Relative Convergence and Cross-Section Dynamics: A New Approach to Convergence

Gerard H. Kuper

Abstract

This paper analyses income convergence between groups of countries relative to the world-wide development. The alternative to conventional convergence tests introduced here provides more transparent and intuitively more reasonable results. Using a combination of cross-section data and time-series data for the period 1970–1990 we find evidence for a separation in levels of income (measured as real per capita GDP) between groups of countries. Africa seems to be trapped in a situation with a low level of real per capita GDP, whereas the OECD countries find themselves in a position with a relatively high level of real per capita GDP. Latin America diverges and Asia converges relatively to the world-wide development.

Keywords: Panel data, Income convergence, Economic growth
JEL-classification: C33, O10, O50

CCSO and Department of Economics, University of Groningen, PO Box 800, 9700 AV Groningen, The Netherlands, Tel: 050 3633756, Fax : 050 3637337, Email: G.H.Kuper@eco.rug.nl. I would like to thank Jan Jacobs, Simon Kuipers and Jan Egbert Sturm and the referees for useful comments and suggestions.

1 Introduction

A vast, and still growing, literature has appeared over the last decade dealing with the question: Do countries or groups of countries have a tendency to converge in terms of the levels of income or GDP per capita (β convergence)? And related to that: If countries do not seem to converge, do they so after holding fixed variables that capture differences in cultures, institutions and policies (conditional convergence)? See, for instance, Barro and Sala-i-Martin's 1995 book on Economic Growth and many other papers for references on convergence and conditional convergence. Obviously, the Solow-Swan neoclassical growth model from the 1950s predicts conditional convergence (see Romer (1986)). The stylized facts however, show large—and indeed growing—differences in income over time and across countries. This has led to a diverse body of theoretical and empirical literature on—what is now known as—endogenous growth theory. For a discussion we refer to the Policy Forum in *The Economic Journal* of 1992 and to the contributions on endogenous growth in the *Journal of Economic Perspectives* in 1994. In particular, we refer to Dowrick's contribution on catch up and divergence in *The Economic Journal* and to Romer (1994) and Pack (1994).

The convergence hypothesis is usually tested by a regression of average growth rates of real per capita GDP (the left-hand side in equation (1)) on initial levels in a cross-country setting (cf. Barro and Sala-i-Martin (1995), p. 384).

$$\log(y_{i,T}/y_{i,0}) = \alpha - \left(1 - e^{-\beta}\right) \log(y_{i,0}) \tag{1}$$

The sign of β is supposed to indicate whether convergence takes place or not. The size of parameter β measures the speed of convergence or divergence. A positive value for β (or $1 - \exp(-\beta) > 0$) implies that countries with a low initial level of income grow faster than countries with higher initial levels of income: the lower the starting level of real per capita GDP (or income, denoted by y), the faster is the growth rate (due to the assumption of diminishing returns to capital). The speed of convergence or divergence is indicated by the half-life or double-life, respectively. The half-life t is derived from $\exp(-\beta t) = 1/2$. The double-life is derived analogously.

Results on convergence are in general not very conclusive, especially not in a broad selection of countries with large differences in tastes and technology. Usually, convergence is tested conditionally on variables that capture differences in cultures, institutions and policies. Most studies on conditional convergence suggest that countries converge at a rate of 2 or 3% per year. Another line of research selects a homogeneous set of countries and perform standard tests. However, the conclusions are then restricted to the selected group of countries (sample selection bias).

Quah (1993a) shows that tests based on cross-country data lead to the wrong conclusions because the estimation results are biased due to regression-to-the-mean (or Galton's *regression to mediocrity*). If convergence is defined as a reduction of the cross-section dispersion of income over time, it is possible to find a positive β without the income dispersion collapsing. Furthermore, Quah suggests to get

rid of world-wide comovements in growth of per capita income by normalizing per capita income for each country because convergence is disturbed by global growth of per capita income. Ben-David (1994, 1995) avoids cross-country regressions altogether and relies on time-series information for determining (lack of) convergence. This seems reasonable since convergence is, by definition, a dynamic concept which cannot be captured by cross-section studies. Combining time-series analysis in a cross-country setting introduces the dynamics needed to analyse convergence in a proper manner.

This paper corroborates Quah's opinion that standard regressions may easily lead to the wrong conclusions because of regression-to-the-mean problems and that normalization of income per capita in a dynamic time-series analysis shows more clearly whether or not convergence occurs. The data we use here are derived from the International Financial Statistics of the IMF. We have gathered information on real GDP per capita for a number of countries for the period 1970–1990. The data appendix provides more detail. Our conclusions clearly point at a "... tendency towards a two-camp world divided between haves and have-nots ..." (Quah (1993b), page 433). Quah reaches the same conclusion by analysing the income distribution across entire economies using a Markov chain transition model. Our analysis is much simpler and similarly transparent.

2 Stylized facts

In order to avoid sample selection bias, we do not restrict ourselves to a small set of homogeneous countries or regions, nor do we want to apply a static analysis in a cross-country setting. However, sufficiently long time-series for a broad selection of countries are not available yet. So, we select countries for which at least 20 data points are available. Our balanced panel consists of information on real per capita GDP for 73 countries for the period 1970–1990. If we require longer time-series the number of countries would be reduced, and if we want to increase the number of countries the length of the sample period is reduced considerably.

For sake of conveniency, the 73 countries in our sample are grouped, somewhat arbitrarily, in four regions. The first group, OECD, consists of advanced Western market economies including Japan. The other groups are geographical groupings, these are Asia (east and west, excluding Japan), Latin America and Africa. The Latin American group includes Caribbean countries like Trinidad & Tobago and the Dominican Republic. Africa includes northern African countries and Sub-Saharan countries.

The stylized facts point at large differences in levels of real per capita GDP between countries as well as large differences in rates of growth of real per capital GDP. The top half of figure 2.1 shows the initial levels of per capita GDP in 1970 and 1990 for about 73 countries (the dashed lines), the bottom half lists the average annual rates of growth of real per capita GDP during the period 1971–1990 (the solid line).

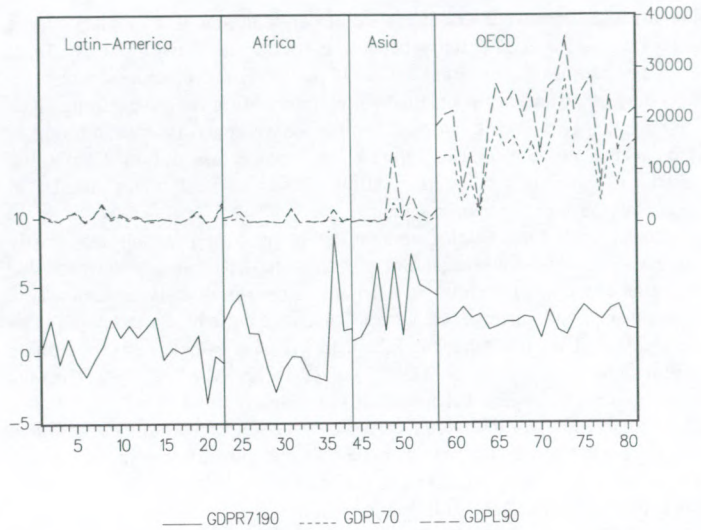

Figure 2.1 *Annual growth rate of real per capita GDP, 1971–1990 and levels of per capita GDP in 1970 (- - -) and 1990 (– – –) for 73 countries*

Latin-American countries and African countries show hardly any improvement in levels of real per capita GDP, whereas the rates of growth show a large variation. For OECD countries (including Japan) rates of growth of real per capita GDP are on average moderate but positive and the levels of real per capita GDP increase significantly. Asian countries (eastern and western Asian countries taken together) grow faster, on average, than OECD countries. If one is to expect convergence one would expect it to be the case for the Asian countries.

Table 2.1 shows sharp differences in growth rates over time and across regions. In the 1970s most countries experienced positive growth, whereas in the 1980s the Latin-American countries show on average a decline in per capita GDP. The fact that Latin American countries, rather dramatically, fall back in terms of rates of growth of real per capita GDP is caused by the second oil crisis in the late 1970s on the one hand, and the debt crisis in Mexico which spread rapidly to other countries, especially in Latin America (cf. Maddison and others (1992) and Lensink (1993)). The economic situation in Africa became more grim in the 1980s. Private capital flows to (Sub-Saharan) Africa—which were already low—reduced even more due to the world-wide recession in the early 1980s. Again, we refer to Lensink (1993).

To give an idea of the data we have constructed, we present some more detailed information on rates of growth in individual countries. In the period 1971–1975 rates of growth of real per capita GDP ranged from -3.6% for Chile to 17.6% for Pakistan. The average annual growth rate for the period 1976–1980 ranged from

Table 2.1 *Average annual rates of growth of real per capita GDP*

	Annual growth rates of real per capita GDP				
period	Latin America	Africa	Asia	OECD	World
1971–1975	2.44	2.46	4.56	2.83	2.89
1976–1980	1.79	0.31	4.41	2.63	2.13
1981–1985	−2.15	0.01	2.40	1.64	0.26
1986–1990	−0.08	0.93	3.79	2.65	1.62

-9.3% for Zaire to 7.8% for Botswana. The highest average rate of growth in the periods 1981–1985 and 1986–1990 is found in Korea, whereas the lowest rate of growth is found in Bolivia for the period 1981–1985 and in Nicaragua for the period 1986–1990. The highest rates of growth are typically found in Asia, and the lowest rates of growth in the African countries. The figures displayed in table 2.1 confirm Baumol's remark that "... there is more than one convergence club, ... poorer less developed countries are still largely banned from the homogenization process ..." (Baumol (1986), p. 1080).

3 Relative convergence

Quah's criticism on traditional convergence tests captures the notion that although levels of real per capita GDP in Latin-American countries and African countries increase, their levels of real per capita GDP decrease relative to world-wide growth. That is, countries which little or no growth in fact fall back in terms of standard of living: "... economic growth, to the extent that it increases socially unrealisable aspirations, may actually reduce social welfare ..." (Ng (1983), p. 277).

In order to abstract from world-wide growth the data on real per capita GDP for each region (OECD, Latin America, Africa and Asia) are divided by the average levels of real per capita GDP for the group to which the countries belong, viz. average world-wide level of real GDP (compare Ben-David (1995)). We define relative real per capita GDP for region i as $\tilde{y}_{i,t}$:

$$\tilde{y}_{i,t} = y_{i,t}/\bar{y}_t \tag{2}$$

where $y_{i,t}$ is region i's average real per capita GDP at time t, and $\bar{y}_t$ is the world-wide average real per capita GDP.

Evidently, the major contribution to the world-wide level of real per capita GDP originates from OECD countries. When we look at the income distribution across regions, table 3.1 shows that the average level of real per capita GDP in the OECD is about 2.6 times the world average level of income. The African average level of income is about 11% to 12% of the world average level of income. The second conclusion we can infer from this table is that the income distribution certainly

Table 3.1 *Average real per capita GDP relative to the world-wide level of real GDP*

	Relative real per capita GDP			
period	Latin America	Africa	Asia	OECD
1971–1975	0.27	0.12	0.19	2.63
1976–1980	0.27	0.12	0.22	2.61
1981–1985	0.24	0.12	0.26	2.62
1986–1990	0.20	0.11	0.29	2.64

does not show any sign of convergence. On the contrary, for the period 1971–1990 the gap between the rich and the poor tends to widen. Because the variation in the development of real per capita GDP over time is rather large, we will present the estimation results on relative convergence for two subperiods, the 1970s and the 1980s, as well as for the total sample period.

Figure 3.1 shows a scatter plot of growth deviations from the world average rate of growth (vertical axis) and level deviations from the world level of real per capita GDP (horizontal axis). Countries in the top half of the diagram catch up with the world steady state (relative convergence). Countries in the bottom half move away from the world steady state (relative divergence).

Relative convergence applies for Asia, relative divergence applies for the Latin-American countries. The OECD and Africa more or less seem to have stabilized their relative positions with Africa slightly falling back. For the OECD this need not come as a surprise since most income is generated in OECD countries. Each of the four groups of countries are plotted in more detail in figure 3.2. These plots clearly show the dynamics. Asia, for instance, is rapidly catching up relative to the world steady state. Latin America is falling behind, especially in the 1980s. OECD is moving around clockwise with hardly any gain or loss. Africa is somewhat falling behind since the early 1980s.

Dowrick (1995) suggests that there is some sort of take-off threshold level of income per capita, below which economies find it difficult to generate the investment in education and infrastructure needed to take advantage of the available technology. Figure 3.1 indicates that this take-off threshold level is certainly not a sufficient condition for sustainable high rates of growth. If it is, Latin America needs to be on a higher growth path, since in the early 1970s, the initial level of income exceeded that of Asia considerably. Edwards (1995) points at differences in the savings rates between East Asia and Latin America to explain why Latin America failed to take advantage of the relatively favourable initial conditions in the 1970s.

Because the data are corrected for the world-wide development of real per capita GDP, the development in real per capita GDP over time for one group of countries should be interpreted in relation to world-wide growth. The first oilprice shock in 1974 reduced growth in the OECD and in Asia. This in turn reduced world-wide

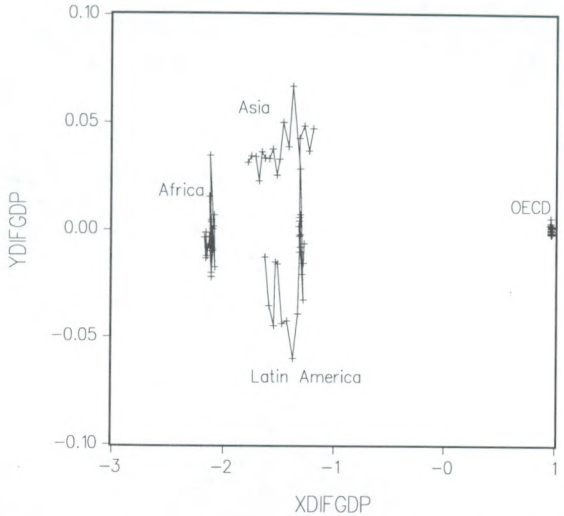

Figure 3.1 *Per capita growth rate versus initial per capita GDP, relative to the group, 1971–1990*

growth and, as a consequence, growth in Africa and Latin America peaked relative to world-wide growth. The second oilprice shock hits Asia in 1979 and the OECD two years later. In 1983, accelerating Asian growth reduced growth in Africa and Latin America relative to world-wide growth. In 1985, growth in Asia dropped sharply, whereas growth in the OECD reached record high rates of growth relative to world-wide growth.

Now, we estimate the following adjusted model, where: $\tilde{y}_{i,t}$ is defined according to equation (2):

$$\log(\tilde{y}_{i,t}/\tilde{y}_{i,t-1}) = \alpha - \left(1 - e^{-\beta_i}\right) \log(\tilde{y}_{i,t-1}) + u_{i,t} \tag{3}$$

Parameter α is zero by construction because the data are centered around the group average (see appendix B). This is in fact confirmed by estimation results not reported here. Parameter β measures relative convergence and is allowed to differ between regions. A positive value for β indicates relative convergence, whereas a value of $\beta < 0$ is to be interpreted as relative divergence. We simply use the standard least squares estimators. Quah (1994) gives a first analysis of the subtleties that arise in unit-roots regression in data that have simultaneously extensive cross-section and time-series variation. The estimation results are listed in table 3.2. The first entry gives the results for the entire sample period. Table 3.1 above revealed rather sharp differences in income distribution across regions and over time, so we re-estimated the model for the period 1971–1980 and for the

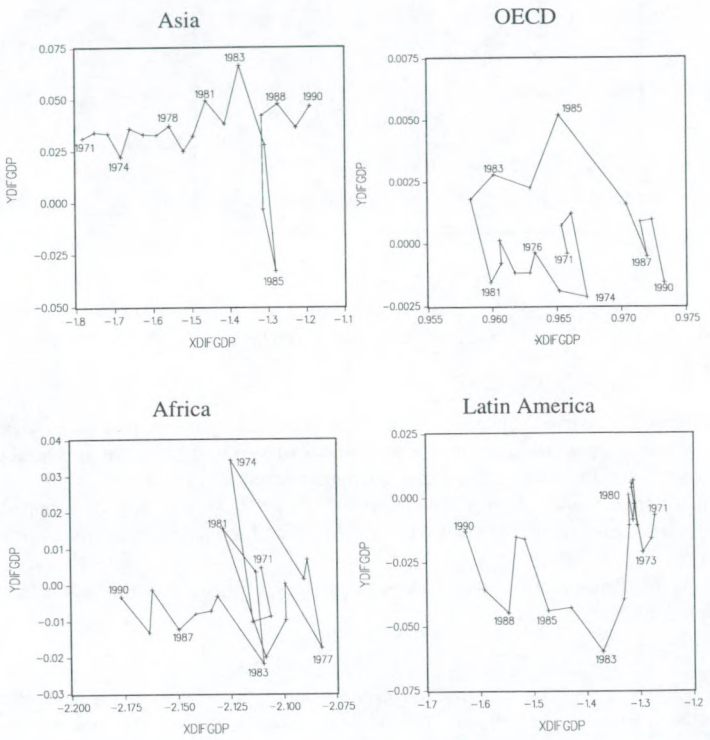

Figure 3.2 *Per capita growth rate versus initial per capita GDP per region, relative to the group, 1971–1990*

Table 3.2 *Parameter estimates (t-values between parentheses). Subscript i indicates the region: 1=OECD, 2=Latin America, 3=Africa, 4=Asia*

	1971–1990	1971–1980	1981–1990	1971–1990
β_1	−0.000	0.001	−0.001	0.020
	(−0.087)	(0.198)	(−0.212)	(0.593)
β_2	−0.014[a]	−0.004	−0.021[a]	0.192
	(−5.592)	(−1.584)	(−5.737)	(2.171)
β_3	−0.002	−0.001	−0.002	0.077
	(−1.012)	(−0.588)	(−0.921)	(1.804)
β_4	0.022[a]	0.020[a]	0.025[a]	0.011
	(9.203)	(10.557)	(5.710)	(0.813)
observations	80	40	40	80
$\bar{R}^2$	0.589	0.712	0.619	0.519

[a] differs significantly from 0 at 1%.

period 1981–1990. These results are in the second and third column of table 3.2. The last column shows the estimation results if we do not normalize the data.

The outcomes are in accordance with the stylized facts reported earlier: OECD and Africa are stable relative to the world-wide development. The relative convergence parameter for the OECD countries as well as for African countries is not significantly different from 0 in both subperiods. Latin America is falling behind in the second half of the sample period, the relative convergence parameter is -0.021 in the 1980s (which is significantly different from 0 at a significance level of 1%). Asia is catching up in both subperiods: the relative convergence factor is 0.022 and differs significantly from 0 at 1%. Latin America diverges relative to the world-wide development of income (relative divergence of 1.4%, i.e. a double-life of 50 years), whereas Asia converges (relative convergence of 2.2%, this implies a half-life of 32 years). Our results confirm Romer's presumption that the relative income gap between rich and poor tends to widen (Romer (1986)).

In order to appreciate the results on relative convergence, we compare the results with those we find if we do not normalize the data (the last column in table 3.2). Here, we only report β coefficients. Kuper (1995) is a more detailed paper on the comparison between both methods. Observe that parameter β is positive for all regions, albeit not very significantly different from 0. If a positive value of β means convergence, then this outcome suggests convergence for all regions. This is not in accordance with the stylized facts reported earlier. Relative convergence, as we define it in this paper, is more consistent with the data.

4 Conclusions

Traditional cross-country income convergence tests exhibit some shortcomings. First, results on convergence are generally not very conclusive, especially not in a

broad selection of countries with large differences in tastes and technology. One way out of this problem is to select a homogeneous set of countries and perform standard tests. However, the conclusions are then restricted to the selected group of countries (sample selection bias).

Another problem has to do with the fact that no account is taken of an individual countries' development of income over time. Biases due to regression-to-the-mean may be the result. Correcting for the growth of income of the group to which the countries belong in a dynamic time-series setting reduces the estimation bias.

Doing so, results in tests in which the convergence or divergence of countries (or group of countries) is analysed relative to the development over time of the income of the group to which those countries belong. Afterall, the theory on welfare economics shows that for the welfare of a country its relative income (that is its income in relation to the income of the group) may be more important than the absolute level of income of a country. This underlines the significance for introducing the concept of relative convergence and relative divergence as opposed to (absolute) convergence and divergence.

The results reported here for the period 1970–1990 show that the OECD and Africa are relatively stable as compared to the world-wide development of income. During the 1970s, Africa stabilized on a low level of income as compared to the OECD. Since 1983, Africa is lagging behind. Latin America is falling behind relative to the OECD, whereas Asia is rapidly catching up. This suggests a dichotomy in the levels of income in the world economy. What we find here confirms Romer's presumption that the relative income gap between rich and poor is widening (Romer (1986)). However, within regions there may be convergence (local convergence). Applying the same methodolgy to each of the four regions reveals interregional rates of income convergence and divergence. In a forthcoming paper we will elaborate more on this issue.

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A Data appendix

A.1 Time-series and countries

We gathered the following time-series information from the International Financial Statistics (IFS) of the IMF for the countries listed in table A.1.

- real GDP (in national currencies)
- nominal exchange rate
- population

Table A.1 *List of countries*

IFS	Latin America (22)
283	Panama
288	Paraguay
233	Colombia
213	Argentina
336	Guyana
299	Venezuela
278	Nicaragua
228	Chile
268	Honduras
223	Brazil
263	Haiti
218	Bolivia
253	El Salvador
369	Trinidad & Tobago
243	Dominican Republic
343	Jamaica
293	Peru
273	Mexico
258	Guatemala
238	Costa Rica
298	Uruguay
248	Ecuador

IFS	Africa (16)
744	Tunisia
686	Morocco
746	Uganda
652	Ghana
199	South Africa
664	Kenya
616	Botswana
674	Madagascar
622	Cameroon
676	Malawi
644	Ethiopia
684	Mauritius
618	Burundi
754	Zambia
636	Zaire
738	Tanzania

IFS	Asia (11)
518	Burma
524	Sri Lanka
558	Nepal
564	Pakistan
534	India
536	Indonesia
566	Philippines
576	Singapore
542	Korea
578	Thailand
548	Malaysia

IFS	OECD (24)
112	United Kingdom
158	Japan
156	Canada
111	United States
146	Switzerland
193	Australia
144	Sweden
184	Spain
142	Norway
178	Ireland
138	Netherlands
174	Greece
137	Luxembourg
122	Austria
136	Italy
186	Turkey
134	Germany
176	Iceland
132	France
196	New Zealand
172	Finland
182	Portugal
128	Denmark
124	Belgium

The selection of countries is based on data availability. Emphasis is on time-series so we only selected countries for which data are available for the period 1970–1990.

A.2 Conversion

Real per capita GDP is calculated as follows. First data on real GDP are converted in US-$:

$$\text{real GDP in US-\$} = \frac{\text{real GDP (base year 1990) in national currencies}}{\text{exchange rates in the base year}}$$

Second, real GDP in US-$ is divided by population:

$$\text{real per capita GDP in US-\$} = \frac{\text{real GDP in US-\$}}{\text{population}}$$

Note:

1. For some countries (Germany, Japan, Iceland and Turkey) we used real GNP.
2. For some countries the base year is 1985.

B Technical appendix

Define $y_{i,t}$ as the average real per capita GDP for region $i = 1, \ldots, K$ at time $t = 1, \ldots, T$. The number of countries in region i is n_i. Note that

$$y_{i,t} = \frac{1}{n_i} \sum_{j=1}^{n_i} y_{j,i,t}$$

where $y_{j,i,t}$ is real per capita GDP for country j in region i at time t.

Average world-wide per capita GDP at time t, $\bar{y}_t$, is defined as

$$\bar{y}_t = \sum_{i=1}^{K} \frac{n_i}{N} y_{i,t} \tag{B.1}$$

where the total number of countries N equals $\sum_{i=1}^{K} n_i$. Equation (B.1) can be written as follows:

$$1 = \sum_{i=1}^{K} \frac{n_i y_{i,t}}{N \bar{y}_t} \tag{B.2}$$

Average real per capita GDP for region i relative to the average world level of real per capita GDP is defined as in equation (2) above:

$$\tilde{y}_{i,t} = \frac{y_{i,t}}{\bar{y}_t}$$

The following model (equation (3) in the main text) is estimated :

$$\log(\tilde{y}_{i,t}/\tilde{y}_{i,t-1}) = \alpha - \left(1 - e^{-\beta_i}\right) \log(\tilde{y}_{i,t-1}) + u_{i,t}$$

or

$$\log \tilde{y}_{i,t} = \alpha + \phi_i \log \tilde{x}_{i,t} + u_{i,t}$$

where $\tilde{x}_{i,t}$ are lagged $\tilde{y}_{i,t}$'s and $\phi_i = e^{-\beta_i}$ (compare Ben-David (1995)). The intercept equals 0 because the data are centered around the world average as will be shown.

The estimator $\hat{\alpha}$ can be calculated from

$$\overline{\log \tilde{y}} = \hat{\alpha} + \hat{\phi}\, \overline{\log \tilde{x}}$$

Since

$$\bar{\tilde{y}} = \frac{1}{T} \sum_{t=1}^{T} \sum_{i=1}^{K} \frac{n_i}{N} \tilde{y}_{i,t} = \frac{1}{T} \sum_{t=1}^{T} \sum_{i=1}^{K} \frac{n_i y_{i,t}}{N \bar{y}_t} = \frac{1}{T} \sum_{t=1}^{T} 1 = 1,$$

using equation (B.2), it follows that

$$\overline{\log \tilde{y}} = 0$$

The same argument goes for $\overline{\log \tilde{x}}$, so

$$\hat{\alpha} = \overline{\log \tilde{y}} - \hat{\phi}\, \overline{\log \tilde{x}} = 0$$

□