Globalisation and the Labour Market

Trade, technology and less-skilled workers in Europe and the United States

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Robert Anderton and Paul Brenton

Introduction

This book is a detailed investigation into the causes of the deterioration in the relative economic fortunes of less-skilled workers across various countries, with a focus on the role of globalisation. Over the past thirty years, the decline in the wages and employment of less-skilled workers relative to skilled workers in Europe and North America has coincided with an acceleration in 'globalisation'. As described by Greenaway and Nelson (2000), the rapid pace of globalisation is indicated by the strong growth in both world trade and foreign direct investment (FDI) which, in turn, have been stimulated by various factors such as: reductions in trade barriers; drastic declines in the costs of communication and transportation; and the internationalisation of production.

Although it is now widely held that the main cause of this rise in inequality seems to be a shift in demand towards higher skilled workers, this book aims to shed light on whether it is trade or technology that is primarily responsible for this demand shift. More specifically: has the rapid growth of labour-saving technological progress reduced the relative demand for less-skilled workers; or has increased international trade with low-wage countries—that is, nations with an abundant supply of low-skill and low-wage labour—decreased the demand for low-skilled workers in the advanced industrialised countries? This is not a new question and is part of an ongoing debate which has stimulated a large amount of research on this issue.[1] So far, the majority of studies conclude that it is technology (i.e. skill biased technical change) rather than trade that has been the main cause of growing inequality in the labour market.

Research on this issue has been steadily evolving, initially using rigid traditional approaches but more recently applying richer methodologies accompanied by more appropriate and sophisticated datasets. This has been partly in response to the realisation that actual inequality outcomes and other economic developments have not always been in line with the expectations of traditional models—the real world has turned out to be far more complex! This book tries to move the analysis further forward by including papers which not only widen the methodologies used but also fine tune the analysis by suitably matching the data and techniques used with the questions being asked. It also tries to give the trade explanation for inequality a 'fair hearing' by thoroughly investigating the trade mechanisms and recognising the important interactions between globalisation, trade and technology. Accordingly, this chapter begins by describing the traditional trade theories and their weaknesses as well as the benefits of newer approaches. Against this background, the motivation for this book is then further explained along with descriptions of the individual chapters and their value-added.

Traditional analysis

The traditional framework for analysing the mechanisms by which trade may influence wages is the Heckscher-Ohlin-Samuelson (HOS) model incorporating the Stolper-Samuelson theorem. This approach assumes high-skilled workers are abundant in the advanced countries, with low-skilled workers prevalent in the newly industrialising countries and emerging market economies. If trade opens up between the advanced countries and the rest of the world, the theorem predicts that the former group of countries will export high-skill-intensive products and import low-skill-intensive goods. Because of the downward pressure exerted by low-priced imports from newly industrialising/emeiging market economies, this implies that the price of low-skill-intensive manufactures relative to high-skill-intensive will decline in the advanced economies. As a result of the decline in relative prices, the theorem predicts that the wages of low-skilled workers relative to that of high-skilled workers will decline in the advanced industrialised countries.[2]

How well does the HOS model describe the stylised facts? At first sight, the theorem seems to correspond with the observed decline in the relative wages of the less-skilled. But the key condition that there must first be a decline in the relative price of low-skill-intensive goods is not clearly evident in the data. For example, Lawrence and Slaughter (1993) investigate developments in US import and export prices and discover that, if anything, the price of low-skill-intensive products rose relative to products using significant amounts of skilled labour (implying, within the HOS framework, that trade contributed to greater equality of wages in the US).[3] Meanwhile, Anderton and Brenton (1999a) show that developments in product prices for broad industrial sectors in Germany and the UK also do not provide evidence of the changes in relative prices required for the HOS theorem to explain rising inequality. However, they did find that the relative price of imports of unskilled labour-intensive products did fall in the UK in the 1980s. That is, if low-wage countries had not increased their share of UK imports then the import prices of low-skilled products would have been higher. Even for high-skilled sectors, such as machinery, trade with the low-wage countries has depressed UK import prices, but by much less than that for unskilled-intensive products. The key point remains, however, that increased trade with low-wage countries does not necessarily translate into changes in relative prices. One reason may be that companies in advanced industrialised countries might respond by upgrading the quality of their products in low-skill-intensity sectors in order to escape increasing import competition from low-wage countries, thereby putting upward pressure on domestic output prices in these sectors. Another relevant point highlighted by Anderton and Brenton (1999a) is that price outcomes within broad sectors usually defined as low-skill-intensive, such as textiles, are far from homogeneous.

These points—and, indeed, some of the chapters in this book—highlight the problems of empirically testing the HOS theorem, particularly in terms of defining and precisely measuring an industry in terms of its skill-intensiveness. For example, if the industry sectors which are usually assessed as low-skill-intensive actually differ across their subsectors in terms of their skill requirements, then increased trade with low-wage countries could lead to a decline of the unskilled-intensive activities and the expansion of skill-intensive activities within the sector. Accordingly, the aggregate relative price of the sector may not change much, while the relative employment of skilled labour will increase in the sector even in the absence of technological advances. Furthermore, the HOS prediction that the demand for labour would fall only in the unskilled-intensive-sectors seems at odds with the fact that the demand for unskilled workers relative to those with skills has fallen across virtually all sectors in many advanced industrialised countries.

Different approaches

It therefore seems that the strict application of the standard HOS and Stolper-Samuelson theories omits the intricacies of the ways firms and industries in advanced economies adjust to increased competition from low-wage countries. In particular, traditional trade theories such as the HOS theorem primarily explain movements in relative wages *across* industries, whereas industrialised countries have experienced a dramatic fall in the relative wages and employment of unskilled workers *within* sectors. Therefore, the impact of globalisation appears to be more complicated than is allowed for within the confines of standard factor proportions trade theory. As a consequence, researchers started to look more carefully at how firms within sectors respond to the more intense competition provided by increased imports from low-wage countries. One explanation of how trade with low-wage countries may push down the relative wages and employment of unskilled workers *within* industries is provided by the notion of 'outsourcing' (see, for example, the seminal papers by Feenstra and Hanson, 1995 and 1996a, b). Outsourcing occurs where firms take advantage of both the low-wage costs of relatively labour abundant countries and modern production techniques—whereby the process of manufacturing a product can be broken-down, or fragmented, into a number of discrete activities—and move the low-skill-intensive parts of production abroad, but continue to carry out the high-skill-intensive activities themselves.[4] Once the low-skill activities have been performed, the goods are then imported back from the low-wage countries and either used as intermediate inputs or sold as finished goods. Hence, trade with low-wage countries via this route will shift demand away from less-skilled towards skilled workers in advanced industrialised countries, and put downward pressure on the relative wages and employment of low-skilled workers *within* industries.

Casual but direct evidence suggests that outsourcing plays a significant role in modern production. For example, Nike employs a relatively small number of persons in the US for marketing and other headquarter services, whereas far more people are employed in low-wage countries producing shoes that are sold to Nike.[5] In their case study analysis, Anderton and Schultz (1999) show that outsourcing of production to low-wage countries is quite common in the medical equipment industry in both Germany and the UK and involves *finished* goods as well as *intermediate* inputs.[6]

So, theory and case study evidence support the notion that outsourcing may have played a substantial part in the wage and employment prospects of unskilled workers in industrial countries. Is this substantiated by statistical evidence across a range of industries in different countries? Early pioneering work by Feenstra and Hanson (1995 and 1996a, b) used US industry import shares as a proxy for outsourcing in the US. Although they found that the growth of imports explained a notable part of the increase in inequality in the US, Feenstra and Hanson proxied outsourcing by US imports from *all* countries, which implicitly captures the outsourcing of production activities to high- as well as low-wage countries. However, there is no obvious reason why firms would outsource *low-skill-intensive* activities—which is the key mechanism by which outsourcing may affect the demand for the less-skilled—to advanced industrialised countries which are relatively abundant in skilled labour.

By contrast, papers such as Anderton and Brenton (1999b, c) and Anderton *et al.* (2002) explicitly identify imports *solely from low-wage countries* and use this as a variable for explaining changes in the relative wages and employment of the low-skilled, and thereby more accurately proxy outsourcing to low-wage countries. Using these more accurate measures, the impact of trade on inequality becomes clearer and is more pronounced.[7] These papers also show that it is important to disaggregate the analysis by industry as outsourcing might be more pervasive in some industries than in others. For example, the scope for outsourcing partly depends on the degree to which production of the final good can be fragmented into discrete stages which embody substantially different factor intensity ratios. This, in turn, will be determined by technological conditions in the industry in question. Hence, whether outsourcing is more prevalent in high or low-skill-intensive sectors is an empirical question.[8]

More recent papers also demonstrate that using appropriate empirical definitions of outsourcing can have an important bearing on the significance and magnitude of outsourcing on inequality. For example, Hijzen *et al.* (2004) proxy UK international outsourcing by imports of intermediates using detailed data from input-output tables for fifty manufacturing industries. This measure shows that international outsourcing has had a strong negative impact on the demand for unskilled labour in the UK over the period 1982–1996. Strauss-Kahn (2003) also uses input-output tables, but constructs a measure of vertical specialisation—defined as the share of imported inputs in production—and investigates its impact on labour demand in France. Her estimates show that vertical specialisation contributed 11 to 15 per cent of the decline in the share of unskilled workers in French manufacturing employment for the 1977–1985 period and for 25 per cent of the decline during 1985–1993.

In summary, the incentives and the potential to outsource may be greater in either high or low technology/skill sectors, and will depend upon a variety of factors which may differ between countries. It follows that outsourcing and its impact may be quite different across countries, particularly if their labour markets are fundamentally different. One would expect adjustment to increased competition from low-wage countries to occur mainly via changes in the relative wages of the less-skilled in the flexible labour markets of the US and UK, while relative employment is more likely to be affected in the more rigid labour markets of continental Europe.

The contribution of this book

The key message from the earlier analysis is that assessing the impacts of trade and technology on inequality requires flexibility and diversity in terms of the theoretical and empirical approaches used. This is where the motivation for this book becomes clear as the individual chapters make a valuable contribution to research on this issue as they continue the evolution of ideas, methodologies and data applied to this question. They apply a wide variety of economic methodologies—ranging from econometrics, general equilibrium models and case studies—across a broad range of countries in order to answer the above questions on the 'globalisation-trade-technology-inequality' debate. By analysing the wage and employment experiences of less-skilled workers across different countries and industries, the book not only attempts to improve our knowledge of the mechanisms by which globalisation and technology might cause inequality, but also seriously contributes to our understanding of how policy-makers might help industries and less-skilled workers to successfully adjust to globalisation and new technology.

The individual chapters constitute a very detailed analysis using, for example, highly disaggregated bilateral trade data combined with detailed industry-level data. This allows distinctions to be made which are important from a theoretical viewpoint, such as distinguishing between, say, high and low-wage country import suppliers, or between skilled-intensive and unskilled-intensive industries. In addition, case studies are undertaken whereby information gained from, for example, visits to manufacturing plants provide detailed information on the impact of technology and globalisation at the firm-level.

In Chapter 2, Anderton and Oscarsson investigate the reasons behind the increase in inequality between skilled and less-skilled workers in the US by assessing the impact of imports and technological change on the wage bill and employment shares of skilled workers. Using highly disaggregated bilateral trade data, which allows the crucial distinction between imports from high- and low-wage countries at a highly detailed industry level the authors' econometric results show that rising imports from low-wage countries seem to explain a significant part of the rise in US inequality in low-skill-intensive sectors, while technological change (proxied by R&D expenditure) explains the rise in inequality in high-skill-intensive sectors. The authors also find that the technology-based explanation for rising inequality in high-skill sectors is actually partly a trade-based explanation due to mechanisms such as 'defensive innovation'.[9]

In Chapter 3, Ana Rute Cardoso adopts a less traditional approach by econometrically analysing the impact of trade and technology on the job creation and job destruction of skilled and unskilled workers in Portugal during the 1980s and 1990s. Several variables explaining job flows are included in the econometric specification, namely: competitive conditions in international product markets (proxied by industry import and export prices), technological conditions (proxied by the share of computer related professionals in the industry) and firm attributes that can capture institutional factors, such as the type of ownership of the company, its age, size and location. The results show that technology indicators seem more relevant determinants of job flows than competitive conditions in international product markets. Indeed, firms in technologically more advanced industries have expanded job opportunities for the skilled labour force (as job creation took place at a faster pace than job destruction), while the net employment of unskilled workers in these sectors remained unchanged. Regarding the impact of international trade, import prices are found to have no impact on job creation or job destruction for the unskilled or on job creation for the skilled. Consequently, there is no evidence of the much discussed possible impact of falling import prices on the jobs of the less skilled in Portugal. By contrast, rising export prices for Portugal—pointing to an increase in the quality of Portuguese exports—have been associated with an increase in the relative employment of skilled workers as rates of job creation have been significantly greater than job destruction for skilled workers (with job creation offset by job destruction for the unskilled). Accordingly, the results therefore point to an economy slowly increasing its specialisation in skilled labour-intensive activities in response to developments in Portuguese trade.

Ludo Cuyvers, Michel Dumont and Glenn Rayp, in Chapter 4, investigate the impact of trade with low-wage countries on the wages and employment of various EU countries. The authors' econometric approach assesses the impact of trade on European wages using a panel econometric approach based on data for 10 countries, 12 sectors (ISIC two-digit level) and 12 years (1985–1996). The results show that only at lower levels of statistical significance does international trade seem to have influenced income inequality among workers, particularly with respect to trade *vis-à-vis* Asia. By contrast, a Generalised Leontief cost function approach revealed more convincing evidence of a significant influence of international trade on employment demand. For virtually all EU countries, the import competition elasticity of low-wage countries with respect to labor demand is statistically significant and negative. However, the effect of technological change on labour demand is found to be greater than the trade impact, implying that technological innovation matters more for employment than the globalisation of trade.

Yet another informative methodology is applied in Chapter 5 where Lisandro Abrego and John Whalley assess the possible impacts of trade and technology on labour market inequality using Calibrated General Equilibrium (CGE) models. They argue that the exploration of the outcomes of alternative structural models within a CGE framework, rather than reduced form econometrics based models, may be the best way forward to sort out trade and technology effects on wage dispersion. They find that in a differentiated-goods CGE model with perfectly competitive labour markets, increased wage inequality is basically the result of technological change, with trade playing a more limited role. By contrast, incorporating labour market imperfections into the model for unskilled labour significantly changes this result, increasing the relative contribution of trade.

The next three chapters are based on case studies of selected industries carried out using various methodologies. Chapter 6 (by Paul Brenton, Anna Maria Pinna and Mark Vancauteren) is a very detailed study of the footwear industry and assesses how producers in a selection of EU countries have adjusted to increased competition from low-wage countries. In the standard HOS model, globalisation should lead to a reallocation of resources in OECD countries from low-skill-intensive (i.e. import competing) industries to skill-intensive sectors in which these countries have a comparative advantage. However, for many unskilled intensive sectors such as footwear, the ratio of exports to output has increased in line with the import penetration ratio, while in the standard HOS model countries either import or export products, not both. Hence, even in low-skill-intensive sectors product differentiation exists, which provides another means of adjustment to globalisation not possible within the standard model (i.e. the within sector adjustment to produce different and higher quality products). Second, there appears to be a range of experience across countries in the evolution of low-skill-intensive sectors. In a number of OECD countries some of these sectors have maintained employment and output whilst in other countries production has declined dramatically. If the trade shock from globalisation is common across countries then this suggests that a variety of responses to globalisation are available to firms in OECD countries. Brenton *et* *al.*'s case studies of the low-skill-intensive footwear industry provide many illustrations of these various mechanisms across a number of European countries.

Markus Diehl in Chapter 7 analyses international trade statistics and input-output tables in order to assess whether international transactions in intermediate inputs in the automobile industry, and mechanisms such as outsourcing, have become more important over time. Detailed results are presented in case studies of four major producers—the US, Japan, Germany and the UK—which show that the share of imported inputs in the gross output value of the motor vehicle industry has grown significantly over the past two decades. Moreover, some low-wage countries have become important exporters of automobile parts, but this trade is regional rather than global. However, Diehl concludes that these developments in the automobile industry and its subsectors are linked to changes in the relative wages of low-skilled workers in this sector.

In Chapter 8, Valerie Jarvis examines the degree of outsourcing and its relation to output quality in the British and German ceramic tableware industries and provides original insights into how technology and trade with low-wage countries affect both production and labour requirements at the firm-level. In contrast to the data-based analyses of the earlier case studies, this study entailed *on-site visits* to more than twenty tableware manufacturers across the two countries involving semi-structured interviews with factory owners, production managers and directors. Significant cross-country differences were found in the ways in which firms typically use technology and low-wage foreign suppliers to supplement their in-house production. Among the larger German firms, the preferred method tended to be the full production of finished products in German-owned (or part-owned) and technician-supervised factories located in low-wage countries. By contrast, the larger British firms tend to buy-in finished items from low-wage country suppliers, to be simply repackaged and marketed alongside domestic output. For many German firms, outsourcing beyond the German border involved sub-contracting the less-skilled labour-intensive elements of decoration activities to specialist lower-cost facilities of the nearby Czech Republic and Poland. In Britain, the lack of availability of a conveniently located supply of lower-cost labour for partial processing has led to an increased reliance on technological innovation, where applicable, as a means of reducing labour costs in the labour-intensive activities. Jarvis finds a somewhat smaller price advantage among low-wage country producers relative to those German and British producers in the *lower-quality grades* of production (with larger price differentials existing in the higher-quality grades), suggestive of a greater impact of competition from low-wage countries in lower quality product markets.

But the responses of tableware manufacturing firms operating in Britain and Germany to this increased competition have been notably different—and perhaps of differing long-term viability. In Britain, the producer's response has been largely one of seeking to *confront head-on* the impact of greater price competition, either through removal of many of the costly labour-intensive processes by means of increased investment in new technologies or the direct importation of low-wage country-produced output for marketing alongside domestically manufactured ranges. The response of the average German producer in this industry has been to seek to *move away* from direct price competition by seeking to produce a higher-quality product, and to accentuate the quality differences of German-made output in the eyes of the consumer. Both tendencies imply a considerable—and continuing—decline in demand for lower-skilled labour in both

Germany and Britain. In summary, this chapter tends to support the notion that the HOS theorem is too restrictive for real world complexities. In particular, it is difficult to define industries as unskilled-intensive as this example shows that even at the individual product-level production is differentiated into high- and low-skill-intensive segments. Furthermore, this level of detail helps us to understand how different firms react differently to globalisation, leading to possibly different policy responses.

What are the appropriate policy responses if globalisation is a significant cause of the deterioration in the economic fortunes of the less-skilled? This is the central question of Chapter 9 in which Paul Brenton argues that anti-globalisation measures such as trade barriers and restrictions on long-term capital flows are inappropriate responses to the problems of inequality and social exclusion. The reason is that trade and capital movements bring substantial economic benefits—hence income redistribution policies which preserve the gains from trade are better suited to addressing the problem of rising inequality. Accordingly, intervention that constrains trade will be one of the least effective mechanisms in combating inequality as such policies will reduce economic welfare. Brenton also argues that poor labour standards in developing countries are not a relevant policy issue in the debate on inequality: first, the impact of low labour standards in developing countries on workers in industrial countries is marginal; second, the effective international implementation of core labour standards will not undermine the ability of developing countries to compete on the world market; and third, it is unlikely that increased global competition will lead to the downward convergence of labour standards.

Although the overall conclusion arising from this volume is that technological progress seems to be the main factor explaining the decline in the relative demand for less-skilled workers, the majority of chapters find that trade has also played an important role in the deterioration in the economic fortunes of the less-skilled over the 1980s and mid-to-late-1990s. Furthermore, many of the studies either find that the rise in technological change has been partly driven by rapid rises in international trade and globalisation (e.g. 'defensive innovation'), or that producers have simply moved into the production of higher-quality products in order to escape direct trade competition with low-wage countries. Accordingly, the technology-based explanation for rising inequality is, on closer analysis, frequently partly a trade-based explanation, making it difficult to assess their individual contributions to the growth in labour market inequality.

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Notes

1 See, for example: Wood (1994); the Summer 1995 and Spring 1997 issues of the *Journal of Economic Perspectives;* Feenstra (1999); Dewatripont *et al*. (1999); Brenton and Pelkmans

(1999); Greenaway and Nelson (2000); *Review of International Economics,* 8 (3) (2000); Feenstra (2001); Choi and Greenaway (2001).

2 See Sachs and Schatz (1996) who look at developments across industries in the context of traditional trade theories using the HOS model incorporating the Stolper-Samuelson theorem.

3 Sachs and Schatz (1994) argue that the trend in the price of computers explains the decline in the relative price of skill-intensive products in the US. However, even when the impact of computer prices are taken out, there is no clear relationship between changing prices and skill intensity in the US.

4 'Moving the low-skill-intensive parts of production abroad' does not necessarily mean that the firm is involved in outward FDI, it can also mean that the low-skill parts of production are closed down and replaced by imports—of either intermediate or finished goods—from low-wage countries.

5 Outsourcing is documented as a feature of many industries such as: footwear (Yoffie and Gomes-Casseres, 1994); textiles (Waldinger, 1986; Gerefii, 1993); and electronics (Alic and Harris, 1991).

6 For example, the domestic production by some UK firms of simple surgical instruments is frequently supplemented by importing *finished* products from low-wage countries and reselling them on the domestic market after carrying out simple tasks such as quality control procedures and packaging. Some of the price differentials in this sector are extremely large: for example, simple scalpels sold by UK firms for £25 can be purchased from Pakistani companies for £1. Hence the price incentives to outsource can be substantial.

7 Anderton and Brenton (1999) estimate that outsourcing may account for around 40 per cent of the rise in the wage-bill share of skilled workers and approximately one-third of the increase in their employment share in the UK textiles sector. Meanwhile, Anderton *et al*. (2002) find that outsourcing to low-wage countries accounted for around 25 per cent of the average sectoral increase in the wage share of skilled workers in Sweden and for around 15 per cent of the increase in the employment share.

8 For a strong theoretical treatment of how various shocks may affect the degree of outsourcing see Kohler (2004).

9 Other relationships between trade and innovation are described in Glass and Saggi (2001). For example, they claim that outsourcing to low-wage countries can lower the marginal cost of production and thus increase profits, thereby creating greater opportunities for innovation.

2
Inequality, trade and defensive innovation in the United States

Robert Anderton and Eva Oscarsson

Introduction

The United States experienced a considerable increase in inequality during the 1980s, with the major increase in inequality occurring *within*, rather than *across*, industries.[1] Although several studies have investigated the possible causes of this decline in the relative economic fortunes of the less-skilled in the United States their conclusions differ quite considerably. For example: Feenstra and Hanson (1995 and 1996a, b) claim that increased imports explain much of the rise in US inequality; Machin and Van Reenen (1998) find that the main cause is skill-biased technological change; and Haskel and Slaughter (1997) argue that it is the *sectoral* bias of skill-biased technological change that matters.

This chapter contributes to this debate by focussing on the relationship between US labour market inequality, US imports and technological innovation, and also investigates whether trade also influences technological change via 'defensive innovation'. In contrast to most previous studies—which investigate the impact of US imports on inequality but do not distinguish between import suppliers—we examine whether the impact of imports from high-wage industrialised countries differs from that of imports from low-wage countries.

The section on Movements in US inequality of the chapter looks at aggregate movements in US inequality. The section on Trade, technology and inequality within high- and low-skill-intensive sectors, describes developments in trade and technology indicators for three industry groups—representing high- and low-tech sectors—while the section on Econometric results econometrically estimates the extent to which these factors explain the trends in US inequality. This is followed by a discussion of what drives technological innovation (proxied by R&D investment expenditure) and, in particular, empirically investigates whether import competition has any impact on innovation. Finally, the chapter summarises our results and suggests issues for further work.

Movements in US inequality

It is now widely held that the main cause of the decline in the economic fortunes of the less-skilled seems to be a shift in demand towards higher skilled workers.[2] Two main explanations are frequently offered for such a demand shift: first, that labour-saving technical progress has reduced the relative demand for less-skilled workers; second, that increased international trade with Low-Wage Countries (LWCs)—that is, nations with an abundant supply of low-skill and low-wage labour—has decreased the demand for low-skilled workers in the advanced industrialised countries. These impacts from trade may come about via Stolper-Samuelson effects or by mechanisms such as ‘outsourcing’.[3] Regarding the impact of innovation, there are various routes by which skill-biased technical progress may reduce the relative wages and employment of the less-skilled. For example, technical progress which is biased towards reducing the use of unskilled labour will tend to increase the share of skilled, relative to unskilled, labour in production. Such falls in the relative demand for unskilled workers—regardless of whether the cause is trade or technology—will tend to push down their wages and employment relative to the skilled. Using non-production workers as a proxy for higher-skilled labour, and production workers to represent the less-skilled, Figure 2.1 shows the wage and employment shares for skilled workers within US manufacturing from the early 1970s to the mid-1990s.

As indicated by Figure 2.1, the increase in US inequality has not occurred at a constant rate. This was highlighted by Feenstra and Hanson (1996a,b) who pointed out that there was a particulary large increase in inequality in the United States in the *early* 1980s. Given that this period corresponds with a recession in the United States, the behaviour of the wage share is not surprising as the relative demand for non-production workers is generally countercyclical. However, two questions remain: why was the change in the wage share so abnormally large in the early 1980s; and why did it not return to its previous level after the recession?

Figure 2.1 Wage and employment shares for non-production workers in the US.

Source: US Census of Manufactures and Annual Surveys.
Notes

Wage bill of non-production workers divided by total wage bill for manufacturing sector. Employment of non-production workers divided by total employment.

The trade-based explanation of inequality may offer some explanation. For example, the hysteresis-type behaviour of the wage and employment shares of non-production workers corresponds to a period when the US dollar temporarily appreciated by around 40 per cent which, in turn, corresponds to a period of possible hysteresis in trade performance.[4] Baldwin (1988) and others argue that the high level of the dollar during the early 1980s caused a surge in US imports, and a fall in US import prices (in dollars), neither of which were reversed when the dollar depreciated back to its previous level from 1986 onwards.

Table 2.1 shows values at key points in time for the wage and employment shares of US non-production workers, total import penetration and R&D expenditure as a percentage of GDP.[5] The latter variable shown as R&D is frequently used in inequality analysis as a proxy for technological change and its behaviour over time lies behind many of the claims that technology has caused an increase in inequality in a number of countries.[6] The table clearly shows that the *major* rise in US inequality—proxied by the wage and employment share of non-production workers—occurred between 1978 and 1986 and roughly corresponds with the period of the appreciation of the dollar. Similarly, US import penetration rose at a more rapid rate during this period, but carried on rising—albeit at a much slower pace—even though the dollar depreciated by around 40 per cent from 1986 onwards (which is consistent with hysteresis-type behaviour).

However, R&D expenditure (as a percentage of GDP) also follows a similar profile. It seems that technological change accelerated extremely rapidly during the early 1980s and then slowed down somewhat from the mid-1980s onwards, but R&D expenditure then remained at a significantly higher level relative to the previous decade (which is again consistent with hysteresis-type behaviour). The increase in both R&D expenditure and import penetration ratios in the early 1980s are shown in Figure 2.2. US Imports are also broken down into imports from high-wage countries (OECD) and low-wage countries (non-OECD).

Table 2.1 US non-production workers' wage and employment shares, import penetration and R&D[a]

Year	*Non-production wage share*[b]	*Non-production employment share*[c]	*Import penetration*[d]	*R&D/Output ratio*[e]
1974	34.5	25.4	5.8	2.19
1978	35.1	26.1	8.0	2.13
1986	41.3	31.2	12.2	3.51
1993	42.5	30.9	13.9	2.94

Notes

a All figures are in percentages.

b Wage bill of non-production workers divided by total wage bill for manufacturing sector.

c Employment of non-production workers divided by total employment.

d Imports divided by US imports plus domestic production of manufactures.

e R&D expenditure in manufacturing divided by manufacturing output.

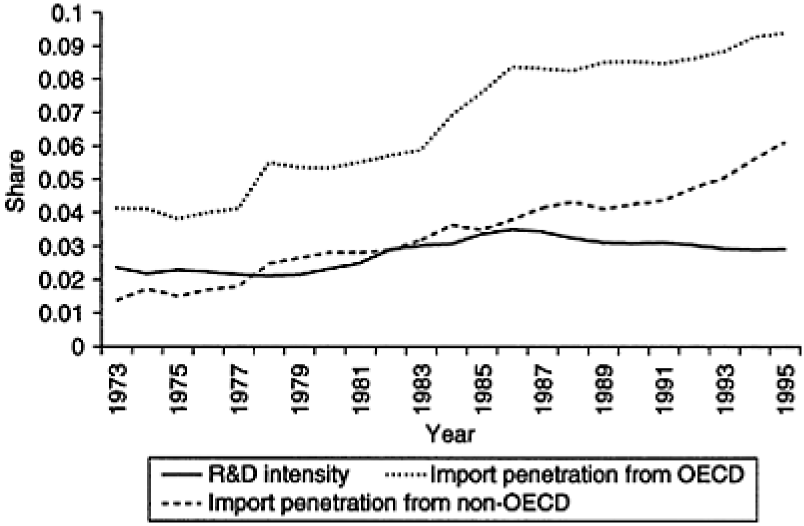

Figure 2.2 R&D and import penetration in the US.

Source: OECD ANBERD database and OECD trade database.

Notes

Imports divided by US imports plus domestic production of manufactures. R&D expenditure in manufacturing divided by manufacturing output

What can we conclude from Table 2.1, Figures 2.1 and 2.2? If our choice of explanations for the rise in US inequality is only between trade or technology then the above evidence seems to suggest that there is more support for the trade-based explanation than suggested by previous studies. This is not only because import penetration increased when inequality increased but also because the rise in the dollar, and the associated deterioration in the trade competitiveness of US industry, may explain the rapid rise in R&D expenditure via various mechanisms. For example, less-competitive firms—most likely comprising low-tech companies offering low quality products, perhaps associated with minimal R&D spending and a high proportion of low-skilled workers in their labour force—would be squeezed out of business (as the dollar appreciation made US imports much cheaper). These possible *compositional* effects imply that, after a considerable ‘shake-out’ brought about by the dollar appreciation, US industry would subsequently consist of a higher proportion of high-tech firms and the average R&D-output ratio would therefore rise (and be associated with a higher proportion of high-skilled workers if the technology is skill-biased). In addition, the deterioration in competitiveness may have encouraged US manufacturers to *‘innovate defensively’*, that is, faced with strong competition from low-cost imports, firms may attempt to escape fierce import price competition by upgrading the quality of their manufactures via ‘product innovation’ which, in turn, is achieved by spending more on R&D.[7]

Trade, technology and inequality within high- and low-skill-intensive sectors

Traditional trade theories can help explain movements in relative wages *across* industries, whereas what needs to be explained is the dramatic fall in the economic fortunes of less-skilled workers *within* US sectors. One possible mechanism which may explain how trade with low-wage countries may have caused increased inequality within US sectors is 'outsourcing'. 'Outsourcing' is where firms take advantage of both the low-wage costs of the LWCs and modern production techniques—where the process of manufacturing a product can be broken-down into numerous discrete activities—by moving the low-skill-intensive parts of production abroad to the LWCs but continue to carry out the high-skill-intensive activities themselves. Once the low-skill activities have been performed the goods are then imported back from the LWCs and either used as intermediate inputs or sold as finished goods. Hence, trade with the LWCs via this route will shift demand away from less-skilled towards skilled workers in countries such as the United States, and put downward pressure on the relative wages and employment of low-skilled workers *within* industries. 'Outsourcing' is claimed to be an important activity in industries such as footwear (Yoffie and Gomes-Casseres, 1994, case 7) and textiles (Waldinger 1986; Gereffi 1993), etc. The above articles also illustrate that outsourcing applies to *finished* goods as well as *intermediate* inputs.

Orcutt (1950) may provide one explanation for a possible link between exchange rate movements and 'outsourcing'. Orcutt argues that the *costs of switching* from domestic to foreign suppliers may cause the price elasticity of imports to be bigger for large price changes than for small changes and a similar argument can be made for disproportionately large increases in 'outsourcing'. For example, when considering whether or not to 'outsource', US producers have to take into account the costs incurred when switching from in-house, or other domestic, supplies to foreign suppliers. For instance, when switching to foreign suppliers US producers may have to modify production techniques to be compatible with the newly imported products and spend time ensuring that the new supplier is both reliable and makes a product of the required specifications and quality. Consequently, small changes in the price of foreign goods will not be acted upon as the change in price differential will not cover switching costs. In contrast, a large appreciation of the dollar could result in a substantial differential between the costs of producing 'in-house' (or domestic) goods and imports—which may be at least sufficient to cover the costs of switching. In summary, *switching costs* may cause a *disproportionate* increase in 'outsourcing' during *large* exchange rate appreciations, which may partially explain the 'lumpiness' of changes in the economic circumstances of the less-skilled in the United States. Furthermore, such increases in 'outsourcing' may be difficult to reverse, even if the large appreciation of the dollar is fully reversed, since US manufacturers now have a greater understanding of the benefits of 'outsourcing' and are now familiar with the quality of goods not previously imported. Consequently, the substantial *temporary* appreciation of the dollar may have encouraged US purchasers to *permanently* switch from domestic to foreign goods (which may suggest a disproportionate increase in 'outsourcing' at a tune when the economic fortunes of the less-skilled in the US deteriorated very rapidly).

Our method for investigating the causes of US inequality is to econometrically estimate the impact of trade with LWCs on the wages and employment of the less-skilled by using a proxy variable for 'outsourcing' similar to Feenstra and Hanson (1996a, b). Feenstra and Hanson (1996a, b) proxy 'outsourcing' by US imports from *all* countries, which implicitly captures 'outsourcing' of US production to advanced industrialised countries as well as LWCs. However, there is no obvious reason why firms would 'outsource' *low-skill-intensive* activities—which is the mechanism by which 'outsourcing' affects the demand for the less-skilled—to advanced industrialised countries which are relatively abundant in skilled labour. Consequently, a major objective of this chapter is to investigate whether the *source* of imports matters by disaggregating US imports according to individual supplier countries and constructing US import share terms for both high and low-wage countries. Therefore, by explicitly identifying imports solely from *low-wage countries* and using this as a variable to explain changes in the wage share of the less-skilled in the US, we are more likely to accurately capture 'outsourcing' to low-wage countries.

In previous work on the United Kingdom, Anderton and Brenton (1999b) find that the impact of trade with LWCs differs considerably between high and low-skill-intensive sectors. Hence in the following analysis we distinguish between groups of industries which we classify as intrinsically high- or low-skill. In Table 2.2 we look at two groups of industries which can be classed as low-skill-intensive (abbreviated as LSA and LSB) and one group of high-skill-intensive sectors (HS). The first part of Table 2.2 shows that the latest rise in US inequality occurred in all three sectors during the period of substantial dollar appreciation, but that inequality continued to increase, albeit more gradually, through the rest of the 1980s and early 1990s.[8]

The last three columns of Table 2.2 show that R&D expenditure expressed as a proportion of output is extremely small in the low-skill sectors (less than 1 per cent in LSA and LSB). Given that the R&D ratios in the low-skill sectors are very small (seemingly confirming that these are indeed low-technology-intensive industries), it becomes doubtful as to whether it is feasible that movements in R&D expenditure/technology can explain the change in the wage share of non-production workers in these sectors. On the other hand, the technology explanation corresponds to movements in R&D expenditure in the high-skill sectors, particularly the large rise in R&D during the period of the dollar appreciation in the early 1980s. In addition, unlike the low-skill sectors, it seems feasible that the large absolute size of R&D expenditure in the high-skill sectors, combined with the significant changes in R&D over time, could have a strong impact on labour-skill requirements in these sectors.

Table 2.2 also shows US imports from LWCs as a proportion of total sectoral imports. Although the relationship between the import share of LWCs in the low-skill sectors and the wage and employment shares of non-production workers is unclear in the early 1970s, there is a large increase in US imports from LWCs during the period when inequality rose more rapidly and the dollar appreciated. Conversely, imports from LWCs for the high-skill sector group remained nearly static between 1978 and 1986—perhaps indicating that defensive innovation succeeded in reducing import competition from LWCs in this sector (the relatively high import share of LWCs in this high-skill sector also suggests that the degree of low-wage country competition may be sufficient to be a plausible cause of defensive innovation).

Table 2.2 US wage bill share and employment share of non-production workers, import share of low-wage countries (LWCs) and R&D in low- and high-skill-intensive sectors a

Year	*Wage bill share*			*Employment share*		
	LSA[b]	*LSB*[b]	*HS*[b]	*LSA*[b]	*LSB*[b]	*HS*[b]
1974	24.8	25.8	41.2	14.6	20.3	30.9
1978	25.1	26.3	42.2	14.9	20.3	32.3
1986	27.3	30.3	49.6	17.1	23.4	38.4
1993	28.6	31.7	51.1	17.5	23.7	37.6
	Import share of LWCs[c]			*R&D/output ratio*		
	LSA[b]	*LSB*[b]	*HS*[b]	*LSA*[b]	*LSB*[b]	*HS*[b]
1974	37.7	26.1	34.9	0.45	0.48	4.24
1978	46.1	26.0	36.6	0.46	0.49	3.85
1986	58.0	30.2	35.8	0.57	0.86	5.79
1993	61.2	33.7	42.8	0.80	0.62	5.42

Notes

a All figures are in percentages.

b LSA=low-skill sector group ‘A’ comprising ISIC sectors 3200, 3300 and 3400 (i.e. Textiles, Apparel and Leather; Wood Products and Furniture; Paper, Paper Products and Printing). LSB=low-skill sector group ‘B’ comprising ISIC sectors 3600,3700 and 3810 (i.e., Non-Metallic Mineral Products; Basic Metal Industries; Metal Products); HS=High-skill sectors comprising ISIC sectors 3500, 3820, 3830, 3850 (Chemical Products; Non-electrical Machinery; Electrical Machinery; Professional Goods).

c Sectoral imports from low-wage countries (LWCs) expressed as a percentage of total sectoral imports.

Econometric results for the ‘inequality’ equations (i.e. wage and employment share equations)

In this section, we econometrically estimate the impact of both trade with LWCs and R&D spending on the wage and employment shares of non-production workers in the United States. We use highly disaggregated US wage and production data—converted from US SIC to ISIC REV2—and define non-production workers as skilled and production workers as less-skilled (source: US Census of Manufactures and Annual Surveys). Technological change is proxied by R&D expenditure as a proportion of GDP (source: OECD ANBERD database). The capital stock data are from the OECD’s International Sectoral Database (ISDB). The bilateral US imports data were supplied by the OECD on an SITC basis and converted to the ISIC REV2 classification. Trade, production and wage bill and employment share data are all disaggregated to the 4-digit ISIC level (hence all variables are on an ISIC basis—further details of the 4-digit sectors used in the analysis are given in the data appendix). In order to provide enough observations for separate ‘panel estimation’ of our three sectoral groupings, we pool the data across the 4-digit ISIC sectors within the LSA, LSB and HS broad groupings using annual data for the sample period 1973–1993 (imposing, in effect, the same parameters across the different 4-digit sectors).

Following Feenstra and Hanson (1995 and 1996a,b), we seek to assess whether industry import shares have contributed significantly to the determination of the within-sector wage bill and employment shares of low-skilled workers in the United States. Following the approach of Berman *et al*. (1993, 1994), and assuming capital to be a fixed factor of production, we start from a variable cost function in translog form:

$$\begin{aligned}\ln C_i = {} & \alpha_0 + \alpha_y \ln Y_i + \frac{1}{2}\alpha_{YY}\ln(Y_i)^2 + \beta_K \ln K_i + \frac{1}{2}\beta_{KK}\ln(K_i)^2 \\ & + \sum_j \gamma_j \ln W_{ij} + \frac{1}{2}\sum_j\sum_k \gamma_{jk}\ln W_{ij}\ln W_{ik} + \sum_j \delta_{Yj}\ln Y_i \ln W_{ij} \\ & + \sum_j \delta_{Kj}\ln K_i \ln W_{ij} + \rho \ln Y_i \ln K_i + \lambda_T T_i + \frac{1}{2}\lambda_{TT}(T_i)^2 \\ & + \lambda_{YT} T_i \ln Y_i + \lambda_{KT} T_i \ln K_i \\ & + \sum_j \phi_{Tw_j} T_i \ln W_{ij}\end{aligned} \qquad (2.1)$$

where C_i is variable costs in industry *i;* Y_i is output in industry *i;* K_i is the capital stock in industry *i;* W_{ij} is the price of variable factor *j* and T_i represents technology in industry *i*.

Cost minimisation generates the following linear equations for the factor shares *(S):*

$$S_{ij} = \gamma_j + \delta_{Yj}\ln Y_i + \delta_{Kj}\ln K_i + \sum_k \gamma_{jk}\ln W_{ik} + \phi_{Tw_j} T_i \qquad (2.2)$$

whilst differencing (denoted by d) generates

$$\mathrm{d}S_{ij} = \phi_{Tw_j}\mathrm{d}T_i + \delta_{Yj}\,\mathrm{d}\ln Y_i + \delta_{Kj}\,\mathrm{d}\ln K_i + \sum_k \gamma_{jk}\,\mathrm{d}\ln W_{ik} \qquad (2.3)$$

assuming homogeneity of degree one in prices imposes

$$\sum_k \gamma_{jk} = \sum_j \gamma_{jk} = \sum_j \delta_{Kj} = \sum_j \delta_{Yj} = 0 \qquad (2.4)$$

which generates with two variable factors, *j* and *k*

$$\mathrm{d}S_{ij} = \phi_{Tw_j}\mathrm{d}T_i + \delta_{Kj}\,\mathrm{d}\ln K_i + \delta_{Yj}\,\mathrm{d}\ln Y_i + \gamma\,\mathrm{d}\ln\left(\frac{W_j}{W_k}\right) \qquad (2.5)$$

In our empirical application of the earlier model we have two variable factors of production, low-skilled (production) workers and higher-skilled (non-production) workers, and adopt a similar approach to Machin *et al*. (1996) and estimate the following US wage bill and employment share equations:

$$\mathrm{dSW}_{it} = \alpha\mathrm{d}\ln K_{it} + \beta\,\mathrm{d}\ln Y_{it} + \rho\mathrm{TECH}_{it} + \lambda\,\mathrm{d}\ln \mathrm{MS}_{it} + \gamma D_t + U_{it} \qquad (2.6)$$

$$dSE_{it}=\alpha \ d \ ln \ K_{it}+\beta \ d \ ln \ Y_{it}+\rho TECH_{it}+\lambda \ d \ ln \ MS_{it} \ +l \ d \ ln \ (W^{hs}/W^{ls})_{it}+\gamma D_t+U_{it} \quad (2.7)$$

where: SW_{it} is the share of the wage bill of the high skilled $(WB^{hs}_{it}/(WB^{hs}_{it} + WB^{ls}_{it}))$, SE_{it} is the employment share of the high skilled (similarly derived as SW_{it}).

WB^{hs}_{it} is the wage bill of the higher skilled (i.e. non-production workers); WB^{ls}_{it} is the wage bill of the lower skilled (i.e. production workers); W^{hs}/W^{ls} is the relative wage rate of high and low-skilled workers; K_{it} is the capital stock; Y_{it} is real output; $TECH_{it}$ is a proxy variable for technological change (proxied by R&D); MS_{it} is the share of the value of domestic demand for the output of industry *i* accounted for by imports; D_t is a set of time dummies included to capture any company preferences for non-manual or manual workers common across industries for a given year; U_{it} is an error term; Subscript *i* represents industry *i*. First differences are denoted by d.

The time dummies capture any changes in firm-level preferences for nonproduction or production workers common across industries in each year. The MS term represents US imports and can be interpreted as a proxy for outsourcing. In this chapter, we follow the approach of Feenstra and Hanson (1995, 1996a, b) and justify the inclusion of the MS term in the wage bill share equation by arguing that merely including the factors derived from a traditional translog production function will not capture other factors—such as outsourcing—which may influence a firm's demand for skilled labour. Given that outsourcing to low-wage countries is claimed to push the range of activities performed by domestic industry away from low-skill towards high-skill tasks, the MS term can be interpreted as representing a reduced-form relationship between outsourcing and a firm's unit input requirement for skilled labour. As we want to distinguish between the impacts of high- and low-wage country import suppliers, we experiment with two different versions of MS:

1 MSO=US imports from high-wage countries (which we define as OECD countries).[9]
2 MSNO=US imports from LWCs (which we define as Non-OECD countries).

Our final wage-bill share specifications based upon (2.6) above are shown in Table 2.3 below. Note that we do not include the relative wage rates for the two types of labour in our final estimated wage bill share equations mainly because relative wages are unlikely to be exogenous. However, the equation includes a set of macro time dummies, which will capture any firm-level changes in preferences for higher-skilled workers due to absent variables such as relative wages. We estimate two equations for each industry group—the first equation uses US imports from high-wage countries (i.e. OECD countries: 'MSO') and the second uses imports from low-wage countries (i.e. non-OECD countries: 'MSNO'). The results show that the change in output is negatively signed and statistically significant (with the exception of industry group LSA) which conforms with our prior that a short-run decline in output tends to reduce the demand for the less-skilled relative to the skilled. The capital stock term is not statistically significant in any of the equations, which may not be surprising for the low-skill-intensive sectors as they are extremely low-capital-intensive industries. Although the capital stock term has the correct positive sign for the high-skill sector grouping—as we expect complementarities between capital and skill—it is not statistically significant (perhaps because it is dominated by the R&D term). One striking result is that R&D is not statistically significant for the low-skill sectors, but is strongly significant for the high-skill sectors.

The statistical significance of the MSNO terms in the LSA and LSB sectors suggests that increased trade with LWCs tends to increase the wage share of

Table 2.3 US wage bill share equations (dSW_{it})

Equation	*LSA*	*LSA*	*LSB*	*LSB*	*HS*	*HS*
C	0.016	0.0149	0.003	0.0032	0.0006	0.0007
	(2.500)	(2.427)	(0.720)	(0.669)	(0.217)	(0.252)
$d \ln Y_{it}$	−0.013	−0.014	−0.042	−0.043	−0.026	−0.025
	(−0.970)	(−1.001)	(−3.205)	(−3.362)	(−2.580)	(−2.516)
$d \ln K_{it}$	−0.045	−0.041	0.005	−0.007	0.059	0.058
	(−0.977)	(−0.869)	(0.074)	(−0.103)	(1.423)	(1.392)
$(R\&D/Y)_{it-1}$	0.118	0.129	0.008	−0.014	0.043	0.042
	(0.131)	(0.142)	(0.030)	(−0.056)	(3.118)	(3.084)
$d \ln MSO_{it}$	0.004		0.0009		−0.003	
	(1.831)		(0.222)		(−0.924)	
$d \ln MSNO_{it}$		0.003		0.0058		−0.0006
		(2.116)		(2.226)		(−0.480)
N	340	340	200	200	440	440
R^2	0.254	0.248	0.551	0.559	0.358	0.356
SEE	0.011030	0.011075	0.008620	0.008543	0.011043	0.011056

Notes
MSO=US imports from OECD countries for sector groups are expressed as a proportion of total US demand for goods produced in that sector; MSNO=US imports from non-OECD countries for sector groups are expressed as a proportion of total US demand for goods produced in that sector. OLS estimation for annual data sample period of 1974–1993 (full set of time dummies included) using White's heteroskedasticity consistent SEs; '*t*' statistics are in parentheses.

Table 2.4 US employment share equations (dSE_{it})

Equation	*LSA*	*LSA*	*LSB*	*LSB*	*HS*	*HS*
C	0.010	0.0097	0.0044	0.0042	0.0004	0.0004
	(2.809)	(2.714)	(1.152)	(1.106)	(0.149)	(0.155)
$d \ln Y_{it}$	−0.007	−0.008	−0.035	−0.037	−0.023	−0.023
	(−0.727)	(−0.748)	(−3.132)	(−3.298)	(−2.705)	(−2.725)
$d \ln K_{it}$	−0.036	−0.033	−0.0004	−0.011	0.051	0.051
	(−1.113)	(−1.005)	(−0.009)	(−0.230)	(1.466)	(1.469)
$(R\&D/Y)_{it-1}$	0.212	0.217	−0.004	−0.025	0.041	0.041
	(0.334)	(0.340)	(−0.021)	(−0.134)	(3.305)	(3.304)
$d \ln MSO_{it}$	0.0024		0.0014		0.0001	
	(1.897)		(0.461)		(0.055)	
$d \ln MSNO_{it}$		0.002		0.005		0.00005
		(2.159)		(2.350)		(−0.046)
$d \ln (W^{hs}/W^{ls})$	−0.107	−0.106	−0.100	−0.099	−0.115	−0.115
	(−8.264)	(−8.080)	(−5.807)	(−6.060)	(−6.528)	(−6.543)

N	340	340	200	200	440	440
R^2	0.529	0.526	0.699	0.706	0.527	0.527
SEE	0.007400	0.007426	0.006554	0.006472	0.009252	0.009252

Notes
MSO=US imports from OECD countries for sector groups are expressed as a proportion of total US demand for goods produced in that sector; MSNO=US imports from non-OECD countries for sector groups are expressed as a proportion of total US demand for goods produced in that sector. OLS estimation for annual data sample period of 1974–1993 (full set of time dummies included) using White's heteroskedasticity consistent SEs;'*t*' statistics are in parentheses.

non-production workers in the low-skill sectors, but that technological change rather than trade partly explains the rise in US inequality in the high-skill sectors. For the LSA sector grouping, there is also some limited—but less-convincing—evidence that any increase in inequality from increased trade may also be partly due to increased imports from the higher-wage OECD countries, whereas only imports from LWCs increase inequality in the LSB sectors.[10]

Table 2.4 shows the results arising from the estimation of the employment share equation (i.e. equation (2.7)). The results support the conclusions drawn in the wage share analysis that imports from low-wage countries seem to explain part of the rise in US inequality in low-skill-intensive sectors, while technological change (proxied by R&D expenditure) explains the rise in inequality in high-skill-intensive sectors. The relative wage term is strongly significant and, as expected, negatively signed. Finally, the explanatory power of the variables in the employment equations is generally better than the wage equations, and the increase in the R^2 is especially large for the LSA sectors.

It is important to note that the above results may underestimate the impact of trade with low-wage countries on US inequality as we do not include the import *price* in our specifications (due to the lack of reliable trade price data for the United States at this level of disaggregation). Relative import price terms may capture other effects in addition to those captured by the import penetration terms such as the *threat* of increased competition from LWCs (e.g. the fall in the import price of LWC products as the dollar appreciated may have made it easier for firms to obtain agreement from their workforce to restrain the wages, or terminate the employment, of less-skilled workers, etc.).[11]

As mentioned before, previous studies such as Machin *et al*. (1996) do not find a significant impact of trade on the relative wages and employment of the less-skilled in the United States. However, unlike our analysis, they do not use trade data which separately identifies imports from low-wage countries—which is important as mechanisms such as 'outsourcing' only influence inequality via trade with low-wage countries—and their empirical work is at a more aggregate level. Although Feenstra and Hanson (1995) do find that imports have increased US inequality, they too do not distinguish between import suppliers. In contrast, we have shown that when assessing the impact of trade on inequality the source of imports matters, which is consistent with economic theory. For the United States, it seems that using aggregate imports to capture mechanisms such as outsourcing may be misleading and that disaggregation of imports in order to identify low-wage countries is necessary, particularly as the impact of trade on inequality may vary across sectors of different skill intensities.

What drives technological innovation?

Given that R&D seems to explain a large part of the rise in inequality in the high-skill sectors, we now turn our attention to investigating the factors behind the rapid rise in technological innovation, particularly as to whether trade influences technological change. Adrian Wood (1994, 1995) launched the term 'defensive innovation' meaning that some innovation may be driven by the need to stay competitive against increased low-wage competition. He argues that some firms in advanced industrialised countries may have to look for new methods of production that are unskilled labour-saving (i.e. 'process innovation' driven by import competition). As we have argued earlier, 'defensive innovation' may also mean that firms upgrade the quality of their products in order to stay competitive (i.e. 'product innovation' driven by import competition). Another relationship between trade and innovation is hypothesised by Glass and Saggi (2001). These authors argue that an increase in outsourcing to a low wage country lowers the marginal cost of production and thus increases profits, thereby creating greater incentives and/or opportunities for innovation.

Considerable empirical research has been carried out regarding the R&D investment decision of the firm (see Cohen 1989). In the standard Schumpeterian framework, firm size and market concentration are the two major explanatory variables explaining R&D at the firm level. Firm size is thought to be important as bigger firms have scale economies in the R&D function, greater access to risky financing on the capital market as well as a larger volume of sales over which they can spread the fixed costs of innovation, etc. Meanwhile, monopoly power (or market concentration) enables firms to reap profits from R&D investments and also provides a more stable environment for the firm's investment decision.

Using data at the industry level, with the objective of investigating whether trade influences technological change, we estimate a simple R&D function for the US loosely based on the specification used by Hirsch (1992) which includes a mixture of industry and firm-level variables. As optimal investment is a function of output (and thus product prices) and relative factor prices, Hirsch includes firm level data on both the physical capital stock and the R&D stock as well as firm-level profitability to take into account firm-specific differences. At the industry level, Hirsch includes the annualised growth rate in industry output, labour costs per employee, the concentration ratio and the share of imports in domestic sales.[12]

Our industry-data approximation of Hirsch's R&D function is as follows:

$$\begin{aligned} d\ln\left(\frac{I_{it}}{\mathrm{PROD}_{it}}\right) = \alpha_i + \beta_C d\ln\left(\frac{\mathrm{CAP}_{it-1}}{\mathrm{RPRDV}_{it-1}}\right) \\ + \beta_W d\ln \mathrm{RWAGE}_{it-1} + \beta_{RP} d\ln \mathrm{RPRDV}_{it-2} \\ + \beta_R d\ln \mathrm{RR}_{it-1} + \beta_M d\ln \mathrm{MS}_{it-1} \\ + \sum \delta_m \mathrm{YEAR}_{mt} + e_{it} \end{aligned} \quad (2.8)$$

where: $I_{it}/\mathrm{PROD}_{it-1}$ is R&D expenditure expressed as a proportion of production; α_i is an industry specific intercept (fixed effects); $\mathrm{CAP}_{it-1}/\mathrm{RPRDV}_{it-1}$ is the real capital stock relative to real production; RWAGE $_{it-1}$ is the real average wage; RPRDV_{it-2} is real production; RR_{it-1} is profitability measured as price over unit labour cost; MS_{it-1} is the share of the value of domestic demand for the output of industry *i* accounted for by imports from low- and high-wage countries respectively; $YEAR_{mt}$ is a set of time dummies; subscript *i* represents industry *i*; first differences are denoted by d.

The real average wage is simply total real wages divided by total employment per industry, while the profitability variable is calculated as the producer price divided by labour compensation[13]. Although the data used in the estimation of equation (2.8) are the same as in the share analysis earlier, the industries are more aggregated in this section according to the more limited sectoral breakdown of the R&D data.[14] Table 2.5 shows the results using this specification for the high-skill sectors.[15] Again, we report two sets of results in first difference form: one using import penetration from the high-wage countries and the other using import penetration from low-wage countries.

The first variable—the capital/output ratio—is expected to have a positive sign due to the assumed complementarities between capital and R&D investment. However, we found this variable to be both statistically insignificant and incorrectly signed. Meanwhile, an increasing real average wage could affect investment in R&D both negatively or positively.[16] Although, the results show that the real average wage has no significant impact on R&D investments, the negative sign is indicative of factor substitution between R&D and labour.

A growing market, or increases in real production, is positively and significantly correlated with an increasing R&D intensity, which is what we expect.

Table 2.5 US R&D investment equations (d $\ln(I_{it}/PROD_{it})$) for US high-skill sectors

Equation	*HS*	*HS*
d $\ln(CAP_{it-1}/$	−0.324	−0.231
$RPRDV_{it-1})$	(−1.348)	(−0.969)
d $\ln RWAGE_{it-1}$	−0.242	−0.249
	(−1.137)	(−1.123)
d $\ln RPRDV_{it-2}$	0.595	0.572
	(3.567)	(3.517)
d $\ln RR_{it-1}$	0.147	0.088
	(0.686)	(0.404)
d $\ln MSO_{it-1}$	0.107	
	(2.092)	
d $\ln MSNO_{it-1}$		−0.004
		(−0.101)
N	180	180
R^2	0.347	0.332
SEE	0.109926	0.111133

Notes

MSO=US imports from OECD countries (as defined in previous tables); MSNO=US imports from non-OECD countries (as defined in previous tables). OLS estimation for annual data sample period of 1973–1994 using White's heteroskedasticity consistent SEs (fixed effects and full set of time dummies included); '*t*' statistics are in parentheses.

Meanwhile, the effect of an increase in profitability on R&D investments can be positive or negative. On the one hand, high profits create less pressure for investing in technology in order to transform products (or the production process) in comparison to low profits. On the other hand, high profits make it easier for firms to finance investments in R&D. We find that increases in profitability, measured as price over unit labour cost, are not statistically significant but tend to have a positive sign.

Finally, the key result shown in Table 2.5 is that growing import penetration from high-wage countries has a significant positive effect on R&D investments in the US high-skill sectors, while imports from low-wage countries have no impact. Our previous analysis of the US wage and employment shares within the high-skill sectors showed that trade had no impact on skill upgrading, while technological change was important. It therefore seems that trade also has an indirect effect on skill-upgrading in the high-skill sectors when we take into account its impact on R&D investments.

In summary, we find some evidence that 'defensive innovation' seems to occur in the high-skill sectors. Although it is not driven by import competition from low-wage countries but from high-wage countries, such defensive innovation will also reduce competition from low-wage as well as high-wage countries, thereby partly explaining why imports from low-wage countries seem to have had no impact on US inequality in high-skill sectors. Again, in comparison to other studies, this result therefore places relatively more weight on the trade-based explanation for skill-upgrading than the technology-based explanation. However, more work is needed on this topic before any strong conclusions can be drawn.[17]

Conclusions

An increase in US imports from low-wage countries, helped by the large appreciation of the dollar in the early 1980s, seems to explain some of the rise in US inequality in *low-skill-intensive* sectors. Rapid technological change does not seem to be an important determinant of labour market inequality in these sectors—which is not surprising given the low technological nature of these industries. By contrast, technological change—proxied by R&D expenditure—seems to be strongly positively correlated with the rise in US inequality in our sample of *high-skill-intensive* sectors. We also tried to establish why skill-biased technological change was so rapid during the early 1980s in the US. Given that the technological change seemed to be strongly positively correlated with rising imports—associated with the deterioration in US trade competitiveness due to the appreciation of the dollar over this period—we investigated whether the two were connected by estimating some R&D expenditure equations. We found that growing import penetration from high-wage countries had a significant positive effect on R&D investments in the high-skill sectors over our sample period, while imports from low-wage countries had no impact. Meanwhile, our analysis of the wage and employment shares within US manufacturing sectors showed that trade had no impact on skill upgrading in the high-skill sectors, while technological change was important. Accordingly, it seems that trade may also have had an indirect effect on skill-upgrading in the high-skill sectors when we take into account its effects on R&D investments via 'defensive innovation'. Although it is not driven by import competition from low-wage destruction for skilled workers (with job creation offset by job destruction for the unskilled). Accordingly, the results therefore point to an economy slowly increasing its specialisation in skilled labour-intensive activities in response to developments in Portuguese trade.

Ludo Cuyvers, Michel Dumont and Glenn Rayp, in Chapter 4, investigate the impact of trade with low-wage countries on the wages and employment of various EU countries. The authors' econometric approach assesses the impact of trade on European wages using a panel econometric approach based on data for 10 countries, 12 sectors (ISIC two-digit level) and 12 years (1985–1996). The results show that only at lower levels of statistical significance does international trade seem to have influenced income inequality among workers, particularly with respect to trade *vis-à-vis* Asia. By contrast, a Generalised Leontief cost function approach revealed more convincing evidence of a significant influence of international trade on employment demand. For virtually all EU countries, the import competition elasticity of low-wage countries with respect to labor demand is statistically significant and negative. However, the effect of technological change on labour demand is found to be greater than the trade impact, implying that technological innovation matters more for employment than the globalisation of trade.

Yet another informative methodology is applied in Chapter 5 where Lisandro Abrego and John Whalley assess the possible impacts of trade and technology on labour market inequality using Calibrated General Equilibrium (CGE) models. They argue that the exploration of the outcomes of alternative structural models within a CGE framework, rather than reduced form econometrics based models, may be the best way forward to sort out trade and technology effects on wage dispersion. They find that in a differentiated-goods CGE model with perfectly competitive labour markets, increased wage inequality is basically the result of technological change, with trade playing a more limited role. By contrast, incorporating labour market imperfections into the model for unskilled labour significantly changes this result, increasing the relative contribution of trade.

The next three chapters are based on case studies of selected industries carried out using various methodologies. Chapter 6 (by Paul Brenton, Anna Maria Pinna and Mark Vancauteren) is a very detailed study of the footwear industry and assesses how producers in a selection of EU countries have adjusted to increased competition from low-wage countries. In the standard HOS model, globalisation should lead to a reallocation of resources in OECD countries from low-skill-intensive (i.e. import competing) industries to skill-intensive sectors in which these countries have a comparative advantage. However, for many unskilled intensive sectors such as footwear, the ratio of exports to output has increased in line with the import penetration ratio, while in the standard HOS model countries either import or export products, not both. Hence, even in low-skill-intensive sectors product differentiation exists, which provides another means of adjustment to globalisation not possible within the standard model (i.e. the within sector adjustment to produce different and higher quality products). Second, there appears to be a range of experience across countries in the evolution of low-skill-intensive sectors. In a number of OECD countries some of these sectors have maintained employment and output whilst in other countries production has declined dramatically. If the trade shock from globalisation is common across countries then this suggests that a variety of responses to globalisation are available to firms in OECD countries. Brenton *et* *al.*'s case studies of the low-skill-intensive footwear industry provide many illustrations of these various mechanisms across a number of European countries.

Markus Diehl in Chapter 7 analyses international trade statistics and input-output tables in order to assess whether international transactions in intermediate inputs in the automobile industry, and mechanisms such as outsourcing, have become more important over time. Detailed results are presented in case studies of four major producers—the US, Japan, Germany and the UK—which show that the share of imported inputs in the gross output value of the motor vehicle industry has grown significantly over the past two decades. Moreover, some low-wage countries have become important exporters of automobile parts, but this trade is regional rather than global. However, Diehl concludes that these developments in the automobile industry and its subsectors are linked to changes in the relative wages of low-skilled workers in this sector.

In Chapter 8, Valerie Jarvis examines the degree of outsourcing and its relation to output quality in the British and German ceramic tableware industries and provides original insights into how technology and trade with low-wage countries affect both production and labour requirements at the firm-level. In contrast to the data-based analyses of the earlier case studies, this study entailed *on-site visits* to more than twenty tableware manufacturers across the two countries involving semi-structured interviews with factory owners, production managers and directors. Significant cross-country differences were found in the ways in which firms typically use technology and low-wage foreign suppliers to supplement their in-house production. Among the larger German firms, the preferred method tended to be the full production of finished products in German-owned (or part-owned) and technician-supervised factories located in low-wage countries. By contrast, the larger British firms tend to buy-in finished items from low-wage country suppliers, to be simply repackaged and marketed alongside domestic output. For many German firms, outsourcing beyond the German border involved sub-contracting the less-skilled labour-intensive elements of decoration activities to specialist lower-cost facilities of the nearby Czech Republic and Poland. In Britain, the lack of availability of a conveniently located supply of lower-cost labour for partial processing has led to an increased reliance on technological innovation, where applicable, as a means of reducing labour costs in the labour-intensive activities. Jarvis finds a somewhat smaller price advantage among low-wage country producers relative to those German and British producers in the *lower-quality grades* of production (with larger price differentials existing in the higher-quality grades), suggestive of a greater impact of competition from low-wage countries in lower quality product markets.

But the responses of tableware manufacturing firms operating in Britain and Germany to this increased competition have been notably different—and perhaps of differing long-term viability. In Britain, the producer's response has been largely one of seeking to *confront head-on* the impact of greater price competition, either through removal of many of the costly labour-intensive processes by means of increased investment in new technologies or the direct importation of low-wage country-produced output for marketing alongside domestically manufactured ranges. The response of the average German producer in this industry has been to seek to *move away* from direct price competition by seeking to produce a higher-quality product, and to accentuate the quality differences of German-made output in the eyes of the consumer. Both tendencies imply a considerable—and continuing—decline in demand for lower-skilled labour in both

Germany and Britain. In summary, this chapter tends to support the notion that the HOS theorem is too restrictive for real world complexities. In particular, it is difficult to define industries as unskilled-intensive as this example shows that even at the individual product-level production is differentiated into high- and low-skill-intensive segments. Furthermore, this level of detail helps us to understand how different firms react differently to globalisation, leading to possibly different policy responses.

What are the appropriate policy responses if globalisation is a significant cause of the deterioration in the economic fortunes of the less-skilled? This is the central question of Chapter 9 in which Paul Brenton argues that anti-globalisation measures such as trade barriers and restrictions on long-term capital flows are inappropriate responses to the problems of inequality and social exclusion. The reason is that trade and capital movements bring substantial economic benefits—hence income redistribution policies which preserve the gains from trade are better suited to addressing the problem of rising inequality. Accordingly, intervention that constrains trade will be one of the least effective mechanisms in combating inequality as such policies will reduce economic welfare. Brenton also argues that poor labour standards in developing countries are not a relevant policy issue in the debate on inequality: first, the impact of low labour standards in developing countries on workers in industrial countries is marginal; second, the effective international implementation of core labour standards will not undermine the ability of developing countries to compete on the world market; and third, it is unlikely that increased global competition will lead to the downward convergence of labour standards.

Although the overall conclusion arising from this volume is that technological progress seems to be the main factor explaining the decline in the relative demand for less-skilled workers, the majority of chapters find that trade has also played an important role in the deterioration in the economic fortunes of the less-skilled over the 1980s and mid-to-late-1990s. Furthermore, many of the studies either find that the rise in technological change has been partly driven by rapid rises in international trade and globalisation (e.g. 'defensive innovation'), or that producers have simply moved into the production of higher-quality products in order to escape direct trade competition with low-wage countries. Accordingly, the technology-based explanation for rising inequality is, on closer analysis, frequently partly a trade-based explanation, making it difficult to assess their individual contributions to the growth in labour market inequality.

Acknowledgement

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Notes

1 See, for example: Wood (1994); the Summer 1995 and Spring 1997 issues of the *Journal of Economic Perspectives;* Feenstra (1999); Dewatripont *et al*. (1999); Brenton and Pelkmans

(1999); Greenaway and Nelson (2000); *Review of International Economics,* 8 (3) (2000); Feenstra (2001); Choi and Greenaway (2001).

2 See Sachs and Schatz (1996) who look at developments across industries in the context of traditional trade theories using the HOS model incorporating the Stolper-Samuelson theorem.

3 Sachs and Schatz (1994) argue that the trend in the price of computers explains the decline in the relative price of skill-intensive products in the US. However, even when the impact of computer prices are taken out, there is no clear relationship between changing prices and skill intensity in the US.

4 'Moving the low-skill-intensive parts of production abroad' does not necessarily mean that the firm is involved in outward FDI, it can also mean that the low-skill parts of production are closed down and replaced by imports—of either intermediate or finished goods—from low-wage countries.

5 Outsourcing is documented as a feature of many industries such as: footwear (Yoffie and Gomes-Casseres, 1994); textiles (Waldinger, 1986; Gerefii, 1993); and electronics (Alic and Harris, 1991).

6 For example, the domestic production by some UK firms of simple surgical instruments is frequently supplemented by importing *finished* products from low-wage countries and reselling them on the domestic market after carrying out simple tasks such as quality control procedures and packaging. Some of the price differentials in this sector are extremely large: for example, simple scalpels sold by UK firms for £25 can be purchased from Pakistani companies for £1. Hence the price incentives to outsource can be substantial.

7 Anderton and Brenton (1999) estimate that outsourcing may account for around 40 per cent of the rise in the wage-bill share of skilled workers and approximately one-third of the increase in their employment share in the UK textiles sector. Meanwhile, Anderton *et al*. (2002) find that outsourcing to low-wage countries accounted for around 25 per cent of the average sectoral increase in the wage share of skilled workers in Sweden and for around 15 per cent of the increase in the employment share.

8 For a strong theoretical treatment of how various shocks may affect the degree of outsourcing see Kohler (2004).

9 Other relationships between trade and innovation are described in Glass and Saggi (2001). For example, they claim that outsourcing to low-wage countries can lower the marginal cost of production and thus increase profits, thereby creating greater opportunities for innovation.

2
Inequality, trade and defensive innovation in the United States

Robert Anderton and Eva Oscarsson

Introduction

The United States experienced a considerable increase in inequality during the 1980s, with the major increase in inequality occurring *within*, rather than *across*, industries.[1] Although several studies have investigated the possible causes of this decline in the relative economic fortunes of the less-skilled in the United States their conclusions differ quite considerably. For example: Feenstra and Hanson (1995 and 1996a, b) claim that increased imports explain much of the rise in US inequality; Machin and Van Reenen (1998) find that the main cause is skill-biased technological change; and Haskel and Slaughter (1997) argue that it is the *sectoral* bias of skill-biased technological change that matters.

This chapter contributes to this debate by focussing on the relationship between US labour market inequality, US imports and technological innovation, and also investigates whether trade also influences technological change via 'defensive innovation'. In contrast to most previous studies—which investigate the impact of US imports on inequality but do not distinguish between import suppliers—we examine whether the impact of imports from high-wage industrialised countries differs from that of imports from low-wage countries.

The section on Movements in US inequality of the chapter looks at aggregate movements in US inequality. The section on Trade, technology and inequality within high- and low-skill-intensive sectors, describes developments in trade and technology indicators for three industry groups—representing high- and low-tech sectors—while the section on Econometric results econometrically estimates the extent to which these factors explain the trends in US inequality. This is followed by a discussion of what drives technological innovation (proxied by R&D investment expenditure) and, in particular, empirically investigates whether import competition has any impact on innovation. Finally, the chapter summarises our results and suggests issues for further work.

Movements in US inequality

It is now widely held that the main cause of the decline in the economic fortunes of the less-skilled seems to be a shift in demand towards higher skilled workers.[2] Two main explanations are frequently offered for such a demand shift: first, that labour-saving technical progress has reduced the relative demand for less-skilled workers; second, that increased international trade with Low-Wage Countries (LWCs)—that is, nations with an abundant supply of low-skill and low-wage labour—has decreased the demand for low-skilled workers in the advanced industrialised countries. These impacts from trade may come about via Stolper-Samuelson effects or by mechanisms such as 'outsourcing'.[3] Regarding the impact of innovation, there are various routes by which skill-biased technical progress may reduce the relative wages and employment of the less-skilled. For example, technical progress which is biased towards reducing the use of unskilled labour will tend to increase the share of skilled, relative to unskilled, labour in production. Such falls in the relative demand for unskilled workers—regardless of whether the cause is trade or technology—will tend to push down their wages and employment relative to the skilled. Using non-production workers as a proxy for higher-skilled labour, and production workers to represent the less-skilled, Figure 2.1 shows the wage and employment shares for skilled workers within US manufacturing from the early 1970s to the mid-1990s.

As indicated by Figure 2.1, the increase in US inequality has not occurred at a constant rate. This was highlighted by Feenstra and Hanson (1996a,b) who pointed out that there was a particulary large increase in inequality in the United States in the *early* 1980s. Given that this period corresponds with a recession in the United States, the behaviour of the wage share is not surprising as the relative demand for non-production workers is generally countercyclical. However, two questions remain: why was the change in the wage share so abnormally large in the early 1980s; and why did it not return to its previous level after the recession?

Figure 2.1 Wage and employment shares for non-production workers in the US.

Source: US Census of Manufactures and Annual Surveys.

Notes

Wage bill of non-production workers divided by total wage bill for manufacturing sector. Employment of non-production workers divided by total employment.

The trade-based explanation of inequality may offer some explanation. For example, the hysteresis-type behaviour of the wage and employment shares of non-production workers corresponds to a period when the US dollar temporarily appreciated by around 40 per cent which, in turn, corresponds to a period of possible hysteresis in trade performance.[4] Baldwin (1988) and others argue that the high level of the dollar during the early 1980s caused a surge in US imports, and a fall in US import prices (in dollars), neither of which were reversed when the dollar depreciated back to its previous level from 1986 onwards.

Table 2.1 shows values at key points in time for the wage and employment shares of US non-production workers, total import penetration and R&D expenditure as a percentage of GDP.[5] The latter variable shown as R&D is frequently used in inequality analysis as a proxy for technological change and its behaviour over time lies behind many of the claims that technology has caused an increase in inequality in a number of countries.[6] The table clearly shows that the *major* rise in US inequality—proxied by the wage and employment share of non-production workers—occurred between 1978 and 1986 and roughly corresponds with the period of the appreciation of the dollar. Similarly, US import penetration rose at a more rapid rate during this period, but carried on rising—albeit at a much slower pace—even though the dollar depreciated by around 40 per cent from 1986 onwards (which is consistent with hysteresis-type behaviour).

However, R&D expenditure (as a percentage of GDP) also follows a similar profile. It seems that technological change accelerated extremely rapidly during the early 1980s and then slowed down somewhat from the mid-1980s onwards, but R&D expenditure then remained at a significantly higher level relative to the previous decade (which is again consistent with hysteresis-type behaviour). The increase in both R&D expenditure and import penetration ratios in the early 1980s are shown in Figure 2.2. US Imports are also broken down into imports from high-wage countries (OECD) and low-wage countries (non-OECD).

Table 2.1 US non-production workers' wage and employment shares, import penetration and R&D[a]

Year	*Non-production wage share*[b]	*Non-production employment share*[c]	*Import penetration*[d]	*R&D/Output ratio*[e]
1974	34.5	25.4	5.8	2.19
1978	35.1	26.1	8.0	2.13
1986	41.3	31.2	12.2	3.51
1993	42.5	30.9	13.9	2.94

Notes

a All figures are in percentages.

b Wage bill of non-production workers divided by total wage bill for manufacturing sector.

c Employment of non-production workers divided by total employment.

d Imports divided by US imports plus domestic production of manufactures.

e R&D expenditure in manufacturing divided by manufacturing output.

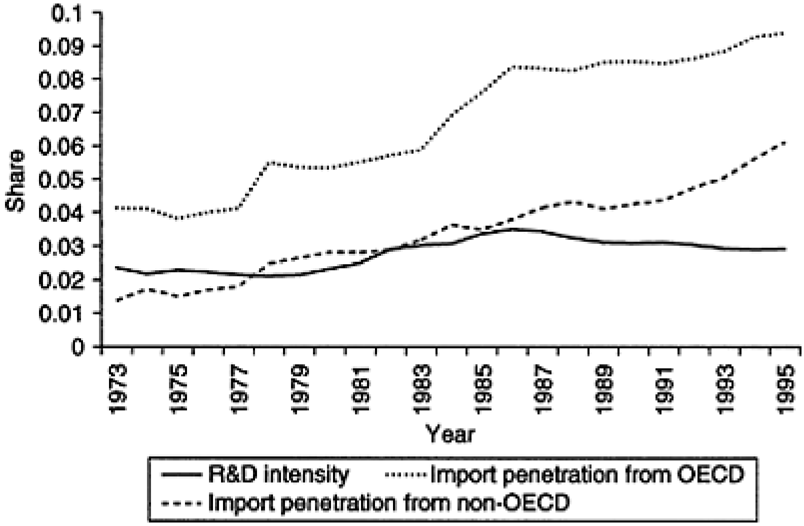

Figure 2.2 R&D and import penetration in the US.

Source: OECD ANBERD database and OECD trade database.

Notes

Imports divided by US imports plus domestic production of manufactures. R&D expenditure in manufacturing divided by manufacturing output

What can we conclude from Table 2.1, Figures 2.1 and 2.2? If our choice of explanations for the rise in US inequality is only between trade or technology then the above evidence seems to suggest that there is more support for the trade-based explanation than suggested by previous studies. This is not only because import penetration increased when inequality increased but also because the rise in the dollar, and the associated deterioration in the trade competitiveness of US industry, may explain the rapid rise in R&D expenditure via various mechanisms. For example, less-competitive firms—most likely comprising low-tech companies offering low quality products, perhaps associated with minimal R&D spending and a high proportion of low-skilled workers in their labour force—would be squeezed out of business (as the dollar appreciation made US imports much cheaper). These possible *compositional* effects imply that, after a considerable ‘shake-out’ brought about by the dollar appreciation, US industry would subsequently consist of a higher proportion of high-tech firms and the average R&D-output ratio would therefore rise (and be associated with a higher proportion of high-skilled workers if the technology is skill-biased). In addition, the deterioration in competitiveness may have encouraged US manufacturers to ‘*innovate defensively*’, that is, faced with strong competition from low-cost imports, firms may attempt to escape fierce import price competition by upgrading the quality of their manufactures via ‘product innovation’ which, in turn, is achieved by spending more on R&D.[7]

Trade, technology and inequality within high- and low-skill-intensive sectors

Traditional trade theories can help explain movements in relative wages *across* industries, whereas what needs to be explained is the dramatic fall in the economic fortunes of less-skilled workers *within* US sectors. One possible mechanism which may explain how trade with low-wage countries may have caused increased inequality within US sectors is 'outsourcing'. 'Outsourcing' is where firms take advantage of both the low-wage costs of the LWCs and modern production techniques—where the process of manufacturing a product can be broken-down into numerous discrete activities—by moving the low-skill-intensive parts of production abroad to the LWCs but continue to carry out the high-skill-intensive activities themselves. Once the low-skill activities have been performed the goods are then imported back from the LWCs and either used as intermediate inputs or sold as finished goods. Hence, trade with the LWCs via this route will shift demand away from less-skilled towards skilled workers in countries such as the United States, and put downward pressure on the relative wages and employment of low-skilled workers *within* industries. 'Outsourcing' is claimed to be an important activity in industries such as footwear (Yoffie and Gomes-Casseres, 1994, case 7) and textiles (Waldinger 1986; Gereffi 1993), etc. The above articles also illustrate that outsourcing applies to *finished* goods as well as *intermediate* inputs.

Orcutt (1950) may provide one explanation for a possible link between exchange rate movements and 'outsourcing'. Orcutt argues that the *costs of switching* from domestic to foreign suppliers may cause the price elasticity of imports to be bigger for large price changes than for small changes and a similar argument can be made for disproportionately large increases in 'outsourcing'. For example, when considering whether or not to 'outsource', US producers have to take into account the costs incurred when switching from in-house, or other domestic, supplies to foreign suppliers. For instance, when switching to foreign suppliers US producers may have to modify production techniques to be compatible with the newly imported products and spend time ensuring that the new supplier is both reliable and makes a product of the required specifications and quality. Consequently, small changes in the price of foreign goods will not be acted upon as the change in price differential will not cover switching costs. In contrast, a large appreciation of the dollar could result in a substantial differential between the costs of producing 'in-house' (or domestic) goods and imports—which may be at least sufficient to cover the costs of switching. In summary, *switching costs* may cause a *disproportionate* increase in 'outsourcing' during *large* exchange rate appreciations, which may partially explain the 'lumpiness' of changes in the economic circumstances of the less-skilled in the United States. Furthermore, such increases in 'outsourcing' may be difficult to reverse, even if the large appreciation of the dollar is fully reversed, since US manufacturers now have a greater understanding of the benefits of 'outsourcing' and are now familiar with the quality of goods not previously imported. Consequently, the substantial *temporary* appreciation of the dollar may have encouraged US purchasers to *permanently* switch from domestic to foreign goods (which may suggest a disproportionate increase in 'outsourcing' at a tune when the economic fortunes of the less-skilled in the US deteriorated very rapidly).

Our method for investigating the causes of US inequality is to econometrically estimate the impact of trade with LWCs on the wages and employment of the less-skilled by using a proxy variable for ‘outsourcing’ similar to Feenstra and Hanson (1996a, b). Feenstra and Hanson (1996a, b) proxy ‘outsourcing’ by US imports from *all* countries, which implicitly captures ‘outsourcing’ of US production to advanced industrialised countries as well as LWCs. However, there is no obvious reason why firms would ‘outsource’ *low-skill-intensive* activities—which is the mechanism by which ‘outsourcing’ affects the demand for the less-skilled—to advanced industrialised countries which are relatively abundant in skilled labour. Consequently, a major objective of this chapter is to investigate whether the *source* of imports matters by disaggregating US imports according to individual supplier countries and constructing US import share terms for both high and low-wage countries. Therefore, by explicitly identifying imports solely from *low-wage countries* and using this as a variable to explain changes in the wage share of the less-skilled in the US, we are more likely to accurately capture ‘outsourcing’ to low-wage countries.

In previous work on the United Kingdom, Anderton and Brenton (1999b) find that the impact of trade with LWCs differs considerably between high and low-skill-intensive sectors. Hence in the following analysis we distinguish between groups of industries which we classify as intrinsically high- or low-skill. In Table 2.2 we look at two groups of industries which can be classed as low-skill-intensive (abbreviated as LSA and LSB) and one group of high-skill-intensive sectors (HS). The first part of Table 2.2 shows that the latest rise in US inequality occurred in all three sectors during the period of substantial dollar appreciation, but that inequality continued to increase, albeit more gradually, through the rest of the 1980s and early 1990s.[8]

The last three columns of Table 2.2 show that R&D expenditure expressed as a proportion of output is extremely small in the low-skill sectors (less than 1 per cent in LSA and LSB). Given that the R&D ratios in the low-skill sectors are very small (seemingly confirming that these are indeed low-technology-intensive industries), it becomes doubtful as to whether it is feasible that movements in R&D expenditure/technology can explain the change in the wage share of non-production workers in these sectors. On the other hand, the technology explanation corresponds to movements in R&D expenditure in the high-skill sectors, particularly the large rise in R&D during the period of the dollar appreciation in the early 1980s. In addition, unlike the low-skill sectors, it seems feasible that the large absolute size of R&D expenditure in the high-skill sectors, combined with the significant changes in R&D over time, could have a strong impact on labour-skill requirements in these sectors.

Table 2.2 also shows US imports from LWCs as a proportion of total sectoral imports. Although the relationship between the import share of LWCs in the low-skill sectors and the wage and employment shares of non-production workers is unclear in the early 1970s, there is a large increase in US imports from LWCs during the period when inequality rose more rapidly and the dollar appreciated. Conversely, imports from LWCs for the high-skill sector group remained nearly static between 1978 and 1986—perhaps indicating that defensive innovation succeeded in reducing import competition from LWCs in this sector (the relatively high import share of LWCs in this high-skill sector also suggests that the degree of low-wage country competition may be sufficient to be a plausible cause of defensive innovation).

Table 2.2 US wage bill share and employment share of non-production workers, import share of low-wage countries (LWCs) and R&D in low- and high-skill-intensive sectors a

Year	*Wage bill share*			*Employment share*		
	LSA[b]	*LSB*[b]	*HS*[b]	*LSA*[b]	*LSB*[b]	*HS*[b]
1974	24.8	25.8	41.2	14.6	20.3	30.9
1978	25.1	26.3	42.2	14.9	20.3	32.3
1986	27.3	30.3	49.6	17.1	23.4	38.4
1993	28.6	31.7	51.1	17.5	23.7	37.6
	Import share of LWCs[c]			*R&D/output ratio*		
	LSA[b]	*LSB*[b]	*HS*[b]	*LSA*[b]	*LSB*[b]	*HS*[b]
1974	37.7	26.1	34.9	0.45	0.48	4.24
1978	46.1	26.0	36.6	0.46	0.49	3.85
1986	58.0	30.2	35.8	0.57	0.86	5.79
1993	61.2	33.7	42.8	0.80	0.62	5.42

Notes

a All figures are in percentages.

b LSA=low-skill sector group 'A' comprising ISIC sectors 3200, 3300 and 3400 (i.e. Textiles, Apparel and Leather; Wood Products and Furniture; Paper, Paper Products and Printing). LSB=low-skill sector group 'B' comprising ISIC sectors 3600,3700 and 3810 (i.e., Non-Metallic Mineral Products; Basic Metal Industries; Metal Products); HS=High-skill sectors comprising ISIC sectors 3500, 3820, 3830, 3850 (Chemical Products; Non-electrical Machinery; Electrical Machinery; Professional Goods).

c Sectoral imports from low-wage countries (LWCs) expressed as a percentage of total sectoral imports.

Econometric results for the 'inequality' equations (i.e. wage and employment share equations)

In this section, we econometrically estimate the impact of both trade with LWCs and R&D spending on the wage and employment shares of non-production workers in the United States. We use highly disaggregated US wage and production data—converted from US SIC to ISIC REV2—and define non-production workers as skilled and production workers as less-skilled (source: US Census of Manufactures and Annual Surveys). Technological change is proxied by R&D expenditure as a proportion of GDP (source: OECD ANBERD database). The capital stock data are from the OECD's International Sectoral Database (ISDB). The bilateral US imports data were supplied by the OECD on an SITC basis and converted to the ISIC REV2 classification. Trade, production and wage bill and employment share data are all disaggregated to the 4-digit ISIC level (hence all variables are on an ISIC basis—further details of the 4-digit sectors used in the analysis are given in the data appendix). In order to provide enough observations for separate 'panel estimation' of our three sectoral groupings, we pool the data across the 4-digit ISIC sectors within the LSA, LSB and HS broad groupings using annual data for the sample period 1973–1993 (imposing, in effect, the same parameters across the different 4-digit sectors).

Following Feenstra and Hanson (1995 and 1996a,b), we seek to assess whether industry import shares have contributed significantly to the determination of the within-sector wage bill and employment shares of low-skilled workers in the United States. Following the approach of Berman *et al*. (1993, 1994), and assuming capital to be a fixed factor of production, we start from a variable cost function in translog form:

$$\begin{aligned}\ln C_i = {} & \alpha_0 + \alpha_y \ln Y_i + \frac{1}{2}\alpha_{YY} \ln (Y_i)^2 + \beta_K \ln K_i + \frac{1}{2}\beta_{KK} \ln (K_i)^2 \\ & + \sum_j \gamma_j \ln W_{ij} + \frac{1}{2}\sum_j \sum_k \gamma_{jk} \ln W_{ij} \ln W_{ik} + \sum_j \delta_{Yj} \ln Y_i \ln W_{ij} \\ & + \sum_j \delta_{Kj} \ln K_i \ln W_{ij} + \rho \ln Y_i \ln K_i + \lambda_T T_i + \frac{1}{2}\lambda_{TT}(T_i)^2 \\ & + \lambda_{YT} T_i \ln Y_i + \lambda_{KT} T_i \ln K_i \\ & + \sum_j \phi_{Tw_j} T_i \ln W_{ij}\end{aligned} \qquad (2.1)$$

where C_i is variable costs in industry *i;* Y_i is output in industry *i;* K_i is the capital stock in industry *i;* W_{ij} is the price of variable factor *j* and T_i represents technology in industry *i*.

Cost minimisation generates the following linear equations for the factor shares *(S):*

$$S_{ij} = \gamma_j + \delta_{Yj} \ln Y_i + \delta_{Kj} \ln K_i + \sum_k \gamma_{jk} \ln W_{ik} + \phi_{Tw_j} T_i \qquad (2.2)$$

whilst differencing (denoted by d) generates

$$\mathrm{d}S_{ij} = \phi_{Tw_j} \mathrm{d}T_i + \delta_{Yj} \mathrm{d} \ln Y_i + \delta_{Kj} \mathrm{d} \ln K_i + \sum_k \gamma_{jk} \mathrm{d} \ln W_{ik} \qquad (2.3)$$

assuming homogeneity of degree one in prices imposes

$$\sum_k \gamma_{jk} = \sum_j \gamma_{jk} = \sum_j \delta_{Kj} = \sum_j \delta_{Yj} = 0 \qquad (2.4)$$

which generates with two variable factors, *j* and *k*

$$\mathrm{d}S_{ij} = \phi_{Tw_j} \mathrm{d}T_i + \delta_{Kj} \mathrm{d} \ln K_i + \delta_{Yj} \mathrm{d} \ln Y_i + \gamma \mathrm{d} \ln \left(\frac{W_j}{W_k}\right) \qquad (2.5)$$

In our empirical application of the earlier model we have two variable factors of production, low-skilled (production) workers and higher-skilled (non-production) workers, and adopt a similar approach to Machin *et al*. (1996) and estimate the following US wage bill and employment share equations:

$$\mathrm{dSW}_{it} = \alpha \mathrm{d} \ln K_{it} + \beta \mathrm{d} \ln Y_{it} + \rho \mathrm{TECH}_{it} + \lambda \mathrm{d} \ln \mathrm{MS}_{it} + \gamma D_t + U_{it} \qquad (2.6)$$

$$dSE_{it}=\alpha \ d \ln K_{it}+\beta \ d \ln Y_{it}+\rho TECH_{it}+\lambda \ d \ln MS_{it} + l \ d \ln (W^{hs}/W^{ls})_{it}+\gamma D_t+U_{it} \qquad (2.7)$$

where: SW_{it} is the share of the wage bill of the high skilled $(WB^{hs}_{it}/(WB^{hs}_{it} + WB^{ls}_{it}))$, SE_{it} is the employment share of the high skilled (similarly derived as SW_{it}).

WB^{hs}_{it} is the wage bill of the higher skilled (i.e. non-production workers); WB^{ls}_{it} is the wage bill of the lower skilled (i.e. production workers); W^{hs}/W^{ls} is the relative wage rate of high and low-skilled workers; K_{it} is the capital stock; Y_{it} is real output; $TECH_{it}$ is a proxy variable for technological change (proxied by R&D); MS_{it} is the share of the value of domestic demand for the output of industry *i* accounted for by imports; D_t is a set of time dummies included to capture any company preferences for non-manual or manual workers common across industries for a given year; U_{it} is an error term; Subscript *i* represents industry *i*. First differences are denoted by d.

The time dummies capture any changes in firm-level preferences for nonproduction or production workers common across industries in each year. The MS term represents US imports and can be interpreted as a proxy for outsourcing. In this chapter, we follow the approach of Feenstra and Hanson (1995, 1996a, b) and justify the inclusion of the MS term in the wage bill share equation by arguing that merely including the factors derived from a traditional translog production function will not capture other factors—such as outsourcing—which may influence a firm's demand for skilled labour. Given that outsourcing to low-wage countries is claimed to push the range of activities performed by domestic industry away from low-skill towards high-skill tasks, the MS term can be interpreted as representing a reduced-form relationship between outsourcing and a firm's unit input requirement for skilled labour. As we want to distinguish between the impacts of high- and low-wage country import suppliers, we experiment with two different versions of MS:

1 MSO=US imports from high-wage countries (which we define as OECD countries).[9]
2 MSNO=US imports from LWCs (which we define as Non-OECD countries).

Our final wage-bill share specifications based upon (2.6) above are shown in Table 2.3 below. Note that we do not include the relative wage rates for the two types of labour in our final estimated wage bill share equations mainly because relative wages are unlikely to be exogenous. However, the equation includes a set of macro time dummies, which will capture any firm-level changes in preferences for higher-skilled workers due to absent variables such as relative wages. We estimate two equations for each industry group—the first equation uses US imports from high-wage countries (i.e. OECD countries: 'MSO') and the second uses imports from low-wage countries (i.e. non-OECD countries: 'MSNO'). The results show that the change in output is negatively signed and statistically significant (with the exception of industry group LSA) which conforms with our prior that a short-run decline in output tends to reduce the demand for the less-skilled relative to the skilled. The capital stock term is not statistically significant in any of the equations, which may not be surprising for the low-skill-intensive sectors as they are extremely low-capital-intensive industries. Although the capital stock term has the correct positive sign for the high-skill sector grouping—as we expect complementarities between capital and skill—it is not statistically significant (perhaps because it is dominated by the R&D term). One striking result is that R&D is not statistically significant for the low-skill sectors, but is strongly significant for the high-skill sectors.

The statistical significance of the MSNO terms in the LSA and LSB sectors suggests that increased trade with LWCs tends to increase the wage share of

Table 2.3 US wage bill share equations (dSW_{it})

Equation	*LSA*	*LSA*	*LSB*	*LSB*	*HS*	*HS*
C	0.016	0.0149	0.003	0.0032	0.0006	0.0007
	(2.500)	(2.427)	(0.720)	(0.669)	(0.217)	(0.252)
$d\ lnY_{it}$	−0.013	−0.014	−0.042	−0.043	−0.026	−0.025
	(−0.970)	(−1.001)	(−3.205)	(−3.362)	(−2.580)	(−2.516)
$d\ ln\ K_{it}$	−0.045	−0.041	0.005	−0.007	0.059	0.058
	(−0.977)	(−0.869)	(0.074)	(−0.103)	(1.423)	(1.392)
$(R\&D/Y)_{it-1}$	0.118	0.129	0.008	−0.014	0.043	0.042
	(0.131)	(0.142)	(0.030)	(−0.056)	(3.118)	(3.084)
$d\ ln\ MSO_{it}$	0.004		0.0009		−0.003	
	(1.831)		(0.222)		(−0.924)	
$d\ ln\ MSNO_{it}$		0.003		0.0058		−0.0006
		(2.116)		(2.226)		(−0.480)
N	340	340	200	200	440	440
R^2	0.254	0.248	0.551	0.559	0.358	0.356
SEE	0.011030	0.011075	0.008620	0.008543	0.011043	0.011056

Notes
MSO=US imports from OECD countries for sector groups are expressed as a proportion of total US demand for goods produced in that sector; MSNO=US imports from non-OECD countries for sector groups are expressed as a proportion of total US demand for goods produced in that sector. OLS estimation for annual data sample period of 1974–1993 (full set of time dummies included) using White's heteroskedasticity consistent SEs; '*t*' statistics are in parentheses.

Table 2.4 US employment share equations (dSE_{it})

Equation	*LSA*	*LSA*	*LSB*	*LSB*	*HS*	*HS*
C	0.010	0.0097	0.0044	0.0042	0.0004	0.0004
	(2.809)	(2.714)	(1.152)	(1.106)	(0.149)	(0.155)
$d\ lnY_{it}$	−0.007	−0.008	−0.035	−0.037	−0.023	−0.023
	(−0.727)	(−0.748)	(−3.132)	(−3.298)	(−2.705)	(−2.725)
$d\ ln\ K_{it}$	−0.036	−0.033	−0.0004	−0.011	0.051	0.051
	(−1.113)	(−1.005)	(−0.009)	(−0.230)	(1.466)	(1.469)
$(R\&D/Y)_{it-1}$	0.212	0.217	−0.004	−0.025	0.041	0.041
	(0.334)	(0.340)	(−0.021)	(−0.134)	(3.305)	(3.304)
$d\ ln\ MSO_{it}$	0.0024		0.0014		0.0001	
	(1.897)		(0.461)		(0.055)	
$d\ ln\ MSNO_{it}$		0.002		0.005		0.00005
		(2.159)		(2.350)		(−0.046)
$d\ ln\ (W^{hs}/W^{ls})$	−0.107	−0.106	−0.100	−0.099	−0.115	−0.115
	(−8.264)	(−8.080)	(−5.807)	(−6.060)	(−6.528)	(−6.543)

N	340	340	200	200	440	440
R^2	0.529	0.526	0.699	0.706	0.527	0.527
SEE	0.007400	0.007426	0.006554	0.006472	0.009252	0.009252

Notes
MSO=US imports from OECD countries for sector groups are expressed as a proportion of total US demand for goods produced in that sector; MSNO=US imports from non-OECD countries for sector groups are expressed as a proportion of total US demand for goods produced in that sector. OLS estimation for annual data sample period of 1974–1993 (full set of time dummies included) using White's heteroskedasticity consistent SEs;'*t*' statistics are in parentheses.

non-production workers in the low-skill sectors, but that technological change rather than trade partly explains the rise in US inequality in the high-skill sectors. For the LSA sector grouping, there is also some limited—but less-convincing—evidence that any increase in inequality from increased trade may also be partly due to increased imports from the higher-wage OECD countries, whereas only imports from LWCs increase inequality in the LSB sectors.[10]

Table 2.4 shows the results arising from the estimation of the employment share equation (i.e. equation (2.7)). The results support the conclusions drawn in the wage share analysis that imports from low-wage countries seem to explain part of the rise in US inequality in low-skill-intensive sectors, while technological change (proxied by R&D expenditure) explains the rise in inequality in high-skill-intensive sectors. The relative wage term is strongly significant and, as expected, negatively signed. Finally, the explanatory power of the variables in the employment equations is generally better than the wage equations, and the increase in the R^2 is especially large for the LSA sectors.

It is important to note that the above results may underestimate the impact of trade with low-wage countries on US inequality as we do not include the import *price* in our specifications (due to the lack of reliable trade price data for the United States at this level of disaggregation). Relative import price terms may capture other effects in addition to those captured by the import penetration terms such as the *threat* of increased competition from LWCs (e.g. the fall in the import price of LWC products as the dollar appreciated may have made it easier for firms to obtain agreement from their workforce to restrain the wages, or terminate the employment, of less-skilled workers, etc.).[11]

As mentioned before, previous studies such as Machin *et al.* (1996) do not find a significant impact of trade on the relative wages and employment of the less-skilled in the United States. However, unlike our analysis, they do not use trade data which separately identifies imports from low-wage countries—which is important as mechanisms such as 'outsourcing' only influence inequality via trade with low-wage countries—and their empirical work is at a more aggregate level. Although Feenstra and Hanson (1995) do find that imports have increased US inequality, they too do not distinguish between import suppliers. In contrast, we have shown that when assessing the impact of trade on inequality the source of imports matters, which is consistent with economic theory. For the United States, it seems that using aggregate imports to capture mechanisms such as outsourcing may be misleading and that disaggregation of imports in order to identify low-wage countries is necessary, particularly as the impact of trade on inequality may vary across sectors of different skill intensities.

What drives technological innovation?

Given that R&D seems to explain a large part of the rise in inequality in the high-skill sectors, we now turn our attention to investigating the factors behind the rapid rise in technological innovation, particularly as to whether trade influences technological change. Adrian Wood (1994, 1995) launched the term 'defensive innovation' meaning that some innovation may be driven by the need to stay competitive against increased low-wage competition. He argues that some firms in advanced industrialised countries may have to look for new methods of production that are unskilled labour-saving (i.e. 'process innovation' driven by import competition). As we have argued earlier, 'defensive innovation' may also mean that firms upgrade the quality of their products in order to stay competitive (i.e. 'product innovation' driven by import competition). Another relationship between trade and innovation is hypothesised by Glass and Saggi (2001). These authors argue that an increase in outsourcing to a low wage country lowers the marginal cost of production and thus increases profits, thereby creating greater incentives and/or opportunities for innovation.

Considerable empirical research has been carried out regarding the R&D investment decision of the firm (see Cohen 1989). In the standard Schumpeterian framework, firm size and market concentration are the two major explanatory variables explaining R&D at the firm level. Firm size is thought to be important as bigger firms have scale economies in the R&D function, greater access to risky financing on the capital market as well as a larger volume of sales over which they can spread the fixed costs of innovation, etc. Meanwhile, monopoly power (or market concentration) enables firms to reap profits from R&D investments and also provides a more stable environment for the firm's investment decision.

Using data at the industry level, with the objective of investigating whether trade influences technological change, we estimate a simple R&D function for the US loosely based on the specification used by Hirsch (1992) which includes a mixture of industry and firm-level variables. As optimal investment is a function of output (and thus product prices) and relative factor prices, Hirsch includes firm level data on both the physical capital stock and the R&D stock as well as firm-level profitability to take into account firm-specific differences. At the industry level, Hirsch includes the annualised growth rate in industry output, labour costs per employee, the concentration ratio and the share of imports in domestic sales.[12]

Our industry-data approximation of Hirsch's R&D function is as follows:

$$\begin{aligned} d\ln\left(\frac{I_{it}}{\mathrm{PROD}_{it}}\right) = {} & \alpha_i + \beta_C d\ln\left(\frac{\mathrm{CAP}_{it-1}}{\mathrm{RPRDV}_{it-1}}\right) \\ & + \beta_W d\ln \mathrm{RWAGE}_{it-1} + \beta_{RP} d\ln \mathrm{RPRDV}_{it-2} \\ & + \beta_R d\ln \mathrm{RR}_{it-1} + \beta_M d\ln \mathrm{MS}_{it-1} \\ & + \sum \delta_m \mathrm{YEAR}_{mt} + e_{it} \end{aligned} \qquad (2.8)$$

where: $I_{it}/\mathrm{PROD}_{it-1}$ is R&D expenditure expressed as a proportion of production; α_i is an industry specific intercept (fixed effects); $\mathrm{CAP}_{it-1}/\mathrm{RPRDV}_{it-1}$ is the real capital stock relative to real production; RWAGE $_{it-1}$ is the real average wage; RPRDV_{it-2} is real production; RR_{it-1} is profitability measured as price over unit labour cost; MS_{it-1} is the share of the value of domestic demand for the output of industry *i* accounted for by imports from low- and high-wage countries respectively; $YEAR_{mt}$ is a set of time dummies; subscript *i* represents industry *i*; first differences are denoted by d.

The real average wage is simply total real wages divided by total employment per industry, while the profitability variable is calculated as the producer price divided by labour compensation[13]. Although the data used in the estimation of equation (2.8) are the same as in the share analysis earlier, the industries are more aggregated in this section according to the more limited sectoral breakdown of the R&D data.[14] Table 2.5 shows the results using this specification for the high-skill sectors.[15] Again, we report two sets of results in first difference form: one using import penetration from the high-wage countries and the other using import penetration from low-wage countries.

The first variable—the capital/output ratio—is expected to have a positive sign due to the assumed complementarities between capital and R&D investment. However, we found this variable to be both statistically insignificant and incorrectly signed. Meanwhile, an increasing real average wage could affect investment in R&D both negatively or positively.[16] Although, the results show that the real average wage has no significant impact on R&D investments, the negative sign is indicative of factor substitution between R&D and labour.

A growing market, or increases in real production, is positively and significantly correlated with an increasing R&D intensity, which is what we expect.

Table 2.5 US R&D investment equations (d $\ln(I_{it}/PROD_{it})$) for US high-skill sectors

Equation	*HS*	*HS*
d $\ln(CAP_{it-1}/$	−0.324	−0.231
$RPRDV_{it-1})$	(−1.348)	(−0.969)
d $\ln RWAGE_{it-1}$	−0.242	−0.249
	(−1.137)	(−1.123)
d $\ln RPRDV_{it-2}$	0.595	0.572
	(3.567)	(3.517)
d $\ln RR_{it-1}$	0.147	0.088
	(0.686)	(0.404)
d $\ln MSO_{it-1}$	0.107	
	(2.092)	
d $\ln MSNO_{it-1}$		−0.004
		(−0.101)
N	180	180
R^2	0.347	0.332
SEE	0.109926	0.111133

Notes

MSO=US imports from OECD countries (as defined in previous tables); MSNO=US imports from non-OECD countries (as defined in previous tables). OLS estimation for annual data sample period of 1973–1994 using White's heteroskedasticity consistent SEs (fixed effects and full set of time dummies included); '*t*' statistics are in parentheses.

Meanwhile, the effect of an increase in profitability on R&D investments can be positive or negative. On the one hand, high profits create less pressure for investing in technology in order to transform products (or the production process) in comparison to low profits. On the other hand, high profits make it easier for firms to finance investments in R&D. We find that increases in profitability, measured as price over unit labour cost, are not statistically significant but tend to have a positive sign.

Finally, the key result shown in Table 2.5 is that growing import penetration from high-wage countries has a significant positive effect on R&D investments in the US high-skill sectors, while imports from low-wage countries have no impact. Our previous analysis of the US wage and employment shares within the high-skill sectors showed that trade had no impact on skill upgrading, while technological change was important. It therefore seems that trade also has an indirect effect on skill-upgrading in the high-skill sectors when we take into account its impact on R&D investments.

In summary, we find some evidence that 'defensive innovation' seems to occur in the high-skill sectors. Although it is not driven by import competition from low-wage countries but from high-wage countries, such defensive innovation will also reduce competition from low-wage as well as high-wage countries, thereby partly explaining why imports from low-wage countries seem to have had no impact on US inequality in high-skill sectors. Again, in comparison to other studies, this result therefore places relatively more weight on the trade-based explanation for skill-upgrading than the technology-based explanation. However, more work is needed on this topic before any strong conclusions can be drawn.[17]

Conclusions

An increase in US imports from low-wage countries, helped by the large appreciation of the dollar in the early 1980s, seems to explain some of the rise in US inequality in *low-skill-intensive* sectors. Rapid technological change does not seem to be an important determinant of labour market inequality in these sectors—which is not surprising given the low technological nature of these industries. By contrast, technological change—proxied by R&D expenditure—seems to be strongly positively correlated with the rise in US inequality in our sample of *high-skill-intensive* sectors. We also tried to establish why skill-biased technological change was so rapid during the early 1980s in the US. Given that the technological change seemed to be strongly positively correlated with rising imports—associated with the deterioration in US trade competitiveness due to the appreciation of the dollar over this period—we investigated whether the two were connected by estimating some R&D expenditure equations. We found that growing import penetration from high-wage countries had a significant positive effect on R&D investments in the high-skill sectors over our sample period, while imports from low-wage countries had no impact. Meanwhile, our analysis of the wage and employment shares within US manufacturing sectors showed that trade had no impact on skill upgrading in the high-skill sectors, while technological change was important. Accordingly, it seems that trade may also have had an indirect effect on skill-upgrading in the high-skill sectors when we take into account its effects on R&D investments via 'defensive innovation'. Although it is not driven by import competition from low-wage