

Sojourns and Software:
Internationally Mobile Human Capital and High-Tech Industry Development
in India, Ireland, and Israel

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in Ashish Arora and Alfonso Gambardella (eds.), *From Underdogs to Tigers: The Rise and Growth of the Software Industry in Some Emerging Economies*, Oxford University Press, 2005.

1. Introduction

Driven by a broadly based easing of rich-country immigration restrictions for skilled workers and booming high-tech economies, the decade of the 1990s saw a substantial increase in skilled emigration from emerging economies. To take an example, the Indian-born population in the United States aged 25 and over increased from 304,000 in 1990 to 836,000 by 2000—80 percent of whom have a tertiary education.¹ A key factor behind this increase has been the introduction and expansion of the H-1B temporary visa program for skilled workers.² The resulting outflow rekindled fears, prominent in the 1960s and 1970s, of a development-stunting “brain drain.” The development costs of talent outflows are certainly hard to dispute when it comes to rich-country recruitment of African doctors, given already staggeringly high doctor-to-patient ratios and worsening disease environments. But the loss of talent in high-tech sectors such as software has produced a more ambivalent reaction, with commentators pointing

¹ We estimate from the 2001 March CPS that 38 percent of Indians aged between 25 and 64 have a graduate degree. This compares with 9 percent in both the US-born and other foreign-born populations. In the 18 to 64 age group, 37 percent of the Indian born have incomes more than 200 percent of the US-born median income (\$23,925 in 2001); only 20 percent of the US-born and 13 percent of the other foreign born have incomes above this level (see Desai, Kapur, and McHale, 2001).

² The most widely discussed case of skill-focused immigration reform was the expansion of the H-1B professional worker temporary visa program in the US. But skilled-focused immigration policy change was a much wider phenomenon in the late 1990s and early 2000s (see e.g., McLaughlan and Salt 2001). Germany introduced a 20,000 a year “Green Card” program for IT professionals (now ended), and its parliament passed legislation introducing permanent residency for high-earning skilled workers (now under court challenge). The United Kingdom announced at the end of 2001 that it is implementing a points-based Highly-Skilled Migrant Programme on a pilot basis, and has dramatically increased the number of work permits it issues to skilled workers since the mid-1990s. Canada recently revamped its points system to make it more focused on education and adaptability to the Canadian skill market, and put in place a pilot program for fast tracking temporary visas for IT workers. Australia introduced a major new class of employer sponsored temporary visa in 1996, in addition to increasing the share of its permanent migration visas that are granted on the basis of skills. Although the current high tech slump and post September 11 fears have stemmed this reform momentum, continued skill-biased technical change, educational system deficiencies (particularly in science and computing), and aging populations make it a fair bet that the competition for skill will reassert itself before long.

to benefits as well as costs.³ In this paper, then, we explore the implications of skilled emigration on the development of the software sectors in three emerging economies—India, Ireland, and Israel.

What are the benefits of skilled emigration to high-tech sector like software? We emphasize three classes of benefit. First, there are the benefits that result from the *prospect* of emigration, as young people are induced by the higher expected return to skills to invest in more (and more internationally marketable) human capital.⁴ Second, there are the economic benefits that stem from close links to the *diaspora*. The diaspora can be a direct source of advantage when its members have the desire and ability to trade with, invest in, and outsource to domestic businesses. It can also be an indirect source of advantage as its members act as “reputational intermediaries”—matching trading partners, supporting contracting by leveraging its long-term relationships with people from their new and former homes, and, possibly most importantly, overcoming negative national stereotypes through demonstrations of their capabilities. Finally, there are the benefits that result when emigrants *return* with enhanced skills, connections, business ideas, and savings.

Before becoming overly excited about the potential benefits, we hasten to add that there are real costs to a country from having a sizable portion of its talent *absent* from the economy. The reduced supply pushes up domestic wages making it more difficult to compete on costs, leads to fiscal losses as net fiscal contributors leave, and undermines local knowledge spillovers. Possibly most damaging is the loss of specialized skills, talents and energies that have few or no domestic substitutes, including the loss of crucial “institution builders.” Recent work in economics has also stressed the importance of complementary skilled workers to the incentive to “import” high-tech capital equipment

³ For example, NASSCOM, the leading lobbying group for the Indian software industry, actually supported increasing the annual cap on H-1B visas, and in the late 1990s, and in the late 1980s senior Irish ministers were actually advising ambitious young Irish graduates to go abroad to get valuable experience.

and know how (see, for example, Caselli and Wilson, 2003, and Acemoglu and Zilibotti, 2001).

The loss of skilled workers may pose a particular challenge to an emerging economy that has managed to attain a surprising comparative advantage in a skill-intensive sector like software. A useful way to think about this advantage is in terms of a multi-sector Ricardian model (see Dornbush et al, 1977). Compared to other sectors in the economy, the software sector has relatively high productivity (for reasons explored in other chapters in this volume). But skilled wages are low because of low average productivity. High productivity and low wages are an ideal basis for profitability. But the resulting international wage gap is also a threat as talent gets lured abroad by the prospect of higher living standards. As talent leaves—or even has the option of leaving—wages rise and productivity falls as specialized skills are lost.⁵

The tension between the costs and benefits of skilled emigration for an industry that relies heavily on outsourced business comes out clearly in a recent paper by Gene Grossman and Elhanan Helpman (Grossman and Helpman 2002). Their paper actually does not address emigration at all, but rather the extent and location of international outsourcing by rich-country firms. Firms outsourcing activities such as software development face the problems of finding qualified outsourcing partners and getting them to make relationship specific investments in customization without recourse to complete contracts. Emigration is clearly relevant to the extent of such outsourcing difficulties.

⁴ Potential entrepreneurs may also be induced to take greater risks with start-up companies by the prospect of being able to move their companies abroad with foreign takeovers or stock market floatations.

⁵ It is sometimes said that these countries have an “excess supply” of human capital. However, care must be taken in using this term as it draws attention to just one side of the skill market. Successful economies can absorb large increases in human capital through such changes as complementary capital accumulation, induced skill-biased technology adoption (and even technology invention), and increases in the share of skill intensive industry. One indicator of “excess supply” is a large negative differential between domestic and foreign wages. But given the forces pushing towards factor price equalization in an open economy, a sustained wage gap is more likely to be due to country-specific factors that affect the utilization of skills than their overabundance.

On the negative side, it “thins” skill markets, making it less worthwhile to search for partners in the skill-losing country. On the positive side, diasporic networks can improve “technologies” for partner search and communication of customization requirements between the outsourcing firm and its suppliers, and also help overcome difficulties of contractual incompleteness by acting as “reputational intermediaries”—ideas we explore in Section 3 below.

Notwithstanding the costs, we argue that international skill mobility has probably been on net an advantage for at least some of the countries in this project. For India, we think that the most important factor has been role of the diaspora in overcoming reputational disadvantages in an industry where *ex ante* quality is very hard to discern. For Ireland, there is convincing evidence that returning Irish professionals with enhanced human capital helped propel the booming high-tech sector in the latter half of the 1990s and early 2000s. More directly, there is evidence that a very high number of the founders of indigenous Irish software companies had international experience. For Israel, the immigration of almost one million members of the human capital rich Jewish diaspora from the former Soviet Union provided an unprecedented increase in the supply of skills to the Israeli economy. Although it is hard to find an overt footprint of this inflow on the Israeli software sector, it must have helped to maintain cost competitiveness at a time of rapid economy-wide skill upgrading.⁶

We have organized the rest of the paper around four sections. Section 2 describes the evolution of the emigrant stocks in some key destination countries. Section 3 reviews the economics of the costs and benefits of emigration with a focus on the welfare effects on home-country populations. Section 4 applies the economics from Section 3 to better understand the effects on software industry development of the migration episodes in Indian, Ireland and Israel noted in the previous paragraph. Finally in Section 5 we outline areas for future research.

⁶ The prevalence of Israeli company floatations on U.S. stock markets also suggests that the prospect of company (as opposed to individual) mobility has also been a spur to software industry development.

Section 2. Emigrant Stocks and Flows

The data on emigration stocks and flows are notoriously poor. In this section, we nonetheless try to piece together a rough quantitative picture on the relevant stocks and flows to get a sense of absent Indian, Irish and Israeli human capital. We start with crude estimates of broad Irish and Jewish ancestral diaspora and then try to narrow our focus to measurements of overseas nationals that are more directly relevant to the development of high-tech industries in the three countries.

2.1 *The Broad Diaspora: Ancestry*

Ireland's Department of Foreign Affairs has estimated that there are as many 70 million worldwide that claim Irish decent (Government of Ireland 1996).⁷ Although this diaspora is in many ways the sad result of Ireland's politically and economically turbulent history, the Irish government considers it a valuable resource: "The existence of this vast extended Irish family creates an immense reservoir of goodwill towards Ireland and is one of our main assets as a nation," (Government of Ireland, 1996, p. 1).

Close to half of this broad diaspora reside in the US. In the 2000 US census, some 30.5 million—10.9 percent of the population—claimed Irish ancestry (though curiously this was down from 15.6 percent of the population—38.8 million—in the 1990 census). From results released from the 1990 census we know that the vast majority of those claiming Irish ancestry were *not* born in Ireland, with some 98.8 percent born in the United States. Among the 270,000 foreign-born (not necessarily all Irish-born) claiming Irish ancestry, just less than 50,000 had entered between 1980 and 1990. We return to

⁷ The department also estimates that there are roughly three million Irish citizens living outside Ireland.⁷ Of these three million, around two-thirds live in United Kingdom and one-sixth live in the United States. It is estimated that 1.2 million of the total number of overseas citizens were born in Ireland. The entitlement to Irish citizenship is relatively generous compared with other countries. People born in Ireland, their children born abroad, and in some cases their grandchildren and great grand children, are entitled to Irish citizenship (Government of Ireland 1996).

the cohort of Irish who were driven to emigrate by poor economic conditions in the 1980s in Section 4.

The Jewish diaspora is estimated to have been 8.4 million at the beginning of 2000, with a further 4.7 million Jews living in Israel (DellaPergola 2000). Israel's Law of return, the legal framework for acceptance and absorption of immigrants, defines a Jew for the purpose of the law as any person born to a Jewish mother or who has converted to Judaism. The law's provisions extend to all current Jews (as defined above) and to their non-Jewish spouses, children, and grandchildren, as well as to the spouses of these children and grandchildren (DellaPergola 2000).⁸ As we discuss in Section 4, this broad diaspora has been a vast source of additional skill for the Israeli economy in the 1990s.

2.2 *The Narrow Diaspora: Emigrants*

We now turn to look more closely at characteristics of *emigrant* (or native born) Indian, Irish and Israeli populations. We initially concentrate on US-resident emigrants because of their importance to each of the three countries and also because the US data is best. We then briefly discuss some other important destination countries.

Table 1 shows how the total numbers of these emigrant populations have evolved in the US since 1960 for the three countries plus Brazil and China. The number of Indian born has sharply increased since 1960, more than doubling in the 1990s alone to top 1

⁸ It is estimated that 43 percent of the world's Jewish population lives in the United States, compared with 37 percent in Israel. Not surprisingly, the number of US residents claiming Israeli ancestry is much smaller. Although results are not yet available for the 2000 US census, 1990 census results show that just under 70,000 claimed Israeli ancestries. Of these, just over 39,046 were "foreign born," 21,980 of whom had entered between 1980 and 1990. Of the broader population claiming Israeli ancestry, 44.6 percent of those over 16 and employed were in managerial or professional occupations and 42.3 percent of those 25 and over had a Bachelor's degree or better. In comparison, 28.5 percent of those in the same age group claiming Irish ancestors were in managerial or professional occupations, and 21.2 percent had a Bachelor's degree or better. The numbers in the native-born populations were 26.4 percent and 20.3 percent respectively.

million. Ireland, which has been sending its people to the United States in large numbers since the 1840s Famine, has seen the number of Irish born drop over the four-decade period as deaths outweighed new emigration, though the fall slowed during the 1980s and 1990s. The Israeli-born population has increased steadily between 1960 and 2000. Like the Indian-born population, both the Brazilian-born and Chinese-born populations also increased dramatically post-1990, though, as we discuss below, these populations are not as human capital rich as the Indian born.

Who are these emigrants? **Table 2.a** records some salient characteristics for the Indian-, Irish-, and Israeli-born populations based on Current Population Survey data for 2001. The first panel shows *when* emigrants residing in the US in early 2001 came to the country. Consistent with the population evolutions in **Table 1**, a tiny minority (1 percent) of the Indian-born came before 1960. 59 percent have come since 1990, and 36 percent since 1996. The Irish-born population shows a very different pattern, with almost a third coming before 1960. Interestingly, following an evident fall-off in US-bound emigration in the 1970s, there is evidence of a pick up in US-bound emigration in the 1980s and first half of the 1990s, before clearly falling as the “Celtic Tiger” economy boomed in the later 1990s. Large scale Israeli emigration to the US is also a relatively recent phenomenon with an apparent peak during the 1980s.

The second panel shows the *age structure* of the US-born and the three emigrant populations using average shares from the 1999 to 2001 March CPS’s. Although there are clear differences in the population age structures, one common feature is the high concentration in prime working age years. 52 percent of the Irish-born are in the 25-44 age group, probably reflecting heavy graduate emigration in the second half of the 1980s and early 1990s. The age structure of the Indian-born population is somewhat surprising given the recentness of its emigrants, with an estimated 62 percent being 45 or older. The Israeli-born population is also concentrated in their prime earning years—45 percent between 25 and 44—with a relatively high share under 18 (21 percent) and a negligible number over 65.

The third panel of **Table 2.a** shows *educational attainment* for those 25 and over. All three emigrant groups have larger shares with a Bachelor's degree or better than the US-born population. What is truly striking here is the education level of the Indian-born population. 77 percent have a Bachelor's degree or better, with 37 percent having a Master's, Professional, or Doctorate degree.

The final panel tells us something about the *work* these emigrant populations are doing. Clearly, the three groups are disproportionately represented in managerial and professional occupations. The pattern is most striking for the Indian- and Israeli-born populations, with 59 percent of working Indians and 64 percent of working Israelis involved in management or professional occupations. 42 percent of Indians are in professional occupations. Compared with the US-born population, the Indian born are substantially over-represented in the engineering professions (1 percent versus 7 percent) and as mathematicians/computer specialists (1 percent versus 16 percent).⁹

Table 2.b uses recently released data from Census 2000 to compare the human capital intensities of the Indian-, Brazilian-, and Chinese-born populations. We limit our attention to the aged group likely to have completed their educations, those 25 and over. Clearly, all three groups increased dramatically in size over the 1990s, with the largest percentage increase occurring for the Brazilian born (186 percent). Of the populations residing in the U.S. in 2000, half or more had entered between 1990 and 2000, with Brazil again posting the largest share of recent emigrants (66 percent). In terms of education attainment, all three of the populations in 2000 were relatively well educated. In each case, more than half of the population had at least some tertiary education (defined here as more than 12 years of education). For comparison purposes, only 14 percent of the Mexican-born population in the U.S. had tertiary attainment. However, the Indian-born had a substantially higher share with tertiary attainment (80 percent) than either the Brazilian born (55 percent) or Chinese born (54 percent).

⁹ Sample sizes for the Irish and Israeli born in the CPS are too small to reliably estimate shares at this level of disaggregation.

What explains the unusually high human capital intensity and emigration timing of the Indian-born population? An important part of the answer is the expansion of the H-1B program for highly skilled migrants through the 1990s as the tech boom gathered steam. The H-1B visa was introduced with an annual cap of 65,000 in the early 1990s. The cap first became binding in September of the 1997 fiscal year. The cap bound even earlier (May) of the following year, spurring industry lobbying efforts to pass legislation to expand the cap. Legislation passed in 1998 expanded the cap to 115,000 for 1999 and 2000, 107,500 for 2001, before returning to 65,000 in 2002. But as IT skill shortages continued to get worse, legislation passed to relax the caps still further: 195,000 for 2001 to 2003, before returning to 65,000 in 2004.

Table 3 shows a sample of results from an INS study of petitions approved during the first 5 months of Fiscal Year 2000 (October 1999 to February 2000). During this time 81,262 petitions were approved, of which 42.6 percent went to Indians. 53.5 percent of the petitions granted for people in computer-related occupations. The sponsoring companies were a who's who of the IT world, and also included a number of Indian companies involved in hiring out personnel for on-site services ("body shopping") for its customer companies.

How did the tech slump affected petitions for H-1Bs? Not surprisingly, the number of approved petitions is down, and stories of hardship and returns home abound in the media. But the numbers are still well above mid-1990 levels before the original cap became binding. In the first 9 months of fiscal year 2002 (October 1, 2001 to June 30, 2002), 60,500 people subject to the fiscal year limit were approved. But this is well down from the 130,700 people who were approved during the same period of fiscal year 2001.

So far we have concentrated on emigration to the US, both because of its importance as an emigration destination and the quality of the available data. But of course there are other important destinations for emigrants from these countries as well. The United Kingdom, for example, is an important destination for emigrants from both

Ireland and India.¹⁰ **Table 4** shows that the number of Irish-born in the UK has fallen steadily since 1985 due to deaths in the generation who emigrated around mid-century, though it still numbers around 400,000. The Irish-born in the labor force held steady in the late 1980s, however, as a new generation of economic migrants refreshed the working emigrant stock. The Irish-born in the labor force then fell by roughly 60,000 over the 1990s. The occupation shares for 1995 and 2000 show that the Irish have done relatively well in the UK, though the rapid increase in the share of the more skilled occupations between 1995 and 2000 suggests that the less skilled were more likely to return home.

Table 4 also shows that the Indian-born population in the UK now numbers around 150,000. Work permit data for 2000 shows that Indian nationals were the second largest recipient of permits (12,292) just after the US (12,684) (see Dobson et al., 2001). 2,616 of the Indian nationals receiving work permits were classed as “engineers and technologists” and 5,973 were classed as “computer analysts/programmers” (Dobson et al. 2001). No other country came close to India in number of work permits received for these highly skilled technical occupations.¹¹

Technically skilled Indians were in high demand in other countries as well. In Canada, 5,738 Indians gained permanent residency under the points system for skilled workers in 2000.¹² In 1999/2000 Indians were the third leading recipient (after the UK and the US) of employer sponsored temporary business visas for skilled professionals in Australia. And Indians were the largest beneficiaries of visas issued in the early stages of

¹⁰ Indeed, the Irish born and Indian born populations are respectively the first and second largest foreign born populations in the UK

¹¹ The US sent 1,767 “engineers and technologists” and 1,004 “computer analysts/programmers.” The US sent many more “managers and administrators, however: 5,247 compared to 1,203 in this category from India.

¹² 6,649 Indians came as the dependents of skilled workers in 2000. Across all categories of permanent immigration to Canada—skilled, business, and family—26,064 Indians immigrated to Canada (11.5 percent of total permanent immigration in that year). Indians account for a relatively small share of temporary workers in Canada. In 2000 the stock of Indian temporary workers was 1,358 (1.7 percent of the total). India is also not among the top senders of students to Canada (Citizenship and Immigration Canada 2001).

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the German “Green Card” program, receiving 1,403 of the 6,988 visas issued between October 2000 and April 2001.

Section 3. Emigration and Industry Development: A Framework

How does the international mobility of a country’s skilled workers affect its capacity to develop a domestic skill intensive industry such as software? In this section we briefly and selectively piece together what the economics literature has to say about the economic effects of emigration. Actually, much of the literature we draw from focuses on the effects of immigration rather than emigration. But since many of the effects are the same with the sign reversed there is much to be learned from this literature as well. In measuring the effects of emigration, our focus is always on the *welfare of domestic residents*—people referred to sympathetically in the literature as “those left behind” or TLBs. Thus we ignore the (important) effects of emigration on the emigrants themselves unless their success or failure has some impact on home country residents.

We aim for a broad coverage of the effects of home country residents, which we discuss under four headings. The first deals with the impact of the *prospect* of emigration on the decision to accumulate human capital that may or may not be eventually taken abroad. The second deals with the direct effects of the *absence* of skilled workers on the domestic economy in terms of such factors as lost surplus, larger skill premiums, fiscal losses, diminished scale economies, and changed comparative advantage. The third considers how the *diaspora* can be an asset as a source and facilitator of international business. That is, we look at the ways that immigrants can have an impact on their home economies from afar. We finally turn to the part played by emigrants when they *return* to the home economy with augmented human capital, financial capital, foreign connections, and entitlements to foreign social insurance benefits.

3.1 Prospect

How does the prospect of emigration affect the incentive to invest in human capital? A number of recent papers have developed models in which the prospect of emigration increases the expected return to human capital investment (see e.g., Beine et al. 2001, 2002, and Stark and Wang 2001). This increase in the expected return can raise the overall level of human capital in the economy if the subsequent *actual* emigration is not too high. One example is where potential emigrants face a lottery for visas such as the diversity lottery run by the US State Department. The chance of winning, and thus of gaining access to a labor market with higher rewards to skill, induces more study and on-the-job learning. But many of those enticed by the prospect of a visa actually fail to win one, so that a portion of this increased human capital stays behind. The possibility of emigration may actually increase human capital if this portion is large enough.

Beine et al. (2001, 2002) provide evidence that is consistent with an overall positive effect on human capital for a number of countries, though they readily admit their data has many limitations. Without forming an overall judgment on the empirical importance of this prospective channel, we note three factors that work to diminish its importance.

First, there will be income as well as substitution effects from an increased expected return to human capital. An Irish secondary (high) school student deciding on how hard to study to win a place at university might, for example, be enticed to slack off by the fall back of a relatively high paying job as a construction worker in London or a nanny in New York.

Second, an overall positive effect on human capital depends on the prospect of emigration inducing study but then many of these more skilled individuals deciding not to go or not qualifying to go. To the extent that the desirable destination countries screen immigration applicants with objective criteria (e.g., the Canadian or Australian point systems) or with jobs offers (e.g., UK work permits or US H-1Bs) the degree of uncertainty is diminished. In other words, those who *want to go* and make the necessary investments are likely to *qualify to go* (see Commander et al. 2002).

Lastly, there is evidence that the value of human capital acquired in one country—especially if it is a developing country—does not always travel well with an emigrant. Looking at the case of immigrants to Israel from the former Soviet Union, Friedberg (2000) finds that education and experience acquired in the former Soviet Union is significantly less valued than human capital acquired in Israel. This suggests that would-be emigrants should wait to acquire their more advanced human capital abroad if possible. Interestingly, Friedberg does find that education acquired in the adopted country raises the return to education acquired at home. This suggests that the prospect of emigration could still provide some incentive to acquire human capital provided that the individual is willing to pursue further education while abroad.¹³ We return to the fascinating case of Israel-bound emigration from the former Soviet Union in the third of our applications in Section 4.¹⁴

Our discussion has focused on how the prospect of emigration affects the expected return to human capital. Having a (potential) emigration option might also affect an individual's willingness to take more risks with their human capital accumulation decisions. Suppose, for example, that the global software industry is growing strongly, but is at a nascent stage domestically. Investing in computer programming skills may be quite risky if options are limited to the domestic economy, which may fail to develop a substantial computer industry. Having the fall back option of emigration may make a young school leaver more willing to take a risk on an emerging industry. From the national perspective, such a propensity to take a more forward looking perspective in developing skills may help the country break out of traditional

¹³ Weiss (2000) reports significant occupational upgrading by for Soviet Union immigrants to Israel over time.

¹⁴ We have focused on how the prospect of emigration affects the willingness to invest in human capital. Given the importance of foreign takeovers and foreign stock exchange listings to Israeli software companies in particular, it is worth noting that the prospect of foreign investor interest can spur high tech entrepreneurial activity as well. Thus, even if foreign ownership eventually curbs the domestic contribution of the firm (including the possibility of moving staff abroad), the prospect of a bit payoff may be an important spur to high risk entrepreneurship in the first place.

patterns of comparative advantage, and also to increase the national proclivity to “explore” new industries for which the country’s characteristics might turn out to make it particularly well suited.¹⁵

3.2 Absence

How are TLBs affected by the absence of a sizable portion of the native-born skilled labor force? **Figure 1** shows the simple case of a closed economy producing a single good (GDP) with skilled workers and other factors under constant returns to scale technology, competitive markets, and no fiscal system. With diminishing returns to skilled workers, skilled emigration pushes up the domestic wage.¹⁶ The size of the aggregate loss to TLBs is shown by the shaded area in the diagram.¹⁷ A loss stems from a difference between an emigrant’s marginal value product (their benefit to TLBs) and the wage they were paid (their cost to TLBs). Since in a competitive labor market skilled workers are paid their marginal product, the loss of *single* skilled worker will have no effect on the aggregate surplus of TLBs. It is clear from the diagram that this is not true for the loss of multiple skilled workers. Moreover, it is easy to show that the total loss (approximately) rises with the square of the number of emigrants.¹⁸ To understand better the source of this loss, note that in measuring this loss we are comparing the value lost from someone leaving with the wage they were paid before anyone left. The real source of the emigration loss is not that the *wage* is pushed up (though it will be in a competitive

¹⁵ See Hausmann and Rodrik (2002) for a model that emphasizes the social value of discovering the costs of domestic activities when such activities can be easily imitated.

¹⁶ The wage rise will be larger the less substitutable other factors are for skill. We assume that domestic skilled labor is supplied perfectly inelastically.

¹⁷ Skilled emigration has distributional implications in addition to this loss of aggregate surplus. Remaining skilled workers clearly gain as their wage goes up. If we make the plausible assumption that skilled workers had above average incomes *before* the emigration, then the emigration will make the distribution of income more unequal.

¹⁸ The size the loss can be approximated by using the formula for the area of a triangle. Expressing this loss as a share of total income yields the formula,

skill market) but that the *marginal value product* of remaining workers is pushed up as others leave (see **Figure 1**).¹⁹ For example, the emigration of a few software engineers will drive the value of remaining software engineers above what they were all initially being paid. If then more software engineers leave, the loss in value to TLBs will be strictly greater than the amount of money they had been handing over to the engineers *before any of the engineers had left*.²⁰

We now consider a number of complications to this simple model of emigration loss. The key to understanding the loss to TLBs is to compare the domestic marginal value product of an emigrant to the wage they were paid. Unlike in our simple model, the first three complications show how the loss of even a single skilled worker can harm TLBs. The last complication considers how things change when the labor-losing economy is open to international trade.

(i) *Fiscal effects*: Our simple analysis assumed away the existence of a fiscal system. In reality emigrants pay taxes and receive benefits from the government. Under a progressive fiscal system it is likely that skilled workers—and especially young high tech workers—are net contributors to the fiscal system. Desai et al. (2001) estimate the fiscal

$$\frac{Loss}{GDP} = \frac{1}{2} \times \varepsilon \times s \times \left(\frac{Skilled\ Emigration}{Skilled\ Laborforce} \right)^2$$

with respect to the skilled labor supply and s is the skilled worker share of GDP (see Borjas 1995).

¹⁹ There is a large empirical literature that attempts to measure the effect of immigration on local wages (see Borjas 1994 and Friedberg and Hunt 1995 for surveys). There are three main types of studies: area studies that compare wages across labor markets receiving different numbers of immigrants; natural experiments that look for immigration changes that are independent of developments in local labor markets; and calibration studies that estimate how relative factor supplies affect relative wages for different skill groups and then calculate how immigration with a given skill mix affects relative wages. Advocates of the latter method argue that the first two types of study fail to account for native outflows in response to immigrant inflows. The first two types of studies tend to find small wage effects (see Altonji and Card 1991, and Card 1990). The third type of study tends to find larger wage effects (see Borjas et al. 1996).

²⁰ The key to identifying such losses is that we consider the skilled emigration in total with the initial wage as our reference point rather than taking each emigrant one-by-one taking previous emigration as given.

loss to Indian TLBs from skilled Indian emigration to the US. Their method is to infer what fiscal contributions emigrant Indians would be making had they stayed in India by combining estimates of what their Indian incomes would be and summary measures of the progressive tax and expenditure system. Using their preferred income inference method and a conservatively high estimate of expenditure saving, they find a tax loss equal to 0.58 percent of GDP and a net fiscal loss equal to 0.24 percent of GDP. The largest component of the tax loss is the loss of central government income tax revenues (0.44 percent of GDP), which represents a substantial fraction of central direct tax revenues.

(ii) *Scale effects* The assumptions of constant returns to scale and strictly diminishing returns to skilled workers may lead us to miss important channels through which emigration harms domestic industry. The scale of the skilled labor may affect an emerging software industry in a number of ways. As examples, the “thickness” of skill markets could affect the willingness of foreign firms to search the economy for investment locations or outsourcing partners (Grossman and Helpman 2002), or there may be uncompensated knowledge spillovers between skilled workers.

(iii) *Non-competitive wage setting and heterogeneous skills*: In our simple model we assume that skilled workers are paid their marginal product so that the emigration of a single worker will not (assuming no fiscal effects) harm the welfare of TLBs. Another situation where this is unlikely is when particular worker skills are uniquely matched to a particular firm. This skill specificity is important for knowledge intensive industries such as software, where competitive advantage can turn attracting and retaining “core competents” (not to be confused with core competence). In this case it is more appropriate to assume that the wage is determined by bilateral bargaining, with the surplus between the worker’s value to the firm and their next best wage offer being split according to their relative bargaining power. Assuming the firm has at least some bargaining power, the wage will be set below the workers marginal value product. Thus

the loss of this worker to emigration will result in a loss to TLBs.²¹ The likelihood that it is uniquely talented workers that are lost to emigration also suggests that we can't look simply at the number of emigrants, or even the number of emigrants in broadly defined skill categories. The loss of even a few "institution builders," for example, might have large development effects. Studies of the graduates of the elite Indian Institutes of Technology provide a good illustration of this concern. The acceptance rate in these institutions is between 1 and 2 percent of an applicant pool that is already highly selective. Analyses of the graduating classes of IIT Mumbai in the 1970s have revealed that 31 percent settled abroad compared to 7 percent of engineers overall. Moreover, 43 percent of the top quartile of graduates had emigrated compared with 27 percent in the rest of the class (Sukhatme 1994).

(iv) *Open economy effects*: Our models have so far assumed economies closed to international trade. India, Ireland, and Israel are, of course, very much open to world trade in information technology products and services. How do our results about the effects of immigration on industry development change when we move from a closed to an open economy setting? The most widely used open economy framework for studying the effects of changes in factor endowments is the Heckscher-Ohlin model. For a small open economy facing given terms of trade, internationally equalized factor prices and using the same technologies as its trading partners, the emigration of skilled workers will cause a reallocation of resources away from skill intensive sectors. But in contrast to our simple closed diminishing returns to skill model there is no change in the skilled wage or any other factor price. Since software is a skill intensive sector, this model predicts that emigration shrinks the software sector, but does not harm the welfare of TLBs as factor

²¹ Monopsonistic wage setting—where wages are set by a single buyer in the relevant skill market—provides another example of non competitive wage setting in which the skilled wage will be below the marginal value product. Employers with monopsony powers in the labor market will weigh increases in the quantity of skilled offered to them when they increase the wage with the cost of raising the wage for everyone. (We assume that the monopsonist employer must pay the same wage to everyone.) The optimal employment equates the marginal cost of hiring more workers with the marginal value product. At this optimal employment the wage is again less than the marginal value product. Such a

incomes are unchanged. The mechanism at work is that described by the well-known Rybczynski Theorem: output is reallocated away from the skill intensive sector until the demand for skill is reduced to match the shrunken supply.²²

Few governments around the world would be sanguine about the shrinkage of high tech sectors even if convinced that current factor prices are not affected. There are several reasons for this and not just the “prestige” of high technology. Policy makers want to promote sunrise industries because of future growth prospects. There are good reasons to believe that high tech sectors such as software—especially at the more innovative end of the industry spectrum—generates ample opportunities for learning by doing and knowledge spillovers (for arguments along these lines see Lucas (1993)). Software and IT are “general purpose technologies” with large spill-over effects in other economic sectors. Capabilities built up in software can be leveraged in other high-technology fields such as bio-informatics, pharmaceuticals, and media and entertainment (on the role of General Purposes Technologies in economic development see Helpman (1998)). An open economy setting moves attention away from current income losses to TLBs, to shifts in the allocation of remaining resources to industries with lower growth potential.²³

monopsony skill market could develop where a large firm, say a Microsoft or an Intel, is a dominant presence in the area.

²² Trefler (1997) examines the effects of migration in a variety of trade models. Though he focuses on immigration in an attempt to dismiss the myth of an “immigration surplus, his results can be turned around to examine the effects of emigration in an economy open to trade. Trefler’s results show that an emigration surplus loss is present in a specific factors trade model, whether skilled workers are the mobile factor or one of the specific factors. He also shows how the Heckscher-Ohlin results change when technologies differ across countries. It turns out that it matters whether the technological (or productivity) differences are inherent to workers (so that the any technological backwardness travels with them) or to countries (so that an emigrating worker can leave their backwardness behind.) When technology differences are inherent to workers, he shows that the standard Heckscher-Ohlin results are not affected as factor price equalization occurs for productivity adjusted factor prices. This is not true when technology differences are specific to countries as emigration leads to favourable movements in the terms of trade and an increase in the welfare of TLBs.

²³ In a provocative recent paper, Davis and Weinstein (2002) have examined the impact of balanced flows of factors to an economy (they focus on the US) with a superior CRS

3.3 Diaspora

It is increasingly recognized that a country's overseas nationals, and even those who claim distant ancestral heritage, can be a valuable economic asset (see e.g., Rauch, 2001, and Saxenian 2002).²⁴ In this part, we briefly explore the broad mechanisms through which such a connected diaspora can be a boon to a country's emerging high-tech industries in doing international business.²⁵

3.3.1 Willingness to interact/transact

The act of emigration rarely leads to the breaking of all connections, not least emotional connections, with a person's original home—emigrants may be gone, but they are rarely completely forgotten. Whereas the emigrants who were forced to leave Ireland through economic adversity in the decades following the Irish Famine in the late 1840s were able to retain few links with the country of origin, modern transport, media, and communications allow for much richer interactions. From a narrowly economic point of view these interactions can be a source of information on new technologies and trading opportunities. Emigrants may also have a preference for goods produced in their home countries, especially when they have developed a taste for home-country specific products. The dedicated, country-of-origin arranged import isles of supermarkets in larger American cities are one visible sign of the importance of such trade.

technology. To the extent that the resulting increased size of the economy leads to a worsening of its terms of trade, the balanced inflow of productive factors leads to lower welfare (see also Trefler 1997). They argue that the US has been made *worse off* due to its openness to foreign capital and workers. On sending side, a balanced outflow of factors will lead to an improvement in welfare provided it is large enough for its terms of trade to change. A welfare loss to the sending country could reemerge if the factor outflows are unbalanced (say all skilled workers) or if there are economies of scale.

²⁴ Rauch (2001) provides a comprehensive recent survey.

²⁵ In passing we note that although conventional transportation costs may be lower for "weightless" output such as software, its often non-standard nature makes it subject to substantial non-transport related transaction costs, increasing the potential importance of a trade-facilitating diaspora.

Such attachments to home country products are probably not of great importance for the high-tech sector. Of more importance is the knowledge that emigrants have of trading and investment opportunities back home, possibly combined with a desire to put business and advice the way of emerging home country businesses where feasible. This willingness to trade and invest goes beyond preference and information; it also reflects *ability to pay*. Skilled emigrants from poorer countries often earn substantially more in their adopted countries than they earned prior to leaving—which can grow into substantial purchasing/investing power as the emigrants sacrifice consumption to accumulate financial wealth. To the extent that this wealth leads to business with home country firms, the origin country gets to share in the emigrant’s gains from leaving or “emigrant’s surplus.”

The transnational economic role of diasporas is the subject of a good deal of informal speculation but little formal analysis.²⁶ Have the large Irish and Jewish diasporas in the US, many of whom are in positions to influence the location decisions of multinational direct investors, tilted decisions at the margin to favor their ancestral homes? It is suggestive that 43 percent of the 1,500 companies that have chosen to establish bases in Ireland are from the United States (PricewaterhouseCoopers 2001); and Ireland’s industrial development agency calculates that Ireland wins close to a quarter of US manufacturing investment in Europe while accounting for roughly 1 percent of the population (IDA Ireland 2002).²⁷

²⁶ A recent paper that looks at the determinants of US foreign direct investment in Ireland is Gunnigle and McGuire (2001). The main source of information is interviews with high ranking executives from 10 major US multinationals. The paper addresses more objective determinants of the decision to invest such as the corporate tax regime and labor cost and quality. Intriguingly, Table 3 in the paper does list one vice president for strategy of an electronics firm as listing “culture and identity” as one of the key factors behind the decision to locate in Ireland.

²⁷ Among other examples of diaspora influence, Breznitz (2003) describes how a member of the American Jewish diaspora, venture capitalist Fred Adler, was instrumental in arranging an important early IPO for the technology firm Elscient in the early 1970s.

3.3.2 Reputational Intermediaries

International business is greatly complicated by poor information on distant trading partners and the difficulties of contracting across national boundaries. To examine how a connected diaspora might facilitate such business, we take the example of a US software firm looking to outsource a once-off software development project, with all the attendant difficulties modeled in the Grossman and Helpman paper referenced in the introduction. The US firm lacks information on the capabilities of the software firms in various locations, and is worried about being “held up” by any overseas party due to difficulties in writing and enforcing contracts with opportunistic trading partners. We note three distinct ways in which members of the diaspora can serve as what we loosely call “reputational intermediaries.”²⁸

(i) *Search*: If the member of the diaspora has an ongoing relationship with the US firms (possibly an employment relationship) they may be able to “put their reputation on the line” by vouching for a particular overseas firm. The incentive to risk reputation in this way could be monetary. For example, an employer pays a premium for foreign country nationals that are well informed about the home country business scene. But it could also reflect a desire to help home-country businesses.²⁹ Rauch and Watson (2002) develop a model in which an employee can build up knowledge about suppliers through the normal conduct of their business over time. The employee then faces the choice of going out on his own as a network intermediary (i.e., becoming an entrepreneur) or staying in

²⁸ As far as we know the term “reputational intermediary” was first introduced in Kapur (2001b).

²⁹ An interesting Fortune magazine article profiling the Indian Silicon Valley businessman and technologist Kanwal Rekhi describes a reputational intermediary of the form we have in mind in action (Warner 2000). Rekhi is the former CTO for Novell and a founding member of the Silicon Valley professional organization The Indus Entrepreneurs, or TiE. Commenting on one Indian-American businessman who had come to him looking for a reference to investors, Rekhi is quoted as responding, “I wouldn’t send you to anyone until I figure out your plan. I have to feel good about someone when I refer them. Or else people call me up and say ‘Why did you send me that one?’” Rekhi’s value as a reputational intermediary comes out clearly in the article

employment. A network intermediary sells the service of matching buyers with suppliers. Members of the diaspora might be well placed to act as such intermediaries if they have richer knowledge of home country firms or ways of finding this information out. Reputational intermediaries are likely to matter more where knowledge is tacit. Information is distant invariant, knowledge is more contextual. Unlike many manufacturing sectors where ex ante knowledge of quality is more easily discernible through third party certification (like ISO, ASTM etc....) this is much less the case with services where quality can only be discerned after use.

(ii) *Contract fulfillment*: Moving beyond the search process, reputational intermediaries can ensure that each side lives up to its side of the deal.³⁰ Once the deal has been signed, the supplying firm may be willing to act opportunistically with its outsourcing partner, but may be unwilling to risk its reputation with the member of the diaspora vouching for their trustworthiness. The power of the vouching party can be greatly enhanced if they can “blacklist” an offending home country businessperson within the diasporic network. On the other side of the deal, the outsourcing firm may also value its reputation for fair dealing with the intermediary and the diasporic network they belong to. In essence, the intermediary is leveraging its long-term relationship with each party to overcome the often severe difficulties with one-shot contracts across weak legal systems.

A diaspora’s influence is a function both of its own characteristics as well as of the country of origin. There are five features of a diaspora’s reputational role that are important to note. First, there is a threshold of the country of origin’s economic openness, below which diaspora’s have little effect. The three countries examined in this paper (as well as China) were all closed economies for many years during which period their diasporas played little role. It is only after the countries began to open up that the effects of diasporas became more important. Second, the diaspora can play a reputational role only when it itself has a reputation. A good proxy for this is the size and education of

from the number of Indian entrepreneurs that come to him seeking his help. The aforementioned quote also shows how seriously he takes the value of reputation.

the diaspora. Thus despite their sizes, the diasporas from Central America and the Caribbean appear to have had little effect (low education) as do those from countries like Germany and Chile, whose higher educational levels cannot compensate for the handicap of smaller size. Third, even the existence of the first two factors while necessary is not sufficient to ensure that a diaspora's reputational potential is actually realized. The reasons for leaving are critical. If the diaspora was forced out for political reasons, then it is likely to leverage its reputational role to block, not promote, investments in the country of origin. Jews of German origin, Cuban Americans, East European immigrants in North America prior to 1990, successful Israeli Arab immigrants or Indian Gujarati Muslim immigrants are all examples of this phenomenon. Fourth, the role of reputation might be even greater in the current context when most countries have liberalized and a MNC potentially has several equally viable investment locations to choose from. Then diasporas within firms can act as champions for their country of origin in internal management battles. Note that the need to protect their *internal* reputation within the firm ensures that they will only do so if their country of origin is indeed a viable candidate to begin with. Finally, as a few MNCs locate investments in these countries, it is the reputation of the MNCs themselves that will signal to other MNCs on the locational viability of that country. Thus the reputational role of diaporas may have its greatest leverage in acting as a "tipping point" with far reaching consequences.³¹

(iii) *Altered profiles*: At a more general level, members of the diaspora can also act as reputational intermediaries to the extent that their business behavior affect the "profile" or "brand" of their countrymen. Firms looking for outsourcing partners under uncertainty will rationally engage in statistical discrimination, whereby they form an expectation of the quality of any given potential trading partner based on observed characteristics *and* their priors about the distribution of characteristics in the population that this firm

³⁰ See Dixit (2001) for a game theoretic model of such intermediary-based contract enforcement.

³¹ The fact that the share of India's IT exports—North America 62 percent, Europe 24 percent Japan 4 percent—is roughly the average of these regions share of India's skill migration and the region's share of global IT industry—is suggestive that incorporating the size and skills of diasporas in gravity models of global IT trade may be worthwhile.

belongs to. These prior beliefs can be altered through contacts with members of the diaspora. For example, if a firm dealing in the US with Indian engineers from the elite IITs, show them to be excellently trained, this experience can lead to upward revision of priors about the quality of Indian engineers in India from these institutions, and possibly other institutions as well. This mechanism will be especially important if the industry and firms in question do *not* share the negative attributes of other more prominent industries in their country—a fact that may be poorly appreciated by the outsourcer.

3.4. Return

Lastly we turn to the impact of returned emigrants. Our interest is how the fact that some part of the population spent time abroad affects the welfare of that population, including the welfare of the returned emigrants themselves. This is consistent with our intention to examine how emigration—prospective, present, and past—affects the existing population at a particular point in time. Time spent in work or study abroad can augment human capital as emigrants acquire knowledge of frontier technologies and market opportunities, management know-how, languages, business contacts, and so on. In addition to direct individual productivity enhancing effects, emigrants may have saved part of their “emigration surplus,” accumulating financial capital they can bring back with them for investment at home. If they have been away for long enough they may also have acquired entitlements to foreign social insurance benefits. For example, 10 years of contributions to the US Social Security system creates entitlement to retirement income benefits. The return on contributions can actually be quite high for returned emigrants given that the average monthly earnings used in the benefit formula is an average of the worker’s highest earning 35 years, and the benefit formula is a progressive function of thus calculated average earnings.³² However, the available evidence suggests that the probability of migrants returning declines with time – hence very few of those who stay for a decade return in the first place. In contrast, most of those who do return do so well

³² Many returned emigrants will have worked far less than 35 years meaning that there are many zeros in the numerator of the average wage calculation.

within 10 years – in which case the loss from uncollected social security taxes is substantial.

Of course the benefits from past emigration must be weighed against the negative impacts on the economy during the time they were gone. One factor increasing the probability of an overall positive balance is that temporary emigrants engage in a form of inter-temporal substitution—leaving when times are bad (and the domestic value of their skills is low) and returning when the domestic demand for their skills is higher. This seems a reasonable description of the well-educated Irish graduates who a slumping Irish economy in the 1980s, many of whom returned to propel the “Celtic Tiger” economy of the 1990s. We return to this example of “brain circulation” as the second of our applications in the next section.

Section 4: Applications

4.1 Transnational connections: India’s Silicon Valley diaspora

In Section 2 we outlined the large increase in the number of highly skilled Indians residing in the US. The Indian-born population in the US increased by more than half a million over the course of the 1990s alone, and an analysis of the March 2000 CPS reveals that 78 percent of these recent arrivals had a Bachelors degree or better—with exactly half in the “or better” category.

In a widely discussed study Saxenian (1999) drew attention to the impact these absent Indians (and Chinese) were having on economic success of high tech industries in Silicon Valley. One fascinating finding was that Indians were running 9 percent of Silicon Valley start-ups from the period 1995 to 1998—almost 70 percent of which were in the software sector.³³

³³ The 70 percent figure is based on all Indian-run start ups from the period 1980 and 1998.

These findings have, however, raised obvious questions about the effect that such absent talent and entrepreneurship is having on the domestic Indian economy. But the study also hints at the connections that these “absent” Indians retained and cultivated with people and businesses back home. Saxenien (2002) followed up on the possibility of these connections with an extensive survey of Indian (and Chinese) members of professional associations in Silicon Valley.

Before reviewing Saxenian’s findings, we first recap the ways our framework suggests that a human capital rich diaspora could be an international business asset. We saw that the combination of preference, knowledge, and ability to pay may make members of the diaspora willing customers, investors and purveyors of information. Their knowledge of the needs and capabilities of both US- and India-based firms make them potentially useful intermediaries in the search and matching process. Their ongoing relationships with both US and Indian firms (and with other members of the diaspora) make them well situated to use their reputations to support complex transactions when legal contracting is difficult. And their success as technologists, managers and entrepreneurs in Silicon Valley can change the perceptions of the Indian technology businesses in general.

In Section 3 we grouped the last three of these functions together under the heading of “reputational intermediaries.” It is well known that reputational concerns have been an obstacle to Indian software firms. Banerjee and Duflo (2000) provide evidence that reputation affects the form of contracts that firms outsourcing customized software enter into with Indian software firms. Indicators of weaker reputations are correlated with opting for fixed-price contracts over riskier (for the buyer) time and materials contracts. Kapur (2001) points out various ways that Indian firms have tried to lessen reputational constraints, including joint ventures with US firms, acquiring or setting up US firms, getting independent quality certifications, getting listed on US stock exchanges, and working on-site for the buyer.

Table 5 records some basic demographic information about the respondents to Saxenian's survey. The Indian respondents are generally younger, more educated, and more concentrated in executive/managerial occupations than the overall Indian-born population in the US (see **Table 2** for a comparison). 38 percent of Indian respondents classed themselves as being in the software industry, which compares with 26 percent of Chinese-born and 19 percent Taiwanese-born respondents. 98 percent of Indian respondents had a Bachelor's degree or better, with 77 percent having a Masters or a Ph.D. Interestingly, 68 percent of Indian respondents said that they earned their highest degree in the US, but this is still lower than the 81 percent of Chinese and 92 percent of Taiwanese who received their highest degree from US institutions.

In **Table 6** we reproduce a sample of Saxenian's findings on the degree of connectedness of these admittedly elite Indian professionals to those in India. 77 percent of the Indian born had one or more friends who returned to India to start a company. 52 percent travel to India on business at least once a year. 27 percent report regularly exchanging information on jobs/business opportunities with those back home, while 33 percent report regular exchanges of information on technology. In terms of the potential role of Silicon Valley Indians as reputational intermediaries, 46 percent have been a contact for domestic Indian businesses. On the investment side, 23 percent have invested their own money into Indian start-ups—10 percent more than once. And, finally, when asked about the possibility of bringing their much augmented human capital home, 45 percent report returning as somewhat or quite likely.

Saxenian's results, while suggestive of strong connections between the Silicon Valley resident Indians and those in India, should however, be interpreted with care. There are strong problems of self-selection into such associations and in the choice to respond to the survey.³⁴ There is also reason to believe that diasporas will exaggerate their contribution to the country of origin. These figures contradict what is known about the activities of Indian diaspora from other sources. One problem is that the investment data is silent on the magnitude of investments. Foreign direct investment from the Indian

diaspora is less than 5 percent of its Chinese counterparts—even though the propensity to invest is comparable for the two diasporas in Saxenian’s survey. Similarly, the finding that 45% would consider returning is belied by reality. While aggregate data on return migration is unavailable, segment specific data such as NSF longitudinal data on PhD students suggests a number closer to 10 percent.

These survey results indicate that the Silicon Valley based Indian diaspora have transnational links with the Indian IT sector. At least for this group, skilled emigration is not simply a one-way “brain drain.” Although the results are revealing, we are still left with the question of whether the loss of such evident productive/entrepreneurial potential from the Indian economy is counterbalanced by the diaspora’s role in breaking down barriers to international business for Indians who remain. One suggestive piece of evidence from the survey itself is that 73 percent of Indians responding to the question “Which factors would figure most importantly in your decision to start a business in your country of birth?” listed the “availability of skilled workers.”³⁵ This answer is interesting in the context of the tradeoff we discussed earlier between emigration thinning domestic labor markets (and thus reducing the incentive to search for business opportunities) and the role of the diaspora in helping to facilitate and fund such opportunities.

4.2 Fueling the Tiger: Irish grads come home

Showing few hints of the “Tiger” economy that would emerge in the 1990s, Irish economic performance through much of the 1980s was anemic. Between 1982 and 1989 employment actually fell by 5 percent, and the unemployment hovered in the mid-teens (OECD 2000). Throughout this period tertiary education enrollments continued to expand strongly, growing by 64 percent over the course of the decade (Clancy 2001). This growth followed rapid growth in the 50s (56 percent), 60s (129 percent), and 70s (92

³⁴ The overall response rate was 21 percent.

³⁵ Of the Indian born who had actually set up business relationships in India, 85 percent listed the availability of skilled workers as a key contributing factor to their decision. 73 percent listed the low cost of labor.

percent). It is not surprising that with such a dire labor market, and Ireland's tradition of emigration in hard economic times, a number of new graduates choose to emigrate.

Figure 2 shows the course of Irish graduate emigration from 1982 to 1997 based on surveys done by the Ireland's Higher Education Authority of the first destinations of jobs/places of study in the year following graduation (see Lydon 1999). Male graduate emigration rose from around 6 percent in 1982 to around 25 percent by the end of the decade. Female graduate emigration shows a similar trend with a peak of around 20 percent. Clearly the Irish economy was losing a substantial fraction of the human capital it was producing.

Economic performance in the 1990s has been quite different. In terms of the labor market, employment almost doubled—47 percent—between 1989 and 1999 (OECD 2000). From **Figure 2** we can see that graduate emigration fell sharply as slump gave way to boom, with the turnaround being especially large for male graduates. Moreover, as the boom gathered pace graduates who had left during the 1980s began to return home.

Figure 3 shows the history of migration since Irish independence in the 1920s. The 1950s was a particularly bleak decade for the Ireland Republic's capacity to provide livelihoods for its young people, many of whom left for the UK with limited education. Better economic conditions in the 1960s and 1970s stemmed the outflows (leading to a significant net inflow during the 1970s), but macroeconomic mismanagement, industrial restructuring away from indigenous labor intensive manufacturing, and poor global economic conditions combined to produce net emigration again in the 1980s. There are arguments in Irish policy and academic circles about what changed in the late 1980s, and a good deal of ex post rationalization, though there is little disagreement that Ireland began a "growth miracle" that gathered pace through the 1990s.³⁶

³⁶ The most plausible explanation is that Ireland was on a long-term fast growth path for some time, underpinned by its initial relative backwardness and thus opportunity of catch-up growth, increased investments in the education starting in the 1950s, and its openness to trade and foreign investment. The 1980s debacle was the result the result of poor macroeconomic conditions—partly brought on by earlier fiscal profligacy—and the

Table 7 records the number of people aged one year and over (usually resident in Ireland and present on census night in 2002) that spent at least one year outside the country. This measure captures both immigrants and returning Irish. In total, 644,444 were so classified, or 16.5 percent of the total population. It is striking that of those who stated the year they took up residence in Ireland, 42 percent report doing so between 1996 and 2002.³⁷ Assuming that relatively few U.S. citizens took up residence in Ireland over this period, it is reasonable to suppose that most of the 24,431 individuals who reported their previous residence as being in the U.S. are returning Irish.

Figure 4 shows the number of *returning Irish* between 1995 and 2001. The number of returnees peaked at over 26,000 in 1999, before falling to just over 18,000 in 2000 and 2001 as the emigrant stock diminished, Irish house prices rose, and commuting times in the major cities lengthened. Barrett and O’Connell (2001) report labor force survey data from the mid-1990s that confirms that the returning Irish were relatively highly educated. 58 percent of returning Irish emigrants—i.e. those born in Ireland but not resident in Ireland 12 months previously—had a third level degree. This compares with 29 percent for non-returnees in the labor force. For the 30 to 39 age group, 50 percent of returnees had a third level education compared with 26 percent in the non-returnee population. Thus returning emigrants provided a significant boost to human capital resources at a time that skill shortages were becoming more apparent.

How does their time spent abroad affect the productivity of these returnees? Barrett and O’Connell (2001) have estimated an earnings equation to examine how emigration affected the 1992 cohort of graduates. Using earnings data from 1998, they found that returnees earned 5 percent premium over those who never left. The premium differed sharply between men and women, with male returnees earning a 10 percent premium and female returnees earning no premium at all. For emigrants who were

working through of a process of creative destruction of older labor intensive manufacturing industries in the context of rigid and excessive real wages in low productivity firms.

deemed to have left for labor market reasons the premium was even higher—8 percent overall and 15 percent for men. Again, the premium for women was essentially zero (with a point estimate of -1 percent).

Of particular interest to the present study, Barrett and O’Connell also separately examine the premium for different industries. The computer sector had the highest overall premium at 16 percent. In contrast to the all-industry results, women actually had a higher premium in computers (21 percent) than men (11 percent).³⁸

There is also evidence that returning skilled emigrants have significantly limited the rise in skill premiums at a time of strongly rising demand for skill (Barrett et al. 2000). Since the increase in surplus to existing factors of production in Ireland from returning emigrants depends, in part, on their effect on domestic wages, this is consistent overall beneficial effect from returnees. Barrett et al. (2000) show that with net immigration of 16,000 per year between 1996 and 1999, and assuming that all of this net immigration is skilled, the supply of skilled labor increases by 3.2 percent and skilled wages decrease by 4.7 percent. A standard social surplus calculation based on these estimates yields a total gain to the preexisting population of less than one-tenth of one percent of the skilled wage bill.³⁹ This calculation, however, ignores any fiscal benefits from bringing in individuals likely to make positive net fiscal contributions, any benefits

³⁷ 36 percent of total were between the ages of 25 and 39 on census night.

³⁸ Barrett and O’Connell considered different explanations for why returnees have higher earnings than those who stay. In addition to the human capital accumulation story, they also considered the possibility of emigration as a signal of quality (positive or negative) and the possibility that it is the more able (with ability unobserved by econometrician) that choose to emigrate. Although they are cautious in their conclusions, they view their results as more supportive of the human capital based explanation than the signaling or self selection explanations.

³⁹ Applying the standard social surplus calculation (ignoring fiscal effects and externalities) yields a small surplus gain equal to 0.07 percent of the skilled wage bill. We can calculate the surplus gain as a share of the initial skilled wage bill as $1/2 \times \varepsilon \times (N/S)^2$, where ε is the elasticity of the skilled wage with respect to the skilled labor supply, N is the net immigration of skilled workers, and S is the initial supply of skilled workers (see Borjas 1995). The elasticity of the wage with respect to the supply

from increased scale or spillovers from the expanded skilled labor supply, the benefits of providing unique skills to the Irish economy, or the investment induced by larger (and cheaper) supplies of skills.⁴⁰

While evidence on how returning migrants have affected the development of the Irish software sector is limited, Sands (2002) reports survey evidence on the background of Irish software entrepreneurs that suggests a significant role for international experience. 66 percent of company founders have worked abroad and 55 percent have worked for multinational companies.⁴¹ 17 percent of Irish entrepreneurs have studied abroad. Moreover, the entrepreneurs who worked for a multinational are almost twice as likely to have worked for that company abroad as they are in Ireland. Sands speculates that this reflects the fact that the lower end activities conducted by these companies in Ireland are less conducive to spurring “indigenous innovators.”

Summing up then, it appears that the Irish economy in general, and the software sector in particular, were fueled over the latter half of the 1990s by returning Irish with augmented skills. With current evidence it is hard to determine exactly how much the software industry has benefited from the resulting improvement in skill availability and cost. One sign that the software industry had much to gain by attracting skilled workers home is that it was an active recruiter of the Irish abroad. An example of this recruitment effort was the setting up of *Opportunity Ireland* in 1998 by Enterprise Ireland (the agency responsible for indigenous industry development). The purpose of this new service was to highlight opportunities for expatriates in the software and electronics industries. That Opportunity Ireland has been disbanded is a sign that the pendulum may be swinging once again.

of skilled labor is given by the ratio of the percentage change in the wage divided by the percentage increase in skilled labor, approximately 1.5.

⁴⁰ On the other hand, it also ignores negative spillovers from rising road congestion and increased pollution. It also ignores any distributional effects that stem from rising housing and land prices.

⁴¹ 74 percent of Irish software companies have a founder who worked abroad. Not surprisingly, company founders are also highly educated: 83 have a Bachelors degree, 31 percent a Masters degree, and 9 percent a PhD (Sands, 2002).

4.1: Almost one million Soviets come to Israel: What boost to Israeli software?

Between 1990 and 2000, 847,600 members of the Jewish diaspora of the former Soviet Union immigrated to Israel—a number equal to 21 percent of the 1990 Jewish population of Israel (Central Bureau of Statistics 2001). These new immigrants were on average more educated than resident Israelis (Weiss 2000), and contained a disproportionate number of scientists and engineers. Of the 534,000 immigrants aged 15 and over who had worked abroad, 30 percent classed their occupation as scientific or academic,⁴² with a further 32 percent classed as “professional, technical and related workers” (Central Bureau of Statistics 2001).

One would expect that such a huge inflow of skilled workers was a boon to Israel’s emerging high tech sector including its software sector. However, finding a large immigration footprint turns out to be harder than, at least we, expected.

The first surprise is that this skilled-biased inflow has not lowered the skilled wage premium (Weiss 2000, Friedberg 2001). Gandal et al. (2000) explore two open economy mechanisms that could explain this puzzling absence of a wage effect. The first explanation is that the timing of the inflow coincided with a global burst of skill biased technical change (SBTC) that increased the demand for skilled workers across sectors.⁴³ This technical change explanation is consistent with a gain from skilled immigration as the increased supply of skill moves the economy down along the (now higher) skill demand curve. Put another way, the immigration prevents the rise in skilled wage costs that would have occurred due to surging skill demands.

The second explanation applies the Rybczynski Theorem to predict a sectoral reallocation of resources towards industries intensive in the use of the newly abundant

⁴² 60 percent of these scientific and academic workers are classed as engineers or architects (Central Bureau of Statistics 2001).

factor of production.⁴⁴ The resulting expansion of skill intensive sectors increases the demand for skill sufficiently to offset the increased supply, which could explain the lack of wage change.⁴⁵ Gandal et al. note their “mild surprise” that the latter mechanism—sectoral output changes—did not play a role in absorbing immigrant inflows.⁴⁶

One limitation of the Gandal et al. analysis is that it is applied at a broad level of industry classification. Thus it is possible that it misses a skill availability-driven increase in certain high-tech sectors. A recent study by the Israeli statistics agency, however, casts some doubt on this explanation as well (Central Bureau of Statistics, 2002). The study reports that high tech employment in Israel increased from 6.6 percent of total employment in 1995 to 8.0 percent in 1999. Of this high tech employment in 1999, 49 percent was in manufacturing, 14 percent in communications, and 37 percent in computers/related services and R&D. Interestingly, the computer services sector underwent the largest percentage expansion of the three sectors over this period, increasing its total employment by 83 percent from 34,700 to 63,400, so the increase in skill availability may well have fueled the expansion of this sector.⁴⁷ Given the skill

⁴³ That is, there is a broad shift in production methods towards using relatively more skilled workers, though the extent of the relative shift can differ across industries.

⁴⁴ In other words, rather than within-industry changes in the use of skilled workers, industries that use skilled workers intensively expand at the expense of other industries. This leads to an overall increase in the demand for skill.

⁴⁵ Weiss (2000) offers the additional explanation that an increase in skill-complementing capital accumulation led to the offsetting increase in the demand for skill. He also considers the possibility that immigrant inflows did not initially compete strongly with domestic skill due to the poor transferability of Soviet skills and qualifications. He finds evidence of increasing substitutability between the skills of veteran Israelis and immigrants over time.

⁴⁶ One puzzling aspect of the Gandal et al. results stems from the fact that skill-biased technical change has raised the skilled wage premium in the US. If factor price equalization was truly operating and Israeli firms had access to the new technologies, then skilled wages should rise in Israel as well—no matter what was happening to skill supplies. The mechanism to bring about the increase in Israeli wages given the common skill-biased technical change and Israel-specific increase in skill supplies should have been a reallocation of resources to skill intensive industries.

⁴⁷ The share of computers & related services and R&D sector employment in total employment remained small: the share was 1.7 percent in 1995 and rising to 2.8 percent in 1999.

requirements of these industries and the skill intensity of the immigrants, we might expect that immigrants would be overrepresented in these sectors. But this is not the case. In 1999, post-1990 immigrants represented 18.5 percent of total employment, just less than the share of post-1990 immigrants in high-tech employment. Immigrants are overrepresented in manufacturing high tech, with a share of 25.3 of the employment in that sector. But for computers & related services and R&D—which includes software—the share is actually slightly below the share of immigrants in total employment at 17.3 percent. In a survey of Israeli software firms that went public on foreign stock exchanges, Breznitz (2002) finds no immigrants from the former Soviet Union amongst the founders.⁴⁸

What can we conclude? Given the massive expansion of the skilled Israeli labor force due to Jewish immigration from the former Soviet Union, it is hard to believe that it did not aid the rapid expansion of the software sector. Yet the studies reviewed here hardly point to a significant effect. The expansion of the skilled labor force does not appear to have led to a disproportionate increase in skill intensive sectors, at least at a broad level of industry classification. When we look more narrowly at the computer services sector we do see evidence of rapid growth, though we don't see disproportionate participation by the post-1990 immigrant group. We can't rule out the possibility, however, that the inflow is having its effect more indirectly by easing the overall tightness of the skilled labor market at a time of economy-wide skill upgrading, thereby freeing new Israeli graduates for the software sector.⁴⁹

Our discussion of the Israeli case has focused on inflows of skilled workers. One concern on the outflow side stems from the substantial number of acquisitions of Israeli start-ups by foreign (typically U.S.) firms. Such acquisitions raise the possibility that

⁴⁸ Breznitz (2002) highlights an indirect effect of the immigration wave: it acted as an inducement to various government initiatives in venture capital, incubation, and cooperative R&D designed to support the high tech sector.

⁴⁹ In 1999, 55 percent of workers in the computer & related services and R&D sector were aged between 18 and 34. The share of such young workers was 45 percent in the

Israel-based human capital will be moved to the acquirer's home base. Based on an examination of the successful Israeli data security industry, Teubal and Avnimelach (2001) emphasize a different concern: that the opportunity to leverage R&D capability into broader capabilities, be it manufacturing or international marketing, will be lost when the Israeli operation is integrated into a larger entity. In the case of the server security firm MEMCO, for example, the firm's international marketing operations were dismantled after being acquired by Platinum (which was subsequently acquired by Computer Associates). So, rather than a direct loss of human capital from the country, Israel loses the opportunity to develop human capital that is complementary to its existing R&D capability.

A second concern relates to Israeli students who leave to study in the U.S. and do not return. National Science Foundation numbers do not suggest this is a severe problem (NSF 2002).⁵⁰ Looking just at PhDs, an NSF survey found 81 Israeli nationals received PhDs from U.S. Universities in 1990. Of these, 51 percent planned to stay in the U.S., with 31 percent having "firm" plans to stay. By 1999 the number of Israelis receiving PhDs from U.S. universities had dropped to 61, though the percentage planning to stay had risen (57 percent with plans to stay and 41 percent with firm plans to stay).

Section 5. Concluding Comments

Although the details of the software industry development stories differ a great deal between the three countries, the broad outlines are similar. All three countries produce impressive levels of high-end human capital; country-specific inefficiencies had meant that the human capital was poorly utilized and thus relatively cheap; and the software sector, for reasons that other papers in this volume examine, has proved relatively effective in taking advantage of this cost advantage. This is the opportunity side of the story. Yet the same international wage gap that created the opening for

high-tech industry overall, and 43 percent in the total economy (authors' calculations from Table 3 of Central Bureau of Statistics 2002).

software also creates a strong incentive to emigrate, possibly undermining the competitive advantage. But although skilled emigration is usually seen in such threatening “brain drain” terms, its effects are multi-faceted and poorly understood. In addition to the harm done by the absence of domestically produced human capital, we must also consider such factors as the commerce facilitating effects of diasporas and the possibility of skill-enhanced emigrant return. Overall, the evidence is strongly suggestive that the benefits of skilled migration have outweighed the costs for the three countries. The Indian experience in Silicon Valley, for example, shows how the diaspora can be a valuable national asset in facilitating international commerce, especially where the business is transactionally complex and reputation concerns are paramount. Although a full cost-benefit analysis is beyond our scope, our judgment is that highly skilled Indian emigration has played a key part in the development of an internationally competitive Indian software sector. The Irish experience shows how one decade’s lost human capital can, under the right conditions, become a skill reservoir that can be tapped to ease resource constraints and sustain economic expansion as domestic labor markets tighten. The experience also suggests a positive productivity effect of time spent abroad that is especially pronounced for the computer sector. And although it is difficult to find a substantial entrepreneurial footprint of Russian emigrants in Israeli software industry, such a massive influx of skilled workers almost certainly has helped to relieve wage cost pressures in this rapidly expanding sector, in part by easing supply constraints in competing sectors.

The foregoing sections have reviewed available measures of international human capital flows for the three countries, provided a (hopefully) comprehensive list of the channels through which such flows could help or hinder the development of their software industries, and applied parts of the framework to look at some specific episodes that we think have been especially important for the countries in this project. In closing we note some questions relating to each of the three countries we think provide opportunities for fruitful research.

⁵⁰ Statistics are un-published tabulations from the Survey of Earned Doctorates, Division of Science Resources Statistics.

The Saxenian (2002) study has painted an optimistic picture of the role played by the Indian diaspora in facilitating international business for home-country firms. Our assessment is that the Indian diaspora is less tightly linked than suggested by her survey respondents. More work is needed to confirm and extend our understanding of the diaspora's role. In this vein, we are currently using data on the location of patenting inventors and the location of patent citations to investigate the extent of knowledge flows to inventors' former homes (see, for example, Agrawal et. al. 2003). We are also beginning a project that uses comprehensive lists of ethnic surnames to track knowledge flows between co-ethnics. Too little is also known about the negative effects from the absence in the Indian economy of some of the country's most talented individuals. Together with a colleague (see Desai et al. 2001), we have taken a modest step to measuring part of this loss by describing the characteristics of the US-resident Indian-born population and estimating the net fiscal impact of their absence. An open question is what emigration has done to the cost and availability of technology and management skills in India. We have found evidence of significant increases in the return to higher education in a preliminary comparison of earnings regression results from the 1993/94 and (recently released 1998/99) rounds of Indian National Sample Survey. In future work we hope to untangle the effects of changing demands and supplies to identify the impact of high skilled emigration on the domestic cost of human capital. In addition, we believe it is critical to test the strong assumption that with high levels of skilled emigration there will be no bottlenecks in the supply of new human capital in critical sectors. One of us has been finding in recent field work that even India's most elite institutions—the Indian Institutes of Technology and Indian Institutes of Management—face increasing constraints in finding and hiring new faculty.

Turning to Ireland, we need to know more about the backgrounds of Irish software workers from detailed survey evidence to gauge the impact of returning emigrants on the development of Irish software firms (see, however, the work of Sands, this volume). How many software professionals are returned emigrants? And how has their international experience increased the value of these returnees through further

education, frontier firm exposure, business contacts, etc? What is the importance of the multinational sector as supplier of talent to indigenous firms? On the issue of the multinationals more generally, it would be interesting to go beyond anecdotal evidence about the role of the Irish, Indian and Israeli diasporas in tilting foreign direct investment in their country's favor to some harder evidence. One possibility is to adopt a difference-in-difference approach, comparing, say, the difference in gap between US-investment per employed worker in Ireland and Scotland and the gap between Japanese investment per employed worker in these two countries. Of course, a significant difference-in-difference could be due factors other than a larger Irish diaspora. But a significant finding would be highly suggestive nonetheless.

Finally the work of Gandal et al. (2000) has provided some intriguing evidence of how mass skilled immigration affected the Israeli labor market and industry structure. Their industry analysis, however, was conducted at too aggregated an industry level to get a good feel for how the software sector was affected in particular. A more disaggregated analysis would give a better idea of how this immigration affected Israeli comparative advantage in software.⁵¹ Other issues we think are worth exploring in greater depth are the extent of "hollowing out" of skills due to foreign takeovers of emerging Israeli software firms and Israeli company listings on US stock markets, the role of prospect of a foreign takeover or stock exchange listing on the incentive to pursue a high-tech start-up in the first place, and the long-run human capital impact of Israeli students getting advanced education abroad.

⁵¹ Breznitz (2002) also discusses the role of the Israeli diaspora in helping to penetrate foreign markets, transfer technological knowledge, and facilitate multinational investment in Israel.

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