Effects of Skilled Migration: Case Study of Professional Engineers

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Abstract

The migration of professional engineers at substantial levels from less developed countries (LDCs) to developed countries (DCs) has significant positive effects for DCs and significant negative effects for LDCs. We use human capital transfer as a framework to discuss migration of skilled professionals: human capital requires investment in child rearing, health services, transport, housing, social security and education. We examine this in the context of a typical DC (Australia) and a typical LDC (Pakistan). We estimate that the investment required to produce a professional engineer is about US$550,000 in Australia and can be as low as US$65,000 in Pakistan. When skilled professionals migrate from a LDC to a DC, the LDC invests in capital creation, but the DC saves having to make a much greater investment. If the inflow of migrant engineers is large compared to the graduation rate for engineers in a DC then there is an increase in the average skill level. We present evidence of significant professional engineering competence differences between Australia and Pakistan, and suggest that migration provides an explanation for observed changes in competence levels over time and helps to account for differences in industrial productivity in non-traded sectors. We show how competition in the engineering sector of DCs promotes rapid productivity improvement rather than lower salaries, generating large economic benefits. We also explain how engineering depends on, and is part of the social, political and economic environment and this helps to explain why skilled migrants who return to LDCs cannot necessarily use their skills productively. We ask whether similar arguments could apply to other groups of skilled workers. We conclude with an argument that DCs need to invest in creating appropriate environments and competency levels in LDCs so that the total skilled labour resources of the world can be substantially increased. One proposal for achieving this is via debt relief; that is, recognizing skilled migration as a form of capital redistribution could be used as a rational basis for providing debt relief to the third world. However this must be invested in creating human capital if any long term benefit is to be obtained.

Preamble

This work started as an attempt to develop equipment and technology for clearing landmines in Afghanistan. Working on the assumption that Pakistan could provide a low-cost engineering environment with similar culture and geographic proximity, we helped set up a research centre in Islamabad[1]. The centre employs 10-12 people including an engineer, technicians, and support staff, and is supervised by a retired chief defence force engineer.

One of the most challenging problems has been to find a competent mechanical engineer to handle technical development issues, particularly when we were not able to be present in Pakistan. We have employed five engineers since 1997 and it has been difficult to find competent applicants each time. One had a masters degree from a UK university, the others all had professional local qualifications. We have terminated four of these for incompetence or unprofessional behaviour. Our current engineer is competent and honest but can only work part-time because he wishes to continue his career teaching in a private school where he is paid several times the normal salary level for engineers. Our technicians and support staff, with one exception, have been competent (within their capabilities), loyal and honest.

Major engineering projects in Pakistan are usually led by foreign engineering firms who bring in their own engineers (and often attractively priced government finance as well) rather than employing locals. The costs are very high: typically it costs around US$250,000 a year to provide a single expatriate engineer.

These difficulties led us to a number of challenging questions.

> Why are expatriate engineers so essential, especially since many local engineers could be hired for the same expense?
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> Why is it so difficult to find a competent local engineer?
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> Is there a major deficiency in the Pakistan education system that could explain this?
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> Pakistan-trained engineers are highly successful in many countries: why not in their own country?
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> What is the cost to Pakistan of replacing the engineers and other trained professionals who subsequently leave for other (more developed) countries?
>
> What costs do the more developed countries save through the immigration of trained professional engineers?
>
> How many trained professionals are migrating and to where?

[1] Hameed and Ali Research Centre (HARC)

> Why, when the Moghuls built such magnificent structures like the Red Fort (*Lal Qila*) and the *Taj Mahal*, can Indian and Pakistan engineers not even approach similar construction standards today? Looking along the two kilometre ramparts of the *Lal Qila* one can see a perfect straight line: there is no sign of movement even after 430 years[2]. Today even new buildings are seldom constructed straight, and often show signs of deterioration before they are opened.

Emigration is a major feature of life of the Indian subcontinent. The socio-economic elite take it for granted that their children will emigrate for privately funded education and a financially rewarding career that will hopefully bring them home one day. Middle classes struggling to elevate themselves above the masses see education as a pathway to emigration, well paid work and financial security. A lucky few will enter high quality schools and university courses. The rest resort to countless private “institutes” and “academies” with names that imitate well-known western institutions and promises of “degrees” and “diplomas”: a thriving industry of dubious quality, preying on the hopes and fears of the less affluent. Australia is one of the countries many aspire to reach.

Migration is also a major feature of life in Australia. Australia has relied on migrants for a significant proportion of population growth and skills. Every engineer raised in Australia represents an investment of around US$500,000. With around 1300 engineers migrating permanently and thousands more temporarily, we realised that that migration represents a huge investment flow, much of it from the developing world. However, the closer we looked at this issue the more we realized that this is only part of the picture.

When we examined migration and trade debates however, there is little mention of the impact of training costs and the enhanced productivity that results from utilizing human skills effectively. Brain drain researchers do not seem to have attempted to quantify these effects. Governments discuss the value of migration mainly in terms of demand growth in specific sectors of the economy, rather than by considering savings in training and child rearing costs and productivity gains resulting from competition. The Australian government estimates the “economic contribution” of skilled migrants at around Au$19,000 per person (DIMA 2001, 16). In comparison to the investment needed and the benefits that we have noticed, this seems a remarkably tiny amount.

Introduction

Every year there is a net international movement of hundreds of thousands of skilled professionals from less developed countries (LDCs) to developed countries (DCs)(Lowell 2002). Some states seek them

[2] Some historical details are provided by Richards, J. F. (1993) The Mughal Empire, The New Cambridge History of India,

actively. For example, Australia permitted 85000 people to migrate permanently to Australia in 2001-2002, and of these 45500 were required to be "skilled labour" in one of many categories that reflect shortages in the Australian labour market (DIMA 2001). This is a very significant gain in human capital in which an considerable investment has been made, but not by Australia. Even developed states not actively seeking skilled labour have created special categories in their immigration programmes to ensure a large proportion of immigrants brings skills that are in short supply.

Despite the abundance of literature about migration, and the migration of skilled professionals in particular, the topic is infrequently discussed in terms of capital gain and loss. One of the reasons for this may be because the acceptance of migrants is often seen as an act of benevolence that does not necessarily entail any gain to the receiving state, while the creation of human capital is viewed by some as a private and not a public cost and so imposes no cost on the sending state.[3] This paper will discuss six issues relating to skilled migration as capital gain and loss with particular reference to engineers:

1. To assess the implications of skilled professional migration it is necessary to recognise and measure the investment needed for a child to be raised and reach adulthood with a high level of skill.[4] The literature on skilled migration does not address this adequately.

2. The level of investment required to produce a skilled worker depends on the country where the person is raised. In Australia we have estimated this to be about US$560,000 whereas in a typical LDC (Pakistan) the investment could be as low as US$50,000[5].

3. Migration of skilled labour implies a permanent or temporary transfer of human capital and the investment that was needed to create it. Several 100000 skilled people migrate permanently and several million migrate temporarily each year. The resource implications of this are very large and worth careful consideration. Migration of this type of worker necessarily represents a significant redistribution of resources, especially in the case of LDCs where signficant proportions of the highly skilled migrate to DCs. This is especially the case if part of the education of a highly skilled migrant from a LDC occurs as an international student in a DC university, as is often the case.[6]

Cambridge University Press, p 121-123.

[3] Another reason may be the difficulty in attempting to quantify both migration flows and capital gain and loss.

[4] This cost is the cost to family and the state of raising and educating a child, and the cost to the state of providing an environment in which this can happen (health, social services, roads etc)

[5] See Appendix for details of these calculations.

[6] The LDC investment includes fees and living costs paid to institutions in the DC.

4. If the level of skilled migration flow is large in comparison to the rate at which native born are educated to comparable skill levels, then migration produces a significant effect on average skill levels. If the migration flow is inward, then skill levels increase. If the flow is outward, skill levels decrease.[7]

5. In the case of engineers, the effects of increased competition between engineers can produce a productivity gain for the companies employing them. The gain is much greater than salary savings predicted by labour market supply and demand pressures.

6. Points 4 and 5 above may provide strong explanations for the large differences in competence levels we have observed between engineers in DCs and LDCs. This may help explain large differences in industrial productivity between DCs and LDCs. However, we argue that it is the operating environment for engineering and infrastructure in a LDC that influence the competence level far more than any differences in intrinsic ability between individuals. For this reason, temporary migrants who return to LDCs will not usually maintain the effectiveness that they could achieve in a DC environment.

If one accepts that skilled migration does represent a significant investment shift from LDCs to the developed world, then with further work this notion could provide a rational basis for LDC debt relief. We also suggest that restrictions on migration result in a less than optimal utilization of the world's investment in skilled labour creation. Also, carefully targeted investment in human capital by the developed world to increase the supply of skilled professional in LDCs could provide substantial positive returns for both LDCs and DCs.

We start this paper with a review of recent literature on economics and migration to reveal different ways to account for the transfer of human capital. Most of the migration literature is concerned with quantitative studies of migration flows to and from DCs and also the level of skill stocks in DCs. Some researchers have looked at LDCs in detail. A few have discussed migration in terms of human capital transfer. Lowell(2002) reminds us that it is difficult to arrive at quantitative conclusions because little data is available.

We then present some estimates of investment needed to create skilled professional engineers in Australia and Pakistan. We follow this with an explanation for the way that large migration flows can effect average skill levels. We explain the role of professional engineers to show how they can influence productivity and how the environment in which they work effects this. We report our observations on competence levels in Australia and Pakistan and relate this to productivity issues in

[7] This fourth point encompasses issues of employability in the host country, gain for the LDC-home via remittances, and skills acquisition, all of which will be dealt with below.

non-traded sectors of the economy. From this we can draw conclusions that seem to provide strong explanations for significant economic performance differences between DCs and LDCs. We also make some observations on the IT sector and differences between permanent and temporary migration.

The observations presented in this discussion are based on 25 years of first-hand experience of employing and supervising 14 engineers and more than 40 support staff in Australia, and 5 years of concurrent experience of employing 6 engineers and 20 support staff in Pakistan. For each engineer employed at least three others were interviewed and assessed in detail as part of the appointment processes. Some observations are based on extensive discussions with colleagues ranging from CEOs of multinationals to individual consultants.

This detailed analysis of the impact of professional engineers moving from LDCs to the first world may provide some insight into the effects of skilled labour that is unable to be accounted for by contemporary texts. It is possible that the magnitude of the economic impact of such migration could be much greater than has previously been acknowledged. If this is the case, then the negative impact on LDCs may be much more difficult to compensate or reverse.

A major issue effecting research in this area is the difficulty of quantifying the effects of migration. The number of permanent migrants can be difficult to assess from government sources. Temporary migration is even harder to measure.(Findlay 2001, 7) As will be shown later, competitive pressures, infrastructure environment, educational differences and skill stocks all influence the economic impact of migration. Interestingly, we find that recent quantitative studies of skilled migration seem to have overlooked investment in human capital prior to migration, and this alone represents a significant factor in the value of human capital flows. This investment can be quantified.

We conclude that our view of migration as a form of capital transfer might be useful in establishing a mechanism for offsetting accumulated third world debt by accepting that skilled migration does represent a significant investment shift from LDCs to the developed world. We suggest that restrictions on migration result in a less than optimal utilization of the world's investment in skilled labour creation. Also, carefully targeted investment in human capital by the developed world to increase the supply of skilled professional in LDCs could provide substantial positive returns for both LDCs and DCs.

Skilled migration as human capital transfer

It is not universally recognised that labour is human capital or that the nature of human capital creation and movement is significantly different to all other forms of capital[8]. Listed below are six ways in which labour, or human capital, is different to other forms of capital. Research on migration generally recognises some of the differences, they are worth explaining because they are the basis for our discussion of international labour movement and its consequences.

1 Owners of ordinary capital invest in the reasonable expectation of a return for their initial outlay. This investment is made exclusively by the owner.[9] However, investment in human capital is not made exclusively by the owner, that is the individual and his/her family. Considerable investment is made by the state, which is a stakeholder, but not the owner of the capital. Below we argue that most conventional texts do not recognise the state as an investor in human capital.

2 Once the investment has been made, the state has little control over the capital or if any returns will accrue to its investment, thus there is no reasonable expectation of a return on the investment. In this way, the state does not behave (or invest) like markets. This also means that a state accepting a migrant receives a unit of human capital at very little cost.[10] Thus countries that are desirable destinations for migrants and in need of human capital are able obtain it at low cost. This is most often the case with DCs, however it is usually the opposite for LDCs. Since the investment required to create a skilled professional in a developed state is large, the developed state can make significant resource savings by accepting migrants. On the other hand, as will be explained below, LDCs have to pay to import skilled labour.

3 The investment made in conventional capital is often reflected in its sale price as well as the expected return on the investment. However, investment made in human capital is not necessarily reflected in the labour price (wages). In fact, as is shown in the appendix, measuring the investment in human capital is difficult.

Also, all units of human capital are not of equal value. Not all writers distinguish between skilled and unskilled migration. The difference is very relevant because varying skill levels are significant determinants of mobility, earning capacity, and likelihood of return to the home country. Some

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[8] The terms ‘human capital’ and ‘labour’ will be used interchangeably. Other forms of capital will be referred to as ‘ordinary capital’.

[9] The state may make indirect contributions such as tax concessions. If the state invests in capital or in infrastructure that will allow capital to operate (ex, harbour facilities to transport minerals overseas), it does so in the certain expectation of reaping returns to the state.

[10] There are administration costs such as processing paperwork etc, involved with assessing migrant applications.

may argue that skilled labour from and educated in LDCs is of less quality than in DCs. We examine this issue below.

4 Information about how much has been invested in a unit of human capital is not observable under conditions of imperfect information. Labour can be under-utilized.[11] This is significant when skilled migrants are under-employed, partly because the receiving country does not invest in training for them to be fully productive. The training is observable as a cost, but the value of prior investment is large compared to this, but not easily observable.

5 Unlike ordinary capital, the most valuable/talented human capital is unable to provide a full return on the investment unless special conditions exist. For example, like most professionals, engineers are most productive in centres where they are surrounded by, have regular access to and are able to consult with similarly talented colleagues. Also, the most productive working environment for skilled labour is where clients are educated about their capabilities and they have access to resources that permit them to achieve their potential(Khadria 2001, 59). That is, a critical mass of professionals needs to be attained. This will be argued in further detail below.

6 Unlike the frequent and widespread calls to remove many barriers to the international movement of ordinary capital, there are few calls for the free movement of human capital. For a range of reasons unrestricted labour movement is considered undesirable. Although classical economic theory argues that migration benefits all parties in the long run, the almost universal imposition of tight restrictions on immigration suggests that issues other than economic efficiency are more influential on government policies.

Skilled labour migration is a form of human capital transfer. However, human capital transfer is quite distinctly different from conventional forms of capital transfer. To assess the effects of international labour movement it is necessary to consider the investment made in the migrating human capital. In general, the literature on skilled migration does not address or calculate the effect of labour movement in this way.

A considerable portion of the literature on international migration is devoted to the effect on host countries[12], almost always focussing on developed countries.[13] Much has been written and debated about this topic, and both academic and public opinion is divided over the merits of immigration. The

[11] Perhaps this explains why in general we do not invest in migrant skilled labour after arrival, even though this would help to maximise the ultimate economic benefits of migration. See Hawthorne (1994) for an interesting study on migrant engineers in Australia.

[12] The terms 'host', 'receiving' and 'destination' country will be used interchangeably to refer to countries accepting migrants. The terms 'home', 'source' and 'sending' country will be used interchangeably to refer to countries from which labour emigrates.

[13] For example, Borjas (1999), Lowell (2001) and Findlay (2001).

most frequent concerns are that migrants compete for jobs and so drive down the price of labour for the native born, they do not assimilate and so in some way threaten the majority ethnic groupings, or that their presence will change the country's ethnic mix.[14]

In this area of focus it is seldom acknowledged that immigration of the highly skilled increases the level of human capital. This rise then has benefits for the receiving country, as the study by Barro and Sala-I-Martin (1995) confirms that an increase in the average level of human capital in a society increases growth.

In calculating the per capita utility that occurs with migration, Kohn's model (Kohn 2001) of immigration and capital transfers illustrates that there is a trade-off between DCs accepting migration from LDCs and donating capital to LDCs to increase growth and living standards thus reducing the desire to migrate. His model concludes that for DCs it is more preferable to donate capital to the point where immigration has been reduced to zero, than to accept migrants!

One possible weakness of Kohn's work is that it does not consider the increase that skilled migration can produce in the average quality of human capital in the work force in either DCs or LDCs. Also, his model only measures the value of migrants based on their contribution after arrival, and not the investment made before arrival.

Although less has been written about the effect migration has on sending countries, interest is increasing, with particular focus on LDCs.[15] As with the debate about immigration, findings about the affects of emigration vary considerably.

For example, Lundberg and Segerstrom (2002) conclude that for a range of reasons, including reduced competition for labour, those who benefit most from migration are the immigrants and those workers remaining in the home country. In fact, they suggest that migrants should pay some form of compensation to workers in the receiving country whose welfare has been reduced by the immigration! Despite their conclusions, it is uncommon to encounter work that portrays migration as entirely beneficial for LDCs.

More frequently, the movement of human capital is recognised as a double-edged sword. In particular, it is migration's duplicitous connection with development that is of interest and studies are divided over which if any parties actually benefit from international migration.[16]

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[14] For example, Borjas (1999)

[15] Sending countries are most frequently recognised as less developed countries (LDCs).

[16] See Findlay and Lowell (2001) for an interesting synthesis of the most recent literature.

Stark and Wang (2001) and Beine *et al* (2001) are both interested in the impact of migration on human capital formation in sending countries. They recognise the connection between low levels of human capital and poverty, and see migration as a way to ameliorate the problem. Stark & Wang argue that a well-specified migration policy can reduce the tendency for people to under-invest in human capital. They note that there are several methods of achieving this – for example, subsidies - but claim that migration entails no cost to the sending government. Beine *et al* (2001) see migration as an opportunity to foster investment in education because of higher expected returns to emigrants. They argue that as long as the level of departure of educated agents is not too high, migration can produce a beneficial brain drain. It is noteworthy that in their work they assume that education is transferable and educational attainment is perfectly observable. However, studies tell us that this is not always the case.[17] They also note that if too many of the educated emigrate then the sending country suffers a brain drain, which produces costs, not benefits.

The issue of 'Brain Drain' that initially emerged in the 1960s has recently attracted renewed interest.[18] Recent works question whether the 'Brain Drain' exists or whether it is simply 'Brain Exchange', but the results are as yet inconclusive.[19] Numerous works discuss the potential benefits to the sending country if the emigrants return with the skills and capital they have acquired.[20] However, some acknowledge that this return has not yet occurred and so few benefits of migration have flowed to those left behind.[21]

Desai, Kapur and McHale (2001) attempt to quantify in dollar terms the fiscal losses to a LDC from skilled labour migration. Despite methodological difficulties, they are able to recognise a clear loss to India from skilled labour migration to the USA. Although the calculated fiscal effect is very large, their calculation omits the very significant cost of producing the human capital, that is, the cost to India of producing the capital that the USA later obtained at little cost.

Investment in Skill

If there is significant migration of skilled labour from less to more developed countries and this movement represents a shift in capital, then what are the resource implications of this movement for DCs and LDCs? Is the situation a zero sum game or are the gains and losses less clear?

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[17] See Hendricks (2001)

[18] The issue first arose in the early 1960s with the work of Bhagwati. See Bhagwati (1976)

[19] See Beine *et al* (2001), Carrington and Detragiache (1999), Desai *et al* (2001), Wadda (2000), Meyer (2001) and Pellegrino (2001).

[20] Meyer (2001), Pellegrino (2001), Thomas-Hope(1999, Khadria(2001) and Johnson & Regrets (1998).

[21] See the work of: Khadria (2001), Thomas-Hope (1999), Carrington and Detragiache (1999) and Wadda (2000).

We have estimated that the investment needed to produce a skilled professional engineer consists of four components in a developed country such as Australia.

- The cost of raising a child from pregnancy till the last year of a formal engineering degree course. This includes public and private contributions: the proportion of public contribution varies from one country to another.

- The cost of education services: once again we combine public and private contributions. There is some difference between state funded education and private schools, so we have taken a value that is the average of both. We have included the average cost of university education per student, with a weighting that recognises that the cost of engineering courses is higher than average.

- The foregone parents' income: we have assumed one parent gives up their full-time earning capacity at a modest wage for 10 years.

- Loss of productivity for the first two years of employment: we have assumed that on average an engineer only achieves 60% of full productivity in their first two years of employment[22].

We have researched child rearing costs and have included estimates from several sources, and then compared these with our own calculations that are based on the cost of boarding at a school with the cost of labour subtracted. The Appendix provides details of these calculations and shows how the total investment was calculated.

Although our investment estimates are for engineers, the cost of producing other skilled professionals is similar. By importing 45500 skilled migrants in 2001-2002, the Australian economy has acquired human capital that would have otherwise required US$20 billion of additional investment. Of these skilled migrants at least 50% have arrived from LDCs(DIMA 2000, 17).

In many instances professionals from LDCs migrating to DCs will have studied in a DC and so contributed fees and living expenses for university education as an undergraduate or postgraduate student.[23] The revenue from the export of education by Australia in 1999 was $3 billion – a significant export industry(DIMA 2001, 45). The purchasers of Australian education services are largely students from LDCs. Applicants for Australian permanent residence are exempt from fulfilling certain requirements if they have completed their qualifications in Australia(DIMA 2001, 45).

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[22] A typical industry assessment of university engineering graduates asserts that they take two years of work experience after graduation to become productive professionals.

[23] In 1999-2000 2459 full-fee paying students studying in Australia were granted permanent residence (DIMA 2001, 46). In granting residency, Australia gained $1.23 billion in human capital assets.

Offsetting the costs of migration from LDCs are remittances: payments from migrants in foreign countries to their families at home. Taylor(1999) assesses the development of potential remittances and cites empirical evidence that remittances may be a positive factor in economic development. Interestingly, Findlay and Lowell(2001, 9) state that "We know…that remittance multipliers are greatest in rural areas". Aziz(2001) has commented that migrants with high education attainment provide the least remittances. The work of Lefebvre shows that remittances are not necessarily invested: he concludes that village migrant households prefer to spend the remittances on basic needs – both material and psychological – than on more productive investments(Lefebvre 1999, 204). As with some other migration issues, too little is known about the effects of remittances for conclusions to be drawn.[24] Do migrants from LDCs to DCs remit their relatively higher incomes, perhaps with the intention of assisting family or establishing savings for their own future entrepreneurial activities? Or does the cost of living and maintaining a lifestyle in a DC[25] consume most of the available earnings so there is little to remit? Are there differences in this between skilled and unskilled labour? Does the likelihood of permanent residency influence remittance patterns? Despite their relevance, these questions remain unanswered.

Effects of Large Skill Flows

If the proportion of migrating skilled professionals is significant in that it adds markedly to the skill stock of the host country then the average level of qualification and standards in the receiving country increases. The only other way to achieve this increase is to spend more on education in the tertiary sector or training. In fact, if Australia had to provide its labour needs from the native-born population, then the standard of professionals would fall because more students of lower ability would be need to be accepted into tertiary courses. Unlike direct education and child-rearing investments, these effects are more difficult to quantify.

Australia receives approximately 1200 engineers annually through the skilled migration program.[26] Australian universities graduate around 6,600 engineers annually, including approximately 1400 foreign full fee paying students.[27] A large proportion of the migrant engineers has graduated from Australian universities as foreign students.

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[24] As with some other migration issues, the dearth of knowledge is because these activities are difficult to quantify and research. Treasury statistics do not provide a complete picture of remittances. Informal funds transfer channels, typically using money changers, are widely used in LDCs to avoid government scrutiny. (Puri & Ritzema 1999)

[25] This includes seeking the best possible education of children and saving for retirement.

[26] Information obtained from the Centre for Population and Urban Research, Monash University, publication *Skilled labour: Gains & Losses - Australian Immigration Research,* July 2001, by B Birrell, I R Dobson, V Rapson and T F Smith.

[27] These numbers are from the Department of Education, Science and Training publication *Students 2000: Selected Higher Education Statistics*, and include completions in the categories of Bachelor's Pass, Bachelor's Honours and Bachelor's Graduate

Entry to engineering courses in Australia is open to students who have studied the necessary pre-requisite subjects in school: physics, chemistry and advanced mathematics (including calculus). These students must also achieve a high enough tertiary entrance score in their final examinations and school assessments. These scores are normalized so that a given level represents a consistent level of ability relative to the entire school cohort at the year 12 level. Therefore, if Australia were to forego migrant engineers and supply its needs with increased numbers of native born graduates, then minimum entry standards to engineering schools would have to fall. Without substantial additional funding for higher education per student, graduation standards may also be lower. Reducing the graduation standard would lead to higher engineering costs in the community.

A LDC with a large proportion of its highly skilled graduates emigrating sees the opposite effects. The education system has to produce many more professional graduates than are needed, and the best ones often leave first Khardria 2001). Those who remain either cannot afford to travel or cannot obtain work outside the home state: these have low levels of achievement both academically and professionally.

The faculty staff are almost always from within the country: it is not usually possible to attract high quality international staff as the salaries are low. This contrasts with Australian universities where a significant proportion of faculty are born and educated outside Australia.

The best and brightest engineers in LDCs migrate in significant numbers that are not replaced by immigration. They are often recruited to satisfy particular labour shortages elsewhere. Emigration is primarily restricted to the highest performing graduates, particularly if they take further education in a developed country(Khadria 2001, 52). Similar to other skilled professionals from LDCs, engineers move offshore, often for temporary postings, and many never return to their original homes. Migrant engineers who cannot match the performance standards of the pool available in developed countries will be less successful in gaining employment, and thus are more likely to return home.

Influence of Engineers

Migration brings large numbers of engineers to the industrialized economies and they compete for work with locals, increasing competition. This reduces the cost of engineering products and services, but not only in the way that classical labour market economics suggests. While there is some influence on salary levels from increased competition, the most significant effect has been dramatic productivity improvement in the industrialized countries, and the resultant significant increase in wealth for their inhabitants. However, to understand why this occurs we need to appreciate the role of engineers in the economy.

Entry for Engineering and Surveying. Please note, the statistics do not differentiate between engineering and surveying and so it is not possible to obtain a more accurate figure.

In essence, an engineer is a person that solves problems by organizing cost-effective solutions. The engineer provides solutions for a predictable cost, on time, and with largely predictable performance and maintenance requirements.

Engineering often requires huge resources in advance: money is spent long before the benefits are realised and cannot be recovered. Therefore engineering relies as much on the confidence of clients as it does on the abilities of engineers to provide solutions. It is only by providing reliably predictable outcomes that engineers can create the confidence that clients need to make the required investment. This confidence is only built by many earlier successes, and can often be lost with one mistake. The Hindenberg disaster, for example, extinguished commercial interest in airships for nearly 70 years; this interest is now slowly re-emerging.

The engineer's role is first to understand the client's problem and to think about possible solutions. Often the most difficult part is simply identifying the problem. Often engineers find themselves working for clients who don't understand the problems they are facing or cannot describe them. Once the problem has been defined and solutions proposed, the engineer then has to persuade the client to provide enough resources (usually money) to implement a solution. As this is often in competition with other engineers, he or she must aim for the cheapest feasible solution and may have to negotiate with the client. An engineer might suggest "If you could possibly do without that particular feature, we could cut the cost by 5%".

Once given the responsibility of implementing a solution, the engineer's role is mostly to control the impact of unpredictable factors. Apart from nature itself, the major unpredictable element in any engineering work is the behaviour of people. Our understanding of science and nature has improved so much that human behaviour presents the greatest risk factor in nearly all facets of engineering work.

Partly because of this, an engineer spends most of the time coordinating projects for which he or she is responsible. Engineers constitute 1-3% of the workforce of the projects they organize: rarely more than 5%. This explains why they spend most of their time on communication and seldom more than 5% of the time on technical work.

Engineers' salaries are naturally affected by competition for paid work. However, competitive pressures have much greater cost implications. Since clients will choose engineers who can produce the lowest cost solutions, competition between engineers will also result in lower costs for the entire projects for which they are responsible[28]. This can provide significantly greater savings than the reduction in engineers' salaries alone. Engineers' salary costs vary, but are typically between 1-3% of

[28] A recent employment advertisement for a maintenance engineering manager reads "The key accountabilities of this position are developing and implementing maintenance technology to achieve at least Au$20,000,000 annually of maintenance cost reductions in four years…." (The Australian, 30th Nov 2002 p 22). Decisions on investment in process control engineering for the same industry typically require productivity gains that are four times the investment over the life of the project.

the project value. Hence, a 1% reduction in the total project cost saves far more than saving 10% on engineering salaries. The quest for invention and innovation by engineers is strongly driven by the need to reduce client costs to gain remuneration through employment.[29]

The Engineering Environment

Engineering is governed by the prevailing social, economic and political environment. Engineers in developed countries design for the "total cost of ownership" (TCO)[30] of a solution, rather than just the supply and installation cost. The total life cycle cost includes not only the initial manufacture and installation cost, but also the costs of lifetime maintenance, environmental impact, and the eventual disposal, disassembly and recycling of the parts or materials. This viewpoint results from a combination of environmental awareness, government regulations, community concerns and clients who reflect the values of sustainable development. This perspective also reflects competitive pressures. For example, Abele *et al* (2002) show how "sourcers" can provide a lower TCO for manufacturers who use engineering components or materials by understanding how the manufacturer uses the product.

However, in a different social environment, such as is commonly experienced in developing countries, most clients are only interested in minimizing the initial purchase cost. Engineers who design to minimize TCO will not be competitive unless they can educate their clients. Since most engineers cannot wait for clients to take on a new set of social values, their engineering solutions reflect the attitude and values of their clients and the social environment in which they work. This can result in lower safety margins, unnecessary environmental damage and long term waste problems. Failure to allow for maintenance costs will inevitably result in lower in-service performance levels[31], resulting in higher cost for a given level of outcome. Maintenance is often not carried out until an actual failure occurs, and then at the lowest cost regardless of how long the repairs will last or whether the repairs cause further damage. This, in turn, reduces performance and accelerates asset depreciation, raising costs still further.

Our experience of employing engineers in Australia and Pakistan has demonstrated that there is a considerable disparity in competence. Engineers in Pakistan tend to be less productive, have little knowledge of any but the most basic materials and techniques, and often have minimal organizational and management skills. This disparity seems to be confirmed by many foreign engineering firms

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[29] There are risks of course. Engineers have compromised on safety in the drive to reduce costs. Innovations can fail, leaving engineers' reputation damaged, possible legal actions against them, and adverse publicity. Sometimes the failures are far more spectacular and damaging. These failures help to explain why there are real limits on cost reduction.

[30] Also known as "Total Life Cycle Cost"

[31] This is the actual performance encountered by the users during the lifetime of the solution.

operating in LDCs who rarely employ local LDC engineers on their projects unless compelled to do so. The costs of employing expatriates are very high: typically it costs around US$250,000 a year to provide a single expatriate engineer. Here we note that this high cost of expatriate engineers demonstrates how LDCs have to pay for importing skilled labour. Note that they pay far more than a developed country would have to pay for the same labour.[32]

Clearly, there is a disparity between DCs and LDCs in professional competence levels of skilled engineers. One could argue that, particularly in some LDCs, there are social and cultural norms that could account for the competence and productivity gaps we observe. However, there are strong counter-arguments to this. With first hand experience we have observed little intrinsic difference between the performance of engineering graduates at the time of graduation between Pakistan and Australia, at least at the upper levels of the range of graduates. There are differences in attitude and specific competencies, but they do not significantly affect their performance in an appropriate environment. However, there is a marked relative decline in competency in the LDC environment in the years immediately after graduation, whereas the opposite applies in the DC environment, even if that environment is provided in a LDC[33]. We have also observed at first hand how engineers from Pakistan perform at internationally competitive levels once they have become established in a DC environment, even though they maintain their cultural and social traditions in the domestic sphere. If there was a strong social or culture factor influencing the quality of engineering work then it would be apparent.

In the industrialized economies, technological competition explains shifts in productivity more than labour cost differentials and many writers have commented on this.[34] Investment in technology and automation not only improves productivity but also reduces opportunities for manual assembly.[35] To remain competitive in a DC environment, an engineer needs exposure to the leading technologies and organizational techniques being used. This can come from first-hand experience, courses provided by equipment suppliers, meeting other engineers, or even formal study. In a LDC, an engineer will find it difficult or impossible to keep up. With limited markets, equipment suppliers seldom provide the training courses that they run several times each year in the major cities of DCs. Many if not most engineering product suppliers will not even have offices or representatives in LDCs. Local universities will seldom have staff who can teach up-to-date courses for professional engineers. For these reasons,

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[32] Many of the projects that utilize the services of expatriate engineers tend to be large infrastructure or development projects funded by international lending institutions and the ultimate cost is transferred to the accumulated LDC debt

[33] That is, working in a LDC for a DC firm.

[34] For example, see Milberg (1999).

[35] Boulton (1997) examines the electronics industry and shows how assembly operations tends to shift to low labour cost regions until technology changes such as surface-mounted devices render manual assembly impossible.

engineers that are not based in DCs need to be frequently on the move to keep their experience and knowledge competitive.

Again, this is influenced by clients. Many clients are well aware of technological developments and will sometimes specify the type of engineering solution they want. Most engineers acquire new knowledge directly as a result of the work they do for their clients. Many clients will insist on quality assurance, and will hire experts to ensure the engineers' work is up to modern standards. Hence the level of technical awareness of the client has a major influence on the quality of engineering work performed. It may not be unusual to find high levels of technical awareness in clients in DCs, however it is rare in LDCs.

In a LDC, it is common for engineers to think they learned everything they will ever need to know during their engineering training[36]. Solutions to technical problems are described in terms such as "they taught us that we should ……". Yet, in a DC, engineers will usually tell you they have never stopped learning during their entire working lifetime. In fact, a rigorous requirement for continuing learning has now become part of the annual re-accreditation process for practising professional engineers in most DCs.

There is also a large difference in industrial productivity between DCs and LDCs. This is not restricted to the traded goods sector where international market forces influence productivity in relation to general wage levels. Where wages are high productivity tends to be high so that traded goods have a competitive price. An example of the non-traded sector is construction. In Australia there is intense competition between engineering firms for construction contracts: profit margins are as low as 1%. In Pakistan, however, profit margins are around 30%. Because productivity is low in Pakistan the cost of construction is about the same as in a DC environment. Residential housing at a comparable level of construction quality costs around US$200-450 per square metre in Pakistan and US$250-450 per square metre in Australia.

In summary, in a typical LDC, there will be relatively few engineers, a lack of competition between them, low professional compentency, and little knowledge of modern materials and organizational methods. In addition, there are few opportunities and little incentive for an engineer to improve his or her skills and knowledge. The result is low productivity and performance levels from infrastructure and services that rely on engineering: construction, energy supplies, transport, manufacturing and process industries. The costs of these services are often as high or even higher than in DCs. However, we must remember that this is almost entirely due to the environment in which engineers perform their roles: it does not imply that engineers in LDCs are intrinsically less able people than their counterparts in DCs. This is also supported by observations of temporary migrants who have returned to their less developed home countries only to find that they cannot achieve the same results as they did in DCs.

[36] Expererienced local engineers in Pakistan have expressed these sentiments to me on many occasions.

Migration or Stagnation?

One might argue that engineering in LDCs will always lag behind the developed world, by definition. However, the Indian sub-continent provides a useful case study because the standard of engineering work has been comparable to industrialized standards in the past. For a few years immediately following independence, engineering in India and Pakistan followed British practices and was internationally competitive. However, standards today are only slightly advanced from that time whereas competence standards and industrial productivity in most DCs have surged ahead. At the same time large numbers of skilled professionals, including engineers, have migrated from India and Pakistan to DCs, particularly English speaking countries.

Our difficulties in finding competent engineers and other evidence suggests an acute shortage. However, with thousands of excess graduates in engineering disciplines unemployed in South Asia, we need to explain why there is a shortage and a lack of competition in the engineering sector of the economy.

Migration offers a strong explanation. As we have detailed, engineering involves far more than the narrow technical competencies acquired in university courses. The broader range of engineering skills and knowledge is acquired through exposure (and training) in professional employment. The few graduates in South Asia who are fortunate enough to acquire this become more attractive to DC employers and so are more likely to migrate. Our experience in trying to find competent engineers in Pakistan shows that the number of engineers available with these skills is very small, and this means that opportunities for new graduates to acquire these important additional skills through supervised employment are few and far between. Without these skills, a graduate engineer cannot perform or develop effectively. This explains why there is little competition in the engineering sector even though the supply of graduates is more than sufficient.

The defence sector contributes to the shortage. The defence establishments of both India and Pakistan have produced nuclear and other advanced weapon systems, and while engineering standards still lag behind those of DCs, they have advanced considerably.

Engineers employed in the defence sector have low salaries but generous fringe benefits that they could never afford even with higher salaries paid in the open market. In the words of one engineer “My classmate works for the atomic energy sector. He was attracted because it offered the kind of technically challenging work you can only get in an advanced country. However, now he is dissatisfied with his job. He has far too many subordinates to supervise and direct, and never has a large enough budget to buy the equipment and materials he needs to develop his ideas. However his job provides a large house, servants, a car, and top quality hospital and medical care for himself and his extended family. He could never afford these on even the highest private sector salary. So he is trapped and cannot leave his job”. This helps to explain why defence sector skills do not easily transfer to the rest of the country.

Information Technology – A Special Case?

Recently we have seen the widespread recruitment of IT professionals[37] directly from their countries of origin.

Several researchers have argued that when temporary IT migrants return to their home countries they stimulate home country industries and investment[38] and some point to recent developments in cities like Bangalore in India as evidence of this. We question this assertion on the basis of our analysis of professional engineers that show similar occupational attributes.

There are significant centres for software development in South Asia and several other LDCs that compete for business with top companies in DCs.

Software centres, however, are not typical examples of working environments in the region. In effect, they are offshore extensions of developed countries. Dedicated power generation plants and satellite links, daily contact with clients in developed countries, and regular travel to meetings provide an extension of the working environment of a developed country. Beyond the compound walls however we see a different picture. In India, chronic congestion in data communication infrastructure and electricity shortages have severely restricted the availability of IT services to the general community. In contrast, electric power and internet infrastructure in Pakistan are almost at developed country standards, but the absence of effective intellectual property protection for software[39] has crippled attempts to build a local software industry.

There is an important factor that distinguishes software development from other engineering and technological ventures. The IT industry is labour intensive: software is essentially produced by skilled 'artisans', and the cost of their labour dominates software costs. Engineers, on the other hand, seldom form a significant proportion of the cost of engineered services or products. Typically, engineering salaries are between 1-3% of the total cost. An engineer succeeds by reducing the total cost of the service or product, and can often *increase* his or her own remuneration in the process. The software industry is changing, however. Software tools are used to increase the productivity of software coding, but the typical level of investment in tools is far lower, as a proportion, than in other longer-established branches of engineering. Consequently, the 'artisan' labour component is still very high.

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[37] Information Technology professionals are mainly programmers with qualifications in computer science or software engineering, and most have been recruited from India between 1998 and 2001.

[38] Meyer (2001), Pellegrino (2001), Khadria(2001) and Johnson & Regrets (1998).

[39] Pakistanis are proud of their young computer hackers. "They download the latest software within hours of its release in the US and remove the software locks within hours. The latest Windows software is out in the markets here for the price of a copied CD before you can buy it in US stores." I was surprised to find a prominent Pakistani writer ardently advocating that software should be free for everyone, yet at the same time complaining about people who copy his work illegally.

Can Temporary Migration Help?

Lowell and Findlay(2001) argue that temporary migration could be beneficial for LDCs because migrants will acquire professional skills which they take home after a few years. This is certainly beneficial for DCs through the competition mechanism described above. However there seems to be little evidence that returned engineers can contribute their skills. Anecdotal evidence suggests that in the LDC environment where personal connections and patronage are as significant as competence attributes in obtaining paid employment, local engineers see returning migrants as a threat and it is difficult for the returned migrant to find productive employment. Appearance is important too: the returned migrant may need to give the impression that this is just a “temporary” return before another offshore assignment. Further anecdotal evidence suggests that migrants in DCs look for further temporary migration opportunities in DCs before considering a return home. Whatever the future possibilities are, our experience so far suggests that there is still a severe shortage of competent engineers in South Asia even if some are returning from DCs with usable skills.

Conclusion & policy suggestions

We have argued that the movement of skilled migrants is the movement of capital and results in a substantial transfer of wealth from the home country to the host country. The wealth transfer is particularly acute in the case of less developed countries. The wealth transfer arises because of the large investment in education and child rearing from the home country, and the savings affected in the host country that does not have to make this investment. This transfer can be quantified.

Apart from the initial wealth transfer that occurs when a skilled professional enters employment in the host country, there are several other effects. These are particularly evident when the proportion of migrating professionals becomes significant in either the home country or the host country. We have focused on two countries because we have first hand experience of employing engineers in both Australia and Pakistan and of individual engineering professionals who have migrated from Pakistan to Australia. These secondary effects have been discussed in qualitative terms. We have not been able to develop quantitative measures in the scope of this study.

We have observed a large gap in engineering competence levels between Australia and Pakistan, and point out that engineering standards in the Indian subcontinent have declined relative to DCs since the 1950s while there has been substantial skilled emigration. There is a large gap in productivity levels in non-traded sectors of the economy that reflects engineering competence levels. The cost of engineered services can be as high or higher in a LDC than DCs, even though labour costs are much lower. In LDCs, low competence levels and emigration substantially reduce workplace training opportunities, reinforcing the problem. While there is an oversupply of engineering graduates in Pakistan it is very difficult to recruit an engineer with internationally competitive skills.

We have observed how migrant engineers from LDCs such as Pakistan can perform at internationally competitive levels in DCs where they compete for engineering jobs. We have shown how the major beneficial outcome of competition between engineers in DCs is in productivity gains for clients rather than engineering salary savings. Competition is also a major incentive for technological change leading to further productivity improvements. Migration from LDCs contributes to this.

We have also shown how engineering depends on, and is part of the social, economic and political environment. Client expectations significantly influence engineering decisions. This means that engineers from LDCs cannot necessarily use the skills and knowledge they acquire in DCs if they return home. Encouraging migrant engineers to return to LDCs will not help to solve the problems we have observed.

We are therefore led to the conclusion that migration of engineers from LDCs contributes to productivity gains in DCs, and skill shortages and low productivity in LDCs. While we cannot quantify these effects there is evidence to suggest that productivity gains are much greater than engineering employment costs.

Since the 1960s some researchers have suggested measures to limit the negative effects of "Brain Drain" - effects such as restrictions on migration. It is not easy to see any positive benefits of the restrictions that have been attempted.

We have argued in this paper as an example of skilled migration that professional engineers are more productive, have higher competence levels and provide more benefits to clients in developed states than they can in less developed countries. Therefore, any measure that restricts engineers to working in a less developed country, and that does not address most of the other issues we have discussed, will decrease or even eliminate the return on the initial educational and child rearing investment. Using the same argument, forcing skilled migrants on temporary work visas to return to their home country is economically inefficient. We have shown that their productivity in the home country environment is likely to be much less than in a developed country.

We can cast this same conclusion in a different setting. A measure that requires engineers to remain in the town of their birth in a developed country would be economically inefficient. If the town offers no suitable employment for the engineer, there will be less return on the investment in child rearing and training. However, in a developed country there are highly developed measures to redistribute the wealth generated by industrial enterprises that require high levels of engineering to build and maintain them. Through taxation and other measures, wealth is redistributed in the form of health care, social security, transport and education services. Therefore we propose that investment by developed countries in health care, social security, transport and education services in less developed countries would be the most effective way to compensate for transfer of human capital investment that occurs as a result of migration.

Another contemporary issue that has emerged as an extension of the debate on the 'Brain Drain' in the late 1960s is third world debt relief. It is plausible that that the large transfer of human capital from many less developed countries to developed countries provides a rational basis for debt relief. It has become clear that many less developed countries will never be able to repay their debt in the foreseeable future. Debt relief on the basis of human capital transfer would recognise the contributions that less developed countries have made to the prosperity of developed countries through migration of skilled labour. Our analysis might provide a starting point for further analysis to develop some rational measures for debt relief.

Of course, as we have pointed out, the creation of human capital represents investment by both the state and the individual. The relative proportion varies between different countries. The financial investment needed to create skilled labour is much higher in a developed country – approximately ten times according to our analysis. This reveals part of the economic efficiency gain from migration. Therefore it is only reasonable that the gains be shared according to some mutually acceptable formula, between the receiving state, the sending state and the individual. One difficulty here is that some receiving states, such as Australia, may not have substantial exposure to third world debt and may not see that such a move furthers their own interests.

However, as the recent IT boom has shown, the less developed world can provide significant resources of skilled labour. Skilled professionals can be trained in less developed countries at substantially less cost than in most developed states, and these workers are highly productive in an appropriate environment. Our analysis shows some of the factors that are essential for engineers to be productive: competition, continuing training, and an appropriate "long term" investment culture. Therefore, there are good reasons for developed countries, or even large individual corporations, to invest in creating appropriate environments in less developed countries so that the total skilled labour resources of the world can be substantially increased. Even if this investment comes only in the form of debt relief, it could make a substantial difference. However, we would argue that the key issue to address is improving the underlying competence level of the skilled workforce in LDCs.

Although we have restricted the detailed discussion in this paper to professional engineers, we would suggest that previously held assumptions about other classes of skilled labour can be questioned by following similar arguments.

We hope that insights gained from this analysis can make a contribution to current rather ill-informed public debates on immigration of skilled workers.

Appendix

Cost of raising and educating children in Australia

Very few works on labour movement take training costs into account. However, these costs are very significant, especially for highly trained professionals such as engineers, and more so in the developed states. The costs include the general cost of raising children, primary and secondary education, tertiary education, post-graduate education and training, and government services that help provide a secure environment for these activities. Several examples of attempts to estimate these costs all help to establish the approximate magnitude of these costs in developed countries. Estimating costs in LDCs is more difficult.

There have been several attempts to calculate the cost of raising children in general. Some of these costs are summarized in table 1 where the cost base has been normalised to the year 2000 at the approximate rate of 2% from years between 1993 and 2000.

Source	Cost (US$)	Common	Schooling	Healthcare	Transport	
Harding & Percival (1999)	81[40]	yes			yes	Calculated in 1993-94 Australian prices, indexed to 2000 at 2% per annum.
USDA (2001)	187	yes	yes	yes	yes	Calculated from 2000 USA prices.
Valenzuela (1999)	64	yes		Yes	yes	Calculated from 1993-94 Australian prices indexed to 2000 at 2% per annum
Trevelyan and Tilli (2002)	116	yes	yes			Calculated from West Australian boarding school fees with after hours care labour costs removed.[41]

[40] All costs were calculated using US$ 0.52 as the exchange rate.

[41] Based on staffing and student numbers at Christ church Grammar School, Claremont, Western Australia. Hourly rates and hours of employment are estimates based on current wage rates.

Trevelyan and Tilli (2002)	85	yes	Private school in Australia, averaged per week for 12 years.[42]
Trevelyan and Tilli (2002)	53	yes	Government school cost per student in Western Australia averaged per week over 12 years.[43]
Trevelyan and Tilli (2002)	76		Australian Government expenditure on transport, police, security, health etc (excluding education)[44]

Table 1: Some cost estimates for child raising expenses

The cost of boarding at a private school, excluding the direct labour costs of after hours care, is US$116 per week. We allow approximately $25 per week for transport and health costs (parents' responsibility). From this we can estimate a cost of $141 per week for one child. Government contributes $76 per week worth of services to provide the required security and environment for this to operate so we end up with a total community cost of US$217 per week. This compares well with the USDA estimate that does not include US Government support for community services.

Investment needed to produce one engineer in Australia

The cost (both private and public) is calculated as shown in table 2 below:

	US$/ week	US$/year	years	cost	notes
Child rearing cost (except schooling)	217	11284	24	270816	middle of range estimate

[42] Boarding school calculations are based on an average of fees from Christ Church Grammar School and Methodist Ladies College, private schools in Western Australia.

[43] Based on information about student numbers in th*e DETYA Annual Report 2000-01 – Education and Training in Australia – The System* and education expenses incurred by government reported in *AusStats:Expendiutre on education* (23/11/01).

[44] This was calculated from the per person expenditure in the Western Australian State budget 2001, and includes spending by the State and Commonwealth governments on health, roads and transport, Social Services, Police and general public services. These sources of spending were chosen because expenditure necessarily increases as population increases. This is in contrast to areas such as defence spending which do not alter in response to changes in population. It was assumed that government spending in Western Australia is similar to the expenditure patterns of the other Australian states and territories.

Schooling	72	3744	12	44928	half way between independent and government school cost
Pre-Primary	36	1872	1	1872	half of schooling cost
Parents foregone income		15600	10	156000	Au$30,000 per year approx
Tertiary Education		10547	4.5	47463	Average cost of Au$12677 per year with weighting of 1.6 for engineering courses
Post graduate training		19240	2	38480	Assume 60% of employment cost for 2 years: employment cost is salary * 2.5 to allow for other costs
Total Cost				**559559**	

Table 2: Cost components in the production of a trained professional engineer in Australia

Revised Table 15th September (JPT)

A typical engineering graduate in Australia takes 5.5 years to complete the standard four or five year degree, takes a year off before or during University studies, and a further 0.5 years travelling or waiting for employment after graduation. This comes after 12 years of schooling and a year of pre-primary schooling, preceded by 5 years of initial child rearing. We assume that one parent gives up ten years of full-time earning capacity at a modest salary of Au$30,000.

We have not yet distinguished the private and public investment. Private investment includes living and accommodation expenses and private contributions to education, health-care and transport. Government investment is mostly represented in Australia by a substantial part of education costs (even private schools are subsidized), health care subsidies, and government spending to provide a secure and healthy environment for child rearing. In other countries the relative contribution by government will be greater or less, but the total investment is not likely to be very different.

Post-tertiary Employment Training

A typical university engineer spends much of the time in the first few years of his or her career acquiring new skills. In larger companies the young engineer will be placed in a graduate development program and given a wide range of experiences with 3-6 month spells in different parts of the company. In smaller companies an engineer has to be versatile and will find many quite different aspects of the job. This means the productivity of a young engineer can be erratic, as shown in figure 1, but rises steadily and can be approximated with a gradual rise to full professional capacity over two to four years.

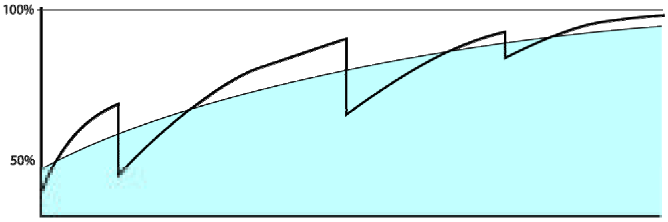

Figure 1: Typical changes in productivity of a newly graduated engineer

This allows us to approximate the cost of employment training. Employing an engineer costs between two and three times the basic salary level. Apart from the normal additional costs (leave allowance, insurance, sick pay allowance etc.), an engineer needs considerable support to be productive. Access to supervision, computers, office space, communications, travel, and technical support staff are also needed. All these costs have to be paid throughout the training period. We can therefore estimate a typical training cost as being a proportion of the full employment cost over the first two years. Given an average productivity of 60% , the proportion that is training is effectively 40%.

Average productivity over first two years: 60%

Salary: Au$37,000 (typical Australian graduate salary over first two years)

Employment cost (40% of full cost, 2.5 times salary for 2 years): Au$74,000 (US$38,480)

A migrant engineer will also take some time to reach full productivity with a new employer. However, the training period would normally be measured in months rather than years.

We assume that government costs are included in these estimates. However, because the company and the staff pay taxes the net government outlay is assumed to be zero.

Investment needed to produce one engineer in Pakistan

We have estimated the investment required to produce a graduate engineer in Pakistan by similar methods to the Australian case.

To assess the investment needed for rearing a child we deducted the cost of labour from school boarding fees and applied this monthly cost for the full year. This closely matches an alternative estimate that we produced by calculating the cost of food, a proportion of housing costs, transport, medical costs, clothing, etc. Actual expenditure can be much higher depending on the wealth of the individual family. The majority of the population cannot afford these costs of course.

We investigated two cases to assess tertiary education investment: a private university college and a government university. The private engineering college fee charges are Rs 100,000 each year. The investment in a government university is comparable, though the fees are much lower due to subsidies. We have used fee levels applicable in the year 2001.

The investment needed for post-graduate on-the-job training is calculated using the same assumptions as we did for Australia except that the salary level is assumed to be 12,000 Rs/month.

All the costs have been converted to US$ at a rate of 55 Rupees = 1US$.

Note that this assumes that all education is completed in Pakistan. A significant but unknown proportion of migrant engineers from LDCs attend a DC university at the expense of their families. The investment needed for this is typically at least US$50,000 - more than we have shown here.

	US$/week	US$/year	years	cost	notes
Child rearing cost (except schooling)	30	1571	24	37702	calculated from cost of school boarding with labour component subtracted
Schooling	30	1145	12	13745	38 weeks each year based on tuition fee of Rs 7000/month
Pre-Primary	30	1145	1	1145	Same fee structure assumed
Parents foregone income	0	0	0	0	If parents cannot look after children, servants provide care: factored into child rearing cost.
Tertiary education fees		1818	4	7273	Assume cost structure for private college: Government university investment will be slightly less.
Post graduate training		2618	2	5236	Annual salary Rs 12000, 2.5 factor for overhead costs, 60% average productivity
Total				**65102**	

Table 3. Investment in Pakistan to produce one engineer

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