Revealed Comparative Advantage: What Is It Good For?

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Abstract

This paper utilizes a many-country, many-product Ricardian trade model to evaluate the usefulness of measures of revealed comparative advantage (RCA) in academic and policy analyses. I find that, while commonly used indexes are generally not consistent with theoretical notions of comparative advantage, certain indexes can be usefully employed for certain tasks. I explore several common uses of RCA indexes and show that different indexes are appropriate when attempting to (a) evaluate the differential effect of changes in trade barriers across producers of different products, (b) identify countries who are relatively close competitors in a given market, or (c) recover patterns of relative productivity.

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1 Introduction

Since Balassa (1965), revealed comparative advantage (RCA) indexes have been employed in countless applications as a measure of the relative ability of a country to produce a good vis-à-vis its trading partners. The concept is simple but powerful: if, according to Ricardian trade theory, differences in relative productivity determine the pattern of trade, then the (observable) pattern of trade can be used to infer (unobservable) differences in relative productivity. However, in practice, developing the appropriate way to measure RCA has proven elusive.[1]

In this paper, I utilize insights from a Ricardian trade model based on Eaton and Kortum (2002) to answer the question, "What is the appropriate way to measure revealed comparative advantage?" and find that the answer is, "It depends."[2] The model highlights two features that a theoretically-correct RCA index should possess. First, because comparative advantage is fundamentally a relative measure, an appropriate RCA measure must be a function of trade flows relative to an appropriate point of comparison, which, it turns out, depends on the purpose of the RCA index. Second, in the presence of trade barriers, market conditions – such as the prices offered by competing producers – vary by destination. This implies that RCA measures based on bilateral trade flows are generally preferable to the most widely used indexes, which utilize trade flows that are first aggregated across importers, because the former measures can separate bilateral and market-specific effects of trade distortions from those of comparative advantage, whereas the latter conflate these effects.

I consider several common uses of RCA indexes and show that, while the most commonly employed indexes are not generally useful, in many cases there *is* an appropriate measure of RCA that is straightforward to calculate and to interpret in light of the model. I show that a bilateral, additive RCA index (BAI) is appropriate when predicting or evaluating the differential effect of changes in trade barriers, such as tariffs, on a countries' exports across product categories. This index reflects the model's prediction that a decrease in the cost of exporting from one country to another induces the importer to reallocate expenditure toward the exporter's comparative advantage products and away from both other exporters and other products. I also define an index that measures the effect of patterns of comparative advantage on the responsiveness of a country's sector-wide exports to changes in the trade barriers faced by its own or other countries' exporters. The appropriate index is the weighted covariance, across product categories, of the BAI values of the country whose exporters experience a change in trade barriers and the values of a bilateral version of Balassa's (1965) index for the exporter of interest. This index captures the notion that, if two countries have very similar patterns of comparative advantage, the trade barriers faced by

[1] See Yeats (1985) for an early critique of Balassa's RCA index, and Vollrath (1991) and De Benedictis and Tamberi (2001) for surveys and discussions of the properties of various proposed measures. There have been many subsequent attempts to develop an index with desirable properties, such as Hoen and Oosterhaven (2006), Yu et al. (2009), and Bebek (2011).

[2] I base the analysis on such a framework due to its close relation to the classical theory of comparative advantage. However, as is clear from Arkolakis et al. (2012), similar results can be derived based on an Armington model, such as Anderson and van Wincoop (2003); a model of monopolistic competition and increasing returns, such as Krugman (1980); or a model featuring firm-level heterogeneity, á la Melitz (2003), such as Chaney (2008). Thus, similar results hold within a relatively broad class of models.

one of the countries will be relatively influential upon the exports of the other, since the countries will be relatively close competitors for customers in foreign markets.

When one is concerned with uncovering countries' fundamental patterns of comparative advantage – defined in terms of the opportunity cost of production in autarky – then the appropriate RCA index is a function of bilateral trade flows relative to those for a numeraire product and exporter. Such an index controls for the effects of both bilateral trade barriers and product- and market-specific distortions in order to isolate a country's relative ability to produce the product of interest, and, because it has a constant reference point, the values are comparable across both products and countries. One RCA measure that falls into this category is the regression-based measure described by Costinot et al. (2012). However, I also define a related but unique index – the Modified Balassa Index (MBI) – which is much more practical to compute when the number of countries and products being studied is relatively large.

In addition to defining appropriate RCA indexes for each of these common tasks, I also briefly discuss the usefulness of such indexes for two other purposes. First, while RCA measures, such as the MBI and the measure of Costinot et al. (2012), can be correlated with country- and product-specific variables in exercises designed to uncover the sources of countries' patterns of comparative advantage, I argue that it is more straightforward and equally consistent with the theory to regress bilateral trade flows directly on variables thought to determine comparative advantage, as in, e.g., Romalis (2004) and Chor (2010). I also argue that RCA measures are not generally useful as a tool for comparing a country's levels of productivity across time periods.

This paper is primarily related to two strands of the literature. First, because it utilizes insights from a Ricardian trade model with micro-level heterogeneity, á la Eaton and Kortum (2002), along with disaggregated trade data to uncover countries' underlying patterns of comparative advantage, it is related to papers such as Anderson and Yotov (2010), Costinot et al. (2012), Caliendo and Parro (2014), and Levchenko and Zhang (2014). However, this paper is unique in its focus on developing simple, useful, and theoretically-founded RCA indexes that can be employed in the countless applications for which more ad hoc RCA measures have traditionally been used. By contrast, the papers mentioned are primarily interested in quantifying the effects of comparative advantage across broadly-defined industries on trade flows and welfare.

This paper is also related to the strand of the literature concerned with developing RCA indexes that improve upon Balassa's (1965) measure in some way. Such papers include Yeats (1985), Vollrath (1991), and Laursen (1998), and there are many more. However, this paper is quite distinct in its approach to the subject in that it relies on a quantitative, Ricardian trade model to determine the appropriate form of RCA indexes, rather than appealing to particular numerical properties of certain indexes.[3] This paper also makes the additional contribution of outlining a framework within which to develop additional forms and appropriate uses of RCA indexes and to identify tasks for which they are not well suited. And, by relying on a formal model, it makes clear

[3]The notable exception is Costinot et al. (2012) who propose a theoretically-founded RCA measure. However, they do not explore the usefulness of this measure for tasks other than their computation of the welfare gains from inter-industry patterns of comparative advantage.

the key assumptions that are needed for the use an RCA index to be appropriate at all: trade barriers that can be separated into bilateral and product- and market-specific components and an elasticity of product-level trade flows to exporters' production and trade costs that is constant across products, both of which indicate that RCA measures can be most appropriately utilized to study patterns of comparative advantage within somewhat narrowly defined sectors.

I describe the model in the following section. In Section 3, I briefly discuss the properties of a few existing RCA indexes, and in Section 4, I discuss appropriate RCA indexes for measuring the differential effects of trade barriers, responsiveness to of aggregate trade flows to changes in trade barriers, and relative productivity. The final section concludes, and the Appendix discusses practical concerns that arise in calculating RCA measures when data on domestic trade flows is unavailable.

2 A Ricardian Trade Model

I will evaluate the properties and usefulness of measures of revealed comparative advantage through the lens of a many-country, many-good Ricardian trade model. The model is a generalization of the model of Eaton and Kortum (2002) and is extended to allow for any pattern of comparative across a potentially large finite number of products. This framework provides an ideal setting within which to study the usefulness of RCA measures for several reasons. First, by allowing for ex-ante productivity differences across products, the Ricardian environment maintains a straightforward link to the classical theory of comparative advantage, which motivated the concept of RCA in the first place. Second, the presence of idiosyncratic micro-level heterogeneity of the form introduced by Eaton and Kortum (2002) allows for intra-product trade, which is staple feature of disaggregated international trade data. Finally, the model implies that product-level bilateral trade flows follow a gravity equation, which, due to the latter's well-known empirical success in predicting the former, implies that the model's quantitative implications can be taken seriously.

The world economy consists of $n = 1, ..., N$ countries. The sector of interest is comprised of a finite number of product categories, $k = 1, ..., K$, and each product category contains a continuum of varieties, $\omega \in [0, 1]$.[4] Thus, a given variety is identified by the pair (k, ω). The remainder of this section presents the details and main results regarding product-level and aggregate trade flows.

2.1 Technology

The cost of producing a unit of variety (k, ω) in country i and delivering it to country n is given by

$$c_{ni}^{k}(\omega) = \frac{c_i d_{ni}^{k}}{Z_i^{k}(\omega)}, \tag{1}$$

[4]The precise definition of a "sector" may vary. Depending on the scope of the analysis, it could be a particular manufacturing industry, such as textiles, the entire manufacturing sector, or all tradeable goods. The assumption of a continuum of varieties within each product category is made purely for analytical tractability. Were there a finite number of varieties, the results that follow would hold in expectation.

where c_i is the overall cost of a bundle of production inputs in i, $d_{ni}^k \geq 1$ is an "iceberg" trade cost, and $Z_i^k(\omega)$ is the productivity with which inputs can be turned into units of variety (k, ω) in i.

Similar to Eaton and Kortum (2002), $Z_i^k(\omega)$ is distributed according to

$$F_i^k(z) = e^{-T_i^k z^{-\theta}}.$$

In this specification, T_i^k determines the overall level of productivity in i for producing all varieties of k. This reflects technological differences across countries as well as other potential sources of comparative advantage such as availability of factors of production used relatively intensively in the production of k.[5] The degree of dispersion in productivity across varieties of k is governed by $\theta > 1$, with a larger value of θ implying a lower variance. Variance in productivity across varieties leads to idiosyncratic within-product comparative advantage and intra-product trade, while comparative advantage across products is driven by differences in relative values of T_i^k across products and countries and determines inter-product trade flows.

2.2 Trade Costs

To simplify the analysis that follows, I assume that trade costs take the following form:

$$d_{ni}^k = d_{ni} d_n^k. \tag{2}$$

Thus, trade costs can be separated into a bilateral component and an importer-product-specific component. The first component captures trade costs specific to a pair of countries, such as geographical trade barriers and bilateral relationships such as membership in a customs union. The second component captures product-specific trade barriers in each destination market, such as import tariffs. Imposing such a restriction is necessary in order to allow for inferences regarding comparative advantage to be made from data on trade flows. Otherwise, any pattern of trade flows could be rationalized by a particular set of trade costs, regardless of the underlying patterns of comparative advantage.

While this restriction is likely violated in the data, it is consistent with import tariffs that are in accordance with the Most Favored Nation principle of the World Trade Organization.[6] The necessity of such an assumption implies that the range of products considered in analyses utilizing RCA measures must be sufficiently narrow that it is reasonable to assume that bilateral trade barriers do not vary significantly and systematically across products. For instance, while the effect of distance on transportation costs is likely to be similar across products in the machinery and transport equipment industries, it is more likely to differ between agricultural products and electronics.

[5] The latter could be modelled via product-specific input costs rather than through differences in Z_i^k across products. However, in the partial-equilibrium analysis of this paper, these are isomorphic, so I have taken the simpler of the two approaches.

[6] Because it may be the case that $d_{ni} \neq d_{in}$, this specification also allows for any form of asymmetry in trade costs, for example due to border costs that vary by country, as in Waugh (2010).

2.3 Market Structure and Demand

Markets are perfectly competitive, which implies that the price actually paid by buyers in n for variety (k, ω) is

$$p_n^k(\omega) = \min_i \{c_{ni}^k(\omega)\}.$$

A representative consumer in country n maximizes a nested Spence-Dixit-Stiglitz utility function over all varieties of all products, which implies that expenditure on product k is given by

$$X_n^k = \tilde{\beta}_n^k \left(\frac{P_n^k}{P_n}\right)^{1-\sigma} X_n,$$

and expenditure on variety (k, ω) is given by

$$x_n^k(\omega) = \left(\frac{p_n^k(\omega)}{P_n^k}\right)^{1-\eta^k} X_n^k,$$

where $\eta^k > 1$ is the elasticity of substitution across varieties of product k; $\sigma > 1$ is the elasticity of substitution across products; $\tilde{\beta}_n^k$ is an exogenous demand shifter, which captures any factors other than relative prices that influence expenditure on product k in n; $P_n^k = \left(\int_0^1 p_n^k(\omega)^{1-\eta^k}\right)^{\frac{1}{1-\eta^k}}$; $P_n = \left(\sum_k \tilde{\beta}_n^k (P_n^k)^{1-\sigma}\right)^{\frac{1}{1-\sigma}}$; and X_n is total expenditure by n on all products in the sector.

2.4 International Trade Flows

Following the analysis of Eaton and Kortum (2002), it can be shown that the share of n's expenditure on product k that is devoted to varieties supplied by i is given by

$$\pi_{ni}^k \equiv \frac{X_{ni}^k}{X_n^k} = \frac{T_i^k (c_i d_{ni}^k)^{-\theta}}{\Phi_n^k}, \tag{3}$$

where $\Phi_n^k \equiv \sum_i T_i^k (c_i d_{ni}^k)^{-\theta} = \gamma^k (P_n^k)^{-\theta}$.[7] In addition, it is straightforward to show that the share of n's total expenditure on tradeable goods that is devoted to product k is given by

$$\frac{X_n^k}{X_n} = \beta_n^k \left(\frac{\Phi_n^k}{\Phi_n}\right)^{\frac{\sigma-1}{\theta}}, \tag{4}$$

where $\Phi_n \equiv \left(\sum_k \beta_n^k (\Phi_n^k)^{\frac{\sigma-1}{\theta}}\right)^{\frac{\theta}{\sigma-1}} = P_n^{-\theta}$.[8] By combining (3) and (4) and summing across the set of products, total sector-level trade flows from i to n can be expressed as

$$\pi_{ni} \equiv \frac{X_{ni}}{X_n} = \frac{T_{ni}(c_i d_{ni})^{-\theta}}{\Phi_n}, \tag{5}$$

[7] The constant $\gamma^k = \Gamma(1 - (\eta^k - 1)/\theta)^{\frac{\theta}{\eta^k - 1}}$, where $\Gamma(\cdot)$ is the gamma function.

[8] The parameter $\beta_n^k = \tilde{\beta}_n^k (\gamma^k)^{(1-\sigma)/\theta}$. This normalization is purely for notational convenience, as it eliminates constants in equation (4) and the expression for Φ_n, and it plays no role in the analysis that follows.

where $T_{ni} = \sum_k T_i^k \beta_n^k (d_n^k)^{-\theta} \left(\frac{\Phi_n^k}{\Phi_n}\right)^{\frac{\sigma-1}{\theta}-1}$.

Equations (3) and (5), which relate product-level and aggregate trade flows to countries' technologies and costs, form the basis of the analysis that follows. Equation (3) demonstrates that a country will import relatively more of product k from a source that is relatively efficient (a high value T_i^k) or has relatively low trade or production costs. Aggregate trade flows, given by equation (5), follow a very similar relationship, except that in the place of the technology parameter T_i^k is the bilateral term T_{ni}. This term summarizes the effect of both i's overall efficiency level and the strength of i's intra-product comparative advantage on its overall exports to n. It implies that i will export relatively more to n if it is relatively efficient at producing products for which n has greater demand (higher β_n^k), lower import costs, and (if $\theta > \sigma - 1$) relatively little access to efficiently produced varieties of k from other sources, which is summarized by the price parameter Φ_n^k.[9]

2.5 Comparative Advantage in the Model

Before examining the usefulness of various measures of revealed comparative advantage, it is useful to briefly explore the model's implications for the relationship between the traditional notion of comparative advantage and observed trade flows. According to the standard definition, due to Haberler (1930), a country has a comparative advantage in producing a given product if, in autarky, it has a lower opportunity cost of producing it, versus another product, than another country.[10] In terms of the model of this paper, this concept is consistent with the following definition:

Definition 1. *Country i has a comparative advantage in producing product k, compared to country i' and product k', if*

$$\frac{\bar{P}_i^k}{\bar{P}_i^{k'}} < \frac{\bar{P}_{i'}^k}{\bar{P}_{i'}^{k'}},$$

where $\bar{P}_i^k$ is the counterfactual price index for product k in i given that $d_{ni} \to \infty$, for all $n \neq i$.

I refer to this as the *strict* definition of comparative advantage, as we shall see that other, less rigorously defined, concepts of comparative are appropriate in certain contexts. The following result demonstrates that there is a straightforward mapping between the model and this conception of comparative advantage.

Lemma 1. *Country i has a comparative advantage in producing product k, compared to country i' and product k', if and only if*

$$\frac{T_i^k}{T_{i'}^k} > \frac{T_i^{k'}}{T_{i'}^{k'}},$$

[9] The condition that $\theta > \sigma - 1$ implies that the elasticity of substitution across sources of a given product is greater than the elasticity of substitution across products. If there were a continuum of products, this condition would be necessary for P_n to be well-defined. With a finite number of products, this is not mathematically necessary. However, if $\sigma - 1 > \theta$, then the counterintuitive result holds that the exports of a country of a given product to a given destination are increasing in the productivity of a competing source country for the same product. In empirical studies (e.g., Broda and Weinstein, 2006), this parameter restriction is generally found to hold.

[10] See Deardorff (2005) for a review of the development of the theoretical concept of comparative advantage over time.

where comparative advantage is defined according to Definition 1.

Proofs of this and all subsequent propositions are given in Appendix A. Lemma 1 demonstrates that, in this Ricardian environment, comparative advantage is determined entirely by relative values of the product-level technology parameters, T_i^k. Therefore, in what follows, I refer to rankings of products and countries according to relative values of T_i^k as countries' *fundamental* patterns of comparative advantage.

Given this result, equations (3) and (5) show how countries' patterns of comparative advantage, combined with the trade barriers they face, determine equilibrium trade flows. And, conversely, they tell us what can be inferred about comparative advantage from observed trade flows. The following two results highlight this relationship. The first makes clear how countries' patterns of comparative advantage determine the pattern of specialization when trade barriers are removed.

Proposition 1. *If $d_{ni}^k = 1$, for all n, i, and k, then for any two countries, i and i', and any two products, k and k', each country exports relatively more of the product for which it has a comparative advantage:*

$$\frac{E_i^k}{E_{i'}^k} > \frac{E_i^{k'}}{E_{i'}^{k'}} \iff \frac{T_i^k}{T_{i'}^k} > \frac{T_i^{k'}}{T_{i'}^{k'}},$$

where $E_i^k = \sum_{n \neq i} X_{ni}^k$.

This result formalizes the intuition that lead to the revealed comparative advantage analysis of Balassa (1965) and countless subsequent studies. When trade is frictionless, countries export relatively more of products for which they have a comparative advantage. However, as Balassa and others have understood, this is not necessarily the case in a world with trade barriers and other distortions. In the model, this is because, in the presence of bilateral trade costs, market conditions – summarized by d_n^k, Φ_n^k, and β_n^k – vary across destinations, and a country's total exports of a product depend on a convolution of these effects and the forces comparative advantage.[11]

The next result, on the other hand, shows that, even in the presence of both non-trivial trade barriers and non-market demand distortions (i.e., differences in β_n^k across countries), relative *bilateral* trade flows follow countries' patterns of comparative advantage.

Proposition 2. *For any set of technologies, $\{T_i^k\}$; input costs, $\{c_i\}$; trade costs, $\{d_{ni}\}$ and $\{d_n^k\}$; and demand shifters, $\{\beta_n^k\}$; and for any destination, n; any two source countries, i and i'; and any two products, k and k'; each source country exports relatively more to n of the product for which it has a comparative advantage:*

$$\frac{X_{ni}^k}{X_{ni'}^k} > \frac{X_{ni}^{k'}}{X_{ni'}^{k'}} \iff \frac{T_i^k}{T_{i'}^k} > \frac{T_i^{k'}}{T_{i'}^{k'}}.$$

Propositions 1 and 2 suggest two principles that are useful in guiding the proper use of RCA measures in empirical analyses. First, in the presence of bilateral trade costs and market-specific

[11] Specifically, $E_i^k / E_{i'}^k = \sum_{n \neq i} \frac{T_i^k (c_i d_{ni}^k)^{-\theta}}{\Phi_n^k} \beta_n^k \left(\frac{\Phi_n^k}{\Phi_n}\right)^{\frac{\sigma-1}{\theta}} X_n \Big/ \sum_{n \neq i'} \frac{T_i'^k (c_i' d_{ni'}^k)^{-\theta}}{\Phi_n^k} \beta_n^k \left(\frac{\Phi_n^k}{\Phi_n}\right)^{\frac{\sigma-1}{\theta}} X_n$.

distortions, bilateral, rather than aggregated, trade flows should be used to uncover patterns of comparative advantage. And, second, reflecting the fact that comparative advantage is, by nature, a relative concept, an appropriate point of reference must be chosen to properly isolate the effect of comparative advantage on observed trade flows from other effects. In the case of Proposition 2, this effect is isolated by relating i's exports of k to those of another exporter and of another product to the same destination.

Note that these results rely on the assumption that θ is constant across products.[12] This is because θ governs the responsiveness of product-level trade flows to production and trade costs, as is clear from (3). If this degree of responsiveness differs across products, then the effects of such costs will also differ and cannot be separated from the effect of comparative advantage using relative trade flows. While there is some evidence that θ varies across broadly-defined industries (see, e.g., Caliendo and Parro, 2014), a constant value across products within such a grouping is likely a reasonable assumption. This reinforces the implication of the restriction on the form of trade costs that analyses utilizing RCA indexes are most appropriately conducted over a range of products within similar industries.

3 Existing Measures of Revealed Comparative Advantage

In the following section, I demonstrate the usefulness of particular measures of revealed comparative advantage in applied analyses. However, it is useful to first briefly discuss a couple of the most commonly used RCA indexes. By far the most widely used RCA index is that of Balassa (1965), which is given by

$$\mathrm{BRCA}_i^k = \frac{E_i^k/E^k}{E_i/E},$$

where $E_i = \sum_k E_i^k$, $E^k = \sum_i E_i^k$, and $E = \sum_i \sum_k E_i^k$. Since its development, this index has been utilized in countless studies for many purposes. It has the benefit of being a simple and intuitive measure. A value greater than unity indicates that country i accounts for a larger share of world exports of product k than it does overall world trade flows, which is typically associated with its having a comparative advantage in producing k relative to a "typical" country and product.

If trade were frictionless, the BRCA index would be a theoretically-consistent indicator of comparative advantage, as relative values of BRCA have the same implications as relative values of E_i^k in Proposition 1. However, in the same way, this measure is not generally useful in the presence of trade barriers. In addition, the relation to Proposition 1 demonstrates that there is nothing inherently special about a value of $\mathrm{BRCA}_i^k = 1$ but that the value must be interpreted relative to the country's exports of another product and those of another country. This implies that the normalization introduced by Balassa, while intuitively appealing, does not increase the usefulness of total exports as a measure of RCA.

The use of the BRCA has been criticized in the literature both because of its ad hoc nature

[12] However, variance in the elasticity of substitution, η^k, across products is not problematic.

(see, e.g., Costinot et al., 2012) and because of its undesirable numerical properties, such as its lack of symmetry around unity and the fact that the point of comparison varies across countries and time periods (see, e.g., Proudman and Redding, 2000, and Laursen, 1998). In response to the second criticism, there have been many attempts to develop indexes that are more comparable across countries and products and that have other desirable properties. Among others, this has led to the development of several additive indexes, such as the Normalized RCA Index proposed by Yu et al. (2009):

$$\text{NRCA}_i^k = \frac{E_i^k}{E} - \frac{E_i}{E}\frac{E^k}{E}.$$

Unlike the BRCA index, the NRCA index lies within the interval $(-1, 1)$, and it sums to zero over both the set of countries and the set of products, which is taken as a sign of its comparability along these dimensions. However, based on (3) and (5), it is clear that not much can be inferred about any of the model's variables from the NRCA index, and, in fact, the additive form of the NRCA index implies that it is not a useful indicator of comparative advantage even in the special case in which the BRCA index is appropriate.

So, are such measures at all useful? It turns out that, in some cases, they are. However, their usefulness and appropriate form depend on the purpose for which they are being employed, which is the focus of the following discussion.

4 Employing RCA Measures

In this section, I discuss several common uses of RCA indexes and use the model developed above to shed light on how an RCA index may be employed in such analyses (if at all) and the form that it should take.

4.1 The Effects of Changes in Trade Barriers

Likely the most common use of RCA measures is in predicting or evaluating the effects of changes in trade barriers (especially tariffs) on a country's producers and exports. In fact, this was the impetus for the analysis of Balassa (1965), which gave rise to the widespread use of RCA indexes. Greenaway et al. (2008), Goldberg et al. (2010), Menezes-Filho and Muendler (2011), McCaig and Pavcnik (2012), and Autor et al. (2013) are recent examples of analyses of the differential effects of changes in trade barriers across products according to countries' patterns of comparative advantage. And, even analyses that are mostly descriptive in nature – for example, Fertő and Hubbard (2003) and Tongzon (2005) – are often intended ultimately to elucidate the effects of past or prospective trade policies, such as tariffs and export subsidies. In this section, I demonstrate that the the use of an RCA index in such a context is consistent with the theory but that a specific RCA measure, which does not necessarily indicate countries' fundamental patterns of comparative advantage, is required.

4.1.1 The Product-Level Effects of Trade Barriers

Consider the elasticity of trade flows of product k from i to n with respect to the bilateral trade cost associated with exporting from a third country, j, to n:[13]

$$\begin{aligned}\frac{\partial \ln(X_{ni}^k)}{\partial \ln(d_{nj})} &= \frac{\partial \ln(\pi_{ni}^k)}{\partial \ln(d_{nj})} + \frac{\partial \ln(X_n^k)}{\partial \ln(d_{nj})} \\ &= \theta \pi_{nj}^k - (\sigma - 1)(\pi_{nj}^k - \pi_{nj})\end{aligned} \tag{6}$$

The first collection of terms represents the fact that the prices of j's varieties of k are increasing in d_{nj}, which increases the likelihood that i is the low-cost producer of every variety, with an elasticity of θ interacted with j's share in n's expenditure on k. The second collection of terms represents the change in the allocation of n's expenditure across products in response to the changes in relative prices, where the relative price increase is greater – causing relative expenditure to fall – for the products in which j has a relatively large market share.

The Bilateral Additive Index Noting the similarity between the final set of terms in (6) and additive RCA indexes, I define the following Bilateral Additive Index of RCA:

$$\text{BAI}_{ni}^k \equiv \frac{X_{ni}^k}{X_n^k} - \frac{X_{ni}}{X_n} = \frac{T_i^k (c_i d_{ni}^k)^{-\theta}}{\Phi_n^k} - \frac{T_{ni}(c_i d_{ni})^{-\theta}}{\Phi_n}.$$

Using this definition, (6) can be rewritten as

$$\frac{\partial \ln(X_{ni}^k)}{\partial \ln(d_{nj})} = \theta \pi_{nj} + [\theta - (\sigma - 1)] \, \text{BAI}_{nj}^k, \tag{7}$$

where $\theta \pi_{nj}$ represents the hypothetical effect of d_{nj} on X_{ni}^k if j were to have no comparative advantage in any product – i.e., if $\pi_{ni}^k = \pi_{ni}$, for all k. The remainder of the expression represents the component of the effect of d_{nj} on X_{ni}^k that depends on j's level of comparative advantage for product k.

Thus, the BAI is useful if one is interested in the differential effects of a change in trade barriers across producers of different products. For example, if $\theta > \sigma - 1$, then the model has the following implications:[14]

1. A decrease in d_{nj} is relatively more harmful for exporters to n, from any country other than j, who produce products for which BAI_{nj}^k is relatively large.

2. A decrease in d_{ni} is relatively more beneficial for exporters from i to n who produce the products for which BAI_{ni}^k is relatively small.

[13] This partial elasticity is calculated holding constant production costs everywhere and total spending on tradeable goods in n.

[14] See footnote 9 for a discussion of the implications of this assumption.

3. Domestic producers of goods for which BAI^k_{nn} is relatively large fare relatively well when tariffs on imports to n fall.

The first implication follows immediately from (7). The second follows from the analogue of (7) for the case in which $i = j$: $\partial \ln(X^k_{ni})/\partial \ln(d_{ni}) = -\theta(1-\pi_{ni}) + [\theta - (\sigma-1)]\text{BAI}^k_{ni}$. For the third, define d_n such that $d_{ni} = d_n \tilde{d}_{ni}$ for all $i \neq n$. Then, $\partial \ln(X^k_{nn})/\partial \ln(d_n) = \theta(1-\pi_{nn}) - [\theta - (\sigma-1)]\text{BAI}^k_{nn}$.

These results are in line with the intuition underlying the use of RCA indexes in predicting and evaluating the effects of trade policy on certain industries or producers, and they make clear that the BAI is the appropriate measure of RCA for such purposes. For example, a common practice when one is interested in the effect of a country's tariff liberalization on domestic production and employment is to estimate a regression of the form

$$\Delta \ln(y^k_n) = \boldsymbol{\beta}_0 \mathbf{x}^k_n + \beta_1 \Delta \ln(1+\tau^k_n) \times \text{RCA}^k_n, \tag{8}$$

where $\mathbf{x}^k_n$ is a vector of control variables, τ^k_n is the import tariff n places on product k, and RCA^k_n is some measure of n's comparative advantage for product k.[15] The the third result, above, indicates that this is an appropriate practice if the RCA measure used is BAI^k_{nn}. Similarly, if one is interested in the effects of a reduction in tariffs on the exports of a particular country, then, based on results 1 and 2, the appropriate measure is BAI^k_{nj}, where j is the exporting country facing the tariff change.

4.1.2 The Aggregate Effects of Trade Barriers

A related question is the role of comparative advantage in determining the degree to which one country's aggregate trade flows are affected by changes in the trade costs faced by another country – in other words, how closely a pair countries compete to export to a given market. Consider the elasticity of total trade flows from i to n with respect to d_{nj}, for $j \neq i$:

$$\begin{aligned}\frac{\partial \ln(X_{ni})}{\partial \ln(d_{nj})} &= \theta\pi_{nj} + [\theta - (\sigma-1)] \sum_{k=1}^{K} \frac{X^k_{ni}}{X_{ni}} (\pi^k_{nj} - \pi_{nj}) \\ &= \theta\pi_{nj} + [\theta - (\sigma-1)]\, \text{TRI}_{nij}\end{aligned}$$

where I have defined the Trade Responsiveness Index, which is a measure of the relative sensitivity – less the effect of j's overall market share in n – of trade flows to n from i to changes in the costs of exporting from j to n.

The Bilateral Balassa Index It turns out that the TRI can be expressed as a function of two RCA indexes. To see this, I first define the Bilateral Balassa Index, which is the bilateral analogue of the classic BRCA index:

$$\text{BBI}^k_{ni} \equiv \frac{X^k_{ni}/X^k_n}{X_{ni}/X_n} = \frac{T^k_i (d^k_n)^{-\theta}/\Phi^k_n}{T_{ni}/\Phi_n}.$$

[15] See, e.g., Goldberg et al. (2010) and Menezes-Filho and Muendler (2011)

Now, the TRI can be calculated as a weighted average of the interaction between the BBI and the BAI.

$$\text{TRI}_{nij} \equiv \sum_{k=1}^{k} \frac{X_n^k}{X_n} \left(\text{BBI}_{ni}^k \times \text{BAI}_{nj}^k \right).$$

In fact, because the weighted average of $\text{BAI}_{nj}^k = 0$, TRI_{nij} is equivalent to the weighted covariance of the values of BBI_{ni}^k and BAI_{nj}^k. While this result may seem surprising, the intuition behind it is straightforward. The BBI measures country i's ability to deliver product k to n, relative both to other countries' ability to supply k to n – summarized by Φ_n^k – and to its own overall relative ability to supply all goods to n – measured by T_{ni}/Φ_n. The BAI, as we have just seen, measures the effect of country j's comparative advantage in product k in shaping the response to a change in d_{nj} of other countries' exports of k to n. Thus, if country i's pattern of comparative advantage, measured by the BBI, is strongly correlated with country j's pattern of comparative advantage, measured by the BAI, then i's exports to n will be relatively responsive – given j's overall market share in n – to changes in the cost of exporting from j to n.

The TRI can be a useful tool for identifying countries that are close competitors for export markets. It can also be applied in policy analysis in several other ways. For example, a foreign market, n, for which TRI_{nii} is relatively low is one for which a fall in export costs would be most beneficial for i's exporters.[16] Similarly, a relatively low value of TRI_{iij} indicates that i would benefit relatively more from a fall in import tariffs applied to producers from j, since it implies a small effect on domestic producers and improved access to consumption goods and intermediate inputs that are not efficiently produced domestically. The TRI can also be employed as a simple indicator of the trade creation and trade diversion effects of a bilateral trade agreement. Specifically, the trade creation effect due to a reduction in trade barriers between n and j will be relatively large if the value of TRI_{njj} is relatively large, whereas trade diversion from a given country, i, will be relatively large if the value of TRI_{nij} is relatively large.

4.1.3 On Bilateral RCA Indexes

In this section, I have defined two bilateral RCA indexes, the BAI and the BBI, which are very similar to the previously-defined unilateral indexes discussed in the previous section. Clearly, each has a place in analyses of the effect of comparative advantage on the responses of trade flows to changes in trade barriers. However, neither is a particularly useful indicator of countries' fundamental patterns of comparative advantage because they do not separate the effect of exporters' comparative advantage on bilateral trade flows from the effects of other factors, such as trade costs. On the other hand, the decision of the point of reference for these bilateral indexes was not ad hoc, unlike with the unilateral indexes which they closely resemble, but were implied by the theory.

This indicates that, for purposes such as this, a slightly different definition of comparative advantage is appropriate. Rather than the strict definition, which depends on the opportunity

[16] This is because $\partial \ln(X_{ni})/\partial \ln(d_{ni}) = -\theta(1 - \pi_{nj}) + [\theta - (\sigma - 1)]\, \text{TRI}_{nii}$.

cost of production in autarky and governs trade patterns in the absence of any distortions, these measures are consistent with comparative advantage defined as a country's relative ability to provide a particular product to a particular market, taking such distortions into account. It is intuitive, then, that such measures are useful in predicting or evaluating the effects of changes in trade barriers that move the world economy from one equilibrium with trade distortions to another. This also makes them quite relevant for policy analysis.

4.1.4 The Properties of Additive and Multiplicative Indexes

It is also worth noting that the BAI_{nj}^k, when weighted by the share of n's expenditure devoted to k, is equivalent to a bilateral version of the NRCA index, i.e.

$$\frac{X_n^k}{X_n}\mathrm{BAI}_{nj}^k = \frac{X_{nj}^k}{X_n} - \frac{X_{nj}}{X_n}\frac{X_n^k}{X_n}.$$

Yu et al. (2009) emphasize that the NRCA index sums to zero across both products and countries, which they interpret as evidence of its comparability over these dimensions. It is now clear that these properties are required of the BAI, given its relationship to the effect of trade barriers on relative expenditure across products. The first property is due to the fact that the sum of changes in expenditure shares across all products must equal zero. The second is due to the fact that the effect of a proportional change in the costs of delivering goods to n from all sources (including domestic sources) has no effect on relative prices or relative expenditure.[17] However, this is despite the fact that the BAI is not comparable across products and countries in the sense of being consistent with an ordering according to relative productivity. Thus, there is no direct connection between such properties and an index's comparability across products and countries or its ability to uncover patterns of fundamental comparative advantage.

4.2 Measuring Countries' Relative Productivity

While researchers utilizing RCA indexes are most commonly interested in the policy and welfare implications of countries' patterns of comparative advantage, there are also many studies in which it is useful to uncover countries' fundamental patterns of comparative advantage for other purposes. An example is in investigating countries' patterns of relative productivity for evidence of particular patterns of specialization, technological change, or technology diffusion, such as Hidalgo et al. (2007), Kali et al. (2013), and Barattieri (2014). As is discussed in the previous section, neither the BRCA nor the NRCA index is useful for this purpose as both confound the effects of productivity on bilateral trade flows with market-specific distortions.

The BBI is proportional to T_i^k – which determines product-level productivity and comparative advantage in the model – but the index values are not directly comparable across products and countries. This shortcoming can be overcome, however, based on the insight of Proposition 2, by

[17] This is due to insight of Anderson and van Wincoop (2003) that it is only *relative* trade costs that affect the level of trade flows.

changing the point of reference. If we define a numeraire good, k_0, and a numeraire exporter, i_0, then it is possible to infer countries' patterns of fundamental comparative advantage from trade flow data based on the following relationship implied by (3):

$$\frac{X_{ni}^k / X_{ni}^{k_0}}{X_{ni_0}^k / X_{ni_0}^{k_0}} = \frac{T_i^k / T_i^{k_0}}{T_{i_0}^k / T_{i_0}^{k_0}}. \tag{9}$$

Because all destination-specific variables have cancelled out in this measure, we can employ data on exports to all destinations to compute an index of relative productivity, which I refer to as the Modified Balassa Index:

$$\text{MBI}_i^k \equiv \frac{1}{N-1} \sum_{n \neq i} \frac{X_{ni}^k / X_{ni}^{k_0}}{X_{ni_0}^k / X_{ni_0}^{k_0}} = \frac{T_i^k / T_i^{k_0}}{T_{i_0}^k / T_{i_0}^{k_0}}.$$

Because the point of comparison is held constant for different products and exporters, this index provides a measure of relative productivity that is comparable along these dimensions.[18] However, in analyses utilizing such a measure, one must keep in mind that, in accordance with Ricardo's basic insight that it is differences in *relative* productivity that determine trade flows, only values of T_i^k relative to those for a numeraire product and country are recovered in this way.

Costinot et al. (2012) provide an alternative measure of RCA that is also capable of inferring countries' fundamental patterns of comparative advantage. They show that, in a model similar to the one of this paper, disaggregated trade flows can be decomposed into the following components

$$\ln(X_{ni}^k) = \delta_{ni} + \delta_n^k + \delta_i^k + \varepsilon_{ni}^k. \tag{10}$$

It is clear from (3) that δ_i^k is determined by the value of T_i^k. Thus, the value of an exporter-product-specific fixed effect from a regression of the form of (10) is a theoretically consistent estimate of the relative productivity of i for product k.

As with the MBI, this RCA measure is only defined relative to a numeraire country and product.[19] In fact, these two measures have much in common. Both are theoretically-founded, making interpretation straightforward, and both are a measure of countries fundamental patterns of comparative advantage vis-à-vis a reference product and country.[20] The differences between the two are purely practical. The Costinot et al. (2012) measure works well when the number of countries

[18] I.e., the MBI can be used to rank products or countries in order of comparative advantage and is also valid as a cardinal measure of the relative magnitudes of differences in comparative advantage.

[19] Technically, this is due to the same principle by which a category must be omitted in regressions involving dummy variables to avoid multicollinearity.

[20] In calculating the MBI, the theory is agnostic about the appropriate way to aggregate the bilateral ratios – which are theoretically equal – across destinations. I chose an unweighted arithmetic average for simplicity. However, one could consider a weighted average or some other measure of central tendency. If all values of X_{ni}^k are positive, a geometric average is numerically equivalent to the Costinot et al. (2012) measure. However, related to the arguments made by Santos Silva and Tenreyro (2006), if measurement error is correlated with the value of X_{ni}^k, then this could be problematic. The median may also be a reasonable choice if one is concerned about outliers.

and products is relatively small.[21] However, as the number of countries and products become large, performing the regression in (10), which requires estimating coefficients on bilateral and country-product dummy variables, quickly becomes infeasible.[22] In addition, the regression drops observations for which $X_{ni}^{k} = 0$, introducing sample-selection bias into estimates of δ_i^k.[23] On the other hand, the regression-based measure of Costinot et al. (2012) allows for straightforward hypothesis testing of whether particular relative productivity levels are statistically different across products or countries.[24]

4.3 Uncovering the Sources of Comparative Advantage

Another use for RCA indexes is in investigating the causes of comparative advantage or in evaluating whether countries actually specialize according to measurable sources of comparative advantage – such as total factor productivity or factor endowments – as predicted by theory. To this end, an appropriate RCA index, such as the MBI, could be correlated with country- and product-specific variables expected to influence patterns of comparative advantage to test whether these factors have significant explanatory power. Such an exercise is suggested by Deardorff (2011) and is employed by Kowalski and Bottini (2011), though in this case, a variant of the BRCA index, which retains its shortcomings, is employed.

A related strategy is to take advantage of the form of (3) to directly estimate the effect of potential sources of comparative advantage on trade flows. Specifically, suppose one posits that T_i^k is a function of country- and product-specific variables and takes the form

$$\ln(T_i^k) = \alpha_i + \alpha^k + \sum_{\ell} \sum_{m} \alpha_{\ell m} L_{i\ell} M_m^k,$$

implying that, in addition country-specific and product-specific effects, comparative advantage is determined by the interaction of country-specific factors, $L_{i\ell}$, such as factor endowments or the presence of particular institutions, and product characteristics, M_m^k, such as factor intensity or dependence on institutions, such as contract enforcement or access to financial markets, for which particular country-specific factors may be relevant.

In this case, equation (3) implies that the effect of these observable variables on comparative

[21] Costinot et al. (2012) employ data on 21 countries and 13 industries.

[22] For example, French (2014) employs data on 132 countries and 4,608 product categories. Estimating (10) with this sample involves inverting a matrix of $N(N-1)+2K(N-1) = 1,224,588$ dummy variables, which greatly exceeds the capability of most computers.

[23] While the MBI has no problem dealing with values of $X_{ni}^{k} = 0$, it does require values of $X_{ni}^{k_0}$ and $X_{ni_0}^{k}$ that are positive. Most countries export a subset of the products exported by the world's largest economies, such as the U.S., Germany, Japan, and China, but in some applications, it may not be possible to compute the MBI for some of the least traded products.

[24] However, such hypothesis testing should be done with care, as the coefficient estimates depend on the choice of numeraire product and country, and the error term likely suffers from heteroskedasticity and is possibly correlated across observations.

advantage and, in turn, on trade flows can be estimated via a regression of the form

$$\ln(X_{ni}^k) = \delta_{ni} + \delta_n^k + \sum_\ell \sum_m \delta_{\ell m} L_{i\ell} M_m^k + \varepsilon_{ni}^k,$$

where the estimate of δ_n^k is a consistent estimator of $\theta\alpha_{\ell m}$. Such an estimation strategy has been employed by Romalis (2004), Chor (2010), and Costinot et al. (2012), among others, and is likely to continue to be a fruitful strategy in similar contexts.

4.4 Changes in Technology Over Time

RCA indexes have also been employed in analyses of technological change over time, for example in Proudman and Redding (2000) and Bahar et al. (2014). In such applications, changes in the MBI – or coefficients obtained from a dynamic version of the regression specified in (10) – are valid indicators of changes in productivity *relative to changes for the numeraire product and country*. However, great care must be taken in interpreting the results of such an exercise, as changes in the index do not necessarily indicate changes in productivity levels for the country and product of interest, but may be due to changes for the numeraire product or country (or both). To see this, consider the ratio of the MBI values for a given product in two periods:

$$\text{MBI}_{i,t+1}^k \Big/ \text{MBI}_{i,t}^k = \frac{T_{i,t+1}^k / T_{i,t+1}^{k_0}}{T_{i_0,t+1}^k / T_{i_0,t+1}^{k_0}} \Bigg/ \frac{T_{i,t}^k / T_{i,t}^{k_0}}{T_{i_0,t}^k / T_{i_0,t}^{k_0}}.$$

Thus, any change in the MBI between periods t and $t+1$ is potentially caused by changes in any combination of eight variables, making it difficult to draw conclusions regarding the meaning of such changes.

Further, it is unlikely that a more suitable index for across-time comparisons can be constructed. For example, consider what may seem to be a useful inter-temporal analogue of (9), replacing the numeraire country with a base time period:

$$\frac{X_{ni,t}^k / X_{ni,t}^{k_0}}{X_{ni,t_0}^k / X_{ni,t_0}^{k_0}} = \frac{T_{i,t}^k / T_{i,t}^{k_0}}{T_{i,t_0}^k / T_{i,t_0}^{k_0}} \times \frac{(d_{i,t}^k)^{-\theta} X_{n,t}^k / \Phi_{n,t}^{k_0}}{(d_{i,t_0}^k)^{-\theta} X_{n,t_0}^k / \Phi_{n,t_0}^{k_0}}.$$

Clearly this measure confounds changes in relative productivity with changes in market conditions over time. The MBI is able to isolate the effect of relative productivity on trade flows by comparing bilateral trade flows for a given product to trade flows from other countries of the same product to the same market (removing product- and market-specific effects of trade distortions) and to trade flows from the same country of other products (removing bilateral effects of trade distortions). However, this strategy cannot be implemented using trade flows from different time periods because, if technologies and/or distortions change over time, then so do market conditions in each destination, meaning that there is no suitable point of comparison by which to separate these effects. Instead, inter-temporal changes in comparative advantage will typically require a more sophisticated analysis which takes advantage of additional data, such as prices or information on factors of production.[25]

5 Concluding Remarks

This paper employs a Ricardian trade model to demonstrate that traditional indexes of revealed comparative advantage are not generally appropriate for the tasks for which they have been employed and that there is no single ideal index that is appropriate for all such tasks. However, the theory implies two basic principles that should guide future uses of RCA indexes in empirical analyses. First, data on bilateral trade flows – and not trade flows aggregated across importers – should generally be utilized because this allows for the effects of comparative advantage to be isolated from other bilateral and market-specific effects of trade distortions. And, second, since comparative advantage is, by nature, a relative value, an RCA index must be a function of trade flows relative to an appropriate point of comparison. This point of comparison must be appropriate for the particular use of the RCA index, and it must not change across products or countries for which values of the index are to be compared in the analysis.

Guided by the model, I have proposed several indexes that are appropriate for specific purposes. The Modified Balassa index is a theoretically consistent measure of relative productivity. The Bilateral Additive Index is the appropriate measure of comparative advantage when evaluating its effect on the response of product-level trade flows to changes in trade barriers. And, the Trade Responsiveness Index, which is equal to the weighted covariance of the BAI and the Bilateral Balassa Index across products, measures the responsiveness of aggregate trade flows to changes in trade barriers. These indexes are easily computed, straightforward to interpret, and theoretically appropriate for their respective tasks, for which more traditional RCA measures have often been employed in the past. Thus, they, and perhaps other similarly derived measures, should prove to be valuable tools to be employed in applied academic and policy-oriented international trade analyses.

[25] See Levchenko and Zhang (2014) for a recent example of a structural approach to such a question.

References

Anderson, James E. and Eric van Wincoop, "Gravity with Gravitas: A Solution to the Border Puzzle," *The American Economic Review*, 2003, *93* (1), 170–192.

_ **and Yoto V. Yotov**, "The Changing Incidence of Geography," *American Economic Review*, December 2010, *100* (5), 2157–86.

Arkolakis, Costas, Arnaud Costinot, and Andres Rodriguez-Clare, "New Trade Models, Same Old Gains?," *American Economic Review*, 2012, *102* (1), 94–130.

Autor, David H., David Dorn, and Gordon H. Hanson, "The China Syndrome: Local Labor Market Effects of Import Competition in the United States," *American Economic Review*, 2013, *103* (6), 2121–68.

Bahar, Dany, Ricardo Hausmann, and Cesar A. Hidalgo, "Neighbors and the evolution of the comparative advantage of nations: Evidence of international knowledge diffusion?," *Journal of International Economics*, 2014, *92* (1), 111 – 123.

Balassa, Bela, "Trade Liberalisation and 'Revealed' Comparative Advantage," *The Manchester School*, 1965, *33* (2), 99–123.

Barattieri, Alessandro, "Comparative Advantage, Service Trade, and Global Imbalances," *Journal of International Economics*, January 2014, *92* (1), 1–13.

Bebek, Ufuk Gunes, "Consistency of the Proposed Additive Measures of Revealed Comparative Advantage," *Economics Bulletin*, 2011, *31* (3), 2491–2499.

Broda, Christian and David E. Weinstein, "Globalization and the Gains from Variety," *Quarterly Journal of Economics*, 2006, *121* (2), 541–585.

Caliendo, Lorenzo and Fernando Parro, "Estimates of the Trade and Welfare Effects of NAFTA," *The Review of Economic Studies*, 2014, *forthcoming.*

Chaney, Thomas, "Distorted Gravity: The Intensive and Extensive Margins of International Trade," *American Economic Review*, 2008, *98* (4), 1707–1721.

Chor, Davin, "Unpacking Sources of Comparative Advantage: A Quantitative approach," *Journal of International Economics*, November 2010, *82* (2), 152–167.

Costinot, Arnaud, Dave Donaldson, and Ivana Komunjer, "What Goods Do Countries Trade? A Quantitative Exploration of Ricardo's Ideas," *Review of Economic Studies*, 2012, *79* (2), 581–608.

De Benedictis, Luca and Massimo Tamberi, "A Note on the Balassa Index of Revealed Comparative Advantage," 2001, *Working Paper.*

Deardorff, Alan V., "How Robust is Comparative Advantage?," *Review of International Economics*, 2005, *13* (5), 1004–1016.

_, "Comparative Advantage: The Theory Behind Measurement," in Przemyslaw Kowalski and Susan F. Stone, eds., *Globalisation, Comparative Advantage and the Changing Dynamics of Trade*, OECD Publishing, 2011.

Eaton, Jonathan and Samuel Kortum, "Technology, Geography, and Trade," *Econometrica*, 2002, *70* (5), 1741–1779.

Fertő, Imre and L. J. Hubbard, "Revealed Comparative Advantage and Competitiveness in Hungarian Agri-Food Sectors," *World Economy*, February 2003, *26* (2), 247–259.

French, Scott, "The Composition of Trade Flows and the Aggregate Effects of Trade Barriers," 2014, *Working Paper.*

Goldberg, Pinelopi Koujianou, Amit Kumar Khandelwal, Nina Pavcnik, and Petia Topalova, "Imported Intermediate Inputs and Domestic Product Growth: Evidence from India," *The Quarterly Journal of Economics*, November 2010, *125* (4), 1727–1767.

Greenaway, David, Joakim Gullstrand, and Richard Kneller, "Surviving Globalisation," *Journal of International Economics*, March 2008, *74* (2), 264–277.

Haberler, Gottfried, "The Theory of Comparative Cost and Its Use in the Defense of Free Trade," originally published in German in *Weltwirtschaftliches Archiv*, 1930, *32*, 349–370.

Hidalgo, C. A., B. Klinger, A.-L. Barabsi, and R. Hausmann, "The Product Space Conditions the Development of Nations," *Science*, July 2007, *317* (5837), 482–487.

Hoen, Alex R. and Jan Oosterhaven, "On the Measurement of Comparative Advantage," *The Annals of Regional Science*, 2006, *40* (3), 677–691.

Kali, Raja, Javier Reyes, Joshua McGee, and Stuart Shirrell, "Growth Networks," *Journal of Development Economics*, March 2013, *101*, 216–227.

Kowalski, Przemyslaw and Novella Bottini, "Comparative Advantage and Export Specialisation Mobility," in Przemyslaw Kowalski and Susan F. Stone, eds., *Globalisation, Comparative Advantage and the Changing Dynamics of Trade*, OECD Publishing, 2011.

Krugman, Paul, "Scale Economies, Product Differentiation, and the Pattern of Trade," *The American Economic Review*, 1980, *70* (5), pp. 950–959.

Laursen, Keld, "Revealed Comparative Advantage and the Alternatives as Measures of International Specialisation," 1998, *DRUID Working Paper No. 1998-30.*

Levchenko, Andrei A. and Jing Zhang, "The Evolution of Comparative Advantage: Measurement and Welfare Implications," 2014, *Working Paper.*

McCaig, Brian and Nina Pavcnik, "Export Markets and Labor Allocation in a Poor Country," 2012, *Working Paper.*

Melitz, Marc, "The Impact of Trade on Intra-Industry Reallocations and Aggregate Industry Productivity," *Econometrica*, 2003, *71*, 1695–1725.

Menezes-Filho, Naércio Aquino and Marc-Andreas Muendler, "Labor Reallocation in Response to Trade Reform," NBER Working Papers 17372, National Bureau of Economic Research, Inc August 2011.

Proudman, James and Stephen Redding, "Evolving Patterns of International Trade," *Review of International Economics*, 2000, *8* (3), 373–396.

Romalis, John, "Factor Proportions and the Structure of Commodity Trade," *The American Economic Review*, March 2004, *94* (1), 67–97.

Silva, J. M. C. Santos and Silvana Tenreyro, "The Log of Gravity," *The Review of Economics and Statistics*, 2006, *88* (4), pp. 641–658.

Tongzon, Jose L., "ASEAN-China Free Trade Area: A Bane or Boon for ASEAN Countries?," *World Economy*, February 2005, *28* (2), 191–210.

Vollrath, Thomas L., "A Theoretical Evaluation of Alternative Trade Intensity Measures of Revealed Comparative Advantage," *Weltwirtschaftliches Archiv*, 1991, *127* (2), pp. 265–280.

Waugh, Michael E., "International Trade and Income Differences," *American Economic Review*, 2010, *100* (5), 2093–2124.

Yeats, Alexander J., "On the Appropriate Interpretation of the Revealed Comparative Advantage Index: Implications of a Methodology Based on Industry Sector Analysis," *Weltwirtschaftliches Archiv*, 1985, *121* (1), 61–73.

Yu, Run, Junning Cai, and PingSun Leung, "The Normalized Revealed Comparative Advantage Index," *The Annals of Regional Science*, 2009, *43* (1), 267–282.

Appendix

A Proofs

Lemma 1 Following the methods of Eaton and Kortum (2002), it is straightforward to show that

$$P_i^k = \gamma^k (\Phi_i^k)^{-\frac{1}{\theta}},$$

where γ^k is defined in footnote 7. In autarky, $\Phi_n^k = T_i^k c_i^{-\theta}$, which implies that the autarky price index of k in i is

$$\bar{P}_i^k = \gamma^k (T_i^k)^{-\frac{1}{\theta}} c_i.$$

This implies that

$$\frac{\bar{P}_i^k / \bar{P}_i^{k'}}{\bar{P}_{i'}^k / \bar{P}_{i'}^{k'}} = \left(\frac{T_i^k / T_i^{k'}}{T_{i'}^k / T_{i'}^{k'}} \right)^{-\frac{1}{\theta}}.$$

The value of this term is less than unity if and only if the term in parentheses is greater than unity.

□

Proposition 1 From equation (3) the definition of Φ_n^k, with frictionless trade,

$$X_{ni}^k = \frac{T_i^k c_i^{-\theta}}{\Phi^k} X_n^k, \tag{11}$$

where $\Phi^k = \sum_i T_i^k c_i^{-\theta}$.

This implies that

$$\frac{E_i^k / E_i^{k'}}{E_{i'}^k / E_{i'}^{k'}} = \frac{T_i^k / T_i^{k'}}{T_{i'}^k / T_{i'}^{k'}},$$

and the left-hand side of this equation is greater than unity if and only if the right-hand side is also greater than unity.

□

Proposition 2 This result follows immediately from equation (3), which implies that

$$\frac{X_{ni}^k / X_{ni}^{k'}}{X_{ni'}^k / X_{ni'}^{k'}} = \frac{T_i^k / T_i^{k'}}{T_{i'}^k / T_{i'}^{k'}},$$

and the left-hand side of this equation is greater than unity if and only if the right-hand side is also greater than unity.

□

B What if There is No Domestic Trade Data?

Because data on domestic trade flows (X_{nn}^k) are often not as readily available as data on international trade flows, in this appendix, I consider measures that require only the latter. Consider the expression for trade flows as a share of destination market imports, rather than total expenditure. For a given product, this is given by

$$\tilde{\pi}_{ni}^k \equiv \frac{X_{ni}^k}{M_n^k} = \frac{T_i^k (c_i d_{ni})^{-\theta}}{\tilde{\Phi}_n^k},$$

$\tilde{\Phi}_n^k = \sum_{i \neq n} T_i^k (c_i d_{ni})^{-\theta}$. Because d_n^k has the same effect on all foreign sellers of k in n, it disappears from this expression. The corresponding expression for aggregate trade flows is

$$\tilde{\pi}_{ni} \equiv \frac{X_{ni}}{M_n} = \frac{T_{ni} (c_i d_{ni})^{-\theta}}{\tilde{\Phi}_n},$$

$\tilde{\Phi}_n = \sum_{i \neq n} T_{ni} (c_i d_{ni})^{-\theta}$. Note that T_{ni} in this expression is the same value as that in (5), which implies that π_{ni} still depends on the values of Φ_n^k and Φ_n.

The MBI, in its original form, does not require data on domestic trade flows. It is also straightforward to define versions of the BBI and BAI which do not require such data, i.e.

$$\widetilde{\text{BBI}}_{ni}^k \equiv \frac{X_{ni}^k / M_n^k}{X_{ni} / M_n} = \frac{T_i^k / \tilde{\Phi}_n^k}{T_{ni} / \tilde{\Phi}_n}$$

and

$$\widetilde{\text{BAI}}_{nj}^k \equiv \frac{X_{nj}^k}{M_n^k} - \frac{X_{nj}}{M_n} = (c_i d_{ni})^{-\theta} \left[\frac{T_i^k}{\tilde{\Phi}_n^k} - \frac{T_{ni}}{\tilde{\Phi}_n} \right].$$

The interpretation of these measures is essentially unchanged except that they now measure i's ability to provide k to n relative to the rest of world, *excluding* n. In fact, since d_n^j drops out of the analysis, the comparison is even a bit more straightforward.

However, the question remains whether these measures are useful regarding questions of the responsiveness of trade flows to trade barriers, as are BBI and BAI. It turns out that this is not generally the case. Consider the partial elasticity of X_{ni}^k with respect to d_{nj} holding constant M_n^k (rather than X_n, as before)[26]

$$\begin{aligned} \frac{\partial \ln(X_{ni}^k)}{\partial \ln(d_{nj})} &= \theta \tilde{\pi}_{nj} + [\theta - (\sigma - 1)](\pi_{nj}^k - \pi_{nj}) \\ &= \theta \tilde{\pi}_{nj} + [\theta - (\sigma - 1)]\text{BAI}_{nj}^k. \end{aligned}$$

While the aggregate component of the elasticity does not depend on domestic trade flows, the product-specific component still depends on BAI, not $\widetilde{\text{BAI}}$. This is because this terms reflects

[26]This is essentially a compensated elasticity, where X_n is adjusted to hold M_n fixed. This exercise allows us to ignore features of the domestic market in n as much as possible.

country j's effect on relative prices in n, which depends on j's share of n's consumption, not only its imports.

However, $\widetilde{\text{BAI}}$ may be a reasonable approximation of BAI under certain conditions. The relationship between the two measures is as follows:

$$\begin{aligned}\text{BAI}^k_{nj} &= \tilde{\pi}^k_{nj}\frac{M^k_n}{X^k_n} - \tilde{\pi}_{nj}\frac{M_n}{X_n} \\ &= \frac{M_n}{X_n}\widetilde{\text{BAI}}^k_{nj} + \left(\frac{M^k_n}{X^k_n} - \frac{M_n}{X_n}\right)\tilde{\pi}^k_{nj} \\ &= \frac{M_n}{X_n}\widetilde{\text{BAI}}^k_{nj} - \tilde{\pi}^k_{ni}\text{BAI}^k_{nn}.\end{aligned}$$

Thus, $\widetilde{\text{BAI}}$ is generally an overestimate of BAI by the inverse of n's overall import share. However, data on X_n is often available, so this can be corrected even when data on X^k_{nn} is not available. More concerning is that it will also overestimate the value of BAI for products for which n has a comparative disadvantage, measured as BAI^k_{nn}. As a results, for destinations which have relatively high import shares or relatively weak patterns of comparative advantage, $\widetilde{\text{BAI}}$ is a good approximation of BAI, but caution should be used in regard to imports of large and/or heavily specialized countries.[27]

The same principles apply to calculating the TRI, which can be expressed as

$$\text{TRI}_{nij} = \sum_{k=1}^{k}\frac{M^k_n}{M_n}\left(\widetilde{\text{BBI}}^k_{ni} \times \text{BAI}^k_{nj}\right).$$

This implies that, while $\widetilde{\text{BBI}}$ can be used in calculating TRI without issue, replacing BAI with $\widetilde{\text{BAI}}$ leads to a measure that deviates from the true value of TRI to the extent that BAI^k_{nn} covaries with BBI^k_{ni}.

[27] It may be reasonable to use measures of n's comparative advantage in other markets to partially correct for this bias. French (2014), in a conceptually similar exercise, uses the full set of bilateral product-level trade flows to estimate the effects of patterns of comparative advantage on the responsiveness of trade flows to trade costs. However, this comes at the cost of giving up the simplicity of utilizing easily calculated measures of RCA.