Property Rights and the Factor Content of Trade: A Product-Level Test of Apparent Comparative Advantage[*]

by

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Abstract. This paper theoretically derives and empirically examines how property-rights imperfections influences the structure of commodity trade. The theory integrates a generalized version of property rights and resource use of Chichilnisky (1994) into the multi-country multi-product model of Romalis (2004) to endogenize factor supplies. Weak property rights lead to underpriced resources causing inefficient oversupply and higher export shares of resource-intensive final products in general equilibrium. The model's predictions find strong empirical support in product-level empirical tests.

Keywords: Property Rights, Commodity Trade, Resource Dependency, Intra-industry Trade

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1. Introduction

When a country with weak property rights trades with a country that has strong property rights, Chichilnisky (1994) showed that the country with weak property rights may end up with inefficiently high exports of resource-intensive products. Weak property rights can lead to inefficiently high supplies and, in turn, inefficiently lower relative prices of these products. Such "apparent comparative advantage"—a term coined by Chichilnisky (1994) to reflect this inefficient relative cost advantage—in turn, increases the share of these products in a country's exports when it trades with countries that have stronger property rights, and thus have higher prices of resource-intensive products (Chichilnisky, 1994; Brander and Taylor, 1997, 1998; Karp et al., 2001).

This paper incorporates central features of the Chichilnisky (1994) model into the multi-product multi-country setting of Romalis (2004) to motivate estimation of the link between the strength of property rights and exports of resource-intensive products. The analysis (i) establishes a link between weaker property rights and the resource-intensity of exports in the global South, and (ii) explains why such an increase in resource-intensity of exports may happen in trade with other southern countries, rather than just in trade with northern countries as previously established.

The key contribution of our model lies in bringing a more generalized version of the property-rights mechanism of Chichilnisky (1994) into a many-country continuum-of-goods setting of Romalis (2004). We link the two models through a multi-tiered production structure that makes factor supplies endogenous. This novel structure allows us to relate the strength of property rights to the supplies of natural resources while preserving analytic tractability of the rich product-level predictions of the Romalis (2004) model. We show that weak property rights can lead to underpricing of the resource base and thereby lead to inefficient oversupply of resource-intensive intermediate products, relative to skill-intensive intermediate products. This oversupply drives down relative prices of resource-intensive final goods. With increasing returns to scale and monopolistic competition in final goods markets, export shares of resource-intensive final goods increase.

Our predictions find empirical support in product-level panels. Beyond validating the predictions and lending credibility to the prescribed mechanism in the model, the empirical analysis makes an additional contribution: To our knowledge, it is the first empirical test of possible impacts of property rights on resource-intensive trade.

Utilizing the variation in resource-intensity of products and resource-abundance of exporters, the product-level test evaluates the directional predictions as well as the mechanism prescribed in the model. The results show that weak property rights magnify the effect of relative resource abundance on resource-intensive comparative advantage.

These findings are important in the context of the policy debate concerning the consequences of enhanced economic integration between low- and middle-income countries (South-South trade). Those in support of enhanced integration argue that expansion of South-South trade will present southern economies with the opportunity to move up the development ladder (Greenaway and Milner, 1990; Panitchpakdi, 2012). The key arguments favoring this view focus on the benefits from increased integration—emergence of bilateral trading relationships between countries that never traded before (UNCTAD, 2011)—as well as the opportunity of diversifying exports towards more sophisticated, skill-intensive products (Das, 2009). Critics who oppose this claim argue that increased Southern integration will benefit only a few emerging economies at the expense of the large majority of poor, resource-dependent economies. Enhanced integration for the smaller resource-dependent economies will lead to a new resource curse (Coxhead, 2007; Greenway et al., 2008). Integration with emerging economies will displace smaller economies' comparative advantage in labor-intensive manufacturing and instead lead to a comparative advantage in resource-intensive products. Our analysis shows that the conclusion depends critically on protection of private property rights. Weak property rights can displace skill-intensive goods and lead to an under-priced resource base. Such underpricing magnifies the resource-intensity of a southern exporter's exports to other southern countries, justifying the concerns of Coxhead (2007) and Greenway et al. (2008). Strong property rights, on the other hand, can help a southern exporter diversify away from resource-intensive products towards more skill-intensive goods, justifying the optimism of authors such as Greenaway and Milner (1990), Das (2009), and Panitchpakdi (2012).

By establishing a link between weak property rights and trade patterns in the South, we contribute to the literature examining the non-standard features of recent South-North and South-South trade flows resulting from greater southern integration, and an emergence of the "middle kingdoms" (Hanson, 2012). Our work is also closely related to literature examining the influence of institutional quality on trade patterns. Two particular papers, Nunn (2007) and Levchenko (2007), are related in vein as they use empirical specifications similar in design to ours. These studies were, however, concerned with the effect of institutional quality on specifically the enforcement of contracts. Neither investigated how property rights influenced trade patterns through its impact on resource extraction, and the resulting resource prices, which is the concern of the present paper. Debaere (2014) also adopted a similar design, but to investigate the role of water abundance in driving comparative advantage.

The rest of the paper is structured as follows. Section 2 discusses our motivating observations. Focusing on three specific exporters—Argentina, Chile, and France—we show that weaker property rights is associated with larger shares of resource-intensive exports not just to the US, a representative northern export destination, but also to Brazil, a representative southern export destination with relatively weaker property rights. Section 3 presents our model. We present the details of the mechanism that leads to southern countries with weak property rights ending up with apparent comparative advantage in resource-intensive products. We show in equilibrium, these countries export more resource-intensive products to *all* other countries—other southern countries with similarly weak property rights and to northern countries with strong property rights. Section 4 tests the model's predictions empirically. Finally, section 5 concludes.

2. Motivating example

This section illustrates the main idea behind our empirical exercise. We conduct pairwise comparisons of non-parametric estimates of US and Brazilian product-level import shares captured by three specific exporters: Argentina, Chile, and France. We pick these countries to permit a casual ceteris paribus comparison. Argentina and Chile have similar relative endowments but Chile has much stronger property rights; Argentina and France have different relative endowments, but similar property rights. Compared to Argentina, Chile is in the same Natural Resource and GDP per capita Quartiles, but has better property rights.[1] [2] [3] France, in contrast, is relatively less resource abundant than Argentina, but has similar property rights.[4] [5]

Brazil is a representative southern export destination as it has weak property rights, whereas the US is a representative northern export destination.[6]

We use Figures 1 and 2 to illustrate the difference between impacts of relative endowments and property rights. The horizontal axis represents a continuum that identifies products by their resource intensity. The vertical axis measures normalized import shares of these products.[7] The dots are mean shares by resource-intensity of the products, whereas the lines are measures of the shares estimated as rolling regressions (Lowess) over the entire product space.

The top panels compare the import shares captured by Argentina and France. Because Argentina and France have identical scores on our measure of property rights, but Argentina has a much larger relative resource endowment, the observed differences in import shares indicate the impact of endowment differences. In both cases Argentina captures larger shares of more resource-intensive imports, while France captures larger shares of less resource intensive (more human/physical capital intensive) imports. This difference in specialization illustrates the impact of endowment differences as emphasized in Romalis (2004).

[1] To calculate a country's location in Natural Capital Quartile we use Natural Resources per worker (NC) from Shirotori et al. (2010).

[2] We measure Property Rights by the Heritage Foundation Property Rights Index Score. This index reflects a country's enforcement of laws promoting the protection of private property—the degree to which the country succeeds in protecting property rights and facilitating private contracting (Levine, 2005). The index measures property rights protection on a scale of 0 to 100, in increments of 10. We use this index as our measure of property rights because of its wide coverage and popularity in the literature. This index has been widely used in the Law and Finance literature. See Beck et al. (2003) for instance.

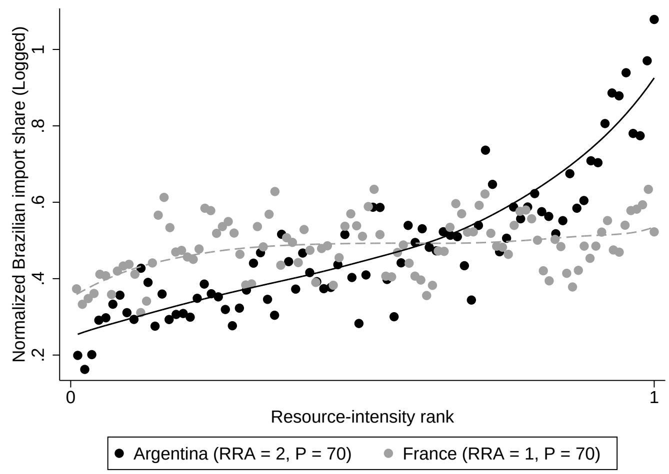
[3] A country's Relative Resource Abundance (RRA) score is calculated by dividing its Natural Capital Quartile Score by its GDP per capita Quartile Score. GDP per capita is a proxy for a country's endowment of human and physical capital. The RRA ratio reflects a country's resource endowment relative to its human and physical capital endowment.

[4] Both Argentina and Chile fall in the 4th quartile in the distribution of exporters by natural resource abundance per worker (q_N), measured by Natural Resources per worker (NC) from Shirotori et al. (2010), and in the 2nd quartile in the distribution of exporters by GDP per capita (q_G). Using the ratio of q_N to q_G as a proxy for *relative resource abundance* (RRA) gives an RRA score of 2 to both these countries.

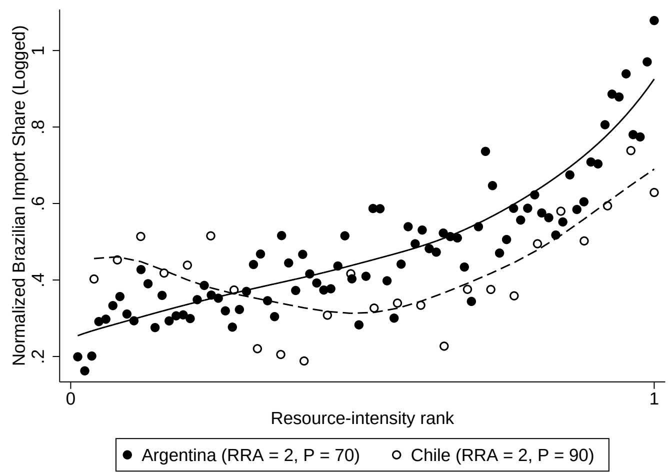
[5] In terms of property-right imperfections as measured by the Heritage Foundation Property Rights Index scores, Argentina and France are identical, while Chile differs: Both Argentina and France have relatively weaker property rights with a score of 70. Chile's score is 90, on par with advanced countries like the US and Germany.

[6] Brazil's choice is also governed by the fact that it is a large enough importer to have enough products to make a meaningful comparison.

[7] These are normalized shares in natural logs. To obtain estimates that are comparable across countries, we first divide an exporter's share of each imported product by the exporter's average share in total imports. We then add one to this value, and then take natural logs to obtain the normalized natural log of shares for each product.



(A) Argentina vs France: The Resource Endowment Effect



(B) Argentina vs Chile: The Property Rights Effect

FIGURE 1. Shares of Brazilian Imports by Resource Intensity

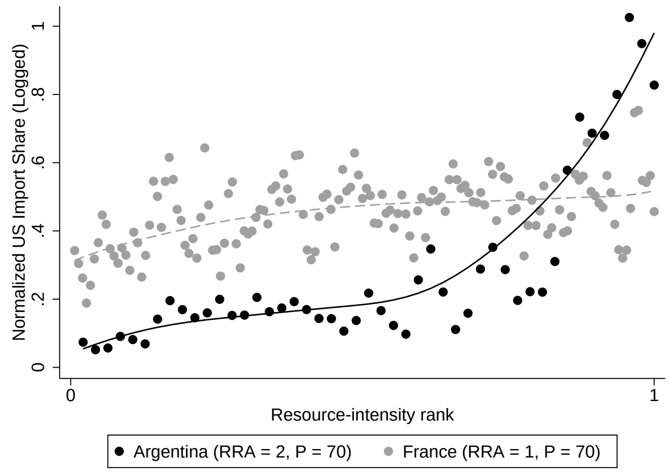
Note (1): Authors' construction based on UN Comtrade data (http://comtrade.un.org/data/ accessed September 11, 2020) on Brazilian imports, and the Shirotori et al. (2010) data on revealed-factor intensities. Resource abundance and intensity are proxied by abundance and intensity of land-per worker.

Note (2): (a) The dots are natural logs of mean import shares by resource-intensity rank; (b) the lines are non-parametric (Lowess) estimates of natural logs import shares. Whereas (a) depicts means only and avoids visual clutter, (b) represents a smoothed estimate using rolling regressions covering the entire product space.

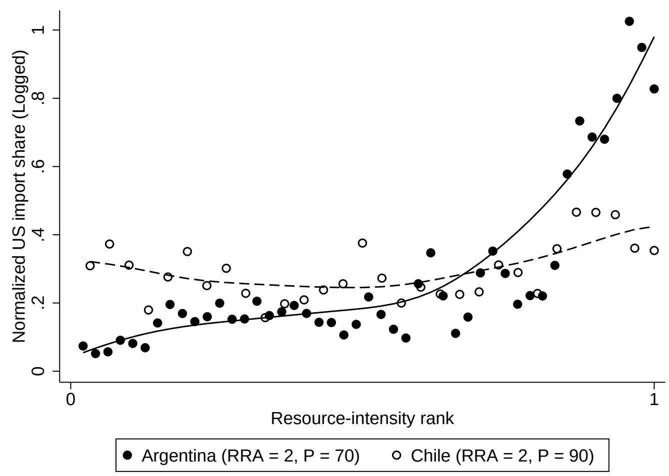
Note (3): The import shares are normalized by dividing a country's actual share of imports of a product by the country's average of import shares over all products.

Note (4): In the year 2000, Argentina's property-rights index score was 70, Chile's was 90. France's was 70. Argentina and Chile both fall in the 3rd quartile in terms of Natural Resource per unit of GDP indicating similar relative resource abundance. France has a much lower relative abundance of resources. Brazil's property rights score in 2000 was 50.

Note (5): RRA measures relative resource abundance, see Footnote2.



(A) Argentina vs France: The Resource Endowment Effect



(B) Argentina vs Chile: The Property Rights Effect

FIGURE 2. Shares of US Imports by Resource Intensity

Note (1): Authors' construction based on UN Comtrade data (http://comtrade.un.org/data/ accessed September 11, 2020) on Brazilian imports, and the Shirotori et al. (2010) data on revealed-factor intensities. Resource abundance and intensity are proxied by abundance and intensity of land-per worker.

Note (2): (a) The dots are natural logs of mean import shares by resource-intensity rank; (b) the lines are non-parametric (Lowess) estimates of natural logs import shares. Whereas (a) depicts means only and avoids visual clutter, (b) represents a smoothed estimate using rolling regressions covering the entire product space.

Note (3): The import shares are normalized by dividing a country's actual share of imports of a product by the country's average of import shares over all products.

Note (4): In the year 2000, Argentina's property-rights index score was 70, Chile's was 90. France's was 70. Argentina and Chile both fall in the 3rd quartile in terms of Natural Resource per unit of GDP indicating similar relative resource abundance. France has a much lower relative abundance of resources.

Note (5): RRA measures relative resource abundance, see Footnote2.

In the lower panels, we compare the import shares captured by Argentina and Chile. Because Argentina and Chile have very similar relative endowments, but Argentina has weaker property rights, the observed differences in import shares captured by these countries indicates the impact of property rights differences. For the products with the lowest resource intensities (values close to zero on the horizontal axis), Chile, which has strong property rights, captures larger shares. As the resource-intensity increases, however, Argentina, which has weaker property rights, captures increasingly larger shares relative to Chile. For the most resource-intensive products, Argentina's share far outstrips Chile's share. Despite similar relative resource abundance, the country with weaker property rights captures larger shares of more resource-intensive products, and the gap widens with resource-intensity.

In both examples, Argentina captures larger shares of both Brazilian and US imports in more resource-intensive products. Since both Argentina and Chile share similar relative resource abundance, and the normalization (see Footnote 7) in calculating the share estimates control for country size effects, these examples support the apparent comparative advantage hypothesis at the product level in exports to countries that also have weaker property rights. The following section presents our formal theoretical model that explains this observation. We then present a formal product-level econometric analysis with a sample of about a hundred exporters to show that the evidence obtained from the two examples, supporting our key predictions, can be generalized.

3. Property rights imperfections and resource-intensity of exports: a two-region model

This section develops a continuum-of-goods North-South trade model with many countries along the lines of Romalis (2004). The Romalis model combines the role of factor endowments with increasing returns and product differentiation to explain global trade patterns. To characterize the influence of property-rights imperfections on equilibrium resource-intensity of export shares, we augment the supply side of the Romalis model. The demand side remains identical to the original model.

There are three specific points of departure between our model and the Romalis model. First, whereas the Romalis model considers a standard single-tiered production structure where two exogenously supplied primary factors—unskilled and skilled labor—are combined to produce final goods, our model considers a two-tiered production structure which allows us to make factor supplies to the final goods sector endogenous. Second, we introduce property rights into the model which, combined with the two-tiered production structure, allows us to examine the impact of property-right imperfections on resource supplies and prices in general equilibrium. Further, our novel approach to modeling property-right imperfections allows us to address impacts of marginal changes in property rights, in contrast to prior work. Third, whereas in the Romalis model the North and South are different in terms of factor endowments, in our model the North and South are identical in terms of factor endowments. Because of its focus on the role of endowment differences on trade patterns, the Romalis model assumes that the North is relatively abundant in skilled labor, and the South is relatively abundant in unskilled labor. In contrast, because our focus is on the role of property rights, the North and the South differ in our model only in terms of property right imperfections; endowments are identical. We show under these conditions, how weak protection of property rights in southern countries can lead to more resource-intensive exports to other countries, both southern and northern. This pattern of higher resource-intensity exports to northern countries is a generalization of Chichilnisky's result. That to other southern countries is novel.

The details are laid out in the following sections. All northern variables are denoted by an asterisk to distinguish them from their southern counterparts.

3.1. **The two-tiered production structure of an economy**

Our framework augments Romalis (2004) by considering a two-tiered production structure (see Figure 3). The primary tier is set up as a Ricardo-Viner specific factors model following Jones (1971), while the secondary tier is set up as a continuum of final-goods producing industries operating under increasing returns to scale. There are three primary inputs: unskilled labor (L), Land (T), which broadly corresponds to the existing natural resource base of the economy, and skill-specific capital H, which broadly corresponds to the infrastructure for educational and various vocational training programs. All primary inputs are internationally immobile. At the primary tier, primary inputs are used to produce intermediate goods, Skills (S) and Resources(R). At the secondary tier these intermediate goods are then used as inputs to produce the final goods (Z).

The primary tier is neoclassical in vein: sector-specific inputs T and H as well as the intersectorally mobile input L are used to produce the intermediate goods competitively under constant returns to scale. The final goods sector is characterized by scale economies and product differentiation in the Krugman (1980) tradition. The final goods sector—the secondary tier in the model, where intermediate goods are used to produce the final goods—retains the structure of Romalis' original model.However, whereas Romalis considers skilled labor as a primary factor of production with an exogenously determined endowment, in our model, "skills" are an intermediate input produced using skill-specific capital (number of universities, vocational training institutions, etc) and unskilled labor as primary inputs. Doing so allows us to explicitly characterize the impact of property-right imperfections on relative supplies of skills and resources. The specific details are laid out below. Introducing the underlying primary tier allows us to explicitly examine the role of property rights in shaping the relative resource supplies to the secondary tier.

3.1.1. *The primary tier*

The detailed two-tier production structure of each economy is outlined in figure 3. At the primary tier, sector-specific capital and unskilled labor are used as inputs to produce two intermediate goods we refer to as "skills" (S) and "resources" (R). These are are pure intermediate goods. They are not consumable. They are only used as inputs in the final goods sector. T is a specific factor for R while H is a specific factor for S. The intermediate goods are produced competitively under constant returns to scale (CRS). We assume that both intermediate good sectors use labor at an identical intensity. This assumption is a simplification reflecting that the relative differences in endowments of land and human capital matter more as drivers of differences in trade patterns compared to relative differences in

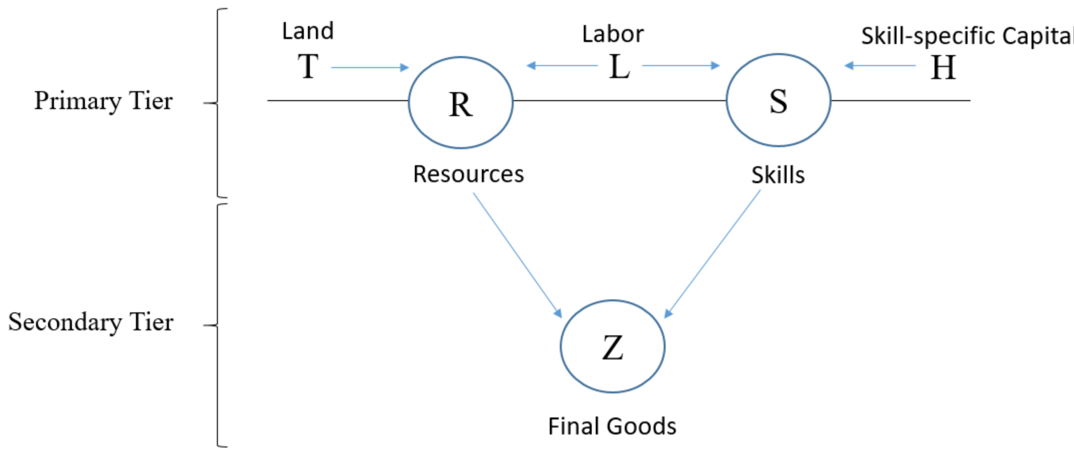


FIGURE 3. The two-tiered production structure.

the endowments of unskilled labor. [8] The output of these two sectors are characterized by the production functions

$$S = H^{\theta_{HS}} L_S^{\theta_{LS}}; R = T^{\theta_{TR}} L_R^{\theta_{LR}}, \tag{1}$$

with $\sum_i \theta_{ij} = 1$ (by CRS), $\theta_{LR} = \theta_{LS} = \theta_L$ (by 'identical labor intensity') and $L_S + L_R = \overline{L}$, where $\overline{L}$ is the total endowment of unskilled labor. Let r_T, r_H and w denote the prices of T, H and L; let p_S and p_R denote the prices of the intermediate goods S and R.

3.1.2. *The secondary tier*

In the secondary tier, the two intermediate inputs are transformed into consumable final goods. These consumable final goods are produced in a continuum of industries indexed by $z \in [0, 1]$. Output in industry z is produced using the two intermediate goods R and S as inputs. The index z ranks industries by resource-intensity: high-z industries are more resource intensive; low-z industries are more skill intensive. Therefore, industries with $z \to 1$ produce goods that are effectively minimally transformed resources that have near-zero skill content, whereas industries with $z \to 0$ produce high-skilled goods that have near-zero resource content.

This tier is characterized by monopolistic competition: there are economies of scale in production of final goods, firms can freely differentiate their products and there are barriers to entry. In each industry z an endogenously determined number of varieties is produced. These varieties are imperfect substitutes in consumption. The number of varieties is represented by $n(z)$ for industry z in the South; $n^*(z)$ for industry z in the North. The total number of varieties produced in industry z is then

$$N(z) = M[n(z) + n^*(z)]. \tag{2}$$

[8] This assumption is motivated by Wood and Berge (1997) who maintain that the relative endowment differences between T and H matter much more, for trade, than relative endowment differences of labor. While they use this assumption in a simplified single-tier production side of the economy, we use it to set up our primary tier in our two-tier structure. This simplification prevents indeterminacy in our intermediate goods sectors that can otherwise arise in models featuring more factors than goods. Relaxing this assumption complicates the analysis by making results case specific without contributing any additional insight.

Each variety is produced using the two intermediate goods under increasing returns to scale (IRS): there is a fixed cost as well as a constant marginal cost per unit of output. Let $q^S(z,i)$ represent the quantity of variety i produced in industry z. The production technology is Cobb-Douglas such that the total cost function C is of the following form:

$$C(q^S(z,i)) = [\alpha + q^S(z,i)]p_R^z p_S^{(1-z)}. \tag{3}$$

The convenient feature of this assumed cost structure is that it ranks industries by their resource intensity. The cost share of R in the industry indexed by z is exactly z. Finally, free entry implies that profits are driven down to zero in equilibrium.

3.1.3. *Property rights and the supply of resources: the protected and unprotected resource sectors*

We simplify the theoretical analysis by assuming property rights to be exogenous in the theoretical model.[9] The extent of property-rights imperfections is measured by the enforceability of private ownership on Land. Although the entire endowment of T is privately owned by a representative owner, ownership rights are protected only on an exogenously given fraction $\lambda \in [0,1]$ of this area. The remaining $(1-\lambda)$ fraction of land is open access. Other resource producers encroach on the unprotected fraction of land and also produce resources. This is a modification of the standard approach to investigating the role of property rights in motivating trade. The standard approach (e.g., Chichilnisky 1994; Karp et al. 2001; Margolis 2009) works with countries that either have perfectly defined property rights or have purely open access conditions. Our modification allows us to investigate equilibria for intermediate cases.[10] Introducing λ as a strict fraction conveniently allows us to parameterize property rights for intermediate cases, and investigate implications for marginal changes in property rights, which facilitates the empirical analysis of our key predictions.

We refer to production on protected land as output from the "protected resource sector," and denote it by R_P. We refer to production on unprotected land as output from the "unprotected resource sector," and denote it by R_O. To keep the analysis simple, we assume that all resource producers have access to the same technology, and there is no qualitative difference between the output produced privately on the protected part of the land and the output produced under open access conditions on the unprotected part of the land. The output from both sources is sold in a competitive market to producers of final goods. Total supply of the intermediary R available for the final goods sector is $R_S = R_P + R_O$, where

$$R_P = (\lambda T)^{\theta_{TR}} L_{RP}^{\theta_{LR}}, \tag{4a}$$

and

$$R_O = [(1-\lambda)T]^{\theta_{TR}}\, L_{RO}^{\theta_{LR}}. \tag{4b}$$

[9] To see how endogenous property rights interact with resource extraction in a static setting, see Karp (2005), and Margolis and Shogren (2009). In our empirical analysis, we do account for the potential endogeneity of property rights.

[10] We can, of course, replicate the standard framework in our model by assuming $\lambda = 1$ for certain countries and $\lambda = 0$ for others. In reality no countries in our sample have absolutely perfect, or entirely absent, property rights. The differences across countries, in terms of property rights, are also smaller—a fact that is hard to capture in a model which only considers the two extremes.

Unskilled labor hired by the representative landowner to produce the resource on protected land is denoted by L_{RP}; unskilled labor hired by resource producers encroaching on unprotected land is denoted by L_{RO}.

3.2. **The North versus the South**

There are $2M$ countries in the world, M in the North and M in the South. The North and the South are different only in terms of protection of property rights. They are symmetric in terms of preferences, endowments of primary factors and transport costs.

3.2.1. *Preferences*

All consumers are identical. They have Cobb-Douglas preferences over final goods; $b(z)$ is the fraction of income a representative consumer spends on final goods from industry z. The shares of total expenditure captured by different industries is thus constant; prices and incomes do not influence these shares. Specifically, consumer preferences are represented by

$$U = \int_0^1 b(z) \ln Q(z) dz; \; \int_0^1 b(z) dz = 1, \tag{5a}$$

where $Q(z)$ in (5a) is a sub-utility function defined over the consumed amounts of each variety z: Assuming $q^D(z,i)$ represents the consumed amount of the ith variety from industry z,

$$Q(z) = \left[\int_0^{N(z)} q^D(z,i)^{\frac{\sigma-1}{\sigma}} di \right]^{\frac{\sigma}{\sigma-1}}; \; \sigma \geq 1. \tag{5b}$$

3.2.2. *Transport costs*

There are ‘iceberg’ transport costs: to ensure arrival of a unit at the destination country, τ units need to be shipped from the source country; $\tau \geq 1$. We assume that transport costs are identical for both within- and between-region trade.

3.2.3. *Endowments and Property Rights*

To focus exclusively on the influence of differences in property rights on resource dependency, we assume that the North and the South have identical relative endowments of T and H: $\frac{T}{H} = \frac{T^*}{H^*}$.

Property rights are fully defined and enforced in the North but not in the South. The entire endowment of land in the North is protected by property rights whereas a strict fraction of the resource base is protected in the South: $\lambda^* = 1$, $\lambda \in (0,1)$.

3.3. **Equilibrium**

The characterization of equilibrium proceeds in two steps. First, we derive the partial equilibrium in any given final-good industry. This step yields, conditional on relative prices, the shares captured by any country of industry z in any other country's imports. We show that relatively lower (domestically) priced varieties capture larger relative shares in any country's imports. Second, we turn to the intermediate-goods industries. In general equilibrium, where all factors of production are fully employed, property-right imperfections result in relatively lower resource prices in the South. As a result, the South's domestic prices become relatively lower in resource-intensive industries. Southern countries capture larger shares of both northern and southern resource-intensive imports. All proofs of propositions and lemmas are relegated to the Technical Appendix.

3.3.1. *Final-goods industry equilibrium*

With a similar demand side, our model's predictions for the final-goods industry equilibrium retain a similar flavor to Romalis (2004). In order to make comparisons straightforward, we follow the same notation and sequence of derivations in this section as in Romalis (2004). The key distinction to keep in mind is that whereas in our model z represents an industry's intensity of R, an intermediate good, in Romalis (2004) z represents an industry's intensity of skilled labor, an exogenous primary input.

Recall that $\sigma \geq 1$ denotes the inter-variety elasticity of substitution within any industry z; let $\widehat{p}(z,i)$ denote the transport-cost inclusive price paid by consumers for the ith variety from industry z; let $I(z)$ denote the set of all varieties in industry z and let $Y \equiv w\overline{L} + r_T T + r_H H$ denote national income; w denotes wages, r_T denotes rent, the returns to land, and r_H denotes returns to skill-specific capital. As shown in Helpman and Krugman (1985), maximizing (5b) conditional on expenditure $E(z)$ leads to the following set of demand functions for every variety $i \in I(z)$:

$$q^D(z,i) = \frac{\widehat{p}(z,i)^{-\sigma}}{\int_{i' \in I(z)} \widehat{p}(z,i)^{1-\sigma} di'} E(z);\ i \in I(z). \tag{6}$$

The share of revenues of industry z captured by any given firm depends on the price charged by the firm itself as well as on the prices charged by all other firms in the industry. If the firm charges a single factory gate price of p, the product sells at price p in its domestic market. But in foreign markets, due to the presence of transport costs, the effective price becomes $p\tau$. Thus if a southern firm charges a factory gate price of p, the product sells at that price in the firm's domestic market. But in the other $M-1$ southern countries as well as in all M northern countries, the effective price of the firm's product is $p\tau$. Recall that due to the assumption on preferences, a constant fraction $b(z)$ of income is spent on industry z in all countries. Suppressing the argument z to avoid clutter, the revenue of a representative southern firm is

$$pq^S = \underbrace{bY\left(\frac{p}{G}\right)^{1-\sigma}}_{\text{Domestic Market}} + \underbrace{(M-1)bY\left(\frac{p\tau}{G}\right)^{1-\sigma}}_{\text{Other southern markets}} + \underbrace{MbY^*\left(\frac{p\tau}{G^*}\right)^{1-\sigma}}_{\text{Northern markets}}, \tag{7}$$

where

$$G = \left[np^{1-\sigma} + (M-1)n(p\tau)^{1-\sigma} + Mn^*(p^*\tau)^{1-\sigma}\right]^{\frac{1}{1-\sigma}} \tag{8a}$$

represents the CES price index in the southern markets. A symmetric expression for G^* applies for northern markets:

$$G^* = \left[n^*p^{*1-\sigma} + (M-1)n^*(p^*\tau)^{1-\sigma} + Mn(p\tau)^{1-\sigma}\right]^{\frac{1}{1-\sigma}} \tag{8b}$$

Equations (6) and (7) follow from utility maximization by consumers and summarize the equilibrium demand and the resulting revenue for a representative southern firm given its price. The firm takes the demand as given and sets its price and output to maximize profits.

As in Helpman and Krugman (1985), given costless product differentiation, each firm produces a unique variety and as a result, if a country produces in an industry at all, it produces different varieties. Every variety has a positive demand in every country. A representative southern firm perceives a constant-elasticity demand curve, provided a large number of varieties are produced, and sets its profit maximizing price at a constant markup over marginal cost:

$$p(z) = \underbrace{\left[\frac{\sigma}{\sigma-1}\right]}_{\text{markup}} p_R^z p_S^{1-z}. \tag{9}$$

By free entry, profits are driven down to zero in equilibrium:

$$pq^S - C(q^S) = 0.$$

Substituting in for p from (9), and for $C(q^S)$ from (3), and rearranging gives

$$q^S = \alpha[\sigma - 1] = q^{S*}. \tag{10}$$

The last equality follows from the equality of α and σ across all countries.

To solve for partial equilibrium, define $W \equiv M(Y + Y^*)$ as world income, $\widetilde{p} \equiv \frac{p}{p^*}$ as the relative price of southern goods and F as the ratio of a representative southern firm's sales in all Southern markets to its sales in its domestic market:

$$F \equiv \frac{bY\left(\frac{p}{G}\right)^{1-\sigma} + (M-1)bY\left(\frac{p\tau}{G}\right)^{1-\sigma}}{bY\left(\frac{p}{G}\right)^{1-\sigma}}$$

where the right-hand side can be conveniently rearranged so that

$$F \equiv 1 + (M-1)\tau^{1-\sigma}.$$

Observe that equations (7), (8a), and (8b), conditional on prices and incomes, represent a system of four independent equations in the four unknowns n, n^*, G and G^*. The solutions for n and n^* are not necessarily positive. Using equations (7) (8a), and (10) to evaluate the possible solutions, we get three possible cases. For low $\widetilde{p}$, only Southern firms produce the good:

$$n = \frac{b(Y+Y^*)}{p\alpha(\sigma-1)}, \quad n^* = 0 \text{ if } \widetilde{p} \leq \underline{p} = \left[\frac{\tau^{1-\sigma}MF\left(\frac{Y^*}{Y}+1\right)}{\tau^{2-2\sigma}M^2 + F^2\left(\frac{Y^*}{Y}\right)}\right]^{\frac{1}{\sigma}}. \tag{11a}$$

Whereas for high $\widetilde{p}$, only Northern firms produce the good:

$$n = 0, \quad n^* = \frac{b(Y+Y^*)}{p^*\alpha(\sigma-1)} \text{ if } \widetilde{p} \geq \overline{p} = \left[\frac{\tau^{2-2\sigma}M^2\frac{Y^*}{Y} + F^2}{\tau^{1-\sigma}MF\left(\frac{Y^*}{Y}+1\right)}\right]^{\frac{1}{\sigma}}. \tag{11b}$$

Finally, for $\widetilde{p} \in (\underline{p}, \overline{p})$, both solutions are positive, and we have

$$\frac{n}{n^*} = \Omega(\widetilde{p}), \quad \text{with} \quad \Omega'(\widetilde{p}) < 0, \tag{11c}$$

where

$$\Omega(\widetilde{p}) \equiv \frac{\tau^{2-2\sigma}M^2\frac{Y^*}{Y} + F^2 - \widetilde{p}^{\sigma}\tau^{1-\sigma}MF\left(\frac{Y^*}{Y}+1\right)}{\widetilde{p}\left(\tau^{2-2\sigma}M^2 + F^2\frac{Y^*}{Y}\right) - \widetilde{p}^{1-\sigma}\tau^{1-\sigma}MF\left(\frac{Y^*}{Y}+1\right)}. \tag{11d}$$

Based on this solution, we have our first Lemma which states that for all industries where both southern and northern countries produce, the relative number of southern varieties in a given industry is declining the relative price of southern goods.

Lemma 1. *The relative number of southern varieties, $\widetilde{n}(z) \equiv \frac{n(z)}{n^*(z)}$, in any industry z in which both $n(z)$ and $n^*(z)$ are positive, is decreasing in the relative price of the product $\widetilde{p}$:*

$$\frac{\partial \widetilde{n}}{\partial \widetilde{p}} = \Omega'(\widetilde{p}) < 0. \tag{12}$$

Proof. See section A.1 in the Technical Appendix. □

We now have enough information to examine how any exporter's share of industry-z imports in any country are related to relative prices $\widetilde{p}(z)$. Hereon, we shall assume parameter values so that $\widetilde{p} \in (\underline{p}, \overline{p})$ holds for all $z \in [0, 1]$, and consider only interior solutions where $\widetilde{n} \in (0, \infty)$.[11]

For any product z, a southern importer imports $nbY\left(\frac{p\tau}{G}\right)^{1-\sigma}$ from the $M-1$ other southern countries, and $n^*bY\left(\frac{p^*\tau}{G}\right)^{1-\sigma}$ from the M northern countries. Any southern country's share of another southern country's total imports of product z therefore equal

$$x_{ssz} = \frac{nbY\left(\frac{p\tau}{G}\right)^{1-\sigma}}{(M-1)nbY\left(\frac{p\tau}{G}\right)^{1-\sigma} + MnbY\left(\frac{p^*\tau}{G}\right)^{1-\sigma}} = \frac{1}{(M-1) + \dfrac{M}{\widetilde{n}\widetilde{p}^{1-\sigma}}}. \tag{13a}$$

Again, for any product z, a northern importer imports $nbY^*\left(\frac{p\tau}{G^*}\right)^{1-\sigma}$ from the M southern countries, and $n^*bY^*\left(\frac{p^*\tau}{G^*}\right)^{1-\sigma}$ from the other $M-1$ northern countries. Any southern country's share of a northern country's total imports of product z therefore equal

$$x_{snz} = \frac{nbY^*\left(\frac{p\tau}{G^*}\right)^{1-\sigma}}{MnbY^*\left(\frac{p\tau}{G^*}\right)^{1-\sigma} + (M-1)n^*bY^*\left(\frac{p^*\tau}{G^*}\right)^{1-\sigma}} = \frac{1}{M + \dfrac{(M-1)}{\widetilde{n}\widetilde{p}^{1-\sigma}}}. \tag{13b}$$

Based on the expressions in (13a) and (13b), we have the following proposition:

Proposition 1. *$\forall z \in (\underline{z}, \overline{z})$, where $\underline{z} = z(\overline{p})$ and $\overline{z} = z(\underline{p})$, any southern exporter's share in another southern country's imports, x_{ssz}, as well in any northern country's imports, x_{snz}, are declining in the exporter's relative price of z:*

$$\frac{\partial x_{ssz}}{\partial \widetilde{p}} < 0,$$

and,

$$\frac{\partial x_{snz}}{\partial \widetilde{p}} < 0.$$

Proof. See section A.2 in the Technical Appendix. □

Lemma 1 shows that the relative number of southern varieties in any given industry is declining in South's relative price. Since all varieties produced are exported, and the amount

[11] All countries produce all goods as long as Y^* and Y are not very far apart. This amounts to assuming that the differences between the South and the North are not too large.

of each variety exported is identical by (10), total exports in any industry varies only with the number of varieties. Proposition 1 shows that because the relative number of southern varieties declines in the South's relative price, export shares in any industry, both to other southern markets and northern markets, also decline in South's relative price.

Note that by equation (9)

$$\widetilde{p} = \left(\frac{p_R}{p_R^*}\right)^z \left(\frac{p_S}{p_S^*}\right)^{1-z}. \tag{14}$$

South's relative price of final good z depends on the relative prices of the intermediate goods and the intensity of intermediate goods in the final good. This precise dependence identifies why property rights imperfections become important. The next section shows, in general equilibrium, weaker property rights leads to an inefficiently high supply of resources. This oversupply, in turn, reduces the relative price of resources (factor price equalization fails). Resource-intensive goods cost less to produce in the South. As a result all southern countries export larger shares of resource-intensive goods.

3.3.2. *General equilibrium*

Conditional on the partial equilibrium solutions, general equilibrium is characterized by the following conditions:

(i) Markets for intermediate and primary inputs clear;

(ii) Production of resources on protected land and the production of skills maximize sectoral profits;

(iii) Production of resources on unprotected land dissipates rents to zero;

(iv) Free entry drives profits from the protected resource sector and the skills sector to zero.

Using these conditions, this section establishes three key results. First, factor price equalization does not hold. Despite identical factor endowments, inefficiently high employment of labor in the unprotected resource sector leads to inefficiently low relative price of land in the South. Second, the relative supply of resources is higher in the South. Third, higher relative supply of resources pushes down the relative resource price in the South. Resource-intensive final goods, thus, are relatively cheaper in the South.

Market clearing for intermediate goods.
Recall that, due to the assumed preferences, prices and incomes do not affect the share of world income that accrues to each final-good producing industry; due to the assumed production technology in the final-good producing industries, the factor shares of the intermediate goods are constant. Intermediate good R always earns a constant share z of revenues in industry z, while intermediate good S always earns the residual share $(1 - z)$ of revenues in industry z. Define $v(z)$ as a representative southern country's share of world revenues in industry z:

$$v \equiv \frac{\overbrace{npq^S}^{\text{A Southern country's revenue in industry}}}{\underbrace{M(npq^S + n^*p^*q^{S*})}_{\text{World revenue in industry}}}.$$

Using $q^S = q^{S*}$, and rearranging terms gives

$$v \equiv \frac{\widetilde{n}(z)\widetilde{p}(z)}{M\left(\widetilde{n}(z)\widetilde{p}(z)+1\right)}. \tag{15}$$

Using this definition of $v(z)$, we have equations (16a) to (16d) as the full-employment conditions for the intermediate goods. The left-hand side represents the demand while the right-hand side represents the supply.

$$R_D \equiv \int_0^1 \frac{1}{p_R} z b(z) W v(z) dz = \overbrace{(\lambda T)^{1-\theta_L} L_{RP}^{\theta_L}}^{R_P} + \overbrace{[(1-\lambda)T]^{1-\theta_L} L_{RO}^{\theta_L}}^{R_O} \equiv R_S. \tag{16a}$$

$$S_D \equiv \int_0^1 \frac{1}{p_S}(1-z) b(z) W v(z) dz = H^{1-\theta_L} L_S^{\theta_L} \equiv S_S. \tag{16b}$$

$$R_D^* \equiv \int_0^1 \frac{1}{p_R^*} z b(z) W\left(\frac{1}{M} - v(z)\right) dz = T^{*(1-\theta_L)} L_R^{*\theta_L} \equiv R_S^*. \tag{16c}$$

$$S_D^* \equiv \int_0^1 \frac{1}{p_S^*}(1-z) b(z) W\left(\frac{1}{M} - v(z)\right) dz = H^{*(1-\theta_L)} L_S^{*\theta_L} \equiv S_S^*. \tag{16d}$$

Market clearing for unskilled labor.
The total demand for unskilled labor equals the sum of the labor demand from the resource and skill sectors. The protected resource sector demands L_{RP}, the unprotected resource sector demands L_{RO}, and the skill sector demands L_S. Since R_P is produced efficiently—the resource producer hires labor on the protected fraction of land to maximize profits—L_{RP} is given by

$$\underbrace{\frac{\partial R_P}{\partial L_{RP}}}_{MP_L} = \theta_L (\lambda T)^{1-\theta_L} L_{RP}^{\theta_L - 1} = \frac{w}{p_R}. \tag{17a}$$

Since R_O is produced under open access conditions, labor is hired until all rents dissipate. L_{RO} is given by[12]

$$\underbrace{\frac{R_O}{L_{RO}}}_{AP_L} = [(1-\lambda)T]^{1-\theta_L} L_{RO}^{\theta_L - 1} = \frac{w}{p_R} \tag{17b}$$

Since skills are produced efficiently, L_S is given by

$$\underbrace{\frac{\partial S}{\partial L_S}}_{MP_L} = \theta_L (H)^{1-\theta_L} L_S^{\theta_L - 1} = \frac{w}{p_S}. \tag{17c}$$

The labor market clears if the labor demands, implicitly defined by (17a), (17b), and (17c), sum to equal the labor supply:

$$L_{RP} + L_{RO} + L_S = \overline{L}. \tag{18}$$

Zero-profit conditions in the protected resource sector and the skills sector.
Since both intermediate goods are sold in competitive markets the profits in these sectors are driven down to zero. The representative landowner's zero-profit condition is

$$p_R R_P - r_T(\lambda T) - w L_{RP} = 0. \tag{19a}$$

[12] Resource producers who encroach on the unprotected fraction of the land operate under open access conditions. They hire labor until all rents are dissipated: $P_R R_O - w L_{RO} = 0$. Rearranging leads to (17b).

Notice in (19a) above, the rental rate accrues only to the protected fraction of land. The unprotected fraction of the land generates no returns for the landowner. The zero-profit condition for skills is

$$p_S S - r_H H - w L_S = 0. \tag{19b}$$

With $\lambda^* = 1$ being the only parametric difference between the North and the South, the northern counterparts for these expressions are straightforward to obtain by setting $\lambda = 1$, $L_R^* = L_{RP}^*$ and $L_{RO}^* = 0$ in equations (17a) to (19b). The key difference is that since the north has no property rights imperfections, labor is hired efficiently in both the intermediate good sectors.

The system characterized by equations (16a) to (19b), and their northern counterparts, provide closed-form solutions for equilibrium relative prices and relative factor supplies. These solutions are summarized in the following Lemmas. All derivations and proofs are relegated to the Appendix.

Lemma 2. *Factor price equalization does not hold. Land is underpriced in the South.*

(i) Despite identical relative endowments, as long as property rights are weaker in the South, the relative price of land in the South is lower:

$$\left(\frac{r_T/r_H}{r_T^*/r_H^*}\right) = \frac{\Theta}{1-\lambda(1-\Theta)} < 1, \tag{20}$$

where $\Theta = \theta_L^{\frac{\theta_L}{1-\theta_L}}$.

(ii) The weaker the property rights in the South, i.e., lower the value of λ, the lower the southern relative price of land:

$$\frac{\partial\left(\frac{r_T/r_H}{r_T^*/r_H^*}\right)}{\partial\lambda} > 0.$$

Lemma 3. *Resources are overproduced in the South.*

(i) Despite identical relative endowments, as long as property rights are weaker in the South, the equilibrium relative output of resources in the South is higher:

$$\frac{R/S}{R^*/S^*} = \left(\frac{1}{\frac{r_T/r_H}{r_T^*/r_H^*}}\right)^{1-\theta_L} > 1. \tag{21}$$

(ii) The weaker the property rights in the South, i.e., lower the value of λ, the higher the southern relative output of resources:

$$\frac{\partial\left(\frac{R/S}{R^*/S^*}\right)}{\partial\lambda} > 0.$$

Lemma 4. *Resources are cheaper in the South.*

(i) Despite identical relative endowments, as long as property rights are weaker in the South, the relative price of resources in the South is lower:

$$\frac{p_R/p_S}{p_R^*/p_S^*} = \left(\frac{\Theta}{1-\lambda(1-\Theta)}\right)^{1-\theta_L} < 1. \tag{22}$$

(ii) The weaker the property rights in the South, i.e., lower the value of λ, the lower the southern relative price of resources:

$$\frac{\partial\left(\frac{p_R/p_S}{p_R^*/p_S^*}\right)}{\partial\lambda} > 0.$$

Condition (i) in Lemma 2 establishes that the resource base in the South is underpriced due to weak property rights. Condition (ii) in Lemma 2 shows that as property rights become weaker still, this underpricing is magnified. The consequence of this underpricing is overproduction of resources, formalized in Lemma 3. The weaker the property rights, the more the unskilled labor drawn to rent-dissipating overemployment on unprotected land away from efficient, profit-maximizing employment in the protected resource sector and the skills sector. This inefficient allocation of unskilled labor in turn pushes the southern relative output of resources higher.[13]

This overproduction of resources, then, results in lower relative prices as shown in condition (i) of Lemma 4. Because a further weakening of property rights causes further overemployment of unskilled labor in the unprotected resource sector and results in resource overproduction, such a weakening pushes relative resource prices further down, as summarized in condition (ii).

Lower relative resource prices in the South lead to lower southern prices in resource-intensive—higher z—goods. This relationship is formalized in Proposition 2.

Proposition 2. *As long as property rights are weaker in the South, the South's equilibrium relative price of final goods is decreasing in resource intensity. Formally,*

$$\forall\lambda < \lambda^* = 1, \frac{\partial\widetilde{p}(z)}{\partial z} = \widetilde{p}(z)(1-\theta_L)\ln\left[\frac{\Theta}{1-\lambda(1-\Theta)}\right] < 0.$$

Proof. See section A.6 in the Technical Appendix. □

3.4. **Resource-intensity of southern exports**

We have two key results so far. First, the share of a southern exporter in good-z imports of a northern or southern country is decreasing in the exporting southern country's relative price $\widetilde{p}(z)$ (Proposition 1). Second, a southern country's relative price is decreasing in z. Higher the resource intensity of a final good, the lower is the South's relative price (Proposition 2). Combining these two results we get our key relationships between property rights and import shares:

Proposition 3. *Countries that have weaker property rights capture larger shares of southern and northern resource intensive imports. Both x_{ssz}, and x_{snz} are increasing in z:*

$$\frac{\partial x_{snz}}{\partial z} = \underbrace{\frac{\partial x_{snz}}{\partial\widetilde{p}}}_{-(\text{by Prop. 1})} \underbrace{\widetilde{p}(z)(1-\theta_L)\ln\left[\frac{\Theta}{1-\lambda(1-\Theta)}\right]}_{-(\text{by Prop. 2})} > 0,$$

[13]This mechanism is straightforward to demonstrate.

and

$$\frac{\partial x_{ssz}}{\partial z} = \underbrace{\frac{\partial x_{ssz}}{\partial \widetilde{p}}}_{-\text{(by Prop. 1)}} \underbrace{\widetilde{p}(z)(1-\theta_L)\ln\left[\frac{\Theta}{1-\lambda(1-\Theta)}\right]}_{-\text{(by Prop. 2)}} > 0.$$

The result in Propositions 3 is intuitive. Weakly defined or enforced rights on private ownership of the resource base of an economy leads to inefficiently high supplies of resources. In general equilibrium, such inefficiently high supplies lead to lower resource-intensive product prices in all southern countries, relative to northern countries. This leads to larger shares of resource-intensive goods in exports both to other southern countries and northern countries.

Resource-intensive South-to-South exports arises through the *intra*-industry variety effect—resource-intensive varieties capture larger shares of a southern country's exports to, and imports from, other southern countries. Because of increasing returns to scale, firms producing resource-intensive varieties find it more profitable to locate in southern economies. Because of costless product differentiation, each firm produces a different variety. Because of love-of-variety preferences, identical countries import and export within the same industry. Consider two southern economies S_1 and S_2. Because of cheaper resource prices, both attract more firms in relatively resource-intensive industries compared to any northern country. However, because of costless differentiation and increasing returns to scale, all firms in S_1 produce different varieties than firms locating in S_2 in each industry. Because of love-of-variety preferences, S_1 imports all varieties produced in S_2, and S_2 imports all varieties produced in S_1. Because more resource-intensive varieties are produced in both countries, resource-intensive varieties capture larger shares of total exports from S_1 to S_2 and larger shares of total exports from S_2 to S_1.

Resource-intensive in South-to-North exports arises through the *inter*-industry variety effect—resource-intensive varieties capture larger shares of a southern country's exports to a northern country; skill-intensive varieties capture larger shares of its imports from a northern country. Despite identical endowments, because of perfectly protected property rights, resource supplies are efficient in the North. Northern relative resource prices are higher, southern relative skill prices are higher. Because of increasing returns to scale, relatively more firms producing skill-intensive varieties therefore locate in northern economies. In general equilibrium, resource-intensive varieties are relatively cheaper in the South; skill-intensive varieties are relatively cheaper in the North. These relative cost differences result in resource-intensive varieties capturing larger shares of a southern economy's exports to the North. Skill-intensive varieties capture larger shares of a typical northern economy's exports to the South.

Economies with weakly defined or enforced property rights over the resource base command larger shares of Southern and Northern resource-intensive imports because these economies price resource-intensive products lower than economies that have identical relative endowments, but better defined, or enforced, property rights. Because of increasing returns to scale, and differented products, such underpricing leads to increased resource-content in exports between countries with similar property rights and endowments.

4. Empirical Estimation

We test whether countries with weaker property rights have a stronger comparative advantage in resource-intensive products. We show that relative resource abundance leads to larger shares in resource-intensive industries for exporters with weaker property rights. The key advantage of the product-level analysis is by exploiting the variation of resource-intensity across a large number of industries, we can test the strength of the proposed relationship by resource-intensity of industry. If property rights do indeed influence an exporter's comparative advantage by influencing the relative supply of resources, and, in turn, the relative prices for resource-intensive products, a country's share of exports in an industry will increase *more* with resource intensity of the industry, the weaker the property rights of the country.

Our approach utilizes two sources of variation to isolate the impact of weaker property rights on resource-intensive comparative advantage: the variation in resource intensity across all products at the HS6 classification,[14] and the variation in relative factor abundance across countries. Romalis (2004) empirically showed that exporters capture larger shares of countries' imports in products that intensively use the exporter's abundant factors: a resource-abundant exporter's shares of any country's import shares would be increasing in resource-intensity of products. In our product-level analysis, we show that weak property rights magnifies this effect. Relative resource abundance has a stronger impact on capturing larger shares of resource-intensive imports is larger for exporters with weaker property rights.

To formalize these predictions into empirically testable hypotheses we follow Romalis (2004), Nunn (2007), Levchenko (2007), and Debaere (2014),[15] and consider the following empirical model:

$$\begin{aligned} x_{eiz} = \beta_k(K_e \times k_z) + \beta_h(H_e \times h_z) + \beta_r(R_e \times r_z) \\ + \gamma_1(P_e \times r_z) + \gamma_2(P_e \times R_e \times r_z) + \sum_{j=\{e,i,z\}} \delta_j + \epsilon_{eiz}. \end{aligned} \tag{23}$$

In Equation (23), x_{ezi} is exporter e's *normalized* share of importer i's imports of product z. The normalization involves computing exporter e's share of importer i's imports of product z in levels, and then dividing this share by exporter e's average share of importer i's imports across all products.[16]

[14] The HS6 classification consists approximately of 5,300 products at 6-digit descriptions. For instance, 090210 represents the product 'Green Tea (not fermented)'. The first two digits (09) represents the group 'Coffee, Tea, Mate and Spices'; the next two digits (02) identify groups within that broad category/chapter. The first four digits (0902) represents 'Tea, whether or not flavoured'. The final two digits (10) describe further specifics (fermented or not, in this case).

[15] Romalis (2004) used a similar empirical specification to investigate the role of relative skill abundance in influencing trade patterns. Nunn (2007) and Levchenko (2007) also adopted similar specifications to investigate the role of institutions in driving trade patterns. These studies were, however, concerned with specific role of institutional quality in the enforcement of contracts. Neither investigated how property rights influenced trade patterns through its impact on resource extraction, and the resulting resource prices, which is the concern of the present paper. Debaere (2014) also adopted a similar specification, but to investigate the role of water abundance in driving comparative advantage.

[16] This normalization is convenient for three primary reasons. First, because of the normalization, country size differences are controlled for. Second, exporter-importer specific issues, such as trading agreements, which may be different across exporters are also accounted for. Third, the normalization makes import shares, and therefore the estimated impacts on import shares, comparable across exporters.

The interaction term $F_e \times f_z$, with $F = K, H, R$, and $f = k, h, r$, captures the comparative advantage effect: It captures the relative effect of F-abundance on e's share in i's f-intensive imports. The larger the estimated β_F, the bigger the impact of factor F on comparative advantage in f-intensive goods. In the equation, K_e, H_e, and R_e are exporter e's endowments of physical capital, human capital and, resources; k_z, h_z, and r_z are the the physical-capital intensity, human-capital intensity and resource-intensity of product z. The coefficient β_k captures the impact that greater physical-capital abundance has on import shares of capital-intensive goods. A positive coefficient reflects that higher physical capital abundance leads to exporter e capturing larger shares of importer i's physical-capital intensive imports. Similarly, β_h captures the impact of human-capital abundance on e's share of i's human-capital intensive imports, and β_r captures the impact of resource abundance on e's share of i's resource-intensive imports.

Exporter e's protection of private property rights are represented by P_e. Our coefficient of interest is γ_2, which captures the effect of the triple interaction $(P_e \times R_e \times r_z)$. The interaction $R_e \times r_z$ represents the comparative advantage effect of resource abundance. The coefficient γ_2 measures the differential impact of property rights on e's resource-intensive comparative advantage in exports to i.

The interaction term $(P_e \times r_z)$ completes the set of all subordinate terms for our triple interaction of interest: The exporter fixed effects subsume P_e, R_e, and their interaction; product fixed effects subsume r_z; $(R_e \times r_z)$, recall, is included to account for the comparative advantage effect of relative resource abundance. The remaining effect of the interaction between property rights and product-level resource intensity is accounted for by γ_1.

The fixed effect terms δ_e, δ_z, and, δ_i capture the effect of exporter-specific, product-specific, and importer-specific observable variables. Finally, ϵ_{ezi} is the idiosyncratic error term.

Our model predicts that conditional on relative endowments, weaker property rights in e leads to larger shares of i's resource-intensive imports; better property rights in e leads to smaller shares in i's resource-intensive imports. With higher P_e reflecting stronger property-rights protection, a negative coefficient would support the predictions of our model. Our theoretical prediction, in terms of the empirical model, translates to $\gamma_2 < 0$, for both southern and northern importers, i.e., $\forall \quad i \in \{\text{South}, \text{North}\}$. In the analysis that follows, we test the null of $\gamma_2 = 0$.[17] Romalis (2004) theoretically showed, and then empirically established, that an exporter captures larger shares of an importer's imports in products that use the exporter's relatively abundant factors more intensively. This prediction translates to the following predicted signs for the interaction coefficients: $\beta_s > 0$, $s = \{k, h, r\}$. These are the signs we expect in our regressions.

We estimate equation (23) using data for the year 2000.[18] The data on trade flows are at the Harmonized System 6-digit level of product disaggregation (approximately 5300 available products) from the UN comtrade database United Nations Commodity Trade Statistics

[17] Our test of significance therefore is one-tailed.

[18] The choice of year is governed by data availability. The biggest number of reliable observations over exporters, importers, and products is available for these two importers and the chosen year.

Database (UN Comtrade, http://comtrade.un.org/data/).[19] From these data, we calculate x_{ezi} for all available exporters e, importers i, and products z.

The factor abundance and HS6 product-specific revealed factor intensity variables are from Shirotori et al. (2010).

After combining product-level imports data from UN Comtrade with endowment and revealed factor-intensities data from Shirotori et al. (2010), our sample has observations on 5005 products from 93 exporters, and 146 importers. We then combine this sample with our property rights data from the Heritage foundation.

The estimation strategy exploits simultaneous variation in property-right protection and resource abundance across countries, and the variation in resource intensity across products, to identify the impact of property rights on resource-based comparative advantage. The key element for identification is our ability to simultaneously use exporter and product fixed effects. The exporter fixed effects absorb the differences in the endowments and property rights levels across origins, this allows us to not rely on lack of correlation between trade flows and exporter property rights for identification. The product fixed effects control for differences across industries in their use of resources. The identification of the triple interaction term γ_2 in equation (23) therefore relies on the strength of the resource intensive comparative advantage across industries for exporters with varying endowments and crucially dependent on the level of their property rights.

The importer fixed effects trace out differences in the relative shares across importers and cast the interpretation of our results in terms of averaged effects to all destinations. This is consistent with our theoretical prediction that the effect of property rights on export shares is similar across the importers. Using the full matrix of importers and importers also justifies validity of our findings for the pattern of comparative advantage worldwide.

Under the assumption that the variation in the interaction of property rights with endowments and resource intensity is conditionally exogenous to import shares, we can identify the causal effect of property rights by estimating (23) by ordinary least squares consistently.

Table 1 presents our main results. The first three columns use arable land per worker to proxy for natural resources, and the last three use non-timber forest products, from the Shirotori et al. (2010) dataset. Within these two sets of natural resource measures, the first columns (1 and 4) measure factor intensity as a percentile rank, the second (2 and 5) imposes a constant-returns restriction, and the third (3 and 6) uses a logged measure.

The measures of intensity in the theoretical framework index industries in the 0 to 1 interval with 1 representing the most intensive. The measures of revealed factor intensity we use from Shirotori et al. (2010) are, specifically, for each traded good, calculated as weighted averages of the factor abundance of exporters of the good; the weights are variants of Balassas Revealed Comparative Advantage index. See Shirotori et al. (2010) for details. In order to match the theoretical measure exactly, our rank measure extracts percentile ranks for each

[19]The database contains detailed statistics on annual import and export flows based on reports from importer- or exporter-country statistical authorities of approximately 200 countries or areas. The database contains most comprehensive trade data available with the number of existing records exceeding 1 billion. Typical records provide for every year since 1962, for each product, and for each exporter/importer, trade flows (export/import) in value terms(US dollars), as well as weight and supplementary quantity (count of units).

factor's intensity for each product. Doing so places the industries on the 0 to 1 range to correspond to the theoretical definition.

Our second measure, denoted CRS, addresses an issue raised by Romalis (2004): consistency with Cobb-Douglas production functions require the factor intensities have to add up to one to satisfy the CRS restriction since the intensities also represent shares of cost allocation to various inputs.

Finally, the third measure, denoted Log, computes a natural logarithm of the original intensity values from Shirotori et al. (2010). This transformation permits an elasticity interpretation, and is consistent with measures of intensities of the other factors which are in natural logarithms.

TABLE 1. Product-Level Regressions, Dependent Variable: Normalized Import Share

Natural Resource Measure	(1) A.Land/Worker	(2) A.Land/Worker	(3) A.Land/Worker	(4) NTR	(5) NTR	(6) NTR
Cap. × Cap. Intensity	0.842	1.458	0.365	0.830	1.373	0.363
	(0.030)**	(0.052)**	(0.012)**	(0.029)**	(0.047)**	(0.012)**
Hum. Cap. × Hum. Cap. Intensity	0.979	1.988	0.821	0.871	2.401	0.646
	(0.086)**	(0.120)**	(0.088)**	(0.085)**	(0.107)**	(0.086)**
Nat. Res. × Nat. Res. Intensity	1.451	1.466	1.021	0.720	0.908	0.265
	(0.081)**	(0.129)**	(0.060)**	(0.047)**	(0.059)**	(0.019)**
Nat. Res. Intensity × Prop. Rights	-0.000	-0.007	0.001	0.034	0.041	0.011
	(0.001)	(0.003)**	(0.001)	(0.003)**	(0.004)**	(0.001)**
Nat. Res. × Nat. Res. Intensity × Prop. Rights	-0.012	-0.011	-0.008	-0.005	-0.007	-0.001
	(0.001)**	(0.002)**	(0.001)**	(0.001)**	(0.001)**	(0.000)**
R^2	0.20	0.18	0.20	0.20	0.18	0.19
N	3,905,177	3,905,177	3,905,177	3,886,472	3,886,472	3,886,472
Intensity Measure	Rank	CRS	Log	Rank	CRS	Log

Notes.
Dependent variable in all specifications x_{ezi} is exporter e's *normalized* share of importer i's imports of product z in natural logarithm. The normalization involves computing exporter e's share of importer i's imports of product z in levels, and then dividing this share by exporter e's average share of importer i's imports across all products. Standard errors in parentheses: + significant at 10%; * significant at 5%; ** significant at 1%. All standard errors are simultaneously clustered by importer-product and exporter-product. All specifications include importer, exporter, and product fixed effects $\delta_i, \delta_e, \delta_z$. Natural Resource, abundance, and intensity, are proxied by two measures from the Shirotori et al. (2010) dataset: arable land per worker (A.Land/Worker) in columns 1 - 3, and non-timber forest resources (NTR) in columns 4 - 6. The data covers 2000 imports by 146 importers from 93 exporters (91 in columns 4 - 6) at HS6 level.

The coefficient on the triple interaction term, the coefficient of interest, is presented in the fifth row in all specifications. First, note that we reject the null hypothesis of $\gamma_2 = 0$ in favor of the alternative $\gamma_2 < 0$ across all specifications at the 1% level. The estimates are negative, quantitatively similar and significant. Better property rights lowers the impact of an exporter's resource-abundance on comparative advantage in resource-intensive products; Weaker property rights increases the impact.

Second, the coefficients on all the double interaction terms have positive signs, as predicted. Recall that the interaction term $F_e f_z$, with $F = K, H, R$, and $f = k, h, r$, captures the comparative advantage effect: the relative effect of F-abundance on es share in is f-intensive imports. The larger the estimated β_F, the bigger the impact of factor F on comparative advantage in f-intensive goods. The first row presents the interaction between physical capital endowment, human capital and, resources; kz, hz, and rz are the the physical-capital intensity, human-capital intensity and resource-intensity of product z. The coefficient k captures the impact that greater physical-capital abundance has on import shares of capital-intensive goods. A positive coefficient reflects that higher physical capital abundance leads to exporter e capturing larger shares of importer is physical-capital intensive imports. Similarly, h captures the impact of human-capital abundance on es share of is human-capital intensive imports, and r captures the impact of resource abundance on es share of is resource-intensive imports.Recall that a double interaction of factor abundance F, and its intensity f, $F \times f$, captures the impact of exporter e's abundance of factor F on import shares of importer i's F-intensive imports. Consistent with Romalis (2004)'s quasi Hecksher-Ohlin results, our estimated coefficients in the first three rows indicate that import shares increase in products that use an exporter's abundant factor intensively. Moreover, the effects appear insensitive to our choice of measures of natural resource abundance, and intensity.

Third, across the entire span of the 3×3 grid of natural resource abundance and intensity measures, the physical capital and human capital interactions have coefficients that are not quantitatively very different. The coefficient on the natural-resource interaction is quantitatively similar as well across all specifications.

To summarize, we find that our predictions are validated in product-level regressions. We find evidence supporting the prediction that weaker property rights increases an exporter's resource-intensive comparative advantage: relative resource abundance leads to larger shares of resource-intensive imports for exporters that have weaker property rights.

5. Conclusion

The theory developed in this paper shows that weak property rights can increase the resource dependency of a southern countries to both the south and the north. The hypothesis of apparent comparative advantage—weak property rights can lower relative prices of resource-intensive products, and lead to higher resource-intensive exports—is shown to hold for southern exports to the North, as proponents of the theory suggest, in a many-country continuum of goods model. The hypothesis is shown to hold for southern exports to the South as well, which is a novel result.

In a two-tiered production structure, weaker property rights lead to underpricing and over-extraction or over-harvesting of the resource base. resource-intensive intermediate goods become cheaper. This leads to relatively lower prices for resource-intensive final goods. In a world characterized by scale economies in final goods production, Dixit-Stiglitz love-of-variety preferences, and monopolistically competitive world markets for final goods, such lower relative prices make a southern exporter's varieties more lucrative than northern varieties in other southern, and northern markets. As a result, the southern exporter's export shares of resource-intensive goods increase.

Our empirical analysis suggests the model's theoretical claims can not be ruled out. In exporter-product panels weaker property rights lead to greater resource-intensive comparative advantage in exports to Brazil, a southern importer, and to the USA, a northern importer.

Such comparative advantage in resource-intensive products is concerning because it is built on the underlying inefficiency arising from imperfectly protected property rights. If southern economies integrate, property rights imperfections may aggravate the inefficient resource-dependency further. The apparent comparative advantage in resource-intensive products makes the countries move away from skill-based exports. Northern economies, on the other hand, that are identically endowed, but have well-protected property rights price the resource-base efficiently. Skills are relatively cheaper, and these economies export more sophisticated, skill-based final goods.

The consequences of enhanced southern economic integration therefore depend critically on protection of private property rights. Integration in the presence of weaker property rights will displace skill-intensive goods. It will also lead to an under-priced resource base that magnifies the resource dependence of a southern exporter's exports to other southern countries. In the presence of weak property rights in a lot of low- and middle-income countries, the concerns of Coxhead (2007) and Greenway et al. (2008) are justified. In the presence of stronger property rights however, enhanced southern integration can benefit southern countries in diversifying away from resource-intensive products towards more skill-intensive goods. The optimism regarding the potential benefits of enhanced southern integration, expressed by authors such as Greenaway and Milner (1990), Das (2009) and Panitchpakdi (2012), can be realized only after property rights protection is ensured prior to integration.

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Appendix A. Technical Appendix: Proofs of Lemmas and Propositions

A.1. *Lemma 1*

The relative number of southern varieties, $\widetilde{n}(z) \equiv \frac{n(z)}{n^*(z)}$, in any industry z in which both $n(z)$ and $n^*(z)$ are positive, is decreasing in the relative price of the product $\widetilde{p}$:

$$\frac{\partial \widetilde{n}}{\partial \widetilde{p}} = \Omega'(\widetilde{p}) < 0.$$

Proof. Denote the numerator in (11d) by

$$\mathcal{N} \equiv \tau^{2-2\sigma} M^2 \frac{Y^*}{Y} + F^2 - \widetilde{p}^{\sigma} \tau^{1-\sigma} MF \left(\frac{Y^*}{Y} + 1 \right), \tag{24}$$

and the denominator by

$$\mathcal{D} \equiv \widetilde{p} \left(\tau^{2-2\sigma} M^2 + F^2 \frac{Y^*}{Y} \right) - \widetilde{p}^{1-\sigma} \tau^{1-\sigma} MF \left(\frac{Y^*}{Y} + 1 \right). \tag{25}$$

Differentiating (11d) with respect to $\widetilde{p}$ gives

$$\frac{\partial \Omega(\widetilde{p})}{\partial \widetilde{p}} = \frac{\mathcal{D} \partial \mathcal{N} / \partial \widetilde{p} - \mathcal{N} \partial \mathcal{D} / \partial \widetilde{p}}{\mathcal{D}^2}. \tag{26}$$

Substituting in for $\partial \mathcal{N} / \partial \widetilde{p}$ and $\partial \mathcal{D} / \partial \widetilde{p}$, using (24) and (25), gives

$$\frac{\partial \Omega(\widetilde{p})}{\partial \widetilde{p}} = - \frac{\mathcal{D} \left(\sigma \widetilde{p}^{\sigma-1} \tau^{1-\sigma} MF \left(\frac{Y^*}{Y} + 1 \right) \right)}{\mathcal{D}^2} - \frac{\mathcal{N} \left[\left(\tau^{2-2\sigma} M^2 + F^2 \frac{Y^*}{Y} \right) + \underbrace{(\sigma - 1)}_{+} \widetilde{p}^{-\sigma} \tau^{1-\sigma} MF \left(\frac{Y^*}{Y} + 1 \right) \right]}{\mathcal{D}^2} < 0.$$

□

A.2. *Proposition 1*

$\forall z \in (\underline{z}, \overline{z})$, where $\underline{z} = z(\overline{p})$ and $\overline{z} = z(\underline{p})$, any southern exporter's share in another southern country's imports, x_{ssz}, as well in any northern country's imports, x_{snz}, are declining in the exporter's relative price of z:

$$\frac{\partial x_{ssz}}{\partial \widetilde{p}} < 0,$$

and,

$$\frac{\partial x_{snz}}{\partial \widetilde{p}} < 0.$$

Proof. Define $V(\widetilde{p}(z)) \equiv \Omega(\widetilde{p}(z)) \widetilde{p}(z)^{1-\sigma}$. Since by Lemma 1, $\Omega'(\widetilde{p}(z)) < 0$,

$$V'(\widetilde{p}(z)) = \overbrace{\underbrace{\widetilde{p}(z)^{1-\sigma}}_{+} \underbrace{\Omega'(\widetilde{p}(z))}_{-}}^{-} + \overbrace{\underbrace{(1-\sigma)}_{-} \underbrace{\widetilde{p}(z)^{1-\sigma} \Omega(\widetilde{p}(z))}_{+}}^{-} < 0.$$

(i) Recall that $x_{ssz} = \dfrac{1}{(M-1) + \dfrac{M}{\widetilde{n}\widetilde{p}^{1-\sigma}}}$.

$$\begin{aligned}
\frac{\partial x_{ssz}}{\partial \widetilde{p}} &= -\left[M - 1 + \frac{M}{\widetilde{n}\widetilde{p}^{1-\sigma}}\right]^{-2} \left(-\frac{M}{(\widetilde{n}\widetilde{p}^{1-\sigma})^2}\right) \left(\frac{\partial\left(\widetilde{n}\widetilde{p}^{1-\sigma}\right)}{\partial \widetilde{p}}\right) \\
&= \left[M - 1 + \frac{M}{\widetilde{n}\widetilde{p}^{1-\sigma}}\right]^{-2} \left(\frac{M}{(\widetilde{n}\widetilde{p}^{1-\sigma})^2}\right) \left(\underbrace{\frac{\partial\left(\Omega(\widetilde{p})\widetilde{p}^{1-\sigma}\right)}{\partial \widetilde{p}}}_{\equiv V'(\widetilde{p})<0}\right) \\
&< 0.
\end{aligned}$$

(ii) Recall that $x_{snz} = \dfrac{1}{M + \dfrac{M-1}{\widetilde{n}\widetilde{p}^{1-\sigma}}}$.

$$\begin{aligned}
\frac{\partial x_{snz}}{\partial \widetilde{p}} &= -\left[M + \frac{M-1}{\widetilde{n}\widetilde{p}^{1-\sigma}}\right]^{-2} \left(-\frac{M-1}{(\widetilde{n}\widetilde{p}^{1-\sigma})^2}\right) \left(\frac{\partial\left(\widetilde{n}\widetilde{p}^{1-\sigma}\right)}{\partial \widetilde{p}}\right) \\
&= \left[M + \frac{M-1}{\widetilde{n}\widetilde{p}^{1-\sigma}}\right]^{-2} \left(\frac{M-1}{(\widetilde{n}\widetilde{p}^{1-\sigma})^2}\right) \left(\underbrace{\frac{\partial\left(\Omega(\widetilde{p})\widetilde{p}^{1-\sigma}\right)}{\partial \widetilde{p}}}_{\equiv V'(\widetilde{p})<0}\right) \\
&< 0.
\end{aligned}$$

The statement follows. □

A.3. ***Lemma 2***

Factor price equalization does not hold. Land is underpriced in the South.

(i) Despite identical relative endowments, as long as property rights are weaker in the South, the relative price of land in the South is lower:

$$\left(\frac{r_T/r_H}{r_T^*/r_H^*}\right) = \frac{\Theta}{1-\lambda(1-\Theta)} < 1,$$

where $\Theta = \theta_L^{\frac{\theta_L}{1-\theta_L}}$.

(ii) The weaker the property rights in the South, i.e., lower the value of λ, the lower the southern relative price of land:

$$\frac{\partial\left(\frac{r_T/r_H}{r_T^*/r_H^*}\right)}{\partial \lambda} > 0.$$

We will prove Lemma 2 in two parts. First, we will demonstrate the failure of factor-price equalization (FPE). Next, we will derive the solution for southern relative price of land and show that land is underpriced in the South.

Part (a): FPE fails

Proof. Substituting in for L_{RP} using (17a) and for R_P using its definition in (19a) and solving for p_R gives

$$p_R = \left[\frac{r_T}{1-\theta_L}\right]^{1-\theta_L}\left(\frac{w}{\theta_L}\right)^{\theta_L}. \tag{27}$$

Substituting in for L_S using (17c) and for S using its definition in (19b) and solving for p_S gives

$$p_S = \left[\frac{r_H}{1-\theta_L}\right]^{1-\theta_L}\left(\frac{w}{\theta_L}\right)^{\theta_L}. \tag{28}$$

Combining (27) and (28) gives the relative prices of resources in the South:

$$\frac{p_R}{p_S} = \left[\frac{r_T}{r_H}\right]^{1-\theta_L}. \tag{29}$$

Similarly, for the North,

$$\frac{p_R^*}{p_S^*} = \left[\frac{r_T^*}{r_H^*}\right]^{1-\theta_L}. \tag{30}$$

We will now demonstrate the failure of factor-price equalization by contradiction. Suppose factor-price equalization holds so that $r_T = r_T^*$, $r_H = r_H^*$, and $w = w^*$. By (29) and (30), the relative price of the intermediate goods are equalized:

$$\frac{p_R}{p_S} = \frac{p_R^*}{p_S^*}. \tag{31}$$

If the prices of intermediate goods are equalized, then by equation (14), $\widetilde{p} = 1$. By equations (11c) and (15), if $\widetilde{p} = 1$, v becomes invariant over z. With factor prices equalized and v being invariant over z, the relative demand for intermediate goods in the South, $\frac{R_D}{S_D}$, equals the relative demand for intermediate goods in the North, $\frac{R_D^*}{S_D^*}$. This can be shown as follows. From equation (16a) and (16b), with v invariant over z,

$$\begin{aligned}\frac{R_D}{S_D} &= \frac{p_S W v}{p_R W v}\frac{\int_0^1 z b(z)dz}{\int_0^1 (1-z)b(z)dz} \\ &= \frac{p_S}{p_R}\frac{\int_0^1 z b(z)dz}{\int_0^1 (1-z)b(z)dz}.\end{aligned} \tag{32}$$

And from equation (16c) and (16d), with v invariant over z,

$$\begin{aligned}\frac{R_D^*}{S_D^*} &= \frac{p_S^* W(\frac{1}{M}-v)}{p_R^* W(\frac{1}{M}-v)}\frac{\int_0^1 z b(z)dz}{\int_0^1 (1-z)b(z)dz} \\ &= \frac{p_S^*}{p_R^*}\frac{\int_0^1 z b(z)dz}{\int_0^1 (1-z)b(z)dz}.\end{aligned} \tag{33}$$

By (32) and (33), if $p_S = p_S^*$ and $p_R = p_R^*$, then

$$\frac{R_D}{S_D} = \frac{R_D^*}{S_D^*}. \tag{34}$$

Therefore if factor-price equalization has to hold in equilibrium, the relative supply of the intermediate goods in the South has to equal the relative supply of the intermediate goods in the North. However, as we show next, given the weaker property rights in the South, such equalization of relative supplies cannot occur.

The relative supply of intermediates in the South is

$$\begin{aligned}\frac{R_S}{S_S} &= \frac{R_P + R_O}{S_S}. \\ &= \frac{(\lambda T)^{1-\theta_L} L_{RP}^{\theta_L} + [(1-\lambda)T]^{1-\theta_L} L_{RO}^{\theta_L}}{H^{1-\theta_L} L_S^{\theta_L}},\end{aligned} \tag{35}$$

where the second line follows from substituting in for R_P, R_O and S. Substituting in for L_{RP} from (17a), for L_{RO} from (17b), and for L_S from (17c) into (35) gives

$$\begin{aligned}\frac{R_S}{S_S} &= \left[\frac{\lambda T}{H}\right]\left(\frac{p_R}{p_S}\right)^{\frac{\theta_L}{1-\theta_L}} + \left[\frac{(1-\lambda)T}{H}\right]\left(\frac{p_R}{p_S}\right)^{\frac{\theta_L}{1-\theta_L}}\left(\frac{1}{\theta_L}\right)^{\frac{\theta_L}{1-\theta_L}} \\ &= \left[\frac{\lambda T}{H}\right]\left(\frac{r_T}{r_H}\right)^{\theta_L} + \left[\frac{(1-\lambda)T}{H}\right]\left(\frac{r_T}{r_H}\right)^{\theta_L}\left(\frac{1}{\theta_L}\right)^{\frac{\theta_L}{1-\theta_L}},\end{aligned} \tag{36}$$

where the second line follows from substituting in for $\frac{p_R}{p_S}$ using (29). Similarly, the expression for relative supply of the intermediate goods in the North,

$$\frac{R_S^*}{S_S^*} = \left(\frac{T^*}{H^*}\right)^{1-\theta_L}\left(\frac{L_R^*}{L_S^*}\right)^{1-\theta_L}, \tag{37}$$

by consecutively substituting in, for L_R^* and L_S^* from the northern counterparts of (17a) and (17c), and for $\frac{p_R^*}{p_S^*}$ from (30), becomes

$$\frac{R_S^*}{S_S^*} = \left(\frac{T^*}{H^*}\right)^{1-\theta_L}\left(\frac{r_T^*}{r_H^*}\right)^{\theta_L}. \tag{38}$$

Recall that by assumption northern and southern relative endowments are identical, so that $\frac{T}{H} = \frac{T^*}{H^*}$. With factor-price equalization, the right-hand side of (38) can be factored to get

$$\frac{R_S^*}{S_S^*} = \left[\frac{\lambda T}{H}\right]\left(\frac{r_T}{r_H}\right)^{\theta_L} + \left[\frac{(1-\lambda)T}{H}\right]\left(\frac{r_T}{r_H}\right)^{\theta_L}. \tag{39}$$

Subtracting (39) from (36) gives

$$\frac{R_S}{S_S} - \frac{R_S^*}{S_S^*} = \left[\frac{(1-\lambda)T}{H}\right]\left(\frac{r_T}{r_H}\right)^{\theta_L}\left[\left(\frac{1}{\theta_L}\right)^{\frac{\theta_L}{1-\theta_L}} - 1\right]. \tag{40}$$

Since by assumption $\theta_L < 1$,

$$\frac{R_S}{S_S} - \frac{R_S^*}{S_S^*} = \left[\frac{(1-\lambda)T}{H}\right]\left(\frac{r_T}{r_H}\right)^{\theta_L}\left[\left(\frac{1}{\theta_L}\right)^{\frac{\theta_L}{1-\theta_L}} - 1\right] > 0.$$

Since with FPE relative factor supplies are not equalized, even though factor demands are, the statement follows. □

Part (b): Land is underpriced in the South

Proof. By Shephard's Lemma, the relative demand for resources R from industry z is

$$\frac{R_D(z)}{S_D(z)} = \frac{\partial C/\partial p_R}{\partial C/\partial p_S}$$
$$= \frac{z p_R^{z-1}[\alpha + q^S] p_S^{(1-z)}}{(1-z) p_S^{z-1}[\alpha + q^S] p_R^{(1-z)}}$$
$$= \left[\frac{z}{(1-z)}\right] \frac{p_S}{p_R}. \tag{41}$$

Integrating over all industries, the total relative demand for R in a southern country is

$$\frac{R_D}{S_D} = \frac{p_S}{p_R} \zeta_Z, \tag{42}$$

with $\zeta_Z = \int_{\underline{z}}^{\overline{z}} \left[\frac{z}{1-z}\right] dz > 0$. The expression for northern countries is symmetric:

$$\frac{R_D^*}{S_D^*} = \frac{p_S^*}{p_R^*} \zeta_Z. \tag{43}$$

Dividing (42) by (43), and substituting in for the relative resource prices using (29) and (30) gives a southern country's relative demand for R as

$$\left(\frac{R_D/S_D}{R_D^*/S_D^*}\right) = \left(\frac{r_T/r_H}{r_T^*/r_H^*}\right)^{\theta_L - 1}. \tag{44}$$

Using (36) and (38), the relative supply of resources in a southern country is

$$\left(\frac{R_S/S_S}{R_S^*/S_S^*}\right) = \frac{(r_T/r_H)^{\theta_L}\left[1 - \lambda(1-\Theta)\right]}{(r_T^*/r_H^*)^{\theta_L}} \frac{T/H\Theta}{T^*/H^*}, \tag{45}$$

where $\Theta = \theta_L^{\frac{\theta_L}{1-\theta_L}}$.

Setting the relative demand in (44) equal to the relative supply in (45) gives:

$$\left(\frac{r_T/r_H}{r_T^*/r_H^*}\right)^{\theta_L - 1} = \frac{(r_T/r_H)^{\theta_L}\left[1 - \lambda(1-\Theta)\right]}{(r_T^*/r_H^*)^{\theta_L}} \frac{T/H\Theta}{T^*/H^*}$$
$$\left(\frac{r_T/r_H}{r_T^*/r_H^*}\right)^{-1} = \frac{\left[1 - \lambda(1-\Theta)\right]}{\Theta} \frac{T/H}{T^*/H^*} \tag{46}$$

Noting relative endowments are identical in (46) , and simplifying gives the solution for southern relative land price as

$$\left(\frac{r_T/r_H}{r_T^*/r_H^*}\right) = \frac{\Theta}{1 - \lambda(1-\Theta)}. \tag{47}$$

The solution in (47) forms the basis of (i) in Lemma 2:

$$\left(\frac{r_T/r_H}{r_T^*/r_H^*}\right) = \frac{\Theta}{1 - \lambda(1-\Theta)} < 1.$$

The statement is satisfied as long as

$$\frac{\Theta}{1-\lambda(1-\Theta)} < 1.$$

$\forall \lambda < \lambda^* = 1$, this condition is satisfied iff,

$$\begin{aligned}
& \frac{\Theta}{1-\lambda(1-\Theta)} < 1 \\
\Leftrightarrow \quad & 1-\lambda+\lambda\Theta > \Theta \\
\Leftrightarrow \quad & 1-\lambda > \Theta(1-\lambda) \\
\Leftrightarrow \quad & 1 > \Theta,
\end{aligned} \tag{48}$$

where the inequality in last line always holds since $\Theta = \theta_L^{\frac{\theta_L}{1-\theta_L}} < 1$, as long as $\theta_L < 1$. Recall claim (ii) in Lemma 2, the southern relative price of land is increasing in protection of private property rights:

$$\frac{\partial\left(\frac{r_T/r_H}{r_T^*/r_H^*}\right)}{\partial\lambda} > 0$$

This result is evident from straightforward differentiation of (47):

$$\frac{\partial\left(\frac{r_T/r_H}{r_T^*/r_H^*}\right)}{\partial\lambda} = \left[\frac{1-\Theta}{[1-\lambda(1-\Theta)]^2}\right] > 0. \tag{49}$$

The statement follows. □

A.4. *Lemma 3*

Resources are overproduced in the South.

(i) Despite identical relative endowments, as long as property rights are weaker in the South, the equilibrium relative output of resources in the South is higher:

$$\frac{R/S}{R^*/S^*} = \left(\frac{1}{\frac{r_T/r_H}{r_T^*/r_H^*}}\right)^{1-\theta_L} > 1.$$

(ii) The weaker the property rights in the South, i.e., lower the value of λ, the higher the southern relative output of resources:

$$\frac{\partial\left(\frac{R/S}{R^*/S^*}\right)}{\partial\lambda} > 0.$$

Proof. Part (i): Follows from substituting in for the equilibrium solution for relative land prices into the expression for relative southern resource demand, (44). Part (ii): Follows from Part (i) and (49). □

A.5. *Lemma 4*

Resources are cheaper in the South.

(i) Despite identical relative endowments, as long as property rights are weaker in the South, the relative price of resources in the South is lower:

$$\frac{p_R/p_S}{p_R^*/p_S^*} = \left(\frac{\Theta}{1-\lambda(1-\Theta)}\right)^{1-\theta_L} < 1. \tag{22}$$

(ii) The weaker the property rights in the South, i.e., lower the value of λ, the lower the southern relative price of resources:

$$\frac{\partial\left(\frac{p_R/p_S}{p_R^*/p_S^*}\right)}{\partial\lambda} > 0.$$

Proof. (i) By (22), the Proposition holds if

$$\left(\frac{\Theta}{1-\lambda(1-\Theta)}\right)^{1-\theta_L} < 1,$$

which is always satisfied as long as $\lambda < 1$ (see the proof of condition (i) in Lemma 3). □

Proof. (ii) Straighforward differentiation of (22) gives

$$\frac{\partial\left(\frac{p_R/p_S}{{p_R}^*/{p_S}^*}\right)}{\partial\lambda} = (1-\theta_L)\left(\frac{\Theta}{1-\lambda(1-\Theta)}\right)^{-\theta_L}\left[\frac{1-\Theta}{[1-\lambda(1-\Theta)]^2}\right] > 0,$$

and the statement follows. □

A.6. ***Propositon 2***

Proof. Recall that by equation (14),

$$\widetilde{p} = \left(\frac{p_R}{p_R^*}\right)^z\left(\frac{p_S}{p_S^*}\right)^{1-z}.$$

Note first that the southern relative price of good z, $\widetilde{p}(z)$ is declining in z if and only if $p_R/p_S < p_R^*/p_S^*$, as shown below. Taking natural logs on both sides of (14), and differentiating with respect to z gives

$$\begin{aligned}
&\frac{1}{\widetilde{p}}\frac{\partial\widetilde{p}}{\partial z} = \ln\left(\frac{p_R}{p_R^*}\right) - \ln\left(\frac{p_S}{p_S^*}\right)\\
\Leftrightarrow\ &\frac{1}{\widetilde{p}}\frac{\partial\widetilde{p}}{\partial z} = \ln\left(\frac{p_R/p_R^*}{p_S/p_S^*}\right)\\
\Leftrightarrow\ &\frac{\partial\widetilde{p}}{\partial z} = \widetilde{p}\ln\left(\frac{p_R/p_S}{p_R^*/p_S^*}\right)\\
\Leftrightarrow\ &\frac{\partial\widetilde{p}}{\partial z} = \widetilde{p}(z)\underbrace{(1-\theta_L)\ln\left(\frac{\Theta}{1-\lambda(1-\Theta)}\right)}_{\ln\left(\frac{p_R/p_S}{p_R^*/p_S^*}\right)\text{ by (22)}} < 0,
\end{aligned} \tag{50}$$

since

$$\left(\frac{\Theta}{1-\lambda(1-\Theta)}\right) < 1 \quad \forall \quad \lambda < 1.$$

The statement follows. $\square$

Appendix B. Data Appendix

B.1. **Property Rights Ranking**

Our measure of protection of private property rights for any importer/exporter is the score on the Property Rights Index calculated by the Heritage Foundation as a part of the Index of Economic Freedom. The Property Rights Score is a measure of the extent to which private property rights are legally protected and the extent to which the laws that protect property rights are enforced. Each country is graded on a scale of 0 - 100, in 10 point increments. A score of zero reflects that "Private property is outlawed, and all property belongs to the state. People do not have the right to sue others and do not have access to the courts. Corruption is endemic." At the other end of the spectrum, a score of 100 reflects "Private property is guaranteed by the government. The court system enforces contracts efficiently and quickly. The justice system punishes those who unlawfully confiscate private property. There is no corruption or expropriation." See http://www.heritage.org/index/property-rights for further details.

B.2. **Endowments**

Data on human capital and physical capital per worker, our proxies for skill-specific capital, and arable land per worker, our proxy for resource endowments, are from Shirotori et al. (2010). GDP per capita is from the Penn World Table, version 6.2.

B.2.1. *Physical Capital*

The physical capital stock is computed by the perpetual inventory method. The investment data used for this purpose are from the Penn World Table (PWT), version 6.2.

B.2.2. *Human Capital*

Human capital is computed using the method prescribed in Barro and Lee (2001). Using attainment data for different educational levels, the method calculates the average years of schooling. A shortfall of the method is that no adjustments are made for differences in education quality across countries.

B.2.3. *Natural Resource*

The endowment of natural resources per worker is measured using the data on arable land hectares per worker, and non-timber forest resources from the World Development Indicators (WDI) from the World Bank.

B.3. **Factor Intensities**

The data for factor intensities are from HS version of the updated version of the UN-COMTRADE "Revealed Factor Intensity" database.[20] This database includes indices of factor intensity for Physical Capital, Human Capital and Natural Resource for products classified at the HS 6-digit level (over five thousand products) and covers the years 1988-2007. The indices are calculated using a data-intensive methodology that capture "revealed"

[20]Available at http://unctad.org/Sections/ditc$_tab/docs/RFII_2010_Excel.zip$.

factor intensity of goods at a highly disaggregated level of product classification (HS 6-digit). Specifically, for each traded good, the factor intensity is calculated as a weighted average of the factor abundance of exporters of the good; the weights are variants of Balassas Revealed Comparative Advantage index. See Shirotori et al. (2010) for details.

Summary statistics for the variables used in the country-level regressions are in table 2 below.

Table 2. Summary Statistics for Key Variables

	Min	Max	Mean	Standard Deviation	Total Observations
RD_{South}	.0022	.9984	.5428	.2757	1392
RD_{North}	.0011	.9999	.5176	.3030	1396
Rank	.0056	1	.4885	.2788	2892
GDPPC	168.9312	110001.1	12749.13	18341.68	2892
Physical Capital per worker	613.8137	265662.4	69064.1	70973.33	1223
Human Capital per worker	.8876	13.0863	7.5258	2.8045	1223
Natural Resource per worker	0	5.0821	.6764	.7198	1223

Notes: Rank is the percentile rank calculated for each country-year pair using the property rights scores from the Property Rights Index component of the Index of Economic Freedom computed by the Heritage Foundation. Larger values for Rank imply worse protection of private property rights. $RD_{i,j}, j \in \{\text{South, North}\}$, is the share of primaries in total merchandize exports to j. GDDPC is GDP per capita. See the Data Appendix for further details and definitions of factor-endowment variables.

Summary statistics for the variables used in the country-product regressions are in tables 3 and 4

Table 3. Summary Statistics, Importer:Brazil

	Mean	Standard Deviation	Min	Max
Physical Capital per worker	133397.6	65709.06	838.1267	231302.1
Human Capital per worker	9.269373	2.086481	.8918922	13.00398
Natural Resources per worker	.6449973	.738556	0	4.906756
Physical Capital intensity	97462.63	39140.95	2048.883	208238.6
Human Capital intensity	8.067786	1.395381	1.591406	11.70278
Natural Resource-intensity	.5775717	.235155	.0667682	4.332201
Property Rights	75.798	17.23333	10	90
Import Share	.1015341	.1934253	1.06e-06	1
N	45088			

Table 4. Summary Statistics, Importer:US

	Mean	Standard Deviation	Min	Max
Physical Capital per worker	112235.7	71664.78	838.1267	231302.1
Human Capital per worker	8.567416	2.307486	.8918922	12.03667
Natural Resources per worker	.6578795	.8964553	0	4.906756
Physical Capital intensity	87236.61	41984.77	2048.883	208766.3
Human Capital Intensity	7.732238	1.540957	1.591406	11.78039
Natural Resource-intensity	.578705	.2394616	.0667682	4.874905
Property Rights	71.15523	19.31542	10	90
Import Share	.0490525	.1292207	4.21e-08	1
N	99547			