CHAPTER 2.2

Ranking National Innovative Capacity: Findings from the National Innovative Capacity Index

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International competitiveness increasingly depends on innovation. With continued operational improvement in education and infrastructure now a given, and with local companies able rapidly to acquire and deploy technology from around the world, producing standard products using standard methods no longer sustains competitiveness. Among high-income countries, differences in prosperity are closely related to differences in the intensity of innovation. For developing nations, low-cost inputs by themselves are no longer sufficient to maintain competitiveness. Companies must increasingly be able to access and ultimately develop global technology. With the erosion of traditional barriers to entry, enhanced prosperity flows from the ability of companies in a nation to create and then globally commercialize novel products and processes, shifting the innovation frontier as fast as rivals catch up.

A higher level of innovation in one nation need not come at the expense of others. Innovation can enhance productivity, improve consumer value, and increase prosperity in all nations, collectively speeding the rate of world economic growth. Innovation is also crucial for addressing pressing social challenges, by relaxing the tradeoffs between near-term economic growth and health, safety, and the environmental impact of development.

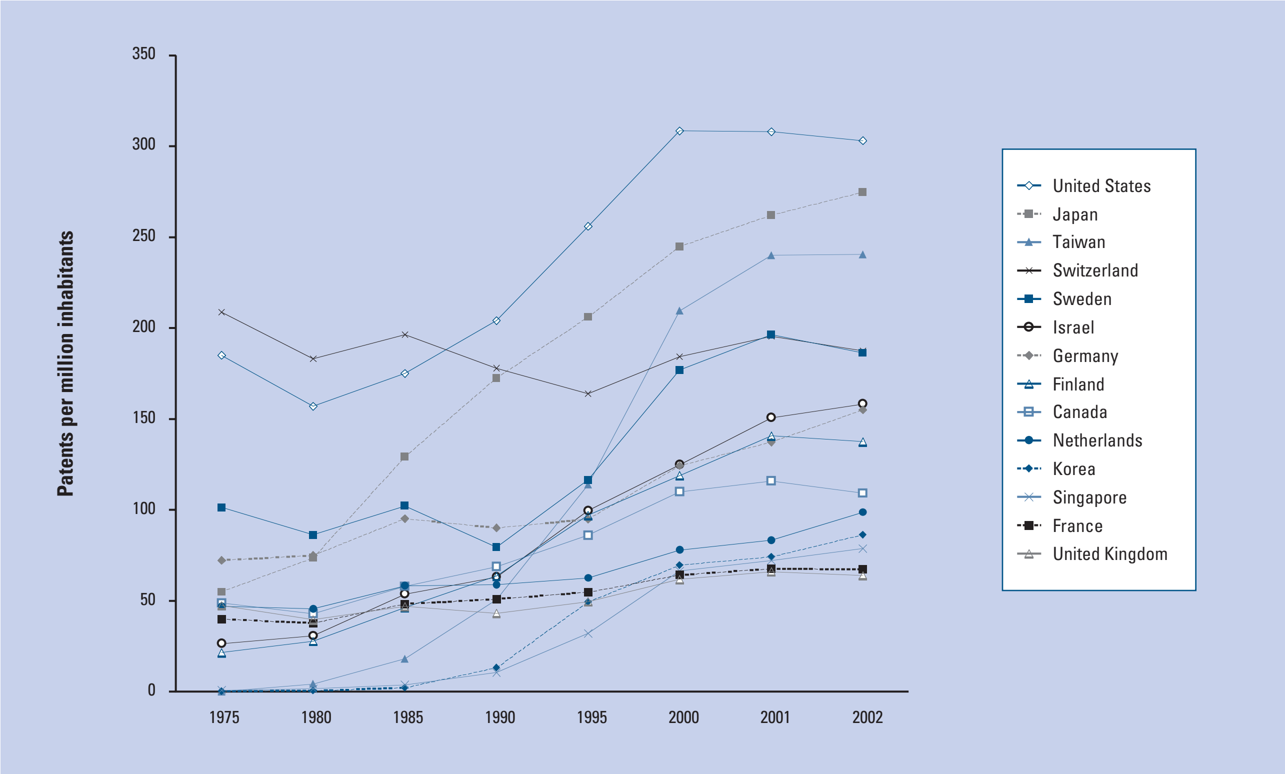
Over the past 15 years, an increasing number of countries have emerged as global innovators.

Although the United States and Switzerland had per capita patenting rates well in excess of those of other economies during the 1970s and 1980s, ten different countries registered per capita patenting rates greater than 100 US patents per million people in 2002, and 25 countries registered a rate of at least 30 US patents per million people (see Figure 1). Within countries, innovation tends to be dominated by geographically concentrated clusters of firms—supported by local institutions and fostered by vigorous domestic competition.

Although the number of countries capable of global innovation is growing, major differences persist among advanced economies. Whereas the Scandinavian countries and Japan have registered sharp increases in innovative output, many western European nations, such as France and Italy, continue to trail, with innovation output at roughly the same level as a generation ago. Some emerging economies, such as Singapore, Taiwan, and Israel, now outpace leading Organisation of Economic Co-operation and Development (OECD) economies, while Eastern European and Latin American countries still depend on low labor costs and imitation of foreign technology.

Why does the intensity of innovation vary across countries? How does innovation depend on locational characteristics? Innovation arises from private-sector initiative, but the R&D productivity of firms in a nation is importantly shaped by local policies and the nature of local institutions. Innovation output, then, depends on the

Figure 1: International patents per capita, leading countries, 1975–2002



Source: US Patent and Trademark Office (www.uspto.gov); authors' analysis

interaction between private-sector strategies and public-sector policies. We term this constellation of factors *national innovative capacity*, or the degree to which a nation offers a favorable environment for innovation at the world technology frontier.[1]

This chapter extends our prior research on the role of location in innovation, using new data from the 2003 Executive Opinion Survey to assess the innovative capacity of 78 countries for which the required data are available. We examine a wide range of national characteristics suggested by the national innovative capacity framework and available from the Survey data to construct a national innovative capacity index (NICI). We rank countries on NICI as well as five subindexes measuring important components of innovative vitality (see Table 1).

Our statistical findings reveal the striking degree to which measures of the national environment for innovation affect innovative output. We also find that the bar for innovation is rising; even countries with an *absolute* increase in innovative capacity over 2001 sometimes register a *relative* decline because of their inability to improve local conditions as quickly as other nations. We find that some countries have aggressively invested in innovative capacity, ahead of that expected given current income, in an effort to enhance competitiveness and prosperity. Conversely, in other nations, innovative capacity lags overall productivity and income rankings, raising concerns about the sustainability of their competitiveness. Finally, there is a close connection between whether a nation's firms chose innovation-orientated strategies and the national environment in which they operate. Though our findings are subject to caveats common to any quantitative study of the causes and consequences of innovation, our results provide consistent support for the role of policy choices in enhancing the national environment for innovation and, with it, international competitiveness.

The determinants of national innovative capacity

The conceptual framework underlying our approach has been described in prior *Reports*. However, because of its importance in interpreting the results, we provide a summary here that incorporates our recent learning.

The vitality of innovation in a location is shaped by *national innovative capacity*. National innovative capacity is a country's potential—as both a political and economic entity—to produce a stream of commercially relevant innovations. National innovative capacity is distinct from

Table 1: National innovative capacity index and subindexes

Country	Innovative Capacity Index 2003		Proportion of Scientists and Engineers Index		Innovation Policy Index		Cluster Innovation Environment Index		Innovation Linkages Index		Operations and Strategy Index		Innovative Capacity Index 2002	Business Competitiveness Index 2003	GDP per capita 2002
	RANK	INDEX	RANK	INDEX	RANK	INDEX	RANK	INDEX	RANK	INDEX	RANK	INDEX	RANK	RANK	RANK
United States	1	36.60	4	8.44	3	5.51	2	7.59	1	7.26	1	7.80	1	2	1
Finland	2	35.96	3	8.53	2	5.58	3	7.55	2	7.02	8	7.28	3	1	15
United Kingdom	3	34.63	17	7.89	7	5.36	13	6.79	3	6.96	3	7.63	2	6	18
Japan	4	34.62	2	8.54	17	5.02	1	7.68	13	5.97	4	7.42	5	13	14
Germany	5	34.29	12	8.06	10	5.34	4	7.37	11	6.11	5	7.41	4	5	12
Singapore	6	34.19	6	8.33	1	5.96	12	6.85	14	5.91	10	7.14	10	8	20
Sweden	7	34.02	5	8.41	15	5.11	14	6.72	6	6.48	7	7.30	7	3	17
Denmark	8	33.95	10	8.15	12	5.18	7	6.99	8	6.27	6	7.36	12	4	4
Switzerland	9	33.73	8	8.19	20	4.92	10	6.89	12	6.09	2	7.65	6	7	5
France	10	33.63	15	7.91	8	5.35	9	6.96	9	6.20	9	7.22	13	10	19
Netherlands	11	33.14	18	7.85	11	5.29	17	6.61	5	6.51	13	6.87	11	9	8
Canada	12	33.11	13	8.00	6	5.37	8	6.98	7	6.39	19	6.37	9	12	6
Taiwan	13	32.84	16	7.89	5	5.39	6	7.19	20	5.63	15	6.74	8	16	n/a
Israel	14	32.64	31	7.35	9	5.35	23	6.27	4	6.62	12	7.05	15	20	23
Australia	15	32.37	11	8.14	4	5.48	21	6.42	10	6.18	22	6.14	17	11	10
Austria	16	32.05	19	7.75	13	5.16	11	6.87	24	5.53	14	6.76	14	17	9
Belgium	17	31.96	14	7.99	14	5.15	25	6.25	15	5.87	16	6.70	16	15	11
Iceland	18	31.86	1	8.65	19	4.92	24	6.25	22	5.57	17	6.47	18	14	3
Ireland	19	31.24	22	7.69	18	5.01	22	6.39	16	5.86	20	6.29	20	21	7
Korea	20	31.13	20	7.75	24	4.74	16	6.67	18	5.79	21	6.19	22	23	27
Italy	21	30.86	39	7.05	29	4.55	5	7.26	21	5.61	18	6.38	21	24	16
Norway	22	30.80	7	8.32	22	4.82	31	5.96	19	5.64	23	6.06	19	22	2
New Zealand	23	30.55	21	7.74	27	4.59	20	6.43	17	5.81	24	5.97	24	18	22
Spain	24	29.77	28	7.56	23	4.77	27	6.13	25	5.46	25	5.85	23	25	21
Hong Kong	25	28.57	64	4.54	26	4.70	15	6.72	23	5.54	11	7.08	26	19	13
Estonia	26	28.42	24	7.66	33	4.42	33	5.79	26	5.37	39	5.17	29	28	33
South Africa	27	28.38	38	7.08	32	4.44	19	6.43	29	5.25	38	5.18	30	27	32
Latvia	28	28.17	40	6.98	37	4.20	32	5.81	27	5.32	26	5.85	44	29	44
Slovenia	29	28.16	23	7.69	28	4.56	41	5.40	38	4.77	27	5.74	25	30	26
Czech Republic	30	27.27	32	7.28	40	4.09	38	5.44	34	4.96	29	5.50	32	35	28
Lithuania	31	27.08	26	7.61	41	4.05	49	5.12	30	5.16	40	5.14	31	40	41
Greece	32	27.01	35	7.24	30	4.50	37	5.45	41	4.65	37	5.18	37	39	25
Portugal	33	26.90	30	7.36	25	4.73	36	5.49	35	4.90	65	4.42	27	36	24
Poland	34	26.87	33	7.28	47	3.94	35	5.50	33	4.98	36	5.18	35	47	37
Malaysia	35	26.85	59	5.07	16	5.04	18	6.47	37	4.78	31	5.48	39	26	42
Slovak Republic	36	26.12	29	7.49	44	4.00	43	5.34	53	4.40	48	4.90	40	43	31
Jordan	37	26.09	27	7.57	36	4.28	51	5.11	47	4.52	58	4.60	n/a	41	66
Tunisia	38	26.03	50	5.82	21	4.89	44	5.29	31	5.10	44	4.94	45	33	54
Hungary	39	26.00	34	7.27	31	4.45	64	4.77	43	4.58	45	4.92	28	38	30
China	40	25.86	43	6.30	45	3.99	26	6.20	40	4.65	56	4.71	36	46	65
Chile	41	25.75	47	5.91	35	4.29	42	5.36	32	4.98	34	5.20	41	32	40
Brazil	42	25.70	51	5.78	53	3.74	29	6.04	36	4.85	33	5.28	33	34	48
Russian Federation	43	25.59	9	8.16	69	3.26	48	5.13	39	4.72	72	4.32	34	65	46
India	44	25.52	60	5.06	38	4.13	28	6.12	28	5.32	50	4.89	43	37	74
Croatia	45	25.23	37	7.08	57	3.61	40	5.40	44	4.58	61	4.56	42	62	36
Costa Rica	46	25.01	44	6.28	55	3.62	52	5.10	46	4.52	30	5.49	38	45	39
Thailand	47	24.74	69	4.30	34	4.37	30	5.98	45	4.53	28	5.56	46	31	53
Mauritius	48	24.73	46	6.03	50	3.84	45	5.23	42	4.59	42	5.04	55	44	34
Ukraine	49	24.51	25	7.66	68	3.31	55	4.99	59	4.20	69	4.35	47	71	63
Indonesia	50	24.04	48	5.89	42	4.03	50	5.11	62	4.18	52	4.83	59	60	73
Mexico	51	24.00	53	5.54	43	4.01	46	5.15	55	4.38	46	4.92	51	48	43
Vietnam	52	23.99	52	5.61	48	3.91	34	5.71	54	4.38	67	4.38	53	50	77
Bulgaria	53	23.62	36	7.18	64	3.42	69	4.61	61	4.18	76	4.24	50	74	49
Turkey	54	23.23	49	5.84	56	3.62	39	5.43	74	3.79	62	4.54	54	52	56
Egypt	55	23.04	45	6.27	81	2.95	60	4.85	52	4.40	60	4.57	n/a	58	70
Argentina	56	22.98	42	6.37	73	3.17	58	4.89	66	4.03	63	4.53	52	68	35
Romania	57	22.97	41	6.82	86	2.76	59	4.87	51	4.41	80	4.11	48	73	57
Panama	58	22.68	62	4.82	52	3.75	63	4.80	49	4.44	51	4.86	57	59	58
Sri Lanka	59	22.52	57	5.25	58	3.56	57	4.97	56	4.26	64	4.49	56	57	72
Trinidad and Tobago	60	22.24	61	4.98	54	3.70	61	4.83	63	4.15	59	4.58	58	53	38
Philippines	61	21.99	58	5.19	65	3.41	54	5.03	79	3.59	55	4.76	60	64	67
Colombia	62	21.84	65	4.50	60	3.53	53	5.03	64	4.13	57	4.65	61	51	52
Dominican Republic	63	21.58	74	3.94	59	3.55	73	4.39	48	4.50	35	5.20	49	61	50
Uruguay	64	20.58	55	5.28	63	3.44	81	3.94	75	3.70	77	4.23	63	69	47

(cont'd.)

Table 1: National innovative capacity index and subindexes *(cont'd.)*

Country	Innovative Capacity Index 2003		Proportion of Scientists and Engineers Index		Innovation Policy Index		Cluster Innovation Environment Index		Innovation Linkages Index		Operations and Strategy Index		Innovative Capacity Index 2002	Business Competitiveness Index 2003	GDP per capita 2002
	RANK	INDEX	RANK	INDEX	RANK	INDEX	RANK	INDEX	RANK	INDEX	RANK	INDEX	RANK	RANK	RANK
Peru	65	20.58	54	5.43	80	2.96	77	4.16	76	3.69	71	4.33	62	78	62
El Salvador	66	20.52	76	3.84	66	3.40	72	4.39	72	3.83	41	5.05	65	63	59
Venezuela	67	20.34	56	5.27	82	2.92	76	4.20	77	3.68	75	4.27	64	80	60
Guatemala	68	19.71	67	4.35	77	2.99	75	4.33	70	3.85	78	4.19	67	81	64
Pakistan	69	19.60	71	4.24	70	3.20	56	4.98	85	3.14	81	4.04	n/a	72	79
Zimbabwe	70	19.47	75	3.94	72	3.18	66	4.74	68	3.92	86	3.70	69	75	80
Ecuador	71	18.78	66	4.42	79	2.97	85	3.75	80	3.52	79	4.12	68	84	71
Honduras	72	18.28	68	4.35	71	3.18	83	3.77	83	3.23	85	3.76	72	89	75
Nicaragua	73	17.80	70	4.29	76	3.08	89	3.40	84	3.16	83	3.87	66	88	n/a
Paraguay	74	17.04	63	4.64	89	2.70	88	3.45	90	2.90	90	3.36	70	91	61
Bangladesh	75	16.94	73	4.09	84	2.81	79	4.04	93	2.62	89	3.37	71	86	82
Bolivia	76	16.32	72	4.23	92	2.45	92	3.12	86	3.08	88	3.45	73	92	76
Madagascar	77	15.81	77	2.51	88	2.72	87	3.46	82	3.26	84	3.85	n/a	85	90
Senegal	78	14.81	78	0.60	83	2.82	82	3.77	78	3.67	82	3.94	n/a	82	83
Algeria	n/a	n/a	n/a	n/a	62	3.46	86	3.70	88	3.00	91	3.32	n/a	83	55
Angola	n/a	n/a	n/a	n/a	91	2.55	95	2.45	94	2.35	95	3.02	n/a	95	78
Botswana	n/a	n/a	n/a	n/a	49	3.89	71	4.42	71	3.85	53	4.82	n/a	54	45
Chad	n/a	n/a	n/a	n/a	90	2.62	90	3.20	95	2.06	94	3.07	n/a	93	85
Ethiopia	n/a	n/a	n/a	n/a	87	2.73	91	3.16	91	2.82	93	3.12	n/a	90	88
Haiti	n/a	n/a	n/a	n/a	93	2.40	94	3.05	87	3.01	87	3.50	n/a	94	81
Jamaica	n/a	n/a	n/a	n/a	61	3.47	70	4.54	57	4.22	32	5.41	n/a	56	68
Kenya	n/a	n/a	n/a	n/a	74	3.15	67	4.69	58	4.20	54	4.81	n/a	66	86
Malawi	n/a	n/a	n/a	n/a	78	2.98	80	4.00	81	3.34	74	4.28	n/a	70	91
Malta	n/a	n/a	n/a	n/a	39	4.11	62	4.83	60	4.18	43	5.02	n/a	42	29
Morocco	n/a	n/a	n/a	n/a	46	3.94	47	5.14	50	4.44	49	4.89	n/a	49	69
Mozambique	n/a	n/a	n/a	n/a	85	2.78	93	3.08	92	2.78	92	3.21	n/a	87	84
Namibia	n/a	n/a	n/a	n/a	51	3.78	68	4.66	69	3.87	47	4.92	n/a	55	51
Nigeria	n/a	n/a	n/a	n/a	75	3.11	65	4.75	67	3.94	66	4.39	n/a	77	87
Serbia	n/a	n/a	n/a	n/a	94	2.15	74	4.34	65	4.11	70	4.34	n/a	76	n/a
Tanzania	n/a	n/a	n/a	n/a	67	3.35	78	4.13	73	3.81	73	4.30	n/a	67	92
Zambia	n/a	n/a	n/a	n/a	95	2.06	84	3.76	89	2.92	68	4.35	n/a	79	89

purely scientific or technical achievements, and focuses on the economic application of new technology. Innovative capacity is not simply the realized level of innovation, but it also aims to measure the fundamental conditions that create the environment for innovation in a particular location. Innovative capacity depends in part on past technological sophistication and the size of the scientific and technical workforce, but it also reflects a series of investment and policy choices by government and the private sector that affect the incentives for research, development, and commercialization activities in a country and the productivity of these activities.

The sharp differences in innovative output across locations make clear the importance of local circumstances in R&D productivity. However, taking advantage of the local environment for innovation is far from automatic. Companies based in the same location can and do differ markedly in their success at innovation. Harnessing the local environment for innovation requires that companies pursue appropriate strategies and make appropriate investment choices.

National innovative capacity is composed of four broad elements that define how location shapes the ability of a company to innovate at the global frontier (see Figure 2). Although the framework was created for application at the national level, it can also be employed to evaluate innovative capacity at the regional or local level.

Common innovation infrastructure

A nation's common innovation infrastructure consists of the set of crosscutting factors supporting innovation throughout an entire economy, including the pool of human and financial resources devoted to scientific and technological advances, the economywide public policies bearing on innovative activity, and the economy's inherited level of technological sophistication. The foundation of a nation's common innovation infrastructure is its cadre of scientists and engineers involved in innovation. Common innovation infrastructure also includes investments in institutions engaged in basic research, which advance fundamental understanding and underpins much commercial technology. Government funding remains the mainstay of virtually every nation's investment in truly frontier research. Areas of crosscutting policy affecting innovation include the protection of intellectual property; the extent of tax-based incentives for innovation; the degree to which antitrust enforcement motivates and encourages innovation; the extent to which innovation is spurred versus impeded by the structure of safety, quality, and environmental regulations; and the openness of the economy to trade and investment. Overall, a strong common innovation infrastructure requires national investments and policy choices stretching over decades.

The cluster-specific innovation environment

Although the common innovation infrastructure sets the basic conditions for innovation, the development and commercialization of new technologies take place disproportionately in clusters—geographic concentrations of interconnected companies and institutions in a particular field. The cluster-specific innovation environment is captured in the "diamond" framework (see Figure 3).[2] Four attributes of the microeconomic environment surrounding a cluster bear on its overall competitiveness and innovative vitality — the presence of specialized and high-quality inputs; a local context in that field encouraging investment and spurred by intense rivalry; pressure and insight gleaned from sophisticated local demand for that cluster's products and services; and the local presence of high quality related and supporting industries.

The importance of clusters reflects important externalities in innovation that are contained in particular geographic areas. Presence within a cluster offers advantages to firms in perceiving both the need and the opportunity for innovation. Equally important, however, are the flexibility and capacity present in clusters to turn new ideas into reality. Within a cluster, a company can rapidly assemble the personnel, components, machinery, and services necessary for commercialization. Suppliers of essential inputs and "lead" buyers become crucial partners in the innovation process; the relationships necessary for effective innovation are more easily achieved among participants that are nearby. Reinforcing these advantages for innovation within clusters is sheer pressure—competitive pressure, peer pressure, customer pressure, and constant comparison. We focus on clusters (eg, information technology) rather than individual industries (eg, printers), then, because of powerful spillovers and externalities across discrete industries that are vital to the rate of innovation.

The innovation environment of a cluster is fundamental to its competitiveness. The recent rise of the Australian wine industry on the global stage is a good example. Though Australia's natural climate has always been conducive to wine production, the emergence of Australian firms as players in the global wine industry did not occur until the Australian wine cluster reflected

Figure 2: National innovative capacity framework

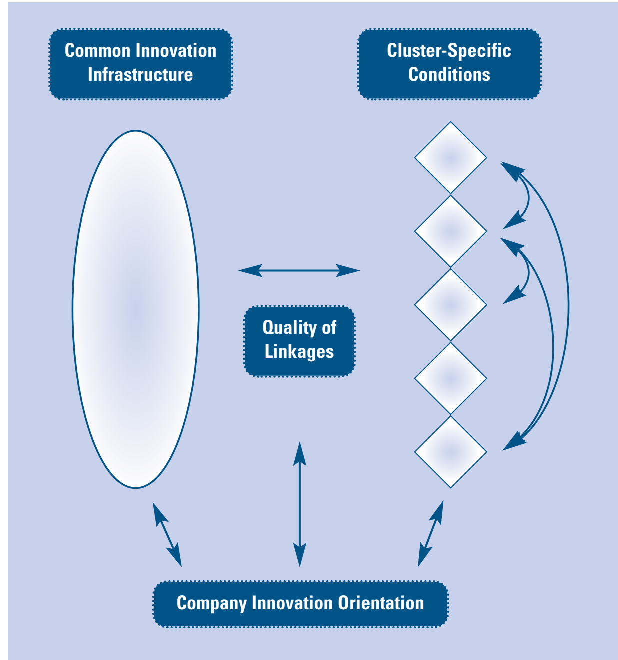
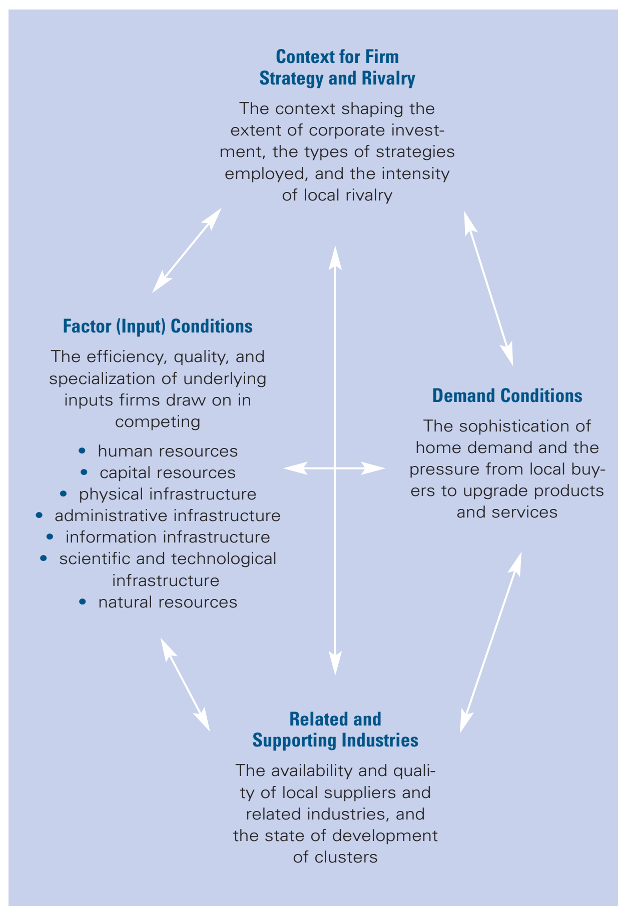


Figure 3: The microeconomic business environment



strength along each element of the diamond. The industry benefitted from the combined impact of sustained pressures from sophisticated Australian consumers, intense rivalry among domestic competitors, and a local environment supporting the use and development of advanced agricultural technologies and methods. The establishment of the Australian Wine Research Institute and domestic winemaking schools in the 1950s was crucial to the industry's takeoff decades later. Similar examples of cluster vitality in innovation occur in many fields, such as the long-term dominance of pharmaceuticals by companies whose research activities are based in the United States and global leadership by Scandinavian companies in environmental technologies.

The quality of linkages

The quality of the connections between a nation's common innovation infrastructure and individual industrial clusters is crucial to innovation. The relationship is also reciprocal: strong clusters feed the common infrastructure and also benefit from it. Without strong linkages, upstream scientific and technical advances can actually diffuse to other countries more quickly than they can be exploited at home. For example, although facsimile machine technology was developed in Britain and the United States, it was the Japanese consumer electronics optical and telecommunications firms that successfully commercialized this innovation on a global scale in the late 1970s.

Particularly important linking institutions are a nation's universities, which can play the role of bridging researchers and companies. A variety of formal and informal organizations including trade associations, standards agencies, and technology networks—which we term "institutions for collaboration"—are present in many nations, and these also build connections between research centers and firms.

Company innovation orientation

Finally, taking advantage of national innovative capacity depends on appropriate choices by companies. Even in locations with a favorable environment for innovation, many companies can be ineffective at it. Companies must embrace strategies based on innovation and choose supportive operating policies in areas such as R&D spending, customer orientation, recruiting, and training. Simply investing in R&D is not enough; advantage flows from the ability of companies to draw on specific strengths in the local innovation environment as part of an overall strategy to build a competitive advantage. In other words, appropriate corporate practices and strategy interact with the other elements of national innovative capacity in determining the propensity of firms to innovate at the global frontier.

Measuring national innovative capacity

To measure national innovative capacity, we extend our prior research by employing new data drawn from the Executive Opinion Survey. Standard governmental data sources are inadequate because they fail to capture the drivers of innovative capacity in a consistent way across a wide range of countries, including an array of innovation policy variables, the cluster-specific innovation environment, and the nature of company operations and strategy.

We employ the single best and most comparable measure of innovative output, "international" patenting, as the dependent variable in our statistical analysis. International patenting is measured by the number of patents granted to a nation's inventors in 2001 and 2002 by the United States Patent and Trademark Office (USPTO). Two years are employed to smooth out transient year-to-year variations. We employ regression analysis to evaluate the relationship between international patenting and over 30 individual Survey measures that bear on the national innovation environment and corporate practices. The regression analysis allows us to assign *relative* weights to individual variables. We use these weights to calculate subindexes of each nation's innovative capacity and combine these into an overall ranking. This procedure ensures that country-level assessment of innovative capacity is closely tied to measures that have a demonstrated statistical relationship to long-term innovative performance.

We employ USPTO patents in constructing the dependent variable for several reasons.[3] First, when a foreign inventor files for a US patent, it is a sign of the innovation's potential economic value because of the costs involved. Patents with significant economic consequences are highly likely to be filed in the United States because it is the world's largest market. Second, the US patent system tests inventions against the global technology frontier and offers a common standard comparable across innovations.[4]

The use of Survey data to measure the innovation environment raises some methodological questions. Survey data are the only alternative because there are no quantitative data at all available on most of the areas measured, much less for a meaningful number of countries, so that Survey data are the only alternative. However, it is important to establish that the Survey responses capture meaningful cross-country differences. Each country-level Executive Opinion Survey measure is computed as the *average* response by respondents within each country. To assess the reliability of this approach, we conducted an analysis of variance (ANOVA) for each Survey measure. We regressed individual Survey responses on a complete set of country-level dummy variables, calculating the share of variation across individual responses) that result from systematic country-level differences. The results are reported in Appendix A.

Considering that there is an average of more than 70 respondents per country included in the final sample, there is substantial within-country consensus. For most measures, between one-quarter and one-half of the overall variation in responses is explained by country-specific differences. For example, more than 45 percent of the dispersion across respondents from all countries on "Effectiveness of intellectual property protection in promoting innovation" reflects country-specific consensus. As a result of this substantial within-country consensus, country averages are meaningfully different from each other; for each of the 34 GCR measures employed in this chapter, the ANOVA analyses statistically rejects equality of the country-level means. By aggregating across the large number of individual respondents within each country, country-level averages isolate the meaningful differences across countries in the competitiveness environment, limiting idiosyncratic biases. Since variation in the number of Survey responses per country and the degree of consensus within countries are important concerns when conducting multivariate regression analysis, we also checked the robustness of our country rankings by weighting the key regressions by the number of respondents and the degree of consensus within each country. The results remain virtually unchanged.[5]

Determinants of innovative capacity across countries

We first regress the average level of international patenting in 2001 and 2002 in a sample of 78 countries, on three base variables: (1) total population, (2) the number of scientists and engineers employed within the nation, and (3) the "stock" of international patents generated by a country between 1981 and 1995.[6] The control for population focuses the analysis on per capita rates of international patenting; it is a nation's intensity of innovation, controlling for country size, that should matter for its international competitiveness.[7] The number of scientists and engineers is a baseline measure of the effort devoted to innovative activity. Historical patenting is a control variable for historical technological sophistication, as well as differences across countries in the propensity to patent inventions in the United States.[8] Both the number of technological personnel and the patent stock vary substantially across countries and time. For example, the percentage of the workforce represented by scientists and engineers is three times higher in Japan than in Italy or Spain though their national living standards are similar. Over 90 percent of the total variance in international patenting across the world can be explained by the three baseline variables.

The *scientific and engineering manpower subindex*, measured as the share of total employment accounted for by scientist and engineering employment, captures the impact of the R&D workforce on innovative capacity.

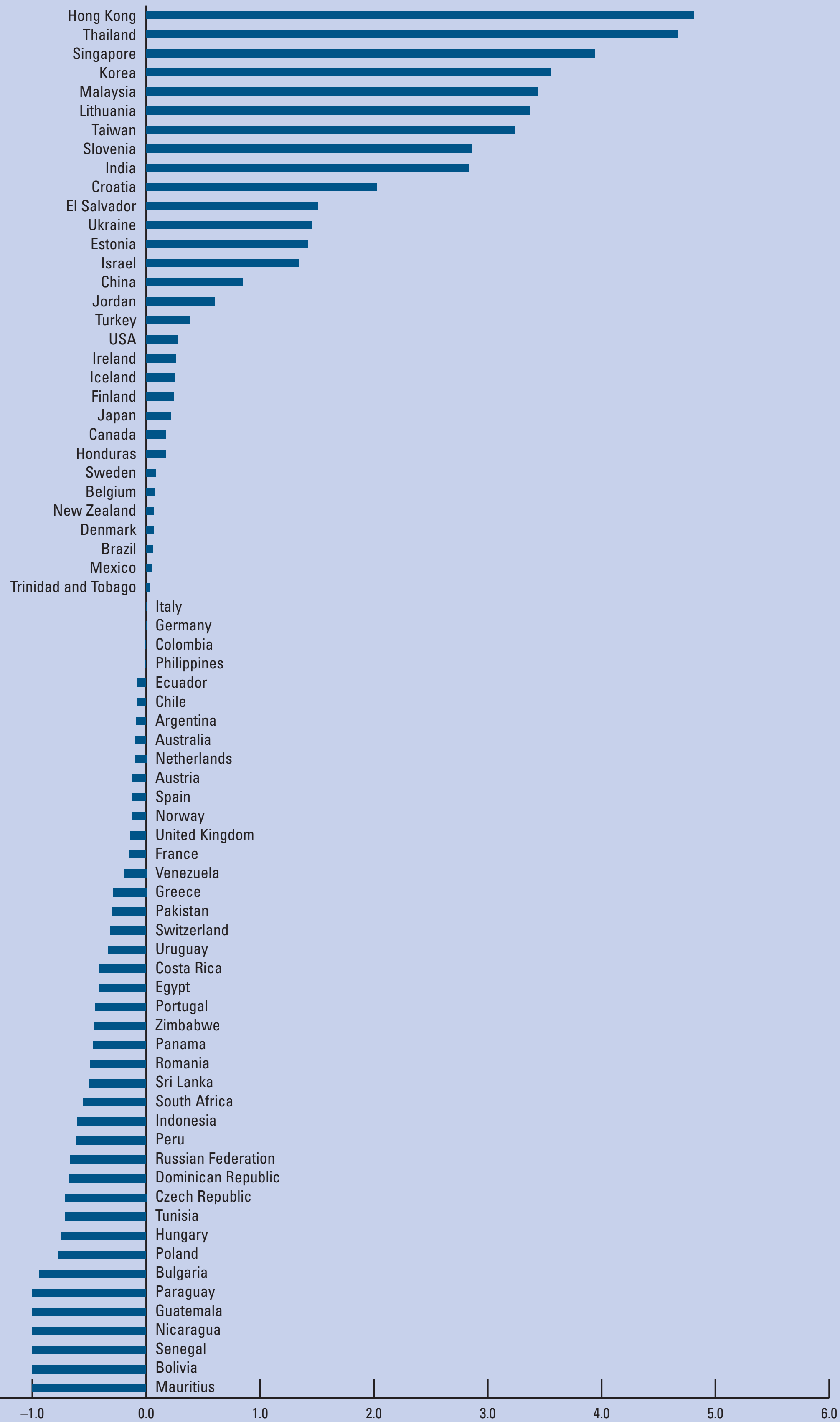
Despite the explanatory power of the baseline variable, countries vary according to whether their realized level of patenting falls above or below the level predicted by the baseline variables. Figure 4 presents the "gap" between the actual level of patenting and the level predicted by the baseline model as a percentage of the predicted level. Some countries, particularly East Asian economies such as Hong Kong, Singapore, and Korea, have patenting levels well above that predicted by the baseline model. India and China also realize a level of patenting well in excess of what would have been predicted by the baseline model. Others nations, such as France and Russia, are substantially below the baseline. The largest positive deviations in absolute terms are associated with the United States, Finland and Japan.

The remainder of our analysis focuses on explaining these gaps between predicted and realized international innovation performance. We incorporated 34 Survey measures related to innovative capacity, divided into four groupings: those bearing an innovation-related public policies (eg, the effectiveness of intellectual property protection; the effectiveness of competition policy), those assessing the cluster innovation environment (eg, the sophistication of local buyers; the quality of local suppliers), those measuring the strength of linkages; and those bearing on the degree of innovation orientation in company operations and strategies. The complete list of national innovative capacity measures and baseline regressions, including each individual measure, is reported in Appendix B.

We introduce each variable, one at a time, into the baseline specification. Out of the 34 measures, all are positive and statistically significant.[9] In other words, even after controlling for the size of a country, the aggregate level of resources devoted to innovation and the stock of past ideas to build on, a series of measures of the national innovation environment are strongly associated with the level of innovative output actually realized by countries.

To calculate an innovative capacity index, it was not feasible to include all 34 variables in a multivariate regression analysis. The reason is straightforward: nearly all of the measures are highly correlated with each other and our analysis relies on a single cross-section of 78 countries. For measures addressing similar parts of the business environment (eg, domestic competition), the correlation sometimes reaches over .9. Rather than attempt to disentangle the distinct effects associated with each measure, we create a parsimonious specification using a few key variables drawn from the range of variables relevant to each subindex. The regressions results, along with all other subindex regressions, are reported in Appendix C.

Figure 4: Actual and predicted international patenting (as a percent of predicted international patenting)



The innovation policy subindex

Three measures were selected to capture the innovation policy environment, each with a strong and robust relationship to international patenting:

- The effectiveness of intellectual property protection
- The size and availability of R&D tax credits and subsidies for the private sector
- Costs of tariff restrictions

These three variables were added to the baseline regression. The innovation policy subindex for a country is calculated as the weighted sum of the three measures, where the weights are based on the regression coefficients for each measure in the specification presented in Appendix C.

Together, these measures are highly statistically significant, and each is predicted to have a substantial impact on the level of international patenting.[10] For example, increasing the Survey response on the availability of R&D tax credits from 4 to 5 (one standard deviation) is associated with over a 35 percent increase in a country's level of international patenting.

The third column of Table 1 presents country rankings on the innovation policy subindex. Singapore registers the highest ranking, followed by Finland, the United States and Australia. Three non-OECD economies (Singapore, Israel and Taiwan) are among the top 5. All the remaining countries in the top 10 are OECD nations, including Canada, the United Kingdom, France, and Germany. Despite weakness in the size of its science and engineering workforce, Malaysia shows particular strength in innovation policy (ranking 16th), recording well above the sample mean on each of three components of the subindex calculation.

A number of OECD economies, including Italy and New Zealand, lag substantially behind in terms of innovation policy. There is an increasing gap between countries in their willingness and ability to implement innovation-oriented policy reforms. Still other OECD countries exhibit *relative weakness* in this area, compared to their rankings on other subindexes. In particular, both Japan and Switzerland register an overall innovative capacity ranking in the top 10 but are ranked outside of the top 15 in terms of innovation policy.

The innovation policy subindex rankings also reveal substantial variation across broad geographic regions. For example, Latin American nations exhibit a weak innovation policy record relative to their overall level of competitiveness. All Latin American innovation policy rankings are below the top 35, and the innovation policy environment of even the more advanced Latin American economies, such as Argentina and Venezuela, are ranked in the bottom quartile in terms of their innovation policy ranking. Eastern European economies such as Russia and Poland also lag substantially behind in terms of implementing an effective innovation policy agenda despite their large pools of scientific and engineering personnel. Interestingly, all of the former eastern European satellite countries rank higher in terms of innovation policy than does the Russian Federation itself. This weakness is consistent with the overall competitiveness problems continuing to plague Russia.

India and China, often cited as emerging innovation economies, register innovation policy rankings far below that of the main OECD economies (both are outside of the top 40). Both China and India are outside of the top 50 in terms of "the effectiveness of intellectual property protection," a crucial aspect of national innovation policy. Similar weaknesses are apparent in nearly all of the individual measures associated with the innovation policy environment. Both China and India have yet to establish the type of innovation policy environment found in emerging innovators such as Singapore and Israel.

The cluster innovation environment subindex

A similar methodology underlies the cluster innovation environment subindex. We selected three measures relating to the quality of the cluster environment in a nation's clusters:[11]

- The sophistication of domestic customers
- The extent of locally based competition
- The extent of product and process collaboration

Together, these measures are statistically significant and each has a quantitatively significant impact on the rate of international patenting, even after controlling for population, the historical propensity to innovate, and the size of the R&D workforce. The cluster innovation environment subindex is calculated by adding together these three factors, using the weights calculated in the regression (reported in Appendix C).

Six countries form "top tier" in terms of the cluster innovation environment, including (in order of ranking), Japan, the United States, Finland, Germany, Italy, and Taiwan. Among OECD economies, both Japan and Italy register relatively high rankings on the cluster subindex (compared with their ranking on other dimensions). The United Kingdom and Sweden record a relatively low ranking in this area.

Perhaps the most striking finding is that several emerging Asian economies demonstrate considerable strength in terms of cluster vitality. Taiwan, Korea, and Hong Kong all place within the top 20, outdistancing more mature economies such as the Netherlands. As well, a number of large Asian economies—including Malaysia, China, India, Thailand, and Vietnam—have begun to demonstrate measurable improvement in their cluster innovation environment. For example, though China's overall innovation ranking slipped from 36 to 40 from 2002 to 2003, China's cluster environment places 26th overall, ahead of some OECD economies such as Spain and Portugal. Overall, the East Asian economies are well positioned compared with most eastern European and Latin American economies, where cluster development continues at a relatively low level.

These patterns highlight meaningful and subtle differences in the sources of innovation across countries. Traditional analyses often assume that a strong innovation policy environment is a precondition for the development of dynamic clusters. However, the pattern observed in emerging Asian economies suggests that innovation-oriented cluster development can *precede* the establishment of a world-class innovation policy environment, driven in the case of China and India by inward foreign investment. Indeed, the growth of world-class clusters can itself spur the enactment of a more effective innovation policy regime, including the establishment of more effective intellectual property protection and the suspension of trade and regulatory barriers. The development of a robust innovation policy environment coevolves with cluster growth, a dynamic not captured using standard data sources.

The linkages subindex

This subindex measures the strength of linkages between the common innovation infrastructure and a country's clusters and firms. Perhaps the most difficult area to measure of the drivers of national innovative capacity, it reflects the subtle but crucial collaboration between public and private institutions and firm investments. Given the limited number of measures, this subindex is based on just two Survey measures closely associated with the process by which a country's innovation resources are directed toward the needs of individual clusters and firms:

- The local availability of specialized research and training institutions
- The availability of venture capital for innovative but risky projects

The availability of specialized research and training institutions highlights the importance of leading universities and other independent research institutions in fostering linkages. The availability of venture capital reflects the role of venture capital providers in seeking out commercializable research and moving it to the marketplace. Each measure is statistically and quantitatively significant in its predicted impact on the rate of international patenting. The linkages subindex is the weighted sum of the two linkages measures, with the weights determined by the regression coefficients reported in Appendix C.

Countries also vary widely in their ability to foster collaboration between the public and private sectors. As reported in the fifth column of Table 1, the United States stands out at the top of this ranking, followed by the Finland, the United Kingdom, and Israel. Even during a period in which the Israeli economy is threatened, linkages have so far remained strong. Japan and Germany both exhibit weakness in this area relative to their overall innovation rankings, registering outside of the top 10. Japan's weakness in fostering linkages is symptomatic of the broader failure of public-private interaction within the Japanese economy. Continued macroeconomic stagnation has its roots, in part, in the inability to leverage Japanese cluster strength as a springboard for broader microeconomic reform.

No emerging economy except Israel ranks in the top 10 on linkages. Relative weakness in this area is endemic in East Asia, Latin America, and eastern Europe. This is not surprising. Most developing countries have weak research institutions and also perhaps a history of sharp divisions across government, business, and universities. The development of linkages requires policy attention, resource investments, institution building, and attitude shifts that require patience and perseverance. This slow process contrasts with the relative speed in instituting policy choices such as R&D tax credits.

The company operations and strategy subindex

The final subindex measures the extent to which company strategies and operating practices are oriented toward innovation versus other modes of competing. The national environment shapes the opportunities and constraints that firms face when setting strategy, but managers must act on these through their choices. By choosing strategies based on innovation, companies link their competitive advantage to the innovative capacity of their local environment. We take advantage of three nuanced Survey measures to capture the impact of corporate practices on innovative capacity:

- The degree to which competitive advantage depends on introducing unique goods and services
- The extent and sophistication of marketing
- The degree to which pay is linked to productivity

At its heart, innovation-oriented strategies result from a choice by managers to seek competitive advantage from sustained introduction of unique products and services rather than rely on low-cost inputs. Premising strategy on innovation affects all aspects of a company's business, from product positioning to internal organization. The second and third measures capture other practices that support innovation-based strategies. As in the other subindexes, each measure is statistically and quantitatively linked to the rate of international patenting. As in the prior subindexes, the company operations and strategy subindex is the weighted sum of these three measures, with the weights determined by the regression coefficients reported in Appendix C.

As reported in Table 1, the United States leads this ranking, followed closely by Switzerland and the United Kingdom. A number of countries are closely bunched together in a second tier, including several European countries such as Germany and Denmark. Relative to the other subindexes, Finland and Australia register poor performance in this area, while Hong Kong achieves its strongest subindex ranking. Four emerging economies—Hong Kong, Singapore, Taiwan, and Israel—are within the top 15, suggesting that innovation-oriented firm strategies and operating practices are not limited to historically advanced economies.

Although there should be a positive relationship between the quality of the innovation environment and the innovation orientation of firm strategies, the relationship is far from automatic as firms may fail to recognize or have the skills to take advantage of national assets. To gain insight into this complex relationship, Figures 5a, b, and c show the relationship between the company operations and strategy subindex and the other subindexes.

The innovation orientation of local companies leads the innovative environment indicators in some countries. In other countries, companies do not seem to be taking full advantage of the innovative capacity of their local environment. For example, though the Swiss innovation environment ranks outside the top 10, Swiss companies remain focused on innovation-oriented strategies (and are ranked second along this dimension). In contrast, Australia's companies lag behind the quality of the local innovation environment. Similarly, in the large Asian economies of China, Vietnam, Malaysia, and India, company operations and strategy lag far behind cluster rankings. In order for such countries to move beyond low-cost manufacturing, individual firms within these countries will need to take better advantage of emerging cluster strengths.

Ranking overall innovative capacity

The national innovative capacity index, reported as the first column of Table 1, is calculated as the unweighted sum of the five subindexes:

- Science and engineering manpower subindex,
- The innovation policy subindex,
- The cluster innovation environment subindex,
- The innovation linkages subindex
- The company operations and strategy subindex.

The United States ranks first, as the result of leadership in two of the five subindexes and a position within the top 5 rankings in all of the subindexes. Finland is a close second, outperforming the United States in terms of science and engineering manpower and innovation policy subindexes. The United Kingdom and Japan round out the first tier, with almost identical overall scores. The remainder of the top 10 countries are closely bunched in terms of their absolute scores; only small differences distinguish the second tier of international innovators. The only non-OECD economies among the top 10 is Singapore, which has maintained a top 10 innovative capacity ranking for each of the last three years. A third tier, composed of another 13 countries (from the Netherlands [11th] to New Zealand [23rd]), are also closely bunched, with small differences in the absolute scores for this group of countries determining the relative positioning within the group.

These findings strongly confirm our earlier research and research by others on patterns of international innovation. Over the past quarter century, the set of leading innovator economies has expanded to include as many as 15 European economies (including nearly all the nations of Northern Europe) as well as several emerging economies, highlighted by the presence of 4 Asian nations within the top 20. Although OECD nations continue to be responsible for the great majority of global innovation, a growing number of emerging economies have achieved the conditions to support innovation. Overall, since the end of the Cold War, steady "convergence" in innovation achievement has resulted from a substantial upgrading in the innovation environment in a group of about 25 nations.

While the remainder of the world lags in innovative capacity, a number of countries are beginning to show positive signs. The large Asian economies, notably China and India, are still at an early stage of development in terms of innovation at the global frontier. Their strength in cluster development, however, has not yet been balanced with improvements in innovation policy or company behavior.

In contrast, despite improvements in macroeconomic stability over the past two decades in Latin America and positive political and economic changes in eastern Europe, these areas of the world do not yet offer environments conducive to innovation at the global frontier. In eastern Europe, a large pool of scientists and engineers has not yet led to comprehensive strategies to develop innovative capacity; as a result these nations continue to register unfulfilled promise. Similarly, African nations as yet have the ability only to absorb and develop technologies applicable to the local market: none is ranked within the top 30. Even South Africa underperforms on innovation relative to its overall level of economic development.

Figure 5a: The relation between company innovation orientation and innovation policy

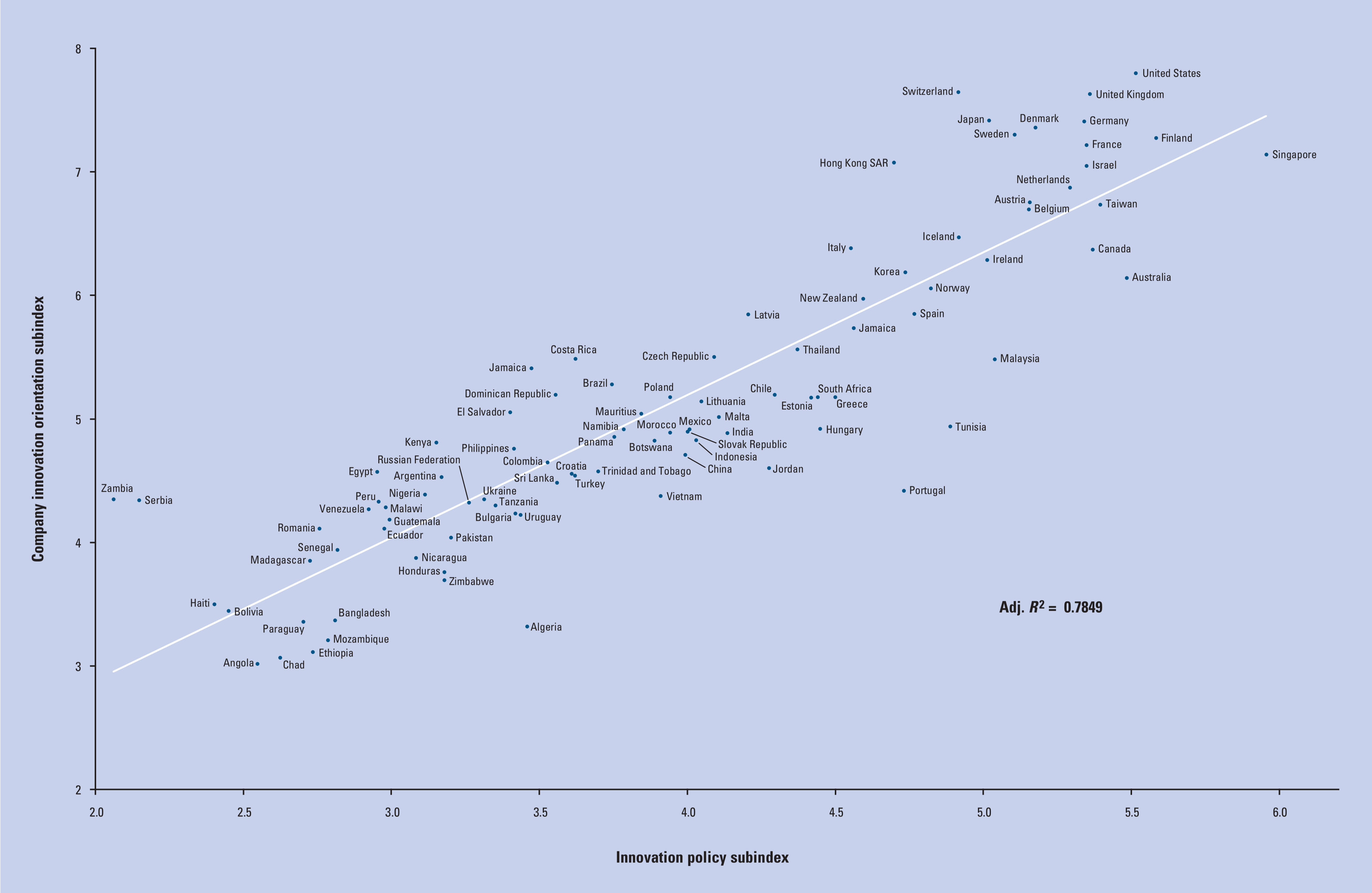


Figure 5b: The relation between company innovation orientation and cluster environment

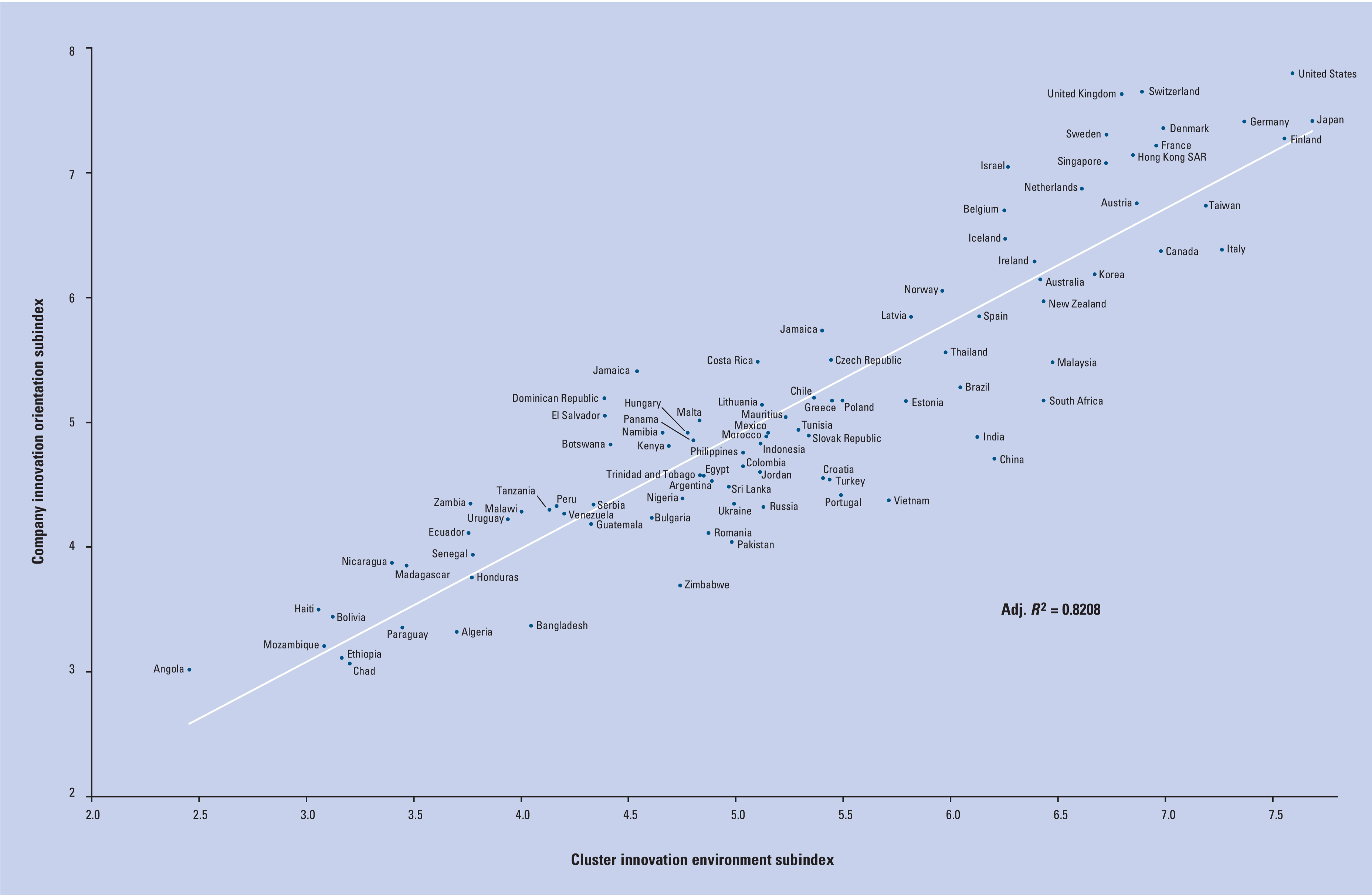
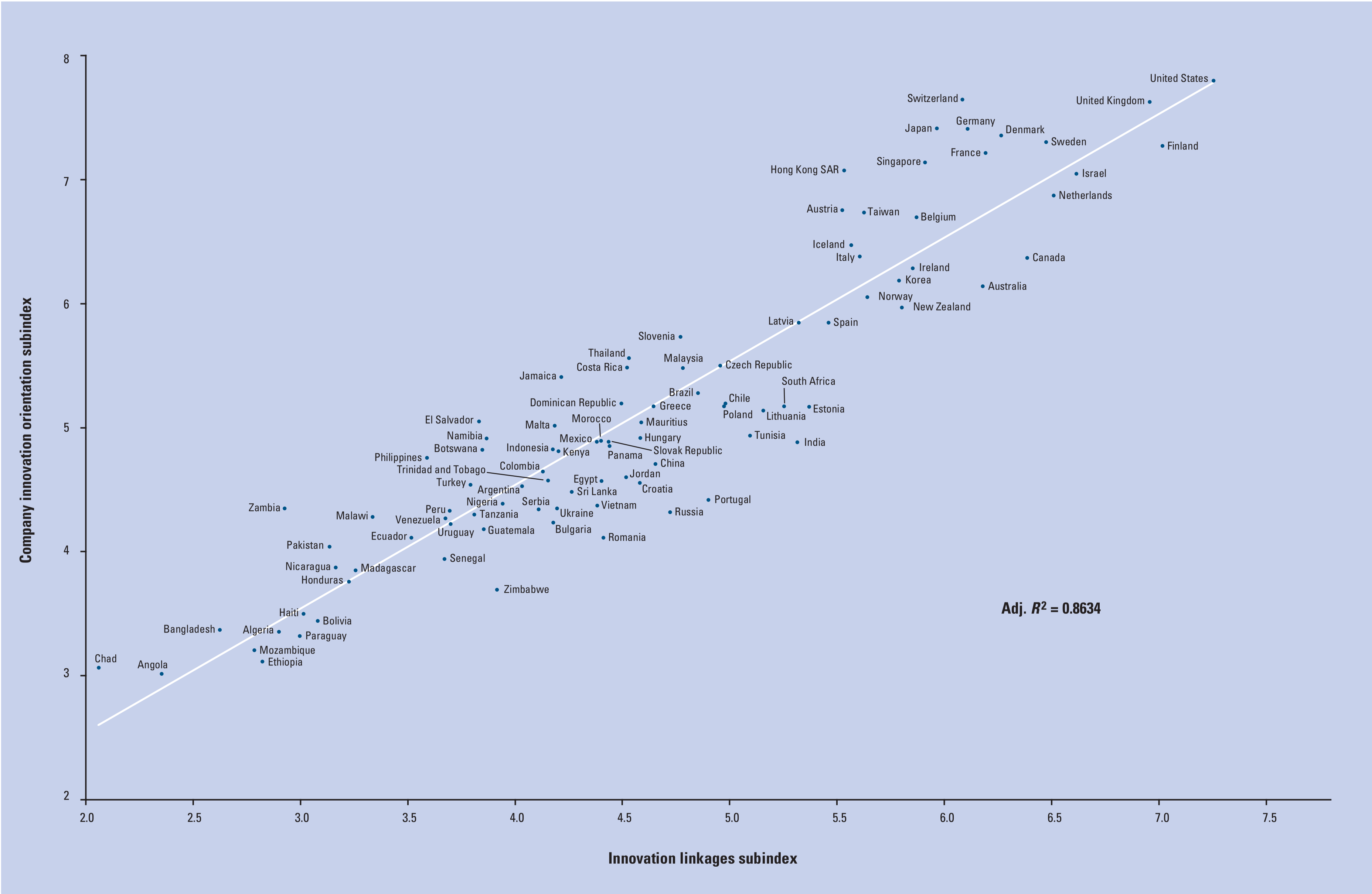


Figure 5c: The relation between company innovation orientation and innovation linkages



The subindexes differ in the extent of variation across countries and so in their relative impact on the overall innovative capacity ranking. Particularly for more mature countries, the innovation policy subindex exhibits the least amount of variation: the essential elements of effective innovation policy have diffused widely, eroding the ability to achieve global innovation leadership purely through policy differentiation. In contrast, the gap in innovative capacity among top tier countries is driven by large differences in the linkages and company operations and strategy subindexes. Differences among middle-tier innovation economies (ranking from 20th to 40th overall in innovative capacity) are more closely linked to differences in the cluster innovation environment and the science and engineering manpower subindexes.

To gain insight into how innovative capacity has shifted around the globe, Table 2 provides a comparison of the national innovative capacity index (NICI) for 2002 and 2003. To make the results comparable, we use the data for each year but impose the same model for both years. In other words, we re-calculated innovative capacity rankings for 2002 using last year's data but the model developed for this year's ranking.

Across the world, absolute innovative capacity has shown a very slight improvement. With the average rate of increase equal to 0.13 (and with a standard deviation of 0.10), the change in innovative capacity over the past year is extremely modest and statistically insignificant. In contrast to the 2002 *Report* where nearly all countries experienced year-to-year improvement (the average level of improvement was more than 3), more than 30 countries experienced a decline in the absolute value of measured innovative capacity between 2002 and 2003 (out of 71 countries for which the comparison was feasible). For example, the level of the index for Hungary declined by more than 2, leading to a ranking decline from 28 to 39.

Overall, the relative rankings of most countries have remained relatively stable, with most OECD economies maintaining their relative standing. While the top 5 nations (the United States, Finland, the United Kingdom, Japan, and Germany) are the same for both years, three countries—the United States, the United Kingdom, and Germany—register an absolute decline in the index. Where the United States had a large lead in 2002 (the absolute level of the index for the United States is more than 2.2 units higher than it is for any other country), its lead has moderated in 2003. Since the majority of countries within the top 25 improve their absolute score, additional convergence between first-tier and second-tier innovator economies has occurred.

Innovative capacity, competitiveness, and prosperity

We are now in a position to explore the complex interplay between innovative capacity, competitiveness, and economywide prosperity. We begin, in Figures 6 and 7, by comparing the Innovative Capacity ranking with the overall Business Competitiveness Index and with GDP per Capita, a summary measure of prosperity.

The innovative capacity index is highly correlated with the overall Business Competitiveness Index (the correlation is just over 0.9). A high level of innovative capacity is integral to achieving the high levels of productivity necessary to achieve and sustain overall competitiveness.

Innovative capacity and competitiveness are related even for lower-income countries. The incentive and ability to embrace new technology is now a sine qua non of international competition. Although most countries are positioned quite close to the regression line, interesting groups of outliers stand out. Although Finland and the United States are only marginally ahead of other countries in terms of overall competitiveness, these two countries demonstrate a decided advantage with respect to innovative capacity. As well, though Japan's overall competitiveness ranks outside of the top 10, its innovative capacity remains strong. As mentioned earlier, Japan continues to suffer from an inability to leverage its strengths in science and engineering and in cluster development given financial market and other weaknesses.

The largest discrepancies between the level of innovative capacity and the level of competitiveness arise in a group of eastern European countries (Ukraine, Romaine, Bulgaria, and Russia), that score much lower on competitiveness than on innovative capacity because of their substantial science and engineering workforces. A major disappointment of the post–Cold War era has been the inability of the former Soviet bloc nations to take advantage of their legacy and upgrade innovative capacity. An even bigger disappointment has been their slow progress on overall competitiveness.

Thailand is a distinct outlier in the opposite direction, with a level of competitiveness substantially above its measured level of innovative capacity. Thailand still largely competes as a low-cost assembler. Its relative weakness in innovative capacity highlights its challenges in evolving from its low-cost position to establish a path toward long-term prosperity.

Turning to the comparison between innovative capacity and GDP per capita, the relationship is still strong but not as close as the relationship with competitiveness. A number of distinct development models seem to be present, even among leading nations. Some advanced economies, such as Finland, Israel, (and perhaps even South Korea), have developed a level of innovative capacity *ahead of the overall competitiveness of the economy*. In these countries, increases in innovative capacity reflected public-

Table 2: National innovative capacity index rankings, 2002 versus 2003

Country	2002 IC (Using 2003 Formula)	2003 IC	Change in Innovative Capacity (2003–2002)
United States	37.21	36.60	–0.61
Finland	34.92	35.96	1.04
United Kingdom	35.55	34.63	–0.92
Japan	33.98	34.62	0.64
Germany	34.48	34.29	–0.19
Singapore	32.45	34.19	1.74
Sweden	33.59	34.02	0.43
Denmark	32.70	33.95	1.24
Switzerland	33.57	33.73	0.16
France	33.14	33.63	0.49
Netherlands	33.04	33.14	0.10
Canada	33.23	33.11	–0.12
Taiwan	32.34	32.84	0.50
Israel	32.56	32.64	0.08
Australia	32.40	32.37	–0.03
Austria	32.75	32.05	–0.70
Belgium	33.34	31.96	–1.37
Iceland	30.88	31.86	0.98
Ireland	31.14	31.24	0.10
Korea	30.59	31.13	0.54
Italy	31.26	30.86	–0.40
Norway	30.93	30.80	–0.12
New Zealand	29.59	30.55	0.95
Spain	30.16	29.77	–0.39
Hong Kong SAR	28.73	28.57	–0.16
Estonia	27.59	28.42	0.83
South Africa	27.16	28.38	1.22
Latvia	25.14	28.17	3.03
Slovenia	29.00	28.16	–0.84
Czech Republic	27.43	27.27	–0.15
Lithuania	26.37	27.08	0.71
Greece	26.25	27.01	0.76
Portugal	28.06	26.90	–1.16
Poland	26.27	26.87	0.60
Malaysia	26.20	26.85	0.65
Slovak Republic	26.13	26.12	–0.01
Jordan	n/a	26.09	n/a
Tunisia	25.05	26.03	0.98
Hungary	28.08	26.00	–2.08
China	26.06	25.86	–0.20
Chile	25.84	25.75	–0.09
Brazil	26.61	25.70	–0.91
Russian Federation	25.32	25.59	0.27
India	25.24	25.52	0.28
Croatia	25.46	25.23	–0.23
Costa Rica	25.50	25.01	–0.49
Thailand	25.16	24.74	–0.42
Mauritius	22.53	24.73	2.20
Ukraine	23.89	24.51	0.62
Indonesia	22.09	24.04	1.95
Mexico	23.13	24.00	0.87
Vietnam	22.82	23.99	1.17
Bulgaria	23.28	23.62	0.35
Turkey	22.80	23.23	0.43
Egypt	n/a	23.04	n/a
Argentina	22.96	22.98	0.02
Romania	23.57	22.97	–0.60
Panama	22.87	22.68	–0.19
Sri Lanka	22.84	22.52	–0.32
Trinidad and Tobago	22.92	22.24	–0.69
Philippines	21.82	21.99	0.17
Colombia	21.49	21.84	0.36
Dominican Republic	23.76	21.58	–2.18
Uruguay	20.92	20.58	–0.34
Peru	20.95	20.58	–0.37
El Salvador	20.34	20.52	0.18
Venezuela	20.97	20.34	–0.64
Guatemala	19.49	19.71	0.22
Pakistan	n/a	19.60	n/a
Zimbabwe	18.70	19.47	0.77
Ecuador	18.26	18.78	0.52
Honduras	17.71	18.28	0.57
Nicaragua	18.95	17.80	–1.14
Paraguay	18.13	17.04	–1.09
Bangladesh	17.66	16.94	
Bolivia	17.14	16.32	
Madagascar	n/a	15.81	
Senegal	n/a	14.81	
Algeria	n/a	n/a	
Angola	n/a	n/a	
Botswana	n/a	n/a	
Chad	n/a	n/a	
Ethiopia	n/a	n/a	
Haiti	n/a	n/a	
Jamaica	n/a	n/a	
Kenya	n/a	n/a	
Malawi	n/a	n/a	
Malta	n/a	n/a	
Morocco	n/a	n/a	
Mozambique	n/a	n/a	
Namibia	n/a	n/a	
Nigeria	n/a	n/a	
Serbia	n/a	n/a	
Tanzania	n/a	n/a	
Zambia	n/a	n/a	
AVERAGE CHANGE			**0.13**

(cont'd.)

Figure 6: The relationship between the innovative capacity index and the Business Competitiveness Index

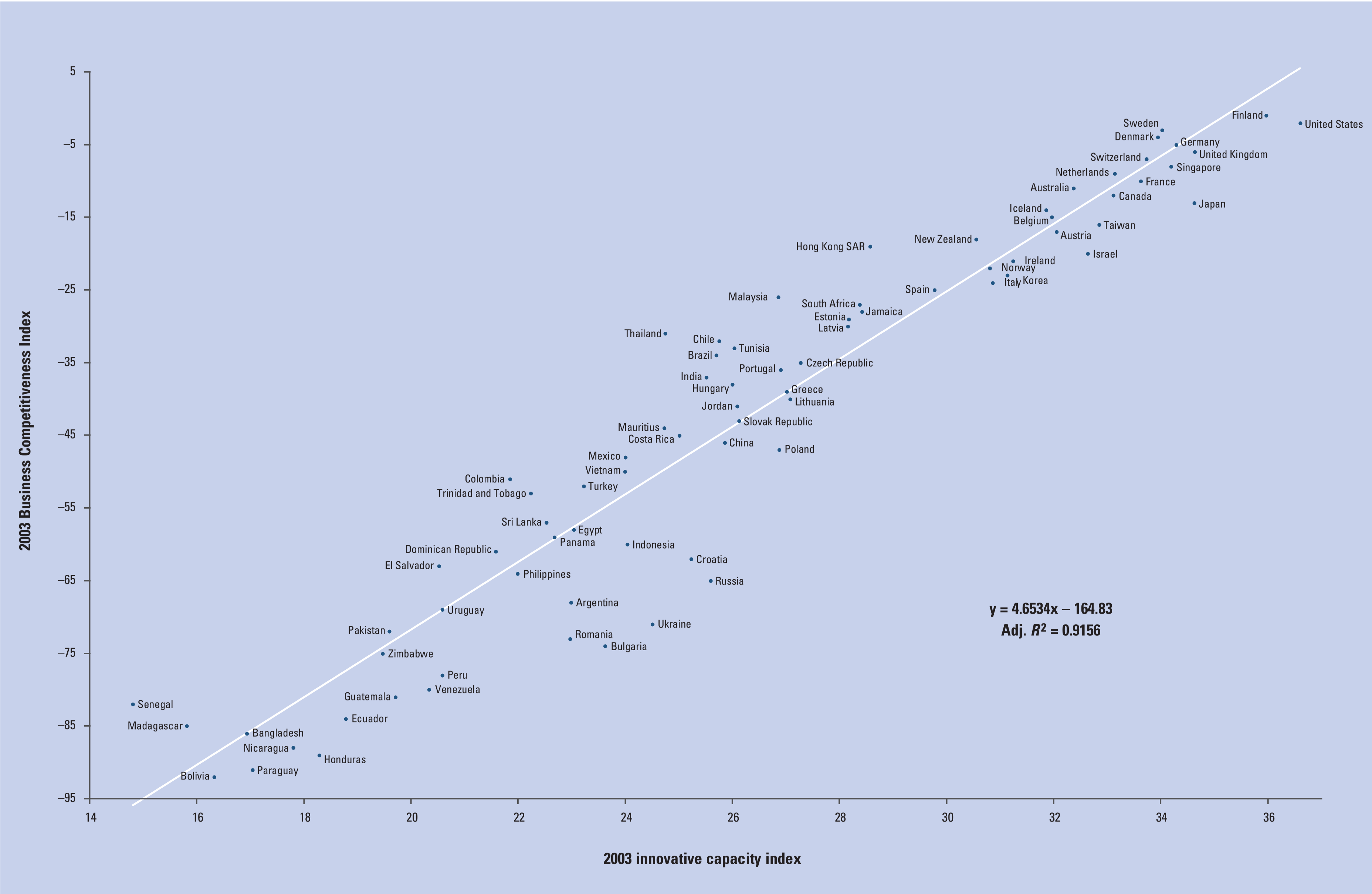
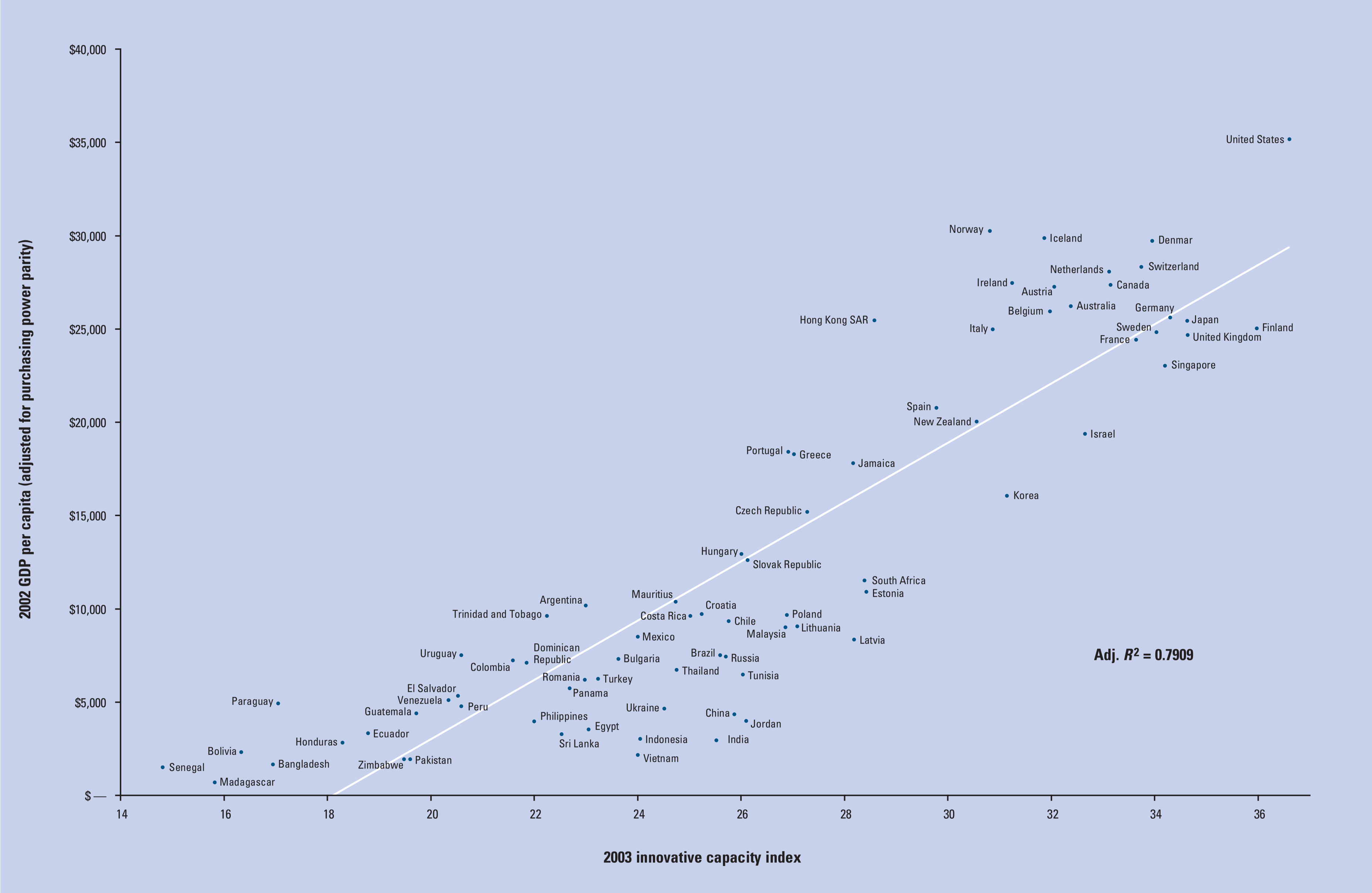


Figure 7: The relationship between the innovative capacity index and GDP per capita



and private-sector consensus about the priority of innovation in driving long-term competitiveness. For example, Finland's current prosperity can be tied closely to investments from the early 1980s onward that have nurtured the development of the telecommunications cluster, stepped up investment in basic research, and improved advanced education, among other things.

In contrast, countries such as Norway, Portugal, and Greece have continued to rely on favorable natural endowments or proximity to major markets. Despite increasing evidence of the role of innovation in long-term prosperity, these countries have as yet made little change in their economic development strategies, raising the possibility of long-term stagnation. Finally, several leading nations, such as France and Germany, are located closely to the regression line, suggesting a "balanced" path in which innovative capacity and the overall environment for productivity progress at roughly the same rate.

The United States continues to lead the world in innovative capacity and current GDP per capita.

Policy makers in the United States remain highly focused on innovation at both the Federal and regional levels. Although continued attention bodes well for the United States., several challenges remain. Perhaps most importantly, the pipeline of undergraduate and graduate students choosing to pursue scientific and engineering careers continues to diminish. The continued availability of a well-trained innovator workforce thus depends on the continued attractiveness of the United States to foreign scientists and engineers. However, convergence between the United States and other countries in terms of innovative capacity may reduce the viability of this strategy. The supply of scientific and technical personnel represent the greatest threat to US leadership.

Creating versus absorbing new technology

Although innovative capacity and competitiveness are correlated even among countries with low incomes, the initial challenge for developing countries is normally to access and exploit technology from elsewhere. Effective technology absorption may well be a precursor to the development of innovative capacity revealed by international patenting. Many of the same attributes affect the ability to absorb technology as affect the ability to create technology. However, it is revealing to separate the two, especially for lower-income nations.

For all countries below median income in our example (less than US$8,900 per year), we computed a "technology absorptive capacity" score by adding together Survey responses to two questions:

- The prevalence of foreign technology licensing
- The ability to absorb foreign technology

Although imperfect, these measures provide a summary of the extent of accessing foreign technology in a country. We then plot this score against the 2003 National Innovative Capacity Index in Figure 8. Perhaps not surprisingly, there is a close relationship between absorptive and innovative capacity (Figure 8). Although the ability to absorb technology typically precedes the ability to develop global innovation, countries differ in the balance among activities. Notably, among lower-income countries, Thailand and India register the highest absorptive capacity scores but a more modest level of innovative capacity, while China scores relatively high on innovative relative to absorptive capacity. Though most analyses of China and India assume that their aggressive approach to technology reflect similar strategies, these findings suggest a more subtle relationship: India's positioning is based more on *exploiting* global technology while China is making systematic investments (relative to its level of development) in *developing* global technology. However, it is important to emphasize that the source of innovation strength in both of these countries is closely tied to workforce and cluster strengths, rather than to specific government policies or the effectiveness of linkages between the public and private sector.

Figure 9 plots technology absorptive capacity against GDP per capita. The results are revealing. India, Thailand, and Brazil register an ability to exploit global technology far higher than would be predicted by their current level of economic development. Conversely, many other Latin American and Eastern European nations register a low level of technology absorptive capacity relative to income. Interestingly, while China is a bit above the regression line linking absorptive capacity and GDP per capita, China's rapid improvements in per capita income over the last decade has resulted in a position where its ability to absorb foreign technology is now roughly consistent with the level of prosperity it has achieved.

The interplay between absorptive capacity, innovative capacity, and competitiveness is subtle. For countries that have not yet emerged from a low level of economic development, improvements in competitiveness are likely to require capabilities, as well as formal policies and institutions, that facilitate access to and exploitation of the best of global technology. However, although some countries have built upon a baseline level of absorptive capacity in order to develop innovative capacity (such as those in East Asia), other countries remain focused on simply adopting and adapting the world technology frontier. For example, despite a low level of innovative capacity to the present day, Chile improved its competitiveness over the past quarter century through openness to foreign technology and investment. However, recent crises in Latin America and other regions maintaining low levels of innovative capacity highlight the fragility of this strategy. As low-cost locations

Figure 8: The relationship between technology absorptive capacity and innovative capacity, lower-income countries

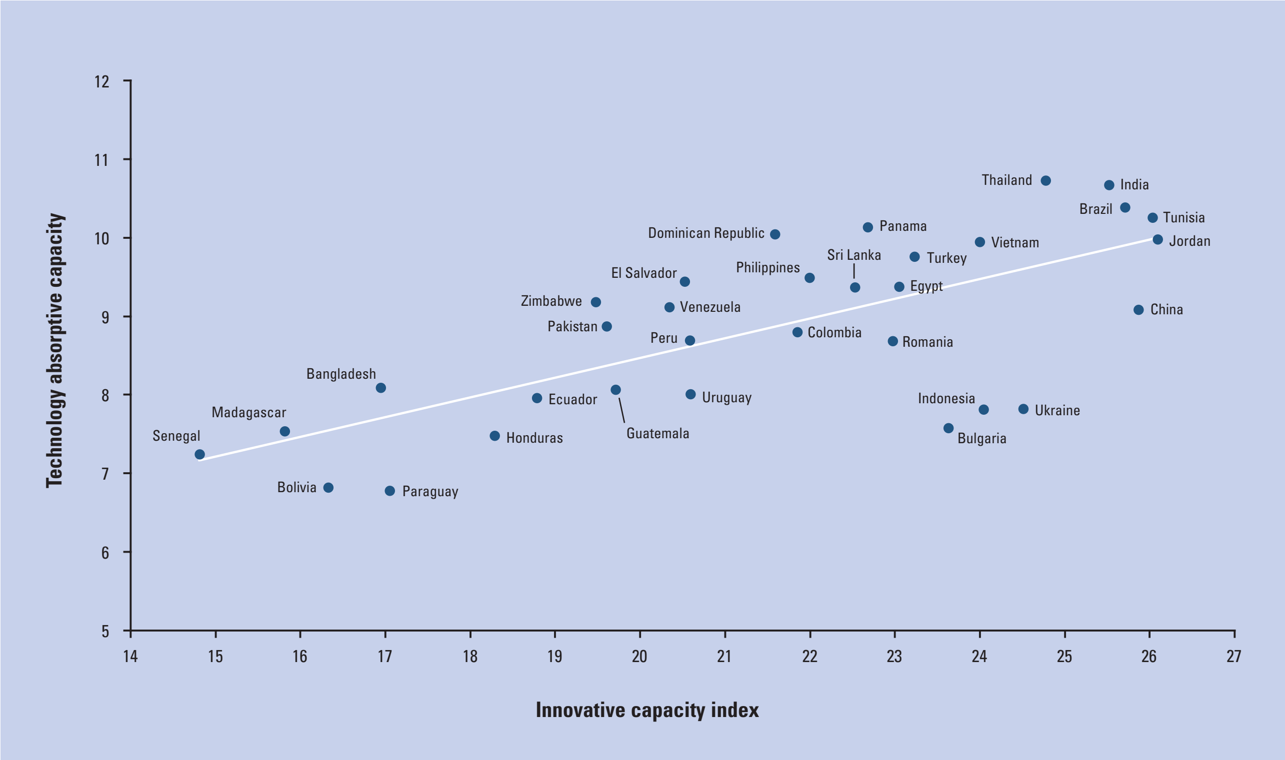
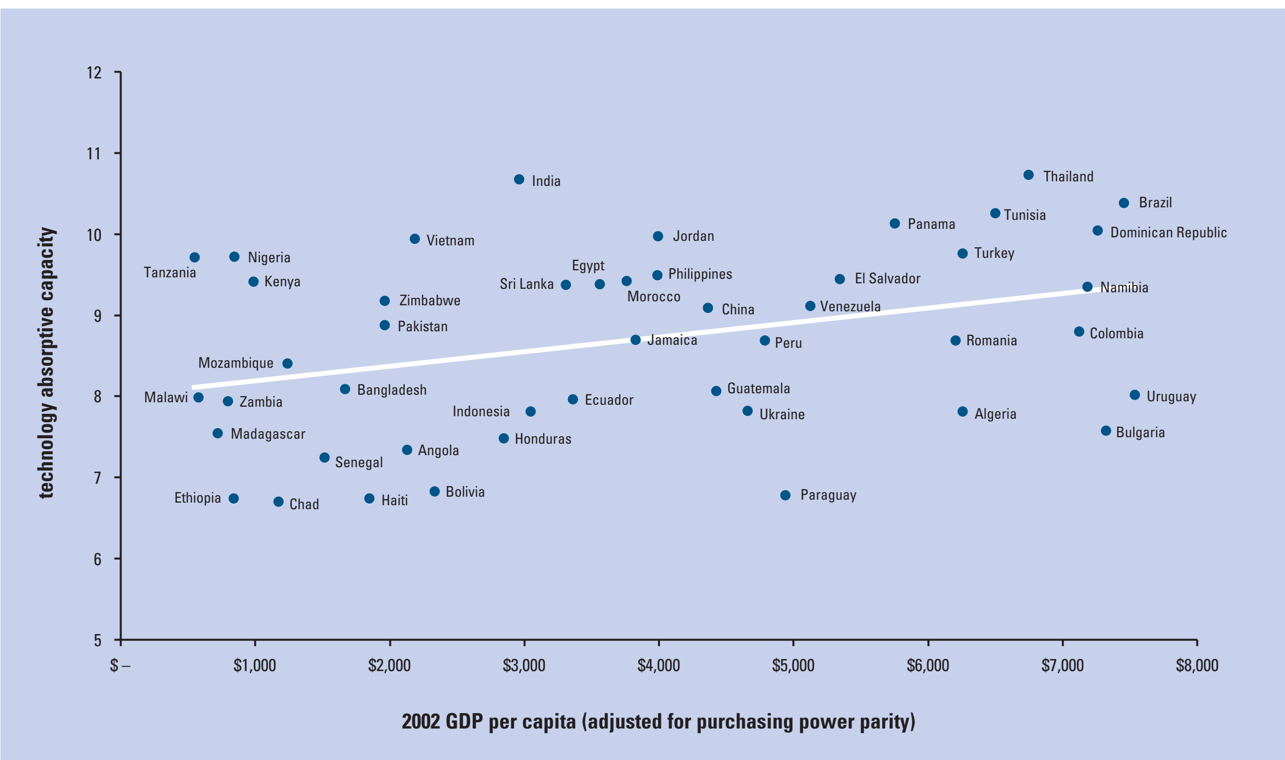


Figure 9: The relationship between technology absorptive capacity and 2002 GDP per capita, lower-income countries



such as China invest aggressively in both absorbing and developing global technology, competitiveness in the absence of innovative capacity has become less sustainable.

Conclusions

Innovation has become perhaps the single most important source of competitiveness in advanced economies, and success in building innovative capacity has a strong relationship to a country's overall competitiveness and level of prosperity. The national innovative capacity framework allows a detailed examination of sources of the large and persistent differences across countries in innovation performance. This chapter provides an assessment of the comparative performance in national innovative capacity around the world in 2003 and provides a scorecard for national policymakers about their relative standing and priorities for policy. Although the data available and feasible statistical procedures are limited by the inherent difficulties in measuring innovation and its causes, the rankings are consistent with our knowledge about individual countries and provide insight into the strengths and challenges facing both advanced and emerging economies.

Those economies, such as Finland and Singapore, that have proactively built innovative capacity have prospered. In contrast, limited investment in innovative capacity has retarded the competitive potential of countries such as Spain and New Zealand. Recent concerns over the rapid movement of innovation-oriented employment away from traditional locations within OECD economies and toward China and India highlight the crucial importance of innovative capacity and cluster development to competitiveness, economic security and prosperity.

Notes

1 For a complete exposition of the national innovative capacity framework, see Furman, Porter, and Stern (2002) and Porter, Stern, and Council on Competitiveness (1999). The term *innovative capacity* has been used extensively in prior research in economics, geography, and innovation policy. For example, Pavitt (1980), along with co-authors at the Sussex Policy Research Unit, employed the term in the economics and innovation policy literature. Suarez-Villa (1990, 1993) provides an articulation of the concept within the geography literature, focusing on the specific linkage between invention and innovation. See Neely and Hii (1998) for a more detailed discussion of the origins and definition of innovative capacity in the academic literature.

2 For a more complete exposition of the diamond framework and its role in understanding the origins of national competitive advantage, see Porter (1990, 1998).

3 Although the systematic use of patent data can be traced back at least to Schmookler (1966), the use of patents has expanded dramatically over the past decade, building on the careful investigations and database development of, among others, Griliches (1984; 1990; 1994). For a thorough discussion of the use of patenting and international patenting data (and alternatives) in studying the causes and consequences of innovation, see Adam Jaffe and Manuel Trajtenberg, *Patents, Citations and Innovation: A Window on the Knowledge Economy*, MIT Press, 2002, as well as J. Furman, M. E. Porter, and S. Stern, "The Determinants of National Innovative Capacity," *Research Policy*, 31(6): 899–933. The use of international patents also has precedent in prior work comparing and assessing international inventive activity (see Dosi, Pavitt, and Soete, 1990; Eaton and Kortum, 1996).

4 Since no single measure of innovation output is ideal, we have explored several alternatives such as the pattern of exports in international high-technology markets and the flow of technology licensing revenues across countries. Overall, international patenting offers by far the best and most consistent measure across time and location.

5 Appendix D reports the rankings from the "weighted" regression specifications. The results for alternative weighting schemes are available by request from the authors.

6 This specification is simply the "ideas" production function, as developed in endogenous growth theory (Romer, 1990). See Porter and Stern (2000) for a full derivation of our empirical formulation.

7 Although controlling for differences in GDP per capita is feasible in this regression (and we have used this formulation in our related work), the focus here is on *explaining* the drivers of prosperity, and so we focus our analysis on measures more closely related to the underlying microeconomic environment.

8 More precisely, we first take the natural logarithm of all of these variables, to smooth out the variation in country size and also to provide for easily interpretable coefficient estimates. Science and engineering resources are drawn from several data sources, as summarized in *World Development Indicators*. Specifically, data for OECD countries are drawn from the OECD Main Science and Technology Indicators, Latin American data are drawn from the RICYT, and the Asian data are drawn primarily from the science and technology statistics from individual countries.

9 Thirty-three of the 34 measures are significant at the 95 percent confidence level; the "Quality of Math and Science Education" measure is only significant at the 90 percent level. Although each of the 34 Survey measures related to innovative capacity framework are positively correlated with the level of international patenting, Survey measures with a more remote relationship to innovation are uncorrelated with the level of patenting. For example, after controlling for the baseline variables, international patenting is uncorrelated with Survey measures such as the "availability of an independent judiciary," "the degree of press censorship," or the "rarity of insider trading."

10 In the multivariate regression, only two of the three innovation policy measures are individually statistically significant. We included these three measures for this subindex as they had the most robust and stable relationship to international patenting when combined with other measures of the innovation policy environment (as listed in Appendix A).

11 This specification differs somewhat from the specification employed in the 2002 innovative capacity index. "The extent of product and process collaboration" measure has been substituted in place of the measure for "the state of cluster development." Although the results are qualitatively similar with either measure, the current specification is more closely tied to the innovative capacity framework and incorporates a more robust and significant statistical relationship with international patenting.

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Appendix A: ANOVA analysis for each subindex area

	Innovation Policy Subindex	Cluster Subindex	Linkages Subindex	Operations and Strategy Subindex
	Adj. R^2	Adj. R^2	Adj. R^2	Adj. R^2
Intellectual Property Protection	0.4552			
Quality of Math and Science Education	0.4267			
Attractiveness of National Environment for Retaining Talented People	0.3906			
Government R&D Tax Credits and Subsidies	0.3631			
Government Procurement of Advanced Technology Products	0.1905			
Tariff Liberalization	0.2839			
Presence of Demanding Regulatory Standards	0.4913			
Effectiveness of Anti-Trust Policy	0.3425			
Environmental Compliance Helps Long-Run Competitiveness	0.1446			
Buyer Sophistication		0.3560		
Local Supplier Quality		0.4010		
Consumer Adoption of Latest Products		0.2751		
State of Cluster Development		0.2553		
Extent of Product and Process Collaboration		0.2898		
Extent of Locally Based Competitors		0.1852		
Absorption of New Technology			0.1762	
Quality of Scientific Research Institutions			0.3260	
Local Availability of Specialized Research and Training Institutions			0.3106	
University/Industry Research Collaboration			0.2940	
Venture Capital Availability			0.2672	
Nature of Competitive Advantage				0.4034
Value Chain Presence of Exporting Firms				0.4497
Extent of Branding for Exporting Companies				0.4484
Capacity of Innovation				0.4258
Extent of Marketing				0.4312
Degree of Customer Orientation				0.2455
Control of International Distribution				0.1886
Breadth of International Markets				0.4357
Company Spending on R&D				0.3506
Extent of Staff Training				0.3807
Pay Linked to Productivity				0.2132
Willingness to Delegate Authority				0.3228
Reliance on Professional Management				0.3142
Quality of Management Schools				0.3942

Appendix B: Bilateral regressions for each of the four subindex areas

Dependent Variable — Log of U.S. Patents, 2000-2001	Baseline			Innovation Policy Variables			Cluster Variables			Linkages Variables			Operations and Strategy Variables		
Independent Variables	Coeff	*t*-stat	adj. R^2	Coeff	*t*-stat	adj. R^2	Coeff	*t*-stat	adj. R^2	Coeff	*t*-stat	adj. R^2	Coeff	*t*-stat	adj. R^2
			0.919												
Log of Patent Stock Metric (patents issued between 1981 and 1995)	0.783	0.051													
Log of Population in 2002	0.161	0.081													
Log of Proportion of Full-time Employed Scientists and Engineers	0.351	0.092													
Intellectual Property Protection				0.627	0.119	0.918									
Quality of Math and Science Education				0.285	0.159	0.889									
Attractiveness of National Environment for Retaining Talented People				0.470	0.131	0.903									
Government R&D Tax Credits and Subsidies				0.674	0.131	0.917									
Government Procurement of Advanced Technology Products				0.843	0.167	0.916									
Tariff Liberalization				0.811	0.228	0.902									
Presence of Demanding Regulatory Standards				1.003	0.175	0.922									
Effectiveness of Anti-Trust Policy				0.601	0.155	0.905									
Environmental Compliance Helps Long-Run Competitiveness				1.157	0.222	0.917									
Buyer Sophistication							0.918	0.140	0.929						
Local Supplier Quality							0.949	0.172	0.920						
Consumer Adoption of Latest Products							1.101	0.162	0.931						
State of Cluster Development							0.829	0.143	0.923						
Extent of Product and Process Collaboration							1.092	0.178	0.925						
Extent of Locally Based Competitors							1.120	0.225	0.915						
Absorption of New Technology										1.259	0.179	0.933			
Quality of Scientific Research Institutions										1.087	0.226	0.914			
Local Availability of Specialized Research and Training Institutions										1.199	0.287	0.908			
University/Industry Research Collaboration										1.043	0.154	0.931			
Venture Capital Availability										0.709	0.156	0.911			
Nature of Competitive Advantage													0.801	0.138	0.922
Value Chain Presence of Exporting Firms													0.621	0.115	0.919
Extent of Branding for Exporting Companies													0.856	0.154	0.920
Capacity of Innovation													1.176	0.193	0.925
Extent of Marketing													0.880	0.152	0.922
Degree of Customer Orientation													1.026	0.197	0.917
Control of International Distribution													1.248	0.240	0.917
Breadth of International Markets													0.697	0.119	0.923
Company Spending on R&D													1.016	0.160	0.927
Extent of Staff Training													0.829	0.135	0.925
Pay Linked to Productivity													0.479	0.180	0.895
Willingness to Delegate Authority													0.855	0.149	0.922
Reliance on Professional Management													0.704	0.158	0.910
Quality of Management Schools													0.518	0.158	0.900

Appendix C: Regressions for each of the four subindexes

Innovation Policy Subindex

Regression Statistics	
Adj. R^2	0.9227
Observations	72

	Coef.	Std. Error	*t*-stat	P-value
Intercept	-5.7469	1.3536	-4.2500	0.0000
Log (Patent Stock Metric)	0.5646	0.0600	9.4100	0.0000
Log (Population)	0.3656	0.1044	3.5000	0.0010
Log (S&E Proportion)*	0.2803	0.1030	2.7200	0.0080
Intellectual Property Protection	0.3157	0.1683	1.8800	0.0650
Government R&D Tax Credits and Subsidies	0.3685	0.1728	2.1300	0.0370
Tariff Liberalization	0.2798	0.2382	1.1700	0.2440

Cluster Innovation Environment SubIndex

Regression Statistics	
Adj. R^2	0.9344
Observations	73

	Coef.	Std. Error	*t*-stat	P-value
Intercept	-6.0751	0.8223	-7.3900	0.0000
Log (Patent Stock Metric)	0.5205	0.0550	9.4700	0.0000
Log (Population)	0.2144	0.0999	2.1500	0.0350
Log (S&E Proportion)*	0.2219	0.0979	2.2700	0.0270
Buyer Sophistication	0.4283	0.2257	1.9000	0.0620
Extent of Locally Based Competitors	0.3633	0.2694	1.3500	0.1820
Extent of Product and Process Collaboration	0.5637	0.2363	2.3900	0.0200

Linkages SubIndex

Regression Statistics	
Adj. R^2	0.9161
Observations	73

	Coef.	Std. Error	*t*-stat	P-value
Intercept	-5.5046	0.8331	-6.6100	0.0000
Log (Patent Stock Metric)	0.5430	0.0660	8.2300	0.0000
Log (Population)	0.3121	0.0841	3.7100	0.0020
Log (S&E Proportion)*	0.1762	0.1182	1.4900	0.1410
Local Availability of Specialized Research & Training Institutions	0.7294	0.3209	2.2700	0.0260
Venture Capital Availability	0.4971	0.1782	2.7900	0.0070

Operations and Strategy SubIndex

Regression Statistics	
Adj. R^2	0.9354
Observations	73

	Coef.	Std. Error	*t*-stat	P-value
Intercept	-6.9765	0.8000	-8.7200	0.0000
Log (Patent Stock Metric)	0.4188	0.0616	6.8000	0.0000
Log (Population)	0.4765	0.0819	5.8200	0.0000
Log (S&E Proportion)*	0.3573	0.0912	3.9200	0.0000
Nature of Competitive Advantage	0.5163	0.1510	3.4200	0.0010
Extent of Marketing	0.5026	0.1692	2.9700	0.0040
Pay Linked to Productivity	0.2922	0.1449	2.0200	0.0480

* Log of Proportion of Full-Time Employed Scientists and Engineers

Appendix D: Innovative capacity rankings: unweighted versus weighted regressions

The "weighted" rankings employ a weighted regression procedure in the calculation of each sub-index, where the weights reflect the degree of within-country consensus. For each question included in a given subindex, we calculated the within-country standard deviation. The regression weighting for each subindex is equal to the inverse of the average of these within-country standard deviations.

Country	Baseline IC rank	Baseline IC index	"Weighted" IC rank (by within-country SD)	"Weighted" IC index (by within-country SD)
United States	1	36.60	1	30.91
Finland	2	35.96	2	30.32
United Kingdom	3	34.63	5	29.17
Japan	4	34.62	3	29.37
Germany	5	34.29	6	28.73
Singapore	6	34.19	4	29.31
Sweden	7	34.02	8	28.60
Denmark	8	33.95	7	28.66
Switzerland	9	33.73	9	28.54
France	10	33.63	10	28.35
Netherlands	11	33.14	13	27.82
Canada	12	33.11	12	28.05
Taiwan	13	32.84	11	28.12
Israel	14	32.64	14	27.61
Australia	15	32.37	15	27.44
Austria	16	32.05	17	27.06
Belgium	17	31.96	18	27.00
Iceland	18	31.86	16	27.13
Ireland	19	31.24	19	26.49
Korea	20	31.13	20	26.43
Italy	21	30.86	22	25.86
Norway	22	30.80	21	26.15
New Zealand	23	30.55	23	25.77
Spain	24	29.77	24	25.13
Hong Kong	25	28.57	29	23.77
Estonia	26	28.42	25	24.21
South Africa	27	28.38	28	23.90
Latvia	28	28.17	27	24.04
Slovenia	29	28.16	26	24.14
Czech Republic	30	27.27	30	23.27
Lithuania	31	27.08	31	23.11
Greece	32	27.01	32	22.99
Portugal	33	26.90	34	22.81
Poland	34	26.87	33	22.90
Malaysia	35	26.85	35	22.77
Slovak Republic	36	26.12	38	22.29
Jordan	37	26.09	36	22.39
Tunisia	38	26.03	39	22.20
Hungary	39	26.00	37	22.33
China	40	25.86	41	22.13
Chile	41	25.75	42	21.68
Brazil	42	25.70	43	21.60
Russian Federation	43	25.59	40	22.18
India	44	25.52	45	21.31
Croatia	45	25.23	44	21.49
Costa Rica	46	25.01	47	21.15
Thailand	47	24.74	49	20.73
Mauritius	48	24.73	48	20.84
Ukraine	49	24.51	46	21.26
Indonesia	50	24.04	51	20.51
Mexico	51	24.00	53	20.15
Vietnam	52	23.99	50	20.71
Bulgaria	53	23.62	52	20.40
Turkey	54	23.23	54	19.77
Egypt	55	23.04	56	19.57
Argentina	56	22.98	57	19.50
Romania	57	22.97	55	19.68
Panama	58	22.68	59	18.85
Sri Lanka	59	22.52	58	19.02
Trinidad and Tobago	60	22.24	60	18.70
Philippines	61	21.99	61	18.43
Colombia	62	21.84	62	18.22
Dominican Republic	63	21.58	63	17.95
Uruguay	64	20.58	65	17.38
Peru	65	20.58	64	17.42
El Salvador	66	20.52	67	17.08
Venezuela	67	20.34	66	17.13
Guatemala	68	19.71	69	16.40
Pakistan	69	19.60	68	16.44
Zimbabwe	70	19.47	70	16.18
Ecuador	71	18.78	71	15.72
Honduras	72	18.28	72	15.37
Nicaragua	73	17.80	73	15.14
Paraguay	74	17.04	74	14.41
Bangladesh	75	16.94	75	14.34
Bolivia	76	16.32	76	13.85
Madagascar	77	15.81	77	13.11
Senegal	78	14.81	78	12.08
Algeria	n/a	n/a	n/a	n/a
Angola	n/a	n/a	n/a	n/a
Botswana	n/a	n/a	n/a	n/a
Chad	n/a	n/a	n/a	n/a
Ethiopia	n/a	n/a	n/a	n/a
Haiti	n/a	n/a	n/a	n/a
Jamaica	n/a	n/a	n/a	n/a
Kenya	n/a	n/a	n/a	n/a
Malawi	n/a	n/a	n/a	n/a
Malta	n/a	n/a	n/a	n/a
Morocco	n/a	n/a	n/a	n/a
Mozambique	n/a	n/a	n/a	n/a
Namibia	n/a	n/a	n/a	n/a
Nigeria	n/a	n/a	n/a	n/a
Serbia	n/a	n/a	n/a	n/a
Tanzania	n/a	n/a	n/a	n/a
Zambia	n/a	n/a	n/a	n/a

(cont'd.)