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Three Measures of Trade Dependence

A Critique

Paul V. Johnston

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Abstract

Economists use various trade dependence indexes as an aggregate measure for comparing across countries the importance of trade and the influence of trade policy. Two commonly used indexes, the trade/GDP index and the export/GDP index, lack mathematical attributes necessary to accurately represent trade dependence. A new index developed in this report, the "trade dependence index" (TDI), should better serve the needs of trade researchers. The TDI unambiguously specifies a country's trade dependence on a scale between zero and 100. Moreover, for any degree of trade dependence there is only one index value.

Keywords: Trade dependence, openness, trade liberalization, competitiveness, comparative advantage

Acknowledgments

Special thanks go to David Torgerson, who suggested a change in the mathematical formula representing the new trade dependence index. The thorough reviews by Tom Vollrath and David Stallings made this a much better report. Editorial reviews by Fred Ruppel, George Frisvold, and Lon Cesal were also helpful.

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Introduction

Autarky, perfect dependence[1], and all intermediate positions denote a trade dependence continuum. Points or ranges on this continuum represent the relative degree to which a country (or a subsector, such as agriculture) relies on trade. Many authors have used this continuum as a guide to develop trade indexes for analyzing such concepts as trade dependence, economic openness, and trade policy orientation. A well-behaved trade dependence index must unambiguously locate a country on this continuum and have fixed bounds. Moreover, for any degree of trade dependence, there can be only one index value, and higher levels of trade dependence should be associated with higher index values.

Two widely used indexes, trade/GDP (gross domestic product) and exports/GDP, have been used to measure such classifications of trade dependence as openness to trade, trade orientation, or trade regimes. However, these two indexes have not been analyzed to determine whether they, in fact, uniquely relate index values to the concepts they purportedly measure. After deriving such mathematical properties, this report examines the two commonly used indexes and finds them to yield ambiguous and misleading conclusions. This report then derives a new trade dependence index (TDI) that does satisfy those properties and demonstrates its unambiguity. Finally, this report uses empirical results to show that comparisons of the traditional trade/GDP index across time and countries yield ambiguous and misleading statements.

The TDI is strictly monotonically increasing with boundaries of 0 and 100. It allows one to make such statements that 75 percent of every $100 of the final value of goods produced by country A is derived from trade. Moreover, country A can be shown to be 20 times more dependent on trade than country B.

The TDI index for three levels of aggregation--total trade, merchandise trade, and agricultural trade--has been calculated

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[1]Perfect dependence refers to a country's total reliance on trade for all goods consumed; all produced goods are exported. Complete specialization refers to the production of particular commodities; for example, if all of good X_i is exported, the country is completely specialized in this good.

for 138 countries and is available in Trade Dependency Index Tables for Total, Merchandise, and Agricultural Trade, 1960-88 (Paul Johnston), SB-835, February 1992.

Recent Uses of Two Common Trade Dependence Indexes

Economists have associated a variety of concepts with the trade continuum, but have not defined a different measure for each (table 1). For example, Kuznets (1964), Kravis and Lipsey (1987), and Edwards (1988) used trade/GDP to measure both trade dependence and openness. Wood (1991) expressed openness as the ratio of exports/GDP, while Leamer (1984) called this ratio trade dependence. In addition to their uses as a direct measure of several concepts, trade/GDP and exports/GDP have been used as an explanatory variable for inter-country price variations (Kravis and Lipsey, 1987) or movements in the real exchange rate (Cottani and others, 1990). Since trade/GDP and exports/GDP are shown to be incorrect measures of these concepts, regression coefficients will be biased.

All authors refer to a range of degrees for which a country (or an economic sector such as agriculture) relies on foreign trade. In this report, the rubric, trade dependence, describes any degree of such reliance.

I propose that four mathematical properties establish necessary and sufficient conditions for an unambiguous measure of trade dependence. I applied those properties to analyze the two commonly used measures, trade/GDP and exports/GDP, and found them to be ambiguous trade dependence indexes. I propose a new index that satisfies each of the four criteria and assigns a specific value to a unique point along the autarky-perfect dependence continuum.[2]

Mathematical Properties of a Well-Behaved Trade Dependence Index

Four mathematical properties describe a well-behaved index: (1) continuous, (2) closed and bounded, (3) strictly monotonically increasing[3], and (4) asymptotic. With these properties, a trade

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[2]Kuznets (1959) noted that the foreign trade ratio should be measured as total trade divided by the "sum of gross national product and imports of all goods" (pp. 93-94 in Economic Growth). However, data limitations prevented him from calculating this index and he substituted trade/GDP. He also used trade divided by GDP in his 1964 article. He did not examine the mathematical properties of either index.

[3]The monotonically increasing property is included to bring out two ideas: any function with this property is one-to-one, and it increases rather than decreases with greater dependence increases. On the other hand, a one-to-one relationship permits a decreasing function value as trade dependence increases.

Table 1--Authors, formulas, and the concepts measured

Author(s) (date)	Formula	Name	Purpose
Kuznets (1959)	$\frac{\text{Trade*}}{\text{GDP + imports}}$	Trade ratio	Production specialization
Kuznets (1964)	Trade/GDP	Trade dependence	Relation to per capita income
Bradford and Branson (1987)	Trade/GDP	Trade liberalization	Trade regime continuum
Kravis, Lipsey (1987)	Trade/GDP	Openness	Impact of trade restrictions on cross-country price levels
Leamer (1984)	Exports/GDP	Trade dependence	Trade profile
Leamer (1987)	Trade/GDP	Openness	Level of trade barriers
Edwards (1988), (Feldstein ed.)	Trade/GDP	Openness	Pattern of trade restrictions over time
Edwards (1989)	Difference between predicted and actual ratio of trade/GDP	Trade intervention	Impact on growth through transfer of technology
Cottani, et al. (1990)	GDP/trade	Trade restrictions	Impact of trade restrictions on the real exchange rate
Wood (1991)	Exports/GDP	Openness	Impact of openness on prices of traded goods

*Trade is exports plus imports.

dependence index can be used to make unambiguous and quantitative comparisons over time and across countries. Continuous and unique trading positions from autarky to perfect dependence can be defined for countries with concave production possibility curves. This autarkic-perfect dependence continuum is closed and bounded if $A \leq f(x) \leq P$ where A and P represent the boundaries of the continuum.

The autarkic-perfect dependence continuum is strictly monotonically increasing in that as you move toward perfect dependence, trade dependence always increases; there are no flat regions where trade dependence is constant. Each point along the continuum depicts an absolute, a, and a relative degree, a/A, of trade dependence.

The index must have the same properties as the continuum. For trade dependence indexes to be strictly monotonically increasing, then $f(d) = b > f(c) = a$, where $d > c$. A linear index function does not have an upper bound unless restrictions are placed on the domain. But, the restrictions have to be changed over time as an economy grows and limited in such a way that the upper bound is the same over time. The asymptotic property makes these kinds of restrictions unnecessary. A trade dependence index having these four properties thus associates a unique degree of trade dependence, a, with a unique value of the index, c, for each point on the continuum.

The Traditional Trade Dependence Index, D

The traditional trade dependence index, D, is defined as:

$$D = \frac{exports + imports}{GDP} \qquad (1)$$

$$where\ GDP = C + I + G + X - M$$

The denominator shows a trade balance, (X-M), but not trade itself. Rewriting the denominator makes trade explicit. From the components of gross domestic product, define E as the value of goods and services (net of imports) produced at home for domestic consumption:

$$E = C + I + G - M_{(C,I,G)} \qquad (2)$$

$$where\ M_{C,I,G} = imports\ used\ in\ producing\ C,\ I,\ and\ G.$$

The net value of exports, X_d, is total exports less M_x or imports used in their production, that is:

$$X_d = X - M_x. \qquad (3)$$

GDP is now expressed as:

$$GDP = E + X_d \qquad (4)$$

Adding and subtracting total imports, M, to equation 4 (with some manipulation) gives:

$$
\begin{aligned}
GDP &= E + X_d + M - M \\
GDP &= E - M + (X_d + M), \\
\text{Let net trade } (Tr) &= X_d + M, \\
\text{then, } GDP &= E - M + Tr.
\end{aligned}
\tag{5}
$$

With the numerator as net trade (Tr), D is reformulated as:

$$D = \frac{Tr}{(E-M) + Tr}. \tag{6}$$

If <u>autarky</u> exists, Tr = 0, and D = 0. The D index is bounded by zero, and a one-to-one correspondence exists between the index value and autarky.

For an open economy, however, Tr > 0, and D fails to satisfy the mathematical properties required of the index. To show this, I determine the sign of D's first partial derivative with respect to trade. This derivative is equivalent to increasing the country's trade dependence since all other components of GDP are held constant.

$$\frac{\partial D}{\partial Tr} = \frac{E - M}{((E - M) + Tr)^2} \tag{7}$$

D is strictly monotonically increasing if for all levels of trade, E - M > 0. This result is not always the case, however, as E - M may be greater than, equal to, or less than zero. These possibilities are demonstrated by the production possibilities frontier and trade triangles in figures 1 and 2 where:

p_i = the world trade price ratio, i = 1, 2,
$p_i = p_{zi}/p_{yi}$,
GDP = $P_{yi}Y_i^* + P_{zi}Z_i^*$; (* denotes equilibrium production),
exports = $(Z_i^* - Z_{ij})$,
$P_{z1}(Z_i^* - Z_{ij})$ = value of exports,
imports = $(Y_{ij} - Y_i^*)$,
$P_{yi}(Y_{ij} - Y_i^*)$ = value of imports,
Tr = exports + imports = total value of trade:
$Tr = P_{zi}(Z_i^* - Z_{ij}) + P_{yi}(Y_{ij} - Y_i^*)$.

In this framework, the general formula for D is

$$D = \frac{P_{zi}(Z_i^* - Z_{ij}) + P_{yi}(Y_{ij} - Y_i^*)}{P_{yi}Y_i^* + P_{zi}Z_i^*}. \tag{8}$$

A one-to-one correspondence between increases (decreases) in trade and increases (decreases) in D may not exist. The resulting ambiguity can occur whether comparisons are made between two countries at the same relative prices or across time at different relative prices.

In figure 1, assume that two countries are identical in their technology and resource endowment, face the same world prices, but have different revealed preferences U_1 and U_2 for goods Y and Z. Since the trade triangle B'BA > C'CA at world prices p_1, total trade at U_2 is larger than at U_1. Thus:

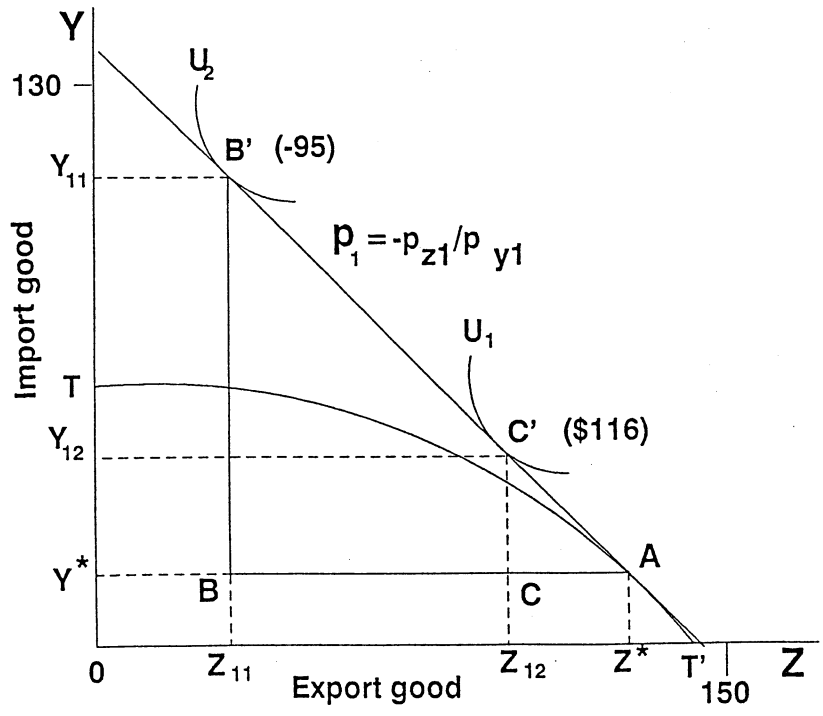
$$M = P_{y1}(Y_i - Y_i^*); \; E = P_{y1}Y_i^* + P_{z1}Z_i$$

$$E - M = P_{y1}(2Y_i^* - Y_i) + P_zZ_i \qquad (9)$$

$$for \; i = 1,2.$$

The signs of E - M differ at preferences U_1 and U_2. At U_1 with equilibrium consumption C', E - M is \$116, but is -\$95 at U_2 with equilibrium consumption B'.[4] Consequently, if both countries increase trade, D will decline for the one with greater trade, but increase for the other (equation 6). Since E - M is continuous and has positive and negative values, it also contains a zero value between equilibriums B' and C'. At this value, D will not change despite an increase (decrease) in trade.

Figure 1
The value of E-M for U_1 and U_2

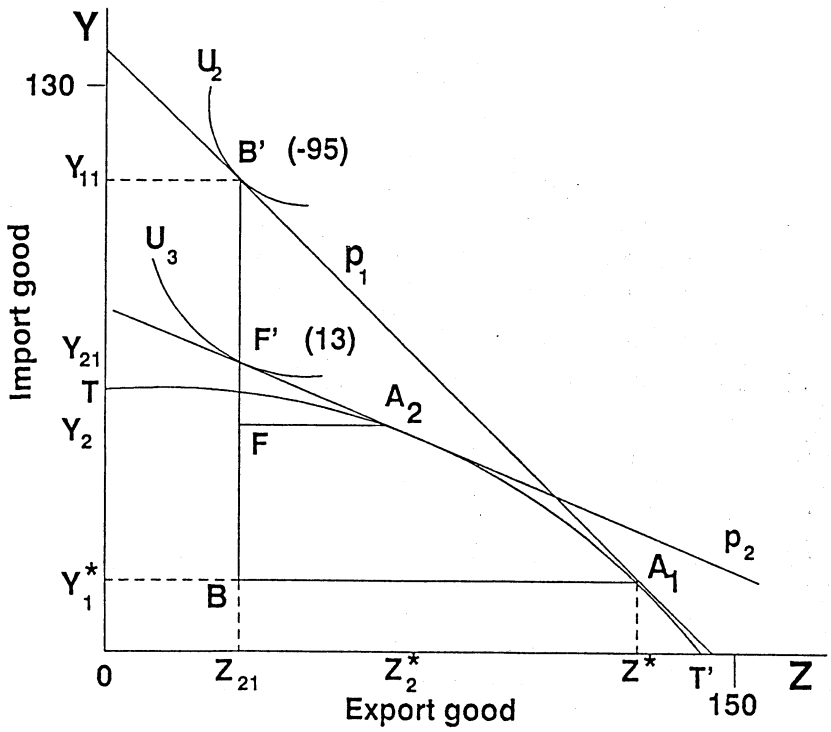


[4]These calculations were made using the scale of Freelance software program.

The ambiguity of D is further demonstrated when, for a single country, changes in relative prices increase (decrease) trade (fig. 2). At world prices p_2, the initial amount of trade is represented by triangle $F'FA_2$. With preferences, U_3, and equilibrium consumption, F', E - M > 0. If the relative price for good Z rises to p_1, with the same preferences, U_2, as in figure 1, the trade triangle $B'BA_1$ shows that trade increases substantially. At U_2 in both figures 1 and 2, E - M < 0. Consequently, an increase in trade, at equilibrium B', would cause D to <u>decline</u>, not increase. On the other hand, at the lower relative price for Z, an expansion of trade would cause the opposite effect on D; that is, D would <u>increase</u>. This contrary movement in D will not occur only when consumer preferences are far enough to the "right" of B' so that E - M > 0.

The first derivative of D with respect to trade cannot be signed, because $E - M \gtreqless 0$. Thus, D does not meet the third criterion of a strictly monotonically increasing function for all values of trade whether one observes the same or different relative prices.

Figure 2
Comparing the value of E-M for two relative prices, p_1 and p_2



D also fails to satisfy this criterion because two values of D may exist for the same degree of dependence. This failure occurs for intermediate and perfect trade dependence, and is due to the fact that D is not invariant to the sign of the trade balance.[5] Is it positive, negative, or zero? This sign problem becomes transparent when we make the trade balance explicit in the denominator.

Intermediate dependence. To show the impact of the different signs on D, manipulate the denominator of equation 4 as follows:

$$E - M + Tr = E - M + X_d + M = E + M + TB. \qquad (10)$$

After substituting ((E + M) + TB) for ((E - M) + Tr), D becomes an explicit function of the trade balance:

$$D = \frac{Tr}{((E + M) + TB)}. \qquad (11)$$

The partial derivative of D with respect to TB is

$$\frac{\partial D}{\partial TB} = \frac{-Tr}{((E + M) + TB)^2} < 0 . \qquad (12)$$

D, thus, varies inversely with the trade balance. In other words, if TB increases (decreases), D declines (increases) while total trade and the value of goods produced for domestic consumption remain unchanged. Hence, calculating D for comparisons across countries or over time depends upon trade balances as well as trade dependence and invalidates the comparisons. For example, assume that two countries have identical initial conditions for trade and GDP. Further assume that one country's trade balance increases while that of the other decreases. D index values for these countries will show opposing movements, implying opposing changes in trade dependence when no change took place. Consequently, when considering the trade balance for the intermediate case, criterion 3 for D is ruled out.

Perfect dependence. Since perfect dependence occurs when all domestic production goes to the export market, E = 0, equation 6 can be expressed as:

$$D = \frac{X_d + M}{X_d} = 1 + \frac{M}{X_d}. \qquad (13)$$

When trade is balanced, TB = 0, and D = 2. When trade is unbalanced, TB $\neq$ 0, and 1 < D < N, where N > 0.

Rankings among perfectly dependent countries according to observed values of D may thus provide conflicting indications of

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[5]An autarkic economy is not discussed because there is no trade.

trade dependence. For example, it would appear that country A with $1 < D < 2$ should be ranked as less dependent on foreign trade than country B with $D > 2$. However, this distinction would be misleading for both countries. D only has to be greater than one to denote perfect dependence. Since both countries have index values greater than one, they should have the same ranking regardless of their particular index value. Consequently, in both cases of unbalanced trade, the ambiguity of D, a very common occurrence, provides further evidence that this index can give mixed signals. Or according to the mathematical criterion, the strict, monotonic, and increasing property may not exist.

A further problem arises because the range of D ($1 < D < N$) overlaps that for intermediate trade dependence. From equation 6, write D as:

$$D = \frac{1}{\left(\frac{E - M}{TR}\right) + 1} \tag{14}$$

Since E - M can be less than zero, D can exceed 1 thus causing the intermediate and perfect dependence ranges to overlap.

The Export Dependence Index, D_x

The second trade dependence index is defined as the ratio of exports to GDP:

$$D_x = \frac{X_d}{C + I + G + X - M}. \tag{15}$$

From equation 4, rewrite D_x as:[6]

$$D_x = \frac{X_d}{E + X_d}. \tag{16}$$

The mathematical properties of D_x satisfy the criteria presented at the beginning of this paper. As shown below, D_x is closed and bounded, strictly monotonically increasing, and asymptotic. Autarky obviously yields an index value of zero. For perfect dependence we have:

$$\lim_{E \to 0} D_x = \lim_{E \to 0} \left(\frac{X_d}{E + X_d}\right) = 1. \tag{17}$$

For the intermediate cases, the first derivative of D_x with respect to exports is strictly positive:

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[6]E has been previously defined as the value of domestic production consumed within the country.

$$\frac{\partial D_x}{\partial X_d} = \frac{E}{(E + X_d)^2} > 0, \text{ since } E > 0. \quad (18)$$

However, unbalanced trade, which causes potential ambiguity for D, also causes potential ambiguity for D_x. Since X = TB + M, rewrite equation 17 as:

$$D_x = \frac{X_d}{E' + TB}. \quad (19)$$

The derivative of D_x with respect to TB is:

$$\frac{\partial D_x}{\partial TB} = \frac{-X_d}{(E' + TB)^2} < 0. \quad (20)$$

Like D, D_x will increase (decrease) if the trade balance increases (decreases). Two countries with the same net domestic production and exports but with different trade balances yield different degrees of export dependence.

Neither the traditional trade nor export dependence indexes completely satisfy the mathematical properties at all levels of trade or for different trade balances. The problem lies in the denominator of D and D_x, which is gross domestic product. Using the expression for the denominator in D_x, D can be written as:

$$D = \frac{X_d + M}{E + X_d}. \quad (21)$$

Since, in this form, the numerator is not a subset of the denominator, how then can one state that trade represents an economy's degree of dependence on international markets?

Trade Dependence Index, TDI

An alternative measure is needed to ensure that, for any country, an increase (decrease) in the value of the trade dependence index denotes an unambiguous increase (decrease) in its reliance on trade:

$$TDI = \frac{X_d + M}{C + I + G + X}. \quad (22)$$

The denominator is the final value of the goods and services produced by the economy. This value includes imports used for producing domestic products.

To make explicit the domestic and trade sectors of the economy, rewrite TDI as:

$$TDI = \frac{X_d + M}{C_d + I_d + G_d + X_d + M}. \tag{23}$$

Substitution of E for $C_d + I_d + G_d$ yields a formula similar to equation 16, which described the index D_x:

$$TDI = \frac{X_d + M}{E + X_d + M}. \tag{24}$$

Further substitution of $Tr = X_d + M$ in the numerator and denominator gives:

$$TDI = \frac{Tr}{E + Tr}. \tag{25}$$

Since the numerator is a subset of the denominator, TDI represents a country's trade dependence. TDI eliminates problems associated with D and D_x because it meets the following four mathematical criteria: continuous, closed and bounded, asymptotic, and strictly monotonically increasing with respect to trade.

It is continuous in the closed and bounded interval [0,1], which contains the range of trade dependence from autarky to perfect dependence. It is continuous since both E and Tr are positive and not simultaneously zero. It is closed and bounded because it contains the boundary points zero and one. It is strictly monotonically increasing, as confirmed from the first partial derivative of TDI with respect to trade (equation 26). It is strictly positive for all trade and the trade balance is not relevant.

$$\frac{\partial TDI}{\partial Tr} = \frac{E}{(E + Tr)^2} > 0, \text{ for } E > 0. \tag{26}$$

TDI is asymptotic to the upper bound since, in the limit, as either trade increases or domestic production for home consumption decreases, the index value approaches one:

$$\lim_{Tr \to 0} TDI = \lim_{Tr \to 0} \left(\frac{Tr}{E + Tr} \right) = 1$$

$$\lim_{E \to 0} TDI = \lim_{E \to 0} \left(\frac{Tr}{E + Tr} \right) = 1. \tag{27}$$

The new trade dependence index, TDI, is concave with respect to trade; that is, it is increasing at a decreasing rate (equations 25, 27, fig. 3).

$$\frac{\partial^2 TDI}{\partial Tr^2} = - \frac{2E}{(E + Tr)^3} < 0, \text{ for } E > 0. \quad (28)$$

The boundary index values for the two extreme cases are:

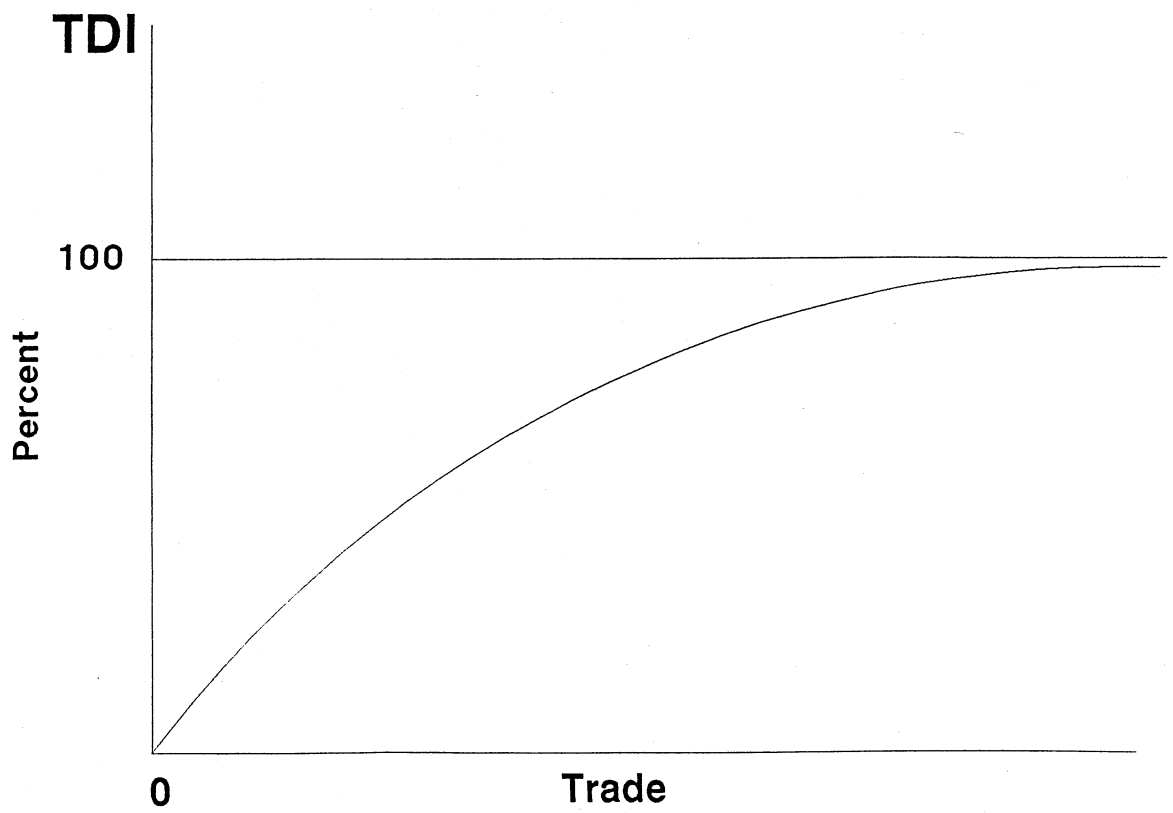
Autarky (Tr = 0)

$$TDI\Big|_{Tr=0} = \frac{0}{E} = 0. \quad (29)$$

Perfect dependence (E = 0)

$$TDI\Big|_{E=0} = \frac{Tr}{Tr} = 1 \quad (30)$$

Figure 3
TDI and trade



Comparing D and TDI for Selected Countries and Years

The mathematical characteristics of two trade dependence measures--trade/GDP and exports/GDP--have shown how those measures are limited in describing the degree to which an economy relies on international trade. The new measure, TDI, permits theoretically unambiguous comparisons of the degree of dependence.

D and TDI index values are empirically compared and ranked for selected countries by numerical order for 1965, 1975, and 1985 (appendix). The Spearman rank correlation coefficients for the three years were 0.986, 0.990, and 0.994, respectively. Such close correlations, however, mask an important result: apart from autarky, values calculated from these two indexes cannot be compared in a meaningful way.[7]

In 1965, two-thirds of the rankings by the TDI index differed from the D index, with differences ranging from 1-36 places. Similarly, in both 1975 and 1985, three-fourths of the rankings differed, the greatest being 21 places.

Contradictory movements in the two indexes occurred between 1965 and 1985. In 1965, the D value of 113.0 for Guyana corresponded to the TDI value of 71.7. By 1985, the TDI value for Guyana had fallen slightly to 71.3, whereas D had risen significantly to 116.3. Kuwait became more dependent on trade from 1965-75, by both indexes, but the indexes diverged in the next decade, 1975-85. TDI showed Kuwait's trade dependence to have declined about 15 percent, but D showed it to have risen slightly.

Policy analysts who make cross-country comparisons of openness by D will find two problems. First, D will vary if a country's trade balance changes. This causes an opposing change in the trade balance of at least one other country. Even if the trade balances of all other countries remain constant, the initial change in the trade balance between two countries affects the rankings of all trading countries. Assume that country A's trade balance increases while its total trade is constant and that all but one other country's trade balances are the same. A's trade dependence index value (D) declines, and its rank moves in the same direction. In country B, however, where the trade balance declines, the higher D value will raise its ranking. The relative change in positions occurs even though total trade for each is constant. Consequently, comparisons of D across countries may not show changes in trade dependence, but rather changes in trade balances, and it would be incorrect to say that country A is reducing its dependence on trade while country B's dependence is increasing.

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[7]Kuznets (1964) takes the opposite view. He stated that ". . .the simple relation between the ratios based on the two denominators, permits an easy shift from one to the other" (p. 7).

Second, the lack of a common and constant upper bound for D also makes cross-country comparisons dubious. If, for a given year, the upper bound is 160 for country A and 130 for country B, a 75-percent index value for both countries suggests that they have the same degree of trade dependence. However, an index value of 75 does not mean the same thing for both countries. For country A, its relative trade dependence is 75/160, while that for country B is 75/130.

The lack of a consistent and common upper bound for each country also makes it impossible to compare a country's own position over time, a fundamental flaw of D as an index. For example, if country A has an upper bound of 160 in 1970, but 130 in 1971, no meaningful statement can be made as to an increase or decrease in its trade dependence between the two periods.

This second problem can cause analysts to give more (less) praise to their country's efforts to liberalize its economy than is warranted by TDI (app. table 2). West Germany, for example, ranked 34th by the D index and 35th by TDI in 1965, suggesting that it was lagging other countries in liberalizing its trade. By 1975, West Germany's D and TDI index values had risen one-third and one-fourth, respectively. However, by D rankings, West Germany fell to 33 while its TDI ranking rose to 38th place. Analysts' doubts about Germany's liberalization would be reinforced by the D index, but allayed by the TDI index. The decrease in the D ranking implies that the upper bounds for D in other countries were increasing relative to that for West Germany, whose actual trade dependence (according to TDI, with a common and constant upper bound) showed an increase.

The difficulty in making accurate policy interpretations from D is also evident when comparing growth rates in the values of the two indexes for 1975-85 (app. table 3). In 1985, West Germany's analysts could point to a 75-percent increase in D's value as an indication of trade-liberalizing policies. The 60-percent increase in TDI's value, while also high, does not support as high a degree of enthusiasm for West Germany's policies. Indeed, West Germany's D index value, with no upper bound, could double or triple its 1985 value of 66 and support any contention that it is liberalizing.

Yet with TDI, perfect dependence would exist at 100 percent and a 66 index value would indicate West Germany was nearly two-thirds of the way toward its maximum trade dependence. The maximum growth would be 50 percent rather than a deceptive 200 or 300 percent. Between 1965 and 1985, West Germany increased its TDI 10 percentage points per decade, showing a consistent rise in trade orientation.

From 1965-85, Luxembourg showed an extremely high divergence in D and TDI growth rates. D's growth rate was 25 times that of TDI. This difference again reveals the importance of the upper bounds

of TDI compared with some positive number N in D.[8] The variability in the upper bound for D that prevents analysts from making cross-country comparisons within D also makes comparisons between D and TDI untenable.[9]

Conclusions

Trade dependence has been applied in a wide variety of studies on economic growth, cross-country price levels, trade restrictions, real exchange rate, trade regimes, and the prices of traded goods. As the number of studies has grown, so has the variety of defining concepts: trade ratio, trade liberalization, openness, and trade restrictions. Confusion has resulted from using only two indexes--trade/GDP and exports/GDP--to measure these concepts. For example, a single index is applied to several concepts and more than one index is used to measure the same concept. The essential element in all these concepts is a country's reliance on trade, or trade dependence (0-100 percent), suggesting the necessity of only one index. What then are the properties of an index that represents trade dependence and how do the properties of the commonly used measures stand up to analysis?

Trade/GDP and exports/GDP were analyzed for their ability to uniquely define trade dependence and relate specific values to a country's position along the autarky/perfect dependence continuum. I concluded that they were misleading and non-comparable over time and across countries.

A new measure of trade dependence (TDI) was developed to overcome these problems and enable quantitative comparisons across countries and time. The new TDI index has desirable properties--strictly monotonically increasing with upper and lower bounds--that the other measures lack. The responsiveness of TDI to government policies is a subject for future research.

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[8]The upper limit for TDI is always 100. The upper limit for D, however, ranged from 179.5 to 188.5 for the years 1965, 1975, and 1985. For the entire period 1960-88, the largest upper limit among the total trade dependence indexes was 210 for Antigua and Barbuda.

[9]The consequence of using the conventional index in regressions is due to its error in measuring trade dependence. Such an error results in an inconsistent least squares estimator and the coefficient is asymptotically biased toward zero (Kementa, 2nd ed., pp 346-352).

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Appendix: Applications of D

Kuznets (1964, section II) used trade/GDP to determine if there was an association between this ratio and several measures of country size. He found no relationship between the ratio and per capita income, but he found significant and inverse relationships with population and gross domestic product.

Kravis and Lipsey (1987) assert a positive relationship between openness and trade and cross-country divergences in price levels. They regressed the price level for a group of countries on per capita income, openness, and the share of nontradables in GDP. In most cases, they found the association to be positive and significant.

Cottani and others (1990, pp. 66-67) regressed the real exchange rate on the international terms of trade, the inverse of the trade dependence index (GDP/trade), net capital inflows as a proportion of GDP, domestic credit creation in excess of devaluation, foreign inflation, real GDP growth, and time. They used GDP/trade as an indicator of such trade policy restrictions as tariffs and quotas. An inverse relationship between openness and the real exchange rate was expected since, they reasoned, import quotas reduce openness and lead to a higher real exchange rate. The coefficient of openness had the expected sign, but significant levels were not reported for any variables.

Export and import shares for TDI. One of the components of D, D_x, has been used in empirical work by Leamer (1987) and Wood (1991). A similar relationship between TDI and its components is addressed here. I distinguish between import and export dependence simply by separating TDI into its two components:

r_x = dependence attributable to the export sector,

r_m = dependence attributable to the import sector.

Then,

$$r_x = \frac{X_d}{E + Tr}$$
$$r_m = \frac{M}{E + Tr}. \qquad (31)$$

TDI is the sum of the export and import shares:

$$TDI = r_x + r_m. \qquad (32)$$

If r_x is high relative to r_m, the primary source of this country's trade dependence is exports. Assume, for example, that for a highly trade-dependent economy, TDI[10] is 80 percent. We interpret an r_x of, say, 60 percent, to mean that 60 percent of

[10]All values of TDI are expressed as percents.

the value of goods and services produced derives from export demand. The import sector contributed 20 percent to this value.

We can assess the relative strength of import and export dependence by measuring their shares. Let w_i be the share of the ith sector in promoting dependence of the economy: (i = x (exports) or m (imports), equation 31).

$$w_x = \frac{r_x}{TDI}$$

$$w_m = \frac{r_m}{TDI} \qquad (33)$$

$$w_x + w_m = 1.$$

Using our hypothetical example, w_x is 60/80 or 75 percent, and w_m is 20/80 or 25 percent. Exports contribute three-fourths and imports, one-fourth, of the country's dependence on international markets.

Table 1--Trade dependence index values, 1965, 1975, and 1985

Country	1965 index values		1975 index values		1985 index values	
	TDI[1]	D[2]	TDI[1]	D[2]	TDI[1]	D[2]
Algeria	36.9	45.4	55.4	81.5	37.1	44.8
Australia	27.2	32.0	25.5	29.1	29.9	35.7
Austria	40.4	50.8	48.1	63.1	57.7	80.9
Benin	30.1	37.4	51.1	76.3	37.5	47.2
Bolivia	33.3	40.0	36.5	46.0	31.7	37.4
Botswana	54.7	82.3	66.9	113.3	74.0	118.5
Brazil	11.9	12.5	16.9	18.8	17.7	18.9
Burkina Faso	25.6	30.7	37.2	51.4	43.7	64.4
Cameroon	37.0	45.2	41.5	53.1	33.5	39.8
Canada	31.5	37.5	37.7	46.8	42.9	54
Colombia	19.8	21.8	26.2	29.8	23.4	26.3
Congo	66.6	97.1	62.1	102.9	70.3	102.0
Costa Rica	42.1	56.1	49.8	69.1	47.7	63.2
Ivory Coast (Cote d'Ivoire)	45.9	58.9	55.3	76.8	59.2	78.4
Cyprus	53.3	74.7	58.8	92.2	67.8	107.7
Denmark	47.6	62.8	46.6	61.1	53.3	72.5
Dominican Rep	27.8	32.6	43.8	56.1	18.7	20.8
Ecuador	29.0	34.4	44.4	58.9	39.4	47.6
Egypt	32.8	39.7	40.0	54.7	37.5	48.5
El Salvador	43.1	55.5	51.6	71.3	40.2	52.2
Ethiopia	22.8	26.0	24.6	28.6	27.9	34.2
Fiji	60.0	88.4	60.3	86.6	61.7	89.4
Finland	34.6	42.2	41.2	53.4	44.7	57.3
France	17.2	18.1	30.9	36.4	38.3	47.2
Gabon	66.5	95.5	47.9	6236	62.1	76.6
Germany	31.9	37.9	40.4	49.9	50.4	65.9
Ghana	34.6	43.9	31.9	37.8	19.1	21.3
Greece	24.3	29.3	34.5	43.7	40.6	54.0
Guatemala	30.5	36.4	36.6	45.3	32.1	38.6
Guyana	71.7	113.0	85.6	149.8	71.3	116.3
Haiti	25.8	30.3	41.6	54.8	42.7	57.3
Honduras	43.0	54.4	50.0	69.8	42.6	55.5
Iceland	54.9	74.9	56.0	81.0	58.8	83.0
India	9.4	9.9	13.1	14.1	13.0	14.1

-- = Not available.

Continued--

See footnotes at end of table.

Table 1--Trade dependence index values, 1965, 1975, and 1985--Continued

Country	1965 index values		1975 index values		1985 index values	
	TDI[1]	D[2]	TDI[1]	D[2]	TDI[1]	D[2]
Iran	26.5	30.4	55.3	73.1	15.9	17.4
Ireland	54.7	78.7	61.5	91.5	75.4	119.9
Italy	23.8	26.9	35.3	43.2	35.3	43.3
Jamaica	59.2	86.2	55.5	80.9	75.4	127.3
Japan	18.8	20.6	24.1	27.4	25.9	29.2
Jordan	39.8	54.9	68.5	134.6	73.1	139.9
Kenya	49.5	65.4	48.0	64.6	41.7	53.0
Korea, Rep	21.2	24.6	47.2	64.4	53.0	71.8
Kuwait	74.4	90.9	84.5	106.5	72.3	108.0
Lesotho	44.9	68.9	62.3	140.9	62.9	147.9
Liberia	71.7	105.6	79.0	127.2	57.5	75.0
Libya	64.9	86.1	68.3	98.4	--	--
Madagascar	30.1	36.5	33.9	41.7	--	--
Malawi	37.5	48.9	51.7	75.8	41.4	53.7
Malaysia	63.4	90.8	62.9	92.6	69.8	104.6
Malta	73.0	124.9	91.2	179.1	85.4	160.9
Mauritius	63.6	93.6	74.9	119.0	70.1	108.9
Mexico	17.9	19.7	15.1	16.5	23.3	25.7
Morocco	32.5	38.3	42.1	55.9	38.6	51.4
Myanmar	27.3	32.2	10.6	11.2	12.1	13.1
Netherlands	62.7	91.6	65.8	96.4	77.0	122.2
New Zealand	37.0	46.0	48.4	52.2	48.6	64.9
Niger	26.2	30.2	42.8	57.1	--	--
Nigeria	30.5	36.4	38.5	47.3	21.6	23.3
Norway	58.1	82.3	60.8	90.3	61.9	86.0
Pakistan	18.6	20.8	26.8	32.4	26.6	32.5
Panama	54.0	74.8	65.7	101.3	52.1	70.3
Papua New Guinea	39.7	53.7	61.3	91.0	63.7	98.3
Paraguay	26.5	30.7	29.4	35.3	42.9	55.9
Peru	31.2	37.2	29.2	36.0	37.4	44.5
Philippines	29.4	34.4	35.0	43.9	32.6	38.4
Portugal	40.7	52.5	40.0	53.2	55.4	77.9
Saudi Arabia	66.7	79.2	84.9	101.5	60.5	90.0
Sierra Leone	47.2	62.6	46.6	63.9	--	--
South Africa	41.6	52.6	43.6	56.5	46.1	56.9

-- = Not available.

Continued--

See footnotes at end of table.

Table 1--Trade dependence index values, 1965, 1975, and 1985

Country	1965 index values		1975 index values		1985 index values	
	TDI[1]	D[2]	TDI[1]	D[2]	TDI[1]	D[2]
Sri Lanka	41.0	51.4	46.3	62.4	46.4	64.0
Sudan	33.1	40.6	23.1	27.0	--	--
Sweden	36.6	45.0	44.0	56.5	51.3	68.2
Switzerland	45.0	58.3	46.6	59.9	56.1	77.7
Syria	32.1	38.3	41.3	55.4	29.8	37.2
Tanzania	40.9	51.2	37.5	49.2	19.3	22.3
Thailand	31.6	37.8	34.7	42.9	40.3	51.2
Togo	37.9	48.2	50.2	72.7	67.0	144.9
Trinidad & Tobago	79.1	133.9	65.2	88.2	47.5	61.0
Tunisia	38.4	50.7	49.5	67.4	51.4	71.3
Turkey	11.6	12.4	18.0	20.6	--	--
United Kingdom	31.8	38.0	41.5	52.9	44.6	57.1
United States	9.1	9.5	15.0	16.1	15.6	17.1
Uruguay	27.6	30.8	30.0	35.9	36.7	44.0
Venezuela	42.8	51.8	46.7	58.5	35.8	41.5
Yugoslavia	36.9	45.1	39.0	50.5	--	--
Zaire	81.3	130.3	47.1	65.2	82.7	133.2
Zambia	65.3	89.4	59.1	92.1	55.7	77.0
Zimbabwe	50.7	69.5	46.1	60.2	42.8	54.1

1/

$$D = \frac{exports + imports}{GDP}$$

2/

$$TDI = \frac{Tr}{E + Tr}$$

Table 2--Trade dependence indexes by rank, 1965, 1975, and 1985

Country	1965 ranking		1975 ranking		1985 ranking	
	TDI[1]	D[2]	TDI[1]	D[2]	TDI[1]	D[2]
United States	1	1	3	3	3	3
India	2	2	2	2	2	2
Indonesia	3	3	27	27	28	28
Turkey	4	4	6	6	--	--
Brazil	5	5	5	5	5	5
Spain	6	7	13	14	30	31
France	7	6	20	19	--	--
Mexico	8	8	4	4	11	10
Pakistan	9	10	15	15	15	15
Japan	10	9	10	10	14	14
Colombia	11	11	14	13	12	12
Korea	12	12	59	59	62	61
Ethiopia	13	13	11	11	17	16
Italy	14	14	26	24	26	27
Greece	15	15	23	25	40	42
Burkina Faso	16	19	30	35	48	55
Haiti	17	17	44	43	44	50
Niger	18	16	46	49	--	--
Paraguay	19	20	17	16	46	47
Iran	20	18	73	69	4	4
Australia	21	22	12	12	19	19
Myanmar	22	23	1	1	1	1
Uruguay	23	21	18	17	29	29
Dominican Republic	24	24	48	46	6	6
Ecuador	25	25	50	51	37	35
Philippines	26	26	25	26	24	23
Madagascar	27	29	22	21	--	--
Benin	28	31	68	71	33	34
Guatemala	29	28	29	28	23	24
Nigeria	30	27	33	31	9	9
Peru	31	30	16	18	32	30
Canada	32	32	32	30	--	--
Thailand	33	33	24	23	39	37
United Kingdom	34	35	43	38	50	49
Germany	35	34	38	33	57	57
Syria	36	36	40	44	18	21

-- = Not available.

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See footnotes at end of table.

Table 2--Trade dependence indexes by rank, 1965, 1975, and 1985, Continued

Country	1965 ranking		1975 ranking		1985 ranking	
	TDI[1]	D[2]	TDI[1]	D[2]	TDI[1]	D[2]
Morocco	37	37	45	45	36	38
Egypt	38	38	35	42	34	36
Sudan	39	40	9	8	--	--
Bolivia	40	39	28	29	22	22
Finland	41	41	39	41	51	51
Ghana	42	42	21	20	7	7
Sweden	43	43	49	48	58	58
Yugoslavia	44	44	34	34	--	--
Algeria	45	46	74	76	31	32
Cameroon	46	45	42	39	25	25
New Zealand	47	47	37	36	56	56
Malawi	48	49	70	70	41	41
Togo	49	48	67	68	81	83
Tunisia	50	50	64	63	59	60
Papua New Guinea	51	57	81	80	79	79
Jordan	52	59	94	104	91	95
Austria	53	51	63	57	69	72
Portugal	54	55	36	40	65	69
Tanzania	55	52	31	32	8	8
Sri Lanka	56	53	52	55	53	54
South Africa	57	56	47	47	52	48
Costa Rica	58	61	65	65	55	53
Venezuela	59	54	56	50	27	26
Honduras	60	58	66	66	43	46
El Salvador	61	60	69	67	38	39
Lesotho	62	68	85	105	78	98
Switzerland	63	62	53	52	67	68
Ivory Coast (Cote d'Ivoire)	64	63	72	72	72	70
Nicaragua	65	64	62	62	20	20
Sierra Leone	66	65	55	58	--	--
Denmark	67	66	54	54	63	62
Kenya	68	67	61	60	42	40
Zimbabwe	69	69	51	53	45	44
Cyprus	70	70	77	83	82	84
Panama	71	71	90	88	61	59

-- = Not available.

Continued-

See footnotes at end of table.

Table 2--Trade dependence indexes by rank, 1965, 1975, and 1985--Continued

Country	1965 ranking		1975 ranking		1985 ranking	
	TDI[1]	D[2]	TDI[1]	D[2]	TDI[1]	D[2]
Botswana	72	76	92	94	92	89
Ireland	73	73	82	81	94	90
Iceland	74	72	76	75	71	74
Norway	75	75	80	79	76	75
Jamaica	76	78	75	74	93	93
Fiji	77	79	79	77	75	76
Netherlands	78	83	91	85	95	92
Malaysia	79	81	87	84	85	82
Mauritius	80	84	97	97	86	86
Libya	81	77	93	86	--	--
Zambia	82	80	78	82	66	67
Gabon	83	85	60	56	77	66
Congo	84	86	84	90	87	80
Saudi Arabia	85	74	105	89	73	77
Guyana	86	88	106	106	88	88
Liberia	87	87	101	100	68	64
Malta	88	89	109	109	101	100
Kuwait	89	82	104	93	90	85
Trinidad And Tobago	90	91	89	78	--	--
Zaire	91	90	57	61	98	98

Spearman rank correlation coefficient between TDI and trade/GDP (all observations)	1965	1975	1985
	0.986	0.990	0.994

1/

$$D = \frac{exports + imports}{GDP}$$

2/

$$TDI = \frac{Tr}{E + Tr}$$

Table 3--Total trade dependence indexes for selected countries and years

Country	Total trade indexes for selected countries 1965, 1975, 1985						Percent increase 1965-85	
	1965		1975		1985			
	TDI[1]	D[2]	TDI	D	TDI	D	TDI	D
Australia	26.9	31.5	25.3	28.8	30.1	35.9	11.9	14.0
Belgium	53.3	72.6	63.0	91.9	83.3	141.2	56.3	94.5
Canada	31.5	37.5	37.7	46.8	42.9	54.0	36.2	44.0
Denmark	47.6	62.8	46.6	61.1	53.6	73.0	12.6	16.2
Finland	34.6	42.2	41.2	53.4	44.6	57.2	28.9	35.6
France	21.8	24.3	30.9	36.4	38.3	47.2	75.7	94.2
Germany	31.9	37.9	40.4	49.9	50.7	66.4	58.9	75.2
Italy	25.3	28.8	32.5	39.1	35.4	43.5	39.9	51.0
Japan	18.8	20.6	24.1	27.4	25.9	29.2	37.8	41.8
Luxembourg	87.8	54.1	93.3	120.9	93.3	140.7	6.3	160.1
Netherlands	62.7	91.6	65.8	96.4	77.0	122.2	22.8	33.4
New Zealand	37.0	46.0	40.4	52.2	49.7	67.4	34.3	46.5
Norway	58.1	82.3	60.8	90.3	61.9	86.0	6.5	4.5
Portugal	40.7	52.5	40.0	53.2	55.4	77.9	36.1	48.4
Spain	16.9	19.2	26.1	30.5	36.0	43.5	113.0	126.6
Sweden	36.6	45.0	44.0	56.5	51.7	69.0	41.3	53.3
Switzerland	45.0	58.3	46.6	59.9	56.0	77.7	24.4	33.3
United Kingdom	31.7	37.8	41.2	52.3	44.4	56.8	40.1	50.3
Unites States	9.1	9.5	15.0	16.1	15.6	17.1	71.4	80.0

[1]Trade dependence index
[2]Traditional index

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