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ABSTRACT

Must Skilled Migration Be a Brain Drain? Evidence from the Indian Software Industry*

We provide a first empirical attempt at understanding the scale and type of skilled migration from the Indian software sector and the consequences for firms experiencing loss of skilled workers. The paper draws on some unique survey evidence of software firms in India. The results are not generally consistent with an adverse or brain drain story but provide a more nuanced interpretation. Not only has skilled migration taken a variety of firms – including significant temporary migration – but the evidence suggests that the impact of mobility on performance in the sending firms has not been unambiguously adverse. There is some evidence of associated wage pressure at the height of the software boom in the late 1990s. But there is also evidence of a strong supply side response as workers acquired training and entered the sector.

JEL Classification: J31, J61

Keywords: skilled migration, software, brain drain

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Introduction

The consequences for developing countries from losing talent to developed countries has again attracted attention, not least because of the latters' explicit use of targeted visa programmes for skilled professionals. For example, the USA's H1B visa and its widespread use by the US software industry in the latter part of the 1990s has received considerable comment, as have later attempts by other OECD countries – such as Germany and the UK - to implement visa programmes aimed at attracting skilled professionals from developing countries.

This paper examines this phenomenon by focussing on one particular sector, software. Aside from being characterised by rapid growth rates, the software industry has also come to be a symbol of the growing internationalisation of production and the associated cross-border division of labour. Among developing countries that have successfully engaged with the industry, the Indian example has been particularly notable. Not only have major Indian software firms established themselves as international players but there has also been substantial cross-border mobility of Indian software professionals working in developed countries. For example, the survey on which much of this paper is based found that between 30-40 per cent of higher level employees in Indian software firms had relevant work experience in a developed country.

Clearly, the collapse of the technology bubble post-2000 has had a negative impact on the volume of such labour flows. Indeed, there is evidence of Indian software professionals returning home as job opportunities have dried up. However, there is some – albeit anecdotal – evidence that migration to other regions than North America has grown, while at home the downturn has been associated with a shake-out of the industry that has led to greater concentration. Given these features, the software industry provides a good laboratory for gaining insight into the consequences of skilled mobility. With the IT and software industry very much in mind, some have suggested that the type of mobility that has been observed conforms to a new paradigm, where so-called 'brain circulation' [1], rather than permanent migration or a brain drain, has been the dominant characteristic. Technological change 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 permanent migration.

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[1] Saxenian (2000)

Yet, another body of work has argued that permanent loss of talent has been significant with immediate consequences for the labour market. One line of argument has been to emphasise that while there have not been generalised supply side shortages of skills, tightening of supply has occurred in the uppermost levels of the skill distribution as much of the top end of the skill distribution has moved abroad, particularly to the USA. Others, for example Arora et al (2001), have argued that one of the major problems perceived by Indian ICT firms has been a wider shortage of skilled labour and this had been associated with wage pressure that has extended beyond the sector. Further, some have argued that the fiscal costs associated with the migration of skilled individuals to developed countries – principally to North America - have been substantial. Such costs would arise if education was largely publicly funded. And although here has been a clear growth in the provision of private educational services in many developing countries – including in India - even when this has occurred, any additional social returns to education would still have been lost with migration. Further, emigration can have an impact on future revenue streams. One study of Indian migrants to the USA has placed the fiscal cost to India of skilled migration to the USA in the region of 0.24-0.58 per cent of Indian GDP [2].

This paper is an attempt to investigate some of these issues more systematically using a unique dataset of 225 Indian software firms. That dataset provides a first, detailed look at the output and skill composition of these firms and their exposure since 1999 to the loss of skilled personnel to firms in developed countries. The dataset also provides extensive information concerning compensation and labour practices. In addition, data on comparable wages in migrant-employing firms have also been compiled from a survey of 60 software firms operating in the USA and this allows us to get a better sense of the size of wage gap, adjusted for skills, that exists across these two countries. The US dataset – while small - also provides some direct information on the skill content of migrants, the extent of screening and some indicators regarding the duration of migrants' stays. Using these two data sources, the paper provides a robust empirical investigation of whether the cross-border mobility of skilled personnel has exerted a positive or negative effect on the sending firms and, by implication, the industry.

The paper is organised as follows. Section 2 provides a brief overview of the analytical literature on the brain drain and highlights the particular channels through which either adverse or positive consequences might arise for the sending or developing

[2] For example, Desai, McHale and Kapur (2002). This is their estimate of the net fiscal loss associated with

country. Section 3 then moves on to summarise the design of the survey instruments and sampling frame and to indicate what of the broader analytical considerations this instrument can help us address. It also provides an introductory set of descriptive statistics. Section 4 looks at the skill composition of the survey firms and their compensation structure. Section 5 then examines explicitly the exposure of firms to external migration. Section 6 begins to quantify the impact of such migration on the sending firms. Section 7 then concentrates on pinning down the consequences of skilled migration for performance, as primarily measured by change in turnover per worker. A conclusion follows.

Brain drain or gain: analytical issues

Early generation models of skilled migration focussed largely – but not exclusively – on the labour market consequences in the sending country. They treated the demand side for emigrants as exogenous and generally assumed that there was a public subsidy to education [3]. In the event of education being mainly financed by public resources, migration could indeed drive a wedge between private and social benefits. Further, with migration a developing country exchequer would lose access to the stream of tax revenues that could be expected to flow from the prior investment in human capital. With respect to the labour market consequences, skilled labour mobility could also exert a variety of effects. It could affect wages through emulation and by unskilled wages following skilled wages, as well as through expected wages responding to the actual foreign wage and the probability of emigration. The latter would then affect education decisions with education in turn carrying a fixed cost. With respect to unemployment, in these types of models, emigration might lower skilled unemployment, but could also exert two other effects. It could raise the expected wage by lowering unemployment and this could be amplified if the emigration wage entered the expected wage. The net result would depend on the elasticity of demand for skilled labour and this would determine whether the skilled labour wage bill increased or not. Second, if the skilled wage increased because of emigration, this might spill over into other sectors and hence have an impact on employment in those other sectors. Letting unskilled wages follow skilled wages would adversely affect the employment of the unskilled.

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the US India born resident population in 2001. The upper bounds are drawn from PPP estimates.

[3] See, for example, Bhagwati and Hamada (1974).

A more recent strand of the literature has viewed skilled mobility in a light potentially more beneficial to the country of origin [4]. Insofar as migration encourages those left at home to acquire more education and this in turn results in higher levels of human capital than would have been the case without migration, a positive impact on growth and income could be predicted. If the accumulation of skills has effects beyond the strictly private gains, the whole economy can benefit [5]. This insight has to be qualified. A necessary criterion for skilled migration to be beneficial for the developing country is that the marginal person in education has a positive probability of emigrating. However, if, for example, perfect screening of migrants by firms in developed countries existed this key assumption would be violated [6]. As such, the extent to which screening is effectively implemented will have an impact on the potential benefits from skilled migration. Of course, if the returns to education in the sending country were primarily determined by the demand for skilled workers rather than, say, the ability of the population, even a perfectly screened emigration would generate net benefits. Further, the extent to which the supply of education can respond to the shift in demand will be relevant. Such response may be qualified if the education sector is itself subject to migration or there are institutional and other barriers to entry. For example, some countries still try to maintain a public sector monopoly on higher education and this tends to be associated with rationing of places.

This body of literature has, however, been largely bereft of empirical content. Nevertheless, it provides clear motivation for looking at a set of empirically verifiable indicators that include focussing on the type and duration of migration, wage setting and compensation levels in and outside the industry being studied, the incidence of education costs, the incidence of reinvestment and other financial flows associated with migration as well as the extent to which migration has been screened at the receiving end and the implications that might have for the acquisition of education by those remaining behind. While the latter cannot be observed directly, a close look at the supply side for skills and their educational content can be informative. Further, having a time dimension can allow better identification of the impact of migration on turnover, firm size and other measures of performance. Information on the duration of migration and the extent to which migration has been associated with access to networks, business and other productive

[4] See, for example, Mountford (1997); Beine, Docquier and Rappaport (2000)

[5] This might be through the assumption that increasing the average skill level of the sending economy is desirable or that the productivity of current labour depends positively on the share of the population who had education in the previous period. See for example, Mountford (1997)

links can help throw valuable light on whether skilled migration has exerted a positive or adverse effect on the sending firms or country.

The survey data – to which we now turn – allows us to look at a number of these indicators. As such, it allows us to pin down more exactly;

- incidence of skilled migration from the universe of sampled firms in two periods, 1999 and 2002/2003
- skill content – including educational attributes – of migrants
- relative weight of temporary as opposed to permanent migration
- motivations for migration including the wage consequences of migration and the size of compensation differentials across countries
- quality of migrants relative to stayers and the extent to which screening of migrants occurs in the developed country and the mechanisms by which such screening is implemented
- consequences of migration for firm performance
- external effects particularly with respect to the supply of educational services

Finally, it is important to emphasise that the data are primarily concerned with only one sector – software – in one country, India. As such, they offer plentiful insights into the phenomenon of skilled migration but clearly do not allow us to focus on the general equilibrium properties of such migration.

Survey design and descriptive statistics

The survey was administered to 225 Indian software firms in the winter of 2002 in collaboration with the Indian software industry association, NASSCOM [7]. Information was collected through repeat on-site visits and interviews with either CEOs/Managing Directors and/or senior Human Resources personnel in the case of the larger companies. The survey collected information on the ownership, financing and activities of the firm; its employment and compensation distribution over a number of skill categories, as well as detailed information on the incidence of mobility from the firm, particularly to firms in developed countries [8]. It also collected information on labour market characteristics and perceptions of the consequences of skilled migration for both the firm and the industry as a whole. Wherever feasible, answers were elicited for two points in time,

[6] These arguments are developed in more depth in Commander, Kangasniemi and Winters (2004)
[7] The survey was implemented by ORG-MARG, Bangalore.

1999 and 2002. As such, firms were only included if they had come into existence prior to 1999.

The sampling frame was set up to include firms primarily engaged in the development, marketing or servicing of software but not IT-enabled services. Sampling was done in five major centres of the industry; Bangalore, Chennai, Delhi, Hyderabad, Mumbai and Pune. The sampling frame was drawn from firms that had previously registered with NASSCOM, as well as firms that were not registered. The latter names were separately compiled using a mix of sources, such as local directories, state level IT departments and so on. The total sample was split 70:30 between the NASSCOM and other registers. Stratification by size followed, distinguishing between firms employing over 50 employees and those with less than 50. The size distribution and the sample size for each location were both set consistent with aggregate numbers from the NASSCOM database. A total of 225 firms were ultimately sampled over a period from October to December 2002.

An additional survey – with a number of common questions – was also implemented in the USA. The procedure used was different in that the survey was web-based and the sampling frame was a list of software firms operating in that country. Screening was done to ensure that only firms with some experience of hiring migrants responded. The total number of responses was 60. Clearly, the sample size is small and unrepresentative. Nevertheless, it provides some useful – largely qualitative – information concerning the skill characteristics of migrants, their duration of stay, as well as the perceived quality and screening of migrants.

Table 1 provides some descriptive statistics for the main Indian sample. It can be seen that the average size of the firm increased over the period from 188 to 320 full time employees. In 2002 the largest firm had over 14,500 employees but 70 per cent of firms comprised 150 employees or less. Mean turnover per worker rose by 28 per cent between 1999 and 2002, while the average share of exports in total turnover climbed from 59 per cent in 1999 to 63 per cent in 2002. In 1999 over 50 per cent of firms – rising to over 60 per cent in 2002- had shares of exports in total revenues that exceeded 50 per cent. Indeed, around 30 per cent of firms only exported in both years. The mean wage, weighted by employment, in the sampled firms rose by nearly 30 per cent in nominal terms between 1999 and 2002. This amounted to a real increase of around 17.5 per cent. Software represents the high compensation end of the Indian economy.

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[8] Copies of the survey instruments are available on request.

Table 2 gives a breakdown of what these firms actually do and what are their ownership arrangements. Nearly two fifths ranked products and packages as their main activity, while a further third cited turnkey projects and 17 per cent cited professional services. However, it is evident that most firms operate across a number of activities. In terms of ownership, over half were either Indian companies or owned by Indian individuals resident in the country. Foreign owned firms comprised 13 per cent of the sample, with a further 8 per cent being owned by Indians who were resident abroad or who were return migrants. A significant share of firms – around 17 per cent - were of mixed ownership with a minority of these firms being owned by a mix of domestic and foreign owners.

Personal and family resources have been the dominant form of financing. However, around two fifths of firms have had access either to venture capital, equity finance or loans from Indian or foreign financial institutions. Of interest in considering the broader ramifications of skilled migration, 14 per cent of firms had received investment from Indians domiciled in a developed country and in a quarter of those cases, such investment accounted for over half of new investment. Indeed, around three quarters of the sample had some form of alliance with a foreign company. Just over a quarter of the sample had either a business or strategic alliance with a foreign company, while the incidence of marketing or technology transfer arrangements was also fairly common.

The broad picture that emerges from this sample is of an industry populated by firms with significant commercial and, to a lesser extent, ownership and financing links to foreign firms, mostly located in the USA. The overwhelming majority of firms have maintained a strong export orientation throughout the period. Compensation levels have remained high compared both to the Indian mean and that for manufacturing.

Skill Composition

Software firms operate in a number of markets and domains, so an initial presumption might be that this will affect the mix of skills with that mix depending largely on the type of activity in which they specialise. The survey instrument distinguishes five main skill categories namely; managers, conceptualisers, developers, modifiers and supporters. *Table 3* breaks down staffing by skill and by the main type of

activity of the firm[9]. Actually what emerges is that the distribution of skills varies somewhat less than might be presumed. All software firms in this sample had a clear preponderance of developers - the share of this category ranged between 41-57 per cent of total employment. Conceptualisers – the highest skill category below managers – comprised around 5 per cent of the workforce in firms whose main activity was not training or computer-aided design. Modifiers and supporters combined accounted for between 10-17 per cent of employment. Thus, although there are identifiable differences in skill mix, it appears that the bulk of firms operate with reasonably similar skill distributions that are adequately captured by the categories used in the survey [10].

Relating the principal functional categories that are used in this paper to their educational attainments, it is clear that the software sector is populated by highly educated people. The overwhelming majority possess, at a minimum, a BA with between 13-26 per cent of managers and conceptualisers respectively holding more than a MA. Even for the lowest skill category – supporters – we find that around three quarters were graduates with a BA or more. Wages and educational attainment were predictably and conventionally ordered [11].

Turning to a closer look at compensation, *Table 4* provides mean and median wages for the main skill categories, as well as the rate of increase for mean wages over the period 1999-2002. It should be noted that the variation of compensation within categories – as indicated by the standard errors - is high. With respect to relative wages, in 1999 managers earned roughly twice the wages paid to the lower skill groups. By 2002 this had jumped to a multiple of three. Relative wages at the top end of the skill distribution did not change significantly in this period. There is clear variation in the rate of increase in nominal compensation over the different skill categories. Managers experienced particularly strong average wage growth of over 50 per cent. Other skill groups, with the exception of supporters, saw nominal wages grow within a relatively small band of 25-30 per cent, implying a real wage increase of between 7-13 per cent. Supporters – the lowest skill category – experienced a real wage decline of over 10 per cent in this period.

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[9] Some definitions are in order. Conceptualisers work on the design of whole systems and include product designers, systems analysts and architects. Developers work on specifying, designing and constructing information technology artefacts. They tend to be responsible for working out the programming inputs of a project and managing the allocation of tasks. Modifiers/extenders modify or add on to an IT artefact. They tend to write code, test and modify programmes. Supporters deliver, install and maintain IT artefacts running computer related services within user firms or help as consultant trouble-shooters.

[10] Non-IT Managers, Other Skilled and Unskilled were the additional skill categories that were included in the survey instrument.

Table 5 allows comparison of wages for comparable skill groups in the Indian and US software industries. The US numbers are derived from a small sample of firms that we implemented in mid-2003 and which provided compensation information for equivalent skill categories to those applied in the Indian survey. The comparison is striking for showing not only how large has been the gap in base compensation (exclusive of stock and other options) but also how persistent it has been. Managers and conceptualisers working in India earned around 10 per cent of their US counterparts when calculated at current exchange rates. This share rose to between 25-30 per cent when calculated in PPP terms. The gap was, if anything, higher for the lower skill categories. This order of difference in wages certainly highlights one of the major incentives for Indian skilled software personnel to move abroad.

Skilled migration: some magnitudes

Table 6 provides information on the incidence of skilled migration from the sample of firms. It shows unambiguously the generalised nature of skilled migration in both 1999 and 2002, particularly in the former year. In 1999 nearly two thirds of firms had experienced some migration of skilled workers. Disaggregated by skill type, it is evident that skilled migration was clearly significantly larger in 1999 when, for example, over 16 per cent of developers left their firms to work in a developed country. Even by 2002 – although rates had dropped – nearly 11 per cent of developers had migrated.

While skilled migration may be a key feature, it is important to appreciate that migration is by no means the only way in which workers have acquired experience in developed countries. Columns 3-6 of *Table 6* indicate that between 20-37 per cent of workers had worked predominantly on-site for clients in developed countries in both 1999 and 2002. In the case of off-site work, the share was yet higher in both years, ranging between 40-60 per cent. What is striking is that this sort of temporary mobility cuts across all skill groups. Further, Column 7 shows that over half of managers and conceptualisers working in the sampled firms in 2002 had relevant work experience in a developed country. Furthermore, there was a strong, positive correlation between firms experiencing migration in a given year and the stock of workers currently employed in the firm with developed country experience. This possibly points to some of the network and repeat features of migration in the context of this industry.

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[11] Results available on request

In short, these descriptive statistics, tell us not only that the incidence of migration has been high – particularly in 1999 – and common across firms, but that migration has likely taken a variety of forms. Many skilled workers appear to have acquired work experience in developed countries but on a temporary basis, while the work of the industry tends to lead to wide exposure for their staff to either on or off site work in developed countries. The picture is clearly one of considerable mobility that does not necessarily involve permanent migration.

There is sufficient variation in the incidence of skilled migration to ask more about the attributes of firms that have experienced such migration. *Table 7* relates the total migration share in each firm in 1999 – defined as the share of all skilled workers that migrated in the previous year relative to total employment in the firm - as well as the share of each of the discrete skill categories that migrated - to a set of variables capturing the attributes of firm from which they left [12]. Those variables include the size of the firm as measured by turnover per worker, whether the firm has an alliance with a foreign company, as well as ownership. For the individual skill categories, a variable summarising total migration from the firm in the reference period is also included. This is an attempt to capture the link from specific skill migration to general skilled migration at the level of the firm. Controls for the main type of activity of the firm and its location are included.

For the total migration estimate –- what emerges is that having an alliance with a foreign firm enters positively and very significantly. The size or turnover per worker variable is also positive but insignificant. Turning to the individual skill estimates, we find that having a foreign alliance exerts a positive impact on the migration share but one that is significant only in the case of managers. The size variable - turnover per worker – changes sign and is only significant in the case of conceptualisers. Migration of a particular skill type is, however, always positively and significantly associated with total migration from the firm. With regard to the activity dummies, turnkey work is always positively associated with a higher migration share. There are some weak region effects but the overall picture is of relatively little variation in terms of either location or activity.

These initial results already point to a link from exposure abroad – in particular through a business alliance - to the incidence of skilled migration. Further, there appears to be a robust link association between migration of particular skill types and general skilled migration from the firm. This suggests that migration of particular groups has

[12] Results for 2002 replicate quite closely the 1999 results and are not reported here.

been positively affected by the incidence of overall skilled migration from the firm. One obvious conjecture is that these findings point to a more complex, two-way relationship between wider exposure abroad and the narrower measure of skilled migration. Although, this is difficult to test with our dataset, these interactions underline the importance of viewing skilled migration in a broader light.

Screening

It is widely accepted that the USA in the 1990s pursued a very active and explicit attempt to attract talent in the software industry and to use a specific class of visa, the H1B, as the vehicle for that mobility. Further, it is quite clear that the bulk of H1B visas issued since the mid-1990s were issued to Indians working in the software industry [13]. This obviously points to active screening by the receiving country. As already indicated in Section 2, the presence of screening can materially affect probabilities of migration and any associated incentives with respect to educational decisions. What light does evidence from the two surveys throw on this issue?

At first pass, the Indian survey shows that the distribution of migrants across skill types clearly points to the upper end of the skill distribution having a higher hazard of migration. In particular, migration to a job in a developed country appears to be concentrated among managers, conceptualisers and developers. Further, the majority of the latter went to firms with which the sending firm had some connection. Across all skill types, roughly 20 per cent went in response to direct job offers, with around 70 per cent being recruited through an agency or so-called body-shoppers. These pieces of information suggest that a significant amount of the recruitment may have been as a result of prior work experience: a widely applied method for screening workers.

The survey also asked respondents to rank those that migrated abroad to a developed country in the last year. The rankings were disaggregated by each skill category. Controlling for the quality of the firm – as proxied by turnover per worker - what emerges is that in all cases bar that of supporters, the overwhelming share of migrants was judged to be above average or better. For developers, modifiers and supporters between 32-43 per cent were judged to be in the top 10 per cent. For conceptualisers that share increased to around 50 per cent, while in the case of IT managers over 55 per cent were put in the top 10 per cent with just over 20 per cent falling in the top 1 per cent. This may suggest that migrants have indeed tended to be

[13] Data are available in Commander et al (2004)

recruited from among the better workers. In short, the Indian evidence points to the presence of screening, not least through repeat contact with the firm to which they subsequently moved or through placement agencies.

The US survey also included a set of specific questions aimed at eliciting information explicitly about screening. Around 60 per cent of firms pursued what they perceived to be a highly targeted hiring strategy for managers [14]. This share dropped to around 35 per cent and below for conceptualisers and other skill categories. To predict the quality of employees recruited from abroad, most relied on formal qualifications but two fifths of the sample also applied explicit testing. Moreover, around 30 per cent of firms tended to hire from companies with whom their firm had worked closely. Indeed, nearly 40 per cent of all skilled workers from developing countries (over 50 per cent for managers) included in the sample came from a firm with which the hiring company had some form of alliance. This suggests that repeated interaction again provides one of the main forms of screening [15].

Finally, the survey provides information on how foreign recruited workers were ranked relative to other employees. When weighted by turnover per worker, over 40 per cent of foreign recruited managers were perceived to be in the top 10 per cent; this share fell to between 25-35 per cent for conceptualisers and engineers. This suggests that foreign hires tend to be ranked high; again reinforcing the impression that significant screening has been applied.

Consequences of skilled migration

We have seen that movement by skilled workers and managers to a developed country has been quite common. Although the mean share of any skill type that moved did not exceed 17 per cent even in 1999, over 50 per cent of firms in the sample had lost conceptualisers in both reference periods, while around 90 per cent had lost developers in this way. What have been the consequences, primarily at the level of the sending firm, but also more widely?

The starting point is the observation that when directly asked no more than 15 per cent of survey respondents reported that their firm had materially suffered from the

[14] A highly targeted strategy involved recruitment of only the best candidates with specific skills and/or extraordinary abilities. Other categories were 'company hires employees with adequate education and some experience but not necessarily specific skills or exceptional ability' and 'company hies anyone who satisfies the minimum technical skill requirements'.

[15] Note that over three quarters of respondents answered that most of their foreign recruited employees ultimately tended to secure 'Green Cards'.

emigration of skilled software workers since 1999. Further, when asked what the consequences of such migration had been for the Indian software sector as a whole, 60 per cent viewed migration as having exerted a positive effect. The reasons for this are themselves interesting. Around 40 per cent of respondents signalled that improving access to cutting edge technology had constituted a major benefit. Improvements in working habits, access to new information and customers in developed countries were cited by around a quarter of the firms as being a benefit. At the same time, the survey indicated that investment by migrating workers back into the Indian software sector, as well as remittances and an overall improvement in the quality of the labour supply had occurred. Further, nearly a quarter of firms reported that they retained links with workers that had gone abroad. The dominant form of such links was either through migrants or their new employers using the firm as a sub-contractor or vice versa, as well as migrants and their new firms being customers of the original Indian firm.

Some confirming evidence also comes from the smaller US sample. The data suggest that there has been considerable return migration. While a major part of this has been turnover at the lower end of the skill distribution – such as modifiers – around a third of responding firms reported quits from among managers and conceptualisers. Further, there was no evidence that such returnees were perceived as being poorer quality workers. Across all categories, most were classified as above average or in the top 10 per cent of employees.

Putting these factors together suggests that – at first inspection – the data might sustain the view that migration has been a positive force for the industry. The following sections now turn to looking in more depth and with more rigour at the incidence and consequences of migration for the sending firms.

Labour market effects

Clearly there has been a great deal of cross border movement of skilled workers that has cut across the sample of firms. The obvious questions that then arise concern the impact of this general flux on the availability of labour for the industry and for compensation more generally. Skill shortages have been widely reported alongside upward pressure on compensation [16].

Figure 1 provides information on firms reporting major shortages for on and off site work in 1999 and 2002 and presents responses weighted by the number of workers

[16] Arora and Athreye (2002)

for that particular skill category in the firm. What is evident is that perceived shortages are actually quite concentrated on a number of skill categories. In both years major shortages for conceptualisers are reported. While this is also true for on site work for managers, there is a sharp decrease in perceived shortages for off site managers. All other categories report far lower incidence of major shortages, especially in 2002. Of interest is the sharp decrease in perceived, major shortages for the most populous migrant category – developers –between 1999-2002. Clearly, major shortages were generally more prevalent in 1999 than in 2002.

Given this evidence that, particularly in 1999, there were major perceived shortages for some skill categories, the obvious question that then arises is whether such shortages at the level of the firm have been associated with the incidence of skilled migration in that firm and the level of compensation. In the latter regard, we might reasonably expect shortages to induce upward pressure on wages of the affected skill groups.

However, looking at the relationship between migration, compensation and the supply side of the labour market raises some obvious endogeneity issues. To try and address these endogeneity concerns, for each of the potentially endogenous regressors that are included, we specify an additional equation where each of these regressors serves as the dependent variable regressed on a number of strictly exogenous covariates. Since all equations are correlated, information about one equation carries implicitly information about all equations in the system. We employ the 3SLS estimator; an instrumental variables GLS procedure that achieves consistency through using instruments and efficiency through simultaneous estimation. As such, we actually estimate the following system of equations:

$$y_{it} = a + X_{it}\beta + W_i\varphi + \xi_{it}$$
$$x_{it}^{j} = a + Z_{it}\delta^{j} + \zeta_{it}$$

where matrix, *X*, includes all endogenous regressors and *W* is a vector of strictly exogenous variables. With y_{it} we denote shortage of a skill type *i* in year *t*. With x_{it}^{j} we denote the endogenous variables, *j*, for skill type *i* in year *t* which now serve as dependent variables. These are skill-specific compensation and the skill-specific migration rate in year *t*. Matrix *Z* includes all instruments. Finally ξ_{it}, ζ_{it}^{j} are error processes.

Table 8 reports the results of the system estimation using information for 1999 [17]. The shortage equations by skill type are related to the log of compensation of the skill type, the log of migration for that skill type, the share of that skill type in total employment and the size of the firm, as measured by the log of the number of full time employees. In addition, region and primary activity dummies were included. What emerges is that shortages are in every case positively and significantly related to the migration rate for the skill category. Shortages are also positively related to the size of the firm though not always significantly. As regards compensation, three out of four skill groups have a predictably positive coefficient on the variable that is highly significant in the case of developers. In the case of conceptualisers, the sign is, however, negative and significant.

The second equation relates migration by particular skill type to the log of compensation for that skill type in the firm, the log of total migration from the firm in the last year, a size variable, using the log of turnover per worker, and a variable indicating whether the firm has an alliance with a foreign firm. Region and activity controls are also included. The sign and significance of the compensation variable is not consistent. In the case of the firm having an alliance with a foreign firm, the coefficient is always positive and significant in the case of managers and conceptualisers. The turnover variable enters positively, as does the total migration variable. In the latter case, it is highly significant for all four categories of skill. This suggests that migration tends to cut across skill types in the sampled firms.

A third equation relates compensation for each skill category to the shortage variable for each category, the migration share for each category, an education variable measured as the share of the skill category with a M.A. degree or higher, a size variable – given as turnover per worker – and variables indicating whether the firm has any foreign alliance. The results suggest that compensation is indeed strongly positively related to shortages at the level of the firm. This variable is highly significant across all skill types. The migration rate enters negatively, as does the education variable. Size and having a foreign alliance enters positively in almost cases.

In sum, the system estimation indicates that there is a robust and predictable positive association running between perceived shortages and compensation of particular

[17] A Hausman specification test was also implemented. For all skill types, it can be seen that the null hypothesis of no systematic differences in estimated coefficients cannot be rejected, indicating that the use of 3SLS is efficient relative to use of 2SLS. For example, in the case of managers, the chi-squared test

skill types. Shortages and the migration rate are similarly positively associated but there appears to be no unambiguous link between compensation and migration. Having a foreign alliance appears to be associated with a higher migration rate and compensation. This exercise suggests that migration in 1999 does appear to have been linked with tight hiring conditions at disaggregated skill levels. Indeed, additional information from the survey indicates that the average time taken to fill a vacancy decreased by between 10-25 per cent between 1999 and 2002 [18]. However, that there was no robust, positive association between the incidence of migration from the firm to the time taken to hire particular skill categories in either year.

Labour turnover

Migration exerts an obvious effect on worker turnover in an affected firm. Although the survey does not permit identifying aggregate gross flows, it does allow us to look directly at the flow of workers, disaggregated by skills, to employment in a developed country. In 1999 between 9-11 per cent of managers and conceptualisers left the firm with an offer abroad. In the case of developers, this share was over 16 per cent. While flows had clearly declined by 2002 – in the case of developers the share had fallen to under 10 per cent and for managers and conceptualisers to roughly half compared to 1999 – nevertheless over 5 per cent of skilled employees left with an offer from abroad.

However, interpreting such turnover is not straightforward. On the one hand, high turnover could be associated with an industry undergoing change, as new work processes and products are introduced. This would certainly be an appropriate characterisation of the software industry. Further, given the substantial adjustment costs relating to both hiring and firing in the Indian context, high turnover might point to an industry refreshingly free of such costs. Alternatively, high turnover could be associated with the loss of valuable firm-specific human capital – with associated productivity costs – and with potential difficulties and costs in filling resulting vacancies on a relatively high frequency. Further, a wider finding is that high turnover tends to result in firms providing lower levels of training – due to the inability to internalise the benefits - than they otherwise might and this again should have adverse implications for productivity. Which of these various interpretations appears to fit the software industry?

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equals 18.63 with 13 degrees of freedom and is associated with a *p* value of 0.1351 which fails to reject the null hypothesis at any conventional significance level.

[18] In the case of managers this meant the time to fill a vacancy went from just over 7 to around 5.5 weeks; for conceptualisers from 5.2 to 4.7 weeks and for developers from 4.5 to 3.5 weeks.

The survey asked directly about the consequences of labour turnover for the firms and, in particular, whether turnover had exerted an adverse impact on the firm's performance. *Table 9* provides the responses. Of interest is the fact that the majority of respondents considered that emigration in general and of specific skill groups in particular had very limited adverse impact on their firm's performance, as well as on the choice of activity or structure of employment. No more than a quarter of firms reported that migration of a particular skill category had a negative impact on performance as measured by revenues per worker [19]. In terms of the firms' main activity, under 10 per cent of the sample indicated that this had been significantly affected. Only 2 firms, for example, reported that they had turned down work opportunities, a further 4 indicated some change in their priorities, while only 16 firms indicated that the structure of their labour force had changed as a result of skilled migration.

Nevertheless, it is also clear that firms have tried to limit labour turnover, primarily through wage increments. Just under two thirds of the sample reported using wage increments as a means for trying to retain workers and limit turnover. Of interest is the fact that nearly 40 per cent of firms perceived using work opportunities abroad in developed countries as a way of retaining talent. Other measures to stem turnover included provision of non-wage benefits, promotion and additional training. Putting these together in a simple index, we then ran an ordered probit estimation relating the index for retaining skilled labour to the share of workers that had migrated in the year prior to 2002 or 1999, turnover per worker and the usual set of controls. For both years, the coefficient on the share of migrants was positive and highly significant suggesting that firms with higher incidences of migration have actively tried to provide incentives to lower turnover [20].

With respect to training, only 3 per cent of firms had *not* provided some in-house training to their workers in the last year. While most of the training was done directly, around a quarter of the firms that did provide training had made use of private training providers, such as APTECH or NIIT on a sub-contracted basis. Finally, over half the sampled firms reported using additional workplace training as a means for trying to limit turnover: a response second only to increments to compensation.

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[19] 26-27 per cent of firms reported a negative revenue effect in the case of conceptualisers and developers, with a lower share – in the range of 14-22 per cent for other categories.

[20] The migrant share coefficients for 2002 and 1999 respectively were .0147 (.004) and 0.128 (.004). Standard errors are in brackets. Both terms were significant at the 1 per cent level.

Education and the supply side

Section 2 indicated that one way in which a beneficial brain drain might occur would be through education externalities. Put simply, the possibility of migration might induce potential migrants to make decisions to acquire education at home as a means for helping their chances of moving. While the survey cannot cast very direct light on this possible channel, there are a number of interesting insights that might emerge. In particular, the dataset provides information on the educational attributes of workers and the sources of training, including through new private providers. Given the strong public role in education in India and the finite supply of places in educational institutions – particularly at the higher quality end – without innovations on the supply side additional demand for education would have run into buffers. And here there is compelling evidence of entry occurring, mostly of private educational suppliers. Probably the best known examples are firms - such as NIIT and APTECH - whose businesses originally were built around training. Using a franchise model, they have mainly entered the lower skill end of the market, providing training for would-be supporters and modifiers in a wide number of locations.

The survey gives some sense of the perception of the quality of such training as well as the extent to which firms have recourse to thee providers for in-house training needs. In terms of hiring preferences, while there was a strong and unambiguous preference for hiring from IITs and Indian universities and engineering colleges, particularly for the higher skill categories, hiring from private training providers scored no worse than for polytechnics for lower skill types, such as supporters or modifiers. At these levels, there seems to be no stigma attached to the new training institutions. Further, as noted in Section 6.3, just under a quarter of firms in the sample sub-contracted some part of their training to such firms.

Skilled migration and performance

We now turn to looking directly at any possible impact skilled migration may have had on the performance of affected firms. *Table 10* provides results from some OLS estimations that relate the performance of the firm – as measured by the log of turnover per worker in 1999 and 2002 - to a set of variables covering migration incidence, work experience abroad, education levels, foreign alliance and the usual controls for region and principal activity. It can be seen that the education level in the firm – as measured by

workers with a M.A or above – exerts an unambiguously positive and highly significant influence on the levels of turnover in both 1999 and 2002. Having a foreign alliance also acts positively and significantly on the level of turnover in both 1999 and 2002. Work experience abroad – measured as the weighted share of workers that have worked mainly abroad in a developed country – exerts a positive and highly significant influence in 2002 but not in 1999. For the migration variable – here measured as total migration from the firm in the preceding period – the sign, while negative in both years, is far from being significant. This suggests that migration has not exerted a robustly negative impact on firm performance, as measured by the level of turnover and controlling for activity and region [21].

Turning now to look at the change in performance as measured by the change in turnover per worker between 1999-2000 and in employment over the same period - *Table 11* reports estimations that relate the above to the share of workers of a given skill category that had migrated in the first period and the share of each skill category that had worked predominantly in a developed country. The estimates include controls for region and type of activity. It can be seen that for the change in turnover equation there are negative signs for managers, conceptualisers and developers but in all cases the coefficients are insignificant. In the case of modifiers, the sign is actually positive and significant. This pattern is repeated for the variable giving the share that had worked predominantly but abroad, except that now all coefficients are insignificant. In the employment change equation, the signs are mostly similar to the turnover equation but all remain insignificant. In short, the estimations suggest that there does not appear to be any evidence of a robust negative impact of migration – as measured by disaggregated skill groups – on some simple measures of performance. We also experimented with the introduction of a variable summarising the perceived quality of migrant in the turnover equation. Specifically, this variable took a positive value when migrants were ranked by the respondent to be in the top 10 per cent of a firm's employees. Although the variable was mostly negatively signed it was always insignificant, suggesting no robust impact of the quality of migrant on the firm's performance.

[21] For the 1999 turnover estimate, the F test takes a value of 2.09 and p-value of 0.008; for 2002 F test is 2.59 with a p-value of 0.008; both reject the null that the estimated coefficients are equal to zero at any conventional significance level.

Conclusion

The software industry has epitomised the shift to a world in which cross-border flows of skilled workers have become integral to the way firms in developing and developed countries connect and transact. Large order differences in compensation across countries have also persisted and been key in promoting such mobility. These flows have, in turn, given rise to a pre-occupation that they might be detrimental to developing countries and constitute a brain drain. Indeed, there is some evidence –mostly anecdotal – that suggests that the top part of the talent distribution has indeed moved to developed countries. In the case of the Indian software industry, this has primarily meant permanent migration to the USA, not least because of active solicitation and screening on the latter's part. However, even if this has been the case, the fact remains that migration has been a larger and more complex story than could be told by a simple brain drain story.

This paper has provided a first empirical attempt at understanding what types of migration have occurred and with what consequences for the firms that have lost skilled workers. The results, on balance, are not generally consistent with an adverse or brain drain story. Rather, they suggest that more nuanced conclusions need be drawn. In the first place, the software industry has been marked by a variety of types of cross-border mobility, much of it temporary. Firms in the sample reported that very significant shares of their workforces performed some part of their work on or off site in developed countries. Further, there was evidence of significant numbers of those employed having work experience abroad in a developed country. Moreover, the share of skilled workers with such experience has tended to be positively associated with the current and lagged incidence of skilled migration from the firm. This may point to the presence of network effects as well as confirming the importance of temporary mobility.

The paper also examined in detail the consequences of skilled migration for the sending firm. In terms of the impact on performance – as measured by the change in turnover per worker and the change in the employment size of the firm – little evidence was found of a strong adverse impact of exposure to cross-border migration on these performance variables. Further, although there was evidence of some wage pressure at the height of the software boom, it would appear that this has subsequently abated, partly due to the industry downturn in the developed countries, as well as to outward shifts in the domestic labour supply curve for skilled workers.

In sum, a close look at the level and dynamics of skilled migration from the software sector to developed countries has found evidence of significant flows of workers. However, the picture that emerges is not one of large permanent migration, rather of a highly mobile world in which temporary mobility has been an important characteristic of the industry. Further, the post-2000 downturn in the United States has clearly reduced the flow of skilled workers from India. Analysing our survey data, a general view that emerges is that firms do not perceive migration to have had a strong negative effect on performance or in terms of their strategic decisions. Rather, in many instances migration has been viewed as positive for the firm and the industry more generally. Moreover, there are clear indications that the industry's strong growth has been met with a powerful educational response, not least through the entry of private training providers. This has clearly helped limit shortages and dampen the rate of wage increase. However, while it seems plausible that the acquisition of education and training has been positively affected by migration, from our dataset it is not possible to derive a robust, direct link. Nevertheless, the balance of evidence points to important external effects at work through changes to the willingness to acquire skills as well through increased provision of educational services.

Table 1: Indian software firms: Descriptive statistics, 1999 & 2002

	Year	Mean	Standard deviation	Minimum value	Maximum value
Employment	2002	320	1146	1	14500
	1999	188	567	1	6000
Turnover per worker	2002	23.34	92.37	0.09	1116.67
	1999	18.34	34.78	0.09	250
Export/turnover ratio	2002	63.45	38.96	0	100
(per cent)	1999	59.11	41.14	0	100
Average wage	2002	306633	225672	9171	2360031
(Rupees per annum)	1999	236560	144373	48000	984844

Comment: Units?

Table 2: Indian software firms: Activity, ownership and sources of capital, 2002

	Number of firms	Share (%)
Activity		
Products and packages	84	37.33
Turnkey projects	73	32.44
Professional services	38	16.89
Support and maintenance	21	9.33
Training	5	2.22
CAD	3	1.33
Media services	1	0.44
Total	225	100
Ownership		
Indian companies or Indian individuals resident in India	129	57.33
Foreign individuals or companies	29	12.89
Individuals resident abroad or returned migrants	19	8.44
Government or government agency	8	3.56
Joint venture	2	0.89
Mixed	38	16.89
Total	225	100
Main sources of capital		
Personal and family capital	116	51.55
Venture capital, equity finance and loans from Indian financial institutions	52	23.11
Venture capital, equity finance and loans from foreign financial institutions	43	19.11
Others	14	6.30
Total	225	100

Table 3: Indian software firms: Average skill shares by type of activity

Share (%) of:	Product	Turnkey	Professional. Services	Support	Training	CAD
Managers	10.67	8.72	9.01	7.31	7.15	33.52
Conceptualisers	6.60	5.29	5.53	6.82	1.74	0.72
Developers	46.72	47.67	55.56	57.48	55.74	40.49
Modifiers	4.94	9.53	4.66	5.54	5.13	0
Supporters	9.39	7.34	5.33	4.52	2.65	8.85
Total	78.32	78.55	80.09	81.67	72.41	83.59

Note: Totals do not add up to 100 per cent because non-IT managers, other non-IT skilled workers and unskilled workers are omitted.

Table 4: Indian software firms: Mean and median wages by skill type in 1999 and 2002 and change in mean wages between 1999-2002

	Mean wage in 2002	Median wage in 2002	Mean wage in 1999	Median wage in 1999	Change in mean wage (%)
Managers	599687	505000	389247	300000	54.1
Conceptualisers	421070	360000	324510	262500	29.8
Developers	280525	245000	223734	205000	25.4
Modifiers	227935	210000	173884	150000	31.1
Supporters	197965	150000	185060	125000	7.0

Table 5: Software industry wages in USA and India by skill category in current US$ and PPP in 1999 and 2002

Type of		2002			1999	
Workers	US	INDIA	INDIA/ US	US	INDIA	INDIA/ US
Current US $						
Managers	98233	12200	0.12	81322	7994	0.10
Conceptualisers	68540	6750	0.10	70185	6734	0.10
Developers	58395	5360	0.09	62571	4671	0.07
Modifiers	39504	3827	0.10	40842	3556	0.09
Supporters	37885	2795	0.07	38946	2544	0.07
Type of		2002			1999	
Workers	US	INDIA	INDIA/ US	US	INDIA	INDIA/ US
PPP						
Managers	101180	31387	0.31	83762	20391	0.24
Conceptualisers	70596	17366	0.25	72291	17178	0.24
Developers	60147	13790	0.23	64448	11916	0.18
Modifiers	40689	9845	0.24	42068	9071	0.22
Supporters	39022	7190	0.18	40115	6490	0.16

Table 6:Indian software firms: Descriptive statistics for migration

	Share of workers who left in last year		Share of workers who have worked on-site and off-site in a DC				Relevant experience in a DC
	2002	1999	2002		1999		2002
			On-site	Off-site	On-site	Off-site	
Managers	3.9	11.3	20.9	60.7	22.8	56.3	54.3
Conceptualisers	3.5	8.4	29.8	59.3	27.2	58.2	54.1
Developers	10.8	16.2	23.0	45.4	25.6	47.7	44.7
Modifiers	5.6	9.3	33.2	43.7	37.2	39.2	17.4
Supporters	2.6	7.4	19.3	46.8	21.9	46.9	6.4

Table 7: Indian software firms: attributes of firms experiencing migration in 1999

Estimation method: OLS
LHS Variable: Migration share of skill type in prior year

Independent Variable	(1) Managers	(2) Conceptualisers	(3) Developers	(4) Modifiers	(5) All
Alliance with foreign firm	0.399***	0.255	0.011	0.456	0.807***
	(0.177)	(0.281)	(0.086)	(0.034)	(0.304)
Log of turnover per worker	-0.078	0.154*	0.009	-0.064	0.029
	(0.067)	(0.095)	(0.038)	(0.149)	(0.104)
Log of total migration from firm	0.537***	0.554***	0.798***	0.471***	
	(0.048)	(0.059)	(0.022)	(0.0810)	
Primary Activity Dummy	✓	✓	✓	✓	✓
Region Dummies	✓	✓	✓	✓	✓
N	179	104	173	61	175

Notes: Standard errors in brackets
Significant at 10 per cent *
5 per cent **
1 per cent ***

Table 8: Indian software firms: 3SLS estimation of shortage and migration share by skill type, 1999

Shortage of skill type	Managers	Conceptualisers	Developers	Modifiers
Log of compensation in 1999	0.196 (0.501)	-0.867*** (0.521)	0.700*** (0.408)	0.235 (0.631)
Log of migration share by skill type	0.190*** (0.067)	0.357*** (0.099)	0.152*** (0.045)	0.203**((0.098)
Log of employments (size)	0.133*** (0.078)	0.267*** (0.111)	0.060 (0.075)	0.128 (0.120)
Share of skill type in total employment	0.922 (0.831)	-0.989 (1.566)	0.377 (0.610)	-0.279 (0.485)
Principal activity dummy	✓	✓	✓	✓
Region Dummies	✓	✓	✓	✓
Share of skill type that migrated in previous year				
Log of compensation in 1999	-0.148 (0.441)	0.867*** (0.461)	-0.629*** (0.229)	0.186 (0.602)
Log of turnover per worker	-0.015 (0.073)	0.600 (0.090)	0.002 (0.042)	-0.041 (0.103)
Log of total migration for firm	0.565 (0.057)	0.503*** (0.065)	0.824*** (0.031)	0.527*** (0.078)
Alliance with a foreign firm	0.433*** (0.229)	0.365* (0.251)	0.156 (0.144)	0.004 (0.376)
Finance by foreign venture capital	0.305 (0.416)	-0.861*** (0.439)	-0.153 (0.229)	-0.547 (0.475)
Principal activity dummy	✓	✓	✓	✓
Region dummies	✓	✓	✓	✓
Log of compensation by skill type in 1999				
Shortage of skill type	0.253*** (0.141)	0.381*** (0.151)	0.650*** (0.153)	0.355*** (0.119)
Migration by skill type	-0.024 (0.066)	-0.037 (0.070)	-0.081*** (0.048)	-0.010*** (0.050)
Log of turnover per worker	0.024 (0.041)	0.076* (0.052)	0.025 (0.030)	0.008 (0.053)
Finance by foreign venture capital	0.092 (0.266)	0.286 (0.260)	-0.020 (0.191)	0.092 (0.247)
Alliance with a foreign firm	-0.068 (0.125)	0.153 (0.154)	0.106 (0.101)	0.321*** (0.167)
Principal activity dummy	✓	✓	✓	✓
Region dummies	✓	✓	✓	✓
N	136	93	138	50

Notes: Standard errors in brackets
Significant at 10 per cent *
5 per cent **
1 per cent ***

Table 9: Indian software firms: Perceived impact of labour turnover on firm performance (as measured by revenues per worker) since 1999

	Slightly negative	Strongly negative	Positive	No impact	n
Managers – IT	19%	3%	4%	74%	185
Conceptualisers	23%	3%	3%	70%	125
Developers	22.5%	5%	4.5%	68%	199
Modifiers/Extenders	13%	6%	1%	80%	79
Supporters	10%	3%	4%	83%	103

Table 10: Indian software firms: Turnover per worker

	Dependent Variables	
Independent Variable	Log of turnover per worker, 2002	Log of turnover per worker, 1999
Alliance with foreign firm	0.495***	0.570***
	(0.199)	(0.274)
Share of staff working predominantly in a developed country	0.010***	-0.004
	(0.005)	(0.006)
Log of total migration from firm	-0.222	-0.057
	(0.053)	(0.056)
Share of staff with education > MA	0.040***	0.026*
	(0.015)	(0.016)
Ownership dummies	✓	✓
Region dummies	✓	✓
Principal activity dummies	✓	✓
N	163	152

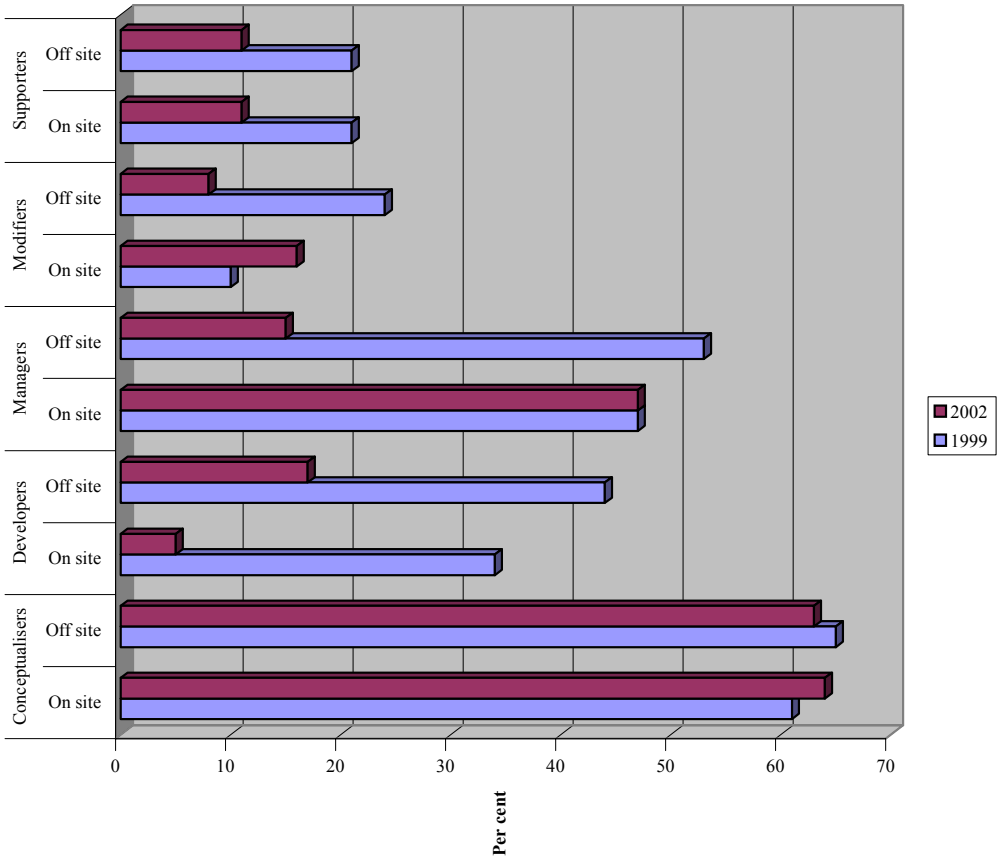
Notes: Standard errors in brackets
Significant at 10 per cent *
5 per cent **
1 per cent ***

Table 11: Indian software firms: Performance and migration

	Dependent Variables	
Independent Variable	Change in turnover for worker, (2002-1999)	Change in size of firm (employment)
Migration shares		
Managers	0.046	-0.077
	(0.115)	(0.093)
Conceptualisers	-0.151	-0.068
	(0.104)	(0.089)
Developers	-0.081	0.306
	(0.126)	(0.097)
Modifiers	0.334***	0.024
	(0.116)	(0.089)
Developed country work experience		
Managers	0.004	-0.003
	(0.003)	(0.003)
Conceptualisers	-0.016***	0.011***
	(0.006)	(0.004)
Developers	0.013	-0.009
	(0.012)	(0.101)
Modifiers	0.006	-0.002
	(0.013)	(0.011)
Alliance with foreign firms	-0.499	0.427***
	(0.279)	(0.216)
Primary activity	✓	✓
Regions dummies	✓	✓
N	43	50

Notes: Standard errors in brackets
Significant at 10 per cent *
5 per cent **
1 per cent ***

Figure 1: Indian software firms - share of firms reporting major shortages in 1999 and 2002, weighted by employment



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