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ABSTRACT

The Brain Drain: Curse or Boon?*

The migration of skilled individuals from developing countries has typically been considered to be costly for the sending country, due to lost investments in education, high fiscal costs and labour market distortions. Economic theory, however, raises the possibility of a beneficial brain drain primarily through improved incentives to acquire human capital. Our survey of empirical and theoretical work shows under what circumstances a developing country can benefit from skilled migration. It argues that the sectoral aspects of migration and screening of migrants in the receiving country are of major importance in determining the welfare implications of the brain drain. These issues, as well as the size of the sending country, duration of migration and the effect of diaspora populations, should be addressed in future empirical work on skilled migration.

JEL Classification: J6, F2, O1

Keywords: brain drain, migration, globalization

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1. Introduction

The term – brain drain – appears to have gained wide usage in the late 1960s when growth in the migration of skilled personnel from developing to developed countries accelerated [1]. The developed countries - by attracting scarce skilled labour - were widely held to be pursuing policies that were costly to developing countries, both in the short and longer run. The costs were not only in terms of output and employment, but also - depending on the way in which education was financed – through additional fiscal costs associated with public subsidies to education. A variety of policy proposals – mostly centred around taxation – were floated, although none were ultimately implemented. Part of this may be attributed to likely difficulties with implementation, measurement problems - including temporary migration and migration linked to education enrolment in developed countries - as well as ambiguities with respect to the welfare consequences.

Many of the same issues – and debate – have undergone a recent revival. This can be attributed to a number of factors. In the first place, it is commonly believed that the emigration of skilled labour from developing countries has again accelerated over the last decade, not least in association with the growth of information and knowledge intensive activities. Second, the developed economies have actively – and openly - set out to poach talent, using a range of incentives and institutional mechanisms for attracting skilled labour. In particular, the use of temporary skilled migrant visas whether in the USA or, more recently, in Western Europe, has been striking.

Possible explanations for why poaching has increased are various. They include, skill shortages resulting from rapid skill biased technical change as well as educational failures. Gaining access to international competence – heterogeneity - may be another factor, while access to technical or market knowledge may be another. The first explanation generally is taken as bringing in substitutes to local human capital, although this need not necessarily be the case. The importing firm would gain through lowering wage costs and/or dampening any domestic wage pressure. The other explanations may however be consistent with complementarity (at least in static or short run terms). By widening the talent pool poaching may result in the selection of the best candidates and hence impart a positive productivity effect.

At the same time, there has been growing recognition not only of the global benefits of greater mobility but also that the emigration of skilled labour may not be negative for the sending country. In the first place, emigration of talent may provide a positive signal that motivates others in the sending country to acquire more education, thereby raising human capital and possibly promoting growth. Second, emigrants may in due course return, or through networks and resource repatriation, such as through remittances, provide essential inputs to new businesses and activities in the sending country. Third, emigration may actively promote a more effective flow of knowledge and information. Fourth, the changing nature of mobility – in part due to major advances in communications technology – may be limiting the extent to which skills are actually lost. A network industry, like software, is possibly a case in point.

This paper has several objectives. First it attempts to take stock of our knowledge concerning the scale, composition and direction of migration from

[1] Note, however, that labour mobility was actually at its peak pre-1914.

developing to developed countries in the recent period. Second, it places that mobility in the context of the existing literature and third, it attempts to indicate ways in which at both an analytical and empirical level, progress can be made in better understanding the phenomenon and, in particular, the appropriate policy implications.

The paper is organised as follows. Section 2 provides a brief empirical survey of our knowledge concerning the scale, distribution and composition of skilled labour flows. Section 3 surveys a class of models developed in the 1970s that focussed primarily on the implications of emigration for labour markets in the sending countries. Section 4 surveys the subsequent class of dynamic models, in particular those that endogenise human capital decisions. We extend the analysis to take account of possible screening by developed countries. Section 5 then examines the empirical evidence for screening while Section 6 looks at the relevance of return flows, remittances and diasporas; factors that may offset some of the negative effects associated with skilled migration. Section 7 then turns to examining the relevance of economic geography models for understanding the brain drain, not least the reasons for why agglomeration occurs. Section 8 then moves on to look in a little bit more detail at two sectors – software and health – that have features that may be helpful in understanding sectoral differences. Section 9 concludes.

2. The Facts

Quantification of the movement of skilled individuals across countries – let alone the exact measurement of any associated brain drain – remains very patchy. National authorities have maintained very limited databases on migration with highly inconsistent skill or education categories [2]. There is a lack of data on the attributes of the individual migrants and the changing nature of migration – away from permanent, point-to-point migration – has itself complicated matters. Further, the link between education and migration has changed over time. For example, a significant component of skilled migration is now accounted for by students that stay on after completion of degrees.

2.1 Skilled migration in the recent period

Carrington and Detragiache (1999) provide a benchmark for skilled migration in 1990. They compiled USA census and OECD migration statistics for that year and then compared the immigrant stocks to the size of the educated population in the sending country using Barro-Lee education data for 1993. Their study has several shortcomings: in addition to possible deficiencies of the basic data they use[3], their figures fail to take into account skilled migration to the Middle East, which for countries like India actually accounts for a large proportion of the total migration. Also, the immigration to the US in their study includes all types of migration, not only employment-based, which is what is usually understood by 'brain drain'.

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[2] The UN recommends defining a migrant in terms of residence by time; short term being less than a year; long term more than 12 months. But actual definitions vary widely, as do those for skill or education levels.

[3] The problems include: many countries are not included because the lack of data and the number of educated migrants to OECD countries is estimated on the basis of the education level of migrants to the US. The estimates of educated population by Barro and Lee are partly based on historical enrolment data, and it is not clear whether the migrants are included in these estimates or not.

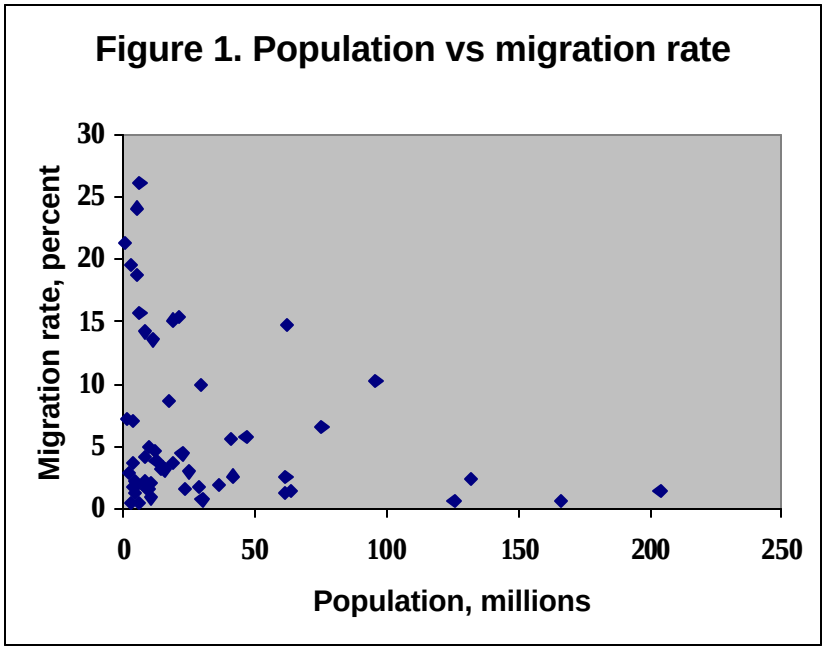
Despite their shortcomings the Carrington–Detragiache estimates are probably the best available estimates of brain drain. We use them to study the relationships between population, GDP and migration. Table 2.1 provides information on population, expenditure on tertiary education and a measure of the intensity of migration - the share of a country's labour force having tertiary education that has migrated. The share presented in the table is based on the assumption that the Barro-Lee estimates do not include the migrants. What emerges is that there are a significant number of small countries – principally in the Caribbean, Central America and Africa – with very high skilled migration rates. Figure 2.1 plots the migration rates against the country's population while excluding some clear outliers. There is a negative correlation between the migration rates and total population. The excluded outliers confirm this observation. For large countries like India and China, which dominate in terms of absolute numbers, skilled migration does not amount to a significant share of their educated workforces. Indeed, only 1.1 and 1.4 percent of India and China's skilled labour forces respectively had moved to the USA in 1990, although additional evidence – see below – suggests that these migrants come from the top end of the skill distribution. For very small countries the migration rate is of a significant magnitude. These patterns are replicated if the reference is extended to the OECD. In Ghana, for example, over a quarter of the educated labour force lived in OECD countries in 1990, the share rises to over 60 percent for the Gambia and approaches 80 percent for Jamaica.

Table 1. Population, Migration and Education Expenditure

	Population, millions	**Migration rate**	**Total Expenditure on tertiary education, per student, international $**
Fiji	0.79	21.3	.
Guyana	0.85	77.3	.
Mauritius	1.16	7.2	5080.9
The Gambia	1.22	59.1	3842.6
Trinidad and Tobago	1.29	57.2	.
Lesotho	2.06	2.9	18452.6
Jamaica	2.58	67.3	.
Panama	2.76	19.5	2006.1
Congo	2.78	0.5	.
Uruguay	3.29	3.7	2047.2
Central African Republic	3.48	1.7	.
Costa Rica	3.53	7	.
Togo	4.46	1.3	6572.2
Papua New Guinea	4.60	2.2	.
Nicaragua	4.79	18.7	.
Sierra Leone	4.85	24.1	.
Paraguay	5.22	1.9	.
Benin	5.95	0.4	2141.0
El Salvador	6.06	26.1	312.0
Honduras	6.16	15.7	1623.9
Bolivia	7.95	4.2	1176.0
Rwanda	8.11	2.2	.
Dominican Republic	8.25	14.2	1567.4
Senegal	9.04	1.6	.
Tunisia	9.34	1.6	3764.8

Zambia	9.67	5	2574.2
Malawi	10.53	2	9066.7
Mali	10.60	0.9	2573.4
Guatemala	10.80	13.5	1074.4
Zimbabwe	11.69	4.6	8783.9
Ecuador	12.18	3.8	1114.3
Cameroon	14.30	3.2	.
Chile	14.82	3.3	1670.2
Syria	15.28	3.1	.
Mozambique	16.95	8.6	.
Ghana	18.46	15.1	.
Sri Lanka	18.78	3.7	2476.9
Uganda	20.90	15.4	.
Malaysia	22.18	4.4	4901.7
Venezuela	23.24	1.6	.
Peru	24.80	3	680.5
Sudan	28.35	1.7	.
Kenya	29.29	9.9	.
Algeria	29.92	0.7	.
Argentina	36.13	1.9	2325.0
Colombia	40.80	5.6	2173.6
South Africa	41.40	2.6	.
Korea	46.43	5.7	881.0
Thailand	61.20	1.2	1618.3
Egypt	61.40	2.5	.
Iran	61.95	14.7	398.6
Turkey	63.45	1.4	3365.2
Philippines	75.17	6.6	560.1
Mexico	95.85	10.3	3459.9
Bangladesh	125.63	0.6	.
Pakistan	131.58	2.4	448.3
Brazil	165.87	0.6	.
Indonesia	203.68	1.4	387.2
India	979.67	1.1	2014.4
China	1238.60	1.4	1943.4

Source: Carrington & Detragiache,1998



Source: Carrington & Detragiache,1998

Similar exercises comparing skilled migration rates and GDP per capita also yield negative correlations. Countries where the fraction of highly educated workers and general productivity (GDP per capita) is already low also tend to lose relatively more skilled workers. Of course, this raises some difficult issues of interpretation. For instance, if the productivity of skilled labour in these countries is low because of factors, such as lack of managerial talent (Rauch 1991) and inability to achieve economies of scale that are hard, if not impossible to correct, then the emigration of skilled labour may indeed be the best outcome. We return to these questions below.

What has happened since 1990? The general consensus appears to be that skilled migration has accelerated. Yet the data are limited mainly to census and labour force surveys. Salt (1997) has arrived at some estimates for high skilled migrant flows to selected OECD countries from a number of developing and transition countries. He draws a number of (weak) inferences to the effect that the stocks of highly skilled foreign workers in OECD countries have increased since 1990. Certainly, the flows of the highly skilled have been increasing at a higher rate than those of less skilled migrants. With respect to the European Union as a whole, labour force survey data show that highly skilled migrants (ISCO categories 1-3)[4] in 1997 accounted for around 38 percent of the total migration inflow into employment but that inflow represented only a minute fraction of the total employment stock - no larger than 0.5 percent (Auriol and Sexton, 2001).

Available evidence also points to significant variation in the sectoral incidence of skilled migration. In the 1960-1970s, much of the concern about a brain drain revolved around the emigration of doctors, nurses and teachers from developing countries. Both sectors are characterised by large externalities and developing countries – by definition – remain under-provided in such services, particularly in rural areas. The possible welfare implications of emigration are

[4] ISCO (The International Standard of Classification of Occupations) categories 1, 2 and 3 include managers, professionals and associate professionals.

evident. In the health sector the likely negative effects arise from the direct impact on the population's health status with associated consequences for the productivity and welfare of the population. Further, the health sector has properties that require a balanced mix of skills (doctors, nurses, midwives etc.) and technology to be effective [5]. As such, loss of part of the skill chain may lead to substantial and adverse ripple effects.

In the recent period, it appears that substantial emigration of health workers has continued. For example, in the U.K. the General Medical Council's data show that the number of newly registered doctors who have obtained their qualifications overseas has remained high throughout the 1990s. The share of non-European Union doctors among new registrants has remained stable at around 40 percent. The leading country in terms of the numbers of registered doctors is India. Chanda (2001) has estimated that there are at least 60,000 doctors of Indian origin in the UK, which amounts to around 12 percent of the total stock of doctors in India and 30 percent of registered doctors in the U.K. [6] However, skilled emigration has become far more diversified in terms of sectoral characteristics. Indeed, much of the recent discussion has followed from the movement of skilled information and communications technology (ICT) sector workers from developing countries.

Although there has apparently been greater sectoral diversity, it is likely that migration has become significantly less diversified in terms of migrant characteristics, as educational-cum-skill thresholds have risen and evidence of screening by developed countries become more apparent. This screening feature looks to be a relatively recent innovation and – as we shall see in Section 4 – has strong implications for the sending countries. We now turn to reviewing the analytical frameworks developed for understanding the brain drain.

3. Early models of brain drain

3.1 Static analysis[7]

The welfare implications of brain drain in static models crucially depend on the assumptions made about wage setting. Some of the earliest work – particularly Grubel and Scott (1966) - was set in the context of perfectly competitive markets. With all markets clearing, wages set equal to marginal product and no externalities, there was evidently no welfare impact on those left behind, as long as domestic wage did not rise as a result of shift in labour supply. [8] This would be the case with for example factor price equalisation through international trade. Thus, the policy conclusion of Grubel and Scott was inevitably *laissez passer*. Introducing distortions, as with a gap between social and private marginal product and/or a public subsidy for education, would naturally undermine these conclusions and result in a welfare loss for those who did not emigrate. Indeed, much of the subsequent literature that

[5] Services are, moreover, not very mobile although some recent developments in telemedicine have made them slightly less dependent on the location of the health workers.

[6] According to the Medical Council of India there were 503,900 registered medical practitioners in India (Health Information of India 1998) in 1998, and the General Medical Council in the UK has a total of 193,000 doctors on their register with 5,700 overseas doctors on limited registration (Five Year Review 1995-2000).

[7] Alan Deardorff's excellent comment on this chapter offers further details of some of these models drawing explicitly on international trade theory.

[8] Johnson (1967), however, points out that the effect actually depends on how much capital the emigrants take with them. If capital is internationally mobile this argument does not hold.

emerged in the 1970s was organised around precisely these two types of departures from a perfectly competitive setting.

Bhagwati and Hamada (1974) worked with a general equilibrium framework. It was used principally to model the sending or home country labour market and to pin down the welfare implications of skilled emigration for those who were left behind and, ultimately, for the sending country. Two sets of distortions were introduced - the first relating to the wage setting, the second to the financing of education - and the implications for employment were then traced through. The model – which was subsequently widely employed - can be boiled down to a fairly simple set of blocs.

The economy produces two outputs, $(M_1 \& M_2)$ with standard neo-classical production functions, $M_1 = F_1(L_1); M_2 = F_2(L_2)$ where L_1 is the amount of skilled labour employed in production of M_1 and L_2 is the amount of unskilled labour involved in production of M_2. The two types of labour are exclusively allocated to their respective sectors. The commodity price ratio is exogenously fixed, $p_1 / p_2 = p$, and M_2 is the numeraire. The real wage for skilled workers, w_1, is determined by unions and includes an element of international emulation whereby skilled wages are partly related to skilled wages abroad. Minimum unskilled wages, w_2, are fixed by association with the skilled wage or 'leap frogging': a rise in skilled wage leading to an increase in the unskilled wage. In addition, the supply side reflects the incentive for educatio n to be acquired so long as the expected wage for educated (skilled) labour exceeds the uneducated (unskilled) wage. A fixed educational cost, k, is introduced. Unemployment enters the initial equilibrium. There is also an exogenous flow of educated emigrants, Z_1, so that the labour market balance equations read; $L_1 + U_1 + Z_1 = N_1; L_2 + U_2 = N_2; N_1 + N_2 = \bar{N}$

In this model the international integration of the skilled labour market can affect both sectors' wages through emulation and leap-frogging, as well as expected wages through the actual foreign wage *and* probability of emigration. Insofar as the latter affects education decisions, and education in turn carries a fixed cost, the channels by which skilled emigration can have an impact on the sending labour market and on welfare, more generally, are clear.

With respect to unemployment, emigration may act directly to lower skilled unemployment, but it also exerts two other effects. First, it can raise the expected wage by lowering unemployment (and hence may have a supply side effect) and this can be amplified if the emigration wage enters the expected wage. The net result depends on the elasticity of demand for skilled labour which determines whether the skilled labour wage bill increases or not. If the elasticity is lower than unity, an x% increase in skilled wages will increase the wage bill and thus be associated with a less than x% fall in employment. Thus the expected wage will have increased and the supply of skilled workers will tend to rise as a result. To the extent that the acquisition of skills through education is subsidised, this will similarly raise the cost to the sending country.

Second, if the skilled wage increases because of emigration, this may also spill over into other sectors and hence have an impact on unemployment in those other sectors. Wage leap-frogging – letting unskilled wages follow skilled wages – would simply tend to extend unemployment to the unskilled and amplify the welfare reducing consequences of skilled labour migration. With respect to national income, a rise in the skilled wage tends to reduce national income because of the

decline in the employment of skilled labour without any offsetting effect from the unskilled sector (in the case of no associated effect on unskilled wages), while the cost of education will also tend to increase. However, with the assumption of wage 'leap-frogging', the implications for national income are not so clear cut. Further, to the extent that emigration raises the wage of the emigrant, this implies that emigrants were receiving less than their marginal product. This surplus – as measured over the group – would be lost to the sending country in the event of emigration. The size of the loss depends on the extent to which such workers are replaceable.

Bhagwati and Hamada (1975) extended their early work by introducing a number of refinements to labour markets in the sending countries. For example, if emigration induced a ladder effect with remaining skilled workers now better matched to skilled, rather than unskilled, jobs thereby reducing unskilled unemployment – a variant of Harris-Todaro – then the effects of emigration could indeed be positive. By contrast, while emigration of skilled workers – such as doctors - might reduce labour market slack, it could also reduce the flow of doctors from urban to rural areas and limit any positive diffusion effect. There is some confirming evidence. From 1996 to 1998 the number of doctors working in rural primary health centres in India actually decreased by 9 percent and the total number of doctors and specialists in rural areas also fell by 4 percent. Over the same period, the number of registered medical practitioners rose by 24 percent (Health Information of India 1995-96 and 1997-98). Finally, to the extent that the external labour market is more efficient at screening workers, the result would be the loss of the most efficient to the sending country [9].

A number of dynamic models – particularly Rodriguez (1975) – had similar points of departure including, inter alia, a Harris-Todaro labour market and sticky wages. In this set-up, flexible wages implied the complete independence of all steady state factor returns from the cost of migration or the foreign wage. For sticky wages, the long run rate of unemployment would also be independent, but in the short run, any increase in the migration cost would raise unemployment. In the Rodriguez case, this was only for unskilled labour. Other differences with respect to Bhagwati and Hamada (1974) include, education not receiving a public subsidy, so that – with some restrictions – the educational decision depends exclusively on the monetary rate of return.

In short, these early classes of models treat the demand side – for emigrants - as exogenous and have a range of assumptions regarding education costs, with a public subsidy to education commonly assumed. At their heart, lies the respective specifications of the sending country's labour market. Under assumptions of wage rigidity, it was generally found that emigration would tend to lower sending country employment with the distribution over sectors being contingent on relative wage setting and ex ante employment levels.

What was lacking, however, was any systematic matching of these results to data, or indeed any disaggregation beyond the skilled-unskilled categories. Sectoral properties were ignored and there was no attempt to take the analysis to the level of the firm. Moreover, while the stylisation was always in terms of sending and recipient countries characterised by a difference in income levels, there was no attention to heterogeneity between sending countries. For example, the literature clearly signals the importance of ex ante employment and skill levels. Thus, a thick labour market for skills with empbyment slack in the sending country could

[9] See also Arrow (1973) and Spence (1974).

generate a very different set of welfare implications from a small tight skilled labour market. This points to the likely importance of size, not least at the level of the country. As we shall see, country size indeed appears to be an important factor in understanding the impact of skilled migration.

Another assumption characteristic of this literature was the dichotomy between those who emigrate and those who stay. Yet, technological change – not least the advent of modern communications – has had some radical implications for the ways in which work can be done across space. Indeed, the recent growth in software activity has been striking for its high network content, linking firms and individuals in developing and developed countries without necessarily inducing spatial migration (Section 8 contains more discussion of this point).

This early literature was also notable for containing explicit policy conclusions. The possibilities to tax brain drain and optimal tax scheme for migrants were extensively explored (see, for example, Bhagwati 1974a, 1974b, 1989). Bhagwati and Hamada (1974) proposed a tax on emigrants, with that tax levied by the receiving (developed country) party and transmitted in one form or other to the sending (developing) country. In terms of the impact on the incomes of those that did not emigrate, two channels could be identified. There is a direct revenue effect, which would depend on the elasticity of emigration with respect to taxation. The second set of indirect effects would affect employment through the impact on expected and actual wages. To the extent that this elasticity of emigration with respect to the tax was less than unity, the income of those left behind would improve. However, other work in this area – such as McCulloch and Yellen (1975) – was more ambiguous in its findings. Not only could total labour earnings fall under plausible assumptions, but a tax would likely raise the relative wage of non-migrating skilled workers at the expense of unskilled workers (and hence have distributional implications), while also affecting the relative size of modern and traditional sectors.

The practical aspects of taxing non-resident citizens are also problematic. In some countries (e.g the USA, Mexico, Philippines) taxation is indeed based on citizenship. Enforcing a tax on non-residents has, however, proved difficult, and extensive assistance of the receiving countries would be required for successful implementation of the Bhagwati tax (Pomp 1989). The idea has been resurrected recently by Desai, Kapur and McHale (2001, 2002), but they also recognise the difficulties and end up suggesting a new research agenda, rather than presenting concrete conclusions about what form the tax should take.

3.2 Empirical foundations

What empirical relevance do the early models have? Estimates of relative wages across countries with appropriate controls are scarce. Nevertheless, all the available (and generally biased) estimates of relative wage differentials signal substantial wage gaps for most categories of skilled workers when comparing developing with developed countries over time. For example, for the software sector, Arora et al. (2001) have compared salaries of professionals in India and the USA. The numbers are for starting salaries in large establishments but they do not control for characteristics like experience or education. What emerges from this biased comparison is that salaries in the USA for some occupational categories are at least ten times higher than in India while generally salaries in the USA are several multiples those in India.

Indeed, other evidence confirms that skilled workers systematically earn less – adjusted for purchasing power – in developing than in developed countries. A recent study of new immigrants to the USA, for example, finds that the average immigrant realized major earnings gains over their last job abroad. Men experienced a 68 percent increase in earnings and women a 62 percent increase. New immigrants who came primarily for work reasons experienced by far the largest increases in earnings. [10]. The reasons for such persistent wage differentials are interesting, not least because skilled wage differentials in favour of developed countries contradict the predictions of much modern growth theory [11].

That there is a substantial income differential across countries that motivates emigration is hardly surprising news. What of the impact on the sending countries' labour market? In particular, can we find evidence of widespread emulation effects? Data concerning occupational wages of professionals in developing countries is scarce. Using Indian data Arora et al (2001) and Kumar (2000) have found that one of the major problems perceived by Indian ICT firms is a shortage of skilled labour. Further, the late 1990s boom in the Indian software sector has clearly been associated with increased demand for engineers and there is evidence of this forcing up skilled wages.

We lack quality data on the two sectors – software and heath – that we are particularly interested in, but the limited and anecdotal evidence that we do have suggests large order differences in wages between their last employment in a developing country and their employment in a developed country. Part of this can of course be attributed to differences in physical capital per worker, but much can be attributed to technology, access to high quality capital, network externalities and so on.

Finally, there is the central question as to whether human capital formation has an impact on performance. The recent empirical growth literature has, for example, generally found that increases in educational attainment have not had any significant and positive impact on growth [12]. Part of this may be attributable to imprecisions in the measurement of education. In addition, there is evidence that suggests that the relatively low gains from the match between education and jobs posted in many developing countries may be at the heart of the problem. This points to possible mismatch between acquired skills and the quality of jobs on offer.

3.3 Cost of education and its financing

The characteristics of the education system are of major importance for the potential costs and benefits in these traditional models of brain drain, as well as for the possibility of a 'beneficial brain drain' to which we turn later in Section 4.

A cost to developing countries that has been widely highlighted concerns lost educational investment. Indeed, in most developing countries at least some part of the cost of education is borne by the government, partly because the social return from education is higher than the private one. However, in the last decade, there has been an increase in the provision of private educational services in many developing countries where the cost is largely, if not exclusively, borne privately. However, even when this is the case, any additional social returns to education, as

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10 Jasso, Massey, Rosenzweig and Smith (2000); Jasso, Rosenzweig and Smith (2000).

11 On the assumption that human capital is immobile, this should imply that both skilled wages and the skill premium should be higher in developing than in developed countries, Easterly and Levine (2001).

12 For an overview of this literature see, Easterly and Levine (2001), also Pritchett (2001).

well as public investment in primary and secondary education, are lost when an individual emigrates.

Estimating the exact cost of education is a very difficult task and the result depends on the approach that is taken in allocating fixed costs across outputs. There are some available cost estimates. For example, the total cost of a medical degree in India has been estimated to be eight times annual GDP per capita (Jayaram 1995), and for engineering degree four times annual GDP per capita (Salim 1996). World Bank/UNESCO data (reported above in Table 2.1) show that average government expenditure per student on tertiary education varies a lot, but mostly lies in the range of 1000-3000 (international) dollars. In both China and India the expenditure is around 2000 dollars per student.

Yet simply assuming that the education costs in developing countries are largely publicly financed misses some important innovations in educational services supply and financing that has occurred in the 1990s. These may in turn have been positively influenced by the emigration of the skilled. For example, in India private institutions have begun training specialists for the software industry. According to Arora et al (2001) while the supply of engineering graduates from the main public educational institutions is relatively inelastic in the short run, due to private training the supply of software professionals has increased substantially, dampening the wage effect of the demand side changes.

In China there is also a number of private institutions. It has been estimated that there has been a strong expansion of private education since the 1980's. According to the official figures in 1998 there were 1274 private tertiary institutions, the majority of which prepare students for national exams rather than confer degrees. However, an estimated 4 million students study in private tertiary institutions, not recognised by the Ministry of Education. (Dahlman and Aubert 2001.)

Of course, such innovations have had little or no impact in sectors where certification and regulation have been far tighter. Both healthcare and teaching are cases in point. Indeed, it is still broadly correct to assume that the bulk of doctors, nurses and teaches in developing countries receive substantial public subsidy to their training. Although the question of new methods of financing higher education has been raised strongly, in most developing countries students' own contributions to the costs of higher education are still small (Johnstone 1998; Tilak 1996 and Jayaram 1995).

4. Endogenous Growth and the 'Beneficial Brain-Drain'

4.1 Analytics

A recent literature has located the brain-drain in explicitly dynamic models and has, on the whole, come up with significantly more optimistic results than the earlier work discussed in Section 3. The central proposition is that if the possibility of emigration encourages more skill-creation than skill-loss, sending or home countries might increase their stocks of skills as opportunities to move or work abroad open up. If, in addition, this accumulation of skills has beneficial effects beyond the strictly private gains anticipated by those who acquire the skills, the whole economy can benefit. Examples of such benefits include enhanced intergenerational transmission of skills and education (Vidal, 1998) and spillovers between skilled workers (Mountford, 1997).

There are two critical features of these models. The first is the nature of the social benefit resulting from higher skills, for which several approaches are evident. In the simplest form Stark, Helmenstein and Prskawetz (1997, 1998) merely assume that increasing the average skill level of the sending economy is desirable. Mountford (1997) postulates a production externality whereby the productivity of current labour depends positively on the share of the population who had education in the previous period. Beine, Docquier and Rapaport (2001a) formalise this by allowing the average skill of one generation to pass directly to the next, who can then build on it by taking education. In all these cases, emigration has a negative direct effect by draining skilled labour out of the sending economy - a 'drain' effect - but a potentially beneficial effect in encouraging human capital formation - a 'brain' effect.

Vidal (1998) assumes an intergenerational transfer whereby the higher the human capital level of one generation, the more effective is the human capital formation of the next generation. This too would seem to be a force for divergence, for skilled emigration would appear to make future human capital acquisition cheaper in the receiving country and dearer in the home country. But, in fact, Vidal prevents this by assuming that, for the purposes of the spillover, migrants' human capital remains at home. This makes no sense for permanent migration - the traditional and main concern of the brain-drain literature - but it may be plausible for temporary migration, an area of more recent interest. In particular, if we are interested in modelling an ability to sell labour services at higher prices abroad while effectively maintaining domicile at home, then it may be reasonable to assume that intergenerational spillovers are likely to be at home. In this case, work opportunities abroad may exert a positive impact on developing countries' ability to accumulate human capital [13].

The second critical issue for the beneficial brain-drain is the mechanism that generates an increased incentive to acquire education but leaves some skilled workers back at home. All the current literature starts with wages for given levels of skills / ability being higher abroad than at home. From there, the predominant approach – Mountford (1997), Stark, Helmenstein and Prskawetz (1998), Vidal (1998) and Beine, Docquier and Rapaport (2001a) – has been to assume that there is uncertainty about the ability to migrate, so that of N who acquire education only pN ($p < 1$) actually emigrate. If p were unity, a permanent brain-drain could not be beneficial as all the incremental education would be lost. A further critical assumption is that the probability of migration is fixed and exogenously given for any individual would-be migrant. This implicitly arises because foreign firms cannot screen migrants to distinguish the able from the less able and it is this market failure that makes it possible for the brain-drain to be beneficial.

We can illustrate the importance of this assumption, using a highly simplified model which nonetheless captures Mountford's (1997) important insight. Following Beine, Docquier and Rapaport (2001a), assume that ability is uniformly distributed between A_{min} and A_{max} and that education yields *private* returns that increase with ability, as in the line in Figure 2, *"with educ"*. With a given private cost of education, indicated by the horizontal line, people with ability between A^* and A_{max} find it profitable to take education. At point A^* private cost of education equals expected returns. Now, allow for the possibility of migration for educated

[13] Such temporary movement of workers is the subject of negotiations under the WTO, at least so far as services provision is concerned - see Winters et al (2002).

people. If an individual can migrate, his or her private returns increase to the line *"with educ and migrn"*. With a probability of migration $0 < p < 1$, the expected returns to education lie between the domestic and emigration rates of return - say along *"E (with educ and migrn)"*, and individuals between A^{**} and $Amax$ will take education. Of these, however, a proportion, p, will emigrate leaving the domestic economy with $(1 - p)$ $(Amax - A^{**})$ educated people, which may or may not exceed $(Amax - A^{*})$. Adding social returns to education is conceptually simple, for they have no immediate effect on private decisions. For simplicity, let social benefits be proportional to the stock of educated remaining at home, i.e. d $(Amax - A^{*})$ with no migration, and $d\,(1 - p)$ $(Amax - A^{**})$ with migration.

Figure 2: Mountford – the possibility of migration raises expected returns to education.

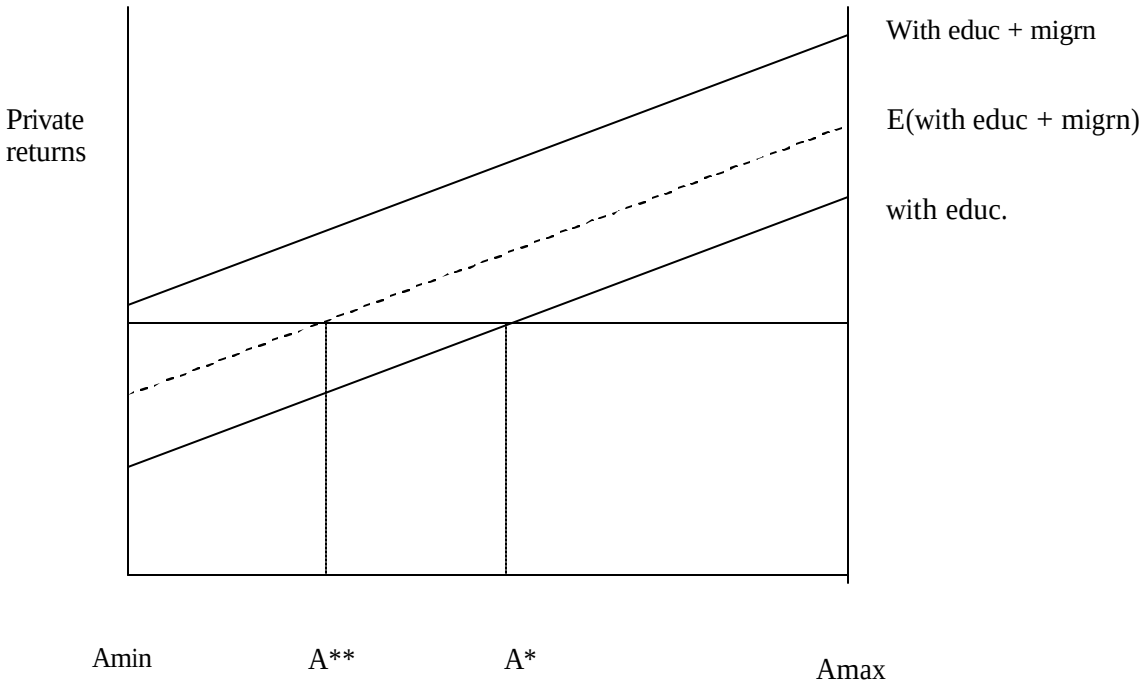
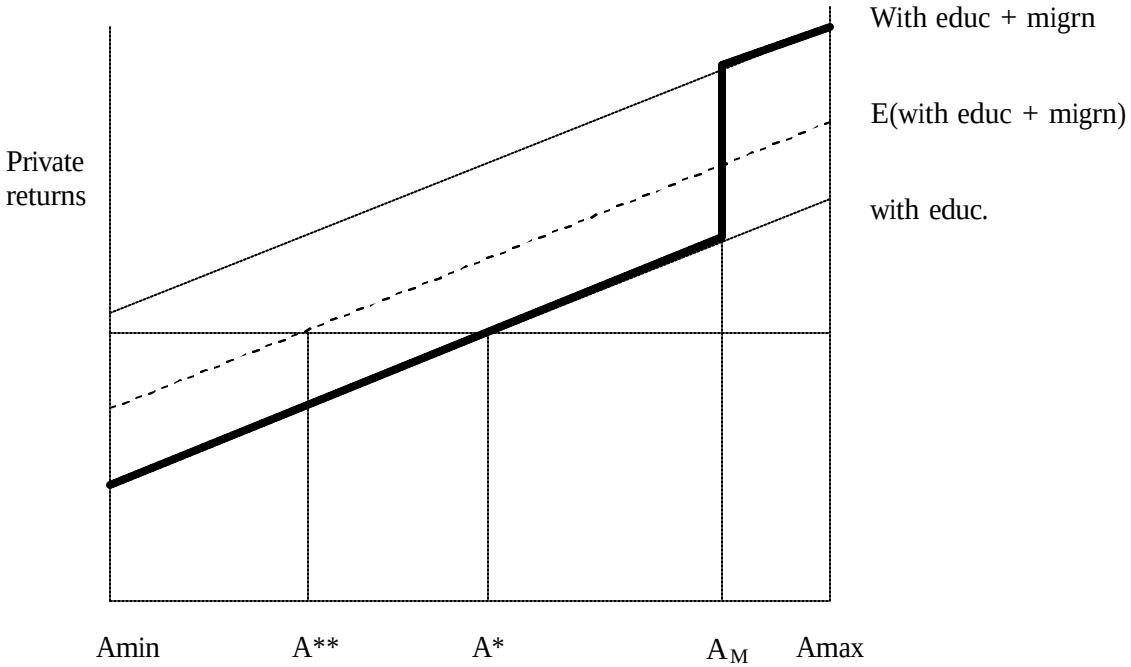


Figure 3: Mountford with perfect screening: the incentives for the marginal student do not change because they will never be chosen for migration.



The possibility of migration raises expected welfare for anyone who takes education. Hence there is an increase in aggregate private income, although, of course, some individuals who do not manage to emigrate will regret their education decisions ex post. The uneducated see no direct change in private returns and welfare and consequently gross private income rises when migration is permitted. What happens to aggregate welfare, of course, also depends on the social benefits of education.

Fundamental to this story is that every educated individual has probability p of emigrating - hence all of them experience increased expected returns, so that in our linear example line *"E (with educ and migrn)"* lies uniformly above *"with educ"*. But now suppose that the country or organisation of immigration can screen migrants perfectly for ability. They admit immigrants but only from the top echelons, so that if, say, they want M people from our target country, they get the top M lying between A_M and *Amax* in *Figure 4.2*. If this is known, the incentives for individuals with ability below A_M are unchanged. The private returns to education follow the thick line in *Figure 4.2*. (*Amax* - A^*) are educated, of whom (A_M - A^*) remain. The increment to total private income is larger than if the migrants had been randomly selected, because the same number of migrants makes gains but no-one makes *ex post* education decisions that they regret. However, there is a loss of social welfare of dM, as M educated people are lost and the social welfare was proportion d of the number of educated individuals.

Clearly perfect screening is implausible, but even with imperfect screening all that would happen is that the vertical section of the thick private returns line would become sloped. But for so long as it meets *"with educ"* above A^*, offering migration would affect no-one's education decisions. Thus, a necessary criterion for a beneficial brain drain to have any chance of applying is that the marginal person in education has a positive probability of emigrating.

Of course, actual decisions about education are taken with respect to subjective probabilities of migration not *ex post* observed probabilities. Thus, if individuals are overly optimistic about their prospects, marginal candidates may believe they face improved expected returns even when they do not. In line with most long-run modelling, however, we discount ever-lasting errors of this sort and presume that eventually subjective probabilities converge to actual ones.

The importance of effective screening is also evident in Stark, Helmenstein and Prskawetz (1997) who distinguish between education and innate ability. For them, the increased incentive to acquire education among less able workers is that, while foreign firms can recognise educational qualifications they cannot, at first, distinguish high from low ability workers. As a result, for a period they offer all migrants with a given level of education the same wage (the mean level averaged over ability for that level of education), with the consequence that less able workers are 'over-paid'. Over time foreign firms may discern workers' true ability and offer 'appropriate' wages, at which time the benefits of emigration erode and, at least with finite probability, the workers return home. Even if they have acquired no skills or networks abroad, they are better educated than they would have been in the absence of migration. In this case it is precisely the imperfections in screening - how quickly and with what probability foreign firms discern true ability - that create the incentives to acquire education.

A possible development of the screening model is that the sending or home country has some unexploited capacity for education, in the sense that the returns to education are primarily determined by the demand for skilled workers rather than the ability of the population. In this case even a perfectly screened emigration

would generate net benefits. Suppose that as the workers between A_M and $Amax$ migrated, they left openings for newly educated workers to take jobs with precisely the same returns. The net effect on the home economy would be to have the same number of educated workers as without migration and hence the same spillovers, but M fewer uneducated workers. This would raise average incomes slightly (and average skill-levels, which in some models is important). In addition, the migrants would record positive private gains.

It is also worth mentioning that the positive effects of brain drain for the sending country could also arise from a different mechanism which is related to the terms of trade as opposed to education. As Davis and Weinstein (2002) point out in their work, a technologically superior country, like the US, is likely to experience inflow of all factors of production, including skilled and unskilled labour. This will eventually lead to deterioration of its terms of trade and consequential gains for the labour-sending country.

4.2 Empirical extensions

An important step forward in the literature on the beneficial brain drain is due to Beine, Docquier and Rapaport (2001a, b) who aim to test the model empirically using cross-sectional data. Their first attempt was hamstrung by data difficulties (e.g. having to use gross migration to proxy the brain drain), but it demonstrates that the probability of emigration does appear to boost human capital formation in poor countries and that the stock of human capital does appear to influence growth positively [14]. These are both necessary conditions for the beneficial brain drain.

Beine, Docquier and Rapaport (2001b) advance these results in several ways. They use Carrington and Detragiache's (1998) dataset that covers more countries, as well as a fuller set of additional explanatory variables in the equations for migration, human capital and growth. The new estimates reinforce the earlier results except insofar as the marginal effect of migration on human capital formation appears to apply equally to all countries, rather than more strongly in the poorer countries, as the theory would predict. They also go on to use their estimates to decompose the effects of migration into a 'brain' effect - human capital accumulation - and a 'drain' effect - losses due to actual emigration. They identify several countries which would benefit from a decline in 1990 stocks of skilled emigration (i.e. reducing the outflow and receiving some nationals back). These countries typically have high rates of emigration coupled with relatively ineffective education and training systems. Some would even benefit from a complete ban on skilled migration. Interestingly, however, the loss of growth due to emigration appears to be rather small, of the order of 0.05% p.a. The obverse of these results is that countries would typically gain from higher emigration if they currently have low rates of emigration and low levels of human capital. (That is, where the costs of further emigration are relatively low and the benefits in terms of incentives relatively high.) There are limited numbers of countries in this class, but they include the larger developing countries, such as Brazil, China and India.

These results are promising. The basic finding that a beneficial brain drain is possible seems quite robust. Their subsequent translation into policy recommendations towards skilled emigration, however, is fragile and cannot be

[14] This latter finding is, of course, rather different from the results of much of the empirical growth literature, see Pritchett (2001).

viewed as anything other than illustrative at present. It depends on point estimates from only one functional specification. Given that theory offers so little information on how precisely to model the relationship between the variables concerned, a great deal more testing of functional forms and more attention paid to estimation and data errors will be needed.

5. Screening: Empirical Evidence

The discussion in Section 4 pointed to the possible importance of screening. In addition, we have already indicated that there appear to be strong sectoral dimensions to skilled migration. What evidence – if any - is there that these features have become more important in the recent period? Certainly, a closer look at targeted visa programmes established in the last decade, as well as information on the job and location choices of developing country students who have received some part of their education in a developed country - in this case the USA - may be instructive.

The clearest example of screening is the visa programme implemented by the USA since the late 1980s and known as the H1-B visa. This programme admits professional and specialised workers for up to six years on the basis of employer's declaration that US workers are not available at the prevailing wage. However, although initially temporary, if an H1-B visa holder can find an employer to sponsor their certification, he or she can eventually become an immigrant. Over the 1990s, the quota for H-1B visas has increased steadily and is currently at around 195 000 per year. Table 5.2 gives the relative shares of selected major source countries of H-1[15] visa issuances, based on Visa Office statistics quoted by Lowell (2000). It is not possible to extract the exact share of all individual developing countries in total issuances from this data, but it is obvious from the total share of developing countries that their importance as source countries has been growing steadily. In 1999 at least 58 percent of H-1 visas were granted to individuals from developing countries and this figure has risen since the early 1990s.

Table 2. Total Issue of USA H-1 Visas & Sending Country Shares 1989-1999

	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
India	4.4	4.6	6.9	10.7	18.0	22.9	26.3	32.0	39.3	44.0	47.2
China	1.7	1.0	1.9	1.7	2.4	2.5	3.2	3.9	4.0	4.2	5.0
Philippines	12.4	12.4	12.2	14.6	18.0	17.8	17.0	7.7	3.3	3.0	2.6
Mexico	6.0	6.4	5.4	4.8	3.1	2.3	2.5	3.2	3.5	2.5	2.1
Russia	4.6	6.3	6.6	3.2	4.5	2.5	2.0	2.1	1.7	1.5	1.4
Total LDCs	29.2	30.8	33.1	35.1	46.0	48.1	50.9	48.8	51.8	55.4	58.2
UK	13.6	12.2	14.8	13.0	9.5	8.6	8.1	9.3	8.6	6.9	5.7
Japan	7.5	6.5	8.7	5.4	5.1	4.5	3.5	4.0	3.6	3.1	2.9
France	4.7	3.9	4.1	3.3	2.1	2.0	2.1	2.4	2.3	2.3	2.3
Germany	3.7	2.8	3.2	2.9	2.4	2.2	2.5	2.5	2.6	2.5	2.1
Australia	1.8	1.4	1.9	1.9	2.0	2.1	1.8	1.9	1.8	1.8	1.4
Total developed	31.4	26.8	32.6	26.5	21.1	19.5	17.9	20.2	19.0	16.7	14.3

[15] H-1 visas include H-1A and H-1B visas, H-1A being the visa type issued to registered nurses. The number of H-1A visas has been very small after 1995.

countries											
Others	39.4	42.4	34.3	38.4	32.9	32.4	31.2	31.1	29.3	27.9	27.4
Total no. of visas	48820	58673	59325	51667	42206	49284	59093	60072	80608	91378	116695

Source: Lowell, 2000.

The new Immigration and Naturalization Service Non-immigrant Information System[16] has detailed records on admissions of non-immigrants into the United States since 1996. These numbers are much larger than the actual visa issuances, because each entry of a visa holder is recorded, rather than the number of individuals with permission to enter the United States. These data also show that since 1996 the share of H-1 admissions of nationals from developing countries has increased from 53 percent in 1996 to 74 percent in 1999. The ratio of admissions to issuances (which in general is much higher for nationals of developed countries) has also increased for some developing countries. For example, for China the ratio was 1.88 in 1996 and 1.97 in 1999, and for Russia the ratio has increased from 1.75 to 2.16 during the same period. This may indicate a change in the nature of immigration.

However, what is particularly striking is the rapid growth in that period of H1-B visa holders coming from just one developing country; India. Since 1995 Indians have accounted for over 40 percent of all H1-B visas. Needless to say, the these migrants have accounted for a minute share of the total receiving and sending labour forces, but a non-trivial share of their respective sectors, particularly at the sending end. A very rough estimate suggests that the stock of Indian H1-B visa holders at the end of the 1990s may have accounted for around 30 percent of the India-based software labour force[17]. Other advanced economies – particularly in the European Union – have also begun to operate visa programmes designed to attract skilled workers for the ICT sector [18].

The growth of the H1-B visa category has a great deal to do with the overall growth of the ICT sector and the software industry, in particular. A recent estimate has put the new immigrant share of ICT workers at around a sixth [19]. But it would be misleading to view this as simply the long run movement of skilled labour away from developing countries. Indeed, it is precisely in this period that ICT - including software - sectors have grown in India and China. Particularly in the former case, this has been associated with the advent of tightly networked communities of firms and individuals that have spanned continents enabled by advances in communications technology. Saxenian (2001) has argued that these new networks of highly mobile professionals, and linked firms, operating over a range of spatial locations violate a more simplistic view of knowledge and asset transfer. However, such networks – though enabled by advances in communications – may still be associated with divisions of labour that may not necessarily work to the advantage of the developing country or firm.

Turning now to the education channel, over the 1990s there has been strong growth in the numbers of students from developing countries pursuing

[16] The numbers of admissions from the system are reported in INS Statistical yearbook. 1997 records were not published because of reengineering of data entry and database management components.

[17] This estimate is based on the sum of H-1B visa issuances in 1997-1999 and an estimate of total professional employment in software sector in India, presented by Rajetva Ratna Shaath from the Ministry of Information Technology 23/10/2001, http://www.nasscom.org/events/india_eu_it_summit/shah_srr.ppt

[18] See OECD (2001b).

[19] Of course, this includes new immigrants from other developed countries. See Guellec and Cervantes (2001).

education in developed countries. The proportion of students who were foreign in the OECD countries rose by 4.6 percent between 1995 and 1998 (OECD 2001b), with as much as half of these being from developing countries [20]. For example, by 1998/99 just over 10 percent of all international students enrolled in US higher education were from China and a further 8 percent were from India. At a doctoral level, between 80-90 percent of these students were enrolled in science and engineering faculties [21]. Clearly a significant share of such students have tended to stay on, but quite what proportion do return home is unclear. Guochu and Wenjun (2001) hazard the view that roughly a third of Chinese students return home on completion of their studies but for those Chinese who have studied in the USA the rate of return has been lower at under 15 percent. One survey found that only 19 percent of the 160,000 Chinese students who studied in the USA between 1978-1998 had returned home [22]

Other examples of return migration exist. Following a large outflow of students from Taiwan to the USA in the 1960/70s, returnees increased dramatically in the 1980s and have indeed played a central role in subsequently developing that country's ICT sector. This is partly reflected in a National Science Foundation study of doctoral students work intentions covering the period 1988/96. Of those surveyed, between 80-85 percent of Indian and Chinese doctoral students intended to try and stay in the USA.. This figure falls to under 50 percent for Taiwanese students (see Table 5.3). The share of Chinese and Indian doctoral students with firm plans to stay was around 50 percent and for the Taiwanese under 30 percent. Clearly, there are several factors at work here. One is the ability to secure employment in the USA; another is the average income level in the developing country as well as the ability to absorb returnees [23].

The relationship between screening, talent and relative earnings still poses major empirical challenges. However, it is interesting that – albeit in a relatively small sample of members of the US National Academy of Sciences and National Academy of Engineering – foreign-born scientists have tended to earn significantly more on average than native ones [24]. This might suggest that they represent the higher end of the ability scale (if we assume that abilities have the same distribution in all countries) and/or that they have the incentive to put more effort into their work. Of course, selection in abilities can occur through selection in the initial emigration decision, screening by employers in the receiving country, as well as selection occurring through return migration. Whatever the channel, if screening is efficient the result will be that the developing country loses some access to its best talent; quite what part depends in part on the sector. To the extent that the best talent leaves, there may be non-trivial implications for the developing country's ability to implement technological progress and move activities up the value chain.

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[20] OECD Education Database. Different countries have slightly varying definitions of foreigners, and thus exact numbers cannot be given.

[21] See OECD (2001).

[22] Cited in Saxenian (2001).

[23] Bratsberg (1995) has studied the determinants of the return rate of students from different countries in the United States. Returns to education in the source country are inversely related to the rate of staying in the USA, as might be expected.

[24] Guellec and Cervantes (2001).

Table 3. Number and percent of foreign S&E doctoral recipients with plans to stay in the United States, by selected countries/regions: 1988–96

Region/country	Foreign S&E doctoral recipients				
	Total	With plans to stay	Percent	With firm plans to stay	Percent
Total: Selected countries	55,444	34,917	63.0	21,779	39.3
Asia	43,171	28,280	65.5	16,964	39.3
China	16,550	14,145	85.5	7,935	47.9
India.	7,843	6,200	79.1	4,290	54.7
Korea.	8,851	3,197	36.1	2,005	22.7
Taiwan.	9,927	4,738	47.7	2,734	27.5
Europe.	8,760	4,898	55.9	3,521	40.2
France.	653	275	42.1	181	27.7
Germany.	1,283	714	55.7	520	40.5
Greece.	1,343	710	52.9	494	36.8
Italy	658	288	43.8	198	30.1
United Kingdom	1,132	784	69.3	595	52.6
Other Western European Countries	1,725	870	50.4	655	38.0
Scandinavian countries	612	276	45.1	195	31.9
Eastern Europe	1,354	981	72.5	683	50.4
North America	3,513	1,739	49.5	1,294	36.8
Canada.	2,387	1,322	55.4	1,027	43.0
Mexico	1,126	417	37.0	267	23.7

Source: Saxenian, 2001.

6. Remittances, Diasporas and Return Flows

It is has long been recognised – but not explicitly modelled in this literature - that any adverse consequences of skilled emigration might be partly or wholly offset by remittances and return migration. Return migrants could come back with enhanced skills.

As usual, the data limitations are severe. Concerning remittances, aside from considerable imprecision in the aggregate numbers, it is not possible to separate out the volume of remittances coming from migrants of different skill groups [25]. Such information that is available confirms that remittances vary systematically with respect to income, conditions in the sending country, planned duration of stay and household attributes [26]. It is likely that remittances from highly skilled migrants follow a very different pattern from those of low skilled migrants.

As to return migration, a positive channel would occur when migrants return with experience, financial resources, links to networks and skills from a stay abroad that are then productively deployed at home. Of course, these effects are

[25] Remittances are discussed in detail and existing research reviewed in Puri and Ritzema (2000).

[26] For example, Straubhaar (1986) for a study of remittances to Turkey.

not fixed but interrelated with each other, as well as remittances, as incentives to remit, as well as save, depend on the planned duration of migration, which in turn depends on migration and visa policies as much as individual intentions. In general, individuals can decide to return if the migrant prefers consumption in the sending or home country, if prices are lower there or if human capital acquired in the receiving country is more valuable in the sending country (Dustmann 1996).

There is some evidence that return migrants tend to choose self-employment or entrepreneurial activity not least because their savings diminish credit constraints. For example, Dustmann and Kirchkamp (2001) have studied returning Turkish migrants and their choice of activity and migration duration as a simultaneous decision. They find that most returnees choose self-employment or non-employment, and that highly educated individuals are more likely to be active after return. Ilahi (1999) has studied occupational choices on return and finds that the level of savings is positively correlated with the choice of self-employment on return. Similarly, McCormick and Wahba (2001) use survey data to investigate links between savings, overseas work experience and choice of activity after return. They find that duration of stay overseas along with savings increases the probability of becoming an entrepreneur for literate return migrants, which would suggest that skills obtained overseas have are useful on return. Positive effects from return migration obviously in turn depend on a variety of factors, including government policy in the sending or home country (see Castles (2000); Dustmann (1996)).

Another important aspect of return migration is the possibility that it is a result of screening of the migrants. Borjas and Bratsberg (1996) have studied the out-migration decisions of foreign-born people in the USA, and conclude that return migration accentuates the type of selection that generated the immigrant flow. In other words, if emigrants represent the high end of the skill distribution in the source country, the returnees are the least skilled of the emigrants. Cohen and Haberfeld (2001) also find that Israeli immigrants returning from the United States are likely to be negatively selected from those Israelis who emigrated in the first place. Reagan and Olsen (2000) on the other hand do not find any skill bias in return migration in their study on the National Longitudinal Survey, when skill is measured with Armed Forces Qualifying Test.

In sum, studies of return migration suggest that those who return may be those that have performed relatively poorly when abroad; the best migrants tend to stay. Of course, these observations do not necessarily hold true for all different migrant groups or countries. Furthermore, other related research suggests that aspects that do not require return migration of skilled individuals, can be of major importance. Such channels for beneficial effects are exports, business and network links related to diaspora populations. There is evidence that such diaspora can have very beneficial effect on exports. (Rauch 1999, Rauch and Trinidade (2000).) Similarly, foreign direct investment and venture capital – particularly in the recent period - have often been related to ethnic networks. An example of this is the Hsinchu Science park in Taipei, where a large fraction of companies have been started by returnees from the United States (Luo and Wang 2001). There is some evidence of these types of networks effects being quite powerful in the Indian software industry.

7. Economic Geography Models

We now turn to the recent economic geography literature (Krugman, 1991; Fujita, Krugman and Venables (FKV), 1999) which brings together in a formal way two of the key elements of the brain drain story - labour mobility and a tendency for uneven development (core-periphery outcomes). The unique contribution of this literature has been to show that uneven outcomes are possible even when countries have identical starting points and when there are no direct spillovers between mobile workers or market failures in the labour market. Rather, their 'unevenness' stems from the pecuniary externalities implicit in the interactions between imperfectly competitive firms. *Appendix 1* attempts a re-labelling exercise to see how far geography can help us to understand high-skilled migration. Here we summarise the main points.

Economic geography models show how economies of scale and transaction costs can combine to determine the level of industrial concentration. The former are necessary for concentration to emerge at all, whereas the latter curtail concentration because they increase the benefits of locating production close to demand. The simplest geography model formalises the notion of cumulative causation in the industrial sector. Imagine an initial expansion of industry in one country. This draws industrial labour into the country from elsewhere and this labour increases the country's demand for industrial output. This, in turn, is met by local producers because, being local, they avoid the transportation costs (and tariffs) faced by overseas producers. Thus, higher sales stimulate output which in turn stimulates labour demand, and so on. The constraint on this process in Krugman (1991) is the existence of an agricultural sector that cannot move and as a consequence generates demand for industrial goods that cannot be concentrated. In extreme versions of the model, with two identical countries, two sorts of outcome are possible: the complete concentration of industry or an equal split between the two countries. At very high transportation costs, perfect diversification rules, whereas at low costs perfect concentration does. In between there is a range where both equilibria are stable. Precisely where this lies depends in part on the relative sizes of demand from mobile and immobile workers. If demand from the latter is large, agglomeration may not be possible, and certainly will not occur until trade costs have fallen very substantially. When economies of scale are not 'too strong', and there are many countries in the world, the model generalises to create several agglomerations, as indeed are observed.

If we think of industry as being the hi-tech sector and agriculture as the rest of the economy we have a potential model of the brain drain as industrial (high-skill) labour migrates in the process of concentration. Moreover, if we add in some further frictions to the model - such as congestion costs - where industry agglomerates and an unwillingness by some hi-tech workers to move, outcomes between the two extremes are possible.

Reinterpreted geography models suggest three significant conclusions. First, the pressure for a brain drain may vary as the parameters of the world economy change. In particular, the pressure for the agglomeration of industry, and thus of the factors of production used in industry, depends on the costs of international trade of final goods. If the latter are very high, production is constrained to locate close to demand and provided the latter starts off relatively dispersed over space, agglomeration never gets underway. As trade costs fall, for either policy reasons (lower barriers) or with technological advance, agglomeration may become more feasible and so pressure for a brain drain may emerge. Such developments *could* lie behind the apparent recent revival in skilled labour mobility in certain sectors.

Second, geography models suggest that uneven development - and hence brain drain pressure - is a natural and inevitable phase of global development, even if countries start off from identical positions. Third, the simplest geography models suggest that that a brain drain will be detrimental to those left behind in the brain-exporting (sending or home) country even in the absence of the labour market failures (including in the absence of direct spillovers between skilled workers) that we have discussed so far. That is, the advantages of agglomeration stem from the fact that proximity economises on transactions and transportation costs, making real wages higher in the core and lower in the periphery than they would be under 'even' development. This effect could be additive to any of the direct spillovers discussed so far.

The geography models – sketched above - offer a return to an earlier vintage of brain drain models (albeit in more sophisticated form), for they admit none of the more recently identified developments that could generate a beneficial brain drain. They have no mechanism for stimulating return migration, no network or diaspora effects, and, because they take the world's stock of skilled labour as given, they are unable to consider the education incentives version of the brain drain.

If, however, there *are* positive direct spillovers between skilled workers, agglomeration will increase average productivity and world aggregate output. This raises the possibility that even workers in the 'brain-exporting' country gain from the brain drain because world output increases. At least in simple models, however, one can show that, as transportation costs fall from infinity, the workers in the non-industrial country are worse off when agglomeration first starts. They start to gain only as transportation costs fall further so that they can more cheaply buy the goods from the concentration of industry in the other country (see, Baldwin and Forslid (2000)).

A strength of the economic geography approach is its general equilibrium nature, which endows it with a strong internal consistency. On the other hand, this makes it a poor predictor of sectoral effects. There is clearly a general equilibrium dimension to the brain drain. In particular, very small economies may just not be able to generate the density of demand necessary to make the application of high levels of skill profitable. However, there are, equally clearly, differences between sectors in the extent of, and incentives for, agglomeration. These cannot be due to the demand linkages that are central to Krugman's geography model, for these are completely general across all industrial sectors. The alternative pecuniary externality found in the geography literature – input-output linkages, where it is intermediate demand that relocates with firms (FKV (1999)) – could conceivably offer an explanation, but it entails no labour mobility.

We conclude, therefore, that while geography provides useful insights into the general position of nations in the brain drain cycle, it cannot be the complete story behind the movements that we observe in areas such as health and ICT. For these, direct and sector-specific spillovers must also be at work too.

8. Sectoral Dimensions

The available evidence points to skilled migration having strong sectoral properties. At the same time, technology itself has had an impact on the structure of demand and the spatial distributions of skilled labour. Two examples stand out; health and software. Both have been subject to skilled emigration but with different durations and dynamics at both sending and receiving ends.

Skilled migration of health care workers appears to be the starkest – and most persistent - form of brain drain (our future research will try to quantify these costs carefully). Health care is generally under-provided in developing countries and provision also tends to be skewed towards urban and relatively privileged consumers. A highly regulated activity, there are long lags on the supply side while educational financing tends to have a strong public component in most developing countries. Further, healthcare work generally has a strong team component – doctors have complementary inputs from nurses and ancillary staff. Advances in medical technology have, if anything, accentuated the team component. As such, loss of some part of this chain may have large, knock-on effects. Among other things, this suggests that relatively narrow interventions that might seek to raise some part of the chain's incentives for staying (or penalise them for leaving) will have limited efficacy. Indeed, the organisation of the industry suggests sector-wide solutions. On the demand side, it appears to be largely public healthcare systems in the developed economies that are the main sources of demand, thereby raising the public policy dimension directly.

The growth of a highly mobile software sector is of more recent origin. Further, the sector has a far smaller public sector involvement. Clearly, an important factor behind its growth has been the falling cost of communications. Thus, the use of satellites (VSATs) has been central to the growth of software firms in India, not least by enabling firms in that country to work effectively with partners or clients in developed countries. In addition, there are clear education thresholds. It is no accident that software sectors in developing countries have mostly emerged in countries with ex ante thick skilled labour markets. The sector has everywhere then been characterised by agglomeration which can be attributed to gains from knowledge sharing, teamwork, and demand (backward) and supply (forward) linkages. This also appears to be associated with positive spillovers including learning-by-doing and, hence, positive productivity effects.

One possible channel for productivity gain is likely to be the reduction in skill-technology mis-match in the developing country [27]. Increased investment in human capital will raise skill levels in turn allowing firms to match workers to new generation technologies more easily. Certainly, anecdotal evidence from the software sector shows workers in developing countries working with very similar technologies as their counterparts in the advanced economies. Over time, this should reduce the productivity – and wage – gap [28]. This, in turn, will lower income differences across countries. By contrast, within country inequality in incomes may well rise, as returns to the skilled increase relative to the unskilled.

This potentially very positive picture does, however, need qualification. Available evidence suggests that the most highly skilled personnel have moved (with screening) to firms located in advanced economies, viz, Silicon Valley. This may be less on account of outright technology differences than differences in the ability to network, the business environment and so on. One possible outcome would be that the skills available to developing country firms then result in them choosing to work lower down the value chain, for example by concentrating more on out-sourced coding than conceptualizing [29]. Yet, even this is far from clear. Movement of skilled workers across borders has often been temporary and – at least in India – there is widespread evidence of high integration in activity between firms in the developing and developed country agglomerations.

[27] We noted above that such factors might explain part of the wage gap across countries for skilled labour.
[28] Thereby counteracting some of the factors analysed in Acemoglu and Zilibotti (2001).
[29] See Desai (2000).

What are the welfare implications for the sending or home country in this type of arrangement? Clearly, the sending country gains from the matching of domestic skilled workers to relatively high productivity jobs, particularly if – as indicated in Section 4 – there is an associated and positive shock to the supply of skills. However, it loses the top end of the skill distribution – and with it, embodied education costs (although there is increasing evidence of greater private education finance). That loss will be potentially qualified by such movers retaining or developing business links at home and by any associated networking effects. It also partly depends on the labour market and the presence or absence of slack. With ex ante slack, emigration may lead to better matching at home. Absent such slack, emigration would directly affect relative wages and, ultimately, the factor mix. Faced with high turnover associated with poaching, firms may simply make production and technology decisions that match to skill levels with lower poaching probabilities. Note also that high poaching probabilities will exacerbate the problem of firms' refusing to internalise training costs.

What might be the longer run implications? On the assumption that developed country firms continue to poach talent, a key question relates to the incentive properties that screening-cum-cherry picking imparts for others. If – as the analysis in Section 4 shows – the human capital acquisition incentives could then be absent or minimal, the longer run effect may be adverse for the sending country. Equivalently, it may affect the way in which talent is distributed. To the extent that the education taken abroad is privately financed, as against some public financing component for those that get recruited later, there will be a fiscal saving. However, there are also likely to be negative externalities from the loss of the best students that may ultimately have an impact on the quality of instruction and graduates. Certainly, these questions require further investigation and more formal treatment; tasks which we reserve for later.

Finally, we should signal that the size of a country (and hence of its skill pool) is likely to matter. Small developing countries will find it difficult to retain skills; they lack the mass for agglomeration and other scale effects to set in. This makes them particularly prone to skills poaching.

9. Conclusion

In this paper we have surveyed the literature and some of the evidence on the brain drain. A body of early work concentrated on modelling the sending countries' labour markets in the presence of a range of distortions, particularly of the labour market in the sending (home) country. The gist of this analysis was that skilled migration lowered welfare for the population remaining behind in the sending country, but this was highly sensitive to assumptions regarding wage setting and ex ante employment levels. (There was never any case that the migrants themselves did not gain.) In the main, migration exacerbated the efficiency losses caused by the various distortions – for example, the subsidy to public education, the under-employment of skilled or other labour arising from distorted wage setting. This literature led to calls for the prevention or taxation of skilled migration from developing countries, although, as history, shows no concrete action ever resulted.

Later more truly dynamic models of the brain drain focussed on the motivation for human capital accumulation and noted how these were affected by the introduction of a non-trivial probability of emigration. Thus although migration drained talent out of a country, in this class of model it also encouraged the

creation of skills and the latter effect could be the dominant one. The mechanisms through which this occurred relied on information failures – most commonly the assumption that, after taking education, developing country residents had an equal, exogenous and less than unity probability of migrating. Implicit in the first condition is the assumption that the receiving country cannot screen potential migrants effectively – it merely chooses randomly among the educated cohort of the developing country. But in fact it appears that recipients screen immigrants quite actively – for example, via recruitment effort, the offer of temporary visas during which workers reveal themselves, and via their local education establishments. In this case, however, the beneficial brain drain can evaporate, for if the recipients can choose only the most able among developing country residents, the incentives for the marginal student to acquire education will not be affected, as they will have no possibility of emigrating. This disappointing outcome may be moderated if screening is imperfect or if there is some ex ante under-employment of skilled labour in the sending country. In the latter case, then the employment ratchet effect resulting from screened emigration could eliminate the social losses while still permitting the strong positive private gains for the migrants themselves.

A third stream of literature of some relevance is that on economic geography. This has not, so far, been concerned directly with brain drain issues, but its models can be massaged to offer an alternative view of skilled migration. Doing so provides a number of insights into the factors behind agglomeration – including in skills – and some likely implications for developing countries. From these extensions, it appears that the brain drain is likely to be a temporary phenomenon, arising only as the transactions costs for 'talent-intensive' activity decline, as through falling communications costs, and possibly reversing itself as they decline even further. While it occurs, however, the brain drain will have negative welfare implications for the 'periphery' (the brain exporting, 'home', countries), as, inter alia, its mobile labour emigrates to the 'core'. This is likely to be especially true of very small countries, which are unable to achieve the mass required to exploit talented labour efficiently. The economic geography explanation of the brain drain is explicitly general equilibrium, which is a strength conceptually, and also empirically for these very small economies. However, among economies large enough to support agglomerations in principle, it is a potential weakness because it precludes explaining the different experiences of different hi-tech sectors.

Indeed, casual observation suggests that in the 1990s, multiple sites for agglomeration, including in the 'periphery', have developed. For example, there is clear evidence of agglomeration in the software industry in India, as in the USA. This might point to some evolving division of labour – and associated distribution of skills across space. As such, this may indeed be where the main welfare implications of a particular type of skilled migration lie and this in turn implies closer attention to the properties of specific sectors and skills.

Overall, our conclusion has to be that while there is clearly a possibility that the brain drain is beneficial to the residents left behind in the home countries, there are reasons – some of them of recent origin – to be suspicious of that conclusion. It is not even certain that there is an overall global welfare gain from the brain drain, although given the apparently large private benefits of the migrants themselves and their higher productivity in their new locations, it seems highly likely. Like all good academic surveys we conclude that much more research is needed to pin down the relevant magnitudes. These are likely to vary by sector and so this work will need to be at a detailed level.

Appendix 1: Re-interpreting the Economic Geography Model

The 'standard' geography model postulates a simple, costlessly-traded competitive numeraire sector, agriculture (A), distributed uniformly and immobile across space. In addition, it has a differentiated manufacturing sector (M) which is costly to trade and which uses industrial labour (L). The latter is internationally mobile but fixed in global supply. Krugman assumes that labour relocates to eliminate real wage differences, and although it does so only gradually, he is ultimately concerned only with the final outcomes. Assuming two identical countries, the latter comprise two possibilities - a diversified symmetric equilibrium in which labour earns the same real wage in both locations, and a concentrated one in which manufacturing clusters in one country and its workers earn more than they could in the other country even if a few manufacturing firms were to set up there. Which of these equilibria arises depends on, inter alia, the importance of manufacturing in demand (and hence in production and income generation), the costs of transportation, fixed costs and the degree of product differentiation in manufacturing (the last two of which determine the extent of economies of scale). It also depends on history. One of the fundamental insights of this literature is that there is an area of the parameter space in which both sorts of equilibria exist and are stable, so that which one prevails depends on which prevailed as the economy entered that area. In the concentrated equilibrium agriculturists also have higher real incomes in the industrialised country than they would under symmetry because, although agricultural nominal wages are fixed and equal across locations, the price of manufactures is lower in the industrialised country. The opposite applies to agriculturists in the 'de-industrialised' country. It is important to note that this clustering depends on pecuniary externalities not technological spillovers.

If we re-interpret *A* as the 'base' economy, including agriculture, immobile 'basic' manufacturing and services, *M* as foot-loose, including skill-intensive, activities and *L* as foot-loose/skilled labour, we would appear to have a potential model of a brain drain. It explains the existence of a brain drain, as well as its consequences, and does so without recourse to the technological spillovers between skilled workers usually assumed in brain drain models.

There are, however, a number of reservations to be noted. It is not clear why foot-loose goods should be subject to trading costs while basic ones are not, and although the model can be adapted to allow the latter to have such costs (FKV (1999)) doing so seems quite likely to make the concentrated (i.e. brain drain) equilibrium infeasible. Similarly if the high-skilled part of the economy is small, most demand is generated by the basic sector that is assumed to be immobile, and concentration is less likely. Additionally, the division between basic and foot-loose parts of the economy is problematic. If the latter is drawn narrowly in order to capture the high-skill element of the brain drain, it may be too small to generate agglomeration while it is not obvious that the basic part of the economy will be free from tendencies to agglomerate. Agriculture may be 'nailed down', but basic manufacturing and services are not, and, as FKV (1999) show, agglomeration is feasible even without migration through backward and forward linkages among industrial firms. If, on the other hand, the foot-loose sector is large,

the mobile labour flows will not be particularly highly skilled, and hence we start to lose the 'brain' component of the brain drain story.

In sum, the economic geography framework is too rarefied to be applied directly. Nonetheless, it offers a number of insights that may be of use in thinking about the brain drain. The critical parameter in exploring possible outcomes is the cost of trading M, now the skill-intensive sector. At very high costs, production must be located near consumption, and the "world economy" has a symmetric, diversified equilibrium. As trade costs fall, the concentrated equilibrium becomes, first, feasible and then, at lower costs, unique. In the simple model, concentration remains the unique outcome right down to zero trade costs, but in more complex variants with diminishing returns (e.g. if *A* also has trade costs or if there are additional locationally fixed factors), the concentrated equilibrium gives way to the symmetric one at positive levels of trade costs (possibly again with a range in which both types are feasible)[30]. If countries were initially perfectly identical, the model cannot predict which will end up with the concentration but it is easy to see that tiny advantages for one country (technological, size, historical) would make it the preferred location and leave it with all the *M* industry. Thus if the world were characterised by improving communications for skill-intensive sectors, we could see a tendency for a brain drain from less to more favoured countries to emerge and then eventually to reverse.

Of course, these are parables and possibilities rather than predictions. At present we have no feeling for what the critical values of trade costs are or where actual costs lie in the world. In addition the models really need to be extended before they can be fitted to the real world. In particular, migration is unlikely to denude one country of skilled labour completely. One can avoid this is in a number of modelling ways, but prominent among them would be to recognise that not everyone wants to move. Second, it is desirable to recognise the possibility of direct externalities in the agglomeration of skilled labour. Fortunately extensions exists in both these dimensions. Third, the lags assumed in migratory flows are not consistent with fixed global supplies of skilled labour. Relaxing the last constraint is necessary for examining the training incentive version of the beneficial brain drain, and awaits attention.

Ludema and Wooton (1997) add preferences over location to the standard geography model. Not surprisingly, doing so makes the symmetric, diversified, equilibria more likely (feasible and unique for a larger range of trade costs) and allows the concentrated equilibrium to stop short of 100% concentration of *M*. This is clearly more realistic than the extremes we saw previously and increases the legitimacy of considering whether a brain drain can occur even in the absence of spillovers between skilled workers.

Externalities between skilled labour have not, to our knowledge, been explicitly added into the standard economic geography model, but Baldwin and Forslid (2000) take a step in the right direction. In keeping with our interpretation of manufacturing as the skill-intensive sector, they postulate that each manufacturing enterprise needs a unit of capital, which is produced with skilled labour using a technology that involves positive

[30] When the trade costs of *M* are zero, location ceases to matter, so any other locational equilibrium would be equally feasible.

learning-by-doing externalities[31]. This combines geography with endogenous growth and thus comes closer to the traditional approach to the brain drain. It makes concentrated equilibria more likely but raises the possibility that a concentrated equilibrium is beneficial even for the de-industrialised country. The static losses (from geography) may be offset by the increase in the global growth rate resulting from the concentration of skilled workers in one place. For this to happen one needs the technological spillovers to be (largely) national - if they were perfectly international, skilled workers would have equal productivity in capital goods wherever they were located - and trade costs to be relatively low. Interestingly, in this model, the level of trade costs at which the growth effects offset the static losses is lower than that at which concentration occurs and hurts the de-industrialised country. That is, as trade costs fall the de-industrialising country first experiences falls in welfare from losing its skilled labour and only subsequently benefits from the higher world growth rate.

[31] This capital lasts only one period, so it is as if each manufacturing firm needs an extra input of skilled labour, but that that input declines through time according to how much has been used for that purpose previously.

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