, result of the export of hinterland resources. Our results hold only to the extent that the actual structure of the world economy resembles our North-South models and world prices fall within the range for which those first-order losses dominate. Both limits should be taken seriously.

First, our South is probably not quite the same set of countries as, say, the set of countries classified as underdeveloped by the World Bank. The defining feature of our South is that its land is less protected by property rights to protect the land. And while the South so defined is also poorer than the North, which corresponds to the South in the usual sense, this only need be so if all else is equal. The direction of trade, and the possibility of losses from trade, depend only on the relation between autarky and world prices, which, in reality, are influenced by variations in factor endowments, technology, and tastes. If a country is rich because, say, its citizens are full of human capital, but trades with a world that demands the output of its hinterland, then by our results it is South – it could lose from trade.

An alternative interpretation of our normative results is to justify policies directed at the protection of a single resource. The second limitation, however, increases the difficulty of designing those policies. Losses occur only within a limited range of prices. Therefore, simply observing that a nation exports hinterland resources is insufficient to justify the claim that reducing those exports will raise income. How truly formidable a task such justification would be can only be appreciated when one reflects on the pervasiveness of market failure. Losses for the South occur because resources are reallocated from functional to dysfunctional sectors. In order to apply this theory for the benefit of the South one would have to know which sectors suffer most from market failures. A trade intervention that reduces pressure on the forests of the South, for instance, does so in part by driving labor into manufacturing, where it adds to air pollution. The benefit-cost analysis required to track all such effects would be substantial.

The North-South worldview offers a way around this immense need for data. If a nation believes itself to be especially filled with institutional malfunction, it can erect generalized barriers to trade. This is doubtless more wisely done as a group of nations, in order to take advantage of economies of scale and traditional sources of comparative advantage. It is also, arguably, what the real-world North has forced on the South in its efforts to protect agriculture and sectors that employ unskilled labor; and what the South has been left with from its own import-substitution policies. Should this, then, be allowed to stand? We could answer that if we knew the South's cone of loss, but that may well prove as difficult to estimate as a whole set of industry-specific market failure measures. The hope offered by the North-South worldview is, if not dashed, at least soured.

Finally, the actual development of institutions governing natural resources may differ from that in our model in two ways that would render our results irrelevant. First, in our model, institutional development occurs only at an extensive margin. Intensive margins are possible too, as when people in the hinterland increase their level of mutual monitoring. One reason losses are possible is that the enclosure response occurs only on a subset of the parcels threatened with increased rent dissipation. With an intensive margin this would no longer be the case.

Second, the optimal enclosure rule plays a critical role, since no rent is earned by enclosing the marginal parcel. If the locals only enclose when the rents from doing so are, say, 10 times the costs, enclosing the marginal parcel could release nine workers to other sectors for each one moved to the police. The enclosure response would then partially compensate for higher losses from trade. Whether it would compensate fully, fractionally, or excessively depends on how much land was marginal and how much submarginal, which stand in no necessary relation. [17]

These qualifications make the second-best case against free trade due to increasing rent dissipation conditional, even in theory. And even if the unconditional case is someday proven, a policymaker deciding whether to restrict trade would need detailed knowledge of the extent of market failure in every sector of the economy to know whether actual prices fall within the range in which losses from trade occur. It is hard to imagine that policymakers gifted with such an abundance of data could not monitor the sources of failure directly and achieve first-best solutions.

[17] This is reminiscent of regulatory federalism (which regulation works best at which level of government). So viewed, the arguments for local action over trade action seem compelling. The locals are likely to know more about the resources they exploit and to be able to define property rights at lower cost than central authorities, i.e., through mutual monitoring. Thus local action is likely to be superior to any national-level policy, and trade intervention is probably not even the best of the central government's options.

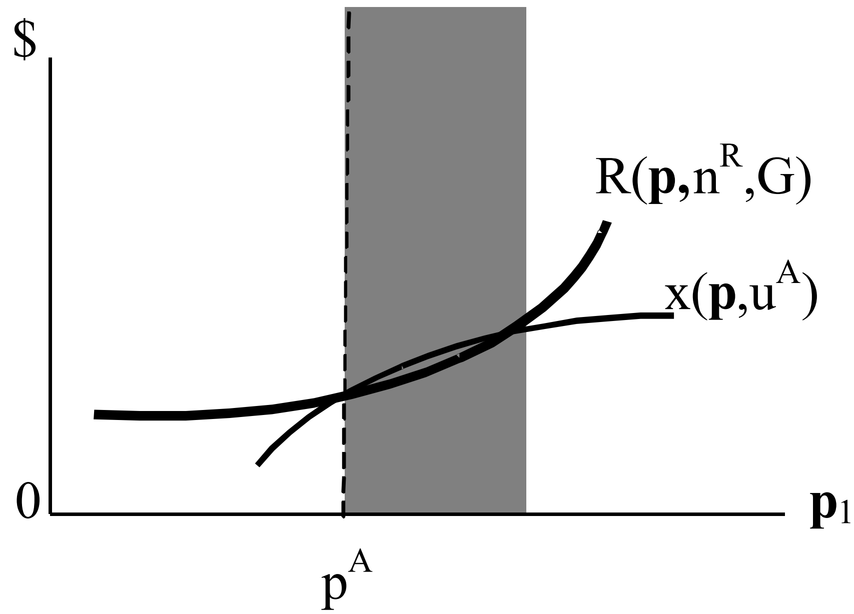

Figure 1: Illustration of the Benchmark Theorem

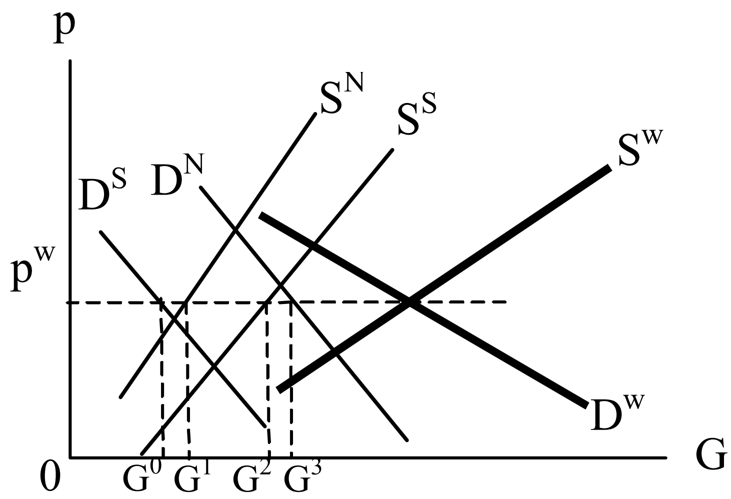

Figure 2: Partial Equlibrium Picture of Global Grain Market

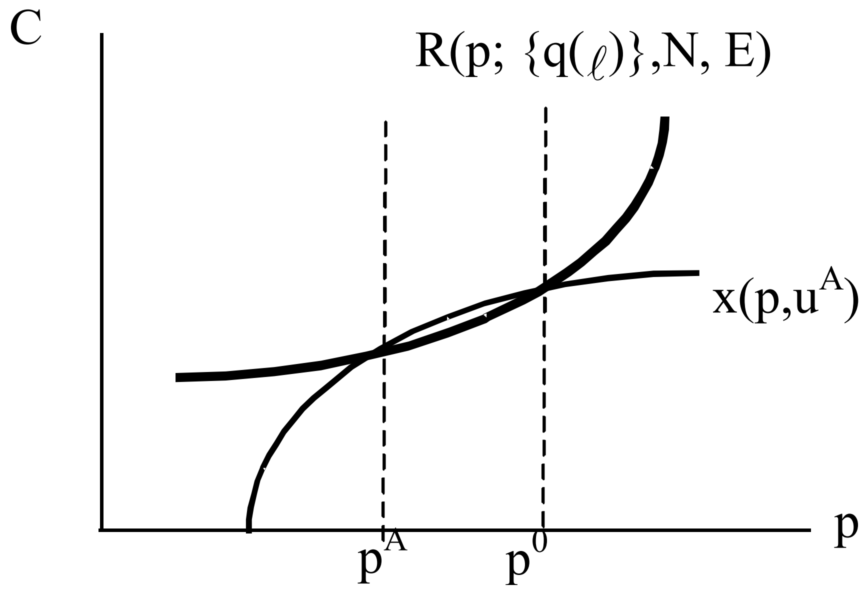

Figure 3: National income (R) and the cost of achieving the autarky utility level (x) as functions of the price of grain.

Appendix of Proofs

Proof : Rent from parcel ℓ is $\rho(\ell)$=pq(ℓ)ϕ[$n^*(\ell)$]-w$n^*(\ell)$. The rent gradient in ℓ is given by

$$\rho'(\ell)=pq'(\ell)\phi\left[n^*(\ell)\right]+\left[pq(\ell)\phi'\left[n^*(\ell)\right]-w\right]\frac{\partial n^*}{\partial \ell} \tag{21}$$

The coefficient of $\partial n^*/\partial\ell$ (the term in big square brackets) is zero from (8) and $\phi(\bullet)>0$, $p>0$ by definition. Therefore $\rho'(\ell)$ shares exactly the sign of $q'(\ell)$.

Proof of Lemma 1: Rent from parcel ℓ is $\rho(\ell)$=pq(ℓ)ϕ[$n^*(\ell)$]-w$n^*(\ell)$. The rent gradient in ℓ is given by

$$\rho'(\ell)=pq'(\ell)\phi\left[n^*(\ell)\right]+\left[pq(\ell)\phi'\left[n^*(\ell)\right]-w\right]\frac{\partial n^*}{\partial \ell} \tag{22}$$

The coefficient of $\partial n^*/\partial\ell$ (the term in big square brackets) is zero from (8) and $\phi(\bullet)>0$, $p>0$ by definition. Therefore $\rho'(\ell)$ shares exactly the sign of $q'(\ell)$.

Proof of Lemma 2: Applying the implicit function theorem to (8) and (9) gives the derivatives with respect to ℓ of n^* and $\hat{n}$. The difference between those derivatives is

$$\frac{\partial \hat{n}}{\partial \ell}-\frac{\partial n^*}{\partial \ell}=\frac{q'(\ell)\phi'\left[n^*(\ell)\right]}{q(\ell)\phi''\left[n^*(\ell)\right]}-\frac{pq'(\ell)\phi\left[\hat{n}(\ell)\right]}{pq\phi'\left[\hat{n}(\ell)\right]-w} \tag{23}$$

Both denominators on the right hand side are negative, so multiplying through by both preserves the sign

$$\frac{\partial \hat{n}}{\partial \ell}-\frac{\partial n^*}{\partial \ell}\text{ s.o. } q'(\ell)\phi'\left[n^*(\ell)\right]\left\{pq\phi'\left[\hat{n}(\ell)\right]-w\right\}-pq'(\ell)\phi\left[\hat{n}(\ell)\right]\left\{q(\ell)\phi''\left[n^*(\ell)\right]\right\}$$

By assumption, $q(\ell),\phi(\ell),\phi'(\ell)$,w are greater than zero, and 0, $\phi''(\ell)<0\ \forall\ \ell$. The parts in angle brackets are the former denominators, which are negative. It follows that $\frac{\partial \hat{n}}{\partial \ell}-\frac{\partial n^*}{\partial \ell}<0$

Because $\hat{n} > n^*$, this implies the two conditional labor density curves $\hat{n}(\ell)$ and $n^*(\ell)$ are coming closer together, which is the first part of the lemma.

From Lemma 1 and (10) $\rho(\ell)) \geq wE$ for all $\ell \leq \ell^*$, with strict equality at ℓ^*. Expanding $\rho(\ell)$ and dividing through by w, this implies

$$\frac{p}{w} q(\ell^*)\phi\left[n^*(\ell^*)\right] = E + n^*(\ell^*) \tag{24}$$

From the full rent dissipation condition that defines $\hat{n}$ (9)

$$\frac{p}{w} q(\ell^*)\phi\left[\hat{n}(\ell^*)\right] = \hat{n}(\ell^*) \tag{25}$$

The difference in labor densities is

$$\hat{n}(\ell^*) - n^*(\ell^*) - E = \frac{p}{w} q(\ell^*)\left\{\phi\left[\hat{n}(\ell^*)\right] - \phi\left[n^*(\ell^*)\right]\right\} \tag{26}$$

The right hand side of (26) is unambiguously positive because $\hat{n}(\ell) > n^*(\ell)\ \forall \ell$ and $\phi' > 0$. Thus $\hat{n}(\ell^*) - n^*(\ell^*) > E$. Proof of Theorem 1: There are three cases to consider.

Case I: E is very high in both countries, resulting in a corner solution to (10) with $\ell^* = 0$. In this case, no labor is used in enclosure, and the income is the same in both countries.

Case II: E is in an intermediate range, resulting in interior equilibria for ℓ^*. From (5) the wage is the same in both countries.[18] Therefore the rent gradient $\rho(\ell)$ is the same in both countries, and applying the implicit function theorem to (10) gives

$$\frac{\partial \ell^*}{\partial E} = \frac{w}{\rho'(\ell^*)} < 0 \tag{27}$$

[18] The equality of the wage, recall, is derived from the assumption of a Leontieff production function and the choice of numeraire, and is therefore as general as the former.

which says ℓ^* falls when E rises for interior solutions.

The impact of E on G is the product of $\frac{\partial \ell^*}{\partial \mathrm{E}}$ and $\partial G/\partial \ell^*$, which is calculated by partitioning (7) at ℓ^* and applying Leibnitz rule

$$\frac{\partial G}{\partial E} = q(\ell^*)\left[\phi(n^*(\ell^*)) - \phi(\hat{n}(\ell^*))\right]\frac{w}{\rho'(\ell^*)} < 0 \tag{28}$$

Equation (28) says that marginally higher enclosure cost results in less grain output for interior ℓ^*. We next show that higher E also results in less cloth output; lower income then follows trivially from lower output in both sectors.

Totally differentiating (11)and setting $dp = dW = d\bar{N} = d\ell^* = 0$ gives

$$dN_C + \ell^* dE = 0$$

Therefore, $\frac{\partial \mathrm{N_C}}{\partial \mathrm{E}} = -\ell^*$, and from (16) and (17)

$$\frac{\partial C}{\partial E} = -w\ell^* \tag{29}$$

Substituting (28) and (29) into $\frac{\partial \mathrm{R}}{\partial \mathrm{E}} = \mathrm{p}\frac{\partial \mathrm{G}}{\partial \mathrm{E}} + \frac{\partial \mathrm{C}}{\partial \mathrm{E}}$

$$\frac{\partial R}{\partial E} = pq(\ell^*)\left[\phi\left(n^*(\ell^*)\right) - \phi\left(\hat{n}(\ell^*)\right)\right]\frac{w}{\rho'(\ell^*)} - w\ell^*$$

which is a negative minus a positive; hence $\frac{\partial \mathrm{R}}{\partial \mathrm{E}} < 0$, which proves that high enclosure costs is associated with low social income for interior solutions.

Case III: If E is very low in both countries so that ℓ^*=L, there is no difference in enclosure or grain production. Income is lower where E is high because more labor is reallocated from cloth production, as captured in (28). Thus $\frac{\partial \mathrm{R}}{\partial \mathrm{E}} = -\mathrm{wL} < 0$.

Proof of Theorem 2: We have already shown that $\frac{\partial \ell^*}{\partial \mathrm{E}} < 0$. Because E does not appear directly in the supply curve for either good the change in the autarky price due to a change in E is

$$\frac{\partial p^A}{\partial E} = \frac{\partial p^A}{\partial \ell^*}\frac{\partial \ell^*}{\partial E}$$

We have already shown that $\frac{\partial \ell^*}{\partial \mathrm{E}} < 0$ (see (27)) and $\frac{\partial p^A}{\partial \ell^*} > 0$ (19). Thus $\frac{\partial p^A}{\partial E} > 0$. Because the South has higher E, the South has a lower autarky price of grain, and the North has a lower relative autarky price for cloth. The trade pattern then follows from the general principle of comparative advantage.

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