

# **Regional Leaders and Patterns of Development**

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March 2008

*Preliminary and Incomplete*

## **Abstract**

If distance, geographic or cultural, affects the ease of technology diffusion across countries then the presence of a regional industrializing leader can have widespread economic effects on neighboring countries. This 'regional leaders' view of development is useful for understanding both past development patterns as well as possible future trends. East Asia, for example, would arguably be a very different place today economically if Japan had never industrialized. This paper examines the evidence for these regional patterns of development and presents a model that provides a framework for analyzing under what conditions 'close' follower countries, in terms of geography and/or culture, may benefit from a leader country's development.

JEL Codes: O1, O33, O4

Keywords: Development, Technology Diffusion, Convergence, Geography, Culture

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## 1. Introduction

One of the most compelling facts in development is the regional clustering of income levels (see figure 1). On average, rich countries tend to be near other rich countries and poor countries near poor. These similarities in income levels reflect common trends in long run growth rates. Moreno and Trehan (1997), for example, find that a country's long run growth rate is closely related to that of its neighbors<sup>2</sup>. There are many potential explanations for these observations. They can include direct geographic effects (disease environment, natural resources, etc.), common shocks, common political and/or cultural developments, and the roles of technology diffusion, trade and investment flows. The broad outlines of modern economic history also suggest that the presence of a regional industrializing 'leader' country(s) can profoundly influence the economic growth of neighboring nations. As the leader country develops, its economic and political influence can stimulate development in countries that are close to it, geographically and/or culturally. The United Kingdom initially played this leader role for Europe and the neo-Europes (like the United States, etc.) in the 18<sup>th</sup> and 19<sup>th</sup> centuries. Japan, in the 20<sup>th</sup> century, played a similar role for much of East Asia. Any explanation of East Asia's dramatic growth that does not include the role an industrializing, fast growing Japan played in spurring regional development would be necessarily incomplete.

This paper will focus on the role technology diffusion can play in creating these regional development patterns<sup>3</sup>. If technology diffusion directly or indirectly depends on 'distance' (geographic and/or cultural) from a leader country then we would expect there to be a regional component to development; i.e. the 'neighborhood' in which a nation exists matters<sup>4</sup>. Geographic distance can directly affect diffusion through trade and investment flows from the leader country, for example if the technology is embodied in capital goods. There is an extensive empirical literature in trade that documents that geographic distance between trading partners significantly affects trade flows and volumes (cite). Cultural distance, though it is more difficult to define (see

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<sup>2</sup> They also find that common shocks and trade cannot account for all of the correlation.

<sup>3</sup> Although to some degree similar arguments could be made in terms of incentives for capital investments as well resulting from trade or from the political competition and income comparison effects described below.

<sup>4</sup> In addition to technology diffusion, 'neighborhood' can also have an impact if there is regional political instability. Ades and Chua (1997) find that such political instability in a country's neighbors significantly reduces its own economic growth.

below) could also affect the ease of learning or copying technologies from the leader. There can be indirect distance effects through economic governance/policies. For example, if the leader country is a rival (militarily or otherwise) then there can be a need to ‘keep’ up technologically and economically, which creates an incentive to improve economic governance. The strength of such rivalries may depend on the distance between the nations.

The rest of the paper is as follows. Section 2 examines the potential roles that geographic and cultural distance can have on technology diffusion, both directly and indirectly. Section 3 presents a simple model that formalizes these ideas. Past and future trends in regional development are considered in section 4. Section 5 concludes.

## **2. Distance and Technology Diffusion**

Distance from a technological leader can be in terms of geography or culture. Geographic distance is a more straightforward concept and easier to measure directly than is cultural distance, although there can be some nuance involved. And in many circumstances geographic distance is related to cultural distance as well: countries that are close to one another are more likely to share similar cultural characteristics than countries that are far apart. A notable exception to this rule is, of course, the so called neo-Europes like the United States and Australia which are relatively distant from the core of European countries, yet are similar culturally. Any explanation of the long run diffusion of technology and development based solely on geographic distance will not be able to account for these European offshoots.

### **2.1 Geographical Distance**

Geographic distance from technological leaders can impact technology diffusion directly through international trade and investment. To the extent that new technologies are embodied in goods, higher volumes of imports of such goods can lead to faster diffusion of technology. Foreign direct investment can also be a source of diffusion, where both technology embodied in physical capital and tacit knowledge are transferred from leader countries to follower countries.

Although geographic distance can simply mean the distance between two countries, its meaning could be broader. Countries that have water-based access to each other could be effectively

closer, in terms of ease of trade, etc., than countries that are closer but can only use ground-based transportation. The effects of geographic distance on diffusion can also change over time as transportation and information technologies improve.

Gravity models have been used extensively to model the trade volume between countries as a function of their distance from each other and their respective 'mass', i.e. GDP. A prominent example of this sort of model on the growth side of the literature is Frankel and Romer (1999) who find, using fixed geographic characteristics of countries (including geographic distance from trading partners), that increased openness to international trade is associated with higher levels of income. Keller (2002), examining technology diffusion between major industrialized countries, finds that geographic distance from the innovating country substantially limits technology diffusion<sup>5</sup>. His estimates suggest that the majority of this is due to trade, with FDI and language issues accounting for the rest. Interestingly, he also finds that the degree of localization has fallen substantially over the time period examined, from 1970-1995, suggesting that geographic distance has, and most likely will continue to become, less important over time. Comin et al (2006) report a similar finding in that the speed of convergence in technologies across countries is significantly higher for post-1925 technologies than it was for pre-1925 technologies.

Geographic distance can also have indirect effects on technology diffusion through economic governance/policies. Political and military competition between nation-states can make it costly to fall behind rivals, creating additional incentives to promote technology adoption and improve economic governance<sup>6</sup>. The degree of political competition between two countries can depend on distance: close or bordering nations are more likely to be potential rivals. This sort of international rivalry has often been argued to have been part of the reason why technological innovation was sustained and spread in a politically fragmented Europe (see for example Jones (1987) for a classic exposition of this view). Such political competition effects have also arguably been present in East Asia as well. South Korea in particular provides an example of this. In the initial post WWII era, according to Lie (1998, p58), "despite expressions of Korean superiority, most South Koreans recognized that Japan was years, perhaps decades, ahead of

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<sup>5</sup> For a review of the extensive technology diffusion literature see also Keller (2004).

<sup>6</sup> See Chaudhry and Garner (2006) for a model in which a government's incentives to block technological innovations are reduced by the presence of a potential military rival.

South Korea. The sense of inferiority, combined with anticolonial, nationalist sentiments, undoubtedly motivated many South Koreans to do all they could to catch up.” And according to Benjamin (1982, p1112) “South Korea made this choice [export-led growth] because it was overshadowed by its giant neighbor Japan, desperate for foreign earnings, and weak economically in the face of North Korea – a determined enemy.”<sup>7</sup>.

## **2.2 Cultural Distance**

As noted above, any explanation based on geography alone cannot explain the pace of technology diffusion between Europe and the neo-Europes. Using some measure of ‘cultural distance’ can help overcome this problem. Culture can be defined in different ways. One broad definition is that it represents the informal social norms that govern how individuals and groups interact with one another. Culture can include (but is not necessarily limited to) language, religion, sense of community and identity, attitudes towards the economy, government, change, risk, science, class, gender, and race. Being close culturally to a technology leader may speed up the process of technology adoption by reducing any existent cultural barriers to the learning process. This can happen, for example, if a common language, worldview, or pre-existing networks through family, business, science, education, etc. facilitate the flow and understanding of information. Take again the case of Korea, which in the post WWII era was able to exploit for its own economic benefit its proximity to Japan. According to Lie (1998, p61) “The founder of Samsung, Lee Byung-chull, for example, was educated in Japan and made frequent and extended visits to Japan in order to see his mistress in Tokyo, to sustain business contacts, and to observe the Japanese economy firsthand. As the president of Samsung’s trading company told an American reporter in the late 1980’s: ‘When [Lee] returned from Japan, he would gather directors of relevant companies and tell them about his ideas,’ including Japanese management techniques,” Again quoting Lie (1998, p59) “South Korean business people, in particular, adopted Japanese idioms and mannerisms. Japanese corporate cultural practices could be found in various South Korean settings”. Such observations and adoption of Japanese business practices were in no doubt facilitated by pre-existing social ties, some which dated back to Korea’s colonial past.

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<sup>7</sup> For a more extensive discussion of the case of Korea see Garner (forthcoming).

There can also be indirect effects through governance. If relative income matters to individuals and people in a foreign country are part of the reference group used for comparisons (because of cultural similarities), then a sense of falling behind in living standards can reduce public support for the current government and contribute to political instability. This could provide additional incentive for a government to pursue growth enhancing policies, or it could lead to a regime change resulting in a more growth orientated government<sup>8</sup>. Thus cultural proximity could lead to similarities in governance as well.

Any empirical work on culture and economic growth must first produce a measurable definition of culture, or at least those aspects of culture that are economically relevant. An interesting and provocative paper by Spolaore and Wacziarg (2006) can be viewed as an attempt to measure cultural distance and its effects on income. They do this by using a measure of genetic distance. Genetic studies have allowed measures of genetic distance between populations to be calculated, where the ‘distance’ corresponds biologically to how long the respective populations have been separated. Spolaore and Wacziarg (2006) find, in pairwise comparisons, that this measure of genetic distance is positively and significantly correlated with differences in income per capita, both current and historical. This remains true even if a wide array of relevant geographical and historical factors are controlled for, including language and religion. The authors interpret these results as evidence for some sort of cultural barriers to the diffusion of development. Under this interpretation countries that are close together in a cultural sense tend to develop together over the long run. It is important to note that their work does not provide a hierarchy of genetic types that are best for technological innovation, they only argue that genetic distance from technology leaders (whoever they may be) tends to slow the process of technology diffusion.

### **3. A Model of Technology Diffusion, Distance, and Economic Governance**

Models of technology diffusion typically hinge on the assumption that the cost of copying is less than the cost of inventing (see for example Barro and Sala-i-Martin (1997), Klenow and Rodriguez-Clare (2005)) so that technology growth can (temporarily) be higher in a follower country than in the leader. Spolaore and Wacziarg (2006), in addition to their empirical work,

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<sup>8</sup> See Garner and Chaudhry (2007) for historical examples of these ‘income envy’ effects and a model of income comparisons between countries and economic growth.

present a model of technology diffusion based on genetic distance (or according to their interpretation cultural distance). Goodfriend and McDermott (1998) present a model in which ‘familiarity’ with a foreign economy makes learning foreign technical knowledge easier. Such familiarity could be associated with having cultural similarities. Building on this previous work, this section presents a simple model of technology diffusion, where the pace of diffusion depends directly on geographic and cultural distance and on a measure of economic governance (economic policies regarding technology creation/imitation, investment, education, etc.). Governance itself can depend on distance through political competition and income comparisons effects. The quality economic governance is chosen by the government in order to minimize a loss function, where this loss depends on a country’s relative productivity level.

### 3.1 Setup of the General Model

There are  $N$  countries. Productivity growth can come from the diffusion of technology from other countries or from domestic sources. The quality of governance affects both the rate of technology diffusion from abroad and domestic technological innovation. Distance, both cultural and geographic, also affects technology diffusion. If trade (imports) is a channel for diffusion, then the volume of trade and the pace of diffusion can depend on the size of the source country’s economy. Technology diffusion is given by:

$$1) A_{it} = (1 + \mu_{it}\gamma_i)A_{i(t-1)} + \max_{j=1\dots N} \{(A_{j(t-1)} - A_{i(t-1)})(1 + d_{cij})^{-\alpha_1} (1 + d_{gij})^{-\alpha_2} f(Y_{jt})\mu_{it}\}$$

where  $A_{it}$  is productivity in country  $i$  at time  $t$ ,  $0 \leq \mu_i \leq 1$  is a measure of the quality of economic governance in country  $i$ ,  $\gamma_i \geq 0$  captures the potential (if any) for domestic innovation<sup>9</sup>,  $d_{cij}$  and  $d_{gij}$  are measures of the cultural and geographic distances between countries  $i$  and  $j$ ,  $\alpha_1, \alpha_2 \geq 0$  are measures of the degree to which distance matters for technology diffusion,  $Y_{jt}$  is the GDP of country  $j$  with  $0 \leq f(Y_{jt}) \leq 1$  and  $f'(Y_{jt}) \geq 0$ . Aggregate output in each country is given by the same production function  $Y = AL^\lambda$  with  $L$  representing labor and  $0 < \lambda < 1$ .

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<sup>9</sup> If the capacity for domestic innovation depends on the size of the domestic economy this could be replaced with  $\gamma_i(Y_i)$ .

Equation 1 has several important properties. For the leader country (the one with the highest level of  $A$ ) technology growth comes solely from domestic innovation<sup>10</sup>. Technology can diffuse directly from the world leader (if distance to world leader is small or if distance doesn't matter much) or through a regional leader (if distance to world leader is large and distance is relatively important). There is the possibility of domestically fueled productivity growth if  $\mu\gamma > 0$ . Economic governance,  $\mu$ , matters for both the diffusion and domestic creation of technology. If  $\alpha_1 = 0$  and  $\alpha_2 = 0$  then distance doesn't matter for technology diffusion. The economic size,  $Y$ , of a leader country can affect the rate of diffusion. If both distances from a leader country equal zero,  $\mu = 1$ , and the economic size of the leader is sufficiently larger ( $f = 1$ ) then there is complete technology diffusion from the leader in one period. And, as will be shown below, for a fixed  $\mu$  this formulation implies eventual convergence in growth rates.

Subject to equation 1, the government of country  $i$  chooses  $\mu_i$  in order to minimize the following loss function:

$$2) L_{it} = -\beta_{1i} \left( \frac{A_{it} - A_{i(t-1)}}{A_{i(t-1)}} \right) + \beta_{2i} \mu_{it} + \sum_{j \neq i} \left( \frac{A_{jt}}{A_{it}} \right) [\beta_{3i} (1 + d_{cij})^{-\alpha_3} + \beta_{4ij} (1 + d_{gij})^{-\alpha_4}]$$

where  $\beta_1, \beta_2, \beta_3, \beta_4, \alpha_3, \alpha_4 \geq 0$ . The first term on the right hand side captures the direct benefit of faster growth to the government, since a faster growth rate will result in lower loss. This could represent increased rents or tax revenue that accrue to the government as the size of the economy increases, and/or the increased consumption of the domestic population, which would matter for a benevolent social planner and also (possibly) for elected officials.  $\beta_{1i}$  would thus measure the direct importance of domestic growth to the government in country  $i$ . The second term captures that to improve or reform economic governance/policies in order to promote technology growth may be costly to the government. This could reflect direct costs such as providing research

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<sup>10</sup> The model makes the simplification that there is some aggregate technology level so that a country is either a leader or a follower. With multiple technology sectors a country could be a leader in some technologies and a follower in others.

subsidies, subsidizing education, building infrastructure to use new technologies, etc. It could also reflect political and rent-seeking costs. For example, improving economic governance may require limiting corruption and the paying of bribes and hence some of the rents captured by the government. Or opening the economy to foreign competition could hurt domestic interests on whose support the government relies upon.  $\beta_{2i}$  would thus measure how costly it is to improve economic governance in country  $i$ . The last term captures potential cross-country political competition and income comparisons effects. In this paper political competition will be associated with geographic distance and income comparisons with cultural distance<sup>11</sup>. The further behind a country falls relative to other countries, the larger the loss associated with political competition and/or with income comparisons.  $\beta_{3i}$  measures the importance of these income comparisons to the government.  $\beta_{4ij}$  measures the degree of political competition between countries  $i$  and  $j$ . This parameter could differ across country pairs depending on treaties, historical antagonisms, etc.  $\alpha_3$  measures the importance of cultural distance to the degree of income envy and  $\alpha_4$  measures the importance of geographical distance to the degree of political/military competition with rival states.

If income comparisons or political competition do not matter to the government, then the trade-off is simply between the costs of improving governance and the direct benefits from faster growth that can occur as a result of better governance. If improving governance is not costly then income comparisons and political competition considerations do not matter (in terms of affecting governance, and through governance, productivity – the government already chooses the ‘best’ policies/governance and needs no additional incentives), and the diffusion of technology will depend only (and directly) on distance. Note that even if distance doesn’t directly affect technology diffusion, it can still have an indirect impact. For example, if  $\alpha_1 = 0$  then cultural distance has no direct influence on diffusion, only geographic distance matters, but cultural distance through the income comparison channel could affect governance which in turn would affect technology diffusion.

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<sup>11</sup> The relationships could be more complex. For example, which countries are used as income reference groups could also depend on geographic distance.

Although in this model the government choice variable is limited to  $\mu$ , it could also be the case that a government can pursue policies that lessen its country's distance with technological leaders. Building and improving transportation infrastructure could lessen effective geographic distance. Cultural distance (at least those aspects of culture important of technology diffusion) could conceivably be influenced by government policies that promote such things as sending students abroad for their education, adoption of some of the social values of the leaders, encouraging a scientific culture, etc. For example, the Japanese government, beginning in the second half of the 19<sup>th</sup> century, made active efforts to 'Westernize' certain aspects of their country, especially with regards to establishing a scientific culture and active observation of Western business and government forms<sup>12</sup>. Political competition considerations (in the form of U.S. warships arriving off the coast in 1854) seem to have been the principle factor in spurring this, and other economic and political reforms, so as to close the technological and military gap with the West<sup>13</sup>.

### 3.2 Two Country Case

Consider first for simplicity a two country case where country 1 is the leader country (in the sense of having a higher initial level of productivity and domestic innovation) and country 2 is the follower. Suppose that  $\gamma_2 = 0$  (no domestic innovation for follower), and  $f(Y_{1t}) = 1$ . All parameters will refer to country 2 so parameter country subscripts are dropped. Then we have for the follower:

$$1') \quad A_{2t} = A_{2(t-1)} + (A_{1(t-1)} - A_{2(t-1)})(1 + d_c)^{-\alpha_1} (1 + d_g)^{-\alpha_2} \mu_t$$

$$2') \quad L_{2t} = -\beta_1 \left( \frac{A_{2t} - A_{2(t-1)}}{A_{2(t-1)}} \right) + \beta_2 \mu_t + \left( \frac{A_{1t}}{A_{2t}} \right) [\beta_3 (1 + d_c)^{-\alpha_3} + \beta_4 (1 + d_g)^{-\alpha_4}]$$

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<sup>12</sup> Of course this cultural assimilation was not, and did not need to be, complete. Which specific cultural aspects are relevant for technology diffusion and which are not is unfortunately still not well understood. Eating British-style food likely had no effect on the ease of copying British technology in the 19<sup>th</sup> century. But adopting an education system and world view grounded in modern science likely did.

<sup>13</sup> Why this occurred, and was successful, in Japan but not (to the same degree at least) in other non-European countries similarly threatened by Western expansion is a more difficult question to answer.

Substituting for equation 1' into equation 2' we get:

$$L_{2t} = -\beta_1 \left( \frac{A_{1(t-1)}}{A_{2(t-1)}} - 1 \right) (1+d_c)^{-\alpha_1} (1+d_g)^{-\alpha_2} \mu_t + \beta_2 \mu_t + \frac{A_{1t} [\beta_3 (1+d_c)^{-\alpha_3} + \beta_4 (1+d_g)^{-\alpha_4}]}{A_{2(t-1)} + (A_{1(t-1)} - A_{2(t-1)}) (1+d_c)^{-\alpha_1} (1+d_g)^{-\alpha_2} \mu_t}$$

The marginal loss of  $\mu$ , which could be positive or negative, is given by<sup>14</sup>:

$$3) \frac{\partial L_{2t}}{\partial \mu_{2t}} = -\beta_1 \left( \frac{A_{1(t-1)}}{A_{2(t-1)}} - 1 \right) (1+d_c)^{-\alpha_1} (1+d_g)^{-\alpha_2} + \beta_2 - \frac{A_{1t} [\beta_3 (1+d_c)^{-\alpha_3} + \beta_4 (1+d_g)^{-\alpha_4}] (A_{1(t-1)} - A_{2(t-1)}) (1+d_c)^{-\alpha_1} (1+d_g)^{-\alpha_2}}{[A_{2(t-1)} + (A_{1(t-1)} - A_{2(t-1)}) (1+d_c)^{-\alpha_1} (1+d_g)^{-\alpha_2} \mu_t]^2}$$

The first two terms capture the domestic factors that influence government loss and the third term captures the international factors. Changes in distance or parameter values can have direct effects on technology diffusion (equation 1') and indirect effects through governance (equation 2'). All of the examples below assume an interior solution to the government's problem.

Example 1: Suppose that  $\alpha_2$  decreases so that geographic distance matters less for diffusion. Then the direct effect on technology diffusion in equation 1' is positive. The direction of the indirect effect through governance, however, is ambiguous: the decrease in  $\alpha_2$  causes the marginal loss associated with the 1<sup>st</sup> term in equation 3 to decrease, but the marginal loss associated with the third term can either increase or decrease depending on the size of the potential productivity gain from diffusion relative to initial the income of country 2 (*appendix with proof to be added*). The decrease in the importance of geographic distance to technology diffusion may diminish the political competition effect by shrinking, other things being equal, the gap between leader and follower.

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<sup>14</sup> It is assumed, for simplicity, that the government cares only about its current loss, i.e. the effects of choosing  $\mu_t$  on future losses are not taken into account, or equivalently that there are only one period  $t$ , with  $t-1$  values given.

Example 2: Suppose that  $\beta_3$  increases so that the income comparison effect is stronger. In this case there is no direct effect on technology diffusion from the leader, only the indirect effect through governance, which will be positive and will result in a higher level of  $A_{2t}$ .

Example 3: Suppose that  $\beta_2$  decreases so that the cost of improving economic governance falls. This could be the result of the coming to power of a government that is less corrupt and hence would face lower costs from reducing corruption, or is more stable and can survive better any instability that may result from economic reforms (for example the opening of an economy). As in the previous example there are no direct effects on technology growth. The indirect effect is to improve governance and hence improve technology diffusion. Thus there is a role in the model for exogenous government regime changes, where individual leaders and their attitudes to economic reforms can matter<sup>15</sup>.

If  $(1 + d_c)^{-\alpha_1} (1 + d_g)^{-\alpha_2} \mu_{2t} \equiv \Delta$  is constant over time and given a constant growth rate of

productivity  $\left(\frac{A_{1(t+1)} - A_{1t}}{A_{1t}}\right)$  in the leader country, then the model possess the well-known

convergence property that the ratio of productivity levels  $\frac{A_1}{A_2}$  converges to a steady state value.

This implies that in the long run the growth rate of productivity in the follower country will equal that of the leader. This convergence is depicted in figure 2.

### 3.3 Diffusion through Regional Leaders

When there are more than two countries, technology can diffuse directly from the world leader or indirectly through a regional leader (regional in the sense of being close geographically and/or culturally). In the model diffusion through a regional leader, rather than the world leader, is more likely if:

- i) distance has large direct effects on diffusion (large  $\alpha_1$  and  $\alpha_2$ )

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<sup>15</sup> A cross-country study by Jones and Olken (2005) uses deaths of national leaders while in office as a source exogenous variation in leadership. They find that these leaderships changes are significantly associated with transitions in economic growth rates, especially in autocratic settings.

- ii) the regional leader has a large economy ( $f(Y)$  close to 1)
- iii) political competition and income comparisons effects are strongly local (large  $\alpha_3$  and  $\alpha_4$ )  $\rightarrow$  low relative income to world leader does little to spur improved economic governance, but low income as compared to the regional leader can be important)
- iv) the political competition effect with the regional leader is relatively stronger than that with the world leader ( $\beta_4$  with regards to the regional leader is larger than  $\beta_4$  with regards to the world leader)
- v) the gap in productivity levels between the world leader and the regional leader is small ( $\frac{A_{world\ leader}}{A_{regional\ leader}}$  is small)  $\rightarrow$  the regional leader is a good source of technology

Consider figure 3, where country 1 is the world leader, country 2 is the regional leader, country 3 is a follower,  $\gamma_{3t} = 0$  and  $(1 + d_{cj3})^{-\alpha_1} (1 + d_{gj3})^{-\alpha_2} \mu_{3t} \equiv \Delta_{j3}$ . The (combined) distance from country 2 to country 3 is less than the distance to country 1. This is represented in the figure by having  $\Delta_{23} > \Delta_{13}$ . In this figure the regional leader is relatively backward and country 3 is better off adopting technology directly from the world leader. The opposite is true in figure 4, where the regional leader is relatively advanced so that country 3 can achieve faster growth by instead adopting technology from this regional leader.

Another condition for being a regional leader is that the country's growth experience must be able to be replicated in neighboring countries. If the growth was a result of technology adoption/innovation and capital accumulation then this sort of development can generally be copied<sup>16</sup>. For some countries a large percentage of their income per capita is attributable to natural resource wealth. Countries whose growth depends on natural resources cannot play this sort of regional leader role, since their growth experiences cannot be replicated in countries lacking such endowments<sup>17</sup>.

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<sup>16</sup> Some technologies may not be appropriate for all countries. Certain technologies may require high levels of capital per worker (for example new software for auto assembly line robots) or may be geography specific (new varieties of some agricultural products). See Basu and Weil (1998) for more on appropriate technologies.

<sup>17</sup> A possible exception to this rule could occur if the resource abundant country uses its wealth to fuel domestic capital accumulation and technology adoption thus eventually emerging as an industrial, as well as natural resource rich, economy.

## 4. Regional Patterns of Development: Past and Future

### 4.1 Past Patterns

A clear and well known example of common regional long run growth is Western Europe and the neo-Europes (see figure 5, all data in figures 5-12 taken from Maddison (2007)). Since at least 1870 there has been convergence among this group of countries. Note that the model of technology diffusion presented above (and most models of technology diffusion) does not necessarily imply convergence in productivity/income levels, instead there is convergence in long-run growth rates so that distribution of income levels (log) stays within certain bounds. This group of countries also fits the requirements of the model for easy technology diffusion: generally good governance, the presence of international rivalries (in the past explicitly military, today perhaps more political and in terms of living standards), within the Europe close geographic distance, arguably close cultural distances in terms of attitudes to science, education, governance, and technology, and democratic states where there is arguably a relatively large political payoff to economic growth (large  $\beta_1$  in the model).

Western Europe is not the only region in the world to display such common long run growth patterns. Take the selection<sup>18</sup> of Eastern European countries depicted in figure 6, also going back to 1870. Here we see that these countries did follow similar growth patterns. This also generally holds as well for a group of Latin American countries (figure 7), East Asian countries (figure 8), and South Asian countries (figure 9). Long run growth in the three North American countries, Canada, the United States, and Mexico also conforms broadly to the model (figure 10). There is no substantial long run divergence in income levels (log). Although geographic distance to the leader country, the U.S., is the effectively the same for Canada and Mexico, the cultural distance is arguably closer for Canada and its governance better, so its income level should be closer to that of the U.S. The most significant break of Mexico's growth with its northern neighbors occurs after 1980 (the debt crisis, etc.). The model (and most models of technology diffusion) would predict that when the productivity gap with the U.S. and Canada becomes large enough,

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<sup>18</sup> The selection of countries in Eastern Europe, Latin America, and East Asia is based on having data available going back to either 1870 or 1900 in Maddison (2007).

eventually growth in Mexico should pick up again so that there will be no significant long run divergence in incomes<sup>19</sup>.

A pattern of common growth is less visible in the Middle East and North Africa (figure 11) and in sub-Saharan Africa (figure 12), but this is to be expected given the prominent role of natural resources in the economies of many of these countries.

*More formal tests of long run regional growth patterns*

## **4.2 Possible Future Trends**

Using the model presented above as a framework, this section offers some speculation about future trends in regional development. As discussed above, the empirical evidence suggests that geographic distance is becoming less important over time in determining the pace of technology diffusion. This could be captured in the model as decreases in the parameter  $\alpha_2$  as transportation and telecommunications technologies improve. Cultural distances between countries could also be changing over time, at least with regards to cultural factors that affect technology diffusion. At the world level, the model would therefore suggest that we should see increasing convergence in income levels and long run growth rates as the world becomes a ‘smaller’ and, perhaps in certain regards, a more ‘uniform’ place.

For Europe and most likely for East Asia as well there is no reason to believe that past convergence trends will not continue in the future, at least in long run terms.

If the comparatively recent acceleration in economic growth in India is sustained<sup>20</sup>, the model would suggest that eventually India’s growth would pull along neighboring countries like

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<sup>19</sup> Perhaps the cultural distance between the U.S. and Mexico will be decreasing in the future as the U.S. absorbs an increasing number of Mexican immigrants. If this occurs then the model would predict a temporary acceleration in growth in Mexico and a permanent narrowing of the income gap with the U.S.

<sup>20</sup> See Kochhar et al (2006) for a discussion of India’s past growth and future prospects, and Bosworth and Collins (2008) for an comparison of China’s and India’s growth performance. Although India faces some impediments to sustainable growth, for example in infrastructure and education, both sets of authors argue that relatively high growth rates are achievable for the immediate future

Pakistan and Bangladesh as well. India has a very large economy and its recent growth is not natural resource based, so it could act as an industrializing regional leader. Certainly political competition effects are present between India and Pakistan, and income comparisons effects may be a factor as well.

Chile has had the fastest sustained growth of any Latin American country over the last few decades. Could it become a regional leader for South America? Although Chile has made broad based improvements in governance and is considered to be a 'poster-child' for successful economic reforms, the relatively small size of its economy and current dependence on natural resource exports (especially copper) may limit the role it could conceivably play. Perhaps income comparisons considerations could eventually have an impact on neighboring countries, especially Argentina. If average income becomes significantly higher in Chile than in Argentina, this could, through domestic discontent, spur economic policies changes in Argentina in order to try to 'keep-up' with its neighbor in terms of living standards. Brazil, due to its size and diversity of its economy, has always had the potential to become a regional economic leader that stimulates broad based economic development in its neighbors, but to date it has not been able to fully assume this role. If Brazil did begin again to grow rapidly in a sustained fashion, then the model would predict that this could act as a catalyst for the entire region.

The presence of abundant natural resource wealth in the Middle East complicates any predictions based on this paper's model, since natural resource fueled growth is not replicable unless a country has abundant natural resources to begin with. Given this, there is no clear candidate for a future regional economic leader. Some of the oil rich Persian Gulf states like Qatar and the UAE have been recently been attempting to move their economies beyond oil dependence by fostering financial markets, industry, etc. These developments can have beneficial economic effects on the region, but the inherently small size of these economies limits their potential role as regional industrializing leaders even if they successfully. A larger oil state that went through such diversification of the economy could be a better candidate. What about Israel? It is the richest non-oil state in the region, and has a reasonably diversified, high technology economy. Political competition effects on neighboring states could be a significant factor as well. The size issue

crops up here again, but perhaps equally significant could be cultural distance from its neighbors which could slow diffusion (and trade) and lessen any income comparisons effects.

The situation in sub-Saharan Africa is likewise complicated. This is partly due to the same natural resource issues, which are important for many countries in this region. Botswana has often been hailed as an “African success story” (Acemoglu et al (2003)), but could not become a regional leader because of its small size and dependence on natural resources (diamonds). Although mining industries are also important in South Africa, its larger size and more diversified economy make its potential as a regional leader higher. But its slow post WWII growth and cultural distance with most other African nations while under apartheid limited the role it actually played. With the end of apartheid and the recent acceleration in economic growth this may change in the future, although significant structural problems remain (see Rodrik (2006) for an analysis of some of these problems especially regarding the tradable sector of South Africa’s economy).

A final speculation is on the implications of the model for foreign aid. If foreign aid could be effective in raising economic growth rates (and the recent empirical literature to date suggests it may not be, see for example Easterly (2003)), then the model would suggest that the aid should be concentrated on helping a potential regional leader country, like South Africa, transition to sustained broad based growth. As this potential regional leader grows and the gap between its technology level and that of neighboring countries increase, growth will eventually spillover to these neighboring countries as well. For example, suppose that a donor country is considering giving aid to a group of underdeveloped countries to which, because of distance, technology naturally diffuses only very slowly from the world leader(s). Suppose further, for exposition sake, that all of the recipient countries start with the same technology level, have good economic governance (perhaps a precondition for the aid) so that distance is the main barrier to technology diffusion, and that the distance (geographic and cultural) between them is small. The aid is in the form of technology. The donor country can either give equal amounts of aid to all of these countries, which would double each country’s individual technology level, or it can give all of the aid to just one country who has the potential of being a regional leader (large), which would triple its technology level. If the latter strategy is followed, then the new technology will diffuse

relatively rapidly from the regional leader to its neighbors, since distances are small, leading to a tripling of their technology levels as well. The aid would thus be more effective if it is concentrated in this fashion, at least from a longer run perspective.

## **5. Conclusion**

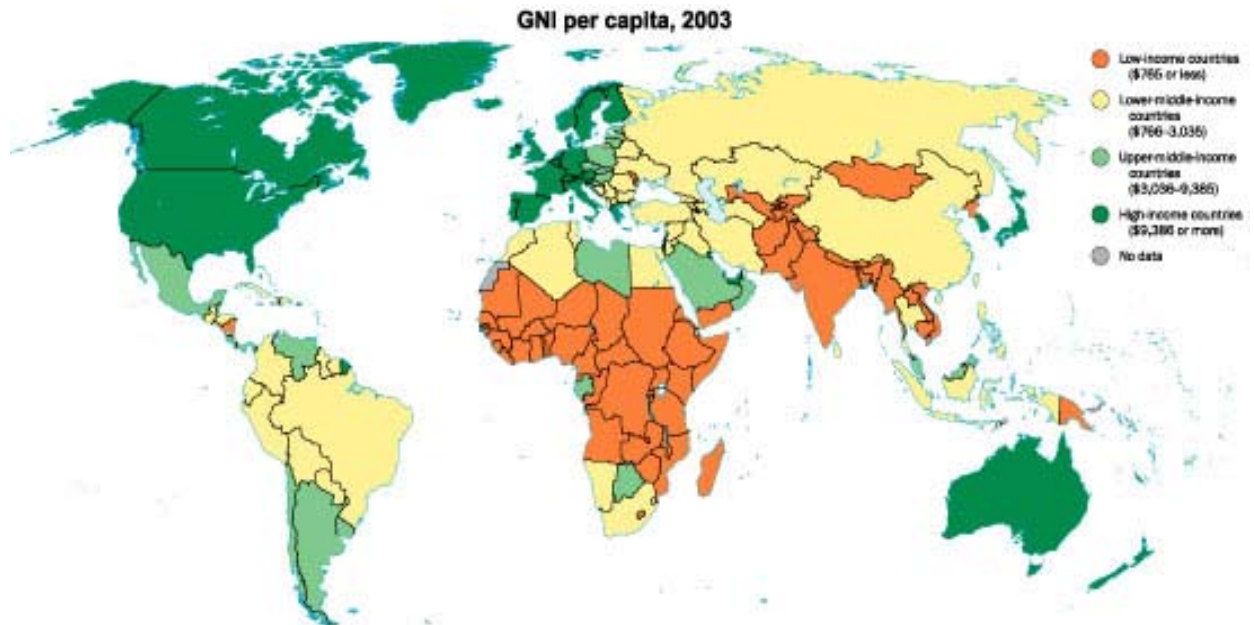
The long run economic development of a nation can depend significantly on the development of its neighbors. If technology diffusion depends on geographic and/or cultural distance, as recent empirical work suggests, then we would expect to see broad regional patterns in long run development. The historical record does provide evidence of such patterns. The presence of a large regional industrializing leader can act as a catalyst, stimulating economic growth in neighboring countries. To account for these trends this paper presents a simple model of technology diffusion based on geographic and cultural distance, where distance can have direct effects and also indirect effects through governance. The model does not however account endogenously for why a initial leader begins industrializing.

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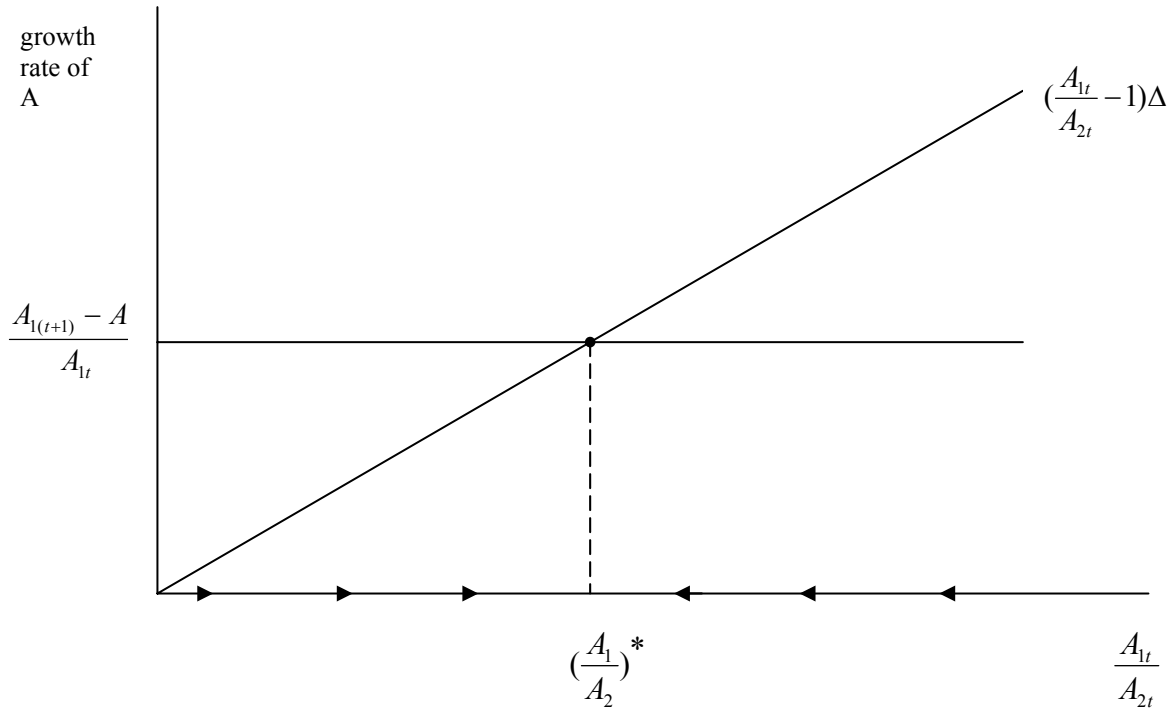
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**Figure 1**

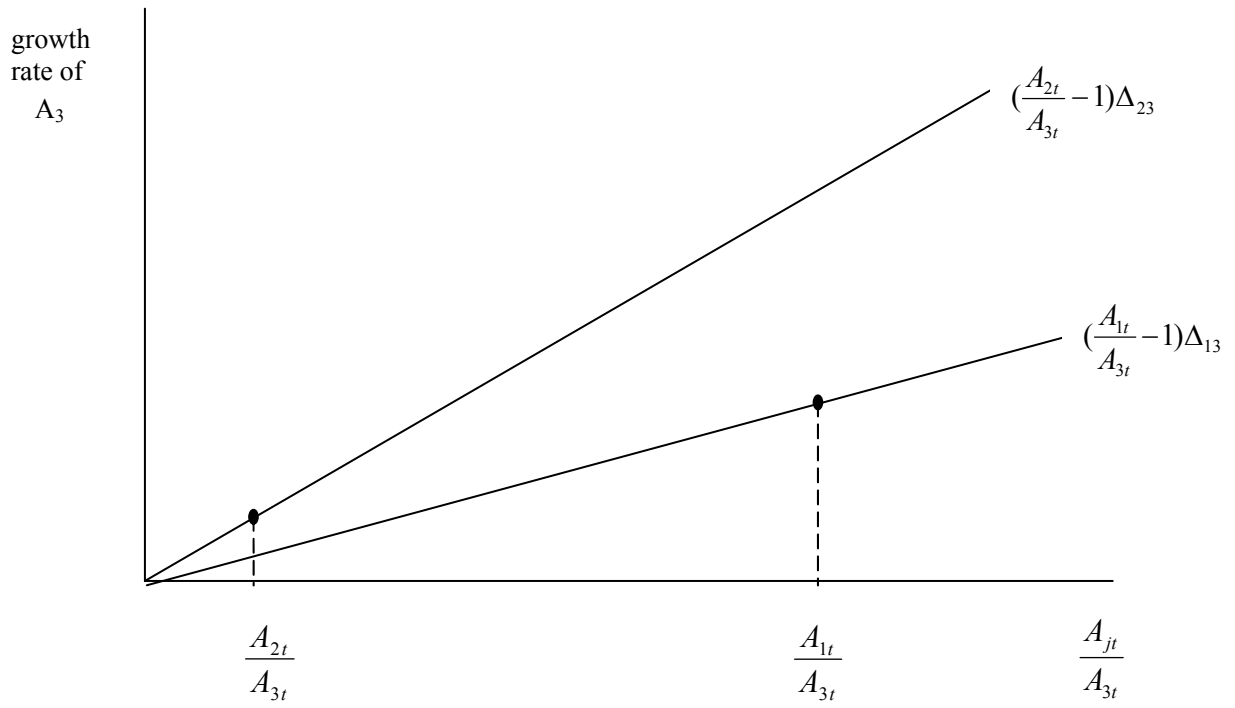


source: World Bank

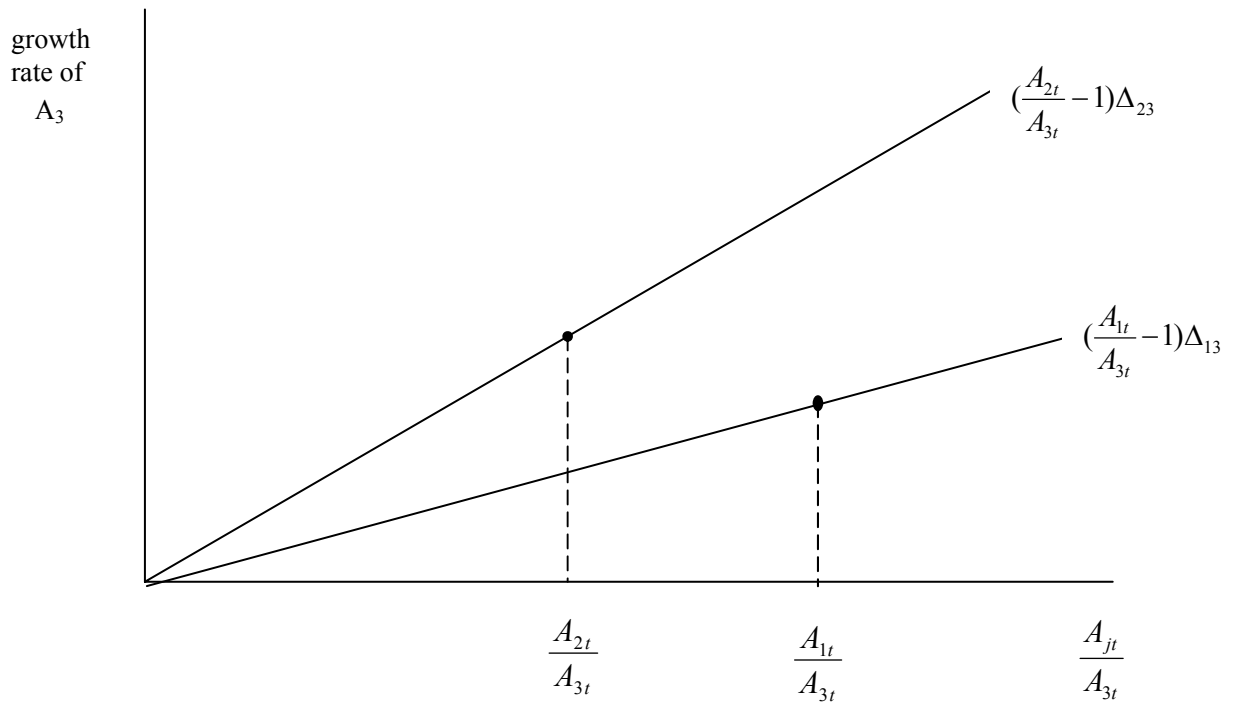
**Figure 2**



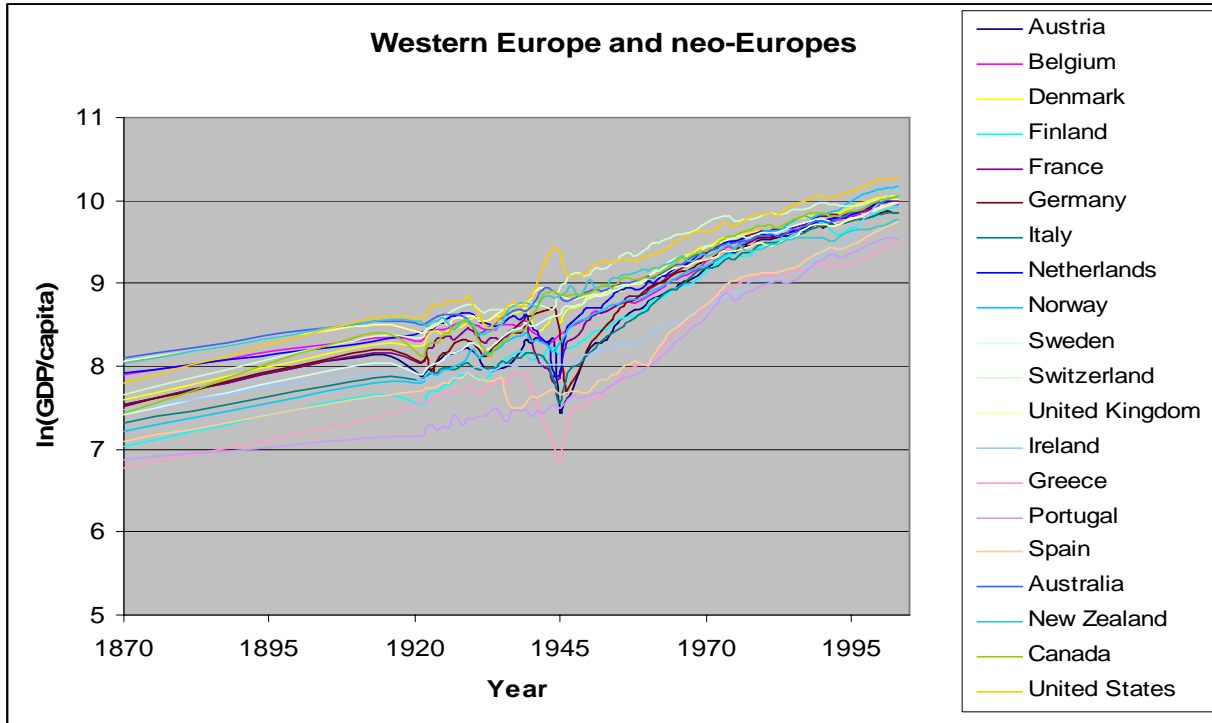
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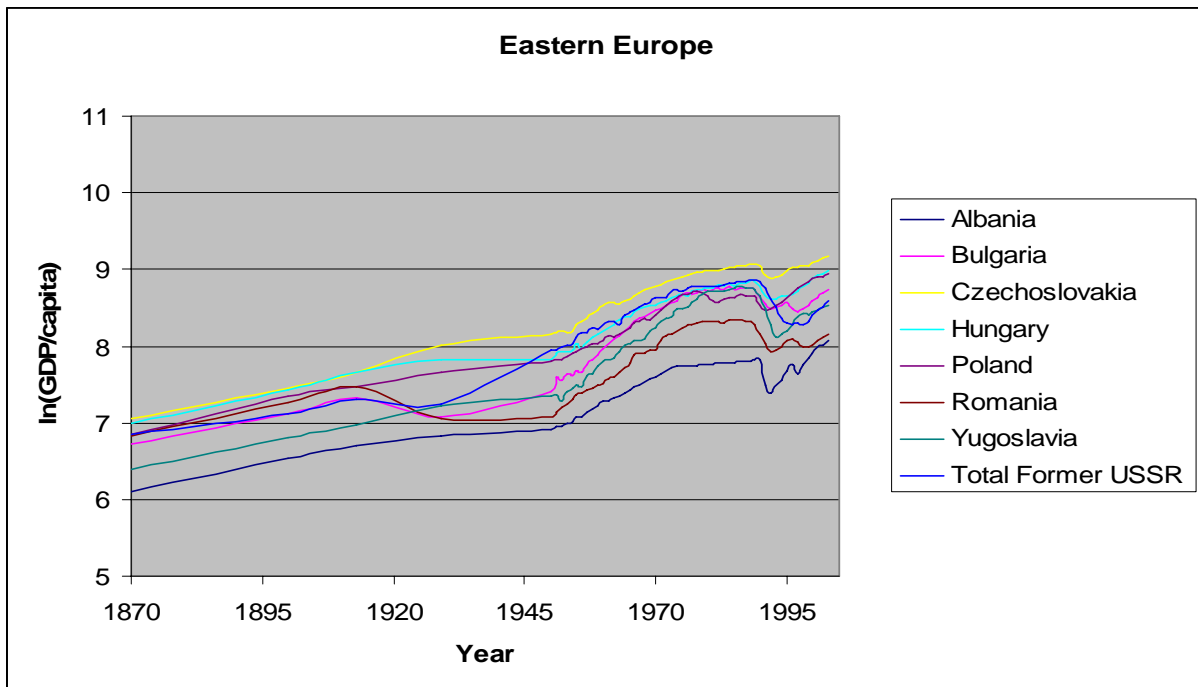
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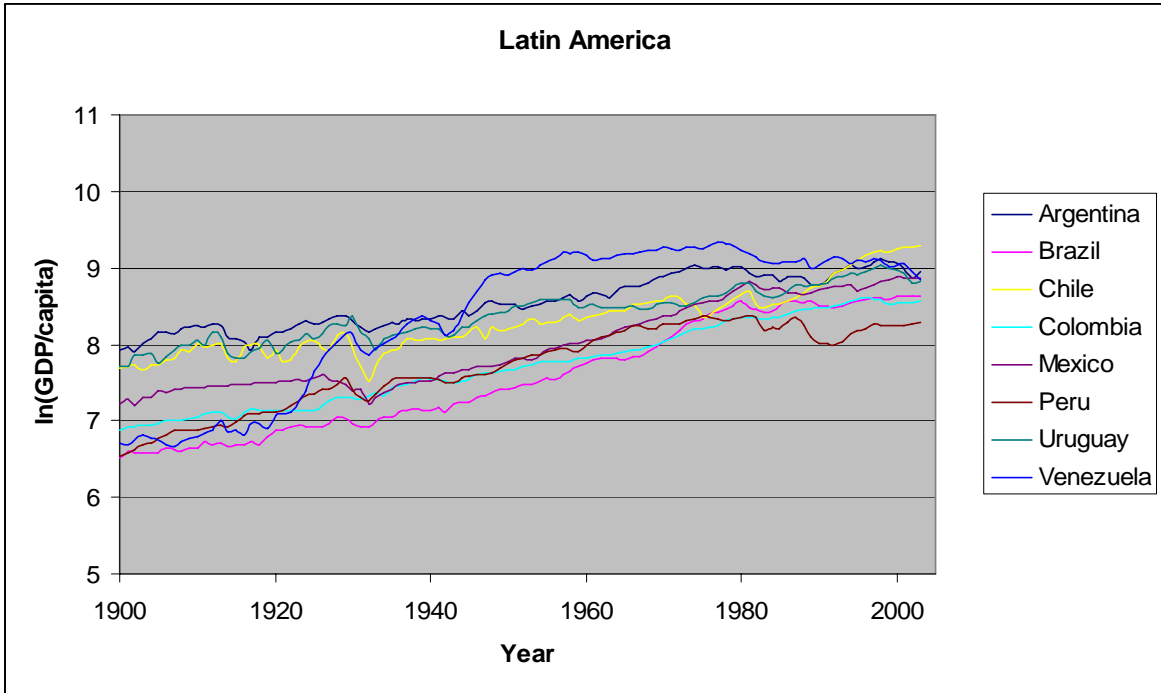
**Figure 5**



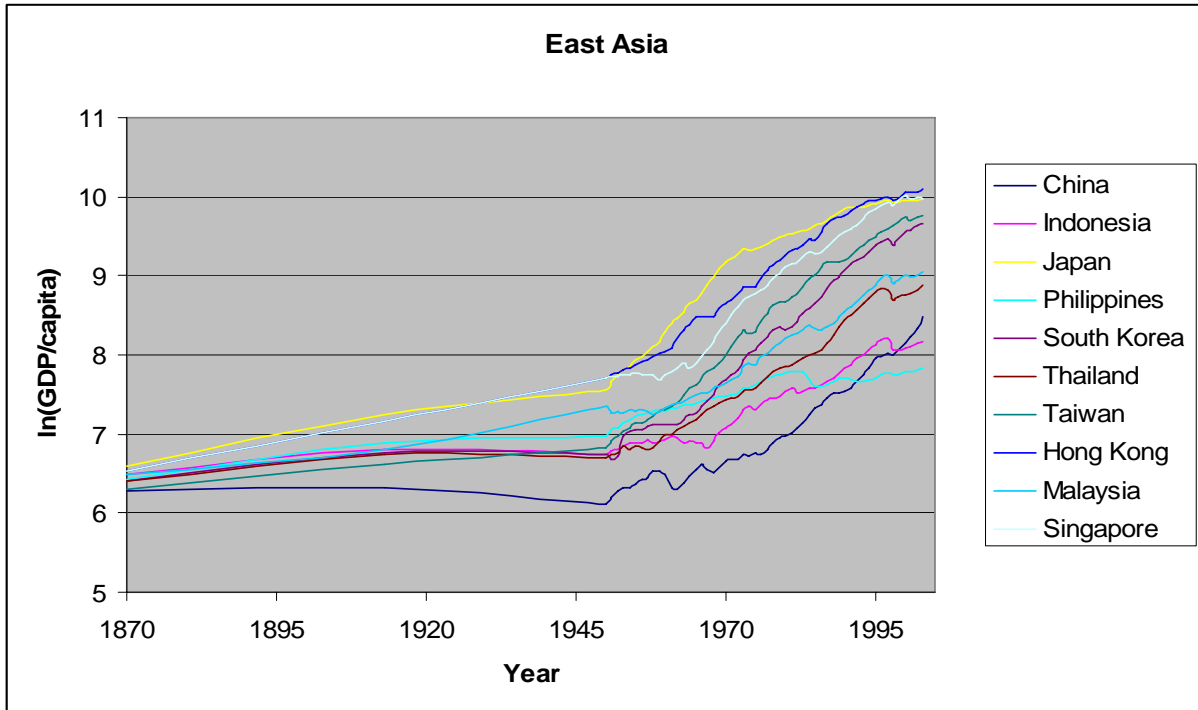
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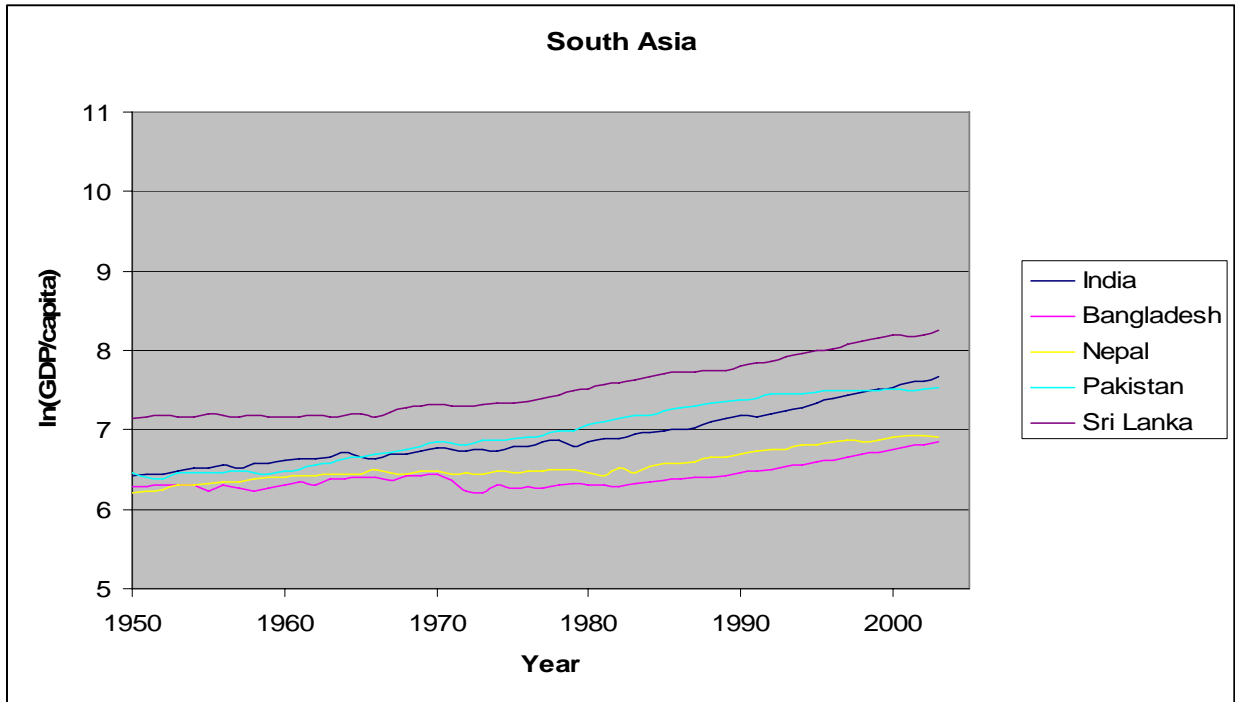
**Figure 7**



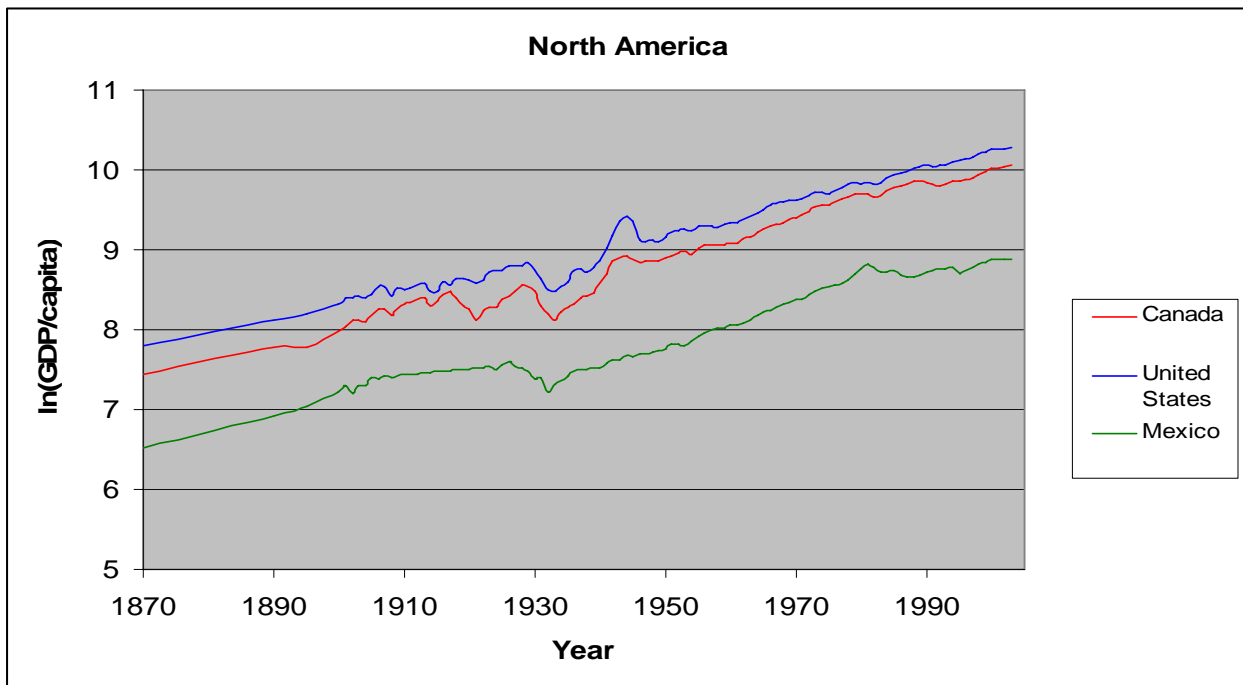
**Figure 8**



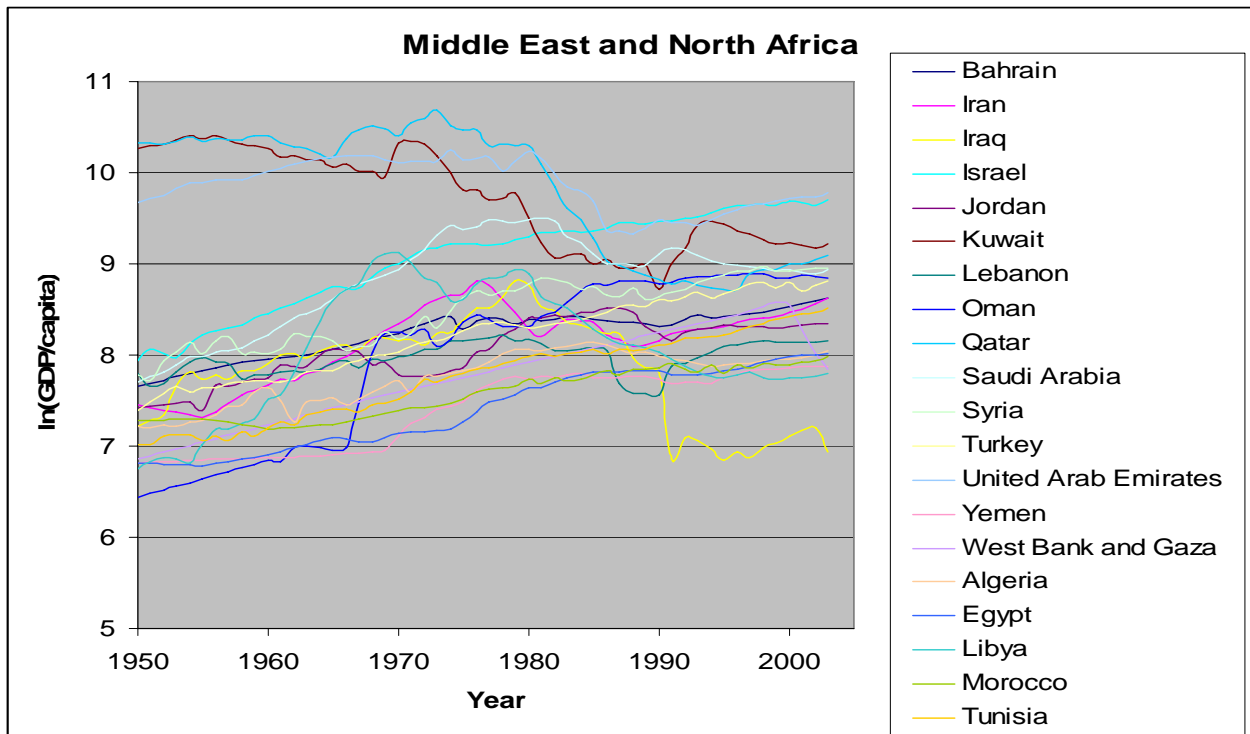
**Figure 9**



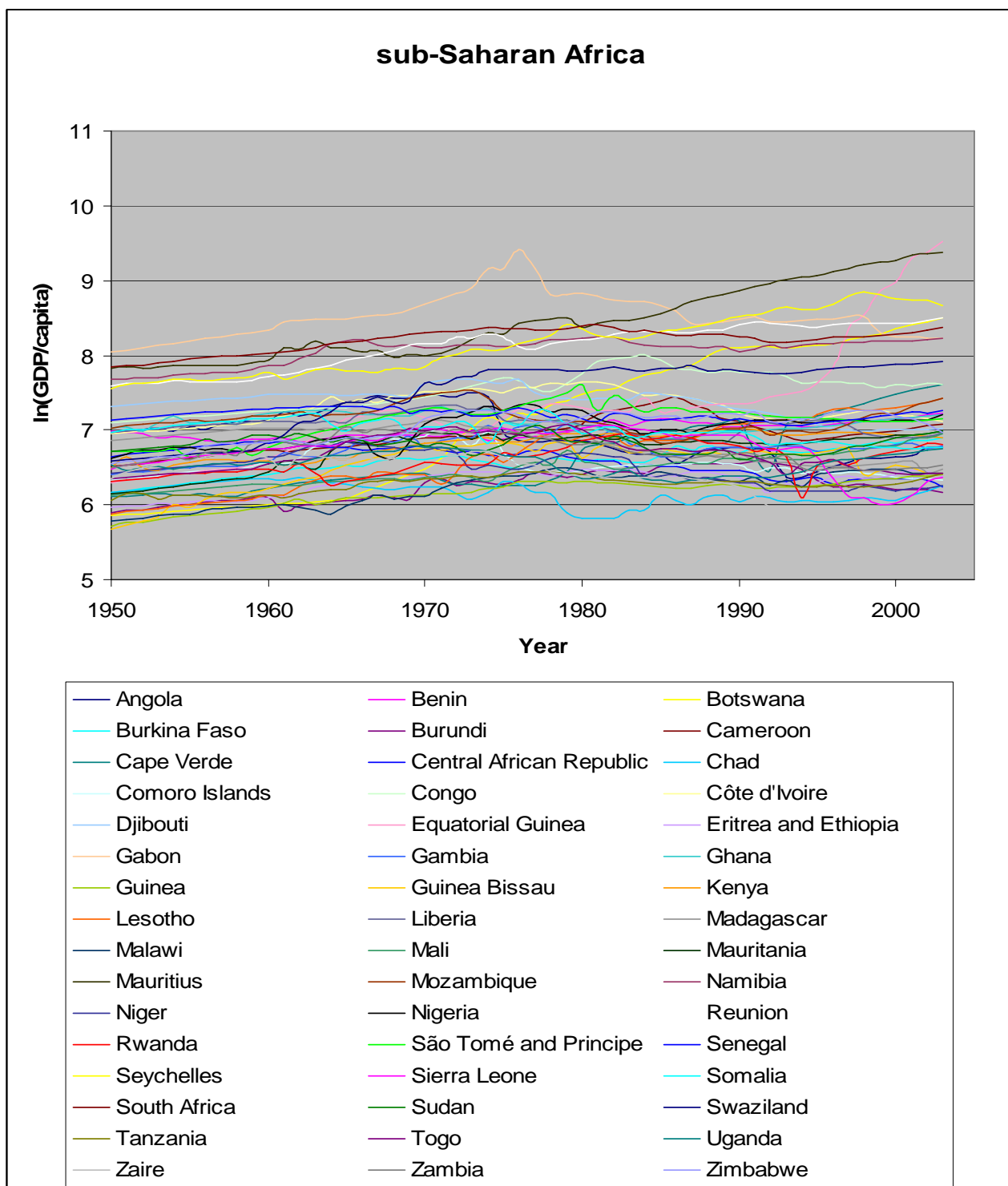
**Figure 10**



**Figure 11**



**Figure 12**



source for figures 5-12: Maddison (2007)