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HIGH TECH AND SOCIETAL INNOVATION IN POLAND: PROSPECTS AND STRATEGIES

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Abstract

Innovation has become increasingly central to the creation of a sustainable competitive advantage for firms, as well as to the success and prestige of nations. In this paper we attempt to assess the state of innovation in Poland, a large transition nation and recent entrant into the European Union. We develop a framework for innovation comprised of the National, Regional, Local, and Enterprise levels. We employ this as a template to investigate innovation in three layers-ICT, high tech, and society-wide. Three sets of secondary data pertaining to Poland are analyzed, leading to the conclusion that Poland's innovation performance needs radical improvement on all three interdependent counts. Recommendations are made based on the more effective management of diverse societal interfaces, as well as the judicious management of a mix of the four innovation systems .

Keywords: Innovation Systems; ICT innovation; high tech innovation; societal innovation; innovation scorecards; Poland's performance

JEL classification: O32, O33

Innovation: the basis of corporate and national success

Innovation has been central to the sustained success of business firms since the Industrial Revolution. Companies like Wedgewood, International Harvester, Thyssen, Honda, IBM, Nokia, Sony, and numerous others have brought superior knowledge, and the ability to apply it successfully, to bear (in diverse ways, and at different points in time) to achieve competitive, if not dominant, positions in their respective industries. Innovation has typically been multidimensional. For instance, Cyrus McCormick, after developing the mechanical reaper, actively marketed his product by displaying it to potential buyers and even pioneered installment purchases to make it more affordable. Thyssen not only established highly efficient steel mills, he was a relatively hands on manager, who believed in meeting with his employees where they worked, rather than summoning them to his office McCraw, 1997; Gordon, 2001). Firms innovate, according to Christensen(2003), by enhancing the performance features of a product, reducing its cost by eliminating non-essential features, or serving entirely new markets. A similar point is made by Kim and Mauborgne(2005), whose "strategy canvas" helps firms identify value gaps and surpluses as a way to transform the product/service concept. Rochlin(2006) asserts that technology stacking(the availability of complementary assets), and the development of the market and functional dimensions, in addition to that of technology, is a key driver of competitive advantage. This multifaceted technology, which we term innovation, has been accentuated in today's knowledge economy. More precisely, innovation, as the OECD (2007) notes, is the development of new ideas and their successful application to market needs, resulting in the creation of wealth.

Just as innovation has become progressively more critical to the success of firms all over the world, the economic growth of nations is also intimately linked to the innovativeness of its organizations, and how effectively new ideas are developed, nurtured, and brought to fruition in society at large. Recognizing that innovation, in small and medium enterprises (SME's) and in large corporations generates sustainable growth is, however only part of the story.

Acting to enable and unleash entrepreneurial energies is far more complicated. Countries like Finland, Ireland, Singapore, and South Korea have implemented apparently successful strategies to enhance their innovative capabilities, while others like China and India have embarked on ambitious programs of their own to foster indigenous capabilities in developing new products with market acceptance. Though China's prowess in production and India's in services have not been matched as yet by their technological skills, both nations plan on redressing the imbalance. Starting with education systems and investment in R&D by transnational corporations (TNCs) and domestic firms, a high rate of growth is expected in innovation-related efforts over the next few years (Economist, 2007). The perception that sustained growth can only be attained through a relentless focus on absorbing, adapting, and developing new technologies, has gained widespread currency both in developed and emerging nations. Countries attempting to sustain or jump start innovation are faced with the question of how best they could do so, given their past history and track record, the nature and quality of their institutions, the existing knowledge in diverse areas, and so on.

It would be no exaggeration to assert that, rather than being a race to the bottom in costs, globalization is fast turning into a race to the top in innovation.

Focus: Innovation in Poland

In this paper, our focus is on innovation in Poland, a country we selected for a few different reasons. Following its liberation from the Soviet Union's tight control, Poland has taken remarkable strides economically, politically, and socially. It is, therefore, of no small interest to investigate whether a similar transformation has occurred in the ability to initiate technological change, and to innovate successfully in order to sustain the rate of economic and social advancement. As a relatively new member of the European Union (EU), Poland stands to gain significantly from free trade with the rest of the EU, as well as from exchange and absorption of vital knowledge. The ability to innovate in products and technologies would only enhance the standing (and prosperity) of one of the larger nations in the 27 member Union. Situated in the heart of the continent, trading extensively with Germany and France, and endowed with a highly literate and well-educated work force, Poland has the potential to become a powerhouse of innovation.

We will commence with our review of Poland's innovation performance by examining the country's actual performance in an industry which is often used as a bellwether of not only innovation and high technology capabilities, but also an indirect measure of productivity – the Information and Communication Technology (ICT) industry. The use of ICT facilitates the innovation process, learning through networking, outsourcing, etc.(OECD, 2004). ICT serves as an enabler of high technology (e.g. biotechnology) research and application. By supporting the development of common IT platforms for use by biotechnology firms, as well as by serving as "toolmaker", or a provider of solutions for common problems, ICT helps spur the rise of high tech, and, for that matter, a broad spectrum of industries (Rochlin, 2006; Cooke, 2002). Investing in ICT, though necessary, is not sufficient for innovative processes and outcomes to be generated. The other building blocks, so to speak, of innovation need to be in place as well. We therefore cast our net wider. After reviewing innovation in ICT, we then study innovation performance in high tech industries as a whole, following this up with available information on society-wide innovation. At all three levels (ICT, high tech, society-wide), we make use of secondary data to tap into direct and surrogate measures of innovation. Drawing on findings from the three sets of data, we then develop a set of broad as well as detailed recommendations aimed at enhancing innovation in Poland.

National Innovation Systems

Over the course of the past few decades nations in the developing world have come, at various points in time, to the realization that in the absence of an ersatz technological capability, they would forever be engaged in a futile game of "catch-up" in which the gap between themselves and developed nations would keep growing. For developed nations, on the other hand, it is imperative that they renew their efforts and abilities in advancing the frontiers of knowledge, both theoretical and applied, in order to sustain economic growth and social well-being. One option is to adopt a strategy of developing technology through centralized guidance and implementation, a form of National Innovation System (NIS). An NIS is comprised of institutions, and the dynamic interactions among them and other elements of society. This serves as a framework for government innovation strategy and actions, aimed at enhancing the development, diffusion, and marketability of new ideas (Lundvall, 1992;Nelson, 1993).

An NIS encompasses a vision of where the country should head technologically, area(s) of expertise/competence envisioned, and a will to allocate resources as needed for implementation (Lall, 2002) The ability to foster greater private initiative in R&D, facilitate the establishment of industry associations and standards, and to nurture appropriate institutions (intellectual property, judicial, science, technology, and entrepreneurial education, sources of finance, etc.) are central to a viable and ongoing NIS for the absorption as much as for the development of innovation. Variants of an NIS have been pursued in Japan (and other Asian countries that sought to emulate it, such as South Korea), and some European nations as well. Though the Japanese NIS was relatively interventionist and directive during the 1970s and 1980s (Johnson, 1993;Okimoto, 1989),the focus later shifted to facilitation(through the establishment of technopolises, university-industry collaboration, etc.), and hence not dissimilar to the system in vogue in Europe(Nishizawa, 2007) In the United States, the approach, historically, has been for the state to avoid excessive involvement in so-called market forces. However, governmental policies and institutions have typically evolved in a direction favorable to innovation. Governmental funding of basic science at universities, incentives to firms in the form of tax relief on R&D expenditures, and to researchers in regard to the income resulting from their work, protection of physical and intellectual property rights, the establishment of regional development agencies, science and technology parks, and so on, have contributed to the evolution of a technology development regime (Young, 2007;Hughes, 2005; Jaunotte and Pain, 2005) intended to buttress and sustain the country’s lead in innovation.

In Finland, after an era of interventionist policies, the government switched to an approach emphasizing facilitation and support through cluster formation. The National Technology Agency directed the implementation of the national strategy (Nauwelaers and Reid, 2002). The focus was on shifting from an economy driven by large resource investments to one based on knowledge and innovation. Strengthening of the higher educational system to create the conditions for cutting edge scientific and applied research bolstered the efforts of domestic firms and attracted foreign companies to Finland as a technology development center. Catalyzing the efforts of government, industry, academia, employees led to an innovation system that has made Finland among the most technologically competitive nations in the world (Hertog and Remoe, 2001).

Ireland, which has recorded dramatic economic growth since its induction into the European Union (EU), has also implemented its version of a National Innovation System. Singapore adopted an even more organized strategy for technology and innovation, based, like Ireland, on FDI, but with the state playing an even more intensively facilitative role. Colleges and universities, research institutes, government departments, transportation, and telecommunication and information infrastructure were upgraded to be aligned with the overall strategy (Mackendrick, Doner, and Haggard, 2000). Countries like Ireland, Finland, and Singapore concentrated on institution-building as well as on, initially, absorbing technology. They realized early on that the quality and magnitude of a nation’s absorptive capacity significantly influences its ability to innovate both by building on existing technologies as well as by “leapfrogging” them.

Local Innovation systems: Clusters

At the other end of the geographic spectrum are localized agglomerations known as clusters, which have been viewed by scholars and policy makers alike as being among the most powerful forces for innovation. Clusters may evolve over time, as did the agglomerations for furniture in North Carolina, automobiles in Detroit, semiconductors, software and biotechnology in Silicon Valley, heavy industry in the Ruhr Valley, and footwear in regions of Italy, to name just a few. (Cooke, 2002; National Governors Association, 2002.) However, the majority of clusters functioning today, especially those in more advanced nations, are designed. Numerous technology parks have been established in the in the United States, South Korea, Taiwan, China, Sweden, India, and other countries, by a range of interested constituents. The initiation and fostering of clusters is done by governments at various levels (local, county, district, state, federal, etc.) development agencies, universities, multinational firms, domestic firms of all sizes, research institutes, venture capitalists, and so on.

The term “cluster” is typically applied to a grouping of organizations within a limited geographic area (one that is small enough to permit personal interaction among the participants) in a specific industry or a shared specialization. The exchange of knowledge, particularly of the tacit sort, is critical to the functioning of clusters, indicating that the members of a cluster must be willing to trust one another with sensitive information. That is, cluster members must be willing to provide resources to others, first, without any fear that it will be used to their detriment, and, second, that it will, in fact, prove to be mutually beneficial. The creation and flow of social capital, which may be defined as a trust based sharing of knowledge, is a hallmark of clusters, one that makes true clusters a relative rarity. Silicon Valley, Oresmund (pharmaceuticals in Sweden), North Carolina’s Research Triangle, Finland’s telecom agglomeration, and Italy’s footwear and tile clusters are instances of clusters rich in social capital. They have also operated rather successfully in terms of durability, value added, robust market linkages, and technology development. (Lundequist and Power, 2002; National Governor’s Association, 2002; Arogyaswamy and Nowak, 2005).

While NISs provide a framework of institutions and strategies for technology development (and absorption), which is of particular importance to large countries with diverse capabilities, traditions, and cultures, innovation often needs to be fostered at the local level as well. Clusters are an effective approach to creating technological capabilities on a limited geographic scale. Paradoxically, in an era of accelerating globalization, considerable advantage appears to accrue to mutually dependent organizations that are located near, and interact frequently and intensively with, one another.

Regional Innovation Systems (RISs)

Regions are spatially more extensive than clusters, have porous boundaries so as to possibly incorporate areas that would otherwise not belong to any collective entity, and may link up with other regions, within the same country or anywhere else in the world. Ohmae (2005) contends that the “region-state” is fast becoming a distinct, viable entity.

RISs are integral to technology policy in Europe, where they are being actively pursued, though not always with consistent or favorable results. Hilpert (2003) refers to the regional concentrations of technological capability, supportive governments, facilitative institutions, market knowledge, and labor competence as Islands of Innovation. These focused centers of competence expand their market horizons to encompass entire countries or continents, or become global in their vision, freely adapting their management practices to their particular needs (Hilpert, 2003). Hilpert identifies 29 Islands, and makes the point that all but three are located in areas that have traditionally been leaders in their field. In a sense, therefore, regional imbalances have either persisted or been exacerbated. One of the outcomes desired by the Lisbon agenda of the EU (Europa, 2006; Bruijn and Lagendijk, 2006) is that the EU as a whole would be the global benchmark for technology development, particularly in regard to the technologies of today by 2010.

The European Regional Development Funds (ERDF) may help in moving in this direction. Through the ERDF, the EU hopes that innovation will be fostered not only in regions that are already strong in this regard, but that new Islands of Innovation will be created. The “stickiness” (Markusen, 1996) of technology is likely to be an impediment to technological catch-up, resulting in the strengthening of already robustly innovative areas. (The disparity between northern and southern Italy, for instance, though slightly diminished remains almost as wide as it was fifty years ago(Governa and Salone, 2005). While the Structural Funds are meant to address local needs and are targeted to projects that will improve human, technological, infrastructural, and other capabilities in areas that lag the most behind the EU average, they amount to little more than 1% of the EU’s budget. The impact on local economies, particularly in a role which requires intensive involvement and staying power, such as those fostering regional innovation, is almost negligible.

As Gruenz (2005), and Kauffman and Wagner(2005) point out, regional innovation, at its core, requires state-level, not supranational, investment. Equally important are stakeholder involvement and a long-term commitment by the regional administration. Of course, supranational coordination might help as they do in the European Research Areas, which bring together innovation centers across the EU (Iammarino, 2005). And structural funds could develop much needed basic facilities particularly in the so-called "cohesion" (recent entrants trying to close the gap with the rest) countries, such as those in Central and Eastern Europe.

Enterprise Innovation Systems

A society may deploy an NIS, RISs, and clusters, or a combination of these, to sustain a high level of innovative capability. However, business firms are the vehicle, so to speak, by which new ideas reach the market, benefit society at large, and create wealth. How effectively corporations create and harness the capabilities that will enable them to be innovative on a sustainable basis could, therefore, be pivotal to the success of any system of innovation. All enterprises, whether for-profit or not, may innovate in any of three areas (or a combination of them): product/service, process, and management (incidentally, the relentless "creative destruction" posited by Schumpeter applies not only to small firms, but also to large corporations and, increasingly, to not-for-profits, educational institutions, and the government (Schramm, 2007)). The familiar S-shaped curve posits that technologies evolve. Initial market approval could spawn alternative forms of the product/service, ultimately coalescing around a dominant design. Competitive pressures lead to a period of ferment helping achieve rapid performance enhancements which, after a period of time, start tailing off (Tushman, Anderson, and O'Reilly, 1997). As the authors observe, S-curves may be extended or truncated by competence-enhancing or competence-destroying innovations.

Competence-enhancement occurs with the development of complementary ideas, much in the way Kuhn(1970) envisioned by way of contributions to "normal" science. Competence-destroying innovations, on the other hand, may be based on entirely different scientific or technological principles, and are analogous to the scientific revolutions that are the focus of Kuhn's(1970) eponymous work. Process innovation, though characteristic of mature products/services, can prove effective in achieving cost reductions, but also in shortened delivery times, greater variety of offerings, and enhanced quality. A company often cited as a glittering example of how to achieve a sustainable advantage through process improvements is Toyota whose lean manufacturing and quality management techniques have helped propel it to a leadership position in its industry. General Electric's deployment of Six Sigma has brought it worldwide success as well, and in the software business firms such as Infosys and Wipro have attained the highest quality certifications possible, thus helping their clients raise productivity and deliver even better service. Interestingly, companies do not have to make a choice between product and process innovation. They can do both. In fact, it now appears as though they must do both. Toyota, GE, Nokia, Samsung, Infosys, and numerous other successful firms have demonstrated the ability to consolidate and enhance the edge enjoyed by existing products while working on new ones. Such firms cultivate a tolerance for ambiguity, a willingness to adopt unconventional approaches to deal with unstructured problems. Kanter (2006), Tushman and O'Reilly (1997) and Hamel (2006), among others, have argued that, in addition to product and process, *managerial* innovation is often crucial to a firm's success. Hamel (2007) asserts that managerial innovation should be accorded the highest priority in any firm, since it determines the philosophy of strategic, product, and operational (that is, competence-enhancing, continuous, or process) that characterizes, and is sanctioned by the organization.

Hamel's contention that innovation has to be an organization-wide responsibility may apply with greater force to certain industries (e.g. consumer products, retailing). However, even in high tech industries such as biotechnology and nanotechnology, without the involvement of a wider cross-section employees than those in the scientific and engineering disciplines, sustained product improvement, market success, and so on, are likely to be jeopardized. Hamel recommends that management innovation be nourished through the devolution of freedom and responsibility to small teams, the cultivation of diversity not merely in physical attributes but in perspectives and interests, and a reliance on free markets for knowledge, both internal and external. Top management also needs to design a critical, flexible balance among, and a flow of, the activities involved in innovation – marketing, operations, design, research, etc. – and in learning. The creation of so called "innovation spaces" or forums and mechanisms, by which the various players involved can come together, and engage in conversations, is central to achieve a harmony in innovation – between continuity and discontinuity, product and process change, and among internal and external players (Lester and Piore,2004).

As the authors emphasize, such innovation spaces are critical to the interfaces within organizations, as well as across industries. For instance, collaboration between radio and telephone was central to the rise of the cell phone business, while interactions between jeans manufacturers such as Levis and laundry equipment firms was instrumental in the development of stone-washing to meet the challenge posed by European fashions. Lester and Piore contend that the analytical, problem-solving approach to innovation needs to be combined with an interpretive system, one in which interaction and mutual adjustment play a central role.

A balance needs to be struck as well between external and internal efforts (Hamel, 2007; Kanter, 2006). Where the knowledge sought involves scientific research – with spillover benefits to other firms – partnering with universities, being embedded in clusters, or regional innovation systems might be the most viable strategy. For technologies that are beyond the capabilities and resources of any single firm (e.g. IBM and Toshiba) to pursue (or the risk is too high) alliances with other firms with similar ends would seem the best option (Doz and Hamel,1998). Some firms depend on vendors for innovation in their respective product/service areas, often sharing knowledge to gain even more knowledge, in an increasingly positive-sum relationship. Just as an outside-inside balance in innovation, fine-tuned as needed, has to be articulated, the extent to which employees are involved has to be consciously formulated and managed. In certain firms, particularly those involved in everyday, consumer products (e.g. Rubbermaid, 3M), there are continuing efforts at innovation dispersed across the firm. In fact, employees are encouraged to take the lead if they see an opportunity worth pursuing. Firms such as IDEO, by enlisting, and serving as catalysts to the efforts of, their clients' teams, assist in the development of offerings finely tuned to the needs of the selected market segments (Kelley, 2004).

Best Buy's new approach to segmentation and its ability to enlist the employees' support have given it a strong competitive position in retail services (Silva, 2005). Procter and Gamble's drive to garner innovations, some of them market-ready, from outside sources, is a noteworthy development in the evolution of corporate innovation.

In industries, in which knowledge development and innovation occur in select, specialist groups (e.g. biotechnology or information technology), firms working near the frontiers of science (with little immediate market application in sight) are likely to be located geographically near a research university/institute and other firms in the same knowledge area, establish alliances, attract funding from the state, and so on (Ackers, 2003; Cooke, 2004; Bastian, 2006). However, even for such organizations, connections to customers (industrial or otherwise) are vital to their continued existence and/or success. The task for management, then, is not so much to determine whether innovation is driven by multiple stakeholders but to constantly adjust and achieve a balance among stakeholder contributions, and by creating the conditions under which they might enter into interactive exchanges with one another e. g. in clusters (Wolfe and Meric, 2004).

Innovation at the corporate level is, therefore, a process of integrating diverse possibilities for change (product, process, managerial), ranging all the way from marginal to radical, with an internal or/and external focus, implemented across an array of activities and a diversity of stakeholders. Innovation in firms may be properly viewed as a system, an Enterprise Innovation System (EIS), consisting of the options and combinations adopted by the firm. Embedded as a business firm often is in various societies, how effectively it adapts to other systems of innovation (National, Regional, Local) could, therefore, in large part relate to how successfully it manages its own EIS. Conversely, the strength of any of the systems articulated in the preceding sections (Local, Regional, National) depends greatly on the innovative capabilities of its business firms.

Poland's performance in ICT innovation

We begin by noting that the country has had a fine education system, at the primary, secondary, and tertiary levels, going back a few hundred years. Scientific learning has always been emphasized, and universities such as the Jagiellonian have been centers of discovery for nearly eight centuries (Davies, 2005). The country has built its solid history of scientific achievement by providing excellent training to its student population in science and engineering. Particularly noteworthy is the fact that Polish school and college students are highly adept in computer related fields and, in fact, regularly win international competitions in programming (Topcoder, 2007). Based on OECD data, the number of science and engineering graduates in proportion to the population compares well with that in the EU as a whole (OECD, 2005). Moreover, employment in the ICT industries, which stands at over 15% of all jobs in the country, is at about the same level as in Spain and Austria, though lagging behind its neighbors Slovakia, the Czech Republic, and Hungary. ICT expenditures as a percentage of GDP place Poland at around the EU average (about 7%).

Other indicators do not place Poland in a very favorable light, however. ICT patents, for instance, are negligible, not even registering perceptibly on the OECD's chart (OECD, 2005). When one compares this to Finland (55%), Ireland (40%), and Hungary (30%), Poland's weak performance on ICT patents (as a percentage of the national total) is placed in stark perspective. Considering that, the number of patents, of all kinds, registered by residents of Poland is itself rather low, the low level of ICT patents seems even more alarming. The share of ICT in value-added in the business sector also appears to be negligible. The picture hardly gets any brighter as one examines other indicators. Research and Development (R&D) in ICT offers us a measure of the magnitude of the investment made in advancing knowledge, and the potential anticipated for growth in the field. As a percentage of total business R&D, Poland spends 12% on ICT, evenly split between manufacturing and service. Compared to Ireland (70%), South Korea (55%) and France (30%), this fraction is rather meager. Even the Czech Republic spends relatively more on R&D in ICT. The scant expenditure by business on R&D as a whole (less than 0.2% of GDP, far below the EU average) makes expenditure on R&D in ICT even more modest (OECD, 2005).

The pattern holds in trade in ICT goods as well, with Poland's total a mere fraction of that of most EU countries about half that of the Czech Republic, and no more than a quarter of Hungary's. Expectedly, then, the overall impact of ICT on the Polish economy as a whole is negligible, in contrast with the impact in the US, Sweden, and Spain where ICT contribute 0.8, 0.7, and 0.5 percent points respectively to GDP. It might be noted here that Poland's economic growth, which is fairly impressive at 5 to 7% per year could become meteoric if ICT were to reach full potential in the country. Piatkowski (2006) contends that Poland's competitive disadvantage in ICT production could be more than offset by the projected contribution of ICT to GDP growth in Poland, which, as we have noted earlier, has been satisfactory. However, as Piatkowski concedes, the potential impact of ICT on GDP may not be fully realized unless ICT is integrated into applied business models, the development of human and social capital, more effective management, and so on. In other words, in the absence of an ongoing program of research in ICT,, solutions customized to Polish needs are unlikely, thereby moderating the impact of ICT on economic growth. Innovativeness in ICT, as we have seen, not only creates and diffuses knowledge within the industry itself, enhancing its competitiveness and ability to offer customized solutions, but also synergizes the advancement of other technologies laterally (e.g. biotech and nanotech), and vertically in functional areas of industries like the automobile, chemical, and so on.

Poland's performance in ICT and other high tech innovation

Clearly, Poland's performance overall in ICT is not encouraging, and given the "multiplier" effect that high tech industries, ICT in particular, have on innovation, corrective action appears to be needed. It might be argued that increasing R&D investment or stimulating foreign direct investment (FDI) in

ICT manufacturing/services could get the growth of ICT jump-started. However, it might be more instructive to look next at high tech innovation (inclusive of ICT), and for this we turn to the Science and Engineering Indicators (2006) published by the National Science Foundation, Later, we will review the European Innovation Scoreboard (2006) to assess the state of innovation in a society-wide sense. The Science and Engineering Indicators (2006) identify four variables deemed to be critical to exporting high technology products, which is an indicator, so to speak, of the ability to win international acceptance for the country's high tech. The variables are National Orientation, Socioeconomic infrastructure, Technological infrastructure, and Productive capacity.

National Orientation reflects the strategies adopted to bring business, the state, academia, research organizations, etc., together in the development and nurturing of high tech industries. The U.S. is the leader on this front, with Israel, Ireland, and the Czech Republic not far behind. Poland is positioned less favorably and is about on par with Hungary and India.

Socioeconomic infrastructure encompasses the human and financial resources needed for high tech development. Poland's standing is somewhat more respectable, being placed at about the same level as Japan and Hungary, though it still lags behind the U.S., Israel, Ireland, and even Malaysia(the latter presumably due to the high foreign investment in high tech in that country.)

Technological infrastructure is measured along five dimensions-the number of scientists in R&D, purchases of data processing equipment, and the ability to(a) provide training in Science and Engineering(S&E), (b) absorb and extend technical knowledge, and (c) bring R&D outputs to the marketplace. Poland's score here is extremely low, well below not only the high-achievers such as the U.S., Japan, China, and Germany, but also ranking behind Brazil, Hungary, and India.

Productive capacity is a composite of the supply of skilled labor, the number of indigenous firms in high tech, the competence of management, and the current level of electronic goods being produced. On this count, Poland's performance is fair, being in the middle of the fifteen countries studied, though it still fares poorly compared to the U.S., Japan, Germany, and China. China's strength in electronics production more than compensated for its deficiency in the other areas. Conversely, Poland's relatively low output of electronic goods appears to be the main factor underlying its score being moderate rather than superior.

When the four elements of high tech export potential are combined, Poland's standing (in 2005) does not seem to be as laggard as the preceding discussion might suggest. With a total score in the neighborhood of 210, Poland ranks only marginally behind Hungary and slightly ahead of Brazil. The gap between Poland and India, the Czech Republic, Ireland, China, and the U.S. has grown progressively larger during the period 1990-2005. The ability to manufacture and export high tech products is reflective both of a country's knowledge base in a particular field, as well as the acceptance of the fruits of this knowledge in the form of products and services by discerning customers with numerous choices. Poland's lackluster performance, therefore, does not bode well for its high tech future.

Overall, the OECD data and the SEI provide some vital pointers on high tech industries, and, in particular, knowledge development in these fields, in Poland. Where employment in, and spending on, ICT are concerned, the country's position is adequate though below the EU average. However, where innovation and developmental work in the ICT sector, and in high tech industries as a whole, are concerned, Poland lags far behind. Its performance in acquiring patents, investing in R&D, engaging in trade, and in adaptation to other industries' needs, appears to be consistently deficient. The SEI offer some insights into why these innovation numbers are alarmingly poor.

One of the main deficiencies identified by the SEI is that the linkages among major institutions (corporations, the state and its agencies, universities, research centers, and so on)are weak. The willingness and ability to conduct R&D and the skills to bring acceptable outcomes to the market are, in part, driven by the intensity and number of such institutional linkages. Risk-propensity, a market system where trust-based transactions are encouraged and enforced, and the availability of capital for high risk, high return ventures also contribute to the flow and stock of innovation. The SEI suggests that a managerial style based on top-down, inflexible approaches need to be moderated as well. Theoretical skills are, no doubt, valuable, but need to be matched by the savvy required to create outputs that will gain market acceptance. Whether the outputs are in the form of products or services is immaterial. What matters is that they be market-tested.

Poland's scores on two (socioeconomic infrastructure and productive capacity) of the four indicators appear to be average, while its performance on national orientation is somewhat less than satisfactory. However, steps to upgrade all three areas would support and enhance the strategies suggested earlier for improving technological infrastructure. Strategies to help enhance performance on the three dimensions might include:

-creating a high-level office to develop a national vision and strategies for innovation
-support for educational institutions in targeted areas of high tech
-fostering institutional linkages(as above)
-offering greater incentives to businesses(domestic and foreign) to invest in ICT R&D
-facilitating a reliable IPR regimen
-underwriting the growth of a venture capital community.

Poland's Societal Innovation Performance and Potential

While the focus of this paper is specifically on innovation in the ICT industry in Poland, it would be unrealistic, even futile, to address this issue without taking note of innovation on a broader, societal scale. Innovation is, at it's core, a social process involving absorption, learning, communication, sharing, and so on. The development, discrimination and acceptance of new ideas in any field is, therefore, at least in part, driven by interactions within that area as well as with other fields. This is particularly true of "apex" technologies, such as biotech and IT, making overall societal innovativeness a significant influence on the development and market success of new technology in ICT.

By the same token, the overall level of innovativeness in any country will have considerable impact on high tech industries including ICT. One of the barometers of innovativeness in the European context is the European Innovation Scoreboard (EIS), which provides a ranking based on data collected on a variety of criteria, of the 27 members of the EU in addition to other nations like Norway, Switzerland, Japan, the U.S., and Turkey (EIS, 2005).
The EIS is comprised of five major dimensions: innovation drivers, knowledge creation, innovation and entrepreneurship, application, and intellectual property. Broadly, these dimensions may be encapsulated as below:

1. Innovation drivers – human and computing / communication resources
2. Knowledge creation – expenditures directed toward innovation
3. Innovation and entrepreneurship – corporate efforts in regard to innovation
4. Application - outcomes of innovation in employment and revenues
5. Intellectual property – new knowledge patented and trademarked

The first three factors are classified as Inputs, and the last two as Outputs in developing the Innovation Scoreboard. Overall, the innovation leaders in Europe are Sweden, Finland, and Switzerland, while countries like Poland, Slovakia, and Bulgaria trail the pack. Though Poland's innovation score improved marginally in 2006 (compared to 2005), a glance at the dimensions on which the scores are based, indicate that certain areas need urgent attention if Poland is not to fall further behind the EU 25. In respect of the five main dimensions, the only category in which the country's performance may be viewed as acceptable is Innovation and Entrepreneurship (40th percentile). In all the other areas, it stands at around the 25th percentile alongside Romania, Bulgaria, Slovakia and so on. Poland's position in knowledge creation and intellectual property are particularly worrisome in the context of high tech (in particular, ICT) potential.

Details of problem areas in societal innovation

In brief, some of the specific components of the five dimensions (the serial numbers and descriptions are taken from the EIS) that appear critical are the following.

Innovation drivers:

1.3 Broadband Penetration, At 5%, Poland lags well behind the EU leaders and is less than one-fifth the EU25 average. Hungary, among its neighbors has a penetration rate over three times that of Poland. Broadband availability and use is an essential element o a modern economy's communication and knowledge development infrastructure. A low penetration rate acts as a brake on technological, market-related, and managerial innovation.

Knowledge creation:

2.1 Public R&D Expenditures. Government expenditure on R&D is 0.43% of GDP in Poland, which is not too far out of line with spending in the EU25 or neighboring countries. Countries like Finland and Sweden are well ahead, but that is only to be expected. However, these efforts do not seem to be directed or linked to application initiatives or at earning a return. To the contrary, the government's contribution could well be a continuation of its lead role in developing new technologies in a Communist society, which could result in "squeezing out" private investment.

2.2 Business R&D Expenditures. The gap in this category is huge in comparison to that in the public sphere. At 0.16% of GDP, Poland ranks behind even Rumania and Turkey. Business R&D intensity in Sweden is over eighteen times that in Poland. Even more alarmingly, business R&D is 40% of Public

R&D in Poland, whereas the EU25 average is almost 2;1. In Sweden, the business to public R&D ratio is nearly 3:1.

2.3 Share of Medium High-Tech and High-Tech R&D: Though Poland's score here almost matches those of the EU15 and other Central and East European nations, the fact that business R&D is so miniscule means that proportionately less goes to medium/high-tech R&D.

2.4 Enterprises Receiving Public Funding for Innovation. This measures the number of innovative enterprises that receive public funding as a percentage of the total number receiving such support. Admittedly, the identification of "innovative enterprises" leaves some room for errors in interpretation. However, skepticism of the results in this dimension (as, indeed, in any of the others) ought to be tempered by the realization that the bias, if any, is likely to be uniform across countries and, hence, is not a serious flaw. Poland's score is the very lowest among all the countries surveyed and seems to indicate an inability to identify innovative (or potentially innovative firms), an unwillingness to fund them, and/or a minimal emphasis on fostering innovation.

2.5 University R&D Funded by Business. Interestingly, Poland (6%) ranks near the EU25 average and well above most of the innovation leaders, (presumably the preponderance of high tech business R&D in the latter nations might necessitate less of an investment in R&D by business in academia). However, in the case of countries like Poland, where high tech R&D is not highly funded, one explanation for the rather high level of funding by business/university R&D might be that businesses are reluctant to commit themselves to a continuing investment in R&D, and would rather utilize existing resources (even if the latter are not tailored to meet their specific market needs.).

Innovation and entrepreneurship:

3.1 SMEs Innovating in-house. Poland's score of 12.5% ranks well below that of the Czech Republic, and far behind leading countries like Sweden, Germany and Switzerland. The explanation for the lag in this category might lie in an unwillingness, inability (e.g. due to lack of sufficient financial or suitable human resources), or the lack of a need (e.g. an undemanding market) to innovate.

3.2 Innovative SMEs Cooperating with Others. Given the resource crunch most SMEs face, in terms of people, equipment, systems, and funding, it is increasingly recognized that SMEs collaborating with one another and with other institutions (e.g. universities) have a far better chance of innovating successfully. Even by this measure, Poland lags behind countries like Hungary and Denmark where SMEs are four times and twice as collaborative respectively. Since SMEs which are innovative are likely to become even more effective through collaboration, multiplying the numbers for 3.1 and 3.2 might provide a useful indicator of overall SME innovativeness. The results are shown in next page.

Clearly, Poland's performance is poor in the SME area while Hungary appears to be doing remarkably well contributing, perhaps, to its ability to "catch up". Countries like Finland, Denmark, and Sweden are positioned where one would expect them to be.

3.3 Innovation Expenditures. At 2.25%, Poland ranks alongside the leading countries. This measure tracks overall expenditures including R&D as well as training, marketing, license fees, etc., as a percentage of the firms' total revenues. Considering that R&D expenditures in Poland are at the lower extreme of the EU25, the favorable position on innovation expenditures is rather intriguing. One explanation might be that companies in Poland (both foreign and domestic) tend to allocate resources to training employees in the use of products/ services developed in other firms and/or countries, on marketing (promotion, channel improvement, etc.), in paying for licensing, and so on, rather than for conducting research and developing new products and services.

3.4 Early Stage Venture Capital. Funding available for high growth ventures (as a percentage of GDP) stands at 0.007% which is about a quarter of the EU25 mean and no more than a fraction of the amount available in countries like Denmark, France, and the UK.

3.5 ICT Expenditures. Poland's record in terms of spending on software, office and computing equipment, etc., is on par with the EU average. The numbers are, remarkably, almost uniform across the EU, suggesting that the impact of ICT on productivity is well understood, and implemented. This resonates with Piatkowski's (2006) thesis that organizations in Poland are adept at using ICTs to enhance productivity.

Table1: Composite of SMEs innovating and collaborating

C Czech	**nD Denmark**	**HHungary**	**Po Poland**	**SlovS Slovakia**	**Fi Finland**	**S Sweden**	**S Switzerland**
120	420	430	100	60	450	460	550

Application:

4.1 Employment in High Tech services. Again, data for Poland are missing, but information provided by the Science and Engineering Indicators (2006) indicate that R&D expenditure in ICT constitutes 6.9% and 5.1% corresponding figures for Finland (53.1, 11.2), Ireland (42.8, 27.6), Sweden (28.6, 4.1), and France (21.0, 9.6) making it clear that Poland has much ground to make up in this area.

4.2 Exports of High Technology Products. Only 2.7% of Poland's exports consist of high tech products, a proportion that is the lowest in the EU. Countries like Lithuania and Italy have an export ratio ten times as high.

4.3 Sales of New-to-Market Products. Poland's position is far short of the EU leaders, but places around the middle of the pack.

4.4 Sales of New-to-Firm. Though again well shy of the pace set by the leaders, Poland (9.6%) is again around the median for the EU25.

4.5 Employment in Medium/High Tech Manufacturing. In Poland, around 4.5% of manufacturing workers fall into this segment, a proportion that seems consistently lower than that in most other EU nations. The statistic reinforces the image of a nation whose capabilities in high technology need to be bolstered.

Intellectual property:

5.1 EPO Patents per Million Population. Poland, with 2.7 patents filed (with the European Patent Office) per million people is almost at the bottom of the scale, ranking far below FI (310.9), se (311.5), DE (301.0), and IE (89.9).

5.4 Community Trademarks Per Million. Though the scores are somewhat better relatively than in the patent categories, Poland is still an order of magnitude short of the EU leaders in registering distinctive signs which constitute product identities, so to speak.

5.5 Community Industrial Designs Per Million Population. Poland's performance in regard to new product styling/appearance is lower than in trademarks – about 5% of the level of the EU25 mean. PL's innovations in product styling and appearance also, therefore, could do with considerable improvement.

In addition to the above five major dimensions, the EIS(2005) identifies another element in the assessment of innovation at the national level- the demand for innovation in society at large. The EIS provides this data by measuring the percentage of a country's population in each of four categories-enthusiastic, attracted, reluctant, and opposed to innovation. The E U 25 average has the population evenly split between the supporting, that is, first two- categories and the opposing categories, Poland's standing is predominantly in the category skeptical of innovation, with about 65% of the population sharing this attitude.

Though consumer demand for innovation does not necessarily have a direct impact on the decisions corporations make in regard to investment in R&D, employee hiring and training, management styles, and so on, it would appear that Poland faces significant challenges both in terms of the supply of, and demand for, innovation. However, as the EIS notes, the demand factor may be viewed as a moderating variable in the conversion of innovation inputs to outputs. According to this perspective, Poland's low score on demand for innovation may be attributable, in part, to its low capabilities in the innovation outputs (application of knowledge to satisfy market needs, and the creation of new intellectual property e.g. patents) which lowers expectations and supports demand. An enhanced competence in providing more inputs for successful ideas is critical to raising innovation's supply and, thereafter, its demand trajectory.

Findings

A review of the areas in which Poland lags behind its EU peers in regard to innovations indicates some rather broad patterns. R&D expenditures, SME involvement and performance, and application of knowledge to market needs (particularly in high tech fields) seem the most salient issues.

We summarize below some of our findings from the three sets of data examined, organized by level (NIS, RIS, LIS, CIS) of innovation system involved. We have also indicated the level at which remedial action would be most effective. Action on multiple levels is, of course, often needed to address most issues, a point reinforced in Fig. 1. It may be noted that the OECD data and the EIS identify specific areas that need addressing, while the SEI are more broad-based in their assessment. We, therefore, start with the SEI and then proceed to analyze findings from OECD and the EIS.

Fig. 1: Findings from three sets of data.

		NIS	RIS	LIS	CIS
A.	**OECD**				
1.	ICT patents, total patents	X		X	X
2.	R&D in ICT (% of total R&D)	X		X	X
3.	Trade in ICT goods	X			X
B.	**SEI**				
1.	Vision and strategy	X			
2.	Scientists in R&D		X		
X					
3.	Absorb and extend technical knowledge	X	X		
4.	Indigenous firms in high tech	X			X
C.	**EIS**				
1.	Broadband infrastructure	X			
2.	Government R&D	X			
3.	Business R&D	X	X	X	X
4.	Innovative enterprises receiving funding	X	X		
5.	SMEs-innovating, collaborating		X	X	
6.	Venture capital support	X		X	

Starting with the more general findings, a broad vision of the country’s position on technology and innovation needs to be articulated B.1). It might be most effective to entrust Innovation Policy to a single agency (as was done in Finland), which is charged with developing such an overarching vision. For instance, this entity would clarify the role of the government in innovation, the strategies adopted, and the resources available for its actions. Whether the country should focus on a particular technology (ICT, nanotech., etc), the expected role of foreign investment in innovative enterprise, and other such decisions, would be part of the vision formulation. The ability to recognize and acquire valuable knowledge is a dimension of absorptive capacity B.3) and, as Uotila, Harmaakorpi, Melkas have shown regional and national authorities have a leading role to play in building absorptive capacity. National policy on stimulating the transfer of developments from universities and research institutes, as well as, enabling indigenous firms to learn from multinationals are areas in which national actions would help. At the regional level, the ability to identify unique opportunities and to leverage existing capabilities to act on them help spur greater absorptive capacity. Such actions would also enhance the effectiveness of domestic firms, while possibly drawing more innovative firms into the industry (B.4). An equally fruitful angle to pursue would be for regions to benchmark themselves against competitive regions with a similar specialization in Western Europe.

The southern region of Poland, for instance, in its attempt to achieve a competitive position in organic fruits and vegetables, might benefit from studying the strategies of similar regions in Holland, Belgium, and other exemplary areas, as well as by establishing communications with them. The Innovating Regions in Europe (IRE) network, created by the European Commission (EC), has, since the mid-1990s, has attempted to facilitate the exchange of ideas and best practice among regions in Europe. The intent is to foster the development of effective and competitive regional strategies. The IRE secretariat helps in coordinated learning. Strategy projects are undertaken with the assistance of the EC, and outcome assessment is conducted to determine achievement of benchmarks (IRE, 2007).

Techniques such as the Regional Development Platform Method (RDPM) could prove valuable insights in identifying areas of expertise that would result in the greatest potential benefit to a region (Harmaakorpi, 2006). The RDPM provides guidance and support in developing a portfolio of core capabilities and aligning them with the broad trends and resultant market opportunities. Applied to the Lahti region of Finland, where educational levels and research efforts fell far short of the national average, the RDPM was instrumental in identifying an array of fields (plastics, environment, furniture, media, etc.) from which informed choices, employing criteria specified in the RDPM, were made.

In regard to the number of scientists in R&D (B.2), this can be addressed better by acting on some of the elements that emerge from the EIS. For instance, by providing more incentives for conducting R&D e.g. tax breaks for business, fewer restrictions on scientists profiting from their ideas, etc.), the level of business R&D (C.3) might be enhanced at the NIS level. However, regional and local authorities may also act to establish regional centers and clusters in areas such as ICT to serve as centers of excellence, and to develop “toolboxes” for other industries such as nanotechnology. Establishing an ICT cluster near existing areas of capability such as the aircraft grouping in the south of Poland or a nanotech center near an organic farming area (e.g. to help monitor crop growth and quality) would help leverage emerging or traditional competence to high tech innovation. Reducing the level of government expenditure on R&D would send a signal to firms and regional authorities that they need to act, while freeing up some funds for investing in clusters and coordinating the strategies of SMEs (C.5, C.6). Working with EU initiatives such as the ERAs, IREs, and others mentioned earlier could be instrumental in getting the SME advancement program off the ground at the regional and local levels. While venture capital seed money is useful, in the absence of a groundswell of innovation, such funding beyond the minimum level may be premature (C.6). Given its significance in communication, making broadband widely available (C.1) is a high priority, and the use of FP7 funds as well as any Structural Funds available is likely to pay dividends.

Addressing the concerns surfaced by the SEI and EIS will go toward dealing with the deficiencies identified in the OECD data. The development of active RISs and LISs based on a vision and set of strategies implemented as part of an NIS, and the cultivation of firms with innovative potential, will go a long way toward creating greater innovative capabilities in ICT coupled with an enhanced ability to manufacture ICT equipment competitively (A.1,A.2,A.3).

Conclusion

Strategic thinkers and decision-makers at corporations, policy makers in many countries, and opinion leaders at influential organizations such as the OECD, EU, and the Council for Competitiveness have asserted in various forums that innovation is the key to the more rapid rise of emerging nations and the continued prosperity of developed countries. At the national level (and where applicable, by extension, at the regional and local levels), innovation is a top priority for governments across the world. We have attempted to lay out a model for innovation and apply it to explicating how a country such as Poland might identify and address its deficiencies in innovation at different levels in order to sustain its pace of economic growth. Considering Poland's relative position in regard to innovation in the EU, we suggest that all four approaches need to be deployed so as to initiate innovativeness in different sectors of society simultaneously. Given ICT's role as a lead technology for the development of other high tech industries as well as in fostering innovation across society, the establishment of clusters for ICT-related industries in areas where centers of knowledge creation and application in this field exist would be a first step to building greater depth in this field.

Developing regions of competence around possible user industries such as aircraft and organic farming would go hand in hand with the cluster strategy. The National Center for Research and Development in Poland (Gorecka, 2007) appears to have some laudable projects in mind, such as a contest to determine which strategic direction in innovation will be funded. However, the program seems to be top-down and does not envision the dispersion of innovation regionally and through collaboration among various institutions. That Poland is taking the issue of innovation seriously is borne out by the fact that the recently elected Prime Minister, Mr. Donald Tusk, at his first press conference, stressed the need for Poland to become an innovative society, and declared that the country would do so in rather short order. Since the first author of this paper had made a presentation at a conference on Innovation in Warsaw just prior to the Prime Minister's speech, the local business paper interviewed the author and reported in its lead article that the reality of innovation in Poland was very different from the one proposed by the Prime Minister (Warsaw Business Journal, 2007). While countries all over the world are convinced that their future is linked to their innovative ability, they appear to emphasize national policy, corporate strategy, or regional development, often focusing on one approach to the exclusion of the others. We have argued here that innovation occurs on multiple levels, within a System of systems, so to speak, and we offer a framework to better understand and implement the process in all it complexity.

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