Understanding Immigration in a National Systems of Innovation Framework

Revised for submission to *Science and Public Policy*
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Abstract

This paper argues that the systems of innovation analytic framework affords valuable insights into the impact of highly-skilled immigrants on innovation processes in developed countries. The paper first reviews why highly-skilled migration has risen on the agenda of policy-makers and researchers and sets forth my interpretation of the systems of innovation framework. It then builds on this interpretation by arguing that the interaction between immigrants on the one hand, and the organizations and institutions into which they are inserted by a national system on the other, can (under some circumstances) affect the system's capacity for innovation by changing transaction costs and the management of uncertainty. Although it tackles just one aspect of the complex puzzle presented by global flows of skilled people, the paper prepares the conceptual ground for a broader assault on this important issue.

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Introduction

International migration of talented people, especially those who have skills integral to technological innovation, is a subject of rising interest among public policy-makers. A growing body of scholarship highlights human capital as a critical factor – perhaps the critical factor (Florida 2005) – for effective competition in knowledge-intensive industries. Because the talent pool is limited in the short run, nations have strong incentives to expand it through immigration. As a result, Desai, Kapur, and McHale (2002, 1) suggest, "cross-border flows of human capital are likely to play an equally influential role in shaping the political and economic landscape of the next fifty years" as financial capital did in the past fifty years.

The change in policy practice is already evident. More nations are "trolling for brains in international waters" (Glanz 2001) than ever before, including some that had virtually no high-technology industry a quarter century ago. A diverse set of nations, including high-, middle-, and even low-income countries, now dangle attractive packages in front of highly-skilled individuals whom they hope to recruit. These packages may include income supplements, tax breaks, housing allowances, and other pecuniary rewards, along with privileged immigration status. (OECD 2005, 134) As a result, more highly skilled people are traveling in more directions than ever before.

Research on the innovation process and related policies has not yet caught up with this change in practice. Bengt-Ake Lundvall, for instance, noted in a recent paper with colleagues (Lundvall et al 2002) that scholars studying systems of innovation (SI) have neglected questions related to human resources in general. Therein lies an opportunity. This paper takes a modest first step in establishing the utility of the analytic framework developed by SI scholars for the study of migration. My main claim is that SI affords valuable insights into the impact of *immigration* on innovation processes in *high-income* countries. Although I therefore tackle just one aspect of the complex puzzle presented by global flows of skilled people, the paper prepares the ground for a broader assault by specifying and applying general SI concepts.

The first section of the paper briefly reviews the history of the highly skilled migration (HSM) issue and shows why it has taken on new weight in recent years. The second section sets forth my interpretation of the SI approach, which emphasizes the impact of organizations and institutions on uncertainty and transaction costs in the innovation process. The third section adapts the ideas laid out in the second section and applies them to immigration. It argues that the organizations and institutions into which highly-skilled immigrants are inserted by national systems shape their contributions to innovation in the receiving country. These organizations and institutions, and thus the resulting innovative capacities, vary considerably across nations. The paper concludes with a consideration of the implications of the argument for policy-makers and researchers.

International Migration and the Innovation Policy Agenda

International migration of individuals knowledgeable in science and engineering, and those skilled at managing them, has long been important in shaping the innovative capacities of nations. Diamond (1997, 256) draws attention to the movement of people as a means of transferring knowledge throughout human history, such as the Arab acquisition of paper-making from Chinese prisoners of war in the 8th century. Nearer to the present day, U.S. industrialization was accelerated by immigrants who brought with them ideas from leading powers. The English mechanic Samuel Slater, for instance, jumpstarted textile manufacturing in the New World not long after the U.S. won its independence. A century and a half later, in the aftermath of World War II, the U.S. captured and subsequently employed many top German scientists, including V-2 rocket inventor Wernher von Braun, who led the American space program in the 1950s.

The term "brain drain" first appeared in 1963. (*OED*) Although it initially referred to British scientists and technologists who sought work in the U.S., within a decade it came to evoke HSM from the "third world" to the "first world." The relaxation of "racial elements" and the insertion of preferences for skilled migrants in the immigration laws of Australia, Britain, Canada, and the U.S. led to a "great spurt" of HSM, as Jagdish Bhagwati (1976, 6) put it, in this period. In addition, western countries' outreach to foreign students, motivated in part by a desire to spread political values and enable development upon the students' return, instead carved a new pathway for many highly-skilled immigrants who were permitted to stay after completing their degrees.

Policy-makers and scholars disagreed not only about what to do in response to these developments, but about whether they constituted a problem at all. Bhagwati (1976), for instance, proposed that emigrants be taxed to compensate sending countries for the educational investments that they had taken with them. Harry Johnson (1968, 73), by contrast, suggested that the new flow served as a "natural safety valve" and emphasized that world welfare almost surely expanded when talented people from developing countries were matched up with complementary assets in the west.

Although the "brain drain" remained an important concern in many sending countries, international dialogue on the issue stagnated. In the 1980s and 1990s, human capital issues were superseded in discussions about international economic competition by other inputs to innovation, such as intellectual property and foreign direct investment. During this period, however, new conditions were being created that would alter the terms of the "brain drain" debate and thrust it back into view in the receiving countries as well as the sending countries by the early 2000s.

In the high-income economies, demand for science- and technology-related skills grew steadily in the late decades of the twentieth century. The infusion of information technology into older industries automated many tasks previously performed by unskilled and semi-skilled workers, while offering greater opportunities for designers, engineers, programmers, and the like. (Acemoglu 2002) The high-technology industries were themselves important users of skills as well as key sources of growth. Public policies that aimed to upgrade older industries and those that sought to expand newer ones contributed to the growth in the demand for skills.

While public policies accelerated the structural shift toward high-skill work, many policy-makers perceived that the supply of sufficiently skilled natives did not keep pace with demand. In a recent report, for example, a committee of the U.S. National Academy

of Sciences (2005) found major shortcomings in the country's education system, leaving a skills "pipeline" that was dangerously leaky. Although such claims have not necessarily been corroborated by economic data (Teitelbaum 2003, Freeman 2005), powerful interests mobilized behind the idea that immigration laws should be liberalized to fill the perceived leaks. Australia and Canada thus modified their "point" systems to provide more preferential access to highly-skilled immigrants, while the U.S., the U.K., and Germany (among others) created or expanded programs that allowed temporary entrance to foreigners with desirable skill sets and experience. (Kapur and McHale 2005, ch. 3)

Newly industrialized and transitional countries also added to the global demand for the highly skilled. The four Asian "tigers," for example, followed the Japanese example, climbing the development ladder in the 1980s and 1990s by pouring resources into technologically sophisticated sectors. To staff these ventures, they not only invested in educating their own populations, but also provided incentives for "brains" who had previously been "drained" to return home. Students from these countries who might have stayed abroad after completing their degrees in decades past more often found attractive employment opportunities in their native lands in recent years.

The successes of these small countries were striking, but it was the apparent entry of China and India onto similar paths of development that prompted the biggest burst of interest in HSM among policy-makers in the high-income countries. The immense populations of these two nations and their potential to concentrate resources on national projects, coupled with rapidly dropping communication costs, led them to be viewed as major new competitors in high-technology sectors. (Lynn and Salzman 2004) The Chinese and Indian diasporas have played important, albeit differing roles, in the rapid economic growth experienced by the two countries. Chinese and Indian students still stock the science and engineering departments of western universities, but may soon find opportunities to return home as attractive as those confronting their Taiwanese and Koreans counterparts. (Larsen and Vincent-Lancrin 2003, Saxenian 2006)[1]

These long-term trends underlie the new "global war for talent." Demand is strong and rising; supply, uncertain and unevenly distributed. The terrorist attacks of September 11, 2001 introduced an additional complication, at least for the short-term. In the immediate aftermath of the attacks, the U.S. made it more difficult for students and skilled workers to gain entry and to find satisfying work. Some of these difficulties have now been relieved, but the country's image has been damaged, and it will likely face continuing challenges in the future. Competitors around the world, in other receiving countries and in sending countries as well, have sought to take advantage of this rare opening to shift migration flows away from the dominant power and to retain talented people who might otherwise be tempted to migrate.

The Systems of Innovation Approach

The elevation of HSM on the global innovation policy agenda has not yet been fully matched in the innovation policy research community. The systems of innovation (SI) approach provides a general, flexible framework for understanding success and failure in international economic and technological competition. In this section, I lay out

[1] Fuller reviews of the new literature on brain "drain," brain "circulation," and brain "strain" include Commander et al. (2003), Lowell et al. (2004), Kapur and McHale (2005), and Ozden and Schiff (2006).

some basic tenets of SI in order to adapt and extend the framework for the analysis of HSM in the following section.[2]

One way to begin to lay out these tenets is to position SI relative to a major competing approach, the knowledge (or ideas) production function (Griliches 1986; Furman, Porter, and Stern 2002; Chellaraj, Maskus, and Mattoo 2006). This approach treats innovative outputs (often operationalized as patents) as a function of inputs to the innovation process, such as investments in intellectual capital (R&D spending) and human capital (education level). The parameters estimated for the function give researchers a sense of how a marginal change in any input can be expected to affect the output. These parameters are taken to be fixed, representing durable relationships within the units being studied, such as nations, regions, or firms.

Scholars who adopt the SI approach seek to move beyond accounting for inputs into the innovation process and extrapolating outputs from them. They argue that the effectiveness with which inputs are translated into outputs depends fundamentally on the organizational and institutional contexts within which the innovation process is embedded. SI interprets the parameters in the knowledge production function approach as embodying these contexts. They should not be assumed to be fixed, this school argues, since organizations and institutions can change. Changes in innovative inputs are linked to changes in innovative outputs much less deterministically than the knowledge production function approach assumes.

In using the terms "organizations" and "institutions," I adopt the conventions established by Douglass C. North (1994). "Organizations" includes economic units, such as firms, that undertake market transactions externally but rely primarily on non-market means (command, norms, rules, etc.) to mediate exchanges internally. "Institutions" encompasses the rules, rule-making processes, and enforcement that undergird all forms of exchange, including market transactions, whether fixed formally in law or established informally as norms.

Economic theory provides strong reasons to believe that organizations and institutions have a profound influence on the innovation process.[3] Innovation is intrinsically uncertain, with respect to what is technically possible, what markets will pay for, who will benefit, and when they might do so. Such uncertainties deter investment under market conditions by reducing the expected return. Organizations and institutions can reduce (but not eliminate) uncertainty. For instance, financial organizations that permit investors to spread their investments across many "economic experiments" allow the majority of failures in such experiments to be offset by the occasional successes. This portfolio approach increases aggregate investment and thus innovative activity. (Rosenberg 1994)

High transaction costs also hamper innovation processes mediated only by markets. Uncertainty contributes significantly to these costs. Another contributor is the difficulty of exchanging information of known value to the innovator. This information cannot be revealed before a market exchange, since the recipient might simply abscond with it; yet, without revelation, it may be impossible to agree on a price for the exchange.

[2] The founding texts in this tradition include Dosi (1988), Lundvall (1992), and Nelson (1993). The interpretation here draws on these and many subsequent works, but it is my own, bearing in mind the admonitions of Edquist (2004).

[3] This section draws on Lundvall (1998) and Edquist (2004).

Institutions like trade secrecy and intellectual property law serve to lower these and other transaction costs. Management techniques that facilitate teamwork and trust may have similar consequences within organizations by lowering the risk and raising the reward for production workers who offer innovative ideas

The SI approach, then, seeks to understand how organizations and institutions affect innovation and how they change, emphasizing the limits of markets for organizing innovation processes. SI claims a kinship with the management of innovation, a discipline that seeks to comprehend the impact of one type of organization on innovation. (There are deep links especially between SI and the "resource-based view" (RBV) of the firm within strategic management, because of the RBV's emphasis on institutions within the firm.) SI scholars, however, concentrate their attention on *interactions* among organizations and institutions as they relate to innovation and on how such interactions constitute "systems" that produce distinctive patterns of outputs. Researchers have identified innovation systems at a variety of analytical levels, from local to global geographically and from narrow specializations to broad industrial groups technologically.

The national system of innovation (NSI) is the level of analysis that has drawn the most scholarly attention. (Lundvall 1992, Nelson 1993) This focus is in part a matter of convenience, since most statistics are gathered at this level and national research funding agencies take a particular interest in it. Yet, there are also strong theoretical justifications for studying nations. National governments are the primary law-making bodies in most societies, and they often exercise great leverage over social norms as well. These national institutions deeply imprint private organizations centrally involved in the innovation process, such as universities and corporations. Moreover, national governments are themselves composed of organizations, some of which may be engaged in innovation-related activities. (Hart 2002)

Economic interdependence has recently reduced the autonomy of governments and produced some institutional convergence across borders. The TRIPS agreement, for instance, harmonizes intellectual property laws that once distinguished NSIs from one another more sharply. The death of the state, however, has been greatly exaggerated. (Archibugi, Howells, and Michie 1999) Transnational flows of people, in particular, remain within the domain of state sovereignty, far less deeply affected by global governance than international flows of goods, capital, and even information.

One major stream of SI research contrasts Japan and the U.S. over the past quarter-century and will serve to illustrate some of the approach's core concepts. Indeed, Christopher Freeman's (1988) seminal theoretical work in the field was motivated by the empirical divergence in the relationship between inputs and outputs between these two NSIs. The U.S. spent much more money on R&D than Japan, yet Japan seemed to be innovating more effectively. Freeman and those who followed in his footsteps argued that institutions explained the difference. Major Japanese firms tended to have long-term relationships with workers, suppliers, and funders, which were embedded in both law and culture. Japanese production workers, for instance, contributed important ideas to process innovation and were able to implement quality control techniques that managers elsewhere thought were too difficult to implement. (Lazonick 1991) In addition, the Japanese government helped to coordinate knowledge-sharing among firms that were otherwise fierce competitors. Taken together, these institutions systematically lowered

the transaction costs of industrial innovation and allowed firms in such sectors as electronics and automobiles to move rapidly down established technological trajectories.

The reversal of fortunes between the U.S. and Japan in the 1990s posed new challenges for SI researchers. One plausible explanation for it focuses on shifting technological opportunities and the ways that the two systems manage uncertainty. In contrast to the highly coordinated Japanese system of innovation, the U.S. system of innovation is pluralistic and competitive. University researchers and entrepreneurial firms seeking financial support may approach an array of potential patrons who utilize diverse criteria for making investments. By disrupting established technological trajectories, the commercialization of the Internet heightened uncertainty about which investments would be the most fruitful, thus making pluralism and the resulting broad portfolio of innovation projects advantageous to the U.S.[4] In addition, American institutions accommodated a rapid ramp-up of resources devoted to innovation during the technology boom. Although massively inefficient, the system was nonetheless effective in creating a first-mover advantage for some of the leading firms and sectors of the "new economy."

This brief treatment of Japan and the U.S. points to a final distinguishing feature of the SI approach. Institutional change tends to be evolutionary and satisficing; the analyst should not assume that institutions exist because they minimize transaction costs or optimize some other variable of interest. (Nelson and Nelson 2002) Both the U.S. and Japan have sought to learn from one another in recent decades and to innovate institutionally on the basis of what they have learned. The U.S., for instance, passed legislation lowering the antitrust risk for competing firms that want to conduct collaborative R&D; Japan, similarly, has devised funding mechanisms for academic researchers that rely more heavily on competitive peer review. Yet, neither of these moves have fundamentally transformed either NSI, nor is it clear that they are even accomplishing the purposes their advocates laid out for them. This relative stability reflects the systemic quality of institutional interactions; institutions are highly interdependent and have co-evolved such that they typically dampen change.

SI Applied To Immigration: Immigrants May Be More than "Human Capital"

Talented immigrants are undoubtedly important inputs into innovation processes. How much they contribute depends, according to SI, on their interactions with their new organizational and institutional contexts.[5] These contexts can be organized into a spectrum for theoretical purposes. At the "assimilation" pole of the spectrum, immigrants' contributions to innovation can be expected to roughly equal those of comparably skilled natives. At the "enclave" pole, these contributions depend on organizations and institutions that are distinctive to the immigrant communities in which they participate. In between, "multicultural" contexts may amplify the contributions of immigrants beyond either pole, producing organizational and institutional as well as technological innovation; however, such a result is not at all a certainty.

[4] This interpretation builds on Ergas's (1987) distinction between "shifting" and "deepening."

[5] It may be worth noting that a similar analysis might be applied to the contributions to innovation of workers in general. Organizations and institutions may encourage and reward or discourage such contributions with important consequences for firms and nations. For such an approach, see Whitley (2003).

Flows of immigrants vary in their skills and capacities across nations and over time. Gross variations are obviously consequential for national innovative outputs. If one nation receives unskilled workers who are fit to employ only in manual, low-wage positions, while another receives an equal number of immigrants with tertiary education and experience in science, engineering, and management, the latter nation will surely improve its performance in the long run relative to the former. HSM to Israel from the former Soviet Union in the 1990s, for instance, may be compared in this manner to low-skill immigration to most Gulf oil states in the same period Such variations can be accommodated rather easily in a knowledge production function framework. The value for the human capital term in the latter country's function is raised, just as the knowledge capital term would be raised if R&D spending rose.

This line of analysis is not incompatible with the SI approach, but SI does not add any special value to the analysis of gross variations in inputs. A more revealing case for purposes of exposition involves two countries that receive equal numbers of similarly skilled immigrants. A knowledge production function approach would predict that outputs would expand in both countries as determined by the parameters on their respective human capital variables. The SI approach opens the possibility that changes in inputs could lead to changes in the parameters. The innovative outputs of the two countries, then, might vary significantly from the predictions of the original knowledge production functions and from one another. Such a result depends on variation in the interactions between immigrants in each country and the organizations and institutions in which they become embedded, and especially on variation in the institutional and organizational changes they provoke.

At the assimilation end of the spectrum, HSM does not affect the knowledge production function. Interactions between immigrants and the organizations and institutions that comprise the national innovation system are the same as those experienced by comparably educated and experienced native-born workers. Immigrants "melt" into the "pot," to use the common American metaphor. They sever ties with their countries of origin and rapidly learn the folkways of their new home. They may in fact be more enthusiastic about these folkways than most natives, echoing the religious zeal of the newly converted. Ideally, teachers, colleagues, employers, customers and others with whom immigrants engage during the innovation process treat them as they would native-born citizens in comparable roles.

Assimilation depends on both the immigrant and the system. Student immigrants are likely to be more capable of fully assimilating than their older counterparts. Other things equal, national innovation systems that receive a high proportion of immigrants who arrive initially as students are less likely to experience organizational and institutional change than those in which most immigrants have already completed school. However, systems of innovation may vary in how they treat immigrants, regardless of the immigrants' desire and ability to assimilate. Some systems have institutions dedicated to facilitating assimilation, while others may accommodate or even enforce ethnic and cultural differences. If immigrants seek and are capable of assimilation and the system accommodates this desire, HSM will affect neither the system's capacity to manage uncertainty nor alter the transaction costs shaping the exchange of ideas.

At the "enclave" end of the spectrum, immigrant communities erect separate organizations and institutions that govern their activities and their interactions with the

wider world. New arrivals are incorporated into these enclaves, rather than assimilated into the dominant culture and its institutions and practices. The state may even delegate formal authority to community institutions. Enclaves may characterize all immigrant communities (as in the Austro-Hungarian Empire) or only particular ones, whether as a result of their weakness or perceived difference (as in the case of European Jews before the nineteenth century) or precisely because of their size and strength (like recent Russian immigrants to Israel or Cuban immigrants to Miami, Florida in the U.S.).

Enclaves are likely to use highly skilled immigrants in ways that are different than the ways that the national innovation system uses highly skilled natives. They may mimic the organizations and institutions of the sending countries or even be extensions of them. Chinese immigrants in southeast Asia, for example, historically maintained business practices and networks more like those in the sending country than those of the receiving country. On the other hand, the surrounding society may close off educational and economic opportunities, wasting the human capital of immigrants in isolated ghettos. The Jewish experience in eastern Europe in the nineteenth century illustrates this sort of exclusion (although it must be admitted that some in the Jewish community preferred isolation to assimilation).

In principle, the contemporary liberal state eschews ethnic enclaves; all citizens are supposed to be equal before the law and in society. As a result, it is difficult to imagine full-fledged enclave versions of many of the key institutions of innovation existing within such states, such as universities and intellectual property regimes. Exclusion, of course, remains a possibility; that has been the fate of many "guest workers" in western Europe in the present and recent past. A careful examination of national institutions may reveal hidden within them informal ethnic enclaves that shape, for example, students' learning experiences and social networks within which ideas are shared at low cost.

Between the assimilation and enclave ideal types on the spectrum of innovation contexts lie multicultural settings in which immigrants have opportunities to participate in the mainstream institutions of society without dissociating themselves entirely from their native milieu. As Zachary (2003) puts it, such immigrants can acquire "wings" without losing their "roots." Over time, the interactions among "wings" and "roots" may change the structure of transaction costs and the management of uncertainty within the innovation system.

Transaction costs between the immigrant's country of origin and her new home are the most directly affected. The immigrant may help to reduce, for instance, the cost of finding commercial or technical collaborators across borders. She may also lower the communication costs within such collaborations as a result of her familiarity with the cultures involved. For example, Indian-Americans have played these roles in recent years in helping American multinationals establish operations in India. (Saxenian 1999, 2002)

On the other hand, immigration may also raise transaction costs in multicultural settings. (Lazear 1998) By definition, immigrants in these settings are somewhat less capable of operating in their new institutional milieu than if they had been required to assimilate. They may not communicate clearly, and they may misunderstand norms and rules. A little knowledge, as the saying goes, can be a dangerous thing. The paradigmatic example in the U.S. is the foreign graduate teaching assistant who is utterly

unaware of his students' complete lack of comprehension. Whether transaction costs rise or decline overall in a multicultural system is an empirical matter.

In addition to affecting transaction costs, HSM in multicultural settings shapes the management of uncertainty. Immigrants broaden the receiving countries' range of ideas and experiences. More important, they diversify the range of new combinations that can be created by bringing aspects of the sending country together with elements of the receiving country. By this reasoning, the resulting portfolios of "economic experiments" in such settings should be broader than those generated by national systems that rely on assimilation or enclaves.

These new combinations may be purely scientific or technological, for instance, when immigrants hail from countries where their disciplines employ a very different technical style than in the receiving country. Aerodynamicists who moved from Germany to the U.S after World War I, for example, brought with them a theoretical bent that blended with the native empiricism to produce a major leap ahead in American aircraft design in the 1920s. (Eckert 2005) As Carlsson and Jacobson (1997) put it in a different context, this blending of technical cultures enlarged the "search space" of organizations previously locked in to a less productive technological trajectory.

New combinations may also involve organizational and institutional innovation. By blending "memes" from the old and new countries, immigrants may also alter the trajectory of the receiving national innovation system. For example, a country characterized by rigid boundaries between academia and industry may find that these break down when immigrants arrive from places where careers that span these two spheres of scientific and technical activity are common. (Mason, Beltrano, and Paul 2004) Recruiting highly-skilled immigrants who can help to reshape institutions in this fashion now seems to be a component of Singapore's national innovation strategy.[6]

Organizational and institutional recombination of this sort is more likely to have a significant impact on the national innovation system than recombination of technical styles simply because cultures vary more across nations than do scientific disciplines. However, this wider variability also means that there will likely be more failed organizational and institutional experiments. Wasteful experimentation might be more costly than none at all. As with transaction costs, the net effect of immigration on the management of uncertainty is an issue for empirical research.

The final insight that the systems of innovation approach brings to the study of HSM is that it is a path-dependent process. Countries are likely to remain where they are on the spectrum from assimilation to enclave for a variety of individual, organizational, and institutional reasons.

For instance, immigration has powerful network effects. Family unification is an obvious example, although with relatively little bearing on the flow of skills (except to the extent that family members crowd out more highly-skilled immigrants). Success stories in education and employment that circulate back to the country of origin through social networks are probably more important for our purposes; such stories often inspire new migrants with aspirations and capabilities similar to the earlier ones. In addition, HSM shapes the recruitment patterns of the organizations that hire immigrants, precisely

[6] Kapur and McHale (2005, 96-99) argue that highly-skilled migrants are more likely to be institution-builders than those they leave behind and that the loss of this inclination and capacity is among the most devastating aspects of the brain drain.

because the transaction costs for identifying talent are lower in the territory that the immigrants know best.

These individual and organizational patterns may produce institutional outcomes. In the source countries, institutional innovation may feed the emigration process. In the contemporary Philippines, for instance, nursing schools produce more graduates than the country can accommodate because many students plan to move to the U.S. (Lucas 2004) In the receiving countries, natives come to expect not only that immigrants will arrive but also that they will achieve a particular level of assimilation.

The foregoing argument does not mean that change is impossible, only that it takes a substantial effort, often abetted by a crisis. The shift in Australia from "White Australia" to a policy that emphasized skills and welcomed Asians, for example, was catalyzed by a deep recession and a change in government in the mid-1970s. Fears about the "Asianization" of Australia nonetheless remain strong. (Castles and Vasta 2004)

Conclusion

The prospect that flows of people may become an ever-more important determinant of the innovative capacities of nations (and regions and firms, for that matter) poses a challenge to the innovation policy research community. We have not paid consistent attention to this factor, and, as a result, our conceptual frameworks do not incorporate it in a sophisticated way. If we conceive of people merely as an input into the innovation process, the same problems that plagued research on other inputs in the past, notably R&D spending, are likely to recur, namely that their relationship to outputs and outcomes is tenuous.[7]

The systems of innovation framework warrants further development in order to meet this challenge. My adaptation of the SI framework suggests that, as with R&D spending, how effectively immigrants are utilized by an innovation system depends on how these people interact with the organizations and institutions that make up that system. Systems that are able to capitalize on the differences between immigrants and native-born – differences in their social networks, technical styles, and norms and routines, for instance – to reduce transaction costs and generate new combinations of native and imported ideas and practices, may become more innovative than they would have been without any influx of foreign talent.

This happy outcome is not guaranteed. Misunderstanding, false starts, and backlash may well raise transaction costs and heighten uncertainty. Indeed, immigration could be counterproductive in some innovation systems. Policy-makers thus take a risk if they seek to create what I have labeled "multicultural" contexts for innovation. Lower risk, but also lower reward, may be found with an assimilationist or even exclusionary approach.

Of course, the SI analysis also cautions against the notion that policy-makers can simply "choose" one or another of these broad approaches. They must cope with constraints imposed by existing norms, power structures, and habits of thought and behavior. These constraints may be very powerful indeed when dealing with immigration, since borders and national identity are important elements of sovereignty.

[7] That is not to say that we should not warmly welcome better data on flows of people and their educational characteristics, as recently developed, for instance, by OECD (2005) and the World Bank (Docquier and Marfouk 2004).

Policy-making is itself likely to be an experimental and evolutionary process in this domain.

The arguments laid out in the previous section may be amenable to a variety of tests, although all will face difficult measurement challenges. Tracing the paths and productivity of matched individual immigrants within different systems might be useful. Perhaps there are natural experiments in which two nations experienced similar influxes of skills, but the innovative outcomes associated with these new inputs varied. In such instances, we might explore whether these outcomes are correlated with aspects of assimilation, exclusion, or multiculturalism.

In addition to being provisional and largely theoretical, the analysis offered here, I should emphasize, is partial. It tries to deal only with the receiving countries and neglects the consequences for the sending countries and for the world as a whole. It fails to consider dynamic interactions among national systems that will surely become more important if the "war for talent" fully materializes.

These caveats notwithstanding, the analysis illustrates a fundamental point applicable to the study of human resources in the innovation process generally. People are not mere accumulations of technical knowledge and skills. They are bundles of habits, nodes in networks, and sets of principles. These attributes affect whether and how their knowledge and skills are put to use. To be sure, habits, networks, and principles are shaped, often profoundly, by their organizational and institutional contexts. But these contexts may also accommodate differences and over time be malleable in response to them. This form of social creativity is ultimately more important for innovation than creativity in science and engineering narrowly considered.

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