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ABSTRACT

This paper empirically investigates the role of established country-to-country trade networks as an important consideration in exploring evidence for the income convergence across countries. Using the β-convergence criterion we demonstrate that within trading networks, poorer economies grow faster than richer ones so that they converge in per capita income. To validate this result we estimate Monte Carlo models that simulate the characterization on β-convergence in randomly created trading networks of 8 to 23 member countries. We find that it is less likely to find income convergence in our randomly created trading networks than in the trading networks that are formed as part of existing trade relationships. This result reaffirms the argument that countries who have established trade relationships within a trade network are more likely to experience income convergence.

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Abstract

This paper empirically investigates the role of established country-to-country trade networks as an important consideration in exploring evidence for income convergence across countries. Using the β-convergence criterion we demonstrate that within trading networks, poorer economies grow faster than richer ones so that they converge in per capita income. To validate this result we estimate Monte Carlo models that simulate the characterization of β-convergence in randomly created trading networks of 8 to 23 member countries. We find that it is less likely to find income convergence in our randomly created trading networks than in the trading networks that are formed as part of existing trade relationships. This result reaffirms the argument that countries who have established trade relationships within a trade network are more likely to experience income convergence.

I. Introduction

Critics of globalization and the implied expanding network of trade relationships claim that trade is an exploitive mechanism that concentrates wealth and income and leads to increasing disparity in the wellbeing of rich and poor countries. In a closed economy context, economists have argued that the stock of physical capital, human capital, technology, and infrastructure represent the primary determinants of the level of per capita output and thus, per capita income. In an open economy context, once countries are allowed to trade, pursuit of comparative advantage allows a country to move beyond the constraints imposed by the in-country resource endowment and the country can increase productive capacity and per capita income. According to past studies (Grossman and Helpman, 1991), trade can affect long-run growth through different channels. First, commodity exchange facilitates the transmission of new technology and technical information. Second, international competition provides incentives for firms in each country to adopt new ideas and innovations. Third, the size of the market that each country faces is enlarged by global integration. Van den Berg, (2001) also demonstrates that the introduction of learning-by-doing, human capital accumulation, and research and development (R&D) in an open country trade model may induce permanent economic growth.

However, because of power asymmetries that govern most trade relationships, the gains from trade may be allocated across the trading network in such a way that some members of the trading network may be relatively disadvantaged in comparison to the relative advantage captured by others in the trading network. It is in this context that this research proposes to add to the literature—by exploring whether countries who trade within established trade networks experience increased capacity for income convergence, or if countries within the network experience an increasing gap between rich and poor countries. In other words, can the existing differences in technology, knowledge, and infrastructure for countries within a trading network be reduced through trade, and, hence, will there be convergence of per capita income within the trade network?

II. Methodological Framework

Barro and Sala-i-Martin (1995, 2003) and Sala-i-Martin (1996) introduce the two types of convergence that reflect the standard used in empirical studies of cross-country income convergence. These two different measures of convergence are termed β-convergence and σ-convergence. β-convergence refers to the situation where poorer economies experience a faster growth rate in per capita income than rich countries and σ convergence refers to the situation where the dispersion of per capita income across a select group of economies decreases over time.

Barro and Sala-i-Martin (2003) demonstrate the difference between σ-convergence and β-convergence by starting with the supposition that β-convergence holds for a group of economies, $i = 1, 2, \ldots, N$. Let the log of the real per capita income for economy i at time t be modeled by the first-order difference equation

(1) $$\log(y_{i,t}) = \alpha + (1-\beta)\log(y_{i,t-1}) + u_{it},$$

where α and β are constants, and u_{it} has zero mean and finite variance, σ_u^2, and is independent of t and i. Suppose now that all the economies converge to a same steady state y^*, then the stationary condition requires that 0<β<1. The sample variance of $\log(y_{i,t})$ is

(2) $$\sigma_t^2 = (1/N)\sum_{i=1}^{N}\left[\log(y_{i,t}) - \mu_t\right]^2,$$

where μ_t is the sample mean of $\log(y_{i,t})$. When *N* is large,

(3) $$\sigma_t^2 \cong (1-\beta)\sigma_{t-1}^2 + \sigma_u^2,$$

since the sample variance is close to the population variance. With 0<β<1, the first-order difference equation for σ_t^2 has a steady state given by

(4) $$\sigma^{2^*} = \sigma_u^2 /[1-(1-\beta)^2],$$

hence, σ_t^2 decreases toward the steady state over time. Given the above first-order difference equation and the steady state,

(5) $$\sigma_t^2 = \sigma^{2^*} + (1-\beta)^{2t}(\sigma_0^2 - \sigma^{2^*}).$$

σ_t^2 could rise or fall depending on whether the initial value σ_0^2 is above or below the steady state value. Therefore, β-convergence could exist when σ-convergence does not. [Question: is σ_t^2 considered the measure of σ-convergence? If so this could use a little clarification in the paper.]

Because β-convergence remains the primary focus for exploring income convergence in the literature of growth empirics, and because it is a necessary condition for σ-convergence we focus on β-convergence as the chosen method for exploring income convergence in this paper. In this study, we propose a comparison approach in which identical regression equations are estimated for both established trading network groups and randomly selected countries assigned to a hypothetical trading network group that has the same network size as the established trading network. The results for the actual trading networks are then compared to the properties of randomly assigned trading networks so that the effect of the trade network is identifiable. The method we employ is similar to that used by Ben-David (1996) to study the convergence among trading partners. We depart from Ben-David (1996) in two ways: first, Ben-David took the σ-convergence approach while this study uses the β-convergence approach. Second, this study uses more recent data and includes larger trading groups than those used by Ben-David (1996). For example, our trading network group size ranges from 8 to 23, whereas Ben-David's (1996) trading network group sizes were 3 to 9.

III. The Empirical Model

Neoclassical growth models generate convergence with a set of exogenous and constant economic parameters; one being a constant saving rate. However, the assumption of an exogenous saving rate could introduce problems like dynamic inefficiency or oversaving. To solve this type of problem, the Ramsey model, which was constructed by Ramsey (1928) and refined by Cass (1965) and Koopmans (1965), relaxes the exogenous assumption of the saving rate by allowing consumers to make savings decisions based on the optimal intertemporal allocation of resources. In the Ramsey model, consumers behave optimally, and the saving rate rises or falls as the economy develops. By using a log-linear approximation of the growth rate of capital per labor and the law of motion of consumption per labor around the steady state, the Ramsey model generates a pair of differential equations. The solution gives the time path of the log of per capita income. Barro and Sala-i-Martin (2003) introduce the following parameterization of the Ramsey model:

(6) $$(1/T)\cdot\log\left(y_{i,t_0+T}/y_{i,t_0}\right)=$$
$$[(1-e^{-\beta T})/T]\cdot\log\left(\hat{y}^*\right)-[(1-e^{-\beta T})/T]\cdot\log(y_{i,t_0})+\varepsilon_{i,t_0,t_0+T},$$

where $y_{i,t}$ is the real per capita GDP of the i^{th} economy at time t; T is the number of years of the time span; β is the parameter to be estimated; and $\varepsilon_{i,t_0,t_0+T}$ is the effect of the error terms between time t_0 and t_{0+T}. Again, Barro and Sala-i-Martin (2003) identify the coefficient β as a measure of the speed of convergence. If β is positive, $(1-e^{-\beta T})/T$ will be positive, hence the coefficient for the initial level of the log of real per capita GDP $\log(y_{i,t_0})$ will be negative. The negative relationship between the growth rate and the initial level of income is referred to as the β-convergence criterion.

The first term of the right-hand side is an expression of the steady-state income value $\hat{y}^*$. By assuming that all economies have the same value for the steady-state income, the following regression equation can be estimated by using an ordinary least squares (OLS) method.

(7) $$(1/T)\cdot\log\left(y_{i,t_0+T}/y_{i,t_0}\right)=\beta_0+\beta_1\cdot\log(y_{i,t_0})+\varepsilon_{i,t_0,t_0+T},$$

where β_0 and β_1 are parameters to be estimated. The dependent variable of the model is the average growth rate of the real per capita GDP of one economy during a certain period of time. The explanatory variable is the initial level of the log of real per capital GDP of the economy. If β-convergence exists in this group of economies, the coefficient for $\log(y_{i,t_0})$ should be negative, which means that the growth rate of real per capita

GDP is inversely related to the initial level of the log of real per capita GDP. If the coefficient is positive, divergence occurs and poorer economies will never catch up with richer economies. In the next section, β in equation (6) and β_0 and β_1 in equation (7) are estimated.

IV. Data and Estimation Methodology

The data used in this study are obtained from the Penn World Table Version 6.0 (Heston et al., 2001), World Trade Organization (WTO, 1998), and International Monetary Fund (IMF, 1998). The Penn World data provide y_{i,t_0}, per capita income of the i^{th} economy in 1960, and y_{i,t_0+T}, per capita income of the i^{th} economy in 1997.

Membership in the trading network group is determined using the following methodology. First, leader countries are selected from the top 25 exporters and the top 25 importers in world trade of merchandise and commercial services in 1997 (WTO, 1998). Not surprisingly, a considerable overlap exists in the leading exporters and importers for both merchandise trade and commercial services, only 30 leader countries are selected from the leading traders.[1] Among the 30 countries, Germany and the Russian Federation are excluded because the per capita incomes in 1960 are not available; Chinese Taipei is also excluded because of the lack of data on bilateral trade with other countries. In the next step, member countries of trading network groups are defined for each of the 27 leader countries.

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[1] Trading network groups are identified by the leader country; e.g., Group France refers to the trading network group based on the pattern of trade relative to exports to and imports from France.

For each of the 27 leader countries, membership in the trade network group is established as follows. Consider the leader county *A* and another country *B*. If country B received more than 1% of country *A*'s total exports in 1997, or if more than 1% of country *A*'s total imports in 1997 were from county *B*, country *B* is included in country *A*'s trading group (data are from IMF, 1998). Within a trading network group, Middle East countries and former communist countries are excluded.[2] There are other countries that are excluded due to lack of data on income growth, e.g., Libya (should be assigned to group Italy). There is no a priori reason that 1% is used as the cutoff point, however it generates a group size between 8 to 32 countries and this gives us a broad range of group sizes to explore the nature of the convergence criteria. If the group size of the trading network is too small, the regression results might not be robust and if the sample size is too large, economies in one group might be so heterogeneous that they will not converge to a same steady-state level of per capita income. Based on this grouping, there are 27 trading groups of 45 countries involved in this study. The names of the countries included in the study are listed in Appendix A.

Other than the 27 groups, we also study another three additional "special case" network trading groups. We call these three additional "special case" groups the industrial countries group, group India (1960-97), and group China (1980-97). The industrial countries group is formed in the same way as the other trading groups, but is limited to inclusion of countries on the list of industrial countries provided by the IMF (1998). The interest in India comes from its growing importance to global trade flows

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[2] China is an exception to the communist country exclusion and enters into our analysis as one of the special case leader countries.

even though it is not identified as a leading exporter or importer in 1997. For China, economic reform started in 1979 when the process of economic liberalization began and we thought it would be important to explore the effect of this event.

V. Empirical Results

The 27 trading groups and regression results for equations (6) and (7) are given in Table 1. $\hat{\beta}$ is the estimator of convergence speed in equation (6), which is estimated by the Gauss-Newton nonlinear least squares method. An estimate of the coefficient on the log of initial income per labor in equation (7), $\hat{\beta}_1$, is estimated using a linear least squares method. Calculated *t*-values for each estimator is listed in parentheses.

With few exceptions, the estimates of β in equation (6) and β_1 in equation (7) reflect interpretive consistency in the sense that they reinforce each other with appropriate signs and magnitudes. The estimated coefficient $\hat{\beta}_1$ indicates that among these 27 trading groups, 24 of them have statistically significant coefficients, and all of the significant coefficients have the expected negative sign. This means the growth rate of per capita income is negatively related to the starting value of per capita income, i.e., poorer economies grow faster than richer ones. Twenty-four trading groups show strong evidence that trading partners converge in per capita income. Ben-David (1996) measures the standard deviation of log real per capita GDP and gets 17 converging groups out of 25 using the Summers-Heston data (Heston et al., 2001) from 1960 to 1985. In Ben-David (1996), the groups whose leader economies are the United Kingdom (U.K.), Ireland,

Table 1

Twenty-seven Trading Groups and Coefficients Estimates

	Leader Economy	Trade Partners	$\hat{\beta}$ (Eq. 6)	$\hat{\beta}_1$ (Eq. 7)
1	U.S. (21)	Bel-Lux, Switzerland, Singapore, HK, Japan, Canada, France, Netherlands, Australia, U.K., Italy, Korea, Malaysia, Mexico, Thailand, Brazil, Venezuela, Philippines, Taiwan, Indonesia	0.0169* (2.600)	-0.0126* (-3.439)
2	Japan (17)	U.S., Singapore, HK, Canada, France, Netherlands, Australia, U.K., Korea, Malaysia, Thailand, Brazil, Panama, Philippines, Taiwan, Indonesia	0.0161* (2.240)	-0.0121* (-2.874)
3	Canada (10)	U.S., Norway, Japan, France, U.K., Italy, Korea, Mexico, Taiwan	0.0344* (2.758)	-0.0194* (-4.979)
4	France (15)	U.S., Bel-Lux, Switzerland, Norway, HK, Austria, Japan, Netherlands, U.K., Sweden, Italy, Ireland, Spain, Portugal	0.0279* (3.085)	-0.0174* (-5.033)
5	U.K. (21)	U.S., Bel-Lux, Switzerland, Norway, Singapore, Denmark, Japan, Canada, France, Netherlands, Australia, Finland, Sweden, Italy, Ireland, Spain, Korea, Malaysia, Turkey, Taiwan	0.0283* (4.035)	-0.0175* (-6.796)
6	Italy (19)	U.S., Bel-Lux, Switzerland, HK, Austria, Japan, France, Netherlands, U.K., Sweden, Ireland, Spain, Greece, Portugal, South Africa, Turkey, Brazil, Algeria	0.0089 (1.536)	-0.0076 (-1.721)
7	Netherlands (16)	U.S., Bel-Lux, Switzerland, Norway, Denmark, Austria, Japan, France, U.K., Sweden, Italy, Ireland, Spain, Malaysia, Taiwan	0.0241* (4.150)	-0.0160* (-6.270)
8	HK (16)	U.S., Singapore, Japan, Canada, France, Netherlands, Australia, U.K., Italy, Korea, Malaysia, Thailand, Philippines, Taiwan, India	0.0148 (2.010)	-0.0114* (-2.502)
9	Bel-Lux (13)	U.S., Switzerland, Austria, Japan, France, Netherlands, U.K., Sweden, Italy, Ireland, Spain, India	0.0049 (1.378)	-0.0045 (-1.389)
10	Korea (21)	U.S., Switzerland, Singapore, HK, Japan, Canada, France, Netherlands, Australia, U.K., Italy, Malaysia, Mexico, South Africa, Thailand, Brazil, Panama, Philippines, Taiwan, Indonesia	0.0182* (2.574)	-0.0133* (-3.496)
11	Singapore (17)	U.S., Switzerland, HK, Japan, France, Netherlands, Australia, U.K., Italy, Ireland, Korea, Malaysia, Thailand, Philippines, Taiwan, India	0.0163* (2.202)	-0.0122* (-2.836)

Table 1 continued

	Leader Economy	Trade Partners	$\hat{\beta}$ (Eq. 6)	$\hat{\beta}_1$ (Eq. 7)
12	Mexico (8)	U.S., Japan, Canada, France, Italy, Malaysia, Taiwan	0.0251 (2.154)	-0.0164* (-3.077)
13	Spain (18)	U.S., Bel-Lux, Switzerland, Austria, Japan, France, Netherlands, U.K., Sweden, Italy, Ireland, Potugal, Argentina, Turkey, Brazil, Algeria, Nigeria	-0.0011 (-0.0034)	0.0011 (0.2821)
14	Sweden (18)	U.S., Bel-Lux, Norway, Denmark, HK, Austria, Switzerland, Japan, Canada, France, Netherlands, Australia, Finland, U.K., Italy, Ireland, Spain	0.0329* (3.108)	-0.0190* (-5.724)
15	Malaysia (18)	U.S., Bel-Lux, Singapore, HK, Switzerland, Japan, France, Netherlands, Australia, U.K., Italy, Korea, Thailand, Philippines, Taiwan, Indonesia, India	0.0126* (2.312)	-0.0101* (-2.780)
16	Switzerland (16)	U.S., Bel-Lux, Singapore, HK, Austria, Japan, France, Netherlands, U.K., Sweden, Italy, Ireland, Spain, Korea, Turkey	0.0312* (2.853)	-0.0185* (-5.025)
17	Australia (23)	U.S., Bel-Lux, Switzerland, Singapore, HK, Japan, Canada, France, Netherlands, U.K., Sweden, Italy, New Zealand, Korea, Malaysia, South Africa, Thailand, Philippines, Taiwan, Indonesia, PNG, India	0.0131* (2.394)	-0.0104* (-2.943)
18	Austria (11)	U.S., Bel-Lux, Switzerland, Japan, France, Netherlands, U.K., Sweden, Italy, Spain	0.0185* (2.232)	-0.0134* (-2.898)
19	Thailand (18)	U.S., Bel-Lux, Switzerland, Singapore, HK, Japan, Canada, France, Netherlands, Australia, U.K., Italy, Korea, Malaysia, Philippines, Taiwan, Indonesia	0.0173* (2.854)	-0.0128* (-3.768)
20	Brazil (22)	U.S., Bel-Lux, Switzerland, Japan, Canada, France, Netherlands, U.K., Sweden, Italy, Spain, Korea, Argentina, Chile, Uruguay, Mexico, Venezuela, Algeria, Paraguay, Taiwan, Bolivia	0.0117 (1.812)	-0.0095* (-2.161)
21	Indonesia (19)	U.S., Bel-Lux, Singapore, HK, Japan, Canada, France, Netherlands, Australia, U.K., Italy, Spain, Korea, Malaysia, Thailand, Philippines, Taiwan, India	0.0115* (2.242)	-0.0093* (-2.642)
22	Ireland (17)	U.S., Bel-Lux, Switzerland, Norway, Singapore, Denmark, Japan, France, Netherlands, U.K., Sweden, Italy, Spain, Korea, Malaysia, Taiwan	0.0319* (4.027)	-0.0188* (-7.223)

Table 1 continued

	Leader Economy	Trade Partners	$\hat{\beta}$ (Eq. 6)	$\hat{\beta}_1$ (Eq. 7)
23	Turkey (19)	U.S., Bel-Lux, Switzerland, Singapore, Austria, Japan, France, Netherlands, U.K., Sweden, Italy, Spain, Greece, Korea, Portugal, Romania, Algeria, Taiwan	0.0189* (2.699)	-0.0136* (-3.698)
24	Denmark (14)	U.S., Bel-Lux, Switzerland, Japan, France, Netherlands, Finland, U.K., Sweden, Italy, Spain, Portugal, Norway	0.0188* (2.992)	-0.0136* (-4.003)
25	Philippines (14)	U.S., Singapore, HK, Japan, Canada, France, Netherlands, Australia, U.K., Korea, Malaysia, Thailand, Taiwan	0.0233* (2.293)	-0.0156* (-3.369)
26	Norway (17)	U.S., Bel-Lux, Switzerland, Denmark, Austria, Japan, Canada, France, Netherlands, Finland, U.K., Sweden, Italy, Ireland, Spain, Korea	0.0276* (4.339)	-0.0173* (-7.093)
27	China (17)	U.S., Singapore, HK, Japan, Canada, France, Netherlands, Australia, U.K., Italy, Korea, Malaysia, Thailand, Brazil, Taiwan, Indonesia	0.0154* (2.907)	-0.0117* (-3.681)

Note: Leader economies are selected from the top 25 exporters and the top 25 importers in world trade of merchandise and commercial services in 1997, considering also the availability of income and trade data. For each leader economy A, if more than 1% of economy A's total exports in 1997 was to economy B, or if more than 1% of economy A's total imports in 1997 was from economy B, B is a trading partner of A. In the second column, the numbers in the parentheses are group sizes. The numbers in parentheses of the last two columns are t-values for the corresponding estimates.

* Indicates significantly different from zero at the 5% level.

Spain, United States (U.S.), Uruguay, Mexico, Argentina, and Chile show significant divergence.

In this study, Uruguay, Argentina, and Chile are not selected as leader economies, but U.K., Ireland, U.S., and Mexico groups show significant convergence. Group Spain is still not significantly converging. In addition to Group Spain, Group Italy and Group Belgium-Luxemburg (Bel-Lux) also have insignificant $\hat{\beta}_1$, although they get the desired negative sign.

The nonlinear least squares estimation in equation (6) gives us slightly different results. There are 21 significant estimates out of 27. The coefficients that are significant have the expected positive signs. Except for the three nonconverging groups estimated by equation (6), Group Hong Kong (H.K.), Group Mexico, and Group Brazil are also nonconverging in equation (6). The value of $\hat{\beta}$, i.e., the estimated convergence speed, ranges from 0.0115 (Group Indonesia) to 0.0344 (Group Canada), which indicates a half life from 20 to 60 years approximately. In other words, it will take 20 to 60 years for an economy to halve the distance from the current per capita income to the steady state. Although the convergence speed is a bit slow, the results give support to the claim that for trading partners, poorer economies grow faster than richer ones; that is, convergence takes place among trading partners.

With regard to our "special case" network trading groups the results are reported in Table 2. Not surprisingly, the results show that the group of industrialized countries and Group China (1980-97) are converging. The converging speed for Group China (1980-97) is greater than that for Group China (1960-97). However, for Group India during 1960-97, the estimated coefficient is not significant.

In contrast to the six nonconverging trading groups in Table 1, including the group India in Table 2, most of these groups consist of either several developing economies or poor economies. There is a need to pay special attention to the difference between developed and developing economies. One reason could be that the assumption

Table 2
Four Trading Groups and Coefficients

Leader Economy	Trade Partners	$\hat{\beta}$ (Eq. 6)	$\hat{\beta}_1$ (Eq. 7)
Industrial Countries (1960-97)	U.S., Bel-Lux, Switzerland, Norway, Austria, Japan, Canada, France, Netherlands, Australia, U.K., Sweden, Italy, Ireland, Spain	0.0213* (2.816)	-0.0147* (-3.989)
China (1960-97)	U.S., Singapore, HK, Japan, Canada, France, Netherlands, Australia, U.K., Italy, Korea, Malaysia, Thailand, Brazil, Taiwan, Indonesia	0.0154* (2.907)	-0.0117* (-3.681)
China (1980-97)	U.S., Singapore, HK, Japan, Canada, France, Netherlands, Australia, U.K., Italy, Korea, Malaysia, Thailand, Brazil, Taiwan, Indonesia	0.0223* (2.395)	-0.0152* (-3.499)
India (1960-97)	U.S., Bel-Lux, Singapore, HK, Switzerland, Japan, Canada, France, Netherlands, Australia, U.K., Italy, Spain, Korea, Malaysia, South Africa, Thailand, Taiwan, Morocco, SriLanka, Indonesia, Bangladesh, Nigeria	0.0060 (1.367)	-0.0053 (-1.465)

* Indicates significantly different from zero at the 5% level.

that all economies have the same characteristics fails to hold. Other than that, in order to catch up with more developed economies, developing economies have to grow faster.

There are 45 economies in total involved in this study. The number of economies in a trading group varies from 8 to 23. In most of the trading groups, poorer economies grow faster than richer ones. In order to highlight the role of trade, it is natural to ask whether a similar result will happen in a group of economies that do not trade much among themselves. We attempt to answer this question by randomly selecting 8 to 23 economies out of the 45 economies, and then estimating the regression coefficients for each group. For groups with 8 economies, there are $C_{45}^{8} = 215{,}553{,}195$ different combinations out of 45 economies; for groups with 23, there are $C_{45}^{23} = 4.117 \times 10^{12}$ different combinations. Since each of the different-sized groups consists of such a large number of possibilities, 10,000 combinations are randomly drawn from the pool of each group size.

Out of the 10,000 regressions for each group, the mean is calculated from the set of only the significant coefficients. Table 3 shows the results from estimating these random groups. The means of $\hat{\beta}_1$'s are still negative but with a scale of 10^{-3} for all

Table 3

Coefficients for Random Groups with Different Sizes

Group Size	**Mean of $\hat{\beta}_1$**	**Standard Deviation of $\hat{\beta}_1$**
8	-0.0071	0.0069
10	-0.0070	0.0058
11	-0.0069	0.0054
13	-0.0069	0.0046
14	-0.0069	0.0043
15	-0.0069	0.0041
16	-0.0068	0.0038
17	-0.0069	0.0036
18	-0.0067	0.0034
19	-0.0068	0.0032
20	-0.0069	0.0031
21	-0.0068	0.0029
22	-0.0068	0.0028
23	-0.0068	0.0027

Note: For each group size, 10,000 regressions are estimated among randomly selected economies. The means and the standard deviations are for the significant (at 5% level) estimates only.

groups. Compared to the values of the significant $\hat{\beta}_1$'s in Table 1, these means are very small numbers although they are significantly different from zero.

The distribution of $\hat{\beta}_1$ for each sample size appears normal, hence, we can use the distribution to generate the probability of observing the coefficient estimate for a trading group. For most of the groups, that is, 20 out of 27, the probability of observing $\hat{\beta}_1$ is less than 5% or 10% (Table 4). We cannot conclude that observing those $\hat{\beta}_1$'s is only by chance. Therefore, it is less likely to find convergence in the randomly selected groups than in the trading groups.

In this study, an indirect method is used to analyze the role of trade in convergence. The results indicate that trade contributes to convergence in per capita

Table 4

Probability of Observing the Results of Trading Groups

Leader Economy	$\hat{\beta}_1$ **(Eq. 7)**	**Prob(observing** $\hat{\beta}_1$**)**
Canada (10)	-0.0194*	0.0154
Sweden (18)	-0.0190*	0.0002
Ireland (17)	-0.0188*	0.0004
Switzerland (16)	-0.0185*	0.0011
U.K. (22)	-0.0175*	<0.0001
France (15)	-0.0174*	0.0040
Norway (17)	-0.0173*	0.0018
Mexico (8)	-0.0164*	0.0869
Netherlands (16)	-0.0160*	0.0084
Philippines (14)	-0.0156*	0.0228
Turkey (19)	-0.0136*	0.0197
Denmark (14)	-0.0136*	0.0606
Austria (11)	-0.0134*	0.1056
Korea (21)	-0.0133*	0.0150
Thailand (18)	-0.0128*	0.0436
U.S. (21)	-0.0126*	0.0268
Singapore (17)	-0.0122*	0.0668
Japan (17)	-0.0121*	0.0708
China (17)	-0.0117*	0.0869
HK (16)	-0.0114*	0.1190
Australia (23)	-0.0104*	0.0918
Malaysia (18)	-0.0101*	0.1736
Brazil (22)	-0.0095*	0.1685
Indonesia (19)	-0.0093*	0.2236

Italy (20)	-0.0076	0.3974
Bel-Lux (13)	-0.0045	0.3015
Spain (18)	0.0011	0.0119

Note: Based on the distribution of $\hat{\beta}_1$ for randomly selected economies for each group size, this table shows the probability of observing the $\hat{\beta}_1$ for trading partners. Fourteen are less than 5% and 20 are less than 10%.
* Indicates significantly different from zero at the 5% level.

income among trading partners. However, this conclusion does not hold for all the trading groups studied, especially for the groups that include both developed economies and poorest economies. Globalization or integration of the countries of the world may raise the per capita income of all countries. But for nations with low per capita income, it is less likely that they will ever be able to catch up with high income countries in a world of increasing interdependence.

VI. Conclusion

This paper makes three contributions to the literature regarding per capita income convergence among countries who are members of established trading network groups. First, empirical evidence suggests that trade within a trade network increases per capita income of poorer countries in the network at a faster rate than richer countries in the trading network. Second, when estimated income convergence parameters are compared between established trading network groups and randomly assigned trading network groups of identical size, there is no evidence of income convergence within the randomly assigned trading network groupings. This result strengthens the case that international trade does exert influence in characterizing β-convergence among countries within an established trading network group. Third, Ben-David (1996) compared change in the dispersion of incomes between trading partners and nontrading partners and found that it is more likely for trading partners to have σ-convergence. It is possible that dispersion in real per capita income is affected by random shocks that are not related to income and therefore, even if an increasing dispersion in per capita income is observed among a group of economies, they still could have β-convergence. Restricting one's focus to σ-convergence limits the exploration of another important aspect of convergence. As a complement to Ben-David's work we now have a more complete picture about the effect of trade on income convergence within trading networks.

In 2002, President Bush called for a new compact for global development, which links greater aid disbursements from developed nations to greater fiscal responsibility from developing nations. The President proposed the Millennium Challenge Account (MCA) in which development assistance would be provided to those countries that satisfy several conditions; one of which is that the developing country should encourage the inflows of private capital and increase trade. In 2003 the United Nations Development Programme (UNDP, 2003) proposed the Millennium Development Goals to end human poverty. This compact consists of 8 goals and 18 targets to help reduce inequality and eliminate poverty. The 8^{th} goal is to develop a global partnership for development, which includes further developing an open, rule-based, predictable, nondiscriminatory trading and financial system. If these countries are able to enter into a pattern of trade within a trading network it is likely that trade liberalization will benefit both the developing countries and the developed countries. In particular, this study suggests that trade will eventually help developing countries catch up with per capita income levels enjoyed by developed countries who they trade with.

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APPENDICES

Appendix A: List of Countries

27 leader economies	45 economies involved in this study
Canada	Argentina
Sweden	Australia
Ireland	Austria
Switzerland	Belgium-Luxemburg
UK	Bolivia
France	Brazil
Norway	Canada
Mexico	Switzerland
Netherlands	Chile
Philippines	China
Turkey	Denmark
Denmark	Algeria
Austria	Spain
Korea	Finland
Thailand	France
US	UK
Singapore	Greece
Japan	HK
China	Indonesia
HK	India
Australia	Ireland
Malaysia	Italy
Brazil	Japan
Indonesia	South Korea
Italy	Mexico
Belgium-Luxemburg	Malaysia
Spain	Nigeria
	Netherlands
	Norway
	New Zealand
	Panama
	Philippines
	Papua New Guinea
	Portugal
	Paraguay
	Romania
	Singapore

Appendix B continued

27 source economies	45 economies involved in this study
	Sweden
	Thailand
	Turkey
	Taiwan
	Uruguay
	US
	Venezuela
	South Africa

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