Chapter 1

# The Convergence Paradox: The Global Evolution of National Innovation Systems

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## Introduction

The investigation of the reasons behind cross-country differences in the creation and international diffusion of advanced knowledge constitutes, in a nutshell, the main interest of the national innovation systems (NIS) approach (Lundvall 1992; Nelson 1993; Edquist 1997). Studies in this tradition have become increasingly popular in the last two decades, and have greatly enriched our understanding of the functioning and evolution of nations' capabilities and competencies. In addition to the great variety of theoretical insights that the systemic perspective has made it possible to achieve, several empirically oriented studies have also tried to operationalize the approach by measuring different aspects of the process of knowledge creation and dissemination in a large sample of countries, and by investigating the extent of cross-country differences (Archibugi and Coco 2004).

Several empirical studies in this tradition are rooted in the traditional literature on technology and convergence (Abramovitz 1986; Verspagen 1991; Fagerberg 1994). Following a technology-gap Schumpeterian approach, applied econometric studies have focused on a few key variables that explain cross-country differences in the innovation ability of countries as well as their different capabilities to imitate foreign advanced knowledge, and analyzed the empirical relationship between innovation and imitation factors and cross-country differences in GDP per capita growth (Fagerberg and Verspagen 2002; Fagerberg, Srholec, and Knell 2007; Castellacci 2008; Castellacci and Archibugi 2008).

Most of this empirical research, however, has so far focused on the cross-country comparative aspect ("why growth rates differ") and mostly neglected the time

*The Handbook of Global Science, Technology, and Innovation*, First Edition.
Edited by Daniele Archibugi and Andrea Filippetti.

series dimension and the analysis of the dynamics of the technological catch-up and economic growth process over time. Further, an exceptional amount of research has been devoted to the study of the determinants of GDP and income per capita growth. By contrast, only a limited number of studies have empirically investigated the dynamics of innovative capability and absorptive capacity over time and the main factors that may explain their long-run evolution (Castellacci 2011; Filippetti and Peyrache 2011; Castellacci and Natera 2013). Thirdly, applied research in this field has so far provided a rather stylized view and highly simplified operationalization of the multidimensional concept of innovation systems, typically focusing on a few key variables (e.g., R&D, patents, human capital) and neglecting several other potentially relevant factors. In short, the existing literature provides only limited insights on the global evolution of national systems of innovation and the mechanisms that may explain their evolution and growth over time. This is a crucial task for future research in this field, and the present chapter intends to take a step in this direction.

Motivated by this background, this chapter presents an empirical analysis of the global evolution of national innovation systems. The objective is to carry out a general and comprehensive study aimed at describing the cross-country distribution of a large number of technological, economic, and social factors that broadly contribute to define national systems of innovation, and how these factors have evolved during the period 1980–2008. The work focuses on six main dimensions characterizing NIS, three of which are related to the techno-economic domain (innovation and technological capabilities, openness, and infrastructures), while the other three define countries' socio-institutional system (education, political institutions, and social cohesion). We adopt a large number of statistical indicators to measure these six conceptual dimensions. These indicators are from the CANA database, a newly released dataset that provides a rich set of information on a large number of countries worldwide for the last three-decade period, and enables a dynamic cross-country analysis of national systems, growth, and development (Castellacci and Natera 2011).

The results of our empirical analysis, in short, point out a contrasting pattern that we call the *convergence paradox*. On the one hand, the three dimensions defining the socio-institutional system – basic education, political institutions, and social cohesion – have experienced a process of worldwide convergence. On the other hand, however, the three dimensions related to the techno-economic system have experienced a marked divergent dynamics with increasing polarization between rich and poor country groups. The paradox we outline is therefore that national systems have progressively become more similar in terms of their socio-institutional frameworks while at the same time diverging and becoming more different with respect to their techno-economic pillars.

Admittedly, the objective and nature of this work is descriptive rather than analytic. The chapter does not intend to analyze the interactions and complex coevolutionary process that links together the techno-economic and socio-institutional variables that define national systems. Rather, as other contributions in this volume, we seek to provide a comprehensive and empirically founded overview of a key issue in the study of global science, technology, and innovation systems.

## Literature and Conceptual Framework

### *Empirical Studies on National Innovation Systems (NIS)*

NIS are key drivers of economic growth and competitiveness. The NIS perspective originally developed during the 1990s to understand the broad set of factors shaping the innovation and imitation ability of countries, and how these factors could contribute to explain cross-country differences in economic growth and competitiveness (Lundvall 1992; Edquist 1997). The study of NIS focuses on the main components of the system, such as private firms and public organizations, and investigates their mutual interactions as well as their relationships with the social and institutional framework in which the system is embedded (Freeman 1995; Lundvall 2007). Empirical studies in this tradition initially focused mostly on advanced economies in the OECD area (Nelson 1993), although the NIS literature has recently shifted the focus toward the study of innovation systems within the context of developing and less developed economies (Lundvall et al. 2009).[1]

NIS empirical literature has traditionally devoted substantial attention to the process of international knowledge diffusion and investigated the set of factors that affect the extent to which a national system is able to grow and catch up with the technological frontier by means of international learning and imitation activities. This approach was originally inspired by the work of authors such as List, Landes, Gerschenkron, and Abramovitz, which, by focusing on historical case studies of the technological catch-up process, pointed out that international knowledge diffusion is a complex and demanding process, and investigated the set of factors that are necessary for imitation-based technological development, so-called *absorptive capacity* of a country (Abramovitz 1986).

More recently, a strand of empirical research made an effort to measure some of the relevant dimensions composing a national system through aggregate data and statistical indicators, and carried out applied econometric investigations of the relationships between these dimensions, on the one hand, and income per capita dynamics, on the other. However, a well-known challenge for applied research in this field is how to operationalize the innovation system view in empirical studies and, relatedly, how to measure the complex and multifaceted concept of NIS and its relationship to countries' economic performance. Quantitative applied studies of NIS and development have so far made use of two different (albeit complementary) approaches.

The first approach is rooted in the traditional literature on technology and convergence (Abramovitz 1986; Verspagen 1991; Fagerberg 1994). Following a technology-gap Schumpeterian approach, recent econometric studies have focused on a few key variables that explain (or summarize) cross-country differences in the innovation ability of countries as well as their different capabilities to imitate foreign advanced knowledge, and analyzed the empirical relationship between these innovation and imitation factors and cross-country differences in GDP per capita growth (Fagerberg and Verspagen 2002; Castellacci 2004; Castellacci 2008; Castellacci 2011; Fagerberg et al. 2007). Since one main motivation of this type of studies is to analyze the dynamics and evolution of national systems in a long-run perspective, they typically consider a relatively long time span (e.g., from the 1970s or 1980s onward), but must for this reason focus on a more restricted sample of countries

(e.g., between 70 and 90 countries). Due to the lack of statistical data for a sufficiently long period of time, therefore, a great number of developing economies and the vast majority of less developed countries are often neglected by these cross-country studies.

The second approach is based on the construction and descriptive analysis of composite indicators. In a nutshell, this approach recognizes the complex and multidimensional nature of national systems of innovation and tries to measure some of their most important characteristics by considering a large set of variables representing distinct dimensions of national systems and capabilities, and then combining them together into a single composite indicator – which may be interpreted as a rough summary measure of a country's relative position vis-à-vis other national systems. Desai et al. (2002) and Archibugi and Coco (2004) have firstly proposed composite indicators based on a simple aggregation (simple or weighted averages) of a number of technology variables. Godinho, Mendonça, and Pereira (2005), Castellacci and Archibugi (2008), and Fagerberg and Srholec (2008) have then considered a larger number of innovation system dimensions and analyzed them by means of factor and cluster analysis techniques. As compared to the first approach, the composite indicator approach has a more explicit focus on the comparison across a larger number of countries. Consequently, due to the lack of data availability on less developed countries for a sufficiently long period of time, these studies typically focus on a relatively short time span, giving a cross-section description of the sample in one point in time (e.g., the 1990s and/or the 2000s).

Most of this empirical research, however, has so far focused on the cross-country comparative aspect ("why growth rates differ") and mostly neglected the time series dimension and the analysis of the dynamics of the technological catch-up and economic growth process over time. Further, an exceptional amount of research has been devoted to the study of the determinants of GDP and income per capita growth. By contrast, only a limited number of studies have empirically investigated the dynamics of innovative capability and absorptive capacity over time and the main factors that may explain their long-run evolution (Filippetti and Peyrache 2011; Castellacci and Natera 2013). This is a crucial task for future research in this field, and the present chapter intends to take a step in this direction.

### *Conceptual Framework and Dimensions*

Although the concept of national system was originally intended to comprise a broad and multidimensional set of capabilities, modeling and empirical exercises have often provided a stylized and simplified operationalization of it. As recently argued by Archibugi and Coco (2004), Godinho et al. (2005), and Fagerberg and Srholec (2008), it is indeed important to adopt a multifaceted description and measurement of the various factors that contribute to shape the innovative capability and absorptive capacity of nations.

Given that the concept of national systems is complex, multifaceted, and comprises a great number of relevant factors interacting with each other, our empirical analysis adopts a broad and multidimensional operationalization of it. Our stylized view, broadly in line with the previous literature, is presented in Figure 1.1.[2] The diagram provides a stylized representation of the main aggregate dimensions that define the

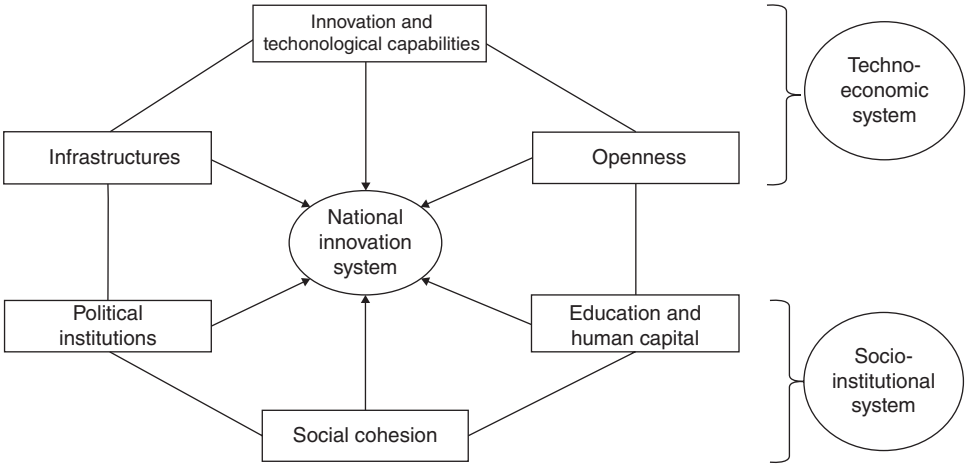


**Figure 1.1** National innovation system: a stylized framework.

dynamics of a national system. Specifically, we represent NIS as composed of six main dimensions: (1) Innovation and technological capabilities; (2) Openness; (3) Infrastructures; (4) Education and human capital; (5) Political institutions; (6) Social cohesion.

The first three dimensions are broadly related to a host of technological and economic factors, which classical neo-Schumpeterian work by Chris Freeman (1987) summarized under the heading *techno-economic system*. The next three dimensions refer instead to a heterogeneous set of social and institutional factors that may be combined together under the label *socio-institutional system* (see also Freeman and Louça 2001; Castellacci 2004). The underlying idea motivating this framework is that the dynamics and complex interactions between these six dimensions represent the driving force of national systems' social and economic development, and it is therefore crucial for empirical analyses in this field to have statistical information available for a large number of indicators and country-year observations, and to study how each of these dimensions evolve in the long run.[3]

Dimension 1: Innovation and Technological Capabilities This is one of the crucial dimension on which empirical literature in this field has so far focused. Three related aspects contribute to shape each country's innovative capability. Innovative inputs represent the total efforts and investments carried out by a country for R&D and innovative activities, that is, its innovation intensity. Its scientific output denotes the result of research and innovation activities carried out by the public scientific and technical system, for example, scientific and technical publications. The technological output refers to the total output of technological and innovative activities carried out by private firms, such as in particular patents, the commercialization and export of new products.

Dimension 2: Openness This represents the openness of the national system, a proxy of the potential for exchanging knowledge and technical information with other nations and hence imitating and absorbing foreign advanced technologies. The

more open the system, the more capable it is to imitate internationally available advanced knowledge (Fagerberg 1994).

Dimension 3: Infrastructures A greater level and quality of infrastructures (e.g., network, transportation, distribution) increases the country's capability to absorb, adopt, and implement foreign advanced technologies (Freeman 2004).

Dimension 4: Education and Human Capital This is the key absorptive capacity variable typically emphasized by technology-gap models, according to which countries' ability to imitate foreign advanced technologies does to a large extent depend on their workforce's human capital (Verspagen 1991).

Dimension 5: Political Institutions A better and more efficient governance system and institutional quality tends to increase the country's commitment to technological upgrading as well as its imitation capability (Fagerberg and Srholec 2008).

Dimension 6: Social Cohesion A national system with a greater level of social cohesion and within-country income equality is in general characterized by a higher degree of trust and knowledge sharing, hence supporting the pace of diffusion and adoption of advanced knowledge within the country (Arocena and Sutz 2003).

### *National Specificities and Cross-Country Heterogeneity*

This stylized framework intends to provide a general background for our empirical analysis of the global evolution of national innovation systems. Nevertheless, it is important to emphasize that, although these six conceptual dimensions are arguably important for all countries, the way in which they combine and interact with each other greatly differs among national economies. In particular, the specific trajectory followed by distinct national systems of innovation and the specific set of key factors driving the dynamics of the system may differ across country groups characterized by different levels of development. To illustrate this, consider for instance some of the main differences between advanced (high-income), middle-income, and less developed economies, as often depicted in the literature.

Advanced countries are usually rich in terms of both absorptive capacity (infrastructures, openness, and human capital) and innovative capability. In particular, private R&D capabilities become a more central engine of growth as compared to less advanced national systems, and they are also more closely related to the development of public scientific activities. This is one of the central points made by historically oriented studies on the emergence of new world leaders such as Imperial Germany (Veblen), the United States (Abramovitz), and Japan (Freeman), as well as the seminal studies on national systems of innovation in advanced economies (Nelson 1993). Therefore, this group of countries is typically characterized by an intense and complex web of relationships among the key variables driving the system, and in particular a two-way process of coevolution between innovative capability and absorptive capacity.

Compared to the advanced group, middle-income countries often lack the innovative capability that is required to become a world technological leader. However,

they have in general a well-developed absorptive capacity and may then exploit the international diffusion of advanced technologies. For instance, previous studies of East Asian innovation systems have pointed out their rapidly increasing levels of human capital, ICT infrastructures, and export specialization and competitiveness (Edquist and Hommen 2008). Compared to the East Asian group, Latin American economies are instead characterized by lower levels of human capital and technical training, as well as a more traditional (resource-based) export specialization profile (Nelson 1993; Alcorta and Peres 1998). Finally, former Soviet countries in Eurasia, in spite of their high levels of human capital, have in general lower private R&D capabilities and weak scientific and technical interactions, which can be explained as the historical heritage these countries have received from the Soviet innovation system and its heavy reliance on publicly funded defense R&D (Freeman 1987; Nelson 1993). All in all, within the broad (and heterogeneous) group of middle-income economies, we normally find weaker interactions among the innovative capability variables, because of the less central role of R&D in the national system and, for the same reason, weaker interactions between innovative capability and absorptive capacity.

Finally, in less developed countries, national systems do not only lack strong innovative and R&D capabilities, but are also characterized by a more limited absorptive capacity, for example, in terms of lower levels of human capital and technical training, infrastructural investments, and ability to reap benefits from international trade activities (Fagerberg et al. 2007; Castellacci 2008; Lundvall et al. 2009). As a consequence, for this group of countries most of the dynamic interactions and coevolution patterns among the six conceptual dimensions noted above are likely to be weaker or non-existent. Below a threshold level of development, innovative capabilities and absorptive capacity are low, and their interaction is therefore not expected to be a key driver of the economic system.

## Data, Indicators and Descriptive Evidence

Our empirical analysis makes use of the CANA database, a newly released cross-country panel dataset containing a large number of indicators for the period 1980–2008 (Castellacci and Natera 2011). The novelty of the database is that it provides full information for the whole set of country-year observations, and so it contains no missing value. The dataset has been constructed by combining together indicators available from a number of existing cross-country data sources, and then applying the method of multiple imputation recently proposed by Honaker and King (2010).[4]

The CANA dataset is an attempt to provide a broad, comprehensive, and widely accessible database of a large number of indicators measuring countries' technological, social, and economic characteristics. In particular, the CANA dataset enables us to measure some of the main characteristics of national systems of innovation and carry out a cross-country comparative analysis of their differences and long-run dynamics. Based on the theoretical framework outlined in the previous section, we use this database to obtain four indicators for each of the six dimensions of NIS (see Figure 1.1).

*Dimension 1: Innovation and Technological Capabilities*

- R&D: R&D expenditures as a percentage of GDP (source: UNESCO, OECD).
- Scientific articles: Number of scientific articles per million people (source: NSF).
- High-tech products: Export of high-tech products as a share of manufacturing exports (source: World Bank).
- Patents: Number of patents registered at the US Patent and Trademark Office per million people (source: USPTO).

*Dimension 2: Openness*

- Inward FDI: Inward FDI flow, share of GDP (source: World Bank).
- Import: Imports of goods and services as a share of GDP (source: UNCTAD).
- Export: Export of goods and services as a share of GDP (source: UNCTAD).
- Openness: (Export + Import) / GDP (source: UNCTAD).

*Dimension 3: Infrastructures*

- Electricity: Kilowatts of electricity consumed per hour per capita (source: World Bank).
- Telephony: Sum of telephone mainlines and mobile phones per 1000 people (source: ITU, UNDP, World Bank).
- Carrier departures: Domestic takeoffs and takeoffs abroad of air carriers registered in the country, per 1000 inhabitants (source: World Bank).
- Paved roads: Paved roads as a percentage of the whole road length of the country (source: World Bank).

*Dimension 4: Education and Human Capital*

- Primary enrollment ratio: Share of primary students (source: UNDP, World Bank).
- Secondary enrollment ratio: Share of secondary students (source: UNDP, World Bank).
- Mean years of schooling: Average number of years of school completed in the population over 14 (Barro and Lee 2001; UNDP, World Bank).
- Tertiary enrollment ratio: Share of tertiary students in science and engineering in the population of that age group (source: UNDP, World Bank).

*Dimension 5: Political Institutions*[5]

- Political rights: People's free participation in the political process. It ranges from –7 (low freedom) to –1 (total freedom) (source: Freedom House).
- Civil liberties: People's basic freedoms without interference from the state. It ranges from –7 (low freedom) to –1 (total freedom) (source: Freedom House).
- Freedom of press: It reflects the degree of freedom that journalists and news organizations enjoy in each country, and the efforts made by the authorities to respect and ensure respect for this freedom. Index from –115 (no freedom) to 0 (high freedom) (source: Reporters Without Borders).

- Freedom of speech: Extent to which freedoms of speech and press are affected by government censorship, including ownership of media outlets. Index from 0 (Government censorship) to 2 (No Government Censorship) (source: Cingranelli and Richards 2008).

### *Dimension 6: Social Cohesion*

- Corruption: Corruption Perception Index, ranging from 0 (High Corruption) to 10 (Low Corruption) (source: Transparency International).
- Inequalities: Gini index (within-country income inequalities).
- Trust: Percentage of respondents who agree with the statement "Most people can be trusted" (source: World Value Survey).
- Happiness: Index ranging from 3 (very happy) to 0 (not happy) (source: World Value Survey).[6]

As noted in the previous section, these dimensions and indicators of national systems have arguably different relevance and patterns for countries characterized by different levels of economic, institutional, and social development. It is therefore important that our empirical analysis of these indicators will not only consider the overall global patterns across all countries in the world, but also take into account the existence of cross-country heterogeneity and the specificities of different groups, or clubs, of economies. We do this by clustering countries into different groups, and then analyzing convergence and divergence patterns within each of these clubs too.

We have chosen to cluster countries in a simple hierarchical two-step manner. First, we identify three major country clubs, which are broadly in line with the existing literature: advanced economies, catching-up countries, and least developed economies (Howitt and Mayer-Foulkes 2005; Castellacci and Archibugi 2008). Second, in order to achieve a finer characterization of the widely different nature of economies within these three heterogeneous clubs, we further divide them into a few subgroups. We make this based on an exogenous and intuitive criterion: we follow broad geographical areas, which on the whole group together countries that are similar with respect to both the initial GDP per capita level (the usual clustering variable in this literature) and the overall institutional context and capitalist mode of development. All in all, we end up with a total of seven subgroups, as defined in Table 1.1.

Although it is clear that no clustering exercise is faultless, the advantage of the intuitive clustering method described here is twofold: it is broadly in line with the three-club specification adopted by most theoretical models and empirical exercises in this field, and at the same time, by working with seven fairly homogeneous subgroups, it deals in a satisfactory manner with the cross-country heterogeneity issue.

In order to illustrate that heterogeneity at a greater detail, we propose a comparative exercise for selected countries from different groups. We evaluate countries' deviation from the world average for each dimension, in order to see how changes are taking place around the globe in two points of time, 1980 and 2008. If a developing country exhibits a higher level in 2008 than in 1980, it means that its relative position has improved or, equivalently, that it has experienced a process of catching up. By

**Table 1.1** Countries with similar GDP per capita by group.

**Advanced Countries**
*OECD*: Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Israel, Italy, Japan, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, United Kingdom, United States

**Catching-up Countries**
*Latin America*: Argentina, Bolivia, Brazil, Chile, Colombia, Costa Rica, Dominican Republic, Ecuador, El Salvador, Guatemala, Guyana, Honduras, Jamaica, Mexico, Nicaragua, Panama, Paraguay, Peru, Trinidad and Tobago, Uruguay, Venezuela
*East Asia*: Cambodia, China, Fiji, Indonesia, Malaysia, Mongolia, Philippines, Singapore, South Korea, Thailand, Vietnam
*Eurasia*: Albania, Armenia, Azerbaijan, Bulgaria, Croatia, Czech Republic, Estonia, Georgia, Hungary, Kazakhstan, Latvia, Lithuania, Moldova, Poland, Romania, Slovakia, Slovenia, Tajikistan, Ukraine, Uzbekistan

**Least Developed Countries**
*South Asia*: Bangladesh, India, Nepal, Pakistan, Sri Lanka
*North African and Middle East*: Algeria, Iran, Jordan, Morocco, Tunisia, Turkey
*Sub-Saharan Africa*: Benin, Botswana, Burkina Faso, Burundi, Cameroon, Ethiopia, Gabon, Ghana, Guinea, Kenya, Lesotho, Madagascar, Malawi, Mali, Mauritania, Mauritius, Mozambique, Namibia, Niger, Nigeria, Rwanda, Senegal, Sierra Leone, South Africa, Swaziland, Tanzania, Uganda, Zambia, Zimbabwe

contrast, if an advanced country shows a lower level in 2008 than in 1980, it means that its leadership position has weakened in relative terms.

Figure 1.2 presents some descriptive evidence on some of the indicators noted above, for a selection of some major large economies for these seven groups. Each panel in Figure 1.2 reports a radar graph, which contains the composite indicators of each national economy on the six NIS dimensions highlighted in this paper and shows the evolution of the NIS between 1980 and 2008 relatively to the world average.

The radar graphs are informative. More advanced countries have on average a much greater surface than the catching-up BRICS and other less developed economies, indicating an overall greater level of the set of relevant technological, social, and economic capabilities both at the beginning and at the end of the period. Regarding the time evolution of these national systems, South Korea is a good illustration of a country that has improved rapidly its relative position during the last three decades, particularly in terms of innovation capabilities and infrastructures. Within the group of BRICS countries, the catching-up process between the beginning and the end of the period has also been striking for China, Brazil, and South Africa, and less so for Russia and India.

## Empirical Analysis

### *Methods*

Our empirical analysis of the global evolution of national systems intends to provide a comprehensive description of cross-country differences in terms of the indicators outlined in the previous section, and how these differences have evolved over the

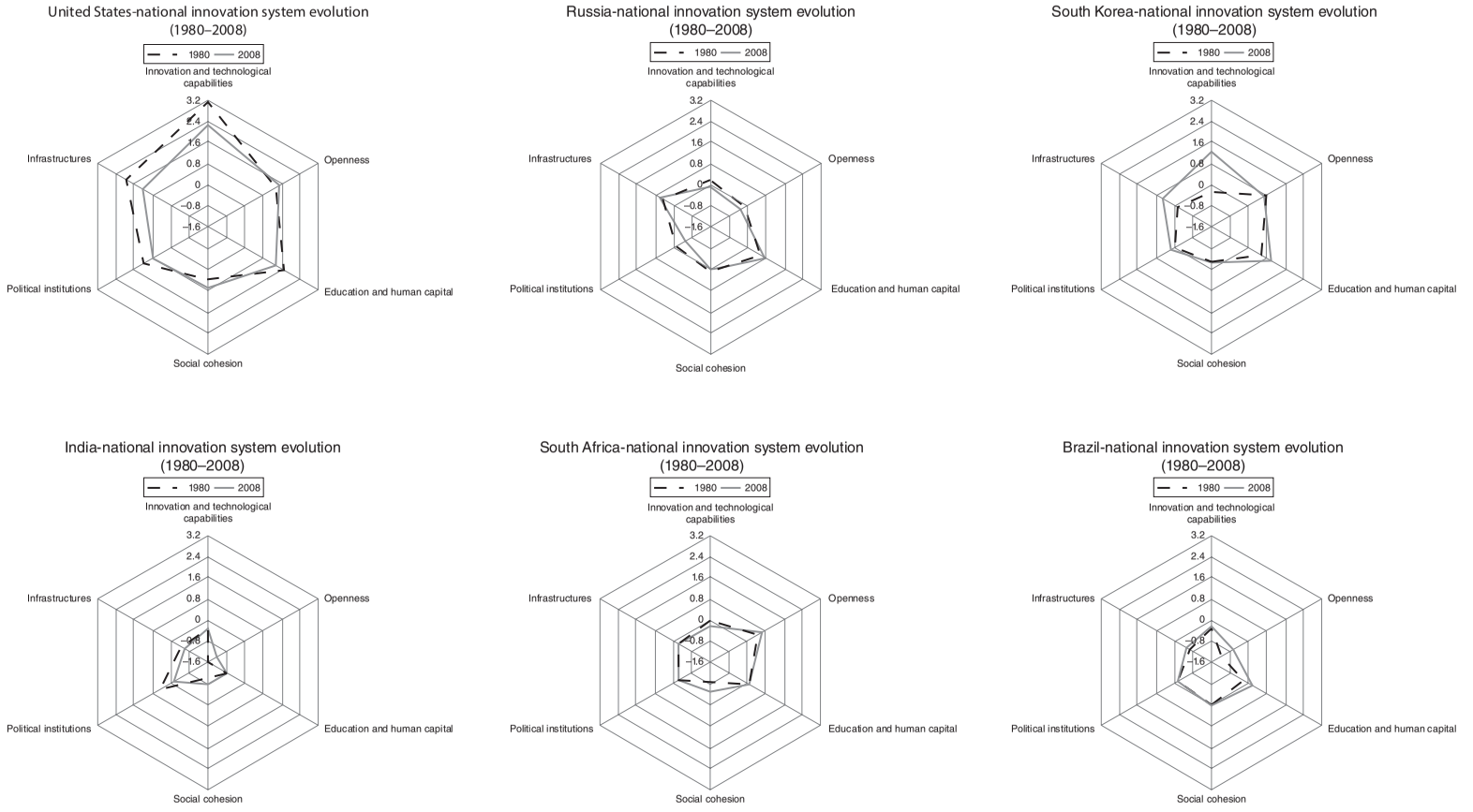


**Figure 1.2** Selected countries' relative evolution to the world average 1980–2008.

period 1980–2008. We make use of a simple and commonly used method of applied economic research: convergence analysis. Cross-country convergence is one of most popular areas of research in applied growth theory and, despite some important limitations, it still provides an appealing method to summarize cross-country patterns and dynamics.

Most of the convergence literature has however focused on the dynamics of GDP per capita and the related determinants. But, while using the same convergence analysis methodology, our paper has a different objective. We intend to investigate the dynamics of each of the six NIS dimensions outlined in the previous sections, and how these have evolved during the last three decades. Since there exists no prior theory or model indicating how exactly these six dimensions evolve over time, we are not able to set up a structural model of conditional convergence, and follow instead a simpler empirical strategy. We carry out a standard analysis of (unconditional) convergence for each of these six factors separately, and study how their statistical distributions have evolved in the period 1980–2008. For each dimension, a pattern of *convergence* would indicate that a process of catching up is in place, meaning that less developed economies have experienced a more rapid dynamics than industrialized countries and hence been able to partly close their initial gap. By contrast, a finding of *divergence* would indicate the presence of a cumulative mechanism that is leading to increasing disparities between rich and poor countries.

More specifically, the analysis proceeds by considering the two most standard notions of (unconditional) convergence: β- and σ-convergence. For the β-convergence, we have estimated a simple regression model for each indicator A, where the dependent variable is the (average annual) growth of that indicator over the period 1980–2008, while the level of the same indicator at the beginning of the period is the only regressor (along with a constant). The cross-country regression model is:

$$\Delta \mathrm{A}_i / \mathrm{A}_i = \tau_A + \beta_A \mathrm{A}_{i,0} + \varepsilon_i \qquad (1)$$

where $\Delta \mathrm{A}_i/\mathrm{A}_i$ is the growth of each indicator for country *i* over the period, and $\mathrm{A}_{i,0}$ is the log of its level at the beginning of the period. The parameter of interest in these regressions is $\beta_A$, which measures the speed of convergence, or divergence, for that indicator.

By contrast, the idea of σ-convergence is to study whether the dispersion of a variable has increased or decreased over time, thus providing a synthetic measure of the dynamics of the variability of its distribution. For each indicator, σ-convergence is computed as follows. First, we have calculated the standard deviation of the cross-country distribution at each time *t*; then we have regressed the standard deviation's time series on a constant and a time trend:

$$\mathrm{SD}_t = \gamma + \sigma t + \varepsilon \qquad (2)$$

If the estimated coefficient of the time trend σ turns out to have negative (positive) coefficient, this means that the indicator in question has decreased (increased) its variability over time, hence it shows σ-convergence (σ-divergence).

It is important to emphasize that the two notions of convergence, albeit related, are quite distinct from each other. β-analysis tells us whether, on average, a

cross-country distribution has experienced a process of catching up – where initially poorer economies have developed more rapidly than richer countries (β-convergence) – or instead a cumulative process according to which initially richer economies have been able to reinforce their leadership position over time (β-divergence). On the other hand, σ-analysis provides information on the dynamics of the cross-country variability of an indicator: σ-convergence indicates decreasing cross-country dispersion, whereas σ-divergence points to increasing polarization between rich and less developed economies.

Further, in order to take into account the existence of substantial differences across country groups, we have undertaken our convergence analysis not only for the whole world distribution, but we have also repeated it for each of the seven geographically defined country groups in Table 1.1.

### *Results*

We will now present the results of the convergence analysis for each dimension separately, and will then conclude by summarizing the main general results. Table 1.2 reports a summary of convergence analysis results,[7] and Figures 1.3–1.8 show geographical maps and kernel densities to illustrate visually the cross-country distribution of selected indicators and their evolution over time.[8]

Dimension 1: Innovation and Technological Capabilities Figure 1.3 shows that the cross-country distribution of innovative capabilities is very skewed, since the bulk of innovative investments and results is highly concentrated in countries within the OECD area. Such a skewed pattern has not changed substantially during the period 1980–2008, indicating that no significant worldwide improvement has taken place in this dimension (Castellacci 2011). More specifically, the convergence analysis results indicate that three out of four indicators (R&D, scientific articles, high-tech products) are characterized by a combination of slow β-convergence and visible σ-divergence. This means that, on the one hand, countries that were less technologically advanced at the beginning of the period have on average improved their capabilities somewhat faster than already developed economies; on the other hand, however, several rich countries have continued to increase their technological efforts, leading to an increasing worldwide dispersion (i.e., the right tails of these

**Table 1.2** Summary of convergence analysis.

| | *Decreasing dispersion (σ-convergence)* | *Increasing dispersion (σ-divergence)* |
|---|---|---|
| *Catch-up process (β-convergence)* | • Basic education<br>• Social cohesion<br>• Political institutions | • Infrastructures<br>• Openness<br>• Advanced education<br>• Innovation (R&D, articles, high-tech exports) |
| *Cumulative process (β-divergence)* | | • Innovation (patents) |

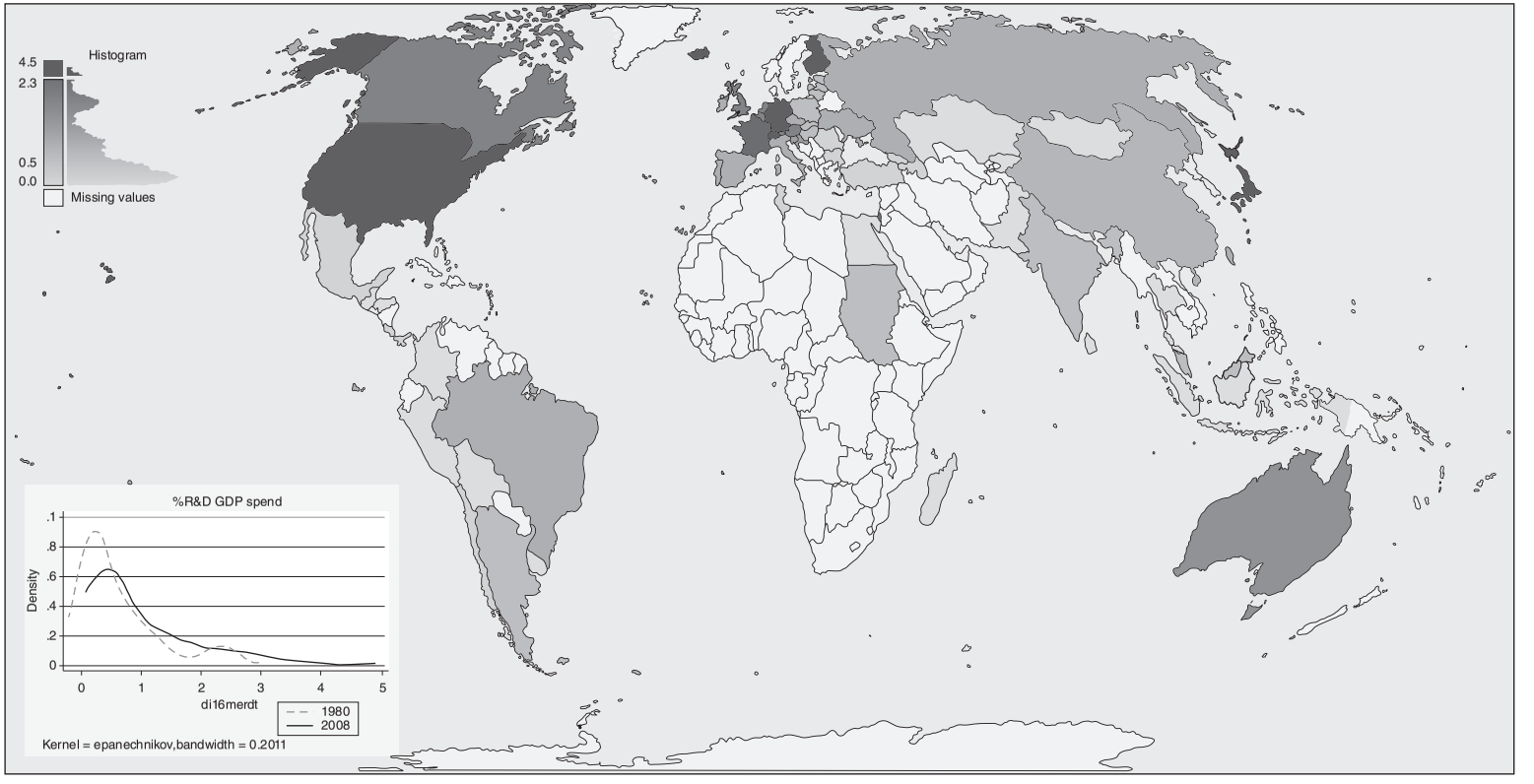


**Figure 1.3** The cross-country dynamics of innovation and technological capabilities: ratio of R&D expenditure to GDP.

cross-country distributions have become longer). This pattern holds for all geographical regions, except the OECD area, which is the only club in which one observes cross-country convergence. The fourth indicator, patents, shows an even more dramatic pattern of divergence, since the variable combines at the same time β- and σ-divergence. This indicates that innovative results and performance are becoming more polarized, with an increasing gap between a small bunch of innovative OECD countries and a large group of non-innovating middle-income and less developed economies. As Lall (2003) does, we also wonder how big could be the influence of the TRIPS agreement on this pattern, in which external conditions might be fostering the divergence process across the world.

Dimension 2: Openness The four openness indicators (inward FDI, export, import, openness) show an overall pattern and dynamics that is largely similar to that of innovation indicators. The cross-country distributions of these variables are quite skewed at the beginning of the period (Figure 1.4). These distributions move rightward over time – indicating an overall worldwide progress in this dimension – but the variability is still high at the end of the period. The convergence results point out a combination of β-convergence and σ-divergence (as it is the case for the innovation indicators). This general pattern holds for most of the geographical regions, although we also observe a more pronounced σ-convergence process within less developed regions such as South Asia, Middle East, and Africa.

Dimension 3: Infrastructures The infrastructures dimension considered in Figure 1.5 does also show a cross-country pattern similar to that observed for the innovation and openness dimensions. The overall convergence dynamics is one that combines at the same time a catch-up process (poor economies' infrastructures have grown on average faster than already developed economies) with an increasing polarization, that is mostly due to the fact that some of the richest countries have continued to rapidly upgrade their infrastructures (e.g., telephony lines, road and air transportation), leading to an enlargement of the gap between the richest and the poorest economies.

Dimension 4: Education and Human Capital A worldwide and relatively rapid process of convergence is instead apparent when we shift the focus to Figure 1.6, which studies the evolution of the human capital dimension. The kernel densities show that the cross-country distributions of these indicators have visibly shifted toward the right, thus indicating an overall improvement of countries' education systems. Differently from the previous dimensions, however, this worldwide growth has not led to increasing polarization but to a rapid convergence process (both β- and σ-convergence), and hence to a more equal cross-country distribution of human capital. This is clearly the case for the three indicators of basic education (primary and secondary education). By contrast, advanced education (measured by the tertiary enrollment ratio) has a markedly different pattern, combining β-convergence and σ-divergence like the indicators of innovation, openness and infrastructures discussed above. In short, it is interesting to point out that while countries are progressively becoming more similar in terms of basic education, this is not the case with respect to advanced education and the university sector's capabilities, where the gap between OECD and less developed economies is indeed enlarging.


**Figure 1.4** The cross-country dynamics of openess: openess 2008 (Exports + Imports / GDP).

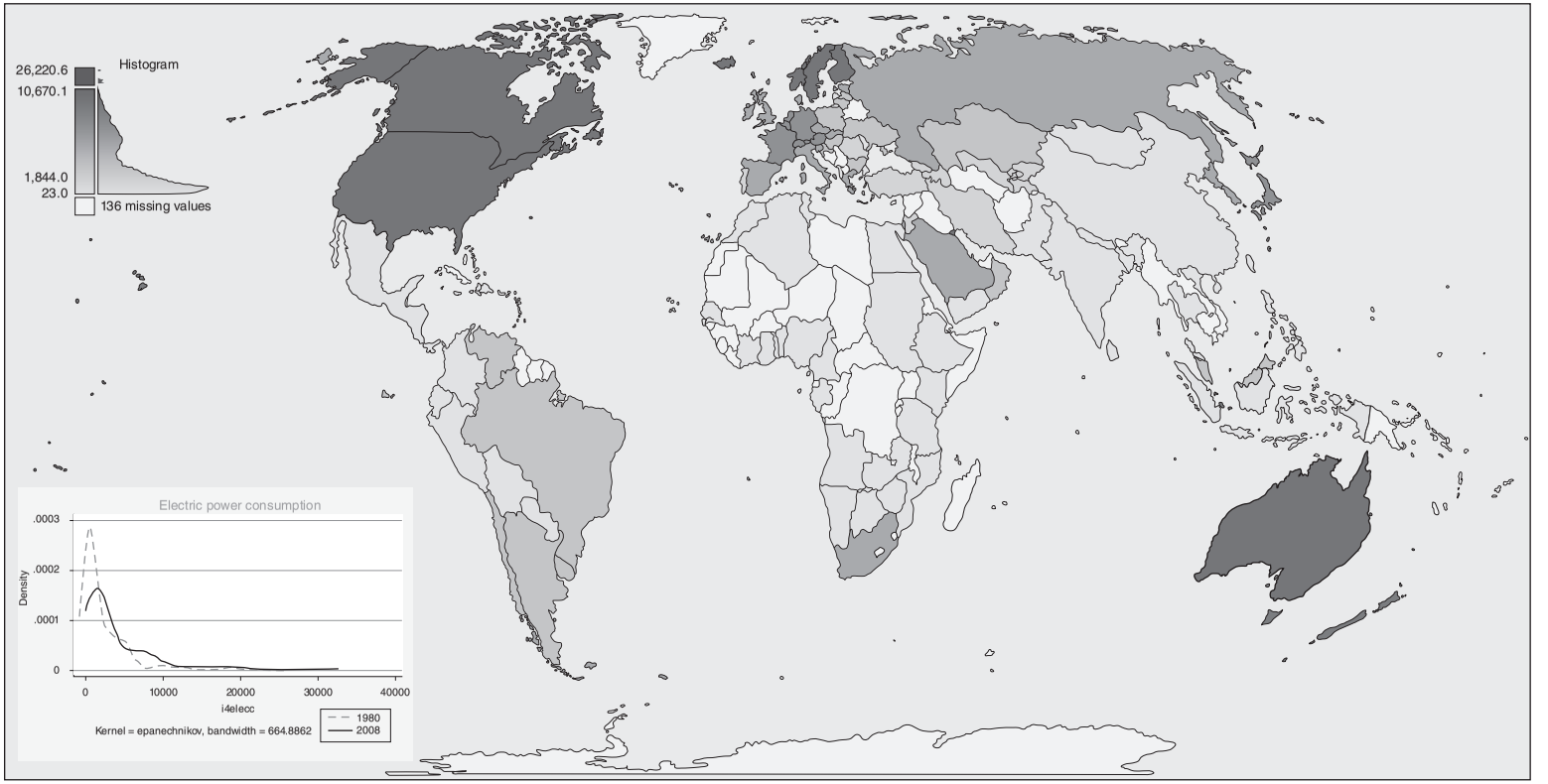


**Figure 1.5** The cross-country dynamics of infrastructures: electric power consumption 2008.


**Figure 1.6** The cross-country dynamics of education and human capital: primary enrollment ratio 2000.

Dimension 5: Political Institutions The four indicators of political institutions follow a cross-country dynamics that largely resembles that of basic education variables discussed above. All of these variables – which are proxies for countries' respect for political rights, civil liberties, freedom of press, and freedom of speech – have experienced both β- and σ-convergence during the last three decades. This convergence pattern also holds within most of the seven geographical regions that we have considered, with the exception of East Asia and Eurasia, where the dispersion of the distribution has actually increased somewhat over time, arguably due to the process of institutional transition that has led to more cross-country heterogeneity within these regions. Figure 1.7, for instance, shows that the shape of the distribution of the freedom of press indicator has substantially modified during this period, shifting from a bimodal and highly polarized pattern at the beginning of the period toward a more even and slightly more concentrated (less dispersed) distribution at the end of the time span.

Dimension 6: Social Cohesion Finally, Figure 1.8 considers the social cohesion dimension. The patterns we obtain from the convergence analysis are somewhat mixed. On the one hand, the two variables that we consider more reliable because of their larger country coverage and data quality – corruption and the Gini index – show an overall process of catch-up and convergence (both β- and σ-convergence), indicating that national systems worldwide have on average become more similar in terms of internal social cohesion. On the other hand, the other two indicators, trust and happiness – which we consider a little less reliable since they are based on survey data for a somewhat smaller sample of countries – seem to have combined a process of catch-up and β-convergence with an overall increasing polarization between rich and poor economies (σ-divergence).

The *Convergence Paradox* Table 1.2 summarizes the main results of our convergence analysis; it is based on convergence results of dimension indicators across the world and for each of the seven country groups defined.[9] The table shows a quite clear overall pattern. On the one hand, the three dimensions defining the socio-institutional system – basic education, political institutions, and social cohesion – have experienced a process of convergence: less developed economies have on average improved these factors at a faster rate than more advanced countries (β-convergence), and at the same time the dispersion and polarization of these distributions have decreased over time (σ-convergence). On the other hand, however, the three dimensions related to the techno-economic system have experienced a marked divergent dynamics: most of the indicators of infrastructures, openness, advanced human capital, and innovation have in fact combined a slow β-convergence pattern (slow and hence not sufficient for less developed economies to close the gap vis-à-vis more advanced countries) with a σ-divergence trend pointing to increasing polarization between rich and poor country groups. In a nutshell, we summarize this contrasting pattern by pointing to the existence of a *convergence paradox*: during the last three decades national systems worldwide have become more similar in terms of their socio-institutional frameworks but increasingly more different with respect to techno-economic dimensions.


**Figure 1.7** The cross-country dynamics of political institutions: freedom of press 2000.

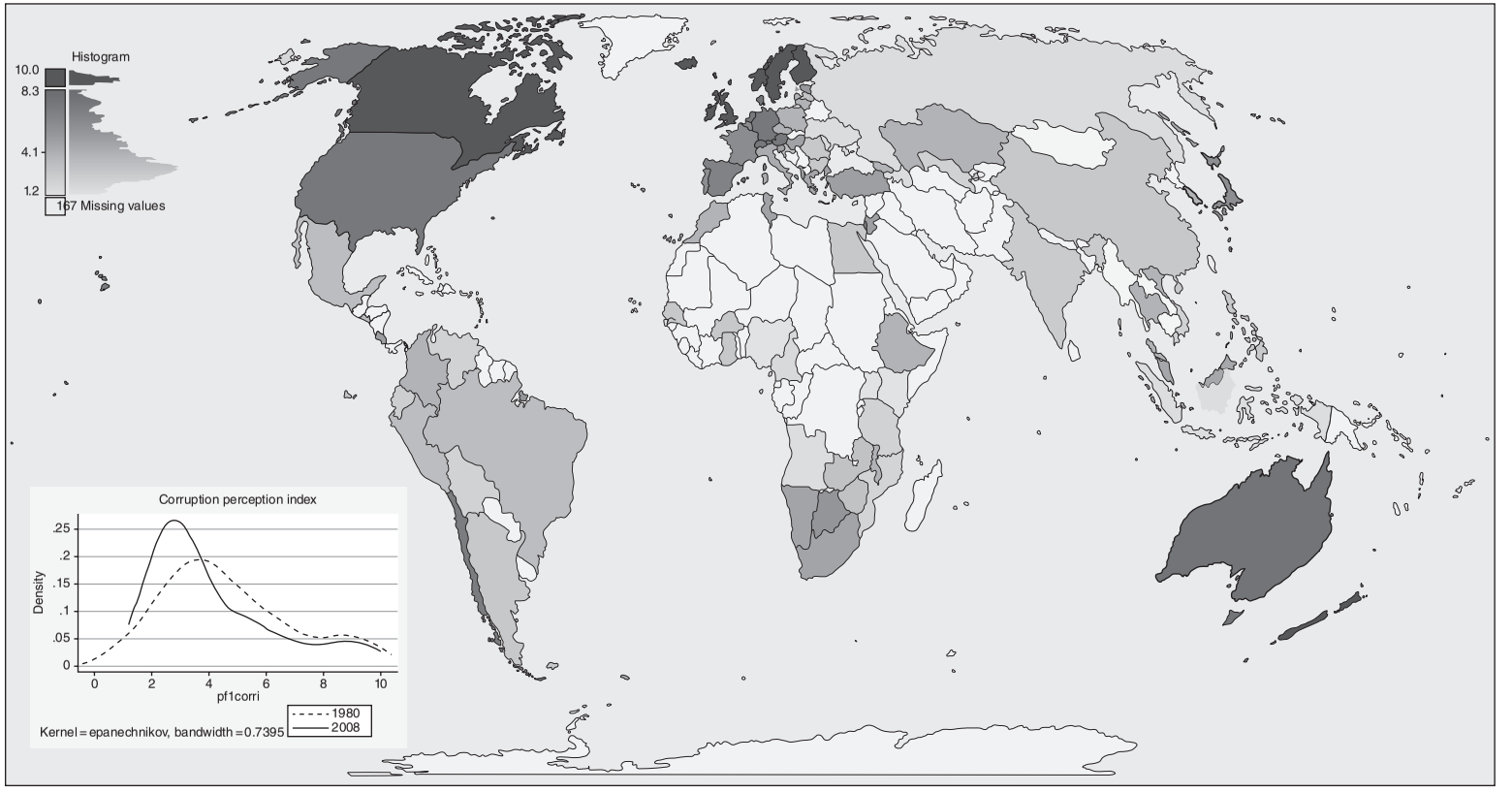


**Figure 1.8** The cross-country dynamics of social cohesion: Corruption Perception Index 2008.

## Conclusions

This chapter has presented an empirical analysis of the global evolution of national innovation systems. The intention has been to carry out a general and comprehensive study, aimed at describing the cross-country distribution of a large number of technological, economic, and social factors that broadly contribute to define national systems of innovation, and how these factors have evolved during the period 1980–2008. We have focused on six main dimensions characterizing NIS, three of which are related to the techno-economic domain (innovation and technological capabilities, openness, and infrastructures), while the other three define the country's socio-institutional system (education, political institutions, and social cohesion). We have then adopted a large number of statistical indicators to measure these six conceptual dimensions. These indicators are from the CANA database, a newly released dataset that is intended to measure some of the main characteristics of national innovation systems. The CANA database provides a rich set of information on a large number of countries worldwide for the last three-decade period, and so enables a dynamic cross-country analysis of national systems, growth, and development.

The results of convergence analysis, in short, point out a contrasting pattern that we have called "the convergence paradox." On the one hand, the three dimensions defining the socio-institutional system – basic education, political institutions, and social cohesion – have experienced a process of convergence. On the other hand, however, the three dimensions related to the techno-economic system have experienced a marked divergent dynamics with increasing polarization between rich and poor country groups. So the paradox is that national systems have progressively become more similar in terms of their socio-institutional frameworks while at the same time diverging and becoming more different with respect to their techno-economic pillars.

One first implication of this pattern refers to the convergence dynamics experienced by socio-institutional factors. It is important to emphasize how relevant this pattern is. Socio-institutional capabilities, in fact, are not only crucial for the impacts they may have on the dynamics of income and GDP per capita, but also because basic education, political institutions, and social cohesion constitute important aspects of social welfare and human development. In other words, they are not simply means to achieve economic progress, but do also constitute achievements that are directly relevant for human development, representing therefore important targets for policy.

The second implication refers to the divergence dynamics experienced by techno-economic dimensions, and brings less encouraging news. Most of the techno-economic variables considered in the paper – measuring innovation and technological capabilities, openness, and infrastructures – are in fact characterized by a process of increasing disparities and polarization between rich and poor economies. This fact is a reason of concern because, due to the cumulative and path-dependent nature of technological and capital accumulation, it is possible to envisage that greater cross-country inequalities today will arguably lead to even greater inequalities in the future. These techno-economic dimensions represent therefore crucial aspects that middle-income and developing economies should more actively upgrade and focus on during the catching-up process. In order to get closer and eventually jump to the

innovation development stage, developing economies should therefore implement an appropriate combination of policies that takes into account the need to simultaneously develop R&D activities, openness and export performance, traditional and ICT infrastructures, and advanced human capital. At the same time, advanced countries should also take their responsibility in this divergence process: living in a globalized world, creating global economic inequalities and limiting the possibilities of latecomers to catch up might lead to unstable situations, affecting not only developing countries but also their own economies. It is in the best interest of both advanced and catching-up countries to increase the level of technological progress of the whole world in the long run. In more general terms, the finding of increasing cross-country divergence in terms of techno-economic dimensions can also be interpreted as evidence of the continuing relevance of the NIS concept: even in the context of an increasingly globalized economy, a large number of techno-economic factors persistently differ across countries, following country-specific and path-dependent trajectories of development. Global economic integration is indeed strengthening country-specific characteristics and hence the relevance of national systems and policies (Archibugi and Michie 1995).

Finally, we would like to conclude by acknowledging one important limitation of the paper and pointing out a related challenge for future research in this field. Our empirical analysis has been provocatively simple, based on a simple description of the univariate evolution and unconditional convergence dynamics of a large battery of indicators. The chapter has said nothing regarding the underlying key issue of interest: how do these factors interact with each other, and how can their coevolutionary process explain the different growth trajectories experienced by national economies in the long run? While there are several papers investigating this question in a cross-country comparative perspective, very few works have approached this issue focusing on the time series process that may explain the complex coevolutionary patterns followed by national systems (Castellacci and Natera 2013). We consider this an important area for future applied research on the evolution of national innovation systems.

## Notes

1 For further references and information regarding the flourishing field of innovation systems and development, see the website of the Globelics network: www.globelics.com.

2 Other empirical exercises in the NIS literature have previously made use of (at least some of) these dimensions and indicators. See in particular Godinho et al. (2005), Castellacci and Archibugi (2008), and Fagerberg and Srholec (2008).

3 In another paper (Castellacci and Natera 2013), we study the interactions among these dimensions and carry out a time series multivariate analysis of their coevolutionary process.

4 The CANA database, along with the sources and definitions of the indicators and a description of the construction methodology, can be downloaded at: http://english.nupi.no/Activities/Projects/CANA.

5 Three indicators of this dimension have been modified from the original sources. We have multiplied the original observed data by minus one (–1) such that a higher value indicates a more favorable situation.

6 This indicator was constructed as a weighted average of the responses of the original data source.

7 Full detailed results are provided in Tables 1.3a–d at the end of this chapter. Interested readers might look at specific dimensions or geographical regions.

**Table 1.3a** Results of convergence analysis: techno-economic system (I).

| | *World* | | *OECD* | | *Latin America* | | *East Asia* | | *Eurasia* | |
|---|---|---|---|---|---|---|---|---|---|---|
| ***Innovation & technological capabilities.*** | ***β*** | ***σ*** | ***β*** | ***σ*** | ***β*** | ***σ*** | ***β*** | ***σ*** | ***β*** | ***σ*** |
| %R&D GDP Spend | −0.327274 (0.234249) | 0.012522*** (0.000822) | −0.029722*** (0.005152) | 0.010344*** (0.001659) | −4.32027 (3.446528) | 0.000085 (0.000299) | −1.234516* (0.549059) | 0.02289*** (0.001011) | −0.03977*** (0.010984) | −0.003345*** (0.000865) |
| Scientific and technical journal articles | −808.246** (312.3217) | 0.00000381*** (0.000000144) | −111.9871*** (20.66416) | −0.00000117*** (0.000000295) | −10483.06* (5345.123) | 0.000000517*** (0.0000000185) | −7579.298 (6318.195) | 0.00000901*** (0.000000481) | −9701.348 (5922.183) | 0.0000036*** (0.000000184) |
| High-technology exports (% of manufactured) | −0.087992* (0.051513) | 0.135567*** (0.027889) | −0.00187 (0.001358) | −0.073104*** (0.019678) | −0.010717 (0.007609) | 0.191656*** (0.060321) | −0.046664 (0.047924) | 0.383142*** (0.057562) | −0.001492 (0.002079) | 0.054928 (0.034804) |
| Patent applications, nonresidents per capita | −0.00000621 (0.0000368) | −31.42311** (11.65714) | −0.0000192 (0.0000526) | 10.06299*** (1.841461) | −0.001083** (0.000448) | 1.520069*** (0.20066) | −0.003317 (0.004959) | 20.2475*** (2.713616) | −0.0000274 (0.0000864) | −102.1013*** (28.84035) |
| | | | | | *Openness* | | | | | |
| Inward foreign direct investment stock | −0.00265** (0.001186) | 1.773146** (0.671757) | −0.000768*** (0.000267) | −0.121833 (0.157576) | −0.00477* (0.002449) | 0.568872*** (0.062479) | −0.011415 (0.013491) | 1.008179*** (0.107496) | −0.018817** (0.008185) | 0.958098*** (0.090196) |
| Imports of goods and services (% of GD) | −0.000438*** (0.0000898) | 0.091432*** (0.028459) | −0.000249** (0.000106) | 0.09532*** (0.021217) | −0.000118 (0.00021) | 0.266961*** (0.086841) | −0.000413* (0.00022) | 0.245843*** (0.029628) | −0.001298*** (0.000336) | 0.167303*** (0.04581) |
| Exports of goods and services (% of GD) | −0.000569*** (0.000104) | 0.174551*** (0.019069) | 0.000000633 (0.000141) | 0.287369*** (0.021758) | −0.000507*** (0.000176) | 0.134757 (0.087911) | −0.000675 (0.000393) | 0.308287*** (0.039623) | −0.00099** (0.000359) | 0.189373*** (0.052187) |
| Openness Indicator | −0.026196*** (0.00792) | 0.000288 (0.002768) | −0.001325 (0.006488) | 0.00437*** (0.000537) | −0.023193* (0.011649) | 0.002993*** (0.001055) | −0.015681** (0.006239) | −0.003522* (0.002009) | −0.15357*** (0.031581) | 0.00058 (0.000854) |

| | *Infrastructure* | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| % Telecommunication Revenue | −0.04868** | 0.07825*** | −0.024378*** | 0.018963*** | −0.009236 | 0.162822*** | −0.037896 | 0.038657*** | −0.097533 | 0.032265*** |
| Electric power consumption | −0.00000333*** (0.000000763) | 72.6738*** (2.568785) | −0.000001** (0.00000047) | 86.02092*** (6.282711) | −0.00000613 (0.0000072) | 24.57857*** (1.545643) | −0.0000304* (0.0000137) | 88.73484*** (2.773622) | −0.00000285 (0.0000022) | 16.69627*** (1.632516) |
| Mobile and fixed-line subscribers | −0.000427*** (0.0000354) | 17.90163*** (1.189618) | −0.000161*** (0.0000147) | 2.171602*** (0.221338) | −0.001135*** (0.00016) | 8.536118*** (0.860196) | −0.000886** (0.000328) | 16.7257*** (1.115447) | −0.000544*** (0.000122) | 17.17018*** (1.574) |
| Registered carrier departures worldwide | −0.007334 (0.004744) | 0.200876*** (0.024771) | −0.000794 (0.000517) | 0.159005*** (0.032081) | −0.022368 (0.013966) | −0.039179** (0.014345) | −0.002147 (0.003147) | 0.461142*** (0.121918) | −0.024986*** (0.005216) | 0.041102*** (0.011321) |
| % Paved Roads | −0.000929** (0.000391) | 0.012855* (0.006756) | −0.000293*** (0.0000541) | −0.090784*** (0.01335) | 0.000447 (0.0004) | −0.074832*** (0.018723) | −0.0000404 (0.000243) | 0.27429*** (0.022949) | −0.008779*** (0.00252) | 0.004101 (0.035683) |

Note: Significance levels: 1%***, 5%**, 10%*. Standard errors in parenthesis.

**Table 1.3b** Results of convergence analysis: techno-economic system (II).

| | *South Asia* | | *North Africa and Middle East* | | *South and Central Africa* | |
|---|---|---|---|---|---|---|
| *Innovation & technological capabilities.* | $\beta$ | $\sigma$ | $\beta$ | $\sigma$ | $\beta$ | $\sigma$ |
| %R&D GDP Spend | −1.249661 | 0.004802*** | −1.368182* | 0.006431*** | −0.15931 | 0.007034*** |
| | (0.964799) | (0.00103) | (0.645719) | (0.000915) | (0.145447) | (0.001377) |
| Scientific and technical | −21624.91* | −0.0000000316* | −1771.593** | −0.000000664*** | −12717.91 | 0.000000487*** |
| journal articles | (6992.043) | (0.0000000155) | (751.8455) | (0.0000000917) | (7837.22) | (0.0000000299) |
| High-technology exports | 0.399452 | 0.029892*** | −0.902152 | 0.075679*** | −0.220056 | 0.016807 |
| (% of manufactured) | (0.357574) | (0.00653) | (0.879375) | (0.019456) | (0.219991) | (0.029601) |
| Patent applications, | −0.227431 | 0.152691*** | −0.0000693 | −0.246017** | −0.004553 | −0.234901** |
| nonresidents per capita | (0.200529) | (0.022684) | (0.000606) | (0.116292) | (0.003307) | (0.105938) |
| | | | *Openness* | | | |
| Inward foreign direct | −0.030409** | 0.035936** | −0.003785 | 0.699126*** | −0.002174* | 3.505717** |
| investment stock | (0.009456) | (0.01497) | (0.003337) | (0.043861) | (0.001162) | (1.339075) |
| Imports of goods and | −0.001032 | −0.137868*** | −0.000395*** | −0.480234*** | −0.000536*** | −0.079536 |
| services (% of GD) | (0.000493) | (0.043821) | (0.0000972) | (0.084992) | (0.000176) | (0.056121) |
| Exports of goods and | −0.002174 | −0.056849* | −0.00059*** | −0.361843*** | −0.000829*** | 0.015189 |
| services (% of GD) | (0.001006) | (0.029188) | (0.000187) | (0.067983) | (0.000187) | (0.022196) |
| Openness Indicator | −0.070948 | −0.00157*** | −0.032903*** | −0.008251*** | −0.00514 | −0.000241 |
| | (0.031934) | (0.000505) | (0.006485) | (0.000953) | (0.022342) | (0.00732) |
| | | | *Infrastructure* | | | |
| % Telecommunication | −0.018586 | 0.013823*** | −0.033731*** | 0.044785*** | −0.081684 | 0.078122*** |
| Revenue | | | | | | |
| Electric power | −0.000274*** | 5.295248*** | −0.00000361** | 114.7191*** | −0.0000142** | 9.01667*** |
| consumption | (0.0000448) | (0.252979) | (0.00000129) | (6.646084) | (0.00000529) | (0.745526) |
| Mobile and fixed-line | −0.015057 | 4.44475*** | −0.000761*** | 12.78409*** | −0.002976*** | 7.800345*** |
| subscribers | (0.00736) | (0.823235) | (0.000127) | (1.240232) | (0.000716) | (0.88737) |
| Registered carrier | −0.071967 | 0.00012 | −0.001921 | 0.2246*** | −0.050535 | −0.044017*** |
| departures worldwide | (0.065898) | (0.002883) | (0.001914) | (0.050897) | (0.045998) | (0.00439) |
| % Paved Roads | −0.001575** | 0.136303** | −0.000484*** | −0.206584*** | −0.001062*** | 0.091045*** |
| | (0.00049) | (0.055325) | (0.000127) | (0.016199) | (0.000358) | (0.00747) |

Note: Significance levels: 1%***, 5%**, 10%*. Standard errors in parenthesis.

**Table 1.3c** Results of convergence analysis: socio-institutional system (I).

| | *World* | | *OECD* | | *Latin America* | | *East Asia* | | *Eurasia* | |
|---|---|---|---|---|---|---|---|---|---|---|
| *Education and Human Capital* | $\beta$ | $\sigma$ | $\beta$ | $\sigma$ | $\beta$ | $\sigma$ | $\beta$ | $\sigma$ | $\beta$ | $\sigma$ |
| Gross Enrollment Ratio Primary | −0.000512*** (0.0000236) | −0.441884*** (0.018528) | −0.000296*** (0.0000543) | −0.089952*** (0.011067) | −0.000284*** (0.0000572) | −0.14632*** (0.017726) | −0.000281 (0.000212) | −0.136063** (0.05171) | −0.000379*** (0.0000596) | −0.212354*** (0.027181) |
| Gross Enrollment Ratio Secondary | −0.000797*** (0.0000587) | −0.046228* (0.024197) | −0.000627*** (0.000124) | 0.183092*** (0.057361) | −0.000665*** (0.0000939) | −0.032679 (0.020521) | −0.00089*** (0.000279) | −0.167756*** (0.021944) | −0.000428*** (0.0000671) | −0.117525*** (0.028813) |
| Mean years of schooling | −0.004363*** (0.000316) | −0.002672*** (0.000594) | −0.003089*** (0.000409) | −0.027338*** (0.001576) | −0.003967*** (0.000899) | 0.001013 (0.000752) | −0.001323 (0.001289) | 0.026851*** (0.002034) | −0.001186 (0.000688) | 0.013124*** (0.00112) |
| Gross Enrollment Ratio Tertiary | −0.016179* (0.008503) | 0.503428*** (0.016155) | −0.001407*** (0.000209) | −0.146808*** (0.039278) | −0.007874*** (0.001866) | 0.343581*** (0.013067) | −0.038421 (0.026216) | 0.689115*** (0.018019) | −0.002927*** (0.000447) | 0.33849*** (0.045999) |
| | | | | | *Political Institutions* | | | | | |
| Political Rights | −0.004673*** (0.001083) | −0.001782* (0.000886) | −0.012937*** (0.002148) | −0.016753*** (0.001347) | −0.010838*** (0.003566) | −0.038184*** (0.002931) | −0.015772** (0.006483) | 0.018313*** (0.001762) | −0.008069* (0.004191) | 0.046577*** (0.004167) |
| Civil Liberties | −0.005172*** (0.000804) | −0.010926*** (0.001313) | −0.010575* (0.005517) | −0.005452** (0.002392) | −0.011601*** (0.002186) | −0.02237*** (0.003148) | −0.009464*** (0.002783) | −0.008044*** (0.002604) | −0.009378* (0.005035) | 0.032111*** (0.002735) |
| Freedom of Press | −0.001029*** (0.000114) | −0.12458*** (0.017158) | −0.004122*** (0.000557) | −0.081799*** (0.010191) | −0.002038*** (0.000451) | −0.330072*** (0.038153) | −0.000702*** (0.000194) | 0.27377*** (0.036365) | −0.000903*** (0.000279) | 0.359378*** (0.037505) |
| Freedom of Speech | 0.205712*** (0.03923) | −0.002253 (0.001792) | −0.083181*** (0.014662) | −0.001926 (0.001488) | −0.009549 (0.02845) | −0.003387* (0.001953) | 0.385553 (0.277164) | 0.003868 (0.002605) | 0.047721 (0.191013) | 0.012976*** (0.002998) |

(*Continued*)

**Table 1.3c** (*Continued*)

| | *World* | | *OECD* | | *Latin America* | | *East Asia* | | *Eurasia* | |
|---|---|---|---|---|---|---|---|---|---|---|
| *Education and Human Capital* | $\beta$ | $\sigma$ | $\beta$ | $\sigma$ | $\beta$ | $\sigma$ | $\beta$ | $\sigma$ | $\beta$ | $\sigma$ |
| | | | | | *Social Capital* | | | | | |
| Corruption Perception Index | −0.007296*** (0.001954) | 0.000663 (0.000804) | −0.003508*** (0.000594) | −0.020309*** (0.001711) | −0.007956*** (0.001764) | −0.018982*** (0.002434) | −0.002494 (0.001947) | 0.002714 (0.001746) | −0.009351*** (0.00151) | −0.006534** (0.002481) |
| Gini Index | −0.000711*** (0.000063) | −0.145552*** (0.010306) | −0.000987*** (0.00026) | −0.011321 (0.009381) | −0.000581*** (0.000146) | −0.029548** (0.012886) | −0.001637*** (0.000384) | −0.2125*** (0.024404) | −0.000961 (0.000596) | 0.232464*** (0.026288) |
| Most people can be trusted | −0.056101*** (0.010627) | 0.000233*** (0.0000826) | −0.011884** (0.005376) | 0.00028** (0.000135) | −0.239054*** (0.051344) | −0.0000566 (0.000134) | −0.078595*** (0.01835) | −0.000459** (0.000183) | −0.145275*** (0.032112) | −0.000301** (0.000118) |
| Feeling of Happiness | −0.000954*** (0.000348) | 0.000216 (0.000181) | −0.001063 (0.001013) | −0.000297* (0.000165) | −0.001251 (0.002033) | 0.00000757 (0.000314) | −0.005749** (0.001697) | −0.000773* (0.000379) | −0.001076 (0.001029) | 0.000398 (0.00031) |

Note: Significance levels: 1%***, 5%**, 10%*. Standard errors in parenthesis.

**Table 1.3d** Results of convergence analysis: socio-institutional system (II).

| | *South Asia* | | *North Africa and Middle East* | | *South and Central Africa* | |
|---|---|---|---|---|---|---|
| *Education and Human Capital* | $\beta$ | $\sigma$ | $\beta$ | $\sigma$ | $\beta$ | $\sigma$ |
| Gross Enrollment Ratio Primary | −0.000331** | −0.331319*** | −0.00038*** | −0.277927*** | −0.000499*** | −0.47073*** |
| | (0.0000771) | (0.038534) | (0.0000427) | (0.047844) | (0.0000478) | (0.033362) |
| Gross Enrollment Ratio Secondary | −0.000449 | 0.219976*** | −0.000901*** | −0.299383*** | −0.002047*** | 0.314106*** |
| | (0.000306) | (0.014315) | (0.000231) | (0.030695) | (0.000378) | (0.018309) |
| Mean years of schooling | −0.006505** | −0.012677*** | −0.005934*** | 0.004681*** | −0.009612*** | 0.016128*** |
| | (0.001369) | (0.0012) | (0.000942) | (0.001113) | (0.001425) | (0.001274) |
| Gross Enrollment Ratio Tertiary | −0.022508 | 0.363008*** | −0.005322*** | 0.061497** | −0.111863 | 0.091934*** |
| | (0.039221) | (0.021236) | (0.000982) | (0.026447) | (0.085062) | (0.007456) |
| | | | *Political Institutions* | | | |
| Political Rights | −0.00509 | −0.008136 | −0.011107*** | −0.000345 | −0.01208*** | 0.015962*** |
| | (0.004675) | (0.011311) | (0.00198) | (0.00379) | (0.001917) | (0.003084) |
| Civil Liberties | −0.005678** | −0.006472* | −0.004826*** | −0.004037* | −0.007711*** | 0.006019*** |
| | (0.00152) | (0.00354) | (0.000911) | (0.002326) | (0.001663) | (0.001769) |
| Freedom of Press | −0.000943* | −0.356358*** | −0.000643*** | −0.523354*** | −0.001352*** | −0.162969*** |
| | (0.000333) | (0.102334) | (0.0000775) | (0.036265) | (0.000265) | (0.019634) |
| Freedom of Speech | 0.215426 | −0.003668 | 0.783036** | −0.004699* | 0.128801 | −0.000663 |
| | (0.252573) | (0.005634) | (0.283735) | (0.002454) | (0.077408) | (0.002164) |
| | | | *Social Capital* | | | |
| Corruption Perception Index | −0.022044 | −0.01011*** | −0.004962** | −0.00675** | −0.029513*** | −0.018602*** |
| | (0.013992) | (0.003497) | (0.001641) | (0.002462) | (0.009261) | (0.00174) |
| Gini Index | −0.000371 | 0.244798*** | −0.000622 | −0.110757*** | −0.000565*** | −0.175183*** |
| | (0.000597) | (0.030138) | (0.000299) | (0.031826) | (0.0000857) | (0.020744) |
| Most people can be trusted | 0.000928 | −0.000546 | −0.040653 | 0.000629* | −0.182915** | 0.0000614 |
| | (0.049108) | (0.000383) | (0.100556) | (0.000319) | (0.078626) | (0.000179) |
| Feeling of Happiness | −0.022786 | 0.0000187 | 0.002167 | 0.001053*** | −0.001165 | 0.000862** |
| | (0.022009) | (0.000377) | (0.002674) | (0.000342) | (0.000981) | (0.000361) |

Note: Significance levels: 1%***, 5%**, 10%*. Standard errors in parenthesis.

8 In order to provide a better perspective of the world maps, we decided to use year 2000 in Figure 1.3, Figure 1.6, and Figure 1.7, instead of using 2008 as we did in all of the other figures. The reason is that we wanted to report only observed data in the cartograms and avoid using imputed (estimated) observations.

9 Detailed results are included in Tables 1.3a–d.

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