Global Economy Journal

Volume 11, *Issue* 3 2011 *Article* 3

Correcting the Size Bias in Trade Openness and Globalization Measures

Kam Ki Tang*

*The University of Queensland, kk.tang@uq.edu.au

Correcting the Size Bias in Trade Openness and Globalization Measures*

Kam Ki Tang

Abstract

The trade intensity index, constructed as exports plus imports divided by GDP, is the most commonly used measure for trade openness and globalization. The index tends to indicate small countries are more open than large countries. We show that it is the inconsistence of two implicit assumptions in the index that leads to a size bias in the openness measurement. We use a combination of axiomatic and parametric methods to derive an unbiased, generalized index that embodies the conventional index as a special case. Correcting the size bias leads to very different results in relative openness measures between countries and in the estimates of the growth effect of trade openness.

KEYWORDS: trade, globalization, openness, growth, measurement, index

*I would like to thank Fabrizio Carmignani, James Laurenceson, Juyoung Cheong, Michael Graff, Dennis Petrie, and seminar participants at the University of Dundee for their helpful comments on earlier drafts. All remaining errors are, of course, mine.

1 Introduction

The trade intensity index (TII), constructed as exports plus imports divided by Gross Domestic Product (GDP), is the most commonly used measure for trade openness[1] and increasingly for globalization[2] as well. It has been deployed widely in empirical economic studies, either as a variable of primary interest[3] or as a variable of controls. It is equally prominent outside the sphere of academic research, being featured regularly in business, finance and policy reports as a standard economic indicator. These facts underlie the important role played by this measurement of trade openness.

The TII, however, often gives counterintuitive results when it comes to large countries. For instance, the U.S. is ranked way below Swaziland and Tajikistan by the index, and likewise China is ranked behind Cambodia and Laos (see Table 4 later). These results are not surprising if the TII is (rightly) interpreted as a measure of *trade dependency*, as large countries are expectedly less reliant on international trade than the small ones. However, when the index is used as a measure of trade openness or globalization, the results become counterintuitive – considering the U.S. is a core nation in the world trade system while Swaziland and Tajikistan are far from that, and China is also way ahead of its two neighbouring countries as a trading power house. In short, the TII 'appears' to understate the degree of openness of large economies relative to small economies.

In fact, this issue has been noticed by many and there are some attempts in the current literature to 'correct the size bias' through modifying the TII (see Table 1 later). A major limitation with those attempts is that, while they are based on the proposition of there being a size bias in the TII, how that proposition comes about is never made clear, and seldom a case is made to explain why a particular modified TII formula should be considered as *the* unbiased (or a less biased) measure. As those modifications are not based on a rigorous theoretical foundation, they appear to be ad hoc and thus their results are contestable.

[1] In reviewing different measures of openness, Pritchett (1991, 1996) categorizes them into four general types: (i) trade to GDP ratio, (ii) measures of tariffs and non-tariff barriers, (iii) differences between the actual trade flows and the predicted trade flows based on some benchmark models, and (iv) real price distortions.

[2] For example, it is used as part of the KOF Globalization Index (Dreher 2006) and the A.T. Kearney/FOREIGN POLICY Globalization Index (http://www.atkearney.com).

[3] For example, Jaumotte, Lall and Papageorgiou (2008) look at the effects of trade openness on income distribution, Dollar and Kraay (2003) and Yankikkaya (2003) focus on its effect on growth, while Dollar and Kraay (2004) examine its effect on growth as well as poverty.

The paper aims to investigate the issue using a new approach. First of all, we tease out the source of the bias and thus indirectly proving[4] that the TII is indeed biased in favour of small countries (or equivalently against large countries). We show that *it is the inconsistence of two implicit assumptions in the TII that causes the size bias,* which once revealed, will automatically point to the direction of appropriate correction. This leads to the development of a more generalized measure of trade openness that embodies the TII as a special case. For empirical work, however, a specific formula is more useful than a general formula. To that end, we first apply an axiomatic approach to pin down the most appropriate functional form for the new index and then use data to parameterize the function. The advantage of combining these two approaches is that the derived index will have a proper theoretical foundation underpinned by the axioms and, at the same time, be agreeable with the data. We apply both the new and the conventional indexes to the data and find that correcting the size bias leads to very difference results in relative trade openness measures between countries and, in relation to that, in the estimates of the growth impact of trade openness.

The rest of the paper is organized as follows. In Section 2 we review some modifications to the TII that have been proposed in the literature. In Section 3 we diagnose the fundamental source of the size bias and propose a generalized trade openness index to rectify the problem. We then in Section 4 combine an axiomatic and a parametric approach to determine the most appropriate specific version of the formula. In Section 5 we examine how the new index affects the trade openness measures and ranking outcomes for different countries. The trade data includes exports and imports of both goods and services. We also re-examine in this section the growth impact of trade openness to illustrate how sensitive the results can be to the correction of the bias, before concluding the paper in Section 6.

2 The Trade Intensity Index (TII)

2.1 The conventional formulation

The trade intensity index is typically computed as the total-trade-to-GDP ratio:

$$TII_i^* = \frac{X_i + M_i}{Y_i^*} \qquad (1)$$

[4] It is a proof because if there is no bias in the TII, then we should not be able to find out the source of the bias.

DOI: 10.2202/1524-5861.1751

where X_i and M_i are respectively the total export and total import flows of country i, and Y_i^* is its GDP.

The rationale of dividing the total trade flows by GDP is to control for economic size, as large countries are likely to trade more in absolute terms. In other words, the TII values for countries of different sizes are *supposed* to be commensurable. Also, since both trade and GDP are measured in the same currency unit, there is no need to adjust for inflation in temporal analysis or for exchange rates in cross-country comparison. That is, the index is scale independent.

An improvement to formula (1) is to use Purchasing Power Parity (PPP)-based GDP in the denominator:

$$TII_i = \frac{X_i + M_i}{Y_i} \qquad (2)$$

where Y_i is PPP-based GDP for country i.

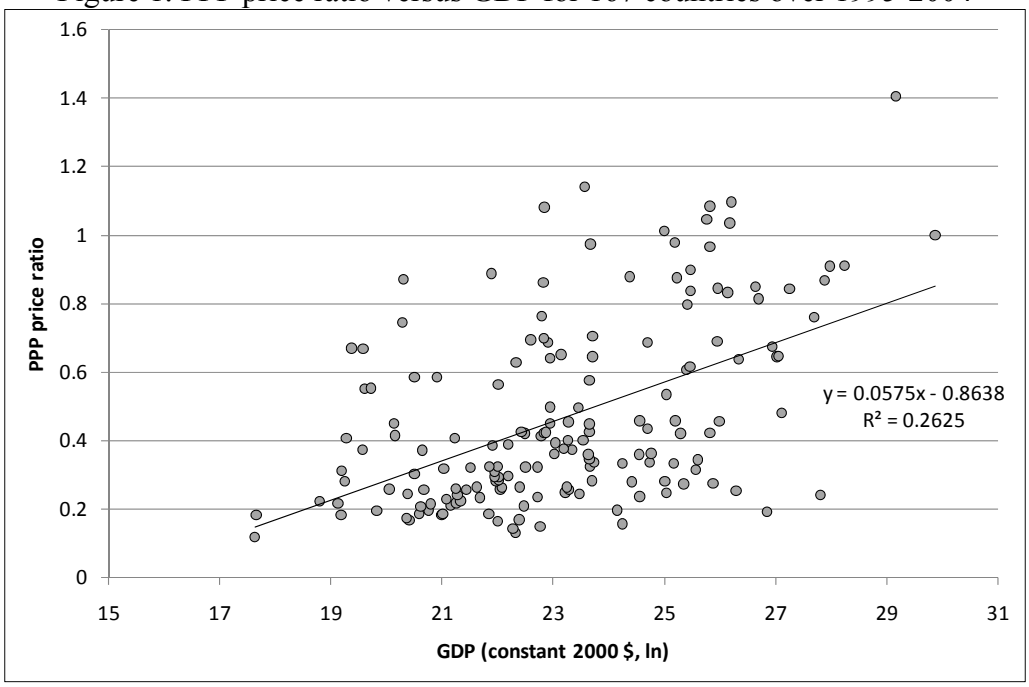
The reason for this is that, due to the Balassa-Samuelson effect, prices of non-tradable goods and services in high income countries are greater than those in low income countries, leading to an overestimation of the former's economic sizes. This improved formula has been used in a number of recent studies, including Alcala & Ciccone (2004) and Dollar and Kraay (2003). Still, this is not a universal practice; some cross-country studies continue to use formula (1).[5] While using PPP-based GDP is important on its own right, it does not remedy the size bias.

On the other hand, if non-PPP-based GDP remains to be used, then it is even more important to correct for the size bias. This is because the share of GDP by the non-tradeable sector is bigger in large economies than in small economies in general; as such the Balassa-Samuelson effect will inflate the GDP of larger economies more, reinforcing the size bias. To illustrate this point, in Figure 1 we plot the PPP price ratio (i.e. non-PPP-based GDP divided by PPP-based GDP) against the log value of non-PPP-based GDP for 167 countries averaging over 1995-2004. All figures are measured in constant 2000 US$ and the data are drawn from the World Development Indicators (WDI). The slope coefficient of the linear regression line is positive and significant at the 1% level. This confirms that

[5] For instance Yanikkaya (2003) and Cavallo and Frankel (2008) do not indicate whether their trade openness measures are constructed using PPP-based GDP. However, Yanikkaya's study uses a large number of trade openness measures and many of them are unrelated to the volume of trade flows.

the degree of overestimation by non-PPP-based GDP increases with the size of the economy.

Figure 1. PPP price ratio versus GDP for 167 countries over 1995-2004



2.2 Modified indexes in the literature

The fact that small countries tend to come out more favourably than large countries in openness assessments based on the TII is not a proof of size bias by itself. To fix the idea of size bias, consider a world of two countries, *p* and *q*, where $Y_p = 2Y_q = 2Y$, and $X_p = X_q = M_p = M_q = X$; that is, country *p* is twice the size of country *q*, and both countries maintain a zero trade balance.[6] The TII will *always* indicate that country *p* is half as open as country *q* regardless their trade regimes or the volume of trade flows between them. This is what we consider the size bias because the *only factor* that leads to a smaller openness measure for country *p* is its relatively larger size.

There have been a few attempts to correct the size bias. Table 1 lists the standard TII, a number of modified measures found in the literature, and the outcome they bring in the above two-country example.

[6] The assumption of zero trade balance is merely for simplicity and is not essential for discussion.

DOI: 10.2202/1524-5861.1751

Table 1. Alternative measures of trade openness for a two-country case

Measure	Formula	Openness measure for the larger country, *p*	Openness measure for the smaller country, *q*
Trade intensity	$\frac{X_i + M_i}{Y_i}$	X/Y	$2X/Y$
Li, Morck, Yang & Yeung (2004)	$\frac{M_i}{Y_i} - \left(1 - \frac{Y_i}{\sum_{j=1}^{N} Y_j}\right)$	$(X/2Y) - (1/3)$	$(X/Y) - (2/3)$
Squalli & Wilson (2006)	$\left(\frac{X_i + M_i}{Y_i}\right)\left[\frac{(X_i + M_i)N}{\sum_{j=1}^{N}(X_j + M_j)}\right]$	X/Y	$2X/Y$
Ferrieri (2006)	$\left(\frac{V_i}{V_{\max}}\right)^{(1-\sigma_i)(1-\pi_i)}$ $V_i = \frac{X_i + M_i}{Y_i}$, $V_{\max} = \max\{V_i\}, i = 1,2...N$, $\sigma_i = \frac{X_i + M_i}{\sum_{j=1}^{N}(X_j + M_j)}$, $\pi_i = \frac{Y_i}{\sum_{j=1}^{N} Y_j}$	$(0.5)^{1/6} = 0.89$	1
Graff (1999)	Residual from $TII_i = \alpha_0 + \alpha_1 GDP_i + \varepsilon_i$		

Li et al. (2004) try to account for the size factor by incorporating a measure of the home country's GDP share in the world in their index. According to their index, the larger country *p* will be more open if $X/Y < 2/3$. The threshold of 2/3 signifies the arbitrariness of the correction; also, the index is not bounded below and could become negative. Squalli & Wilson (2006) suggest a composite index consisting of the product of two components – the conventional trade intensity measure and the ratio of the country's trade flow to the world's average trade flow. The second component aims to account for the fact that small economies have less trade flows in absolute terms. In the above example, their measure however yields exactly the same result as the conventional one. Using the world's average trade flows also has a drawback that the home country's openness measure will be affected by the integration or disintegration of other

countries even if its trade flows remain the same. Ferrieri (2006) proposes to modify the conventional measure using a power function but fails to provide an explanation for this choice. The proposed measure still indicates country *q* is more open than country *p*, though the gap has been substantially narrowed.

Graff (1999) takes the very different approach of using a parametric method. Specifically, he regresses the conventional trade openness measure against GDP and a constant, and then takes the residual as the trade openness measure. There are pros and cons of the parametric approach. While it can control for multiple factors, not just GDP, the results could be sensitive to the dataset and estimation method. Moreover, the openness measure needs to be constantly updated when new data become available. On the contrary, using non-parametric statistics like the others in Table 1 means the results are strictly reproducible[7] and typically of more intuitive meanings. Furthermore, the estimates for any given period are independent of what data being available in the past or in the future. This paper combines these two approaches.

The vastly different outcomes amongst the modified indexes in the above example reveal a fundamental issue. In providing a modification to the TII, researchers are suggesting that there is a benchmark of unbiased (size-wise) measure of openness. While there can only be a single unbiased benchmark, it is not clear in the previous studies why one particular modified index constitutes that benchmark while the others do not. To address this issue a more coherent theoretical framework is required.

3 A generalized trade openness index (TOI)

In the aforementioned example, the TII of country *p* can be written as a linear combination of an export openness measure and an import openness measure:

$$TII_p = \frac{X_p + M_p}{Y_p} = \frac{X_p}{Y_p} + \frac{M_p}{Y_p} \qquad (3)$$

The rationale of normalizing exports by GDP is that a large country may export more than a small country, and therefore it is necessary to adjust a country's export volume with its economic size to give a more meaningful measure of its export openness. Likewise, the import volume needs to be normalized by GDP as a large country may also import more than a small country. In other words, in formula (3) Y_p *serves as respectively a proxy for country p's*

[7] In theory, the same should be true for the parametric approach; but in reality, it is often not the case.

DOI: 10.2202/1524-5861.1751

supply capacity in its export openness measure and a proxy for its demand capacity in its import openness measure. Yet, this formulation of the TII implicitly suggests that country *p* is not constrained by the demand capacity of country *q* for its exports or by the supply capacity of country *q* for its imports. Here the internal inconsistency of the TII becomes very clear: if Y_p is constituting a constraint on X_p, so is Y_q on X_q and thus on M_p because $M_p \equiv X_q$. Once we realize the problem, the correction reveals itself immediately: X_p and M_p should be adjusted for both Y_p and Y_q to yield an unbiased trade openness measure for country *p* (and likewise for country *q*). Indeed, this conclusion would have emerged straight away if one invokes the gravity model framework. As the most robust empirical framework for international trade, the gravity model framework dictates that bilateral trade between two countries is determined by, amongst other factors, the sizes of both countries.

This logic extends to a multi-country world: as a country's total trade is equal to the sum of all its bilateral trade with other countries, it must be constrained by their aggregate demand and supply capacities. Accordingly, in constructing a trade openness measure, the trade volume of the home country should be adjusted for, besides its own GDP, the GDP of the rest of the world (ROW). The latter includes GDPs of the countries that are currently not trading with the home country because otherwise it would overstate the external constraints confronted by closed economies.

A general formula that serves this purpose is

$$TOI_i^{\#} = \frac{X_i}{f(Y_i, RWY_i)} + \frac{M_i}{f(RWY_i, Y_i)} \qquad (4)$$

where $TOI_i^{\#}$ is the generalized trade openness index for country i, $RWY_i = \sum_{j=1; j\neq i}^{N+1} Y_j$ is the total PPP-based GDP measure of the ROW for country i, and N is the total number of countries in the ROW.

Here RWY_i serves as a measure of the demand constraints for the home country's exports and as well as a measure of the supply constraints for its imports. $f(.,.)$ is a function of the two GDPs. $TOI^{\#}$ is broken down into the export and import openness measures, as we do not want to presume at this stage that supply and demand capacities must have symmetric effects on trade flows.

At this point, an inevitable question is: Given RWY_i is much bigger than Y_i, would the incorporation of RWY_i into $TOI_i^{\#}$ be inconsequential in practice?

The answer is no, except for some special cases. We demonstrate this with the following example, which becomes highly relevant later.

Consider the case of $f(.,.)$ being a constant-elasticity-of-substitution (CES) function[8] with equal weighting on its two augments. Thus, $f(Y_i, RWY_i) = f(RWY_i, Y_i)$ and we have

$$TOI_i^*(r) = \frac{X_i + M_i}{[(Y_i)^r + (RWY_i)^r]^{1/r}} \qquad (5)$$

Table 2 shows various specific forms of $TOI_i^*(r)$ for different values of r, including the linear ($r = 1$), Cobb-Douglas ($r \to 0$), and Leontief functions ($r \to -\infty$).

In the case of the linear function, the denominator becomes the world GDP. Since the world GDP is common to all countries, using $TOI_i^*(r = 1)$ to compare trade openness across countries is the same as comparing their gross trade volumes. On the other hand, in the case of the Leontief function, as $RWY_i > Y_i$, $TOI_i^*(-\infty) = (X_i + M_i)/Y_i$. That is, the conventional measure TII is a special and, in fact, an extreme case of the generalized index. Also, $\ln TOI_i^*(-1) = \ln[(X_i + M_i)/Y_i] - \ln(1 - Y_i / \sum_j Y_j)$, which closely resembles the formula of Li et al. (2004) except that all terms are now in log.

Table 2. Specific forms of $TOI^*(r)$ for different elasticities of substitution

r	Elasticity of substitution $s = 1/(1-r)$	$TOI_i^*(r)$	Openness measure for p and q
1 (Linear)	∞	$\frac{X_i + M_i}{Y_i + RWY_i}$	$2X/3Y$
0 (Cobb-Douglas)	1	$\frac{X_i + M_i}{(Y_i)^{1/2}(RWY_i)^{1/2}} = \frac{X_i + M_i}{Y_i}\left(\frac{Y_i}{RWY_i}\right)^{1/2}$	$2^{1/2}X/Y$
-1	0.5	$\frac{X_i + M_i}{[(Y_i)^{-1} + (RWY_i)^{-1}]^{-1}} = \frac{X_i + M_i}{Y_i}\frac{1}{1 - (Y_i / \sum_j Y_j)}$	$3X/Y$
$-\infty$ (Leontief)	0	$\frac{X_i + M_i}{\min(Y_i, RWY_i)} = \frac{X_i + M_i}{Y_i}$ if $Y_i \le RWY_i$	$2X/Y$

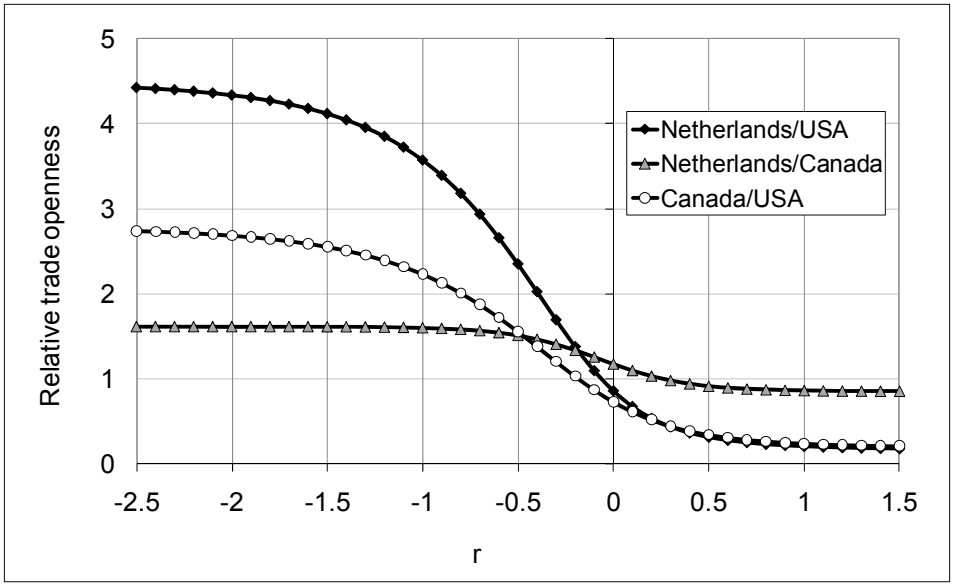
[8] It should be emphasized that the CES function is merely an example here and we do not suggest that it is the only appropriate function form *at this stage*.

DOI: 10.2202/1524-5861.1751

Different values of *r* have different scaling effects on the absolute openness measures of countries *p* and *q*, but their relative openness is always equal to unity. This is because the two countries trade under exactly the same set of (mutual) constraints and therefore there is no information to differentiate their openness. However, this is not the case in a multi-country world.

Figure 2 shows the relative trade openness of a small (the Netherlands), a medium (Canada), and a large (the U.S.) country against the value of *r*. The data are the same as those in Figure 1. In terms of PPP-based GDP, the U.S. is over 10 times the size of Canada and over 20 times that of the Netherlands. The relative trade openness measure of any given pair of countries is bounded: the upper bound corresponds to the ratio of their TIIs, while the lower bound corresponds to the ratio of their trade volumes. Thereby, the ratio of the maximum to minimum values of the relative openness measures of two countries is exactly equal to the inverse of their GDP ratio. In other words, the wider the GDP gap between two countries, the larger the variation in their relative openness measure as the value of *r* changes. This is why the relative openness between the Netherlands and the U.S. has the biggest variation.

Figure 2. Relative trade openness of the Netherlands, Canada, and the U.S., 1995-2004



Furthermore, the relative openness measures of the three countries change from bigger than one to smaller than one as *r* increases from –2.5 to 1.5, meaning that there are changes in the country rankings of openness. For example, when *r* = –2.5, the Netherlands is 1.6 times more open than Canada and 4.4 times more open than the U.S.; when *r* = 1.5, the U.S. becomes 4.7 times more open than

Canada and 5.5 times more open than the Netherlands, implying a complete reverse ordering of their rankings!

Three messages emerge from Figure 2. First, although RWY_i is much larger than Y_i, the incorporation of RWY_i into $TOI_i^{\#}$ could be consequential. Second, the choice of the functional form for $f(.,.)$ could make huge differences to countries' relative trade openness measures. Third, acknowledging the need to incorporate external supply and demand constraints into the trade openness measure is only the first step towards correcting the size bias. To arrive at a specific measure that can be used in empirical work, further theoretical inputs are needed to pin down the precise form of $f(.,.)$.

4 A more specific trade openness index

4.1 An axiomatic approach

We take formula (4) of the generalized trade openness index $TOI^{\#}$ as the starting point. In what follows, we propose a number of desirable properties (i.e. axioms) that an appropriate trade openness index (TOI) should exhibit and then use these axioms to determine the appropriate form of $f(.,.)$.

Axiom 1: *An increase in the GDP of a country or the rest of world or both, other things equal, does not increase the country's TOI value.*

This implies that $f_1 \geq 0, f_2 \geq 0$ and $f_{12} \geq 0$. This axiom comes from the basic premise that a country should not be deemed as more open if it maintains the same trade flows under less stringent supply or demand capacity constraints. It is a weaker condition than requiring the TOI value to decrease when the GDP increases for a given volume of trade flows.

Axiom 2: *Demand and supply capacities as measured by GDPs are of the same weights in the TOI.*

This axiom implies that $f(Y_i, RWY_i) = f(RWY_i, Y_i)$ so that the exports and imports of a country are scaled by the same GDP factor. Thereby, formula (4) becomes

$$TOI_i^{\#} = \frac{X_i + M_i}{f(Y_i, RWY_i)} \qquad (6)$$

DOI: 10.2202/1524-5861.1751

This axiom arises from the quest for simplicity. As explained before, this implies that in a two-country world the two countries will always have the same degree of trade openness.

Axiom 3: *The TOI is scale independent.*

This axiom means that the index value is independent of the currency unit in which trade flows and GDP are expressed. Since the numerator $(X_i + M_i)$ in (6) is expressed in the linear form, the axiom requires the denominator $f(Y_i, RWY_i)$ to be of constant returns to scale: $f(\alpha Y_i, \alpha RWY_i) = \alpha f(Y_i, RWY_i)$. The most general functional form for $f(.,.)$ that exhibits this property while satisfies Axioms 1-2 at the same time is a CES function with equal weights on Y_i and RWY_i (repeating formula (5)):

$$TOI_i^*(r) = \frac{X_i + M_i}{[(Y_i)^r + (RWY_i)^r]^{1/r}} \qquad (7)$$

Here it is useful to emphasize that the CES function is not an arbitrary choice here anymore; it is the only functional form for $f(.,.)$ that makes the TOI satisfy all three Axioms.

Axiom 4: *The TOI value of a country is independent of the number of countries in the rest of the world, other things equal.*

This axiom means that the TOI value of a country will not be affected by the integration or disintegration of other countries, provided that its trade flows and its and the ROW's GDPs remain unchanged. This excludes the possibility of the TOI taking forms like $TOI_i^*(r) = (X_i + M_i) / \{N[(Y_i)^r + (RWY_i / N)^r]^{1/r}\}$, which measures the GDP-adjusted average trade flows between country i and an average country in the ROW.

Axiom 5: *A country's TOI value tends towards its TII value as the rest of the world's GDP increases, other things equal.*

As the economic size of the ROW gets bigger, the external constraint on the home country's trade flows becomes less binding and, therefore, the TII should become closer to the unbiased measure, i.e. $\lim_{RWY_i \to \infty} TOI_i = TII_i$. The

axiom implies $r < 0$ and thus excludes the possibilities of $f(.,.)$ being either a linear or a Cobb-Douglas function:

$$TOI_i^*(r) = \frac{X_i + M_i}{[(Y_i)^r + (RWY_i)^r]^{1/r}}, \; r < 0 \qquad (8)$$

Although the five axioms together restrict the functional form of $f(.,.)$ to a specific CES function, for the TOI to be useful in empirical work, we need to further pin down the value of *r*. Since no theoretical considerations can help achieve that, we look to the data for plausible answers.

4.2 A parametric approach

We follow the practice of the parametric approach to look for a value for *r* that can maximize the correlation between the GDP factor and trade flows.[9] The regression model is based on formula (8) so that the final, parameterized index formula will have a rigor theoretical foundation underpinned by the aforementioned axioms. In a sense, we are estimating a structural model. The following non-linear regression is estimated:

$$\ln T_i = r^{-1} \ln[(Y_i)^r + (RWY_i)^r] + \varepsilon_i \qquad (9)$$

where T_i is equal to either X_i, M_i or $X_i + M_i$, and ε_i is the error term.

Our dataset covers 1975 to 2004 and is divided into three periods: 1975-84, 1985-94, and 1995-2004. The first decade covers 101 countries and the last one 145 countries. The data series include exports and imports of goods and services, and PPP-based GDP, all measured in constant 2000 US$. The data are sourced from the WDI. Since size matters most in inter-country comparison, we focus on the cross sectional aspect of the data by taking simple average over each decade and treat them as a pooled cross-sectional dataset.

The results are reported in Table 3. Besides the full sample, we also estimate the model using data for each of the three decades. The figures in parentheses are heteroskedasticity robust standard errors. In all estimates the coefficient *r* is significant at the 1% level and the R-squared is larger than 0.99, thus we do not litter the table with those information. The results indicate that formula (8) is highly agreeable with the data.

[9] This approach is the same as using gravity models to measure openness in that coefficients are chosen to maximize the joint explanatory power of the regressors and then the residual is used as a measure of openness.

DOI: 10.2202/1524-5861.1751

Table 3. Regressional results for the TOI formula

Dependent variable	*1975-84*	*1985-94*	*1995-2004*	*Full sample*
lnX	-0.1457	-0.1459	-0.1572	-0.1498
	(0.0038)	(0.0034)	(0.0039)	(0.0022)
lnM	-0.1571	-0.1538	-0.1635	-0.1582
	(0.0036)	(0.003)	(0.0034)	(0.0019)
ln(X+M)	-0.1889	-0.1873	-0.2062	-0.1942
	(0.0058)	(0.0051)	(0.0063)	(0.0033)
# of obs.	101	138	145	384

Figures in parentheses are heteroskedasticity robust standard errors.

The estimated coefficients for the export and import regressions are very similar across all the samples, providing support to normalizing exports and imports with the same denominator. All estimates for the coefficient r are significantly less than zero, verifying the theoretically motivated restriction that we imposed on its sign. The estimates are nearly identical for the first two periods and are only marginally different for the third period. This allows us to focus on just the full sample.

The results for total trade with the full sample suggest that, rounding up to one decimal point, $r = -0.2$.[10] This implies that the elasticity of substitution between supply and demand capacities in international trade flows is at the order of 0.8. We take this as our preferred value for r and set the *final form* of the TOI as:

$$TOI_i = \frac{X_i + M_i}{[(Y_i)^{-0.2} + (RWY_i)^{-0.2}]^{-5}} \qquad (10)$$

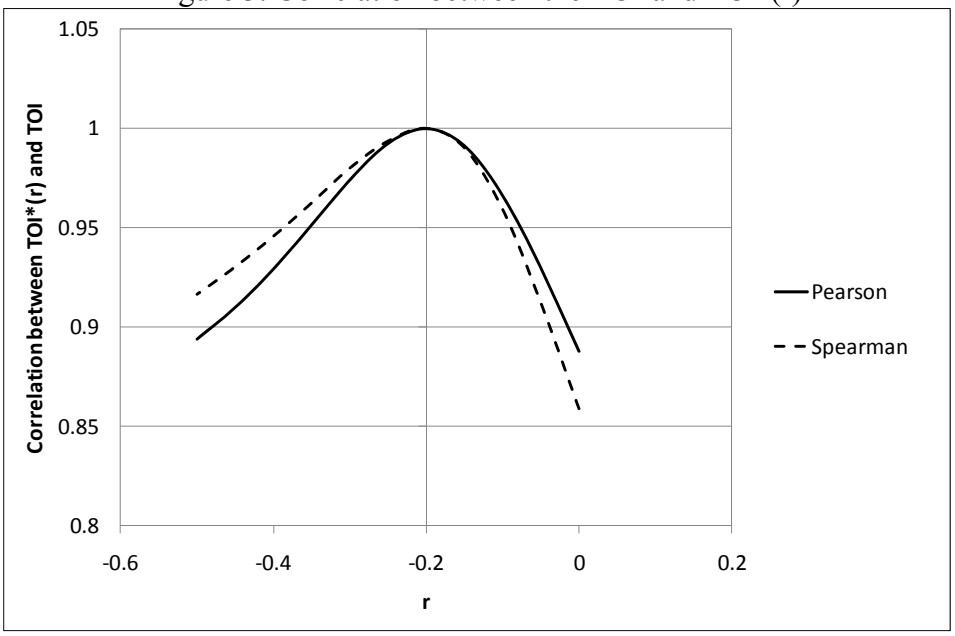
The TOI can be interpreted as the trade volume as a share of the home country's *GDP factor*, which is defined as a CES function of its own GDP and the GDP of its potential trading partners as a whole. In other words, the TOI can be interpreted in a way very similar to the TII despite the difference.

A potential criticism of this formulation is in order. If a country's GDP and trade stay constant while the ROW's GDP grows, why should we think the country is becoming more closed? In a gravity model framework, a country that trades with a smaller partner (the ROW here) is considered to be more open than a country of the same size and trading the same amount of goods but with a larger partner. The same intuition appears here.

[10] The value of –0.2 actually falls within the 95% interval of the point estimate.

Formula (10) can also be written as $TOI_i = TII_i \cdot Y_i[(Y_i)^{-0.2} + (RWY_i)^{-0.2}]^5$. Here we can consider $Y_i[(Y_i)^{-0.2} + (RWY_i)^{-0.2}]^5$ as the correction to the TII and, thus, its inverse as a measure of the size bias. In our dataset, the average size bias is 0.35 (or 35%) with a standard deviation of 0.13. In other words, the extent of size bias is fairly severe on average but the degree of biasness varies substantially across countries.

Figure 3. Correlation between the TOI and TOI*(r)



Since $r = -0.2$ is only a point estimate, it is natural to ask how sensitive the index value is with respect to the coefficient value. Figure 3 shows two correlation coefficients between the TOI and $TOI^*(r)$ for $0 > r \geq -0.5$. Over a wide neighbourhood around $r = -0.2$ based on the scale its standard error (i.e. 0.0033), the Pearson and the Spearman rank correlations are extremely high. This gives us confidence that the TOI is robust to estimation errors in *r*.

Figure 2 shows that, at $r = -0.2$ the openness gaps between the Netherlands, Canada and the U.S. are greatly reduced as compared to $r = -\infty$ (i.e. when the index becomes the TII). For instance, the relative openness between the Netherlands and the U.S. shrinks from the ratio of 4.5 to 1.4, and that between Canada and the U.S. shrinks from 2.8 to 1. The openness gaps between some other countries, however, are enlarged as a result of correcting the size bias, as to be shown next.

DOI: 10.2202/1524-5861.1751

5 Applications

5.1 Comparing the TOI and TII

Table 4 reports the TOI and TII values for the 145 countries over the 1995-2004 period. The index values are normalized such that a value of 100 is assigned to the most open economy, which is Hong Kong for both indexes. The two normalized index values for any other country therefore indicate its trade openness relative to Hong Kong with and without rectifying the size bias. For instance, the TII suggests that when only their own size constraints are accounted for, Germany is 20% as open as Hong Kong; on the contrary, the TOI suggests that when both internal and external size constraints are accounted for, the former is 44% as open as the latter.

The Pearson correlation between the TOI and TII is equal to 0.78. Despite the overall positive correlation between the two indexes, the scatter plot of their log values in Figure 4 shows that there remains a fair amount of discrepancies between them. The figure also reveals that the size bias leads to more cases of overstatement than understatement of trade openness by the TII. This is because small-sized countries outnumber their large-sized counterparts in the dataset.

Previously, Figure 2 showed that using the TOI leads to a substantial reduction in the openness gaps between the three sample countries. This finding, however, cannot be generalized to other countries. For instance, before correcting the size bias, Canada and Estonia are deemed as equally open with an openness measure equals to 24; after the correction Canada's measure increases by more than 50% to 38 while Estonia's measure decreases by 40% to 14, creating a big gulf between them. Since the TOI only controls for size factors, the differences in its values between countries would be attributed to factors unrelated to size, such as trade barriers, distance from potential trading partners, institutional setting and endowment.

Table 4. Normalized TOI, normalized TII, and country rankings for 145 countries, 1995-2004

Country	TOI	TII	TOI ranking	TII ranking	Change in ranking	Country	TOI	TII	TOI ranking	TII ranking	Change in ranking
Hong Kong, China	100	100	1	1	0	Portugal	14.97	14.79	38	49	11
Luxembourg	60.18	94.77	2	2	0	Lebanon	14.38	23.69	39	25	-14
Belgium	54.06	47.88	3	5	2	Estonia	14.35	24.24	40	24	-16
Netherlands	50.46	39.19	4	9	5	Trinidad and Tobago	14.26	24.46	41	21	-20
Ireland	46.79	52.61	5	4	-1	New Zealand	14.20	17.06	42	42	0
Germany	43.85	20.63	6	32	26	Slovak Republic	13.70	17.35	43	41	-2
United Arab Emirates	43.49	53.23	7	3	-4	Venezuela, RB	13.43	14.13	44	52	8
Canada	37.71	24.26	8	23	15	Nigeria	12.56	14.20	45	51	6
United States	36.53	8.72	9	86	77	China	12.54	4.11	46	133	87
Malaysia	36.08	34.96	10	10	0	Croatia	11.96	16.34	47	46	-1
United Kingdom	35.07	18.18	11	34	23	Greece	11.61	11.34	48	68	20
Switzerland	33.79	31.66	12	12	0	Seychelles	11.56	26.83	49	19	-30
Sweden	32.05	29.77	13	14	1	Philippines	11.51	9.91	50	79	29
France	31.02	16.33	14	47	33	Jordan	11.45	17.92	51	37	-14
Denmark	30.18	31.17	15	13	-2	Chile	11.24	11.78	52	64	12
Austria	28.54	26.63	16	20	4	Turkey	11.16	8.74	53	85	32
Norway	28.42	29.24	17	15	-2	Russian Federation	11.12	6.62	54	108	54
Korea, Rep.	27.19	17.96	18	36	18	Costa Rica	11.06	16.02	55	48	-7
Italy	26.02	13.95	19	54	35	Yemen, Rep.	10.88	18.06	56	35	-21
Japan	25.83	10.07	20	77	57	Poland	10.79	8.66	57	87	30
Macao, China	23.25	41.33	21	8	-13	Dominica	10.71	27.85	58	18	-40
Finland	21.42	22.89	22	28	6	Belize	10.61	24.35	59	22	-37
Spain	21.23	13.35	23	56	33	Mauritius	10.34	17.89	60	38	-22
Kuwait	21.00	28.38	24	16	-8	Swaziland	10.31	20.55	61	33	-28
Congo, Rep.	20.96	42.72	25	7	-18	Indonesia	10.29	7.18	62	101	39
Israel	20.79	21.92	26	31	5	Lithuania	9.91	14.30	63	50	-13
Mexico	20.77	13.20	27	57	30	Grenada	9.45	23.37	64	27	-37
Panama	20.66	33.25	28	11	-17	Gabon	9.35	17.05	65	43	-22
Saudi Arabia	18.92	16.77	29	44	15	Belarus	9.26	12.33	66	62	-4
Antigua and Barbuda	18.64	45.51	30	6	-24	Dominican Republic	9.17	12.03	67	63	-4
Australia	16.99	12.79	31	60	29	St. Vincent and the Grenadines	9.11	22.79	68	29	-39
Hungary	16.68	17.84	32	39	7	Latvia	8.71	13.79	69	55	-14
Thailand	16.45	13.05	33	59	26	Guyana	8.50	17.83	70	40	-30
Slovenia	16.42	23.54	34	26	-8	Tunisia	8.44	10.76	71	73	2
Czech Republic	16.17	16.46	35	45	10	Turkmenistan	8.23	14.00	72	53	-19
Oman	15.26	22.12	36	30	-6	Bulgaria	8.09	10.64	73	74	1
Iceland	15.25	27.94	37	17	-20	South Africa	8.04	6.47	74	115	41

DOI: 10.2202/1524-5861.1751

Table 4. Normalized TOI, normalized TII, and country rankings for 145 countries, 1995-2004

Country	TOI	TII	TOI ranking	TII ranking	Change in ranking	Country	TOI	TII	TOI ranking	TII ranking	Change in ranking
Hong Kong, China	100	100	1	1	0	Portugal	14.97	14.79	38	49	11
Luxembourg	60.18	94.77	2	2	0	Lebanon	14.38	23.69	39	25	-14
Belgium	54.06	47.88	3	5	2	Estonia	14.35	24.24	40	24	-16
Netherlands	50.46	39.19	4	9	5	Trinidad and Tobago	14.26	24.46	41	21	-20
Ireland	46.79	52.61	5	4	-1	New Zealand	14.20	17.06	42	42	0
Germany	43.85	20.63	6	32	26	Slovak Republic	13.70	17.35	43	41	-2
United Arab Emirates	43.49	53.23	7	3	-4	Venezuela, RB	13.43	14.13	44	52	8
Canada	37.71	24.26	8	23	15	Nigeria	12.56	14.20	45	51	6
United States	36.53	8.72	9	86	77	China	12.54	4.11	46	133	87
Malaysia	36.08	34.96	10	10	0	Croatia	11.96	16.34	47	46	-1
United Kingdom	35.07	18.18	11	34	23	Greece	11.61	11.34	48	68	20
Switzerland	33.79	31.66	12	12	0	Seychelles	11.56	26.83	49	19	-30
Sweden	32.05	29.77	13	14	1	Philippines	11.51	9.91	50	79	29
France	31.02	16.33	14	47	33	Jordan	11.45	17.92	51	37	-14
Denmark	30.18	31.17	15	13	-2	Chile	11.24	11.78	52	64	12
Austria	28.54	26.63	16	20	4	Turkey	11.16	8.74	53	85	32
Norway	28.42	29.24	17	15	-2	Russian Federation	11.12	6.62	54	108	54
Korea, Rep.	27.19	17.96	18	36	18	Costa Rica	11.06	16.02	55	48	-7
Italy	26.02	13.95	19	54	35	Yemen, Rep.	10.88	18.06	56	35	-21
Japan	25.83	10.07	20	77	57	Poland	10.79	8.66	57	87	30
Macao, China	23.25	41.33	21	8	-13	Dominica	10.71	27.85	58	18	-40
Finland	21.42	22.89	22	28	6	Belize	10.61	24.35	59	22	-37
Spain	21.23	13.35	23	56	33	Mauritius	10.34	17.89	60	38	-22
Kuwait	21.00	28.38	24	16	-8	Swaziland	10.31	20.55	61	33	-28
Congo, Rep.	20.96	42.72	25	7	-18	Indonesia	10.29	7.18	62	101	39
Israel	20.79	21.92	26	31	5	Lithuania	9.91	14.30	63	50	-13
Mexico	20.77	13.20	27	57	30	Grenada	9.45	23.37	64	27	-37
Panama	20.66	33.25	28	11	-17	Gabon	9.35	17.05	65	43	-22
Saudi Arabia	18.92	16.77	29	44	15	Belarus	9.26	12.33	66	62	-4
Antigua and Barbuda	18.64	45.51	30	6	-24	Dominican Republic	9.17	12.03	67	63	-4
Australia	16.99	12.79	31	60	29	St. Vincent and the Grenadines	9.11	22.79	68	29	-39
Hungary	16.68	17.84	32	39	7	Latvia	8.71	13.79	69	55	-14
Thailand	16.45	13.05	33	59	26	Guyana	8.50	17.83	70	40	-30
Slovenia	16.42	23.54	34	26	-8	Tunisia	8.44	10.76	71	73	2
Czech Republic	16.17	16.46	35	45	10	Turkmenistan	8.23	14.00	72	53	-19
Oman	15.26	22.12	36	30	-6	Bulgaria	8.09	10.64	73	74	1
Iceland	15.25	27.94	37	17	-20	South Africa	8.04	6.47	74	115	41

Figure 4. TOI versus TII for 145 countries over 1995-2004

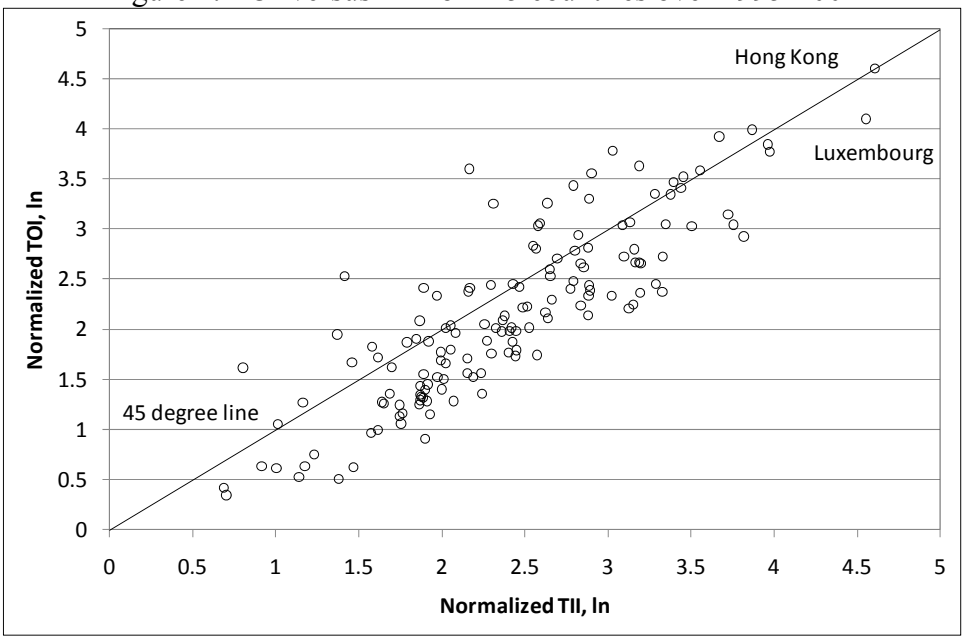
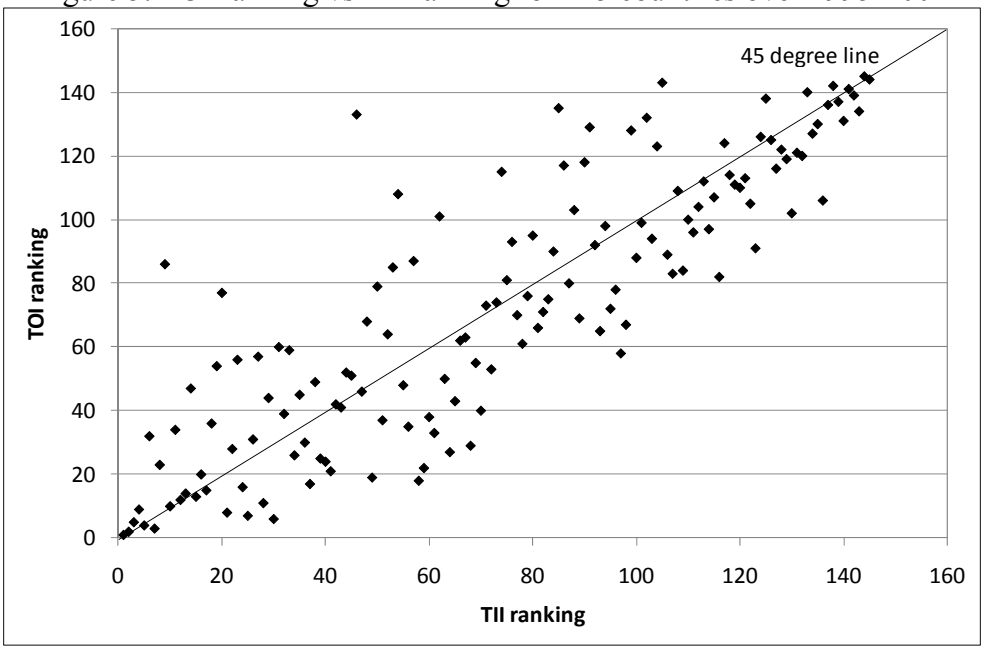


Figure 5. TOI ranking vs TII ranking for 145 countries over 1995-2004



The significant changes in relative openness between many countries mean that there are also substantial movements in their rankings. The country rankings according to the two indexes, as well as the changes in the rankings are

also reported in Table 4. If the change in ranking is positive, it means that the TOI ranks the country in concern higher than the TII does. For instance, Germany is ranked 32nd by the TII but 6th by the TOI, so its ranking improves by 26 places when the size bias has been rectified. The average change of ranking is equal to 16.4 (against the total number of 145 countries), and the standard deviation is 15. The effect of the new index on country ranking is shown in Figure 5, which is a scatter plot of the TOI ranking against the TII ranking. The Spearman rank correlation between the two indexes is equal to 0.84. So the rank correlation between the two indexes is moderately high.

As expected, a lot of large economies have moved up the ranking ladder as a result of correcting the size bias. China exhibits the largest change in ranking with an upward jump of 87 places to rank 46th, followed by the U.S. (up 77 to 9th), Japan (up 57 to 20th) and Russian Federation (up 54 to 54th). On the other hand, those have moved down the ladder are very small economies, including Dominica (down 40 to 58th), Djibouti (down 39 to 97th), St Vincent and the Grenadines (down 39 to 68th), and Grenada (down 37 to 64th).[11] Returning to the examples in section 1, after correcting for the size bias, the U.S. is now ranked well ahead of Swaziland and Tajikistan, and China is considered much more open than Cambodia and Laos – as one would expect.

5.2 Trade openness and growth

The change in country ranking as evident above could have significant implications to cross country analysis of issues such as the effect of trade openness on growth or inequality. How the use of the TOI would affect an empirical outcome is obviously case dependent. As an illustration, we follow Dollar and Kraay (2004) (referred as DK hereafter) to examine the growth impacts of trade openness, but use the TOI and TII in turn to compare and contrast their results. This exercise only serves to illustrate the potential impact of correcting the size bias in empirical work. It is not meant to be an in-depth study of the determinants of growth. Thereby, we will draw mostly on the sensitivity of the results with respect to the two openness measures.

We adopt model (2) from Table 4 of DK. The model involves regressing log income on its own lag, the log value of the trade openness measure, country fixed effects and time fixed effects. The first fixed effects capture time invariant country specific factors, such as geography and institutions, while the second ones

[11] These changes in the openness ranking can be summarized crudely by the changes in rank correlations between the economic size and openness measures. The Spearman correlations between lnGDP (PPP, constant 2000$) and the openness measure increases to 0.37 with the TOI from –0.11 with the TII. In other words, there is a general but mild reverse ordering of openness rankings when the size bias is rectified.

capture time variant country common factors such as world commodity prices. Certain portion of country specific but slowly evolving factors such as demography and policies can be captured by lagged income. For the remaining omitted factors, as long as they are not correlated with both income and trade, they will not cause bias to the coefficient estimate for openness. DK show that this parsimonious model is very robust in that, adding a number of other possible determinants neither improves the model nor significantly affects their results on trade openness. The simplicity of the model allows us to focus on the differences that the new trade openness measure could make.

The dataset is the same as that in section 4.2. Due to the use of first differencing and lag variable, it covers only 101 countries. It is, thus, a typical "large N and small T" panel. Following the estimation strategy of DK, the model is estimated in first difference to remove the country fixed effects. This means that in practice we are regressing the income growth rate of the 1990s (i.e. from 1985-94 to 1995-2004) on the income growth rate of the 1980s (i.e. from 1975-84 to 1985-94) plus the growth rate of trade openness of the 1990s.[12] This is essentially a dynamic panel model and necessitates instrumenting the growth rates of lagged income and trade openness. Here the initial income, trade openness and trade volume in 1975-84 are used as the instruments.

The results are presented in Table 5. We first estimate the model using OLS regressions. All variables are significant at the 1% level with the expected signs. Yet, there are noticeable quantitative differences in that the point estimate of the TOI coefficient is nearly 50% larger than of the TII coefficient. On the other hand, the coefficient on the lagged income in the TOI model is slightly smaller than that in the TII model. However, since trade openness could be endogenous, the OLS estimations may be biased.

[12] The time fixed effects become a constant term after first differencing.

DOI: 10.2202/1524-5861.1751

Table 5 Estimation results of the effect of trade openness on income

Model	*(1)*	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*
Estimator	OLS		2SLS		2SLS	
Sample	Full sample		Full sample		Excluding Hong Kong and Luxembourg	
Openness measure	TII	TOI	TII	TOI	TII	TOI
Lagged income	0.507	0.489	0.541	0.327	0.581	0.364
	(0.081)***	(0.076)***	(0.169)***	(0.150)**	(0.207)***	(0.164)**
Trade openness	0.119	0.175	0.165	0.304	0.172	0.298
	(0.047)***	(0.041)***	(0.087)*	(0.089)***	(0.090)*	(0.086)***
R-squared	0.432	0.465	0.426	0.401	0.418	0.420
Over-identification test (p)			0.223	0.342	0.220	0.330
# of obs.	101	101	101	101	99	99

*, ** and *** denote significance at 1, 5 and 10% levels respectively. Figures in parentheses are robust standard errors. Results for the time fixed effect are omitted.

To address the endogeneity problem, we re-estimate the model using 2SLS estimators (columns 3-4). All variables remain significant at the 1% level with the exception that the TII's significance drops just below the 5% level (p=0.058). All variables retain their expected signs. Quantitatively, the use of IV estimation sees the coefficients on trade openness increasing. Interpreting the results mechanically, the TOI model suggests that a 100% increase in trade openness would lead to a 30% increase in income, while the TII model suggests a 17% increase only. This means that, after arresting endogeneity, the difference between the TOI and TII coefficients becomes even wider. Yet, one should also be aware that the 95% confidence intervals of the two coefficients overlap. Notwithstanding, for this dataset and model specification, removing the size bias reveals a higher point estimate for the effect of trade openness on income.

The coefficient on the lagged income in the TOI model is noticeably smaller with the use of instruments. Lastly, results from Wooldridge's (1995) over-identification test, which is robust to heteroskedasticity, suggested that the instruments are valid.

In columns (5)-(6), we exclude the two most open economies – Hong Kong and Luxembourg – from the sample as their openness could be overstated

due to their heavy re-export activities.[13] Notwithstanding, the previous results are found to be very robust to the exclusion of these two entrepôts.

Overall, we observe that using the TOI as compared to the TII makes discernible quantitative differences not only to the results for trade openness itself but sometimes also to the results for other variables. On the other hand, there seem to be little qualitative differences. This is reasonable given the TOI is an improvement of the TII, not an overhaul. However, one should not attempt to generalize these findings to other analyses involving trade openness. The use of the TOI may make much bigger differences when alternative datasets, specifications or estimation methods are used, not to mention when different topics (e.g. poverty or inequality instead of growth) are considered.

6 Conclusion

The trade intensity index (TII) is a very basic measure of trade openness as it only controls for the home country's GDP. Then why should we concern with modifying the index 'at the margin' when much more elaborative measures are already available? Firstly, GDP is the most important single factor in determining trade flows. Recall that the GDP variables can 'explain' over 99% of the cross country variation in trade flows in our dataset. Therefore 'just' improving the GDP component of the TII is still of great practical value. Secondly, although many sophisticated measures have been developed, the TII remains the most commonly used measure not only of trade openness but also increasingly of trade globalization. Measures derived from more elaborative processes, while may be more accurate per se, are typically weighted down by their complexity[14] and sometimes lack of intuitive interpretations. In developing the TOI, we endeavoured to ground the modification on a solid theoretical foundation to avoid the ad hoc approach featured in previous studies, while at the same time to maintain the simplicity of the original index to maximize its chance of being deployed by other end users.

The TOI has a number of merits to recommend for: (1) it exhibits a number of desirable properties as spelled out in the axioms; (2) it corrects for the size bias of the TII but maintains its simple structure; (3) it can be interpreted in a way very similar to the TII; (4) it ties with the very robust gravity model framework; (5) it is easy to compute; (6) it requires only one additional piece of

[13] Another major entrepôt, Singapore, is not on the list due to the lack of data in the WDI.

[14] For instance, Lloyd and MacLaren (2002) use the Global Trade Analysis Project (GTAP) computable general equilibrium model to derive measures of trade openness.

DOI: 10.2202/1524-5861.1751

information, the world GDP, which is easily available;[15] and (7) it is highly agreeable with the data.

We demonstrated that incorporating the external size constraint can lead to significant changes in the relative openness measures between countries and in the estimated effect of trade openness on income. To the extent that trade openness often matters in cross country analyses, using the unbiased measure in the form of the TOI should help deliver more reliable results.

References

Alcala, Francisco, and Antonio Ciccone (2004) "Trade and productivity" Quarterly Journal of Economics, 119(2): 613-646.

Cavallo, Eduardo, and Jeffrey Frankel (2008) "Does openness to trade make countries more vulnerable to sudden stops, or less? Using gravity to establish causality." Journal of International Money and Finance, 27(8): 1430-1452.

Dollar, David, and Aart Kraay (2003) "Institutions, trade and growth" Journal of Monetary Economics, 50(1): 133-162.

---------- (2004) "Trade, growth, and poverty". The Economic Journal. 114(493): F22-F49.

Dreher, Axel (2006) "Does globalization affect growth? Evidence from a new index of globalization" Applied Economics, 38(10): 1091-1110.

Ferrier, Gaetano (2006) "A method for measuring international openness" Social Indicators Research 77: 245-255.

Graff, Michael (1999) "Education imbalance, socio-economic inequality, political freedom, and economic development" Journal of Economic Development, 24(2): 1-18

Jaumotte, Florence, Subir Lall, and Chris Papageorgiou (2008) "Rising income inequality: technology, or trade and financial globalization" IMF Working Paper WP/08/185.

Li, Kan, Randall Morck, Fan Yang, and Bernard Yeung (2004) "Firm-specific variation and openness in emerging markets" The Review of Economics and Statistics, 86(3): 658-669

Lloyd, Peter, and Donald MacLaren (2002) "Measure of trade openness using CGE analysis" Journal of Policy Modelling, 24(1): 67-81.

[15] Even if the world GDP figures are not available, one can easily use the total GDP of the G20 countries as a close approximation.

Pritchett, Lant (1991). Measuring outward orientation in developing countries. Can it be done? Trade Policy Working Papers, The World Bank, WPS 566.

---------- (1996). Measuring outward orientation in LDCs: can it be done? Journal of Development Economics, 49(2), 307–335.

Squalli, Jay, and Kenneth Wilson (2006) "A new approach to measuring trade openness" http://www.business.curtin.edu.au/files/squalli_wilson.pdf

Wooldridge, Jeffrey. M. (1995) "Score diagnostics for linear models estimated by two stage least squares". In Advances in Econometrics and Quantitative Economics: Essays in Honor of Professor C. R. Rao, ed. G. S. Maddala, P. C. B. Phillips, and T. N. Srinivasan, 66–87. Oxford: Blackwell.

Yanikkaya, Halit (2003) "Trade openness and economic growth: a cross-country empirical investigation" Journal of Development Economics 72(1): 57-89.

DOI: 10.2202/1524-5861.1751