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We Can Work It Out: The Impact of Technological Change on the Demand for Low-Skill Workers

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Abstract
There is little doubt that technology has had the most profound effect on altering the tasks that we humans do in our jobs. Economists have long speculated on how technical change affects both the absolute demand for labour as a whole and the relative demands for different types of labour. In recent years, the idea of skill-biased technical change has become the consensus view about the current impact of technology on labour demand, namely that technical change leads to an increase in the demand for skilled relative to unskilled labour painting a bleak future for the employment prospects of less-skilled workers. But, drawing on a recent paper by Autor, Levy and Murnane (2003) about the impact of technology on the demand for different types of skills, this paper argues that the demand in the least-skilled jobs may be growing. But, it is argued that employment of the less-skilled is increasingly dependent on physical proximity to the more-skilled and may also be vulnerable in the long-run to further technological developments.

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Introduction

The jobs that people do today are dramatically different from those done by people 50, 100, 200 or 2000 years ago. There is little doubt that the main driving force behind these changes is technology that is complementary to some tasks (e.g. makes possible things like brain surgery that simply could not be done before) and a substitute for others where machines can do things much better than humans (no-one in industrialised countries now cuts corn with a scythe).

Given this, it is not surprising that there is a long history of economists speculating about the impact of technology on the demand for labour. Some of this has been about the impact of technology on the absolute demand for labour and some of it about the impact on the relative demand for different sorts of labour. For example, Adam Smith (1986, p383) in the Wealth of Nations, wrote that "all such improvements in mechanics…are always regarded as advantageous to every society" so that he was firmly of the view that technology acted to increase the demand for labour. This view was shared by among others Keynes (1931, p364) who in his essay 'Economic Possibilities for our Grandchildren' (written in the depths of the Great Depression) predicted that "the standard of life in progressive countries one hundred years hence will be between four and eight times as high as it is today", the result, he argued, of techincial change and capital accumulation[1]. In contrast other economists have argued that the application of technology acts to reduce the total demand for labour. Perhaps the most celebrated example of this is the immiserisation hypothesis put forward by Karl Marx in *Capital* and other writings (e.g. see Marx, 1965, in which he wrote that "in the course of development

[1] Though he was probably wrong in his belief that our demands for material goods would become sated and we would come to care less about status goods.

there is a double fall in wages: firstly, relative in proportion to the development of general wealth; secondly, absolute since the quantity of commodities which the worker receives in exchange become less and less" – quoted in Rowthorn (1980)[2]).

The consensus today among economists is that the impact of technology on the absolute demand for labour has been to raise it. The reason is the enormous increase in the real wages over time together no discernible trend in unemployment rates. It is hard to reconcile these stylized facts with the view that technology and capital accumulation reduce the demand for labour. Why then does the view that technology destroys jobs continue to have so much hold over the popular imagination (see for example, Rifkin, 1996)? The explanation is probably that there are almost always both winners and losers from the introduction of new technology and the losers are often much more visible than the winners.

To expand on this argument consider the example of the introduction of mechanical loom in the early years of the 19th century. This dramatically increased productivity in weaving, raising the output that could be produced by a weaver in a day and lowering the cost of clothing. This fall in the cost of clothing led to an increase in the demand for clothing but not by enough to keep in work all those previously employed in weaving jobs (whether this happens or not depends on elasticities of demand – see Nickell and Kong (1989), for a working-out of this). The consequence was a dramatic fall in the employment of weavers, especially hand-loom weavers who did not use the new technology, and widespread poverty among them. These were the very visible losers from the new technology who became the original Luddites blaming (correctly) the new machinery for their misfortune.

[2] Who also argues that, later in life, Marx came to change his views about this 'iron law of wages'.

But the winners were harder to identify. The fall in the cost of clothing meant that most people in the economy had more to spend on other things raising the employment used to produce those things. But it was impossible to point to a newly-employed brewer and say 'they only have their job because of the mechanical loom' even though there was a very real sense in which that was true.

So it is the case that the application of technology has consequences for the relative demand for labour. For those who have invested their lifetime in a specific skill that is then replaced by technology the impact can be disastrous. But, it is not just different specific skills that can be affected by technology. In recent years economists have emphasised the process of 'skill-biased technical change' (SBTC) the idea that technology increases the demand for skilled relative to unskilled workers. That this is the impact of technology has become the conventional wisdom among labour economists but this paper argues that, while there is some element of truth in it, it is too simplistic a story and we need to refine it to get a better understanding of the impact of technology on the labour market.

The plan of the paper is as follows. The next section reviews the evidence for SBTC and argues that it is too simplistic an idea. It argues that the routinization hypothesis of Autor, Levy and Murnane (2003) is a more fruitful way to think about the impact of technology on the labour market and that the data on occupational changes over time supports this. The Autor-Levy-Murnane (ALM) hypothesis paints a less bleak future for the employment prospects of the less-skilled than would be suggested by the SBTC hypothesis. But the rest of the paper discusses reasons why this conclusion might be a bit complacent. The second and third sections argue that the demand for low-skill

workers is increasingly confined to non-tradeable sectors and is increasingly dependent on being in physical proximity to richer high-skill workers as it is the expenditure of these individuals that is the main source of labour demand for low-skill workers. The fourth section then considers what would happen if technology did substitute for the labour of low-skill workers arguing that this would remove a powerful stabilizing force in our society. The final section concludes.

1. SBTC or BSTC?

The basic idea of SBTC is very simple, namely that the impact of technology is to, for given relative wages, raise the employment of skilled relative to unskilled workers. The source of this diagnosis of the current impact of technology comes from consideration of movements in relative wages and employment levels. A simple diagram makes the point very simply. Suppose there are two types of worker, skilled and unskilled. Relative demand and supply curves that give a relationship between relative wages and relative employment for skilled relative to unskilled workers are shown in Figure 1. In countries like the US and UK there has been a rise in the relative employment of skilled workers (meaning, in empirical application, more educated or white-collar workers) and a rise in the relative wage suggesting a move as indicated in the Figure. It should be apparent that an outward shift in the relative demand curve is required for a competitive supply-and-demand model to be able to explain these changes.

There are additional pieces of evidence – see Machin (2003) for a good review. The employment shares of educated and white-collar workers are rising and rising fastest in industries that are (on various measures like R&D and computer use) the

technologically most advanced. Although the emphasis in the literature on SBTC is on the problems it causes in terms of increased wage inequality and worsening employment prospects for the unskilled, there is a silver lining: it means that the average job is getting better. And any problems caused by it can be avoided by, to use Tony Blair's mantra, '*education, education, education*' to raise the relative supply of skilled labour (Card and Lemieux, 2001, suggest that it is the failure of relative supply to grow as fast as before rather than an acceleration in the rate of SBTC that can account for much of the rise in wage inequality).

It seems plausible to think there is some truth in the SBTC hypothesis although good reason to think it is not as new as much of the literature on the subject might lead one to believe and not as new as the problems in our economy it is alleged to have caused (see Goldin and Katz, 1998, for a discussion of SBTC in the early years of the 20th century and Card and diNardo, 2002, for a more critical discussion of the SBTC hypothesis). But, this paper argues is that while SBTC may well characterise the net change, it is too simplistic to capture all that is happening. In particular the idea of SBTC might lead one to think there is a uniform shift in labour demand against less-skilled and in favour of more-skilled workers making the future for low-skill workers is very bleak. But is this really what is happening?

In a recent paper, Autor, Levy and Murname (2003) argue that the impact of technology (computers in particular) is to substitute for human labour in tasks that can be routinised. The reasons is that computers require a programme that is a list of instructions 'if this, then do that' but some tasks are simply too complicated to be summarised in this way economically. The important point is that the tasks that can be

routinised are not the lowest-skill jobs in the economy. For example, cleaning and restaurant work are both relatively low-paid occupations but technology has little impact on the way these jobs are done. But many skilled craft jobs and book- and record-keeping jobs require precision (and hence, skill, if these tasks are done by humans) so are not the worst-paid jobs but are essentially repetitive so are jobs in which capital and technology can readily substitute for human labour – see Leontief and Duchin (1986) for an early prediction that this would be the impact of automation on the structure of employment. And many of the high-paid jobs use cognitive and interactive skills that machines cannot perform effectively.

If the Autor, Levy and Murname hypothesis is correct we should expect to see falling employment in the middling occupations, and rising employment at the extreme ends of the distribution. Goos and Manning (2003) investigate whether this is the case in the UK. They define a job as an occupation (of which, using the most detailed classification, there are approximately 370) and the quality of a job by the median wage in that job. They do a lot of robustness checks but Figure 2 summarises the results. In this Figure occupations are allocated to a decile of job quality based on their median hourly wage in 1979. By construction, 10% of employment must be in each of the deciles in 1979. Goos and Manning then look to see the distribution of employment in 1999 – the results are shown in Figure 2. There is a big growth in employment in the 9th and 10th deciles – something that is in line with the SBTC hypothesis – but also growth in employment in the bottom decile, something one would not expect from the SBTC hypothesis. The biggest falls are in the 8th decile.

Further evidence that the ALM hypothesis is a plausible explanation for these changes comes from an examination of the particular occupations that have large rises or declines in employment. Table 1 presents the 10 occupations with the largest employment growth – 7 out of the 10 are professional jobs primarily using cognitive and interactive skills. But 3 out of the 10 are low-paid jobs – care assistants, educational assistants and hospital assistants. These are jobs in which the application of technology has little impact. Table 2 then presents the 10 occupations with the lowest employment growth. Most of these have an hourly wage above the median. They are primarily jobs in manufacturing where the application of new technology typically leads to big gains in productivity. But one also sees a low wage job – petrol station forecourt attendant – where technology has acted to substitute for human labour. Table 3 then shows that what is happening to employment in the 10 lowest-paying occupations. One sees growth in employment in most but not all of these including some very large occupations like shop assistants and shelf-fillers[3].

To be sure not all of the changes one sees in Tables 1-3 are the result of the impact (or lack of impact) of technology. There are more care assistants partly because there are more old people cared for outside the family (although technology, more widely interpreted, is partly responsible for these trends), there are many fewer workers in steel and coal because the government no longer subsidises loss-making enterprises in these areas and there are fewer workers in textiles because of competition with lower-wage developing countries. But the ALM hypothesis about the impact of technology can explain much of what is happening.

[3] And some of the apparent declines – in the numbers of hairdressers and cleaners – may be somewhat spurious as a result of changes in the forms of employment most common for these workers.

Goos and Manning describe the process observed in Figure 1 as the polarization of work. One of the implications of this polarization is that, even if the wage distribution between and across occupation remain constant, there will be a rise in wage inequality – Goos and Manning show this effect is quantitatively important. But the ALM hypothesis also suggests that the future employment prospects of low-skill workers is not as bleak as the SBTC hypothesis would imply – there are going to be lots of jobs in the future in shops, bars and restaurants and caring for the young, old and sick that would seem eminently suitable for those workers with little in the way of skills beyond what the vast bulk of humans are endowed with. We are not alone in this view: in the US Bureau of Labour Statistics projections for employment growth by occupations over the period 2002-2012 (see Hecker, 2004), of the 10 with the largest predicted employment growth 3 are from the top quartile of occupations (ranked by median annual earnings), none are from the second quartile, 2 are from the third quartile and 5 are from the bottom quartile – these last occupations are retail salespersons, fast-food workers, cashiers, janitors and cleaners and nursing aides. These projections are simply not consistent with the idea of SBTC but do seem very consistent with the ALM hypothesis.

There is one Achilles heel to the argument put forward by Goos and Manning (2003). Their analysis is based on the assumption that the skills used in an occupation change relatively little over time. But it might be the case that there is SBTC within occupations e.g. the skills required of shop-workers are changing over time so that this assumption is invalid. It is certainly true that, as Goos and Manning (2003) document, there is great deal of educational up-grading in low-wage occupations. Goos and Manning (2003) do present some evidence from the US and the UK suggesting that

SBTC within occupations may not be very important but the data used is not of the highest quality. Recently Spitz (2004) has presented data from Germany for the change in the skill structure (measured by the tasks done) within 2-digit occupations over the period 1979-99 that is almost certainly better quality data. She concludes that there has been very substantial change in the skill content of occupation and that, of the total change in skill use in the economy, over 85% is within-occupation. At the very least this suggests a degree of caution in the argument put forward here.

But, even if the Goos-Manning conclusion that the future employment prospects of low-skill workers are not as bleak as often painted is correct, this does not mean that the future for these workers is rosy. There are a number of potential problems. As the general level of educational attainment rises and the number of middling jobs falls low-skill workers may face increasing competition for low-wage jobs from those more educated workers who are unable to get one of the growing number of jobs at the top end of the occupational scale. The basic problem is that employers are apt to ask for minimum educational standards in job applicants that are determined as much by what is available in the supply as by what is necessary to do the job. This has been written about elsewhere (see, for example, Teulings and Koopmanschap, 1989, van Ours and Ridder, 1995, Gautier et al, 2002) and I will not discuss it further here as I want to focus on two other issues.

First, although technology in the recent past may not have substituted for the labour of the lowest-skill workers, this cannot be a guarantee that the future will be the same. This possibility is discussed in the final section of the paper.

One other characteristic of the low-skill jobs listed in Tables 1 and 3 is that they are all non-tradeable in the sense that the customer needs to be in physical proximity to the consumer in order for the job to be done. This contrasts with, for example, coal-miners, for whom the consumers of the product of their labour need not be in the same geographical area. This suggests that the employment of low-skill workers will be increasingly dependent on being in physical proximity to their customers. And because the rich are the best customers this means that the demand for low-skill workers is likely to be higher in areas where there are more high-skill workers.

A very powerful reason for why low-skill employment will be concentrated in non-tradeable sectors is that low-skill labour is much much cheaper in developing countries and most (though not all) jobs whose products can be traded across areas within countries can also be traded across national borders. So textiles and call centres will tend to locate outside the UK to take advantage of cheap labour elsewhere.

The next section presents a simple model to formalise these ideas and then tests the predictions of that model.

2. A Simple Model of the Evolving Demand for Unskilled Workers

Let us consider a very simple model to capture this idea that the employment of the low-skilled may be very dependent on the presence of the rich in the local area.

Assume there are a number of 'cities' that all contain both skilled and unskilled workers but differ in the proportion of skilled workers (we treat this as exogenous). To keep things simple, assume this is the only difference between cities.

Assume there is a production sector that produces a good that is traded across cities and is subject to SBTC. To keep things very simple assume there is perfect substitutability between skilled and unskilled workers in this sector and that output is given by:

$$Y = \alpha_u N_u + \alpha_s N_s \tag{1}$$

where N_u is employment of unskilled workers and N_s is employment of skilled workers. One of the reasons for making the assumption of perfect substitutability in the traded goods sector is that I want to abstract from the fact that, with imperfect substitutability, a rise in the share of skilled labour will lead to a rise in the demand for unskilled workers. The specification in (1) can also be interpreted as the 'production' function at city level when the city is within the 'cone of specialization' so is not as restrictive as might be thought. If the price of the produced good is p then the skilled and unskilled wage payable by the production goods sector is:

$$\frac{w_i}{p} = \alpha_i, \quad i = u, s \tag{2}$$

In the set-up we will model SBTC as an increase in α_s relative to α_u and we will consider the impact of such a change in what follows.

There is also assumed to be a 'housework' sector, the output of which is not tradeable – think of it as cleaning the house. In this sector individuals can either do the work themselves or employ someone else to do it for them. To keep the model as simple as possible we will assume that, within each sector, there is perfect substitution between the two types of labour though the conclusions (in a less extreme form) will follow with a more general assumption and that the total amount of housework done is given by:

$$h = h_0 + \beta h_1 \tag{3}$$

where h_0 is the own-time that is put into it and h_1 is the amount of bought-in time. We assume that $\beta < 1$ so that there is an 'agency cost' to buying-in time caused by the problem that servants have a mind of their own and because of the wedge between pre- and post-tax wages caused by the tax system. We also assume that both unskilled and skilled workers are equally effective in this type of work – because everyone is assumed to be as good at cleaning as everyone else – and hence there is no SBTC within this sector.

The structure of this model is such that no skilled worker will ever work in the household sector (because if they did, it would always pay both unskilled and skilled workers to do the housework themselves) so the wage at which domestic help can be hired is w_u the unskilled wage. Given the agency cost a further implication is then that no unskilled worker will ever hire any help in household production as they would be better doing it themselves.

Skilled workers will seek to maximise a utility function assumed to be given by:

$$U = U\left(C, T - n - h_0, h_0 + \beta h_1\right) \tag{4}$$

where C is consumption, T is the endowment of time, n is hours of work in the production goods sector, h_0 is the own-time that is put into housework and h_1 is the amount of bought-in time. This maximisation is subject to a budget constraint given by:

$$pC + w_u h_1 = w_s n \tag{5}$$

The solution in terms of the demand for domestic help will be an increasing function of the real wage of skilled workers and a decreasing function of the real wage of unskilled workers: let us denote this by[4]:

$$h_1^* = h_1^d\left(\frac{w_s}{p}, \frac{w_u}{p}\right) \tag{6}$$

Unskilled workers will, given that they do not hire domestic help, seek to maximise:

$$U = U\left(C, T - n - h_0, h_0\right) \tag{7}$$

subject to a budget constraint given by:

$$pC = w_u n \tag{8}$$

This has as a supply of labour to the labour market a solution that depends on the real wage of unskilled workers: let us denote this by:

$$n_u^* = n_u^s\left(\frac{w_u}{p}\right) \tag{9}$$

There are two possible types of equilibria. In one, some unskilled workers work in the production goods sector, the unskilled wage is equal to (α_u / p) and the numbers working in the household sector is determined by the demand of skilled workers at this real wage. For this equilibrium to exist the supply of unskilled workers must exceed the demand for unskilled workers by skilled workers at this wage. The real wage of unskilled workers must be equalized across all cities that are in this equilibrium

[4] Given the assumptions made, skilled workers will only hire unskilled workers to do the housework when the gap between skilled and unskilled wages is sufficiently high to compensate for the agency cost.

But if at the wage payable by the production goods sector to unskilled workers the demand for household help from skilled workers exceeds the labour supply of the unskilled we will have an equilibrium in which no unskilled workers are in the production goods sector and the unskilled workers all work in providing household labour for the skilled.

Which equilibrium we will have in a particular city depends on relative numbers of skilled and unskilled workers in that city. The simplest way to decide which equilibrium a particular city is in is to compute what would be the equilibrium wage for unskilled workers if all the unskilled work in the homework sector. Equating supply and demands (6) and (9) the equilibrium unskilled wage must solve:

$$L^u . n_u^s \left(\frac{w_u}{p} \right) = L^s . h_1^d \left(\frac{\alpha_s}{p}, \frac{w_u}{p} \right) \qquad (10)$$

where L^u and L^s are the numbers of unskilled and skilled workers in the city respectively. Note that the unskilled wage in this equilibrium will be increasing in the share of skilled workers in the population of the city for the simple reason that this increases the demand for housework relative to the supply. In contrast the unskilled wage in the equilibrium where some unskilled work in the traded goods sector is independent of relative supplies within the city (this can be thought of as the case where 'factor price insensitivity' holds). Which equilibrium we are in will be determined by the equilibrium in which the unskilled wage is highest. So there will be some critical level of the relative supply of high-skill workers, below which some unskilled workers work in the production goods sector and above which none do. Hence, the model has the following predictions:

Prediction 1: the real consumer wage of the unskilled is non-decreasing in the proportion of skilled workers in the city.

Prediction 2: the employment rate of unskilled workers is non-decreasing in the proportion of skilled workers in the city.

Prediction 3: the fraction of unskilled workers in the production goods sector is non-increasing in the proportion of skilled workers in the city.

In the simple model presented here with its rather extreme predictions these relationships have the particular form presented in Figures 3a-3c. In a more general, realistic, model we would expect smoother relationships. But the basic idea remains. If there are more skilled workers (relative to unskilled workers) in a city then we would expect the demand for unskilled labour in the non-traded sector to rise leading to fewer unskilled workers in the traded sector and a rise in demand and a rise in the wages of the unskilled.

Now consider the likely impact of skill-biased change in the production goods sector on the equilibrium. This will raise the wage differential between skilled and unskilled workers payable by the production goods sector. The consequence is a rise in the demand by skilled workers for unskilled workers in the housework sector leading to a rise in the equilibrium unskilled wage payable by that sector. Consequently we would expect to see the cut-off proportion rising over time leading to the following prediction:

Prediction 4: skilled workers will be increasingly employed in the non-traded sector and unskilled workers in the non-traded sector.

We test all these four predictions below. In doing so, one must recognize that the model presented above is very simple in a number of dimensions. First, the skilled wage is equalized across cities because the skilled work in the traded-goods sector and factor price equalization occurs. In fact we know there are large differences in wages across cities so that there must be some productivity benefit to employers who locate in high-wage cities. Quite what this productivity benefit is the subject of a sizeable literature on agglomeration economies – see Duranton and Puga (2003) for a recent survey. But the explanations proposed in that literature do not off-set the mechanism at work here.

Secondly, labour mobility between cities would be expected to equalize the real unskilled wage through the mechanism of equalizing the proportion of skilled and unskilled workers. But this process of labour mobility is not instantaneous especially for less-skilled workers (see Gregg, Machin and Manning, 2004, for UK evidence on this). For example, the ethnographic account by Ehrenreich (2002) about life as a low-wage worker in the US has almost as many pages about the difficulties of finding accommodation in a new city as on the actual experience of low-wage work. Low-skill workers often find themselves in a catch-22 where they cannot find somewhere to live without a job (because they seem a bad risk to landlords) and cannot get a job without a local address, a problem compounded by the fact that low-skill jobs are typically only advertised locally. Gregg, Machin and Manning (2004) argue that speculative regional moves by the unskilled to find work are exceedingly rare in the UK.

Thirdly, we have not introduced a housing market that is very important in causing differences in the cost of living in different cities and in driving a wedge between consumer and producer wages.

But all of these complications without altering the basic story: if the demand for low-skill workers partly comes from a non-traded 'housework' sector then their wages and employment prospects will be better in cities with more skilled workers.

3. Empirical Evidence

In taking the very stylized model of the previous section to the data, decisions need to be made about the empirical counterpart of the theoretical constructs.

In terms of low- and high-skill we use education. For the UK data we define four educational levels – those with no formal qualifications, those with 'GCSEs' or equivalent, those with 'A' levels or equivalent and those with a university degree or above. For the US our four educational categories are high-school drop-outs, high-school graduates, some college and college graduates.

In deciding whether workers are employed in a traded or non-traded sector we use the industry in which they work. The basic criterion should be whether the producer of a good/service has to be located in physical proximity to the consumer of that product. For some industries this criterion is very easy to apply e.g. the producer of a manufactured good does not need to be close to the consumer of that good as the good can be transported to them while a hairdresser does have to be in close physical proximity to the consumer. But there are many industries where there is considerable ambiguity. There are a number of sources of this ambiguity.

First there is the intrinsic ambiguity captured by the fact that there are many goods/services that can be moved to a consumer from a producer at some cost so that these things are neither fully tradeable nor fully non-tradeable.

Secondly there are ambiguities caused by the fact that the industrial classification with which we work is not fine enough to be able to ascertain whether an individual should be assigned to the tradeable or non-tradeable sector. For example, many of those working for the electricity industry (and other utilities) are involved in electricity generation that does not have to be close to the consumers. But others are involved in maintaining the cabling into people's houses that does require physical proximity to the consumer. And workers in construction might be involved in building factories (so the ultimate people paying for their labour is elsewhere) or building a hairdressing salon or a residential house (which should be classed as non-tradeable labour)

Thirdly, activities like wholesale and transportation involve moving people and goods from one place to another. It is not clear where the workers involved in these activities have to be located as the act of moving the goods also serves to move the people involved.

Fourthly there are some goods/services that need to be provided in proximity to consumers but are not paid for by these consumers but by people located elsewhere. This situation is particularly characteristic of activities like health and education in countries like the UK where the money for these services comes out of the public purse. These activities can survive in low-income areas because they are effectively being paid for by those located elsewhere.

Fifthly there is considerable change over time in what is tradeable and what is non-tradeable largely because of falling communication and transport costs. For example, it used to be the case that most financial services were provided locally but are now provided somewhere else so should probably be classed as tradeable. And things like internet shopping make retail more tradeable than it previously was.

Sixthly, there are simply sectors where it is not clear what the right way to classify it is. A good example of this is business services. There are probably advantages to being located close to the consumer for many of these activities (many people choose a local lawyer) but they can also be done over a distance. In addition it is not clear whether these services are being provided to firms engaged in tradeable or non-tradeable production as this affects whether they have to be located close to consumers. We can get some indication of the appropriate classification of business services from input-output tables – for example, for the US in 1999 (the latest input-output tables available) some 22% of the output of business services that was not used within the sector went to the traded goods sector, compared to only 12% to the non-traded sector (the other big users were wholesale/transport (17%), personal consumption (12%), finance (12%), construction (11%), and health/education (11%)). These figures suggest that business services are more traded than non-traded within the country.

Give all this we use a nine-fold classification of employment

- clearly traded
- clearly non-traded
- construction
- utilities

- wholesale and transport
- fiancial services
- business services
- government
- health and education

The precise way in which the industrial classification is mapped into these categories is described in the Table in the Appendix.

Let us now consider the trends in employment in these different sectors for different education groups. Using annual data from the UK LFS from 1983-2003 and from the US CPS for 1983-2002 we estimate the trend change in employment shares in the different sectors for each of the four education groups. The trends, measured as percentage points per decade, are reported in Table 4. Because the dependent variable is the employment share, the coefficients in every row must add to zero.

Looking at the overall trends in the in the rows marked 'All' one sees declining employment in the traded goods sector (this is mostly declining employment in manufacturing) off-set by trend growth in business services, health/education and (in the UK) the non-traded sector. When we disaggregate by industry we see that the move out of traded goods is less marked among the best-educated in both the US and the UK, the shift towards the non-traded sector is more marked for the less-educated and a stronger shifts towards business services for the most educated. These results are in line with the predictions of the model of the previous section that, over time, the employment of low-skill workers will come to be increasingly concentrated in non-traded sectors.

Now consider the other predictions of the theoretical model presented in the previous section. In Table 5 we investigate the impact of the presence of high-skill workers on the overall economic situation of workers of different skill levels. The data set we use is annual data on approximately 240 US cities for the period 1994-2002 inclusive from the Current Population Survey. As a measure of the presence of high-skill workers we use the fraction of college graduates. Although we have a panel data set there is not enough variation in the fraction of college graduates within cities to estimate a fixed-effects model so we simply estimate a model with clustering on city to correct the standard errors. We do also report estimates using a instrument proposed by Moretti (2004) – the presence of a land grant college[5].

There is an existing literature that investigates the linkages between the fraction of skilled workers and the labour market outcomes of the less-skilled (see Acemoglu and Angrist, 2000, Moretti , 2002, 2003, 2004 and Ciccone and Peri, 2002) that is motivated primarily by interest in the hypothesis of estimating the extent of human capital externalities that is one potential source of agglomeration economies[6]. These studies focus on the effect of the proportion of skilled workers in a city on the producer wage of unskilled workers as this is what is appropriate for their question of interest. But, what we are interested in is the effect on the welfare of unskilled workers so we would want to use a consumer wage. At city level this is very difficult to estimate because city-level price indices are not produced. So, instead we focus on the impact on the employment-

[5] Though one might question the validity of this instrument using the model presented here as the presence of a college affects the demand for labour through employment in the college and not just the supply as is its intention.

[6] But (perhaps unsurprisingly given the different focus of interest) the linkages between skilled and unskilled workers in these papers are different from the ones emphasized here, looking at effects through the production function and not through effects from the consumption function. It is quite likely that some

population and unemployment rates of the fraction skilled in the belief that higher consumer wages will be reflected in higher employment rates because of moves along an upward-sloping labour supply curve. The basic results are summarized in Figure 3 – this plots the employment rate for high-school drop-outs against the fraction of college graduates for 220 US cities in 2001 and shows a strong positive relationship.

Turning to regression results, the first column of Table 5 shows that there is a big positive significant effect of the proportion of college graduates on the employment-population ratio of high-school drop-outs and of high-school graduates with a stronger effect for the drop-outs. There is no significant effect on the employment-population rates of more-skilled workers. The second column shows this conclusion is robust to the inclusion of controls on city characteristics and the third column derives similar results when using the Moretti instrument of the presence of a land grant college. The final three columns change the dependent variable to the unemployment rate with similar conclusions. So there does seem evidence that the labour market position of the less-skilled is better in cities where there are more skilled workers.

These results are all from the US and one might wonder whether the same relationship holds in the UK. The main problem with doing a similar exercise for the UK is that the Labour Force Survey has little in the way of regional disaggregation – 20 crude regions are the best one can do. But, for what it is worth, Figure 4 plots the employment rate for those with no educational qualifications against the fraction of college graduates in each of the 20 regions. With one very large outlier there is a positive relationship as in the US. The outlier is Inner London which is unusual as it is not a self-contained labour

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of the tests proposed for identifying human capital externalities are not robust to the sort of model considered here.

market and has some curious features like the co-existence, only a bus-ride apart, of areas with some of the highest unemployment rates and the highest vacancy rates in the country.

These results are consistent with the hypothesis that more skilled workers raises the demand for less-skilled workers through the increased demand for non-tradeable employment. But they are also consistent with the ideas in the human capital externality literature that the presence of more skilled workers raises the productivity of the less-skilled through a familiar process of substitution or through some kind of externality.

One way to see whether there is any truth in the idea put forward in this paper that part of the demand for low-skill labour comes from the consumption of non-tradeables of high-skilled people is to see whether there is any effect on the employment rates of low-skill workers from educated older workers. Workers who are retired (and not working) cannot have any impact on the demand for low-skill workers by substitution in the production function and it seems unlikely that they would have much of a spill-over effect. But they obviously consume goods and can contribute to the demand for labour in this way. In Table 6 we report the results of regressing the employment-population ratio for different education groups on the fraction of college graduates of working age, the fraction of college graduates among older workers and the ratio of older workers to those of working age (as this should also be important). For high-school drop-outs we see that there is a significant positive relationship between their employment-population ratio and the presence of educated old people. In fact the effect is stronger than that of educated people of working-age. For the other education groups there does not seem to be much

impact from educated older workers though there is a negative impact from the fraction of old workers in the city.

A further way of distinguishing these hypotheses and of providing further evidence on the hypothesis put forward in this paper is to investigate the impact of the share of skilled workers on the structure of employment. If the externality literature is correct we would not expect to see any effect on, for example, the share of low-skill employment in tradeables while if the hypothesis put forward here is correct we would expect to see less low-skill employment in tradeables and more in non-tradeables in cities with more skilled workers.

This is investigated in Table 7. Here we regress the share of employment in different sectors for different skill groups on the fraction skilled in a city. The reported coefficients are the coefficients on the fraction skilled. Looking at the first panel we can see that, as the model of this paper predicts, the presence of more skilled workers in a city leads to a higher fraction of low-skill workers in non-traded sectors and a lower share in traded sectors. This effect is strongest for high-school drop-outs, and weakens to nothing as one increases the education level. This does suggest that traded goods industries employing low-skill workers are at a competitive disadvantage in cities with many high-skill workers. This might appear to be at variance with the conclusion of Moretti (2002) that manufacturing plants (which produce tradeables) are more productive in cities with more skilled workers with a productivity premium that approximately matches the wage premium so that they are not at a competitive disadvantage. But a reconciliation is simple: the presence of skilled workers in a city raises the demand for unskilled workers in non-tradeables, raising wages and making manufacturing less competitive. But the

only plants that survive and make it into Moretti's sample are the high productivity ones.

The evidence presented in this section suggests that the employment prospects of low-skill workers are dependent on physical proximity to rich workers and increasingly so. That suggests a new approach to regional policy based on the idea that one cannot improve the employment prospects of the low-skilled in an area without inducing more high-skilled people to live in the area i.e. it is high-skilled labour not capital that is crucial to regeneration. To some extent this idea is already present in government initiatives on depressed areas from the construction of 'yuppie' waterside apartments in northern cities to the proposed relocation of civil servants away from London.

I have emphasized so far that less-skilled workers have had their employment protected by the fact that machines have been unable to substitute for the skills that most humans find very easy, namely hand-eye coordination and that provides a limit (maybe a very wide limit) to the maximum amount of wage inequality in our society. Put at its simplest, if wage inequality is large enough the rich will always want the poor to do mundane tasks for them thus providing a natural demand for their labour. And the source of this demand is the inability of machines to substitute for this mundane labour. And this fact keeps out society more or less stable though it must be admitted that the equilibrium level of wage inequality may be very high. But, just because this is the current situation does not mean it will always be so and we now turn to speculation about the future.

4. Science Fiction Economics

One very powerful reason for thinking that the future impact of technology on the demand for labour may be different from the present, is that we have seen changes in the nature of technological progress in the past. For example, the current consensus view among economists (see Goldin and Katz, 1998 or Acemoglu, 2002, for recent summary discussions of this) is that the impact of technology in the early days of the Industrial Revolution was to reduce employment among skilled artisans (and the wage declines that resulted from this can be argued to be the origin of Marx's immiserisation hypothesis, another lesson about the dangers of extrapolation from the past into the future).

Another particularly pertinent example is the decline in the employment of servants in the middle of the 20th century. The jobs done by servants were non-tradeable and dependent on the presence of the rich in exactly the same way that I have argued is increasingly characteristic of the employment of the low-skill workers today[7]. But, the share of workers in domestic service declined rapidly from a peak of 8.2% in England and Wales in 1931 to 1% in 1971 and from 6.5% in the US in 1930 to 1.7% in 1970 (figures from Singelmann, 1978, who also has data from other countries that show a similar trend). The most common explanation for this collapse is the invention of the vacuum cleaner, the washing machine and other domestic appliances i.e. technological change (though declining wage inequality may also have played a role). If that has happened in the past, then it can happen again.

So, let us consider what would happen if machines could be cheaply employed to do mundane human tasks like cleaning the house. This is not beyond the bounds of

[7] Though it seems likely that modern-day servants will be doing one particular job for many employers rather than many jobs for a single employer as in the past.

possibility: in the field of robotics there is a lot of research about designing machines that can do hand-eye coordination and 2003 saw the launch of the RoomBa RoboticFloorVac a moving disk that can be left alone in a room to clean it. The manufacturer's web-site is full of praises for it though one must realize it still has considerable limitations as it can only traverse "uneven floor transitions up to one half-inch tall" (i.e. if you want it to go upstairs, forget it) it can't do thick carpets and it might occasionally throw itself down the stairs, all characteristics one might think of as problematic in a human cleaner. The nature of technological progress is partly determined by what is scientifically possible but also by what is economically worthwhile (see Acemoglu, 2002, for a recent analysis of this). For example the Economist of March 13th 2004 contained an article entitled 'the gentle rise of the machines' about the increasing use of robots and quoted the inventor of the first industrial robot (Unimate, employed by General Motors in 1961), Joe Engelberger as saying that care of the elderly is the opportunity the robotics industry should be pursuing as "every highly industrialized nation has a paucity of help for vast, fast-growing ageing populations", something that can be readily understood from the main argument in this paper.

But, while these technological changes might happen this is probably not something that that will happen anytime soon (that has a bad track record - compare the representation of the year 2001 in the film '2001' made in 1968 with the reality[8]) or of anything that will inevitably come to pass. So let us think about it in a 'what if' kind of a way: that is why it might best be described as science fiction economics. Science fiction

[8] It is a bit sad that at the newly-established Robot Hall of Fame, http://www.robothalloffame.org , only two of the 2003 inductees are real and one of the fictional robots is HAL from the film '2001'.

is generally concerned with transformations of society (otherwise it is just fiction) but the economics in most science fiction is terrible.

It is a common theme in science fiction that machines will come to be intelligent and have a 'mind of their own' and then, through some act of revolution, come to dominate humans – a good recent example would be 'The Matrix'. In economic terms one is envisaging in this film a violent change in property rights with a change from humans owning machines to machines owning people[9] but, in that film, humans are then used as a source of energy, suggesting that the machines' understanding of the laws of economics was somewhat deficient as humans could not possibly be an efficient source of energy.

But this emphasis in science fiction on change through violence underestimates the potential impact of change through the laws of economics. For example, in science fiction the problems for humans often start when machines get as intelligent as them and have a 'mind of their own'. In contrast, an economic approach would suggest that the problems will be worse when they are not that intelligent and do not have a mind of their own. One of the big problems with employing humans to do jobs is that they do have a mind of their own, so that the extraction of labour from labour power (as Marx put it) or incentivizing workers (as business school professors put it) is a problem. An obedient machine is far more of a threat to most humans than a thinking machine.

In a world where menial jobs can be done more cheaply by machines than humans the demand for the labour of the least-skilled would collapse, quite conceivably below the 'cost' of creating and maintaining a human. Unless they own capital they would be

[9] A new twist on the issue (beloved of economists of a more philosophical bent) of whether capital hires labour or the other way round

unable to obtain an adequate source of income by selling their factor endowments[10]. We would finally have ended up in the world of Marx's immiserisation hypothesis in which the wages of many workers would decline in absolute terms and the levels of inequality between humans are determined by inequalities in the ownership of capital. In this scenario it is the distribution of capital ownership that is crucial and it is important to know whether this tends to become more or less unequal over time. Recent papers on France (Piketty, 2003) and the US (Piketty and Saez, 2003) suggest that progressive taxation (and, less optimistically, wars) may be able to put a brake on rising inequality in capital income but, left unchecked the distribution of wealth would tend to become more unequal.

This section has argued that the Autor-Levy-Murnane hypothesis can also be used to shed light on the type of technological change that would bring very widespread disruption to our society. We are not particularly close to that scenario right now but it is clear that there is a lot of research in this area and it would be complacent to assume that it would never happen.

[10] One might think this a very implausible scenario but Sen's (1983) analysis of famines puts emphasis on the role played by the catastrophic decline in the real wages of landless labourers causing them to be unable to buy the food necessary for subsistence.

5. Conclusions

In this paper we have argued that the idea of skill-biased technical change is too simplistic as a description of the impact of technology on the demand for different types of labour. It probably gets the net change correct in the sense that the average job is more skilled now than it used to be but it misses out on a number of important facets. These can be best understood using the Autor-Levy-Murnane hypothesis that technology substitutes for human labour in tasks that can be routinized and that these jobs are typically in the middle of the wage distribution. This view of the impact of technology on the demand for labour points to a less bleak future for the employment prospects of the low-skilled – there will be lots of caring jobs, jobs in bars, shops and restaurants – than the idea of SBTC suggests. However the employment of the low-skilled does seem to be increasingly dependent on physical proximity to the high-skilled as the work that they do is increasingly in non-traded sectors. And it may be that the future impact of technology is not like the current impact and is to the considerable disadvantage of the low-skilled.

Table 1
Top 10 Occupations by Job Growth

Occupation	*Median wage in 1979*	*Employment in 1979*	*Employment in 1999*	*% change in employment*
All	3.052	24 332 613	27 343 467	12.373
Care assistants & attendants	2.345	103 837	539 407	419.474
Software engineers	5.008	34 009	171 769	405.065
Management consultants & business analysts	4.745	18 811	81 803	334.868
Computer systems & data processing managers	5.065	43 239	178 701	313.286
Computer analysts & programmers	4.842	76 083	302 617	297.745
Educational assistants	2.272	45 040	173 763	285.793
Hospital ward assistants	2.572	7 460	26 986	261.705
Actors, entertainers, stage managers & producers	4.719	22 549	73 030	223.870
Treasurers & company financial managers	5.105	37 794	119 812	217.015
Financial institution and office managers	4.511	107 138	322 608	201.114

Notes: Employment data are taken from the LFS using 3-digit SOC90 codes. Wages are 1979 median hourly wages taken from the NES using 3-digit SOC90 codes. More details are in Goos and Manning (2003).

Table 2
Bottom 10 Occupations by Median Wage

Occupation	*Median wage in 1979*	*Employment in 1979*	*Employment in 1999*	*% change in employment*
All	3.052	24 332 613	27 343 467	12.373
Hairdresser & barbers	1.745	123 986	96 073	-22.513
Bar staff	1.832	119 455	188 319	57.647
Shelf fillers	1.938	49 699	97 144	95.462
Sales assistants	1.939	954 200	1 321 251	38.466
Retail cash desk & check-out operators	1.969	112 816	218 581	93.749
Petrol pump forecourt attendants	1.979	13 304	9 935	-25.321
Kitchen porters	2.003	178 758	143 092	-19.952
Waiters & waitresses	2.020	124 780	187 391	50.177
Cleaners	2.132	854 535	649 362	-24.009
Beauticians	2.145	24 536	28 946	17.972

Notes: Employment data are taken from the LFS using 3-digit SOC90 codes. Wages are 1979 median hourly wages taken from the NES using 3-digit SOC90 codes. More details are in Goos and Manning (2003)

Table 3

Bottom 10 Occupations by Job Growth

Occupation	*Median wage in 1979*	*Employment in 1979*	*Employment in 1999*	*% change in employment*
All	3.052	24 332 613	27 343 467	12.373
Boring & drilling machine setters & setter-operators	3.584	29 276	1 731	-94.086
Coal mine laborers	3.696	29 782	1 818	-93.892
Face trained coalmining workers, shotfirers & deputies	5.237	76 301	5 095	-93.322
Ginding machine setters & operators	3.557	56 426	8 164	-85.531
Laborers in foundries	3.219	14 801	2 505	-83.070
Laborers in engineering & allied trades	3.025	58 243	12 758	-78.095
Electrical, energy, boiler & related plant operatives & attendants	3.684	36 352	8 009	-77.968
Spinners, doublers & twisters (in textiles and tannery process operatives)	2.802	16 941	4 173	-75.363
Originators, compositors & print preparers (in printing and related trades)	3.404	48 878	12 162	-75.116
Rail signal operatives & crossing keepers	3.010	13 761	3 571	-74.045

Notes: Employment data are taken from the LFS using 3-digit SOC90 codes. Wages are 1979 median hourly wages taken from the NES using 3-digit SOC90 codes. More details are in Goos and Manning (2003)

Table 4
Trends in Employment Shares in Different Sectors by Education

	Traded	Non-traded	Const-ruction	Wholesale Transport	Utilities	Finance	Govern-ment	Health Education	Business Services
				United Kingdom, 1984-2003					
No Quals	-6.41 [0.215]	3.014 [0.226]	-0.049 [0.228]	1.224 [0.074]	-0.733 [0.056]	-0.02 [0.048]	-0.488 [0.135]	1.256 [0.138]	2.208 [0.074]
GCSE	-4.988 [0.554]	5.269 [0.435]	-1.586 [0.565]	0.478 [0.154]	-0.604 [0.080]	-1.001 [0.418]	-0.987 [0.303]	1.947 [0.106]	1.472 [0.227]
A Level	-6.058 [0.388]	4.982 [0.231]	0.888 [0.301]	0.486 [0.121]	-1.36 [0.115]	-0.234 [0.147]	-0.847 [0.169]	0.512 [0.230]	1.632 [0.188]
Degree	-1.691 [0.182]	2.489 [0.151]	-0.192 [0.055]	0.477 [0.066]	-0.203 [0.054]	0.743 [0.098]	0.723 [0.265]	-6.068 [0.395]	3.722 [0.220]
All	-6.076 [0.162]	2.007 [0.171]	-0.327 [0.125]	0.256 [0.071]	-0.578 [0.061]	0.29 [0.068]	0.086 [0.164]	1.485 [0.187]	2.856 [0.094]
				United States, 1983-2002					
HS Drop-out	-4.76 [0.358]	3.606 [0.175]	1.485 [0.272]	0.011 [0.096]	-0.483 [0.044]	-0.242 [0.036]	-0.63 [0.061]	-0.594 [0.083]	1.606 [0.058]
HS Grad	-3.371 [0.129]	1.225 [0.104]	1.231 [0.134]	0.644 [0.040]	-0.622 [0.045]	-0.704 [0.057]	-0.607 [0.048]	0.547 [0.090]	1.656 [0.082]
Some College	-2.71 [0.122]	-0.296 [0.139]	0.358 [0.125]	0.063 [0.068]	-0.303 [0.058]	-0.409 [0.075]	-0.1 [0.039]	1.315 [0.183]	2.084 [0.126]
College Grad	-2.338 [0.107]	-0.461 [0.128]	-0.092 [0.049]	-0.109 [0.049]	0.027 [0.031]	0.371 [0.076]	-0.272 [0.044]	-0.378 [0.198]	3.251 [0.145]
All	-4.072 [0.089]	0.116 [0.091]	0.22 [0.122]	0.161 [0.040]	-0.306 [0.029]	-0.002 [0.044]	-0.107 [0.027]	1.495 [0.136]	2.494 [0.101]

Notes.
1. Data source is Labour Force Survey for UK and Current Population Survey for US.
2. Coefficients are decadal trend in employment share in percentage points coming from a regression of employment share on a linear trend.
3. Standard errors in brackets.

Table 5
The Impact of High-Skilled Workers on Low-Skill Employment Rates: Evidence for US Cities

Dependent Variable	Employment-Population Ratio	Employment-Population Ratio	Employment-Population Ratio	Unemployment Rate	Unemployment Rate	Unemployment Rate
Method of Estimation	OLS	OLS	IV	OLS	OLS	IV
HS Drop-out	0.227	0.214	0.37	-0.103	-0.124	-0.162
	[0.052]	[0.047]	[0.152]	[0.031]	[0.028]	[0.083]
HS Grad	0.157	0.142	0.257	-0.071	-0.058	-0.083
	[0.034]	[0.028]	[0.106]	[0.017]	[0.012]	[0.036]
Some College	0.046	0.029	0.239	-0.041	-0.034	-0.094
	[0.034]	[0.026]	[0.096]	[0.011]	[0.009]	[0.030]
College Grad	-0.006	-0.032	0.096	0.015	0.018	-0.027
	[0.023]	[0.022]	[0.074]	[0.005]	[0.006]	[0.018]
Other Controls	No	Yes	Yes	No	Yes	Yes

Notes.

1. The coefficients reported are the coefficient of the fraction of the population who are college graduates.
2. Data come from the Current Population Survey for 1994-2002. Each observation is a particular city (defined as an MSA code) in a particular year. All variables are computed using those aged 18-64. In each regression there are 2150 observations.
3. Standard errors are in brackets and computed clustering on city.
4. Where IV is the estimation method, the presence of a land grant college is used as the instrument as in Moretti (2004).
5. Where no other controls are used, year dummies are included. Where controls are indicated these are percentage of education group aged 18-24, 35-44, 45-54, 55-64, the proportion of women, blacks and Hispanics.

Table 6
The Impact of Educated Older Workers on Employment-Population Ratios

	HS Drop-Outs	HS Graduates	Some College	College Graduates
Fraction of College graduates (working age)	0.151	0.124	0.038	-0.083
	[0.047]	[0.030]	[0.025]	[0.024]
Fraction of College graduates (age 65+)	0.141	-0.003	-0.05	-0.006
	[0.047]	[0.026]	[0.027]	[0.022]
Ratio of old to working-age individuals	0.012	-0.102	-0.089	-0.092
	[0.049]	[0.024]	[0.024]	[0.024]
Observations	2150	2150	2150	2150
R-squared	0.23	0.25	0.22	0.15

Notes.

1. Data come from the Current Population Survey for 1994-2002. Each observation is a particular city (defined as an MSA code) in a particular year. All variables are computed using those aged 18-64. Dependent variable is employment-population ratio.
2. Standard errors are in brackets and computed clustering on city.
3. Other controls included are percentage of education group aged 18-24, 35-44, 45-54, 55-64, the proportion of women, blacks and Hispanics.

Table 7

The Impact of High-Skilled Workers on the Structure of Employment Among Low-Skill Workers: Evidence for US Cities

	(1)		(2)		(3)	
Estimation Method	OLS		OLS		IV	
Other Controls	No		Yes		Yes	
			High School Drop-Outs			
Non-Traded	0.208	[0.063]	0.164	[0.057]	0.203	[0.197]
Traded	-0.384	[0.085]	-0.331	[0.076]	-0.248	[0.242]
Construction	0.037	[0.044]	0.008	[0.041]	0.099	[0.133]
Wholesale/transport	-0.014	[0.022]	-0.007	[0.022]	-0.172	[0.065]
Utilities	-0.005	[0.006]	-0.003	[0.006]	-0.026	[0.017]
Business Services	0.101	[0.015]	0.097	[0.015]	0.135	[0.055]
Finance	0.007	[0.006]	0.008	[0.006]	0.016	[0.019]
Government	0.006	[0.010]	0.005	[0.009]	0.044	[0.034]
Health/education	0.044	[0.028]	0.059	[0.026]	-0.05	[0.074]
			High School Graduates			
Non-Traded	0.008	[0.032]	0.032	[0.031]	0.128	[0.095]
Traded	-0.243	[0.054]	-0.275	[0.052]	-0.524	[0.176]
Construction	0.041	[0.020]	0.041	[0.018]	-0.015	[0.049]
Wholesale/transport	0.017	[0.017]	0.029	[0.017]	-0.061	[0.061]
Utilities	0.005	[0.008]	0.005	[0.008]	0.009	[0.020]
Business Services	0.083	[0.012]	0.088	[0.012]	0.104	[0.037]
Finance	0.068	[0.015]	0.066	[0.015]	0.18	[0.070]
Government	0.022	[0.021]	0.02	[0.019]	0.203	[0.102]
Health/education	-0.002	[0.029]	-0.006	[0.026]	-0.025	[0.103]
			Some College			
Non-Traded	0.009	[0.030]	0.007	[0.027]	-0.006	[0.095]
Traded	-0.132	[0.043]	-0.169	[0.040]	-0.448	[0.137]
Construction	0.005	[0.015]	0.001	[0.013]	-0.007	[0.036]
Wholesale/transport	0.004	[0.017]	0.018	[0.017]	-0.047	[0.062]
Utilities	-0.001	[0.009]	-0.002	[0.009]	-0.052	[0.024]
Business Services	0.151	[0.016]	0.161	[0.017]	0.144	[0.047]
Finance	0.053	[0.016]	0.055	[0.015]	0.17	[0.092]
Government	-0.01	[0.026]	0.002	[0.024]	0.243	[0.115]
Health/education	-0.079	[0.031]	-0.074	[0.027]	0.003	[0.087]
			College Graduates			
Non-Traded	0.035	[0.034]	0.026	[0.035]	-0.008	[0.080]
Traded	-0.05	[0.044]	-0.102	[0.041]	-0.484	[0.154]
Construction	-0.011	[0.009]	-0.011	[0.009]	-0.021	[0.023]
Wholesale/transport	0.011	[0.017]	0.024	[0.016]	-0.027	[0.055]
Utilities	0.02	[0.011]	0.016	[0.010]	-0.065	[0.030]
Business Services	0.339	[0.030]	0.335	[0.032]	0.252	[0.096]
Finance	0.119	[0.029]	0.105	[0.029]	0.183	[0.122]
Government	-0.035	[0.036]	-0.019	[0.037]	0.349	[0.144]
Health/education	-0.427	[0.059]	-0.374	[0.055]	-0.178	[0.210]

Notes.
1. The dependent variable is the fraction of employment in that sector among the relevant education group. The coefficients reported are the coefficient of the fraction of the population who are college graduates.

2. Data come from the Current Population Survey for 1994-2002. Each observation is a particular city (defined as an MSA code) in a particular year. All variables are computed using those aged 18-64. In each regression there are 2150 observations.
3. Standard errors are in brackets and computed clustering on city.
4. Where IV is the estimation method, the presence of a land grant college is used as the instrument as in Moretti (2004).
5. Where no other controls are used, year dummies are included. Where controls are indicated these are percentage of education group aged 18-24, 35-44, 45-54, 55-64, the proportion of women, blacks and Hispanics.

Figure 1
A Simple Representation of the Evidence for SBTC

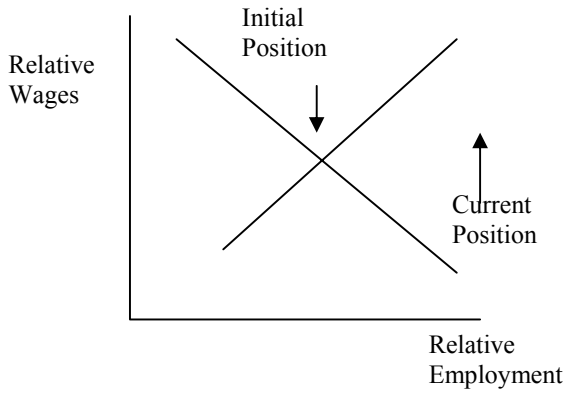
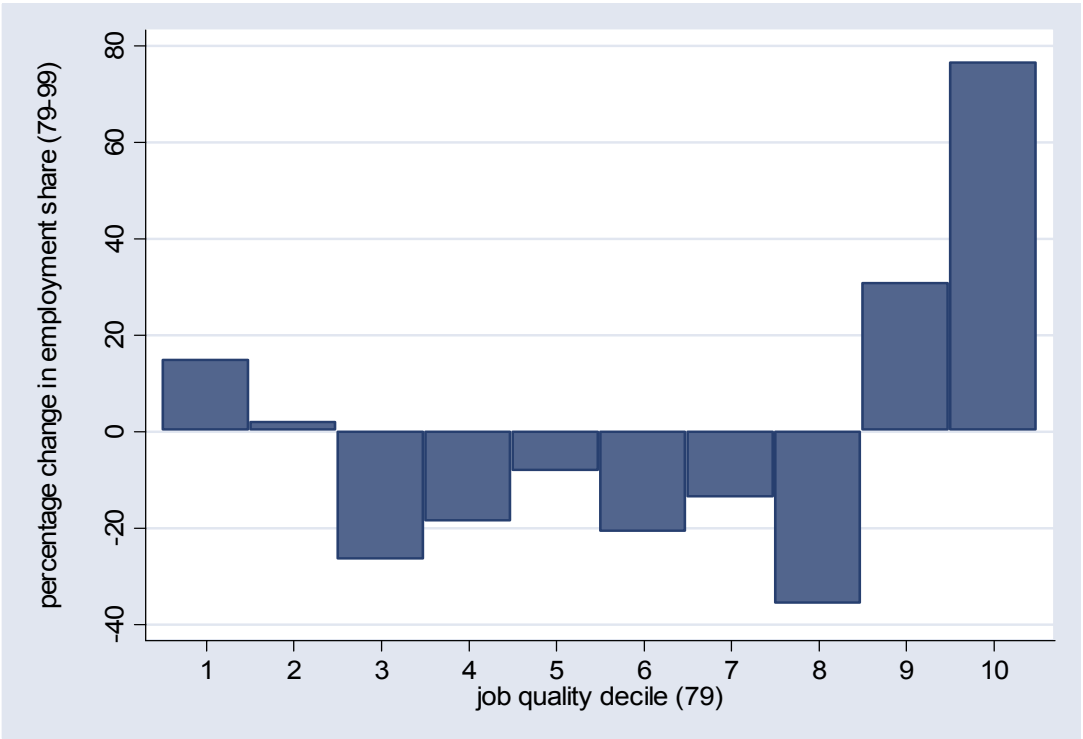


Figure 2
Percentage Change in Employment Share by Job Quality Decile: UK 1979-99



Notes: Employment data are taken from the LFS using 3-digit SOC90 codes. Employment changes are taken between 1979 and 1999. Quality deciles are based on 3-digit SOC90 median wages in 1979 taken from the NES. More details in Goos and Manning (2003).

Figure 3a
The Relationship Between The real wage Of Unskilled Workers
And the Share of Skilled Workers

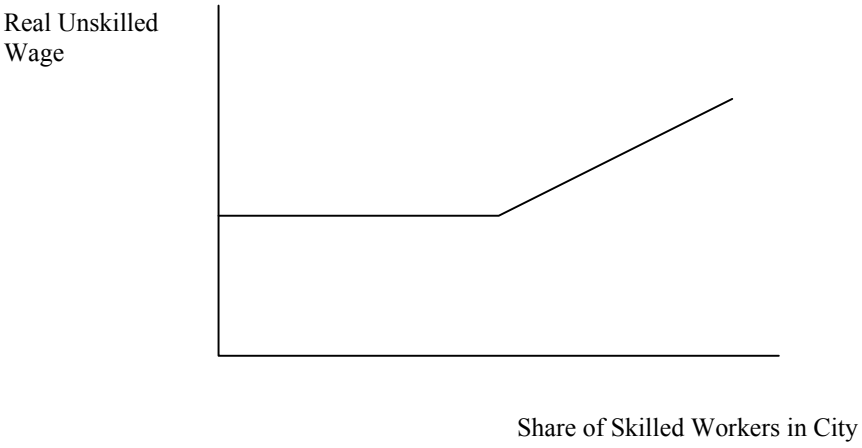


Figure 3b
The Relationship Between The Employment Rate Of Unskilled Workers
And the Share of Skilled Workers

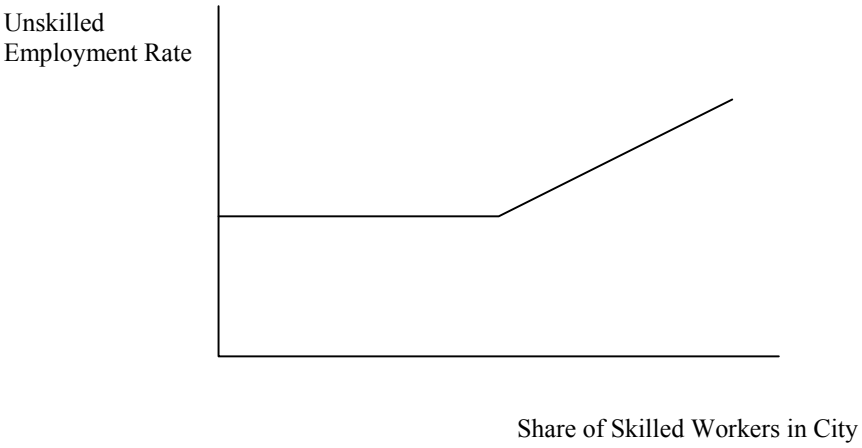


Figure 3c
The Relationship Between The Share Of Unskilled Workers in the Production Sector And the Share of Skilled Workers

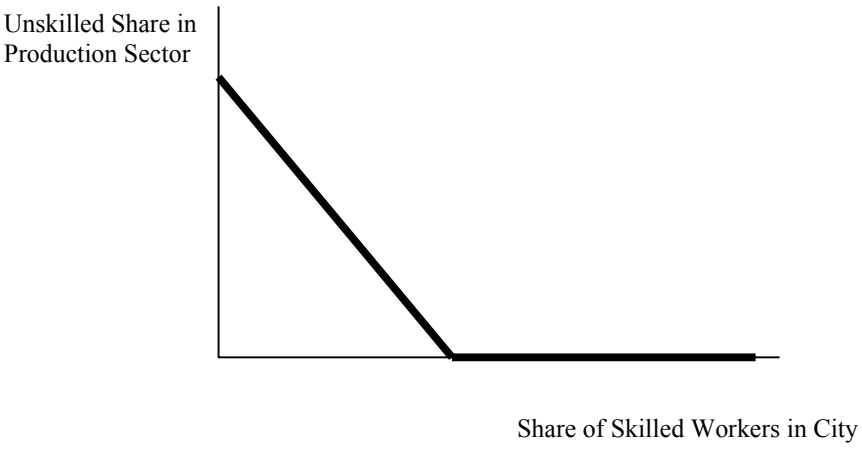
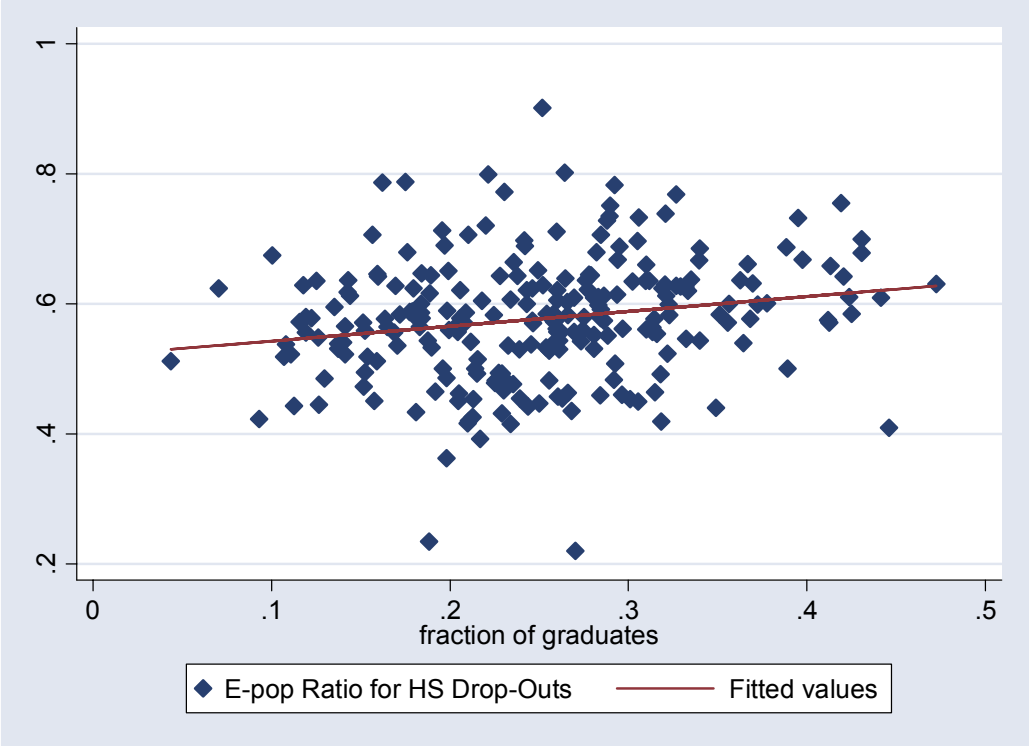
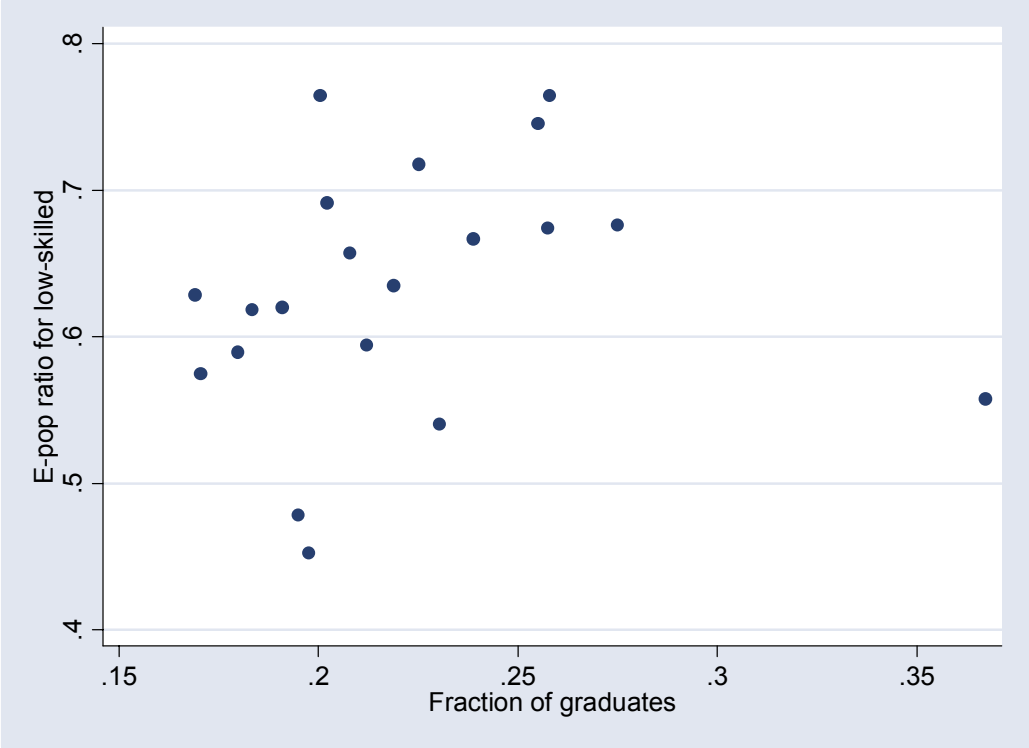


Figure 4
The Relationship between the Employment Rates of Low-Skill Workers
And the Fraction of College Graduates in US Cities



Notes.
1. The data come from the Current Population Survey. This scatter plot is drawn for 242 cities in 2001. The regression line is also drawn on the Figure – the slope coefficient is 0.23 with a standard error of 0.07.

Figure 5
The Relationship between the Employment Rates of Low-Skill Workers And the Fraction of College Graduates in UK Regions



Notes.
1. The data come from the Labour Force Survey in 2001. Low-skilled is defined as those with no educational qualifications.

Appendix
Table A1

Assigning Industries to Traded/Non-Traded Status

Main Division	Classification Used
Agriculture Hunting and Forestry	TR
Fishing	TR
Manufacturing	TR
Electricity, Gas and Water Supply	UT
Construction	CO
Wholesale and Retail Trade	Wholesale → WT Retail → NT Sale, Maintenance, Repair of Cars → NT
Hotels and restaurants	Hotels → T Restaurants → NT (except Canteens → T)
Transport, Storage and Communication	Railways + land transport → NT Freight Transport → WT Pipelines → WT Sea Transport → WT Air Transport → WT Space Transport → T Cargo Handling/Storage → WT Travel Agents → T Postal → WT Telecommunications → UT
Financial Intermediation	FI
Real estate, Renting and Business Activities	Real Estate with Own Property → T Letting of Own Property → T Estate Agents → NT Car Rental → NT Renting of oth transport equipment → BS Renting of equipment → BS Renting of personal goods nes → NT Computer and Related Activities → BS Research and Development → BS Other Business Activities → BS
Public Administration and Defence	GO
Education	HE except Driving Schools → NT
Health and Social Work	HE except Veterinary Activities → NT Social Work → NT
Other Community, Social and Personal Service Activities	NT except Motion picture activities → T News agency Actvities → T
Private Households with Employed Persons	NT
Extra-Territorial Organizations	Excluded

Notes.
This is based on the UK SIC92 industrial classification but similar principles are applied to the US data.

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