Geo-Regional Competitiveness in Central and Eastern Europe, the Baltic Countries, and Russia

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Chapter 2

National Innovation System Dynamics in East Central Europe, the Baltic Countries, and Russia

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ABSTRACT

In this chapter, the structure and dynamics of national innovation systems are explored to produce a comprehensive picture of the current, as well as the past, performance of the countries of East Central Europe, the Baltic countries, and Russia vis-à-vis their competitiveness and innovative capabilities. The results highlight the importance of political and economic freedom, science, and education for promoting innovation. According to the principal component analyses, the best performing countries of the East Central Europe and the Baltic countries, in terms of their national innovation systems, have developed rapidly after the disintegration of the Soviet bloc and compare well in global rankings of innovative capabilities and competitiveness with standings above the countries of Latin America and South-East Asia. The countries under closer examination here that are members of the EU seem to be in a better position compared to the non-EU member countries. Thus, most of the countries in East Central Europe and the Baltic countries have been able to catch up with the global leaders during the analysed time period (1992–2008). However, this kind of development is yet to manifest in Russia.

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INTRODUCTION

In today's globalising knowledge economy the role of innovations has been highlighted as one of the most important engines for productivity growth in individual firms and economic growth on national and regional levels. Therefore, in recent decades much attention has been turned towards researching the enablers of national innovative capability and performance. In this work the concept of 'National Innovation Systems' (NIS) has been brought repeatedly into the fore of scholarly debate. The NIS concept was developed in the late 1980s and early 1990s, by leading researchers in the field including Freeman (1987), Lundvall (1992) and Nelson (1993), not only as an academic framework but also as a tool for policy makers to enhance their nations' competitiveness in terms of innovation. The concept was endorsed and included in science, technology and innovation policies early on in countries such as the Nordic countries of Denmark, Finland and Sweden. The encouraging experiences gained from the Nordic countries have led other nations to follow their example. Similarly, the sheer volume of innovation system studies have manifold in recent years underlining the popularity of the concept among academic circles (Fagerberg & Sapprasert, 2011; Uriona-Maldonado, dos Santos & Varvakis, 2012), policy-makers and international organisations (David & Foray, 1995; OECD, 1999). This wide interest has included several theoretical discussions, but also a series of studies on methodological measurement issues related to the empirical treatment of NIS resulting in a rich literature on cross-country NIS rankings and comparisons. In short, the NIS framework has proven to be a valuable tool in comparing national competitiveness and innovative capabilities (by showing how technological infrastructure differs between countries and how such differences are reflected in international competitiveness) as well as a practical instrument for promoting economic development (Freeman, 2004; Fagerberg & Srholec, 2008).

Globally the literature has, however, more commonly been concentrated on the already well-developed countries of the Western Europe, North America and Japan in terms of comparisons between the most developed OECD countries, countries of the EU etc. However, there are some refreshing exceptions with wider sets of included countries (Castellacci & Archibugi, 2008; Fagerberg & Srholec, 2008). Moreover, an increasing amount of interest has been laid in the socio-economic development of the BRICS countries (Brazil, Russia, India, China and South Africa) and the new EU member states of the Eastern Europe *vis-à-vis* NIS (Cassiolato & Vitorino, 2009; Krammer, 2009). In addition, empirical findings have pointed towards an evident catching up in progress between the global leaders in innovation and (some of) the East European countries (Makkonen & Inkinen, 2013). Still, the research on the countries of the East Central Europe (ECE) and the Baltic countries (Baltics) as well as on Russia has been mainly comparative and cross-sectional. The lack of longitu-

dinal research has been mainly due to limitations in the availability of comparable panel data. Socio-economic data for ECE and the Baltics varies in its scope and coverage prior their entry into the EU. The same applies to the differences between the statistical data on EU and Russia and other non-EU countries in the region. To allow comparisons, the data had to be compiled from multiple sources with differing statistical procedures hampering the country-wise comparability. However, now a newly compiled database, namely the CANA database, has been formed to allow a comparison of more than 130 countries for an extensive time period of 1980–2008. The dataset includes a great number of indicators measuring six key country-specific dimensions of NIS: innovation and technological capabilities, education system and human capital, infrastructures, economic competitiveness, political-institutional factors and social capital (Castellacci & Natera, 2011a; 2011b; 2013).

The aim of this chapter is thus to empirically compare and benchmark the innovative capability and competitiveness of ECE, the Baltics and Russia against the global leaders in innovation. The methodological workbench applied is that of multivariate analysis, namely principal component analysis (PCA) (Jolliffe, 2002; Tabachnick & Fidell, 2007). By applying PCA, the rich data provided by the CANA database can be condensed into a reasonable number of composite indexes without risking the possibility of losing data in the process. In short, PCA has been widely used when studying socio-economic development with multiple indicators. It has proven to be a valuable tool for finding latent dimensions under the directly observable data and in grouping variables into easily interpretable composite indexes. The utilization of PCA will allow the examination of the structure of the NIS in the study region and globally, namely it will show what the most important measures of national innovative capabilities are and whether this composition has changed in the time period from 1992–2008. An interesting question given the global changes experienced during this observation period. Moreover, the calculated principal component scores (PCS) i.e. index scores for individual countries allow country-wise comparisons between not only the countries under closer examination here, but all the countries in the dataset. With the panel data at hand, the analysis is able to show if the countries have experienced catch up in terms of innovative capability since the times of the disintegration of the Soviet bloc. Thus, the concrete research questions of this chapter can be summarized as follow:

1. What is the structure of NIS in the countries included in the CANA database?
2. Has this structure changed during the time period of 1992–2008?
3. How do ECE, the Baltics and Russia, compare with global leaders in their innovative capabilities and competitiveness?
4. Is there a catching up in progress between ECE, the Baltics and Russia and the global leaders?

By answering these questions the chapter offers interesting insights into the composition and evolution, i.e. dynamics, of NIS over a time period of nearly two decades. It will offer a benchmark and a comprehensive picture of the current, as well as the past, performance of ECE, the Baltics and Russia *vis-à-vis* their competitiveness and innovative capability and show how the countries compare to global leaders in innovation. Moreover, it will demonstrate if there are signs of catching up, to the global leaders, in progress. The chapter will thus make an original contribution to the existing empirical literature on NIS measurement and to the comparative literature on the competitiveness and innovative capabilities of ECE, the Baltics and Russia.

BACKGROUND: CONCEPTUAL DEBATES AND EMPIRICAL MEASUREMENT OF NATIONAL INNOVATION SYSTEMS

Despite the over two decades of work concerning the NIS approach, no single universally agreed definition of the concept has evolved. Rather, researchers tend to define the concept in varying ways (Table 1). What is agreed upon is that, as its name suggests, NIS is a systemic approach (as opposed to linear models) to study innovation. Instead of focusing solely on the innovative performance of firms it encompasses also research and development efforts by public actors as well as a variety of other determinants of innovation such as learning processes, incentive mechanisms and the availability of skilled labour (Balzat & Hanusch, 2004).

To be precise, the concept of NIS has been defined in a narrow and broad sense. Whereas the narrow approach revolves around the main sources of innovation, i.e. those institutions that are deliberately promoting the acquisition and dissemination

Table 1. Selected NIS definitions by some prominent early advocates of the approach (adapted from OECD, 1997; Niosi, 2002)

"The network of institutions in the public and private sectors whose activities and interactions initiate, import, modify and diffuse new technologies" (Freeman, 1987)
"The elements and relationships which interact in the production, diffusion and use of new, and economically useful, knowledge ... and are either located within or rooted inside the borders of a nation state" (Lundvall, 1992)
"A set of institutions whose interactions determine the innovative performance ... of national firms." (Nelson, 1993)
"The national institutions, their incentive structures and their competencies, that determine the rate and direction of technological learning (or the volume and composition of change generating activities) in a country" (Patel and Pavitt, 1994b)
"That set of distinct institutions which jointly and individually contribute to the development and diffusion of new technologies and which provides the framework within which governments form and implement policies to influence the innovation process" (Metcalfe, 1995)

of knowledge, the broad approach takes into account a much wider socio-economic system including political and cultural determinants (Lundvall, 1992; Freeman, 2002). Thus, in a way NIS is a set of institutions/actors including universities and other research institutions, firms, intermediaries and governments that produce and implement innovation (Guan & Chen, 2012), where a central role is given to the interaction and interplay between these different actors in the NIS (Lundvall, 1999), as well as the wider socio-economic, cultural and political conditions of a given country (Gregersen & Johnson, 1997). The approach was developed, not only as a framework for economic and innovation studies, but also has definite policy roots as the advocates of the approach commonly try to influence and inform policymakers in drawing innovation policies (Sharif, 2006). In short, developing the institutions within NIS and the interplay between them should result in a heightened innovation efficiency of a given country. Moreover, the definitions of NIS come close to the definitions of national competitiveness, that is for example, “the set of institutions, policies, and factors that determine the level of productivity of a country” (Sala-i-Martin, Bilbao-Osorio, Blanke, Drzeniek Hanouz & Geiger, 2011, p. 3). Accordingly, innovations are commonly considered as (one of) the most important factors affecting the productivity growth of firms and nations. Thus, efforts promoting the functioning of NIS can be considered as actions that will also subsequently promote national competitiveness.

Drawing from the early work on NIS, the approach has evolved to encompass a range of other concepts (delineated according to geographical scope or industrial branch) including continental, cross-border, local, regional, scalar, sectoral, spatial, technological and territorial innovation systems. Moreover, the role of multinational companies, global networking and cross-border cooperation are of growing importance. However, as stated by Freeman (1995), NIS remains essential for economic development: “the influence of the national education system, industrial relations, technical and scientific institutions, government policies, cultural traditions and many other national institutions is fundamental” (p. 5). Thus, the concept of NIS has been discussed together with the reforms experienced in ECE, the Baltics and Russia in the post-Soviet era. Notably, in the end of the last century Radosevic (1999) noted that when it comes to ECE and the Baltics “it is not yet possible to talk about national or regional systems of innovation” (p. 313). More than a decade later the NIS of ECE and the Baltics are still described as inefficient, since they have, in fact, lost some of their advantage (inherited from the socialist period) in terms of the size of research and development (R&D) expenditures and have unexpectedly low levels of productivity compared to their R&D capacities as well as low demand for technology (Kravtsova & Radosevic, 2012). Similar trends apply in many respects also to Russia (Radosevic, 2003). Thus, in general the countries have problems in converting science, technology and R&D into innovations and productivity.

The NIS approach has also raised a considerable amount of criticism. Notably, the approach has difficulty accounting for bounded change i.e. changes that lead to the creation and restructuring of institutions and interaction within the national systems, but not to the transformation of the system as a whole (Hart, 2009). Similarly, the delineation of various NIS has proven to be a difficult task. In essence the problem has to do with the difficulty of how to define the actors within NIS in a way that the most essential interactions occur inside rather than outside the NIS (Carlsson, Jacobsson, Holmén & Rickne, 2002). In relation to the use of the NIS approach as a policy tool, serious concerns may be raised upon its applicability across the global realities (Miettinen, 2002). Thus, the chances of reproducing favourable conditions based on the successful benchmarks are slim (Tödtling & Tripl, 2005). Therefore, the national peculiarities have to be taken into account when implementing innovation policies based on the NIS approach. However, despite this well-placed criticism the NIS approach has proven to be a valuable analytical tool in economic studies concerned with the empirical estimation of the current state and dynamics of national innovative capability and performance, applied in a range of studies discussed in greater detail below.

The empirical measurement of NIS is by no means a simple task. The sheer complexity of the approach and the volume of actors and interactions involved in the functioning of the systems render the quantitative analysis empirically challenging. Nonetheless, several empirical analyses have taken upon the task to empirically validate the approach with comparable cross-country analysis (for early attempts see Niosi, Saviotti, Bellow & Crow, 1993; Patel & Pavitt, 1994a; and for recent efforts see Guan & Chen, 2012; Pinto & Pereira, 2013). However, the main emphasis of these studies has been on the most developed countries of the OECD or EU. Here the discussion is centred on the (few) studies that include data and evidence comprehensively from ECE, the Baltics and Russia.

With respect to ECE, the Baltics and Russia, the empirical literature has mainly focused on descriptive analyses and case studies (Krammer, 2009). However, following the NIS approach, Radošević (2004) has shown that in terms of innovative capabilities the countries of ECE and the Baltics belong to the middle tier or to the less advantaged group of EU economies (for a global comparison on NIS efficiency including the Czech Republic, Hungary, Poland and Russia see Nasierowski & Arcelus, 2003). A more recent account has confirmed that although catching up in some distinct indicators, the new EU-member countries of ECE and the Baltics still lag behind in terms of their NIS capabilities measured in innovation, education and economic development (Makkonen & Inkinen, 2013). In line, Krammer (2009) has shown, with an approach that combines elements from endogenous growth theory and the NIS approach, that in contrast to the more developed countries the government's contribution outperforms the business R&D investment in ECE, the Baltics

and Russia. Moreover, Krammer (ibid.) pinpointed various aspects of NIS, where ECE, the Baltics and Russia were lagging behind their Western counterparts. Accordingly, empirical investigations (leaning closely to the NIS approach) into the impacts of the current economic crisis have shown that in the EU the countries most affected by the downturn in terms of innovation, science and technology have been the new member countries of Central and Eastern Europe (Filippetti & Archibugi, 2011; Makkonen, 2013).

In a recent global account, Fagerberg and Srhrolec (2008) have employed factor analysis (with a dataset of 115 countries and 25 indicators collected mainly from the World Bank – World Development Indicators 2006 – complemented with a multitude of other sources) in an attempt to identify the variables most relevant for NIS capabilities. They concluded that the most relevant measures for development, diffusion and use of innovations were patents, science and engineering articles, ISO 9000 certifications, fixed line and mobile phone subscribers, Internet users, personal computers, primary school teacher-pupil ratio, secondary school enrolment and tertiary school enrolment. According to their analysis it seems that in a global perspective the ECE, the Baltics and Russia are doing rather well, topping for example most of the countries in Latin America and South-East Asia. However, they still lag behind the most developed countries of the west and the “Asian Tigers” of South Korea, Singapore and Taiwan. The analysis also confirmed that the NIS capabilities of the countries in question here have developed positively between the time periods of 1992–1994 and 2000–2004. Accordingly, Castellacci and Archibugi (2008) have employed factor analysis in an attempt to classify countries into distinct technology clubs according to their NIS. They employed data gathered from the ARCO database (for a description of the database see Archibugi & Coco, 2004) and included 131 countries and eight indicators into their analysis: patents, scientific articles, Internet penetration, telephone penetration, electricity consumption, tertiary science and engineering enrolment, mean years of schooling and literacy rate. Their analyses pointed out that there seems to be three distinct groups (technology clubs) of NIS and that the ECE, the Baltics and Russia are among the follower countries (middle group) in innovation. However, they observed only a few notable changes to the cluster composition (in terms of countries belonging to it) over time; from the beginning to the end of the 1990s (Castellacci & Archibugi, 2008).

In sum, despite the criticism directed towards the NIS approach, especially as a policy tool, the importance of the approach as an analytical framework has been proven in earlier literature, evidenced by the growing number of NIS related scientific articles (Fagerberg & Sappasert, 2011; Uriona-Maldonado et al., 2012). Consequently, a range of studies have probed the validity and empirical treatment of the NIS approach but, however, with comparative cross-country data on the most developed countries of the world. Therefore, as observed from the above, despite

some exceptions, there is a lack of empirical cross-country, in general, and longitudinal, in particular, research on the dynamics and structure of the NIS of ECE, the Baltics and Russia.

DATA AND METHODS: CANA DATABASE AND PRINCIPAL COMPONENT ANALYSIS

The data used here was gathered from the CANA database. The database is comprised of 41 indicators (34 with full country coverage and seven for a smaller sample) from distinct NIS related categories (innovation and technological capabilities, education system and human capital, infrastructures, economic competitiveness, political-institutional factors and social capital) for 134 countries, covering the years from 1980 up to 2008 (Castellacci & Natera, 2011a; 2011b). As stated by the constructors of the dataset: “the novelty of the database is that it provides full information for the whole set of country-year observations, i.e. it contains no missing values” (Castellacci & Natera, 2013, p. 583). The dataset has been constructed by combining together indicators available from a number of existing cross-country data sources and by applying the method of multiple imputation in the missing data treatment (for methodological notes on multiple imputation see Honaker & King, 2010). In short, the original data does have missing values, but in the CANA database there are none for the variables included in this paper, since the authors of the database have conducted the multiple imputation treatment i.e. they have mathematically replaced the original missing values by best available estimates and validated the reliability of the dataset (for a detailed description see Castellacci & Natera, 2011b). The variables, of which most are in common use when discussing NIS, included (after checking their communalities, see below) into the analysis here are presented in Table 2. The inclusion of variables related to innovation and technological capabilities, education system and human capital, infrastructures, economic competitiveness and social capital is a common practice in the NIS literature (Castellacci & Archibugi, 2008; Fagerberg & Srholec, 2008). The inclusion of political-institutional factors is also justifiable. As discussed by Hartmann, Pyka and Hanusch (2010), the efficiency and the capabilities of all actors to contribute to innovation and development depend on the notion that they are free to participate in economic life. After all: “what is a culture of innovation: it’s a freedom of thought, freedom of speech and freedom of action” (Lockwood, Smith & McAra-McWilliam, 2012, p. 755). However, the inclusion of a large number of variables to proxy political-institutions can introduce some bias when analysing, in particular, the Russian NIS.

Table 2. Chosen variables for depicting distinct NIS dimensions (for exact descriptions and original data sources see Castellacci & Natera, 2011b).

Variable	Abbreviation	Description
Patents	Pat	Number of utility patents granted by the USPTO*
Scientific articles	Sart	Number of scientific and engineering articles
Finance freedom	Ffree	Subjective assessments by Heritage Foundation staff
Secondary enrolment ratio	Serat	Ratio of total enrolment (secondary level)
Tertiary enrolment ratio	Terat	Ratio of total enrolment (tertiary level)
Mean years of schooling	Myschool	Average number of years in school
Primary pupil-teacher ratio	Pptrat	Number of pupils / Number of teachers
Electric power consumption	Epc	Production, efficiency and use of power plants
Internet users	Ius	Internet users per 1000 people
Mobile and fixed telephony	Mftel	Total telephone subscribers per 1000 inhabitants
Carrier departure	Cdep	Domestic and global take-offs per 1000 inhabitants
Corruption	Corrup	Transparency International Index
Freedom of press (I)	FreepressI	The degree of print, broadcast, and internet freedom
Freedom of press (II)	FreepressII	The degree of freedom that journalists enjoy
Freedom of speech	Freespeech	Extent to which freedom of speech is affected by censorship
Human rights	Hrights	Physical integrity
Women's rights	Wrights	Women's economic, political and social rights
Political rights	Prights	People's free participation in the political process
Civil liberties	Clib	People's basic freedoms
Freedom of association	Freeasso	Freedom of assembly and association
Electoral self-determination	Eself	Freedom of political choice
Democracy vs. autocracy	DvsA	Free vs. suppressive political participation
* United States Patent and Trademark Office		

Since there is no single agreed geographical definition on the list of nations belonging to the ECE (Ágh, 1998), a decision to include the following ECE countries was made: Bulgaria, the Czech Republic, Hungary, Moldova, Poland, Romania, Slovakia and Ukraine (the delineation, however, is debatable and in some definitions also countries such as Albania, Croatia and Slovenia are included when discussing Central and Eastern European countries). These countries are accompanied with Russia as well as the Baltic countries of Estonia, Latvia and Lithuania. Despite the usefulness and extensiveness of the CANA database, there were, however, some limitations due to data availability issues:

National Innovation System Dynamics

1. Belarus had to be excluded from this study, since it is not included in the CANA database.
2. R&D expenditures and the dimension of social capital had to be excluded from this study, since they are covered only for some countries in the dataset.
 - a. Social capital has been positioned as an important impetus for innovation and NIS. However, at the same time it has been acknowledged that the measuring of such an intangible asset as social capital is extremely difficult and subjective (Tura & Harmaakorpi, 2005).
3. The impacts of the most recent (global) economic downturn were not traceable here, since the CANA database covers a time period (only) up to the year 2008.
4. The fact that “national borders do not necessarily form the boundaries of the systems” (Carlson et al., 2002, p. 236) remains an unsolved measurement issue for most country-wise data.

Additionally, the notion by Castellacci and Natera (2013) in which the set of key factors driving the NIS vary across distinct country groups according to their levels of development implies that the results produced by the PCA might have deviated from the aggregate level analysis (all countries included) conducted here, if measured in accordance to distinct income groups. The validation of this notion was, however, out of the scope of this study for methodological reasons since the reliability of the analysis would suffer from the use of smaller samples.

As described above, researchers frequently employ multivariate analysis, such as factor analysis (Castellacci & Archibugi, 2008; Fagerberg & Srholec, 2008), in the empirical treatment of NIS. This is because the concept itself contains a multitude of measurable (as well as non-measurable, latent) items influencing its capability and performance. However, some of the variables described in Table 2 do not fulfil the requirements of normal distribution (tested with Shapiro-Wilk test of normality), as is commonly the case when using cross-country data, set for factor analysis. Therefore, a decision to use its non-parametric counterpart, PCA, was made. PCA is a commonly used tool for supressing data from a large number of variables into one composite index (or few indexes). The advantage of PCA is that it produces weights, given the measured importance of the variables (based on correlation matrixes), for the index calculus, compared to the cruder employment of fixed equal weights (Archibugi & Coco, 2004). These weights are used in a way similar to regression analysis to produce the composite indexes, i.e. PCS, describing the dimension under examination. PCA is, thus, commonly employed to identify latent dimensions, that is, principal components (PC) behind the directly observable data (Pinto, 2009). Here, this latent dimension concerns the structure of NIS. At the same time, the critique directed at accounting for change in NIS (Hart, 2009) is (at least partly) taken into

account here, as the analyses are conducted in a year-to-year basis allowing changes in the variable composition (structure) of NIS. The fitness of the PCA solutions were tested with the most commonly applied tests of PCA suitability, namely the Bartlett test of sphericity and the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy (Jolliffe, 2002; Tabachnick & Fidell, 2007): the solutions passed these fundamental tests for every year analysed (for all years: KMO > 0.9 ; Bartlett test < 0.001). Similarly for the measures presented in Table 2, the variances accounted for by the PC (i.e. communalities) were large enough (although there were some minor fluctuations just below the threshold value of 0.3 for individual measures for individual years) for them to be included in the analysis, whereas twelve variables with low communalities had to be excluded from the final analysis.

RESULTS: STRUCTURE AND DYNAMICS OF NATIONAL INNOVATION SYSTEMS IN EAST CENTRAL EUROPE, THE BALTIC COUNTRIES AND RUSSIA

A large number of measures showed significant loadings (loadings indicate how well the variation in an observed single variable is explained by the PC; loadings have a range between -1 and 1) concerning the first PC, interpreted as the “structure of NIS”. Thus, here the focus is on the interpretation of the first PC for the years 1992–2008, which had eigenvalues (eigenvalues indicate how well the PC explains the variation between all the observed variables in the analysis) greater than 11.5 (accounting for 53–58% of the total variation) for all years. Figure 1 illustrates the changes (dynamics) in the most relevant measures for NIS structure in the time period of 1992–2008. As the figure suggests, civil liberties and freedom of press (I) were the leading and distinct measures of the structure of NIS in a global context. The significance of the measure depicting Internet users has grown steadily and was in 2008 the variable with the third highest loading. In turn, mobile and fixed telephony, the most important measure for the structure of NIS at the start of the observation period, has steadily lost its importance from 2004 onwards. Other measures with high loadings included corruption, political rights, scientific articles and tertiary enrolment ratio. Additionally, other subtle changes in the structure of the NIS include, for example, the increasing importance of finance freedom from a loading of 0.538 in 1992 up to 0.781 in 2008 (indicating a growing significance of entrepreneurship).

Maybe somewhat surprisingly, patents (a commonly used proxy for innovation) had only a mediocre importance to the structure of NIS throughout the time period observed. The reason why patents are not that important in terms of PCA, however, might be more to do with the fact that the data was initially gathered from USPTO.

National Innovation System Dynamics

Figure 1. Selected extracts of the variables with the highest loadings to the first principal component: “structure of NIS”. Source: author’s own elaboration based on data from Castellacci and Natera (2011b).

Relying solely on patent data from USPTO inserts a certain amount of country bias into the analysis, as for some countries patenting on the US markets is more important than for others (Criscuolo, 2006). Furthermore, the fact that patents can be considered as a proxy for innovative outputs (performance indicator), whereas the other measures used are strictly innovative inputs (capability indicators), might explain the reasons behind the mediocre correlation scores between patents and the other measures analysed.

To answer the first research question, the results of the PCA indicate that basic freedoms and liberties, as well as a non-corrupt economic and political system, are extremely important in a global context for the structure of NIS to emerge and evolve in the first place. Moreover, the importance of science, education (also the loadings for the measures depicting secondary enrolment ratio and mean years of schooling were relatively high) and knowledge sharing practices (Internet users and mobile and fixed telephony) in this development are central as expected, given the status laid on knowledge and learning as the cornerstones upon which the NIS approach relies on.

To answer the second research question, the structure of NIS has remained relatively unchanged throughout the time period analysed. However, some clear changes have occurred. Most importantly, the shift in the loadings between the

measures for mobile and fixed telephony to Internet users indicates a change in the global patterns of knowledge sharing and acquisition: the Internet (email, etc.) has replaced telephones as the most prominent means of knowledge sharing and communications (Feldman, 2002). In addition, the importance of finance freedom has grown steadily during the time period analysed, highlighting the significance of a transparent and open financial system, which consequently promotes entrepreneurship in the context of NIS (Miller & Kim, 2011).

When compared to the global leaders in innovation (Norway, Sweden and Finland) in NIS capabilities, ECE, the Baltics and Russia still have a lot of work ahead of them in terms of catching up with these best in the class performers (Table 3; Figure 2). Still, the best performing countries of ECE (Hungary, the Czech Republic, Poland and Slovakia) and the Baltics indeed rank higher than the countries of Latin America

Table 3. The standing in the principal component score rankings of “structure of NIS” for global leaders, the “Asian Tigers” and the countries of Eastern Central Europe, the Baltic countries and Russia (highlighted in grey), arranged according to average standings. Source: author’s own elaboration based on data from Castellacci and Natera (2011b).

COUNTRY/YEAR	92	93	94	95	96	97	98	99	00	01	02	03	04	05	06	07	08
Norway	1	1	1	1	1	2	2	2	2	2	2	2	2	1	1	1	1
Sweden	3	3	3	2	3	1	1	1	1	1	1	1	1	3	4	4	2
Finland	5	5	5	4	4	4	3	3	4	3	3	3	3	4	3	3	3
Estonia	25	25	23	21	24	24	22	22	20	21	20	18	18	17	20	20	17
Hungary	23	26	25	25	26	26	26	29	26	25	25	27	27	22	26	27	26
Czech Republic	51	20	22	26	22	25	25	24	24	27	26	25	22	28	24	26	22
South Korea	39	31	31	28	29	29	29	26	25	26	27	26	24	27	23	24	24
Lithuania	32	34	27	27	27	27	28	30	29	30	29	28	30	26	27	29	27
Poland	31	30	29	33	30	31	30	32	30	31	31	32	31	33	33	32	31
Latvia	30	33	32	29	31	30	33	33	33	34	33	31	32	30	28	30	30
Slovakia	83	36	34	37	39	38	31	27	31	29	30	29	28	24	29	28	28
Bulgaria	33	41	40	43	48	46	49	43	47	42	39	39	37	35	36	36	41
Singapore	45	48	46	46	43	47	46	44	40	38	40	34	38	38	40	43	43
Romania	65	55	63	58	47	50	43	49	54	50	49	47	53	49	47	45	46
Moldova	63	60	53	51	61	60	54	56	51	60	66	66	58	61	60	57	66
Ukraine	57	59	58	56	57	64	65	60	71	65	62	72	70	55	48	48	51
Russia	52	56	54	64	63	65	64	77	76	80	80	87	88	89	89	87	86

National Innovation System Dynamics

Figure 2. Principal component scores of “structure of NIS” for the best performing countries of the East Central Europe (ECE) and the Baltic countries (top), other ECE countries and Russia (middle), as well as the global leaders and the “Asian Tigers” (bottom). Source: author’s own elaboration based on data from Castellacci and Natera (2011b).

and South-East Asia. Moreover, when compared to the “Asian Tigers” (South Korea and Singapore; Taiwan is not included in the CANA database) they are performing rather well. For other countries of ECE (Bulgaria, Romania, Moldova and Ukraine) and Russia this is, however, not the case. As a side note the poor performance of the Republic and Slovakia in 1992 was due to the contemporary political situation: the dissolution of Czechoslovakia into the Czech Republic and Slovakia did not happen until January of 1993.

What is not obvious from Table 3, but is clear from Figure 2, is the catch up between the global leaders in innovation and the best performing countries of ECE and the Baltics. Although the global leaders have more or less stayed the same, the follower countries are catching up with them in terms of NIS capabilities. Indeed, the PCS in the best performing countries of ECE and the Baltics have improved quite steadily throughout the time period analysed. Therefore, as a general trend, they show positive signs of development. Again, with other countries of ECE and Russia this kind of development is not as evident. Moreover, in the last years of the observation period, the PCS scores of Russia have actually been declining. The deepest decline coincides with the financial crisis of Russia in 1998. However, it seems that there are some positive signs in terms of the NIS structure in Russia, as the decline seems to have halted in 2005–2006 and the country was able to slightly improve its performance during the last two years observed.

To answer the third research question, the innovative capabilities, in terms of the structure of NIS of ECE, the Baltics and Russia have mixed profiles. The best performing countries of ECE and the Baltics are doing rather well when compared to Latin American and Asian countries but still trailing behind to the global leaders in innovation. However, the rest of the countries of ECE and Russia are not performing that well in terms of their NIS capabilities and they posit only mediocre standings in the global rankings.

To answer the fourth research question, there is an evident catching up (when compared to the global leaders in innovation) in progress when discussing the best performing countries of ECE and the Baltics. Their PCS show increasingly signs of a positive growth trend in global comparisons. However, when it comes to the other countries of ECE and Russia, this trend is less evident. In fact, the PCS of Russia have been in steady decline (up until the very recent years observed).

DISCUSSION AND CONCLUSION

It can be stated that, in general, ECE and the Baltics have developed rapidly after the disintegration of the Soviet bloc. As the results presented here relate to the potential and resources, in terms of present innovativeness as well as social and economic development, of the countries concerned, it is evident that the countries with higher

rankings have good innovation and technological capabilities, well performing educational systems and adequate technological infrastructures. Moreover, as the operationalization of the NIS approach incorporates a copious number of political-institutional factors, the countries under closer examination here that are members of the EU (with democratic, free, inclusive and open political systems) seem to be in a better position compared to the non-EU member countries. Still, although the results indicate good standings for most countries of ECE and the Baltics, the regional imbalances remain unobserved here. In fact, existing evidence suggests that NIS might be decomposed into smaller subsystems that operate under different dynamics (Lengyel & Leydesdorff, 2011). At least in ECE and the Baltics, economic growth as well as innovation resources are heavily concentrated in the national capital regions (Varga, 2007; Makkonen & Inkinen, 2013). Moreover, as stated by Varblane, Dyker, Tamm and von Tunzelmann (2007), simply favouring high-tech sectors in hopes of replicating the success stories of the global leaders at the expense of low-tech sectors is not an option for catching up countries. Therefore, to fully profit from the NIS approach and take advantage of the full potential within the country, policy makers should bear in mind the limitations of concentrating on general policies as well as on a (too) narrow geographical scope or sectoral specialisation.

Moreover, whereas most of the countries under closer examination here have been able to improve their performance in terms of NIS capabilities and catching up with the global leaders, as observed also by Fagerberg and Srholec (2008), the same kind of development has not yet realized itself in Russia (also Dezhina, 2011). This development is likely to mature in the future as Russia has just recently started to rebuild its innovation system after the disintegration of the Soviet Union (Liuhto, 2011). However, this development might be hampered by the socio-economic realities of Russia, as the adoption of western style innovation system policies into Russian decision making is difficult, due to Russia's unique economic, political and social structures (Klochikhin, 2012). Some authors have even suggested that for the countries under study here, it was probably already too late to shape their NIS with policy initiatives when the countries in question entered their transition period (see Lengyel & Leydesdorff, 2011). However, others sustain that NIS development is possible for ECE, the Baltics and Russia, as long as the particular characteristics of the countries are taken into account before adapting (well-functioning) practices from elsewhere (Varblane et al., 2007; Klochikhin, 2012; Makkonen & Inkinen, 2013). Therefore, in order to improve their innovative capabilities and the structure of NIS ECE and the Baltics as well as Russia should not simply copy the practices of the best in class (global leaders) as such.

It is not possible to pinpoint here the exact challenges concerning NIS development for ECE, the Baltics and Russia. Rather, development is needed in every dimension (although the dimension of social capital, was unobserved here) of the NIS approach. Moreover, due to the varying innovation profiles of the countries

under closer examination, the analysis here provides a general view of the functioning of NIS. Thus, it is acknowledged that a thorough country specific investigation would raise these issues to the fore in a more detailed way as observed here. Still, it can be stated that according to the results, the implementation of policies aiming at economic and political freedom and equality are necessary for NIS to develop and evolve. This might be self-evident for the global leaders, but not necessary the case in the catching up countries. Accordingly, investments on the development of the scientific (proxied by articles) and educational (shown here through the high loadings of secondary and tertiary enrolment ratios as well as mean years of schooling) systems seem worthwhile in the light of the evidence presented here. Similarly, the sharing of knowledge (as shown by the importance of fixed and mobile telephone subscribers and Internet users) should be promoted. Moreover, for meeting the growth goals set for national innovative capabilities, encouraging entrepreneurship (as indicated here by the growing importance of finance freedom and also pinpointed in several recent assessments; for example in a review of the Estonian NIS by European Research Area Committee, 2012) is highly advisable. As suggested in earlier studies (Krammer, 2009) the problems have also much to do with the local private sector. Since knowledge diffusion is essential for catching up in today's knowledge based economy, firms should (and be encouraged to) enhance their technology using capabilities to be better adapted for exploiting the knowledge generated by the NIS (Kravtsova & Radosevic, 2012). In sum, as innovations are important for boosting economic development, the measures targeted on improving the functioning of NIS should also result in improvements in the competitiveness of a given nation.

To conclude, the results presented here are useful as a global benchmark and in showing what specific measures seem to affect the structure of NIS the most. The results highlight the importance of basic liberties and freedoms as well as science, education and knowledge sharing as the cornerstone upon which the structure of NIS is built upon. In terms of NIS dynamics, during the time period analysed, the most evident change has been the rise of the importance of the Internet in knowledge sharing. In global comparisons on the innovative capabilities and competitiveness, according to the PCS rankings, the best performing countries of ECE and the Baltics are doing rather well, tailing the most developed countries in the world but ranking higher than Latin American and most Asian countries. However, in the case of some ECE countries and Russia, this is not the case. The results indicate a clear "convergence" in terms of innovative capabilities, as evidenced by the PCS, in the case of the best performing countries of ECE and the Baltics: they are definitely catching up with the global leaders in innovation. Again, for other countries of ECE and Russia this kind of development is not as evident. In sum, in terms of the structure of NIS, ECE, the Baltics and Russia have mixed profiles: some are doing increasingly well in terms of innovative capabilities, whereas others are yet to reach their potential.

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REFERENCES

- Ágh, A. (1998). *The politics of Central Europe*. London: SAGE. doi:10.4135/9781446279250
- Archibugi, D., & Coco, A. (2004). A new indicator of technological capabilities for developed and developing countries (ARCO). *World Development*, 32(4), 629–654. doi:10.1016/j.worlddev.2003.10.008
- Balzat, M., & Hanusch, H. (2004). Recent trends in the research on national innovation systems. *Journal of Evolutionary Economics*, 14(2), 197–210. doi:10.1007/s00191-004-0187-y
- Carlsson, B., Jacobsson, S., Holmén, M., & Rickne, A. (2002). Innovation systems: Analytical and methodological issues. *Research Policy*, 31(2), 233–245. doi:10.1016/S0048-7333(01)00138-X
- Cassiolato, J. E., & Vitorino, V. (Eds.). (2009). *BRICS and development alternatives: Innovation systems and policies*. London: Anthem.
- Castellacci, F., & Archibugi, D. (2008). The technology clubs: The distribution of knowledge across nations. *Research Policy*, 37(10), 1659–1673. doi:10.1016/j.respol.2008.08.006
- Castellacci, F., & Natera, J. M. (2011a). A new panel dataset for cross-country analyses of national systems, development and growth (CANA). *Innovation and Development*, 1(2), 205–226. doi:10.1080/2157930X.2011.605871
- Castellacci, F., & Natera, J. M. (2011b). A new panel dataset for cross-country analyses of national systems, growth and development (CANA). *NUPI Working Paper*, 783.
- Castellacci, F., & Natera, J. M. (2013). The dynamics of national innovation systems: A panel cointegration analysis of the coevolution between innovative capability and absorptive capacity. *Research Policy*, 42(3), 579–594. doi:10.1016/j.respol.2012.10.006

- Criscuolo, O. (2006). The home advantage effect and patent families: A comparison of OECD triadic patents, the USPTO and the EPO. *Scientometrics*, 66(1), 23–41. doi:10.1007/s11192-006-0003-6
- David, P., & Foray, D. (1995). Accessing and expanding the science and technology knowledge base. *OECD STI Review*, 16(1), 13–68.
- Dezhina, I. (2011). Policy framework to stimulate technological innovations in Russia. *Journal of East-West Business*, 17(2-3), 90–100. doi:10.1080/10669868.2011.634770
- European Research Area Committee. (2012). *Peer-review of the Estonian research and innovation system: Steady progress towards knowledge society*. Tallinn: EU.
- Fagerberg, J., & Sapprasert, K. (2011). National innovation systems: The emergence of a new approach. *Science & Public Policy*, 38(9), 669–679. doi:10.3152/030234211X13070021633369
- Fagerberg, J., & Srholec, M. (2008). National innovation systems, capabilities and economic development. *Research Policy*, 37(9), 1417–1435. doi:10.1016/j.respol.2008.06.003
- Feldman, M. (2002). The Internet revolution and the geography of innovation. *International Social Science Journal*, 54(1), 47–56. doi:10.1111/1468-2451.00358
- Filippetti, A., & Archibugi, D. (2011). Innovation in times of crises: National systems of innovation, structure and demand. *Research Policy*, 40(2), 179–192. doi:10.1016/j.respol.2010.09.001
- Freeman, C. (1987). *Technology policy and economic performance: Lessons from Japan*. London: Pinter.
- Freeman, C. (1995). The national system of innovation in historical perspective. *Cambridge Journal of Economics*, 19(1), 5–24.
- Freeman, C. (2002). Continental, national and sub-national innovation systems: Complementarity and economic growth. *Research Policy*, 31(2), 191–211. doi:10.1016/S0048-7333(01)00136-6
- Freeman, C. (2004). Technological infrastructure and international competitiveness. *Industrial and Corporate Change*, 13(3), 541–569. doi:10.1093/icc/dth022
- Gregersen, B., & Johnson, B. (1997). Learning economies, innovation systems and European integration. *Regional Studies*, 31(5), 479–490. doi:10.1080/00343409750132270

- Guan, J., & Chen, K. (2012). Modeling the relative efficiency of national innovation systems. *Research Policy*, 41(1), 102–115. doi:10.1016/j.respol.2011.07.001
- Hart, D. (2009). Accounting for change in national systems of innovation: A friendly critique based on the U.S. case. *Research Policy*, 38(4), 647–654. doi:10.1016/j.respol.2009.01.015
- Hartmann, D., Pyka, A., & Hanusch, H. (2010). Applying comprehensive neo-Schumpeterian economics to Latin American economies. *Structural Change and Economic Dynamics*, 21(1), 70–83. doi:10.1016/j.strueco.2009.11.003
- Honaker, J., & King, G. (2010). What to do about missing values in time-series cross-section data. *American Journal of Political Science*, 54(3), 561–581. doi:10.1111/j.1540-5907.2010.00447.x
- Jolliffe, I. T. (2002). *Principal component analysis*. New York: Springer.
- Klochikhin, E. (2012). Russia's innovation policy: Stubborn path-dependencies and new approaches. *Research Policy*, 41(9), 1620–1630. doi:10.1016/j.respol.2012.03.023
- Krammer, S. (2009). Drivers of national innovation in transition: Evidence from a panel of Eastern European countries. *Research Policy*, 38(5), 845–860. doi:10.1016/j.respol.2009.01.022
- Kravtsova, V., & Radošević, S. (2012). Are systems of innovation in Eastern Europe efficient. *Economic Systems*, 36(1), 109–126. doi:10.1016/j.ecosys.2011.04.005
- Lengyel, B., & Leydesdorff, L. (2011). Regional innovation systems in Hungary: The failing synergy at the national level. *Regional Studies*, 45(5), 677–693. doi:10.1080/00343401003614274
- Liuhto, K. (2011). The EU-Russia innovation cooperation: Some experiences emerging from Finnish-Russian innovation collaboration. *Journal of East-West Business*, 17(2-3), 156–169. doi:10.1080/10669868.2011.634775
- Lockwood, J., Smith, M., & McAra-McWilliam, I. (2012). Work-well: Creating a culture of innovation through design. In E. Bohemia, J. Liedtka, & A. Rieple (Eds.), *Leading innovation through design* (pp. 747–756). Boston: Design Management Institute.
- Lundvall, B.-Å. (Ed.). (1992). *National systems of innovation: Towards a theory of innovation and interactive learning*. London: Pinter.
- Lundvall, B.-Å. (1999). National business systems and national systems of innovation. *International Studies of Management and Organization*, 29(2), 60–77.

Makkonen, T. (2013). Government science and technology budgets in times of crisis. *Research Policy*, 42(3), 817–822. doi:10.1016/j.respol.2012.10.002

Makkonen, T., & Inkinen, T. (2013). Innovative capacity, educational attainment and economic development in the European Union: Causal relations and geographical variations. *European Planning Studies*, 21(12), 1958–1976. doi:10.1080/09654313.2012.722968

Metcalfe, J. S. (1995). The economic foundations of technology policy: Equilibrium and evolutionary perspectives. In P. Stoneman (Ed.), *Handbook of economics of innovation and technological change* (pp. 409–512). Oxford, UK: Blackwell.

Miettinen, R. (2002). *National innovation system: Scientific concept or political rhetoric*. Helsinki: Edita.

Miller, T., & Kim, A. (2011). Defining economic freedom. In T. Miller, K. Holmes, J. Roberts, & A. Kim (Eds.), *2011 Index of Economic Freedom* (pp. 19–27). Washington, DC: The Heritage Foundation.

Nasierowski, W., & Arcelus, F. J. (2003). On the efficiency of national innovation systems. *Socio-Economic Planning Sciences*, 37(3), 215–234. doi:10.1016/S0038-0121(02)00046-0

Nelson, R. (Ed.). (1993). *National innovation systems*. Oxford, UK: Oxford University Press.

Niosi, J. (2002). National systems of innovations are x-efficient (and x-effective): Why some are slow learners. *Research Policy*, 31(2), 291–302. doi:10.1016/S0048-7333(01)00142-1

Niosi, J., Saviotti, P., Bellow, B., & Crow, M. (1993). National systems of innovation: In search of a workable concept. *Technology in Society*, 15(2), 207–227. doi:10.1016/0160-791X(93)90003-7

OECD. (1997). *National innovation systems*. Paris: OECD.

OECD. (1999). *Managing national innovation systems*. Paris: OECD.

Patel, P., & Pavitt, K. (1994a). National innovation systems: Why they are important and how they might be measured and compared. *Economics of Innovation and New Technology*, 3(1), 77–95. doi:10.1080/10438599400000004

Patel, P., & Pavitt, K. (1994b). *The nature and economic importance of national innovation systems*. Paris: OECD.

- Pinto, H. (2009). The diversity of innovation in the European Union: Mapping latent dimensions and regional profiles. *European Planning Studies*, 17(2), 303–326. doi:10.1080/09654310802553571
- Pinto, H., & Pereira, T. S. (2013). Efficiency of innovation systems in Europe: An institutional approach to the diversity of national profiles. *European Planning Studies*, 21(6), 755–779. doi:10.1080/09654313.2012.665033
- Radosevic, S. (1999). Transformation of science and technology systems into systems of innovation in central and eastern Europe: The emerging patterns and determinants. *Structural Change and Economic Dynamics*, 10(3-4), 277–320. doi:10.1016/S0954-349X(99)00016-8
- Radosevic, S. (2003). Patterns of preservation, restructuring and survival: Science and technology policy in Russia in post-Soviet era. *Research Policy*, 32(6), 1105–1124. doi:10.1016/S0048-7333(02)00117-8
- Radosevic, S. (2004). A two-tier or multi-tier Europe? Assessing the innovation capacities of Central and East European countries in the enlarged EU. *Journal of Common Market Studies*, 42(3), 641–666. doi:10.1111/j.0021-9886.2004.00522.x
- Sala-i-Martin, X., Bilbao-Osorio, B., Blanke, J., Drzeniek Hanouz, M., & Geiger, T. (2011). The Global Competitiveness Index 2011–2012: Setting the foundations for strong productivity. In K. Schwab (Ed.), *The Global Competitiveness Index 2011–2012* (pp. 3-50). Geneva: World Economic Forum.
- Sharif, N. (2006). Emergence and development of the national innovation system concept. *Research Policy*, 35(5), 745–766. doi:10.1016/j.respol.2006.04.001
- Tabachnick, B., & Fidell, L. (2007). *Using multivariate statistics*. Boston: Pearson.
- Tödtling, F., & Trippel, M. (2005). One size fits all? Towards a differentiated regional innovation policy approach. *Research Policy*, 34(8), 1203–1219. doi: 10.1016/j.respol.2005.01.018
- Tura, T., & Harmaakorpi, V. (2005). Social capital in building regional innovative capability. *Regional Studies*, 39(8), 1111–1125. doi:10.1080/00343400500328255
- Uriona-Maldonado, M., dos Santos, R., & Varvakis, G. (2012). State of the art on the systems of innovation research: A bibliometrics study up to 2009. *Scientometrics*, 91(3), 977–996. doi:10.1007/s11192-012-0653-5
- Varblane, U., Dyker, D., Tamm, D., & von Tunzelmann, N. (2007). Can the national innovation systems of the new EU member states be improved? *Post-Communist Economies*, 19(4), 399–416. doi:10.1080/14631370701680048

Varga, A. (2007). Localised knowledge inputs and innovation: The role of spatially mediated knowledge spillovers in Hungary. *Acta Oeconomica*, 57(1), 1–20. doi:10.1556/AOecon.57.2007.1.2

ADDITIONAL READING

Ahlqvist, T., & Inkinen, T. (2007). Technology foresight in scalar innovation systems: A spatiotemporal process perspective. *Fennia – International Journal of Geography*, 185(1), 3–14.

Archibugi, D., & Coco, A. (2005). Measuring technological capabilities at the country level: A survey and a menu for choice. *Research Policy*, 34(2), 175–194. doi:10.1016/j.respol.2004.12.002

Archibugi, D., & Filippetti, A. (2011). Is the economic crisis impairing convergence in innovation performance across Europe. *Journal of Common Market Studies*, 49(6), 1153–1182. doi:10.1111/j.1468-5965.2011.02191.x

Braczyk, H.-J., Cooke, P., & Heidenreich, M. (Eds.). (1998). *Regional innovation systems: The role of governances in a globalized world*. London: UCL Press.

Cooke, P. (1992). Regional innovation systems: Competitive regulation in the new Europe. *Geoforum*, 23(3), 365–382. doi:10.1016/0016-7185(92)90048-9

Doloreux, D. (2002). What we should know about regional systems of innovation. *Technology in Society*, 24(3), 243–263. doi:10.1016/S0160-791X(02)00007-6

Doloreux, D., & Parto, S. (2005). Regional innovation systems: Current discourse and unresolved issues. *Technology in Society*, 27(2), 133–153. doi:10.1016/j.tech-soc.2005.01.002

Dosi, G., Freeman, C., Nelson, R., Silverberg, G., & Soete, L. (Eds.). (1988). *Technical change and economic theory*. London: Pinter.

Edquist, C. (Ed.). (1997). *Systems of innovation: Technologies, institutions and organizations*. London: Pinter.

Edquist, C., & Hommen, L. (Eds.). (2008). *Small country innovation systems: Globalization, change and policy in Asia and Europe*. Cheltenham: Edward Elgar. doi:10.4337/9781847209993

Fagerberg, J., Mowery, D., & Nelson, R. (Eds.). (2005). *The Oxford handbook of innovation*. Oxford, UK: Oxford University Press.

- Furman, J., & Hayes, R. (2004). Catching up or standing still: National innovative productivity among follower countries, 1978–1999. *Research Policy*, 33(9), 1329–1354. doi:10.1016/j.respol.2004.09.006
- Hall, B., & Rosenberg, N. (Eds.). (2010). *Handbook of the economics of innovation*. Amsterdam: Elsevier.
- Lundvall, B.-Å. (2007). National innovation systems: Analytical concept and development tool. *Industry and Innovation*, 14(1), 95–119. doi:10.1080/13662710601130863
- Lundvall, B.-Å. (2011). Notes on innovation systems and economic development. *Innovation and Development*, 1(1), 25–38. doi:10.1080/2157930X.2010.551064
- Lundvall, B.-Å., Johnson, B., Andersen, E. S., & Dalum, B. (2002). National systems of production, innovation and competence building. *Research Policy*, 31(2), 213–231. doi:10.1016/S0048-7333(01)00137-8
- Malerba, F. (2002). Sectoral systems of innovation and production. *Research Policy*, 31(2), 247–264. doi:10.1016/S0048-7333(01)00139-1
- Mowery, D. (1992). The U.S. national innovation system: Origins and prospects for change. *Research Policy*, 21(2), 125–144. doi:10.1016/0048-7333(92)90037-5
- Mowery, D., & Oxley, J. (1995). Inward technology transfer and competitiveness: The role of national innovation systems. *Cambridge Journal of Economics*, 19(1), 67–93.
- Muscio, A. (2006). From regional innovation systems to local innovation systems: Evidence from Italian industrial districts. *European Planning Studies*, 14(6), 773–789. doi:10.1080/09654310500496073
- OECD. (2005). *Oslo manual: Guidelines for collecting and interpreting innovation data*. Paris: OECD.
- Oinas, P., & Malecki, E. (2002). The evolution of technologies in time and space: From national and regional to spatial innovation systems. *International Regional Science Review*, 25(1), 102–131. doi:10.1177/016001702762039402
- Polenske, K. (Ed.). (2007). *The economic geography of innovation*. Cambridge, UK: Cambridge University Press. doi:10.1017/CBO9780511493386
- Stoneman, P. (Ed.). (1995). *Handbook of economics of innovation and technological change*. Oxford, UK: Blackwell.
- Trippl, M. (2010). Developing cross-border regional innovation systems: Key factors and challenges. *Tijdschrift voor Economische en Sociale Geografie*, 101(2), 150–160. doi:10.1111/j.1467-9663.2009.00522.x

Vuori, S., & Vuorinen, P. (Eds.). (1994). *Explaining technical change in a small country: The Finnish national innovation system*. Heidelberg: Physica-Verlag. doi:10.1007/978-3-642-95913-4

KEY TERMS AND DEFINITIONS

Baltic Countries: Estonia, Latvia and Lithuania.

East Central Europe: The set of countries that are geographically situated between Russia and Germany including (in this paper) Bulgaria, the Czech Republic, Hungary, Moldova, Poland, Romania, Slovakia and Ukraine.

Innovation: A process where knowledge is converted into new products, services or processes successfully introduced on the market.

Innovative Capability: The potential (input) for innovation in a given entity (country).

Innovative Performance: The innovative output of a given entity (country).

National Competitiveness: The set of actors and institutions whose actions and interactions determine the level of productivity of a given country.

National Innovation System: The set of actors and institutions whose actions and interactions determine the innovative capability of a given country.

Principal Component Analysis: A statistical multivariate method for condensing data from various measures into composite indexes.