Wage Structures and Employment Outcomes in New Zealand, and Their Relationship to Technological Change

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Abstract

After 100 years at an historically low level, inequality began to rise in the late 20th century, a trend which was especially marked in the English-speaking countries including New Zealand. Various explanations have been advanced, but internationally the most favoured theory is skill-biased technological change, driven by the new information and communication technologies. This thesis used income and wage data from the New Zealand Population Census and the New Zealand Income Survey to examine wage trends between 1991 and 2004. As in other developed countries wage dispersion was increasing in the 1990s, though it appears to have slowed since 2001, and the increased inequality is strongly correlated with workers' skills and qualifications. There is also a correlation between new technology and earnings inequality, but this appears to be attributable to the demand for skills in the industries which are changing fastest, rather than anything intrinsic to the new technology.

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Chapter 1

Introduction

1.A Inequality and Productivity

1.A.1 The inequality problem

Inequality is important. During the mid 20th century inequality was low and stable, and was largely ignored by the economics profession, except in relation to third world countries. However, since the 1970s many of the more developed countries have experienced rising inequality, and in recent years it has received greatly increased attention (Atkinson and Bourguignon, 2000). The English speaking countries, especially the United States and the United Kingdom, have recently experienced a very marked rise in inequality (Galbraith, 2000; Machin, 2001; Borland, Gregory and Sheehan, 2001), and New Zealand has had a similar experience (Chatterjee, Podder and Mukhopadhaya, 2003).

It has long been known that inequality is socially undesirable. All goods show diminishing returns, and unequal distributions of wealth or income do less good for the rich than the harm they do to the poor (Sen and Foster, 1997). But recent research has brought an additional urgency to our understanding of inequality. For many years it was assumed that inequality would boost savings and growth, and inequality was therefore a trade-off between equity in the present and efficiency for the future (Okun, 1975). However the increasing availability of data over the last 30 years has called this assumption seriously into question (Osberg, 1995), and it is now widely recognized that inequality has negative effects on growth which generally outweigh any benefits that might accrue (Easterly, 2002). Inequality is therefore a major public policy issue, and it is important that we try to understand the reasons behind the recent increases and to consider what policy responses might be cost-effective.

1.A.2 Possible explanations for rising inequality

The late 20th century was a period of various and far-reaching changes. Prior to the 1970s nation states were very strong and many aspects of international commerce were relatively tightly controlled. But the last three decades have seen trade barriers reduced and capital flows increasing (Weinstein, 2005), increasing migration of workers to better locations and the migration of enterprises to cheaper locations (Feenstra, 1998; Streeten, 2001; Taylor and Driffield, 2005). The demographics of the labour force have also changed dramatically, with married women taking a greatly increased role in paid work, both in numbers and in levels of responsibility (Cancian, Danziger and Gottschalk, 1993). And especially in the English-speaking countries there has been reduced government involvement in the economy generally, in accordance with the policies of the "Washington Consensus" (Aghion and Howitt, 2005), policies which were followed with exceptional single-mindedness in New Zealand (Evans, Grimes, Wilkinson and Teece, 1996).

Over much the same period there has also been a computer revolution. The cost of computing has plummeted, to the point where computer power which used to be seen as the preserve of large institutions is now affordable to the average household (Gittleman and Handel, 2003). Moreover connectivity has improved vastly, and cheap computers anywhere can now exchange information with other computers around the globe. These developments in information and communications technologies have opened up previously unimagined ways of structuring production, and the workplace of the future is rapidly evolving far beyond the simple replacement of some workers with machines (Bresnahan, Brynjolfsson and Hitt, 2002).

Explaining the recent rise in inequality is therefore seriously overdetermined. Any of several explanations is plausible: The demographic changes, the adoption of neoliberal policies, globalization of production and the new technologies (Katz, 2000; Machin, 2003). In all probability more than one of these changes may have contributed to some extent, and there may well be some interaction effects between combinations of these changes. The challenge is therefore to tease out which of these possible causes is most likely to be a principal driver. And further, to the extent that any one of these explanations appears to be the prime suspect, it is important to consider what policy responses would be most likely to have worthwhile benefits.

1.A.3 Productive systems and technological change

Productive systems are constantly evolving, and every development in the way production is organised is likely to change the patterns of labour force demand. When we think of technology we initially think of machines, but within economics technology is used to mean more than just equipment. The technological system in use at any one moment is the combination of all factors of production (Krugman, 1994), including both the fixed items such as land and facilities, and the workers who are employed in their use.

Many technological changes proceed incrementally, and we are very familiar with constant improvements in the goods and services available to us. But from time to time radical new inventions emerge, like steam power or electricity, which have applications in countless situations (Bresnahan and Trajtenberg, 1995). Lipsey, Carlaw and Bekar (2005) list just 24 of these radical general purpose technologies (GPTs) since the dawn of human society. It is always dangerous to assume that a current development is special, but nonetheless there are good reasons for believing that the new Information and Communication Technology (ICT) does indeed represent one of these radical inventions (David, 2000).

When a new technology becomes available different skill sets are likely to be required. Most technological changes are incremental, and the changing demands they impose on the workforce can usually be accommodated through retraining and other progressive adjustments. However the emergence of a new General Purpose Technology may well initiate far reaching changes with the potential for serious disruption of the workforce (Aghion, Howitt and Violante, 2002). If a major change renders some skills obsolete, the effects across the workforce will not be uniform. Some workers will be well placed to benefit while others may be seriously disadvantaged. The only certainty is that the pattern of workers' earnings will inevitably be altered (Murphy, Riddell and Romer, 1998).

1.B The hypothesis of this study

It is the hypothesis of this study that the new information and communications technology (ICT) is a general purpose technology, that recent technological change has been skill-biased, and that the widespread adoption of new technology has therefore been a major contributor to the recent rise in inequality in the developed countries. That it is to say it is a radical technology which affects production techniques in a wide range of industries; and further, it is a development which rewards the more-skilled workers out of proportion to the less-skilled.

There is no theoretical reason for assuming that new technology will necessarily either raise or lower the demand for skills. Some new technologies have displaced skilled workers, whereas some have complemented the skilled workers while taking over routine tasks. The outcome of any particular development can therefore only be determined empirically, but earnings inequality is likely to rise or fall depending on the nature of the most recent changes. As Alan B Krueger explains:

> "The new computer technology may be a complement or a substitute for skilled workers. In the former case the computer revolution is likely to lead to an expansion in earnings differentials based on skill, and in the latter case it is likely to lead to compression in skill-based differentials." (Krueger, 1993: 35).

In order to test this hypothesis I examine the trends in incomes and wages in New Zealand since 1991. Different industries vary widely in the extent to which they have adopted new technology, and data exist which indicate earnings patterns by industry. It is therefore possible to study wage dispersion by rate of ICT-adoption, and to see whether new technology is connected in any way to earnings inequality. There is also data on occupations and the qualifications and other skills of workers in different industries and at different earnings levels. Thus wage dispersion can also be analysed according to the characteristics of the workers.

The data also allow an analysis of trends in employment patterns. If new technology changes worker demand patterns, this should be reflected in the numbers of workers of different types who are employed in the various industries. If for example the total numbers of workers in one industry have changed little, but the numbers of workers with few qualifications have dropped substantially, it can be seen as a skills bias in that industry’s employment pattern.

The key question is which categories of workers are doing better and which are doing worse as a result of the recent developments, and whether changing inequality is industry-specific or more a function of worker characteristics. To the extent that inequality is rising within groups of workers with similar characteristics, it lends support to deindustrialization in a more open trading climate as the prime mover. If, however, the greatest rises have been experienced between groups of workers, and especially if a rising skills premium is found across a wide variety of industries, then the technological hypothesis of this study looks the most plausible.

If the skills-bias hypothesis is supported by the findings on inequality patterns, it would be interesting to know exactly what skills are in increased demand. For example, is there a wage premium for computer-specific knowledge, or is general education commanding a greater return. Ever since Nelson and Phelps (1966) it has been appreciated that general education raises the adaptability of workers, and therefore has an added value during times of change. Thus, even if a skills premium is found, it could be that better skilled workers are more in demand because they can cope better with the changes, rather than any direct complementarity between their skills and the new technology.

Finally, it is to be hoped that the findings of this study might inform public policy. In particular, it has been noted that inequality within groups of workers with similar characteristics tends to be transitory, whereas higher inequality between groups of workers is more likely to be permanent. If most of the rise in inequality is within-group it follows that the best public policies will probably be those which ease workers through the adjustment process. By contrast, rising between-group inequality would suggest the need for a greater commitment to a general upskilling, especially for young people early in their working lives.

1.C Arrangement of the thesis

Chapters 2 to 4 review the New Zealand and international literature on technology and inequality. Chapter 2 addresses the importance of technological change as the engine of growth, and the need for an appropriately skilled workforce if new technology is to be adopted at the optimal rate and at the lowest social cost. Chapter 3 examines the inequality problem, and the reasons why inequality is to some extent unavoidable but at the same time both socially undesirable and an impediment to growth.

Chapter 4 reviews the international literature on the theories which have been advanced as possible explanations for the return to rising inequality which was a feature of the more developed economies in the late 20^{th} century. In particular, the interactions of technology and inequality are discussed, and the possible pathways by which recent technological changes may be exacerbating the inequality problem, and the extent to which new technology is a more plausible explanation than others which have been put forward. But this chapter also considers the effects of inequality on the speed at which a society can adapt to a new technology.

Chapter 5 outlines the data sources and methods used in this thesis; the following four chapters present the empirical findings. Chapter 6 examines the trends in income inequality, using data from the Population Censuses of 1991, 1996 and 2001. Wage equations are estimated for each industry in each Census year, and the ratio of the wage premium for a bachelor's degree to the wage premium for only holding School Certificate is taken as indicating the return to skills in each industry. Trends in this ratio are followed over each Census period to investigate any tendency for different industries to show different patterns of income inequality, with those trends compared to the uptake of new technology in each industry.

Chapter 7 considers the changing patterns of employment, again using Census data from the years 1991 to 2001. The proportions of workers at each qualification level in each industry are compared, as an indication of the extent to which employment opportunities are improving or declining for workers of different skills in industries with greater or lesser technology uptake.

Chapters 8 and 9 use the more wage-specific data from the New Zealand Income Surveys of 2002 and 2004. This more recent source of data allows a check on trends since the 2001 Populations Census. In Chapter 8, quantile regression on wage data is used to estimate trends at the 10^{th} percentile and the 90^{th} percentile simultaneously, indicating the extent to which wage inequality is related to new technology. Controlling for qualifications and other skills it is possible to estimate how much the wage dispersion reflects differences which are intrinsic to the industries, and how much it reflects higher rewards for the workers' skills and characteristics which are valued in those industries which are making more use of new technology.

Chapter 9 uses the technique pioneered by DiNardo, Fortin and Lemieux (1996) for reweighting one set of observations to the characteristics of another, as a method of isolating which variables explain the differences between two sets of workers. The workers in the New Zealand Income Surveys for 2002 and 2004 are divided into two approximately equal groups, according to whether they work in industries with high or low uptake of new technologies. As a confirmation of the quantile regressions in Chapter 8, the DiNardo, Fortin and Lemieux technique is then used to test how much the difference between the two sets is explained by the characteristics of the workers, and how much it is driven by the industries themselves.

Chapter 10 summarizes the findings and considers their policy implications.

Chapter 2

The Literature on Technology, Technical Change and Growth

2.A Technology in the economy

It is part of the hypothesis of this study that the new Information and Communications Technology is a General Purpose Technology, which is bringing about far-reaching changes in the way work is organised in a wide range of industries. The nature of technological change is therefore an important part of the background to this study.

The present chapter reviews the international literature on technology as an economic phenomenon, with special attention to the processes of technological change and the role of work force skills as an integral part of the technological system. It begins with an overview of the recent literature on the role of technology, and the different elements which make up the whole technological system, including economic institutions.

Neoclassical economics held a dominant position for much of the late 20th century. However neoclassical analysis is primarily concerned with efficient allocation, and was almost silent on technological change which it took as exogenous. The endogenous growth theory of the 1980s and 1990s moved technological change to the centre of the growth process, and because of the interactions of workforce skills with technological systems it also brought a change of emphasis from physical capital to human capital formation.

This chapter reviews the literature on endogenous growth and the importance of recent developments in human capital theory. In particular it looks at the literature on so-called General Purpose Technologies (GPTs), those technological developments which have far-reaching effects on a wide variety of industries, and the importance of human capital in an age of adjustment to a new GPT.

2.B Technology and technological change

2.B.1 The significance of technology

Living standards today vary immensely between the world's richest and the world's poorest countries. However this is a relatively recent phenomenon, and before the industrial revolution the gaps were very much narrower (Galor and Weil, 1999; Olson, 1996). David S. Landes notes that Switzerland today is some 400 times richer than Mozambique, whereas 250 years ago "this gap was perhaps 5 to 1" (Landes, 1998: xx), and Dosi and Fabiani (1994) suggest the ratio may have been 2 to 1 or less. The difference lies in the different ways in which production is organized and performed. In a poor country, long and exhausting hours of human effort produce very few of the goods and services which the workers desire. The more prosperous economy is the one with the more efficient productive systems, the one which achieves greater output per worker (Lutzker, 2003).

The gaps have appeared in the last few centuries because the productive systems improved faster in some places than others (Lucas, 1988). When compounded over many decades, even small differences in the growth rate add up to a very large difference in productivity (Landau, Taylor and Wright, 1996), and:

> "Output per hour worked in the United States today is 10 times as valuable as output per hour worked 100 years ago" (Maddison, 1982, quoted in Romer, 1990: S71).

The productivity of an economy depends on the level of technology in use. The word “technology” conjures up images of machines and equipment, of greater or lesser sophistication, from simple tools such as axes and wheelbarrows through to the most advanced satellites and fibre optics. These things are indeed technologies, but within economics the words technology and technological change are used in a rather broader sense than this. The current technology of a society incorporates every part of the way production is organised (Stoneman, 2002), including purely organisational or administrative features such as the legal system and social organisation. As Paul Krugman puts it:

> "When economists speak of technological change... they mean any kind of change in the relationship between inputs and outputs” (Krugman, 1994: 58).

The way production itself is distributed over a greater or lesser number of firms, and the organisation of tasks within a firm are all aspects of a society’s technology. Any development in the way natural resources, labour and capital goods are combined represents a technological change, even if there is no introduction of any new equipment. Thus a technological change can be any change in the way inputs are combined, any “improvement in the instructions for mixing together raw materials” (Romer, 1990: S72). It is the recombination of these inputs in more efficient ways that is fundamental to improved productivity (Bresnahan and Gordon, 1997; Freeman, 1991; Pasinetti, 1981), and without which standards of living cannot rise:

> "For real economic miracles one must look to productivity growth." (Baumol et alia, 1989: 9)

2.B.2 Institutions as part of the productive system

Any improvement in general welfare therefore depends crucially on changing methods (Aghion and Howitt, 1998), but changing methods depend as much on institutions which foster change as they do on the ideas for specific change (Freeman, 1996; Nelson, 1991). If a country has a strongly traditional organization, and all activity is governed by traditional institutions and relationships, there will be neither incentive nor opportunity for any sort of innovation. "China was much richer in the sixteenth century than England" (Drucker, 1971: 131), but China's productive systems stagnated in a very traditional society, while Britain succeeded in shaking off its medieval past and establishing institutions which fostered mercantile and industrial expansion (Rosenberg and Birdzell, 1986).

Domestic institutions such as habits, social ties and legal systems all affect the extent to which a society promotes or inhibits change (Freeman, 1992; Simon, 1994). The feudal economy based on a manorial system gave its members considerable security and mutual support, as well as allowing sufficient specialization for a range of skills to be developed and passed on between generations. But it was essentially static. People knew their place and had no incentive to think about making changes to the way production was organized. The rise of individualism and escape from rigid social structures appears to have been a prerequisite for the entrepreneurship which brought technological changes and rising productivity (Cameron, 1993; Landes, 1998):

> "The history of technology suggests that changes in technology and changes in organization and institutions are intimately related…" (Helpman and Trajtenberg, 1998a: 73).

There are many examples of governments and other community institutions impeding change, but a social infrastructure which facilitates change will not arise by itself; it has to be created (Hall and Jones, 1999). The recently successful Asian economies have been notable for relatively high levels of strategic government intervention (Rowen, 1998). By contrast, the stagnation of the more laissez faire Latin American countries is a reminder that positive change is most unlikely to occur without positive government and effective democracy (Freeman, 1996; Olson, 1996; Stiglitz, 1998).

The institutions that foster new methods and new ways of thinking cannot spring up automatically. Especially in areas like education and infrastructure, where there are large complementarities and powerful network effects (Hall and Khan, 2003), change promoting institutions can only be put in place by a community which separates government from vested interests (Putterman and Rueschemeyer, 1992):

> "Domestic institutions have been the most important differentiators between those countries that have ultimately succeeded in attaining widely spread and widely shared economic development and those that have not" (Adelman and Morris, 1997: 834).

2.B.3 The evolution of industrial patterns

It is inconceivable that every sector of an economy will progress at the same rate as every other, so every area of change will lead to changes in the relative prices of different goods and services. If, for example, the introduction of new techniques raises the efficiency of the textile industry, the cost of clothing relative to other costs can be expected to fall. As relative prices change relative demand patterns will also change, resulting in a different pattern of revealed preferences.

Thus any innovation in any aspect of the productive system will have flow on effects, both in terms of demand for goods and services and also in terms of the demand for workers in the industries which produce them. Traditionally the majority of workers were employed in rural areas, either directly in agriculture or in closely associated cottage industries. But every innovation in industrial practice led to different patterns of worker demand, and also to different patterns of industrial location and land use.

> "Technological change impacts on all areas of economic activity" (Stoneman, 2002: 249)

Moreover, unless there are major barriers to trade, changes in different parts of the world alter the production frontier for everyone. When any one local economy changes it will bring about new possibilities for other economies which trade with it, worsening their comparative advantage in fields where the one has shown gains in efficiency, and improving their comparative advantage in all other areas:

> "The relative importance of different activities, as measured by their economic weight, is subject to continual change both within nations and between nations" (Metcalfe and Gibbons, 1991: 485).

2.C History of technology and the increase in complexity

2.C.1 Urbanization, specialization and market expansion

The history of technology traces the evolution of complexity. In the middle ages, the ways in which people produced the world's goods and services were very stable for centuries. But since the Renaissance, and especially since the Industrial Revolution, they have been in constant change. Moreover the pace of that change is increasing exponentially, with new ideas, tools and organizational systems, both within firms and in society at large, replacing older ones at ever increasing speed (Streeten, 2001: 74).

There was never a time without some specialization of tasks, and even the ancient Greeks were aware that production could be raised by having people specialize in particular roles, with some arrangement for exchange so that everyone enjoyed a full range of goods (Xenophon, quoted by Maitland, 1819, 1962: 282). But the ability to develop specialized skills is constrained by the size of the market available. There were always some goods travelling substantial distances, and trade fairs for long-distance trade were emerging as early as the 7^{th} century (Derry and Williams, 1960). But prior to the fifteenth century "by far the greatest part of commercial exchange, both by volume and by value, was local" (Cameron, 1993: 119), and as late as 1530:

> “the majority of English men and women lived in rural households which were almost economically self-sufficient” (Hill, 1969: 20).

The evolution from a world of feudal estates to a modern individualistic economy required sweeping changes in settlement patterns as well as social institutions. It is common to think of the great changes in productive methods resulting from the industrial revolution (Crafts, 1977; Spiezia and Vivarelli, 2000). But the 200 years from 1530 to 1730 saw far-reaching developments in social and mercantile structures which were a necessary precursor (Landes, 1989). Even before the start of the Industrial Revolution, Daniel Defoe was recording a high level of specialization:

> "Almost everything that is sold, whether it be the product of nature or art, passes through a great variety of hands, and some variety of operations also, before it becomes (what we call) fit for sale" (Defoe, 1730, 1979: 212).

The process of modernization involved three interrelated developments: urbanization, specialization and trade, each of which is both necessary for and a product of the others. From the early sixteenth century people moved to the towns and cities in unprecedented numbers. Work became more specialized, and activities which had taken place within a broader context (if at all) emerged as individual industries in their own right.

In addition to creating more efficient urban industries, the drift of population away from the rural estates gave an impetus to increased efficiency on the land. Where traditionally the large estates had fed their owners and all the workers on the estate, agriculture was increasingly required to supply food for urban consumption with an ever declining proportion of the workers on the land.

> "The massive shift of population from agriculture [would not] have been possible without the mechanization of farming, and without the creation of urban jobs through reduced prices as a result of industrial mechanization" (Oshima, 1994: 253)

The possible rate of urbanization was thus constrained by the rate at which agricultural productivity could rise, and efficiency gains were as much a part of the rural sector as of the urban (Rosenberg & Birdzell):

> "It was not surprising that the Netherlands, with the largest proportion of town dwellers and a constant shortage of grain, was the leader in innovation" (Pennington, 1989: 71)

2.C.2 The evolution of institutions

It was noted at the start of this chapter that institutions are as important a part of the current technology as the equipment and methods used by firms. Markets are themselves institutions, and the urbanization of the population was only possible through the evolution of markets and ownership structures which facilitated the formation of independent trading and manufacturing enterprises:

> "In the blooming of certain economies, such as medieval Flanders and Renaissance Italy, institutional change such as the development of markets and the growth of trade and specialization loomed large." (Mokyr, 2002: 286)

Progress since the Industrial Revolution has been marked by ever increasing complexity of commercial relationships, and every such increase has required appropriate commercial institutions (Abramowitz and David, 1996). The inadequacy of social institutions is therefore widely held to be one of the major impediments to growth, responsible for some countries falling so far behind others (Day, 1994; Engerman and Sokoloff, 1997):

> "Many historical accounts... point to the importance of institutional innovation in both Germany and the United States which facilitated their 'catching up' with and forging ahead of Britain" (Freeman, 1996: 166)

Thus, with every increase in economic complexity it appears that structural and policy issues gain increased importance in facilitating development (Grossman and Helpman, 1991).

2.D Growth, technology and human capital

2.D.1 Early growth theory

Since the 1950s growth theory has been dominated by the neoclassical model, in which growth is seen as a function of capital and labour, while technology is taken as exogenous and equally available to all countries (Conceição and Galbraith, 2001). However, in the last 25 years the belief that neoclassical growth theory would help our understanding of economic development has increasingly come to be doubted (Adelman, 2000; Nelson, 1994).

Firstly, the idea of capital formation as a driver of growth has been seriously questioned. Early growth theory was rooted in the idea of a dichotomy between a traditional agricultural sector with a low capital to labour ratio, and a more modern urban industrial sector with a higher ratio of capital to labour (Abramowitz, 1994). In this framework growth was seen as the process of building up the latter and progressively transferring labour from the one to the other (Grossman and Helpman, 1991). Modern industry was therefore seen as requiring major capital investments. Rich people were believed to have more capacity to save and therefore to invest, so the rich were seen as growth promoting (Epstein and Gintis, 1995a; Lindert and Williamson, 1985).

> “If savings are the key to economic growth, through their deployment in increasingly productive technology, and if the marginal propensity to save rises as income rises, then a more unequal society will save more and grow faster. This at least is the conventional wisdom..." (Kaelble and Thomas, 1991, pp. 1-2).

In recent years this line of argument has been seriously called into question. For one thing no evidence has been found for savings rising with inequality (Birdsall, Graham and Sabot, 1998; Galbraith, 2001). The rich do not appear to save more. But more fundamentally, savings do not appear to drive investment (Epstein and Gintis, 1995a); rather it is the investment level which leads savings

(Gordon, 1995; Carvalho, 1997); Schmidt-Hebbel, 2001). As Keynes pointed out, savings are an effect, not a cause:

> “Increased investment will always be accompanied by increased saving, but it can never be preceded by it. Dishoarding and credit expansion provides not an *alternative* to increased saving, but a necessary preparation for it. It is the parent, not the twin of increased saving" (Keynes, 1939: 572)

Various attempts have been made to use capital to boost productivity. It has been tried extensively in third world countries, where borrowing abroad was hoped to kick start growth (Van der Ploeg and Tang, 1992), as well as in the socialist countries like the former Soviet Union where domestic savings were generated by official planning. The dismal results of all these schemes suggest that Keynes had an important point.

A second serious shortcoming of the neoclassical model lies in its prediction that the less advanced economies will tend to catch up with the more advanced (Amable, 1994; Dornbusch, Fischer and Startz, 2004). The rationale behind this belief is that technology is a public good and available to all, and that capital will flow to the places where it will earn the highest returns. Following this logic capital will flow away from the most advanced economies toward the less advanced where labour is cheaper, and these latter will show higher growth rates (Boltho and Holtham, 1992; Pack, 1994).

If this prediction were close to the truth the world would look very different. As soon as one country got somewhat ahead of the others, capital would start flowing toward the laggers and the gaps would close up again (Lutzker, 2003). The world would be expected to display a high level of uniformity. Some evidence has been found for convergence within clubs of similar countries (Baumol, 1986; Howitt, 2000), but world wide over the last 500 years the gaps between rich and poor countries appear to have been widening inexorably (Lucas, 1988; Pritchett, 1997), and:

> “different countries have remained on seemingly disparate growth paths for relatively long periods of time." (Grossman and Helpman, 1994: 23).

2.D.2 Technology and endogenous growth

In addition, and probably more fundamentally, neoclassical ideas on growth have come under fire because of their inability to address technological change (Mokyr, 1990; Crafts, 1998). Neoclassical thinking emphasizes the importance of the efficient allocation of resources, and while distorted allocations are certainly wasteful this approach provides little help in understanding the processes of changing productive systems and improving output:

> "General neoclassical theory... is basically about inputs, outputs, prices, equilibrium configurations and associated phenomena. It is not well oriented toward considering things like technologies, firms as productive organizations, or institutions..." (Nelson, 1994: 303)

It is now widely accepted that technological change is the ultimate source of economic growth (Helpman, 1998; Lau, 1996). Moreover, technology is not an exogenous given but is constantly evolving within economies, an intuition which gave birth to the endogenous growth theories which have gained increasing acceptance over the last 20 years (Amable, 1994; Arrow, 1991). Paul Romer, the founding father of endogenous growth theory, has written that it:

> “distinguishes itself from neoclassical growth by emphasizing that economic growth is an endogenous outcome of an economic system, not the result of forces that impinge from the outside" (Romer, 1994: 3).

Thus endogenous growth theory discards the idea that technology is a public good which is universally available, and treats it as the most important variable influencing growth rates in different countries (Grossman and Helpman, 1994). It is therefore a more helpful approach in terms of accommodating different technologies, and coping with the wide variation in growth rates and rather general global divergence of growth paths noted in the previous section (Aghion and Howitt, 1998).

2.D.3 Human capital as a factor of production

Human capital is the general term applied to all “acquired characteristics of workers that make them more productive" (Filer, Hamermesh and Rees, 1996: 84), including general education and vocational training, as well as skills and understanding picked up on the job.

Workers are far from homogeneous. They vary widely in terms of innate ability, but almost all are capable of acquiring skills at least to some extent, and it is clear from the labour market that employers are willing to pay very large premia for workers who have acquired greater skills. Evidently human capital improves their usefulness (Autor, Katz and Kearney, 2005; Green and Riddell, 2003).

An extensive literature documents the relationship between human capital and productivity (Arrow, 1994). Workers are a fundamental part of the total productive system, and different levels of technology require workers with different sets of skills. Thus human capital is itself a vital part of the current technology. The rise of specialization noted earlier was accompanied by rising levels of both general education and occupation-specific skills, and workers in the more industrialized countries are spending more time in education and training than ever before, a reflection of the symbiosis between human capital and other aspects of the productive system. (Green, Felstead and Gallie, 2003; Murphy and Welch, 1993).

If technological change is seen as central to growth (Bresnahan and Gordon, 1997; Freeman, 1991), and human capital is a vital part of technology, then in terms of promoting growth, human capital gains increased significance over fixed capital (Dunne and Schmitz, 1995). This is an idea which goes back at least as far as Edward F Denison:

> "Past studies have identified increasing education of employed persons as a major source of growth since at least 1910, and especially since about 1930” (Denison, 1985: 15)

2.D.4 The special characteristics of human capital

One problem with the neoclassical approach to growth is that capital markets are imperfect and capital does not automatically flow to the place of best use. But with human capital the problems are much more extreme, since:

> “intangibles such as human capital and knowledge capital have peculiar economic properties that may well not be well represented by the standard formulations." (Grossman and Helpman, 1991: 22).

For several reasons information is ill-suited to allocation by conventional markets. Some skills are highly task- or industry-specific, but many skills are generic, and represent an advantage in a variety of employment settings. Human capital is an attribute of individual workers which they take with them when they change employers, so it is only partially excludable (Fischer, 2003). It is generally non-rival (Dowrick, 2002a; Jones, 2005) and far from homogeneous (Hodgson, 1999). And a feature which distinguishes it markedly from physical capital is that it has such high complementarities that skilled workers flock together (Romer, 1994).

The benefits of R&D are also very hard to keep entirely private, and indeed it has been established that spillovers have public benefits that outweigh their private costs (Baumol, 2000; Engelbrecht , 2003; Stiglitz, 1999; Verspagen, 1994). For all these reasons knowledge and knowledge expansion are likely to be seriously underprovided if left to an unmodified market.

2.E Technology and skills

2.E.1 Technology-skill complementarity

There are two distinct linkages between technological change and human capital (Engelbrecht, 2001). Firstly, new technological ideas need to be conceived, but secondly, these new techniques need to be adopted and adapted to meet the different needs of different firms and circumstances.

Obviously it is human capital which creates new technology. There will be no new technology unless there are people thinking about different ways of doing things, and human capital applied to R&D is therefore seen by many commentators to be the driver of new technology (Abramowitz and David, 1996; Bartel and Sicherman, 1999; Jones and Williams, 1998; Verspagen, 1994).

> "The new growth theory has explicitly drawn the connection between technological change and investment in knowledge production" (Mokyr, 2002: 291).

But new technologies are seldom created in a form that is instantly applicable, since the combinations of other inputs will vary from one economy to another (Basu and Weil, 1998). Different communities will want to use new technologies in the way that is most appropriate to their circumstances (Maddison, 1994), and the existence or lack of complementary infrastructure and equipment in a society, as well as skills among the workers in charge of implementing the new technology, will affect the efficiency with which new equipment and methods are adopted:

> "Even the initial process of technology transfer is fraught with problems because technology is never completely codified, and to operate it optimally in different environments requires adaptation" (Amsden, 1992: 55).

R&D has often been used as a proxy for new technology (Allen, 2001; Berman, Bound and Griliches, 1994; Katz and Autor, 1999), but it has also been widely criticized for its failure to proxy the diffusion of technology (Hollanders and ter Weel, 2002). Production and diffusion are both necessary, but R&D only measures the first (Stoneman, 2002).

Many of the most innovative firms are SMEs which conduct little R&D (Baldwin, 1996), and there appears to be scant connection between those firms which produce new technology and those which are innovative in its application (Lundgren, 2000; Metcalfe and Diliso, 1996):

> "A range of new OECD data show that the United States, Canada, New Zealand, Australia, the Nordic countries and the Netherlands have the highest rate of diffusion of ICT" (Pilat, 2002: 4)

The United States is a world leader in the development of computing hardware and software and the Scandinavians have been major contributors to telecommunications. But diffusion has clearly occurred in several of the above countries without any significant contribution to ICT production. Dean Parham has noted that “Australia is an advanced ICT user, not producer" (Parham, 2002: 197), and the same comment doubtless applies to New Zealand.

Thus human capital is important in terms of keeping up to date with new trends, and the imagination to see how they may be adapted to local needs (Helpman and Rangel, 1999). Rates of technological diffusion vary widely from country to country, a fact which has often been seen as one of the reasons behind the wide variation in growth rates (Baumol, Batey Blackman and Wolff, 1989). It therefore seems highly likely that technological diffusion is an important factor in the widely reported correlation between human capital and growth (Barro, 1991; Haveman, 2000).

> "The absorptive capacity of an economy, which is to a large extent determined by its stock of human capital, will influence the ability of a country to take on board either embodied or disembodied knowledge" Engelbrecht and Darroch, 1999: 284

2.E.2 Changing skills demand over time

At least since the beginnings of industrial society, firms have paid a premium for workers who are perceived to have skills which are of value to the firm (Blundell, Dearden, Meghir and Sianesi, 1999; Bowles and Gintis, 2000). The size of this skills premium is an indicator of the comparative values of different forms of human capital, since the acquired skills represent the difference which the firm is willing to pay more for (Ashenfelter and Rouse, 2000).

This skills premium has not been constant over time, but has risen or fallen in different periods. This has given rise to the theory that some phases of technological change have been biased toward skilled workers while some phases have been biased in favour of the unskilled. There is no reason to expect technological change to be generally either skill-biased or unskill-biased, and it is easy to think of specific examples of each. Especially in factory work new machinery may well replace skilled workers and need only unskilled workers, whereas other technologies may complement the talents of the highly skilled and displace the less skilled.

However the skills premium will also reflect the availability of skills in the labour force. In the western democracies the supply of educated workers has been constantly on the rise since the early nineteenth century (Easterlin, 1981), and a number of countries, especially in the Far East, have joined this trend more recently (Stevenson, 1998). The late nineteenth century was a period of rapidly rising basic literacy (Sokoloff and Engerman, 2000), secondary education was extended to many more pupils in the early twentieth century, and higher education has expanded greatly since the 1960s (Goldin and Katz, 1996).

In New Zealand, the Education Act of 1877 which established free, secular and compulsory education up to age 12 saw literacy rise from 83% in 1874 to 93% at the start of the twentieth century, and:

> “By 1939, two-thirds of all children between the ages of 12 and 18 attended some form of secondary education, compared with around 8 percent in 1900” (Statistics New Zealand, 2000:112).

The rise of the factory system has been widely seen as deskilling:

> “Historically, changes in technology have been associated with deskilling the labour force in the longer run. The substitution of machines for skilled labour in the industrial revolution in the 19th century and the move towards Fordist manufacturing techniques in the 1950s are the most widely cited examples." (O’Mahony, Robinson and Vecchi, 2004: 3).

However there is considerable reason to think that it was not so much deskilling as a movement from one set of skills to another. Many of the traditional artisanal skills were indeed replaced by machines (Krugman, 1994), skills which in earlier times had been passed down within families from generation to generation. But with rising mechanisation the pattern of labour demand inevitably changed. Fewer workers were needed on the shop floor for a given quantity of production, but more workers were needed in marketing and transport, as well as technical skills in maintaining the new factory equipment, if the new possibilities which had been opened up by new production methods were to be realized. Williamson has estimated that human capital was important for growth in Britain as early as 1850 (Williamson, 1991b: 67).

The rising general level of skills was associated with a strong pattern of rising demand (Acemoglu, 2002; Katz, 2000). During a phase when supply is outstripping demand it is quite possible that the skills premium would decline even as the aggregate demand for skills was rising (Heckman, 2003), and this appears to have occurred in some decades:

> “The growth in relative skill supply was smaller and the increase in relative skill demand was larger in the 1980s than in the 1940s and 1970s - the decades in which the education premium fell." (Juhn, 1999: 439)

But since 1980 the skills premium has been rising in many countries (Galor and Moav, 2000; Nickell and Bell, 1996) despite a steady rise in numbers of students continuing to higher education. This suggests that the recent rise in the demand for skills has been particularly strong (Topel, 1997).

2.E.3 Returns to adaptability

Every current technology requires a particular skill set, and changes in the available technology mean that the optimal skill set is also constantly changing as old skills obsolesce (Bartel and Sicherman, 1998; Howitt, 1996).

But change itself places particular demands on workers. Ever since the pioneering work of Huffmann (1974) and Schultz (1975), it has been known that workers with better education are better equipped to manage change. This is not so much a function of the skills required to use the new technology, as the ability to assess the new possibilities and manage the change process itself:

> “Decision makers with more education can more quickly grasp changes and adjust more quickly and accurately to them..." (Huffmann, 1974: 95-96).

A strong correlation has been found between skill growth and the pace of change (Wolff, 2000), and in recent years an extensive literature has appeared on the economics of volatility. In particular, increased volatility is widely seen as tending to dampen growth, probably because of the costs of uncertainty (Ramey and Ramey, 1995). Dynamic communities are always in transition (Landau, Taylor and Wright, 1996), and the greater the rate of change, the greater the need for a workforce that can adapt to the new opportunities (Galor and Moav, 2000; Phelps, 1997):

> “Education is more productive the more volatile the state of technology" (Psacharopoulos and Patrinos, 2004, p. 111).

Thus two distinct kinds of human capital are required during a phase of change, and there is a premium paid for the possession of skills appropriate to the current technology, but also a premium paid for adaptability during periods of change. All change incurs risk (Helpman and Rangel, 1999). The workers of greatest value during a period of change are therefore those who are best equipped to assess and minimize risk, rather than those with the specific skills associated with the technology itself (Nelson and Phelps, 1966). And the greater the step being taken, the more critical the need for good risk assessment becomes:

> “Entrepreneurs face a trade-off between productivity and difficulty. A great innovation, giving a large productivity gain over the technology previously used, implies a higher degree of ignorance about its optimal use and a larger scope for mistakes" (Hassler and Rodriguez-Mora, 2000: 889).

2.F The nature of technological change

2.F.1 Radical versus incremental change

Technological change takes two distinct forms (Freeman, 1992; Metcalfe, 1994). A large proportion of change is incremental improvement, which builds slowly over long periods. Persistent refinement brings about ever improving reliability, economy or value for money of some sort. One example might be the remarkable improvements in the efficiency of commercial aircraft, which have seen a mode of travel which was very expensive 50 years ago evolve into mass transport.

However from time to time radically new technologies emerge which, rather than merely improving on existing techniques, offer a fundamental change in the productive system (Soete and Verspagen, 1991). Lipsey, Carlaw and Bekar (2005) estimate that there have been some 24 radical inventions since the start of recorded history, such as steam power in the nineteenth century or electrification at the start of the 20th.

The ultimate effects of radical change are often so far-reaching that only a tiny part of the full potential is initially evident, either to the inventor or to the industrialists who might benefit by adopting the idea. For example "The telegraph facilitated the formation of geographically dispersed enterprises..." (Brynjolfsson and Hitt, 2000: 24), a downstream effect of far greater significance than could have been imagined by those who simply thought they were developing a faster form of communication. Thus a wave of change can be initiated which ultimately redefines a wide range of productive activities.

2.F.2 General purpose technologies (GPTs)

Radical new technologies of this sort are often referred to as General Purpose Technologies (GPTs). These GPTs are:

> "characterized by the potential for pervasive use in a wide range of sectors and by their technological dynamism." (Bresnahan and Trajtenberg, 1995: 84).

Technological change does not proceed at a smooth rate over time. Commonly, change comes in waves which start with a new technology and follow a sigmoid curve on a very long time frame (Aghion and Howitt, 2002; David, 2000). At first change is very slow (Freeman, 1992), partly through uncertainty or lack of knowledge on the part of those who might benefit, but largely because of the lack of supporting technologies which only begin to evolve as the need for them is felt (Crafts, 2003):

> "The fruits of the Industrial Revolution were slow in coming. Per capita living standards increased little initially, but production technologies changed dramatically in many industries and sectors, preparing the way for sustained Schumpeterian growth in the second half of the nineteenth century, when technological progress spread to previously unaffected industries." (Mokyr, 1990:83)

As the technology becomes more widely adopted the pace of change quickens. Complementary products begin to appear, which make the new technology easier to implement profitably, and awareness of the new technology diffuses through the community (Helpman and Trajtenberg, 1998a). Change proceeds very rapidly in the middle phase, around the time when the minority of firms which pioneered the new practices swells into a majority. When most firms have made the move the pace slackens again, as the outstanding firms resist making the change either through innate conservatism or because of particular reasons why the old technology suits their purposes better.

Many commentators have noted that the early phase of adoption of a new GPT is accompanied by lowered profitability and poor productivity figures (Howell and Wolff, 1992; Jorgensen and Stiroh, 1999). Initially there were surprised comments that technology changed but productivity did not rise simultaneously (Gottschalk and Smeeding, 1997; Rosenberg, 1996), a pattern which gave rise to Solow's oft-quoted paradox:

> "You can see the computer age everywhere but in the productivity statistics" (Solow, 1987).

But closer study of GPTs has established that poor productivity is inevitable at the beginning of a wave. New technologies arrive in two distinct phases (Helpman and Trajtenberg, 1998a). During the first phase firms are investing in the new technology but the lack of complementary skills and facilities holds back productivity and profitability, since "most GPTs play the role of 'enabling technologies', opening up new opportunities rather than offering complete, final solutions" (Bresnahan and Trajtenberg, 1995: 84). During the second phase the complementary inputs in terms of institutions, skills and other goods begin to catch up, and positive returns begin to be realized (Helpman and Rangel, 1999). Moreover, the faster the change, the more it may impede the growth of productivity in the short term (Howitt, 1998):

> "It is only as new technologies are used and spread widely in an economy that any real welfare gains arise from those technologies" (Stoneman, 2002: 3)

2.F.3 ICT as a general purpose technology

Many authors have suggested that information and communication technologies (ICT) represent the latest of these GPTs (Brynjolfsson and Hitt, 2000). Lipsey, Bekar and Carlaw (1998) set down three criteria for a GPT - pervasiveness, technological dynamism and innovational complementarities - and ICT meets all of these.

> "The pervasiveness of ICT is not just a question of a few new products or industries but of a technology which affects every industry and every service, their interrelationships and indeed the whole way of life of industrial societies." (Freeman and Soete, 1994: 42)

In terms of technological dynamism, the ratio of computing power to cost has increased at a startling rate, making simple but useful ICT affordable for even very small business applications (Jorgensen and Stiroh, 1999). This increased affordability led to an explosion in complementary goods and software packages, with

> "cheaper and better ICT facilitating co-invention of more and more complex uses" (Bresnahan, 1999: F402).

ICT has far-reaching complementarities (Bertschek, 2003; Brynjolfsson and Hitt, 2000). The nature and quality of services supplied have been changing and improving ever since the beginning of telegraphic communication in the late nineteenth century. But the most dramatic changes came with the development of networks which allow computers to communicate over large distances. The combination of computing with telecommunications has facilitated such developments as the world wide web for information and marketing (Brynjolfsson and Kahin, 2000), and the ability of large companies to centralize customer services on call centres.

Tasks which in the past would have been performed within companies are today much more easily outsourced. This often leads to redistribution of tasks between firms (Lindbeck and Snower, 2000; Rubery and Grimshaw, 2001), not infrequently in different countries at distant locations (Feenstra and Hansen, 1996):

> "The most striking findings are that the main thrust has come not from final demand but from its pervasive role through inter-industry relationships, supplying other producers (Greenhalgh and Gregory, 2001: 644).

2.G Impact of new technology in the workplace

2.G.1 GPTs and workplace organization

An important reason for treating ICT as a General Purpose Technology is that its effects run far beyond mere automation. Early computerization used machines to save on labour costs by carrying out specific tasks. But the development of shared information systems meant a breakdown of traditional roles in many workplaces, as it became possible to share virtually all firm information with all staff, at sites almost anywhere in the world (David, 2000; Lindbeck and Snower, 2000).

Many commentators have noted a strong correlation between ICT adoption and workplace reorganization (Black and Lynch, 2003; Fernald and Ramnath, 2004). The adoption of ICT in the workplace has led to changes in management systems (Ducatel and Miles, 1994), as workflows have been freed from the constraints of specific units with traditional hierarchies (Simpson, 1999). But with better informed staff it has also encouraged flatter structures (Caroli and van Reenen, 2001):

> “in which nonmanagerial workers are involved in problem solving and identifying opportunities for innovation and growth” (Black and Lynch, 2003: 545)

But workplace reorganization is not merely encouraged by new technology, it appears to be almost necessary. There is strong evidence that merely automating traditional systems results in little benefit, and the effective use of new technologies actually depends on reorganization (Brynjolfsson and Hitt, 1998; Pilat, 2002):

> "In order to reap the benefits from computerization, firms have to redesign the organization of work… decentralize decision making, and make flexibility a prime goal in planning production and product design" (Helpman and Trajtenberg, 1998a: 73).

It has also been found that more flexible organizations are more receptive to new technology (Roos, 1991). Thus new technology and reorganized workplaces are systematically connected in a positive feedback loop (Hitt and Snir, 1999), in which ICT adoption facilitates workplace reorganization, but reorganization necessarily accompanies ICT adoption (Wolff, 2002). This view is supported by the finding that change tends to be a feature of specific firms and workplaces rather than countries (Brown and Campbell, 2002).

> "IT and organisational change have complementary effects on technology" (Askenazy, 2000: 100).

2.G.2 Skills and adaptability

It is now widely accepted that there is a link between increasing use of technology and greater returns to education, since returns to schooling have been found to be higher in industries making greater use of advanced technology (Bell, 1996; Chennells and van Reenen, 1997), and the rate of skill upgrading tends to be greatest in industries with greater computer investment (Autor, Katz and Krueger, 1998; Johnson, 1997).

Evidently there is a complementarity between worker skills and new technology, with more skilled labour rendering new technology more productive (Acemoglu, 1998; Booth and Snower, 1996; Lloyd-Eills and Roberts, 2002). However, the evidence suggests that rather than a simple complementarity between computer use and individual workers' skills, there is a complementarity between skilled workers and the automated workplace mentioned above (Bresnahan, 1999; DiNardo and Pischke, 1997). A more educated workforce is more adaptable to new ways of working (Bowles, Gintis and Osborne, 2001; Griliches, 1997; Hassler and Rodriguez Mora, 2000; Phelps, 1997), so the returns to adaptability described in section 2.E.3 are especially significant in the context of ICT:

> "The effects of IT on labor demand are greater when IT is combined with the particular organizational investments we identify, highlighting the importance of IT-enabled organizational change" (Bresnahan, Brynjolfsson and Hitt, 2002: 339).

Change in the workplace not only requires higher levels of skills, it also requires different skills. There is little evidence that computer skills as such are enjoying increased demand (Borghans and ter Weel, 2004), and it appears that the returns to general education have been rising faster than returns to vocational training (Aghion and Howitt, 2002; Dearden, McIntosh, Myck and Vignoles, 2002). At a higher pace of change, experience and task specific training lose value faster than general education (Rosenzweig, 1994), since:

> "Technological change influences the rate at which various types of human capital obsolesce" (Bartel and Sicherman, 1998: 747)

It is general education and cognitive skills that are being rewarded, as firms find learning strategies (Lundgren, 2000) and adaptability more important than vocational training in an environment of change (Sheehan and Esposto, 2001).

2.G.3 Skills and inequality

If the ideas underlying endogenous growth theory are accepted, including the belief that firms particularly value workforce skills during a period of change, then it is to be expected that a period when new technology is being introduced will be one of generally rising wage inequality. As explained in 2.E.3 above, the better educated workers are known to be generally more adaptable workers. Thus a period of changing technology is likely to give higher rewards to those who are better educated, exacerbating the skills premium which exists at any time and increasing overall wage inequality.

The appropriate response to such a skills premium will depend on whether inequality is seen as economically good or bad. Chapter 3 will review the literature on inequality, and the reasons why a technologically-driven rise in inequality may have important policy implications.

Chapter 3

The Literature on Inequality

3.A The inequality problem

3.A.1 Introduction

No society is totally egalitarian, nor can such an ideal ever be realized. However the extent of inequality has varied greatly between different cultures and different eras. The early industrial society of the nineteenth century had immense inequality by comparison with the late twentieth century social democracies, and in our own time most of the nations of East and Southeast Asia are much more egalitarian than those of Latin America.

Inequality received little attention in the high-growth, low-inequality period following World War II. But since the mid-1970s growth rates have fallen and inequality has risen (Gottschalk, 1997; Greenwood and Yorukoglu, 1997), and economists have come to appreciate (a) that it has important economic and social consequences, and (b) that it is not immutable. Different policies have different outcomes in terms of inequality, and inequality is now recognized as an important aspect of public policy.

In this chapter I review the international literature on the inequality problem, and the recent trends in inequality both in New Zealand and in other developed countries. There are a number of different ways of measuring inequality, so the first section is a review of these various methods and the reasons why some of them show more exaggerated dispersion than others. This chapter then considers the significance of inequality as an economic phenomenon, the relationship between inequality and growth and the reasons why inequality has damaging effects.

Finally, I review the literature on unemployment, since access to work is itself unequally distributed. Those who are most likely to be unemployed are also those who command the lowest wages, so unemployment represents an added dimension to inequality, with a tendency to exacerbate the differences in financial rewards.

3.B Measuring inequality

3.B.1 Different dimensions of inequality

Inequality can be measured in various ways, and is characteristically wider in some dimensions than others. Inequality of wealth is typically wider than inequality of income (Davies and Shorrocks, 2000; Scholz and Levine, 2004), which itself is wider than inequality of earnings. Of these various measures, the most commonly used are wealth and income, wealth because it is widely seen as the most revealing indicator of economic differences (Castello and Domenech, 2002; Shapiro, 2001), and income because it is often the most readily available figure.

Inequality of wealth and inequality of income are very different, with some individuals enjoying high incomes while accumulating few assets, while others are asset-rich but income-poor. In particular, since the pioneering work of Modigliani and Brumberg (1954), there has been a vigorous debate about the nature of saving for retirement, with the life-cycle hypothesis suggesting a "hump-saving" pattern as workers build up assets prior to retirement, and run them down again when they are no longer working. The relationship between income and wealth is therefore partly a function of age, as workers progress from being highly dependent on income early in their working lives to increasing dependence on assets as they approach retirement.

Related to this life-cycle theory is the “permanent income hypothesis, which implies that, for any cohort of people born at the same time, inequality in both consumption and income should grow with age" (Deaton and Paxson, 1994: 437). If this hypothesis is correct there will be a rise in overall inequality in any country where the population is generally aging (Deaton, 1997). Deaton and Paxson (1994) found that this was indeed the pattern in the United States, in the United Kingdom and in Taiwan, but as yet there has been no study of this effect in New Zealand.

However income inequality is an important factor in wealth inequality (Deininger and Squire, 1998), and each is to some extent a proxy for the other since the two interact and tend to reinforce each other. Assets often generate investment income, and conversely, those who have greater incomes have more discretionary income and are therefore more likely to supplement their earnings through investment (Burtless, 1998):

> “Typically a skewed income distribution reflects concentration of ownership of assets” (Amsden, 1992: 75).

Incomes are more dispersed than earnings, because low-wage workers seldom have any income other than their earnings, whereas the better-off are more likely to enjoy unearned incomes such as dividends and rents. However earnings and total incomes are highly correlated, since “earnings make up the lion’s share of individual incomes” (Snower, 1998: 69). Earnings inequality in turn is greater than wage inequality because workers on low wages are more vulnerable to casualization, part-time work and spells of unemployment (Booth, 1999), a point I will return to in more detail in section 3.G.

Finally, the social significance of inequality is complicated by household dynamics, and the tendency of household inequality to be more exaggerated than personal inequality. Assortative mating exacerbates inequality. High income earners group together and stay together, while the low income earners are more likely to be living in single income households. In the past the members of poor households depended on two incomes and in richer families women were less likely to take paid employment. This pattern has reversed in recent decades, highly skilled people marry people of similar skill levels, and both are much more likely to pursue careers (Cancian, Danziger and Gottschalk, 1993; Oshima, 1994; Burtless, 1998).

That households today are more polarized than individuals has been found in the United States (Hyslop, 2001), in Australia (Burbidge and Sheehan, 2001), and also in New Zealand (Callister and Singley, 2004). Women are more likely than men to vary their hours of work according to family financial circumstances (Devereux, 2004), and the potential impact of assortative mating on household inequality is therefore somewhat dampened. But for New Zealand couples Paul Callister (2004) has established that average weekly hours worked where both partners are well qualified are higher than where both partners have few skills, leading to household inequality being more exaggerated than personal inequality.

3.B.2 Uses of different inequality measures

Inequality of wealth is widely regarded as the most meaningful dimension for the purpose of comparing welfare between individuals and communities. Many studies have found wealth to be the most robust proxy for the explanation of economic and social phenomena (Lovell, Richardson, Peter and Wood, 1994; Perotti, 1996; Fishman and Simhon, 2002). In particular it is inequality of wealth which most strongly predicts the educational achievements of the next generation, making this measure especially significant in terms of the mobility issue which I will return to in section 3.D.

However, the present study is concerned with the effects of technology on the workforce, and therefore uses trends in wages as far as possible, since it is "wages which are more closely related to market prices for human capital components" (Juhn, Murphy and Pierce, 1993: 411). In Chapters 6 and 7, when using Population Census data, there is no alternative to using income figures. These are not ideal, but all inequality measures are interconnected, and many studies have used incomes as a proxy for earnings. As Peter Gottschalk notes in the US context:

> “the increase in inequality of wages was mirrored by an increase in the dispersion of family income” (Gottschalk, 1997: 21).

3.C Inequality, wellbeing and growth

3.C.1 Inequality and the standard of living

From an economic perspective, inequality matters both in the present and in terms of its effects on future growth. In static terms, it has long been appreciated that inequality is socially undesirable, and an abhorrence of poverty in the midst of plenty dates back at least as far as Adam Smith:

> “No society can surely be flourishing and happy, of which the far greater part of the members are poor and miserable"
> (Smith, 1789, 1961, Vol 1: 88)

Almost 200 years ago Jeremy Bentham pointed out that the utility function would be concave, and show diminishing returns (Bentham, 1811). For people at the poor end of the income spectrum, money is closely related to wellbeing (Lane, 2000; Layard, 2006); a small increase in income can bring real relief, and even a small decline can be disastrous (Freeman, 1999). In contrast, at the rich end of the spectrum small increases or decreases have negligible effects:

> "except among the very poor, income is surprisingly weakly related to one's reported sense of well-being"
> (Bowles and Gintis, 1998: 365).

More than 80 years ago Hugh Dalton explained in a more formal fashion the significance of the relationship between inequality, diminishing returns and aggregate wellbeing:

> "Let us assume... that the economic welfare of different persons is additive, that the relation of income to economic welfare is the same for all members of the community, and that, for each individual, marginal economic welfare diminishes as income increases. Then, if a given income is to be distributed among a given number of persons, it is evident that economic welfare will be a maximum when all incomes are equal." (Dalton, 1920: 349).

Thus for a given level of production the utility function of the whole community is maximized when inequality is minimized. In static terms inequality is clearly a bad.

3.C.2 Inequality and rising productivity

The dynamic effects of inequality are much more contentious, and the interactions of inequality with growth have been the subject of an extensive literature over the last 50 years. The idea that inequality and growth might be connected was first raised by Simon Kuznets (1955) who saw a causality running from the growth path to the pattern of inequality. But since the 1970s there has been increasing interest in the reverse causality, the extent to which inequality enhances or impedes growth.

As explained in Chapter 2, rising productivity is necessary for a rising standard of living. But it follows from the concave welfare function that a productivity indicator such as rising per capita GDP is not on its own a sufficient descriptor of an economy (Alkire, 2002; Osberg and Sharpe, 2002). Production and distribution must both be considered:

> "The limitations of gross national product (GNP) and its rate of growth as indicators of economic well-being are now well appreciated. GNP does not tell us how the benefits of economic activity are distributed" (Fields, 1980: 8).

For a given level of production a higher level of inequality means a lower overall standard of living. Thus, if growth occurs but inequality rises with it, the rising inequality tends to offset the benefits of the growth. This degradation of the growth effect may be only partial, but in extreme cases, with slow growth and a serious rise in inequality, the median standard of living can fall (Slaughter, 1999), leaving the majority of the population actually worse off than before:

> "The U.S. experience of recent decades shows that increases in inequality of labor market income can fully offset the effects of increase in the mean…" (Gottschalk, 1997: 24)

Indeed, in New Zealand during the years from 1988 to 2000, there is some evidence that the median household income rose more slowly than the Consumers Price Index, leaving the majority of households worse off (Hector, 2004). Thus, a general rise in welfare requires not only growth, but that growth be shared (Harberger, 1998; Katz, 1994; Meier and Rauch, 2000).

3.C.3 The equity-efficiency trade-off concept

Prior to the 1970s the received wisdom that inequality was necessary for growth went virtually unquestioned, and the "common wisdom among economists was that inequality should, if at all, have a stimulating effect on accumulation and growth" (Aghion and Howitt, 1998: 280). The Classical economists took for granted that inequality promoted growth (Lindert and Williamson, 1985; Roemer, 2000). Progress was seen as rooted in capital investment, the rich were disproportionately able to invest, and greater egalitarianism was therefore assumed to be growth inhibiting (Galor, 2000; Thorbecke and Charumilind, 2002). Inequality was known to be bad in itself, but the social obligation to place limits on inequality was seen as standing in a tension with the imperative of inequality as a driver of growth, a tension which Arthur Okun described as the "equity-efficiency tradeoff" (Okun, 1975).

Productivity improvements are promoted by secure property rights and by well structured incentives, and these necessities for economic efficiency lead inexorably to some inequality between the members of a society. While inequality might have costs, for a long time it was widely believed that inequality provided the incentives necessary for growth (Aghion, Garcia-Penelosa and Caroli, 1998). In particular, any government intervention which might address inequality was assumed to be distortionary (Boadway and Keen, 2000; Burtless, 2003) and almost certain to impede growth (Welch, 1999).

If we accept that inequality is growth promoting, then it is a necessary evil. There can be no improvement in the general standard of living without an increase in productivity, so if inequality is a necessary component of growth the benefits it conveys will outweigh the damage, at least up to a point. And as Jeffrey Williamson notes:

> "For at least a century and a half, mainstream economists and government officials were guided by the belief that the national product could not be raised if the poor were given a larger share" (Williamson, 1991a: 7).

3.C.4 The effect of inequality on growth

However, the last 30 years have seen the assumption that inequality is growth promoting come under ever increasing scrutiny. As long ago as the 1970s development economists had noticed that countries with very high inequality tended to be particularly stagnant. In practice the more egalitarian developing countries were more likely to have growing economies (Adelman, Morris and Robinson, 1976; Adelman, 1979). In particular, Latin American stagnation with high inequality was frequently compared to East Asian growth with lower inequality (Bridsall, Graham and Sabot, 1998; Hikino and Amsden, 1994).

Cross-national studies, looking at countries which were otherwise similar but not equally egalitarian, found that better growth generally followed lower initial inequality (Freeman, 1996; Birdsall, Ross and Sabot, 1995), especially initial inequality of assets such as land (Alesina and Rodrik, 1994; Deininger and Squire, 1998; Fields, 2001).

For example, Roland Bénabou compared the growth paths of Korea and the Philippines, two countries which in the 1950s were very comparable in terms of standard of living and the extent of industrialization, but which had markedly different levels of inequality. Korea, with the lower inequality, enjoyed rapid growth, while the Philippines stagnated (Bénabou, 1996).

At first it was assumed an equity-efficiency trade-off would be the norm, and efficiency would only be compromised when inequality became excessive (Epstein and Spiegel, 2001). Damaging levels of inequality could be expected in third world countries where inequality was very high, so there would be some circumstances under which the promotion of equity could simultaneously promote efficiency (Atkinson and Bourguignon, 2000; Blank, 2002; Lindbeck, 1998).

But in recent years the debate has widened to include much more than merely the extreme inequality situation. Studies which looked at intertemporal trends for individual countries also found that stronger growth was correlated with phases of lower inequality, even among developed countries where levels of inequality were moderate (Gottschalk, 1997):

> "Both historical panel data and postwar cross sections indicate a significant and large negative relation between inequality and growth" (Persson and Tabellini, 1994: 600).

There continues to be some debate around the phases of growth, and the idea that inequality may be helpful at certain periods. Robert Barro (2000) claims that higher inequality impedes growth in developing countries, but may be helpful in the more developed countries, and Stephen Knowles (2005) agrees that it is consistently harmful in the less developed. However Oded Galor (2000) takes quite the opposite position, believing that inequality was useful in the early industrial era, when growth was rooted in the ability of a country to build up physical assets, but that it is undesirable in more advanced economies which are more human capital dependent.

But as increasingly comprehensive datasets became available the facts consistently refuted the idea of any equity efficiency trade-off (Deininger and Squire, 1996, 1998; Thorbecke and Charumilind, 2002; Lloyd-Ellis, 2003), and the notion of inequality promoting growth is now being questioned very generally (Birdsall, 1997; Epstein and Gintis, 1995b; Galor and Zeira, 1993; Furman and Stiglitz, 1998):

> "The traditional argument that inequality has a positive impact on growth is strongly challenged." (Aghion, Garcia-Penelosa and Caroli, 1998: 32).

and

> "Many articles, both theoretical and empirical, lead to the conclusion that countries characterized by greater equality grow faster, other things equal" (Osberg, 1995: 5).

3.D Outcomes, Opportunities and Mobility

3.D.1 Mobility

The reality that inequality impedes growth more than it promotes it is now very widely accepted, but the path by which this happens is far from fully understood. There are probably several mechanisms at work, but social mobility is often seen as one of the most important.

Social mobility matters because greater mobility leads directly to greater efficiency in the economy (Owen and Weil, 1998; Iyigun, 1999; Amiel and Bishop, 2003). Theory suggests that economic efficiency will be maximized when the talents available in the workforce are able to find their best possible uses, and empirical studies bear out this expectation: Communities with higher mobility do better (Bjorklund and Jantti, 1997; Topel, 1999).

Up to the mid 1980s there was a general belief that modern democracies had largely eliminated the immobility problem. In one of the most frequently cited studies Gary Becker and Nigel Tomes claimed that:

> "Aside from families victimized by discrimination, regression to the mean in earnings in the US and other rich countries appears to be rapid" (Becker and Tomes, 1986: S32)

However, there was relatively little longitudinal data available twenty years ago. Also, Becker and Tomes were writing shortly after the end of the exceptional period of high growth and low inequality which followed World War II. Substantially higher levels of inequalilty have now re-established themselves in many of the most developed countries, and this trend, coupled with much more comprehensive data, have led to a serious re-evaluation:

> "In the seventies and early eighties, researchers argued… that there was considerable economic mobility across generations and little evidence of a vicious cycle of poverty. This consensus changed in the late eighties and nineties when researchers used longitudinal data to examine the persistence of economic status across generations" (Boggess and Corcoran, 1999: 77-78)

It is now generally agreed that higher levels of inequality in society lead to lower mobility (Erickson and Goldthorpe, 1991; Dearden, Machin and Read, 1997; Freeman, 1999; Maoz and Moav, 1999). In particular, greater inequality in a country makes upward movement more difficult (Sloane and Theodossiou, 2000), and what mobility there is, is mostly short range (Gardiner and Hills, 1999).

3.D.2 Inequality of outcomes and inequality of opportunities

Arthur M Okun (1980) drew a crucial distinction between inequality of outcomes and inequality of opportunity. As noted at the start of this chapter, some inequality of outcomes is inevitable. For any productive system to function it is important that effort and contributions be rewarded, and that savings and assets be secure, which in turn leads to some variation in outcomes for different members of a society.

By contrast, inequality of opportunity is generally accepted as being a bad. It is a feature of an efficient economy that the members of the workforce can move easily to work which is best suited to them. Mobility within society is a key indicator of labour market efficiency, since any tendency for workers to be locked into certain categories of work because of their background or circumstances inhibits the efficient matching of skills to jobs. As Christopher Jencks notes, members of the general public are “full of contradictions” (Jencks, 1972: 3), because they fundamentally do believe in equality of opportunity while not believing there should be equality of outcomes (Bénabou, 2000).

The difference between inequality of outcomes and inequality of opportunity is simple in principle, but much less clear in practice. The outcomes for one generation profoundly affect the opportunities of the next, and the likelihood that children will fall into the same socioeconomic position as their parents has been estimated at 40% (Solon, 1992; Zimmerman, 1992). The children who are born into fortunate circumstances have a head start, both in material and in attitudinal terms, and also because they tend to be much better connected in society (Atkinson, Maynard and Trinder, 1983).

In particular, there is a strong correlation between wealth and education, with “educational attainment… responsible for almost half of observed immobility” (Checchi, 1997: 331). This in turn appears to affect subsequent success in careers, earnings and ultimate wealth (Micklewright, 1989; Solon, 1992; Dearden, Machin and Reed, 1997; Jianakoplos and Menchik, 1997):

> “Many societies are concerned about the association between parental income and child schooling because it is perceived that the stronger this association is, the less is intergenerational social mobility and the less equal is opportunity”
> (Behrman and Knowles, 1999: 237).

There is an extensive literature on this effect, which probably reflects a combination of the advantages of parental wealth and the advantages of parental education. Firstly, the child is likely to do better simply as a result of the better housing, health and nutrition which a richer family offers (Gould, 1982; Bianchi, Cohen, Raley and Nomaguchi, 2004; Grossman and Kaestner, 1997):

> "Studies have shown that children who are economically and socially deprived in their first three years of life suffer permanent negative consequences in terms of their personal development" (Sharpe, 2003: S10)

Secondly, better educated parents are likely to encourage the education of their children in a number of ways. They often create a better learning environment at home (Butcher and Case, 1994; Iyigun, 1999), and it has also been found that schools “are more effective for children from strong backgrounds than for children from weak ones” (Coleman, 1987: 35).

Thirdly, good schools develop in good communities. Prosperous families flock together in prosperous neighbourhoods, while poor families have no choice but to live in cheap housing, which usually means in poor neighbourhoods. The schools in the good neighbourhoods have all the advantages of serving families which are more likely to take an interest in education and be supportive of the school, and where the children are surrounded by the children of other well-to-do and well-educated families (Carbonaro, 1998). In America there is a strong tendency toward the selection of school district by house purchase (Durlauf, 1996; Wanner, 2005), and the same trend appears to be emerging in New Zealand (Gibson, Sabel, Boe-Gibson and Kim, 2006).

Finally, the idea of “social capital” has attracted much attention in recent years (Schiff, 1992; Streeten, 2002). The term remains ill-defined and very difficult to quantify, but the intuition underlying it is the evident fact that some citizens are much better connected than others (Isham, Kelly and Ramaswamy, 2002). These social connections can substantially improve people’s access to jobs or influence, and conversely social exclusion can limit their opportunities (Narayan, 2002; Woolcock, 2002). Well-connected parents greatly improve the opportunities of the next generation, and while individuals naturally do their best for their children, this leaves a legacy of immobility which is counter-productive for society as a whole.

3.E Incentives, investment and the role of government

3.E.1 Investment behaviour

A second area in which inequality may impede growth lies in the effect of inequality on public and private investment activity, including the inability of governments to promote forward looking investment in polarized societies. (Sharpe, 2003).

The classical and neoclassical economists assumed that savings drove investment, and investment drove growth. The rich were seen as able to save more, and were therefore the investing class on which growth depended (Lindert and Williamson, 1985; Carvalho, 1997). This sequence was first questioned by Keynes (1939), who radically suggested that investment preceded savings. The bulk of evidence now supports Keynes' contention (Gordon, 1995; Palley, 1996; Chaudhri and Wilson, 2000) and encouragement of private saving appears to do little to boost investment (Foster, 1990; Epstein and Gintis, 1995a). The assumption that a group of wealthy investors would be needed as a catalyst for growth has therefore lost its underpinning, and recent studies strongly suggest that it is more important to have a large middle class of investors, (Galor and Zeira, 1993; Aghion and Bolton, 1997), rather than a small elite.

3.E.2 Access to investment capital

The more egalitarian is the distribution of wealth, including both assets and the wealth value of income streams, the more equal will be the access to investment capital. What an individual or household already owns determines both the ease and the extent to which they can borrow for further investment. For people who are poorer the price of borrowing is therefore effectively higher (Amsden, 1992; Chiu, 1998; Fender and Wang, 2003), and:

> “In the face of capital market imperfections the distribution of wealth significantly affects the aggregate economic activity" (Galor and Zeira, 1993: 50).

The credit constraint argument has often been used in support of publicly funded education, since it is harder for poor families to invest in the human capital of their children (Behrman, Pollak and Taubman, 1989; Chiu, 1998; Birdsall, 1999). But the same argument is equally valid for any form of investment (Bénabou, 2000), such as purchases of land or equipment, or even to finance migration (Rapoport, 2002). The returns to capital would be greater if the poor could invest in their own self-advancement (Bowles and Gintis, 1995), but, to use Amartya Sen’s terminology, they are unable to gain command over capital (Birdsall and Londoño, 1997).

Moreover "the degree of risk aversion is inversely related to wealth" (Bowles and Gintis, 1995: 575), leaving the poor as unwilling as they are unable to take on debt in order to invest. A laissez faire approach to capital markets therefore tends to be suboptimal (Katz, 1994; Fender and Wang, 2003), especially in the human capital market since education has far-reaching positive externalities and is therefore socially desirable (Durlauf, 1998; Finegold, 1996).

However a number of authors have called into question the extent to which access to credit is really the binding constraint (Shea, 2000). While the credit constraint is real, and doubtless affects some poorer households, it has been estimated that the numbers for whom this is critical are probably less than 8 per cent of the population (Carneiro and Heckman, 2002).

3.E.3 Capital : Physical and human

It was suggested in chapter 2 that endogenous growth theory comes closer to the reality of the growth process than does the neoclassical approach, and one outcome of placing greater emphasis on technological change is to increase the significance of human capital. It has been known for twenty years that countries with higher human capital grow faster (Denison, 1985; Barro, 1991; Rosenzweig, 1994). If technological change is the engine of growth, and human capital facilitates technological change (Galor and Moav, 1994; Booth and Snower, 1996), the rate of investment in human capital is likely to be the binding constraint on growth (Jorgensen and Fraumeni, 1995).

It is now widely asserted that, at least in relatively developed economies, human capital is more important than physical capital (Abramowitz and David, 1996; Stiglitz, 1998). Many authors have noted that development is marked by a rising ratio of human capital to other forms of capital (Birdsall, 1999; Judson, 2002), and a recent study has found this ratio to be a clear pattern in New Zealand (Le, Gibson and Oxley, 2006). But rather than a simple reversal of roles this may reflect the ways that different kinds of capital interact (Aghion and Howitt, 1998). As noted in the previous chapter, there appears to be an important complementarity issue (Jorgensen and Fraumeni, 1995), since a better skilled workforce is better able to use new technologies (Lloyd-Ellis, 2002). Investment in human capital therefore also encourages investment in physical capital, since it raises the returns to that investment (Helpman and Rangel, 1999).

The investment problem is therefore closely linked to the mobility issue raised in section 3.D above, since “mobility promotes economic growth via its effect on the accumulation and allocation of human capital” (Maoz and Moav, 1999). Any increase in inequality and its associated tendency to dampen human capital investment is therefore likely to promote a suboptimal pattern, in which excessive investment is devoted to fixed capital, and human capital investment falls short of the ideal (Zhang, 2005).

3.E.4 Polarization and the role of government

In addition to the purely economic effects of inequality, there are also political complications which arise when divisions in communities force governments to follow policies with anti-growth implications. Many investments, including both the human capital investments mentioned above as well as much infrastructural investment, have large externalities (Acemoglu, 1996; Verspagen, 1994). Infrastructural investments are also prone to very large economies of scale, which renders a free market approach inefficient and expensive. It is therefore unsurprising that growth has been found to accompany higher levels of government investment (Temple, 1999).

Median voter theory suggests that in countries where large numbers of citizens are trapped in low incomes, governments have no option but to follow expensive and growth inhibiting redistribution programmes (Alesina and Rodrik, 1994). Since governments are always constrained by the willingness of the public to pay taxes, greater pressure to fund current consumption has a tendency to inhibit the ability of government to fund growth promoting investments:

> “Countries with high shares of government consumption in GDP have grown on average more slowly than others... whereas those with high rates of government investment have tended to grow more rapidly" (Grossman and Helpman, 1991: 2),

An extensive body of literature has established the importance of a large middle class (Galor and Zeira, 1993; Aghion and Bolton, 1997; Rowen, 1998). Whenever a society experiences a disappearing middle, political activity becomes increasingly factionalized. The rich have a vested interest in maintaining the status quo, the poor lobby for a better share, and governments focus on short term appeasement (Persson and Tabellini, 1994; Perotti, 1996).

> "An economy in which workers are sharply divided by income must operate differently from one dominated by a large, confident middle class" (Freeman, 1999: 48).

Inequality diverts taxation revenue, with rising inequality leading inexorably to larger numbers of people in need of public assistance. Safety nets for the poor are expensive in terms of the administration they entail as well as the funds redistributed (Alesina and Rodrik, 1994; Borland, 1999), and the social imperative of reducing poverty interferes with the government's ability to address longer term goals.

With rising polarization it becomes increasingly difficult for action supportive of long term growth to gain political support (Bénabou, 2000). The rich control ever more of the capital, but become increasingly distanced from the interests of their own communities (Galbraith, 2000; Streeten, 2001), a process which has been dubbed "the secession of the successful" (Reich, 1992: 282).

> "Any factor that breeds polarization will worsen policy, and thus cause lower growth." (Easterly, 2001a: 259*)*.

3.F The Effect of Growth on Inequality

3.F.1 The Kuznets curve

Recent literature has concentrated on the effect of inequality on growth, as outlined in the previous two sections. But the first studies to investigate growth-inequality relationships focussed on the likelihood of an effect running in the opposite direction (Epstein and Spiegel, 2001; Topel, 1999).

Simon Kuznets (1955) used data from the early industrialisation phase in the United Kingdom, the United States and Germany, and discovered a pattern of inequality rising during the first period of industrialization, but falling off again as industrialization became more advanced. Growth was seen as requiring workers to move from unproductive agriculture to the modern industrial sector. Initially this would produce a rise in inequality, while there was a premium for working in the modern sector. But as the distribution of the workforce between the traditional and the industrial sectors settled, inequality was expected to drop back again (Lundberg and Squire, 1999).

However the data available to Kuznets were limited to the three early industrializers. Many more countries have joined the industrialized club in the twentieth century, and the wealth of data provided by these newcomers have provided the Kuznets hypothesis with little support (Kanbur, 2000). The right hand side of the Kuznets curve appears to be a widespread phenomenon, with inequality declining as development proceeds (Lindert and Williamson, 1985). However the initial rise of inequality during early industrialisation is a much less regular pattern (Deininger and Squire, 1997). In particular, there has been no Kuznets curve in East and Southeast Asia through a period of exceptionally rapid industrialization, and it seems that it is possible to manage growth without any phase of rising inequality:

> "The Kuznets curve... does not explain the bulk of variations in inequalilty across countries or over time" (Barro, 2000: 5)

3.F.2 Does growth reduce inequality?

Several studies have concluded that income tends to be more equally distributed within wealthier countries (Blank and Card, 1993; Galor and Zeira, 1993). But growth can be accompanied by either an improvement or a deterioration in the level of inequality (Ravallion and Chen, 1997; Lundberg and Squire, 1999), and certain phases of industrialization show inequality rising with growth (Williamson, 1991b; Violante, 2002). Recent trends in the United States are a case in point, where growth has picked up in the 1990s while inequality remains at a relatively high level (Burtless, 2003).

However a lack of growth is strongly associated with high and entrenched inequality. While growth does not appear to guarantee a reduction in inequality it does appear to be a prerequisite (Freeman and Gottschalk, 1998), and growth has been identified as essential if the standard of living of the poor is to be raised (Dollar and Kraay, 2002).

"Generally sustainable economic growth benefits all layers of society" (Bruno, Ravallion and Squire, 1998: 117). But a lack of growth impedes mobility (Maoz and Moav, 1999; Hassler and Rodriguez Mora, 2000) and is generally accompanied by widening inequality as the rich are able to improve their position relative to the poor (Galbraith, 2000). So the reverse causality of growth on inequality is an asymmetric one, with growth unable to guarantee inequality reduction, but nevertheless essential if inequality is not to worsen (Fields, 2001).

3.F.3 Feedback loops

It is now widely accepted that the linkages are bi-directional (Carter and Coles, 1998; Sharpe, 2003). If better growth helps to contain inequality, and lower inequality helps to promote growth, we would expect to find different economies on divergent paths over the long term, and this is indeed the historic experience. I will return to the history of inequality in detail in chapter 4, but the general pattern is one of widespread divergence (Amable, 1994; Baumol, Nelson and Wolff, 1994; Landau, Taylor and Wright, 1996; Pritchett, 1997; Lutzker, 2003).

There may be other explanations for the long run divergence of nations, but the facts are strongly supportive of the idea that reinforcement mechanisms of some sort create the possibility of multiple equilibria (Owen and Weil, 1998) and work to cement long term path dependency. A feedback mechanism between growth and inequality, while not proven, is therefore at least fully compatible with the observed facts.

3.G Unemployment as a form of inequality

3.G.1 Access to work

Differences in wage rates are not the only form of labour market inequality. No less important is access to a wage in the first place.

Firstly it is a matter of efficiency that talents which are available should be put to good use. If a society has an underutilised workforce it follows that it is performing inside its production frontier (Layard, Nickell and Jackman, 1991). Secondly, work is important, not only for income. It is demoralizing if those who would like to work are unable to find anything suitable. Work is an end in itself (Saunders, 2002). It gives people a sense of belonging (Morley, 1994; Phelps, 1997), a sense of identity (Barrett and Spoonley, 2001) and a sense of self-worth in addition to the financial rewards (Lane, 1991; Freeman and Soete, 1994). People need to be needed (Layard, 2006).

Moreover, unemployment is peculiarly persistent. The intergenerational transmission effect discussed in section 3.D is reflected in the likelihood of unemployment as much as in dimensions of human capital and earnings (McKnight, 2000), and further:

> "the experience of joblessness itself is likely to disadvantage low-paid workers even more in their quest for better paid work" (Dunlop, 2001: 96).

Unemployment can therefore be seen as raising particularly strong mobility issues, and is therefore a form of inequality which should be of special concern to policy makers.

3.G.2 Inequality of employment opportunities

Lifelong earnings are a function of wages and of hours in employment. If workers on different wages were all equally likely to spend a given proportion of their working life unemployed, then their lifetime earnings would reflect their wage rates. But this is not the case, and those who command low wages are much more likely to be afflicted with periods of unemployment (Phelps, 1997; Pryor and Schaffer, 1999). Total earnings inequality over the lifetime is therefore more exaggerated than wage inequality.

Between the Second World War and the 1970s unemployment was low in the more developed countries, and exceptionally low in New Zealand (Hawke, 1985). But the last 25 years have seen a substantial rise in unemployment levels in most OECD countries (Nickell and Bell, 1995), which have been accompanied by profound changes in labour market institutions, as well as changing expectations of both employers and workers (Spoonley and Davidson, 2004). Casualisation of work has become increasingly common (de Bruin and Dupuis, 2004), as has the use of part-time employment (Burbidge and Sheehan, 2001).

A more casual approach to work is not bad for everyone. For those who are relatively well off it can bring the social benefits mentioned in the previous section and augment incomes, while avoiding some of the obligations of a permanent full-time position (Blank, 1998). But casualisation and part time work, like unemployment itself, are concentrated on workers in the bottom quartile of the wage distribution (Shirley, 1996; Dunlop, 2001), precisely those who least want it and can least afford it (Booth, 1999). This further reduces lifetime working hours and compounds the income inequality problem (Sloane and Theodossiou, 2000).

3.G.3 Interaction of unemployment and wage flexibility

Many authors have suggested that high wage inequality lowers unemployment. The underlying intuition is that higher wages at the low end would reduce employment opportunities, and minimum wage regulations and trade unions can therefore blamed for penalising the unemployed (Hutton, 1995). As proof, it is sometimes pointed out that Britain and the USA have wide wage dispersion, whereas the Continental West European nations have higher levels of unemployment (Bettio and Rosenberg, 1999; Card, Kramarz and Lemieux, 1999; Slaughter, 1999). However this argument is questionable, as unemployment patterns on the Continent are spread more widely over different groups of workers, and appear to be driven more by macroeconomic policies than by wage tradeoffs (Nickell and Bell, 1996).

In the United Kingdom and the United States unemployment particularly afflicted the low-skill workers who would have been paid the lowest wages (Freeman, 1995a; Galbraith, 2000). Since the seminal work of Blanchflower and Oswald (1990, 1994) it is now widely appreciated that there is no tradeoff between low wages and unemployment (Borjas, 2005), the general case being that depressed wages at the low end of the distribution occur at the same time as high unemployment. This so-called ‘wage curve’ has been found to hold true in many country studies (Glyn and Salverda, 2000a), including New Zealand (Morrison and Poot, 1998; Papps, 2001):

> “The standard model of supply and demand suggests that if wages are raised... employers' demand for labor should drop... The opposite is true.. workers in regions of a country with high unemployment have lower wages than comparable workers in regions with lower unemployment" (Ackerman, 1998b: 18).

3.H Conclusion

It now seems reasonably unequivocal that inequality is an economic bad in every dimension. It has long been known to lower current welfare, but it is now largely accepted that it is also damaging in terms of its effect on growth into the future. It lowers mobility and reduces the ability of the all-important middle class to invest in their own self-advancement. Moreover it promotes socially and politically undesirable polarization, which diverts government activity into short-term palliatives at the expense of investment in education and the infrastructure, where large externalities make public intervention desirable.

But however damaging may be the side effects of inequality, any attempt to reduce it will also have costs. It is therefore important to understand the driving forces underlying an increase in inequality, so that the most appropriate and cost-effective corrective measures can be taken. Chapter 4 reviews the wide variety of explanations for rising inequality that have been advanced over the last two decades, with special attention to the possibility that the technological developments described in Chapter 2 are the principal driver of the most recent phase.

Chapter 4

Explanations for Changing Inequality

4.A Introduction

Inequality has risen and fallen over long periods. From the Industrial Revolution to the late nineteenth century inequality was rising, but from about the 1870s to the 1960s it was stable or trending downwards, and by 1970 the developed countries had reached a position of exceptional egalitarianism. Then, in the mid-1970s, the trend abruptly reversed (Greenwood and Yorukoglu, 1997), and inequality once more began to rise.

Simon Kuznets (1955) published a seminal paper suggesting that industrialization would see inequality initially rise and then fall again as a new distribution of workers across industries stabilized. During the "golden age" following World War II dispersion was so low and so stable that inequality was seen as largely a problem for the third world, and with respect to industrialized countries it attracted little interest (Myles, 2003).

But the latest reversal, coupled with a growing awareness of the social and economic problems attached to inequality, brought the topic back onto the agenda of inquiry (Atkinson, 1997), and in particular prompted economists to revisit the economic forces which drove inequality.

When inequality began to rise in the 1970s it was initially popular to focus on the labour market institutions. This was the Reagan/Thatcher era, when it was widely believed that failure of labour markets to clear was the result of union activity or misguided government intervention (Schettkat, 2003; Simonazzi and Villa, 1999). More recently the balance of opinion has swung toward mismatches of supply and demand, with attention increasingly focused on the skills premium (Pryor and Schaffer, 1999) and explanations based on changing industrial patterns and workforce requirements (Katz, 2000; Pianta, 2001).

The present chapter will review the international and New Zealand literature on the historical trends in inequality, and the arguments which have been advanced in the literature regarding the plausibility of each of these explanations. It will also introduce the empirical work of this thesis and explain how the econometric methods used can help to identify which of the explanations fits the New Zealand data best.

4.B Historic patterns of inequality

4.B.1 Historic trends in inequality

Prior to the eighteenth century production systems and the way of life changed very slowly (Simon, 1994), and inequality, like other indicators of social life, persisted at relatively constant levels (Holderness, 1976: 198). From the mid-eighteenth century, however, inequality has risen and fallen and recently risen again on a very long cycle, and William J Baumol notes:

> "The historic course of reduction in income dispersion... has swung violently several times, meaning that the change that occurred in the 1970s was hardly unique." (Baumol, 2000: 9)

However some countries had lower inequality than others, and given the importance that is now attached to a large middle class, it is perhaps not surprising that the Industrial Revolution of the eighteenth century started in

Britain. At that time Britain had lower inequality than any other European country and had acquired a relatively large, affluent, entrepreneurial middle class (Landes, 1998; Maland, 1968):

> "As the trading, middling sort of People in England are rich; so the labouring, manufacturing People under them are infinitely richer than the same Class of People in any other Nation in the World" (Defoe, 1728: 74).

The Industrial Revolution sparked a massive social upheaval (Mokyr, 1990). Mechanization and the development of an increasing range of manufactured goods saw factories operating at a much larger scale than previously, and large numbers of workers relocating from agricultural areas to cities and factory towns. Urban factory workers would have been more cash dependent than rural dwellers, but the new opportunities provided previously unheard of income levels:

> "Wages in Britain's cities in the 1830s were some 73 percent higher than on farms" (Williamson, 1991b: 68).

However, from the mid eighteenth century onwards the new specialization and urbanization were accompanied by very diverse outcomes for different people. Large returns on capital meant rapidly rising wealth for the fortunate few, while the poor made only small gains (Cameron, 1993), and from the later 1700s until about 1870 inequality was steadily rising (Kuznets, 1955; Karoly, 1993).

In the late middle of the nineteenth century the long term rising trend in inequality reversed. The peak of the Kuznets curve in Britain has been placed around 1860 (Williamson, 1991b: 74) and for the USA around 1870 (Aghion, Garcia-Penalosa and Caroli, 1998: 9). In many of the more developed countries inequality began to decline as the poor made greater gains than the rich (Rosenberg and Birdzell, 1986: 26-27).

In particular, the mid twentieth century, from the 1930s to mid-1970s, was a period of exceptionally low dispersion in all the OECD countries (Juhn, 1999; Karoly, 1993). The depression was a great leveller in terms of wealth (Danziger and Gottschalk, 1995), and once growth began to pick up in the mid 1930s earnings dispersion also declined (McLean, 1991). World War II created an unprecedented demand for unskilled labour, and wage inequality fell so remarkably that the 1940s have been labelled “the great compression” (Goldin and Margo (1992).

Following World War II the low inequality was coupled to unusual growth, and the benefits of that increased production were spread through communities to an unprecedented extent. The median standard of living rose even faster than total production, delivering a great improvement to the general population (Baumol, 2000; Blank and Card, 1993). But this long period of stable or declining inequality reversed again in the mid-1970s (Greenwood and Yorukoglu, 1997; Kosters, 1994). The last quarter of the twentieth century once again saw inequality generally rising (Danziger and Gottschalk, 1993; Wolff, 2004), though this latest movement has not been felt equally in all countries and there is considerable international variation.

4.B.2 International comparisons of recent trends

The English speaking countries have been at the forefront of the rise in inequality (Gottschalk, 1997), with the USA (Acemoglu, 2002; Galbraith, 2000) and the United Kingdom (Haskel and Slaughter, 2001; Schmitt, 1995) leading. The trend was so marked that US inequality continued to rise even through periods of recovery (Levy and Murnane, 1992), though trade cycles usually show inequality declining during expansionary phases (Blank and Card, 1993).

By contrast, the rising inequality experienced by the Continental Europeans was generally rather less (Slaughter, 1999). Germany had a smaller rise than the United Kingdom or the USA (Nickell, 1998; Osberg, 2003), with the Nordic countries showing least of all (Gottschalk and Smeeding, 1997):

> "In the United States the poor are getting poorer. In Germany, by contrast, the poor are getting richer. Britain is in between. The rich, on the other hand, are getting richer in all three countries” (Nickell, 1998).

Some Continental European economies have been troubled by high levels of unemployment, which, as noted in Chapter 3, is a form of inequality in itself. This has given rise to a theory that the United Kingdom and the United States have kept unemployment down by tolerating low minimum wages, while the Continentals have protected their low paid workers at the cost of high unemployment (Atkinson, 2001, 2002), a theory which has come to be known as the “Transatlantic Consensus”.

But the Transatlantic Consensus suffers from two major shortcomings. Firstly, the simple view of the facts themselves may be misleading. As discussed in the previous chapter, the risk of unemployment for the least skilled is just as high in the United States as it is in continental Europe (Glyn and Salverda, 2000a) suggesting that the greater wage flexibility is doing little to help. The ability of wage flexibility to cure unemployment appears to be quite limited Bettio and Rosenberg, 1999; Freeman, 1995a; Nymoen and Rodseth, 2003).

Secondly it portrays Continental Europe as more homogeneous than it is, and the various countries show a wide variety of unemployment outcomes (Abraham, 1999). There are several possible explanations for high levels of unemployment in Europe. Simonazzi and Villa (1999) put it down to poor growth. Pianta (2000, 2001) takes a slightly different view and considers the nature of European growth to be critical, with its emphasis on improving processes, in contrast to US and Japanese emphasis on new products. The tight monetary policies required in the run-up to monetary union have almost certainly contributed (Peters, 1995; Vivarelli and Pianta, 2000), and in Germany’s case there have been the added problems of funding reunification.

Within the English speaking countries, Canada has lower inequality than Australia, which in turn has lower inequality than the United Kingdom (Gottschalk and Smeeding, 2000). New Zealand joined the trend a few years later than the other Anglo-Saxon countries. Jeff Borland (2000) commented that rising inequality in the 1980s appeared to be greater in Australia than in New Zealand, and Peter Saunders also agreed that up to about 1990 the pattern in

New Zealand was less clear (Saunders, 1994), though by 1996 the OECD was putting New Zealand alongside the USA as having a greater rise in inequality than Australia (OECD, 1996).

When it did arrive the rise in inequality in New Zealand was particularly marked (Hyslop and Maré, 2001, 2005; O'Dea, 2000). Podder and Chatterjee (2002) found New Zealand to be extreme compared to other OECD countries, as did Richard B. Freeman who wrote that "excluding tiny New Zealand the US led the pack in increased inequality" (Freeman, 1999: 37).

One particularly disturbing feature of the latest rise in inequality is that in some countries the poor are actually going backwards. The rising inequality during the Industrial Revolution saw the rich pulling ahead of the poor, but everyone becoming better off to some extent (Cameron, 1993). For most countries this has also been the pattern in the last thirty years, but in the United States there is strong evidence that the poor are absolutely worse off than they were before (Juhn, Murphy and Pierce, 1993; Slaughter, 1998). Despite significant growth, many people have not gained as much as they lost through rising inequality (Gottschalk, 1997; Haveman, 2000; Slaughter, 1999). In the USA:

> "Since 1973 CPI-deflated real wages have fallen about 0.4% per year... For many less-skilled workers the declines have been staggering" (Slaughter, 1998: 145).

The pattern of a declining median also appears to be true for New Zealand (Barker, 1996). Between 1986 and 1991 median incomes fell significantly for men of all races. The median fell slightly for Maori women and was almost constant for non-Maori women. Between 1991 and 1996 the median for men recovered part of its fall, while the median for women of all races continued at a constant level (Statistics New Zealand, 2000: 137). Since men make up the majority of the workforce it appears that the median worker was worse off in 1996 than in 1986. The big losers in New Zealand have been male workers, exactly the pattern Freeman (1999) found in the United States.

4.B.3 Changing demand for skills

Throughout history, workers with higher skill levels have naturally commanded higher wages than those without the same skills. However the magnitude of the skills premium has varied over time, and at least over the last 100 years the general trend in inequality has moved closely in step with trends in the skills premium. The twentieth century up to the 1970s was an era of generally declining inequality, and it was also a time in which the margin for skills was in decline (Juhn, 1999). The wages of unskilled workers were generally rising faster than those of skilled workers (Freeman, 1999). Since the 1970s the skills premium has been opening out once more, with a surge in the 1980s (Sill, 2002).

This trend has been found in the USA (Borjas, 1995; Bound and Johnson, 1992; Goldin and Katz, 1998), and in the United Kingdom (Machin, 1996), where the gap between skilled and unskilled wages fell more or less continuously from the end of World War II to the late 1970s. “Since then they have risen very sharply" (Haskel and Slaughter, 2001: 163). The rising skills premium has also been noted in Australia (Pappas, (2001), New Zealand (Engelbrecht, 2000a), and in most states of the European Union (Gregory and Machin, 2000).

Moreover the extent of the general rise in inequality is closely correlated with the size of the skills premium. The USA has greater inequality than Canada, and the skills premium is also much more substantial in the USA than in Canada (Murphy, Riddell and Romer (1998). Similarly, Continental countries like Germany and the Netherlands have strong public policies of providing good schooling for all their young people (Nickell and Bell, 1996), and the general level of inequality is lower than it is in the English speaking countries where schooling is less egalitarian (Checchi, 1997; Haskel and Martin, 1996).

Throughout the more developed countries both employment opportunities and wage rates have held up well for well-qualified workers, and even risen. However wage rates have plummeted for the unskilled workers, and in addition their employment opportunities have been seriously eroded (Nickell, 1998; Phelps, 1997), with rising unemployment and increasing casualisation exacerbating their difficulties.

4.B.4 The technology-education race

Following the pioneering work of Jan Tinbergen (1975) there has been a strong theme in labour economics that technology and education are locked in a never-ending race (Heckman, 2003; Sattinger, 2003). According to this theory, the global production system is constantly becoming more sophisticated, and the associated capital deepening changes the pattern of demand in the labour force (Goldin and Katz, 1996). The demand for skills in the workforce is therefore constantly growing as the proportion of jobs requiring greater skills rises (Abramowitz and David, 1996). On the supply side, education and training are also reaching an ever growing proportion of the workforce, so inequality will rise or fall depending on whether it is the demand or the supply which is currently winning.

The patterns of returns to schooling since World War II suggest that the supply of skills was winning the race during the 1950s and 1960s. At that time secondary education was already universal in the developed world, and the proportion of school leavers continuing to higher education was rapidly rising in OECD countries (Machin, 2001), including New Zealand (Maani, 2000). During the 1960s and 1970s the supply of more qualified workers outstripped demand (Juhn, 1999) and the returns to skills declined.

The reversal in the returns to skills since the 1970s would therefore suggest that for some reason changes in the production system came along faster than the rate of increase in the skills required, and the skills premium opened out (Juhn, Murphy and Pierce, 1993; Mayer and Peterson, 1999; Pryor and Schaffer, 1999). Not only has the earnings dispersion increased, the demand for the less skilled has plummeted (Berman, Bound and Machin, 1998; Levy and Murnane, 1996; Nickell and Bell, 1995):

> “returns to schooling rose over the last thirty years despite the unusually rapid increase in the supply of educated workers" (Acemoglu, 2002:11).

Rising general levels of inequality are thus strongly correlated with rising levels of wage inequality, which in turn are strongly correlated with the rising skills premium. For any explanation of rising inequality to be plausible, it is important that it also makes sense of this crucial aspect of labour market demand.

4.B.5 Sheepskin effects

It has been suggested that rising demand may be more apparent than real. Workers with more ability are likely to self-select themselves into higher levels of education. Thus it could be that the premium paid by employers is a premium for native ability rather than for anything gained during education (Taber, 2001). Higher qualifications would then represent a signalling device rather than a good investment; the so-called sheepskin effect.

However this argument has been largely demolished by the empirical evidence. Denny and Harman (2001) carried out cross-national studies testing earnings against schooling and found: “that there are well determined positive returns to the completion of educational levels" (Denny and Harmon, 2001: 635). Ashenfelter and Rouse (2000) and Bowles and Gintis (2000) likewise found that the return to schooling is not caused by an omitted correlation between ability and schooling, but that : "Those with more schooling earn more at least in substantial measure because they are educated” (Bowles and Gintis, 2000: 120).

Nor is education merely a positioning device:

> "Recent research has shown… that it's a person's absolute amount of education, not her position in the distribution, that affects earnings. As average levels of education have increased over time, years of schooling have had a consistent, positive effect on earnings, while relative position in the distribution of schooling has had little, if any, effect" (Filer, Hamermesh and Rees, 1996: 109)

4.C Possible explanations for the latest rise in inequality

4.C.1 Introduction

The abrupt turning point of the mid 1970s has provoked an extensive debate as to its underlying causes. Why, after a century of stable or declining inequality, did income start to polarize again? After such a long period in which any growth which occurred had been distributed very generally, why did the trend suddenly turn back toward the nineteenth century pattern, with growth predominantly captured by the wealthy few?

Firstly, the possible explanations fall into two broad classes: Arguments based on labour market institutions, and arguments around mismatches of supply and demand. Secondly, the supply and demand issues are split further into two camps: The supply side view, which sees labour markets changing as increasing numbers of women and migrants entered the workforce, and the demand side position based on changes in production systems and the evolving pattern of demand for workers of different types.

Thirdly, the demand side arguments are yet further divided over the source of changing demand (Gregory and Machin, 2000). In the 1990s globalization was widely seen as a major driver of higher inequality, especially through the effect of increased openness to imports from low-cost third world countries. However the last ten years have seen trade-based arguments seriously called into question, and increasing interest in the idea that skill-biased technological change has driven up the skills premium.

I will address the labour market institutions theory and the supply side issues in the next two subsections. But it is the demand side arguments which are currently the most widely accepted and studied, and the questions they raise concerning the global production system are also the arguments which this thesis attempts to address. I will therefore return to them in detail in sections 4.D and 4.E.

4.C.2 Labour market institutions

At the end of the 1970s there was a worldwide shift in the received wisdom on economic management. The post World War II belief in maintaining low unemployment was sidelined and inflation control rose to the top of the agenda. New Zealand in particular was subjected to a swift change in macroeconomic policy (Silverstone, Bollard and Lattimore, 1996) and exceptionally strict policies were put in place in the late 1980s and early 1990s (Evans, Grimes, Wilkinson and Teece, 1996; Kelsey, 1995).

This change in macroeconomic direction was accompanied by a more conservative approach to labour market institutions. Strong unions and government intervention with minimum wages and worker protection were widely held to be responsible for high wages at the bottom end, implying that wages had been artificially compressed for the benefit of those in work but to the disadvantage of the unemployed and labour market efficiency in general.

The appeal of the labour market institutions theory is largely based on its ability to explain the difference between the Anglo American countries and the Continental Europeans (Nickell, 1997; Schettkat, 2003). The English speaking world was much more enthusiastic about rolling back workplace legislation, and union density is lower in the United Kingdom, and substantially lower in the USA, than it is in continental Europe (Blanchflower and Slaughter, 1999).

Card and DiNardo (2002) believe the sudden relaxation of the labour market institutions led to a reallocation of workers which prompted the spike in wage inequality, and Claudio Lucifora (2000) also rejects the alternative explanations as unsubstantiated and falls back on the theory that labour market institutions made a significant difference. But for two reasons the facts do not seem to fit the theory. Firstly, in most countries, and especially in the USA where the rise in inequality began in the early 1970s, the timing does not fit. The reversal in the trend in income dispersion had begun some years before the changes in economic policies (Greenwood and Yorukoglu, 1997).

Secondly, if this theory had been correct it would be expected that lowering wages at the bottom of the distribution would reduce unemployment. But no such effect has been detected (Glyn and Salverda, 2000a). There is a strong correlation between high unemployment and low bottom end wages (Galbraith, 2000), and no evidence that any relaxation of minimum wage regulations would have helped the unemployment problem (Simonazzi and Villa, 1999).

While different labour markets may explain some of the different unemployment patterns between the Anglo-Saxon and the Continental countries, most commentators conclude that the effects are small compared to those of changing labour demand (Acemoglu, 2003a; Heylen, Goubert and Omey, 1996; Webster and Tseng, 2002):

> "The… mismatches suggest that technological change, the composition of the economy and demand factors can offer a powerful explanation for current unemployment, a more convincing one than that provided by traditional views looking at labour markets alone, emphasizing the lack of flexibility of labour regulations, wage levels or the skill composition of the work force." (Pianta, 2001: 144).

4.C.3 Demographic effects

The supply of workers in many countries has been changing, partly because of married women becoming much more active in the paid workforce and partly because of rapidly rising migration in recent decades (Haveman, 1997).

To the extent that women take low-paid jobs this could help to explain rising inequality through increased supply at the low end of the labour market. However in most developed countries, and certainly in New Zealand, gender inequality has been declining for at least 40 years. In the 1930s and 1940s women in paid employment were very largely confined to low-paid low-skill work (Ferguson and Galbraith, 2001; Karoly and Burgess, 1995). But attitudes began to change with the women's movement of the late 1960s, and equal opportunities were formally legislated in the 1970s.

Female education rapidly overtook male in the period 1965 to 1990, and by the early 1990s more young women than young men were completing high school and tertiary qualifications (Statistics New Zealand, 2000). Particularly in New Zealand, the primary industries remain a bastion of male dominance, whereas female paid work is generally urban and frequently white collar. As will be detailed in chapter 6, it is precisely the white collar industries, where women tend to be clustered, that have shown wages and inequality to be rising fastest. It is therefore not surprising that "returns to higher education have been higher for females since 1981" (Maani, 1997: 78), and that women have been gaining on men in terms of acquiring education, and in applying that education to gain more skilled work (Engelbrecht, 2001).

> "About half the total reduction in the gender log hourly earnings differential between 1984 and 1995 can be attributed to the increased similarity of male and female characteristics" (Dixon, 1996: 39)

Since women are overtaking men in terms of skills and opportunities, arguments that women have suddenly swamped the low-skill end of the labour market do not seem very plausible.

Immigration is another supply side argument that has been advanced. This has been studied extensively in the United States, where large numbers of migrants have entered, especially from the Latin American countries. These are typically low-skill workers (Rosenthal, 2004) who might have had the effect of reducing job opportunities and forcing down wages at the low end of the market, though Borjas et alia note that "area studies have generally found that immigration has had only a slight effect on native outcomes." (Borjas, Freeman and Katz, 1996: 246).

Harford (2006) compares the serious rise in wage inequality in the United States where many migrants were unskilled, with the less extreme rise in the United Kingdom, where immigrants were screened according to skills and low-skill migrants were largely excluded. However this explanation fails to fit the New Zealand case. Immigration into New Zealand is subject to strict rules, and being an island nation with access only by air, it is readily monitored. Apart from small quotas of Pacific Islanders and refugees, most migrants are required to meet strict conditions for education and other skills, and the skill levels of migrants are generally higher than those of the native population. Of full-time workers in the 2004 Income Supplement data, 27 percent of migrants have university degrees compared to 13.3 percent of non-migrants, and 14.5 percent of migrants have no qualifications compared to 20.7 percent of non-migrants. With immigration policy biased towards the high-skilled workers it seems highly unlikely that recent immigration has promoted increasing wage inequality.

4.D Globalization

4.D.1 Introduction

The period from the 1929 crash until the early 1970s was one of fixed exchange regimes and substantially regulated international trade. The abandonment of fixed currencies started with the United States in 1973, and was quickly followed by many countries including New Zealand in 1984. GATT and the WTO encouraged the elimination of barriers to trade, and north-south trade increased substantially in the more liberal climate (Feenstra, 1998; Obstfeld, 1998).

Many commentators have suggested that greater global integration may be responsible for the renewed rise in inequality (Moran, 1999), through two possibly related trends: Displacement of low skill workers in developed countries as a result of increased imports from low wage countries; and changes in the patterns of industries in the more developed countries as low-skill intensive work is abandoned or outsourced, and domestic industry concentrates increasingly on the more capital intensive areas.

4.D.2 Import penetration

Import penetration from third world countries has often been suggested as a major driver of rising inequality (Bhagwati, 1998; Burtless, 1995). This argument usually takes the following form: Third world countries have a shortage of skilled labour, but an abundance of cheap unskilled labour. Increasing trade between developed countries and third world countries results in the developed countries importing increased quantities of manufactured goods with a large low-sill labour content. The effect of these imports is to force down the wages of unskilled workers in the richer countries, or eliminate their jobs altogether, while leaving the more skilled workers relatively unaffected (Wood, 1995).

In its simplest form this argument has been largely rejected. The greatest rises in trade volumes have been between the developed countries, and trade with third world countries does not appear large enough to have the observed effects (Machin and van Reenen, 1998). Robert Z Lawrence points out that US trade with third world countries nearly doubled in the decade of the 1980s, but this still only amounted to 2.1% of US GDP in 1990. The “arithmetic does not add up” (Lawrence, 1995: 19).

> "Trade with industrialized countries contributed as much to the growing wage gap as did trade with developing countries, contrary to the assumptions of the most commonly expressed trade argument" (Brauer and Hickok, 1995: 72)

But the most common basis for rejecting this theory lies in the apparent results for different industries. Burtless (1998) and Machin (2003) both note that industry inequality rose equally for those industries which do trade and for those which do not, whereas the trade effect would be expected to show up as rising inequality between industries.

The New Zealand experience also tends to confirm this international experience. As noted in section 4.B.2 above, New Zealand has suffered one of the greatest rises in inequality of any country, but its export trade is not in the industries with high worker skill-levels. New Zealand exports are predominantly in the primary industries which are the industries least affected by lack of worker skills (Ballingall and Lattimore, 2002). By contrast, as the empirical sections of this thesis will show, the industries where the skills premium has risen most, like banking, insurance and public administration, are among the least traded.

4.D.3 Outsourcing

One variant of the trade argument has greater plausibility. The great reduction in freight costs has made it practical to outsource the more labour intensive stages of much manufacturing, and trade today is increasingly intra-industry rather than inter-industry (Feenstra and Hansen, 1996; Rodrik, 1997). Outsourcing would be obscured in the between industry comparisons of Burtless (1998) and Machin (2003), since it is only the labour that is being purchased instead of the goods themselves.

However, the outsourcing argument has also been questioned on the grounds of its being too small to have the observed effects. Rodrik (1998) notes that despite very large gross capital flows, the net flows are quite small, and:

> "There is little evidence... that U.S. multinationals are reducing the demand for [production workers] ... by shifting large numbers of production worker jobs out of the country" (Moran, 1999: 105).

While the globalization arguments continue to circulate, most commentators are agreed that neither trade nor outsourcing explains more than a minor part of the recent inequality trend. Brauer and Hickock (1995) concluded that trade explained 10 percent of the rise, and Gary Burtless believes it is “no more than one fifth” (Burtless, 1998: 62). Feenstra and Hansen (1999) estimate that outsourcing caused 15 percent of the rise, and:

> "My scorecard reads; trade matters, but it is neither all that matters nor the primary cause of observed changes" (Freeman, 1995b: 30).

4.E Skill biased technological change (SBTC)

4.E.1 Introduction

The cause of rising inequality remains unproven, but the majority of commentators favour explanations based on technological changes which are biased against low-skill workers and in favour of higher-skilled workers (Chennells and van Reenen, 1997; Piva, Santarelli and Vivarelli, 2003).

Technology is never skill neutral. As noted in Chapter 2, productivity in different industries is constantly changing, and the proportions of the workforce in each industry or performing different tasks within each industry are therefore also undergoing constant readjustments as an economy evolves. It follows that every change in the production function is likely to be reflected in a changing level of inequality, raising inequality if the technological change is skill biased, and lowering inequality if it favours the unskilled.

In the early phase of industrialization it was common for new technologies to deskill the workforce, as machines replaced artisans and relatively low-skill workers were capable of controlling the machines (O'Mahony, Robinson and Vecchi, 2004). The abrupt change in the 1970s and the rising skill premium suggest that technological change is now generally skill-biased (Acemoglu, 2002).

There are two possible paths whereby industrial change might favour more highly skilled workers. Firstly, SBTC might occur within industries, with automation displacing process workers more than it affected skilled tasks. This would lead to a changing pattern of labour demand of the sort that has been identified in the last few decades. Or secondly, there might be changes between industries, as a result of some industries changing or expanding faster than others.

4.E.2 Information and communication technologies (ICT)

The period when the advantage enjoyed by skilled with respect to less skilled workers began to widen was also a period of rapidly changing technology in the workplace. Computers were applied to a wide range of tasks from controlling manufacturing processes to a mass of information handling in offices. Technological change has not been proven as the principal driver of rising inequality, but the last decade has seen it emerge as the prime candidate (Bound and Johnson, 1995; Goldin and Katz, 1998).

The importance of technological change as a source of economic growth was noted in Chapter 2, and this has given rise to extensive research into different kinds of technology and the nature of technological change. Some technologies, especially those relating to specific industries, evolve progressively and display steady incremental improvements rather than more radical innovations (Freeman, 1992). In contrast, "General Purpose Technologies" or GPTs (Bresnahan and Trajtenberg, 1995; David, 2000) spark a revolutionary change in modes of production, affecting countless industries. Examples of GPTs include steam power in the nineteenth century and electrification at the turn of the century (Helpman, 1998), and many authors have suggested that information and communication technologies represent the latest of these general purpose technologies (Brynjolfsson and Hitt, 2000), with the general purpose nature of cheaper and better ICT permitting co-invention of more and more complex uses (Bresnahan, 1999; Lipsey, Bekar and Carlaw, 2005).

Whether a new general purpose technology, such as ICT, raises or lowers the demand for skills can only be determined empirically. Either outcome is possible depending on which segment of the labour market is most affected and the nature of the impact (Autor, Levy and Murnane, 2003; Krueger, 1993). But a causal link between increasing use of technology and the decline in demand for less skilled workers is widely accepted as very plausible, since returns to schooling have been found to be higher in industries making greater use of advanced technology (Allen, 2001). Moreover, the rate of skill upgrading has tended to be greatest in industries with greater computer investment (Autor, Katz and Krueger, 1998; Johnson, 1997).

4.E.3 The sources of the skill bias

Early studies (eg. Krueger, 1993) established that there is a wage premium associated with computer use, the implication being that computer use directly raised the contribution of the worker. Since the late 1990s, however, the idea that computers directly drive wages has been increasingly questioned. Rather than a simple complementarity between computer use and the skills of workers, most commentators now consider that there is a complementarity between skilled workers and an automated workplace (Bresnahan, 1999; DiNardo and Pischke, 1997).

Freeman (2002) studied employment figures by industry for the USA, and established that demand is strong for those who are working with computers as well as for those in the IT industry proper. If well educated workers are continuing to enjoy an enhanced premium at a time when demand for ICT specialists has stabilized, this provides evidence that the skills premium is driven by the new workplace rather than the technology itself.

Since the pioneering work of Richard Nelson and Edmund Phelps it has been appreciated that better educated workers are better equipped for decision making in all areas, and not merely their own field of specialization (Nelson and Phelps, 1966; Huffman, 1974). This return to adaptability may explain why computerization appears to be strongly associated with occupational restructuring (Brynjolfsson and Hitt, 2000; Wolff, 2002), with better educated workers enjoying a comparative advantage in implementing new technology (Bartel and Lichtenberg, 1987).

There is significant evidence to suggest that the workplace reorganisation facilitated by ICT has boosted demand, not so much for ICT specialists, as for the generally well educated workers who are best able to adapt to and operate in a rapidly changing environment (Howell and Wolff, 1992; Schultz, 1993). New Zealand evidence provides support for this theory, with a recent study showing that employment of IT specialists as a proportion of the total workforce has peaked at only some 4%, and while still growing in absolute numbers its share of the workforce actually declined during the 1990s (Blumenfeld and Thickett, 2003: 2).

The existence of a correlation does not establish either the nature or the direction of causality. At least in part, the computers could be following the higher incomes rather than driving them, since “firms may allocate computers to their most able workers, so what is measured is the combined effect of computer use and ability” (Daldy and Gibson, 2003: 14). However the results of a study using panel data from the British National Child Development Study to control for worker heterogeneity suggest that the wage premium exists independently of the unobserved characteristics of either firms or individuals (Bell, 1996).

4.F Purpose of the present thesis

4.F.1 Summary of the existing literature

In most developed countries inequality has risen considerably since the 1970s, and unemployment has also risen especially among the less-skilled members of the workforce. In terms of wage inequality the New Zealand case is one of the more extreme, and unemployment, while less serious in this country than in many, is likewise a problem which particularly afflicts those at the low end of the skills spectrum.

If we can identify where the rise in inequality is occurring, we may have some indication of what is driving it. If inequality is rising within industries rather than between industries the implication is domestic SBTC. It would seem the supply of skills is not matching the demand generated by new work practices, and those who have skills are enjoying a premium over those who lack them. By contrast, to the extent that inequality is rising between industries it would be more likely to reflect deindustrialization and globalization. Rises in between industry inequality suggest a Kuznets-type intersectoral evolution, with stickiness in the reallocation process as industrial patterns change while it takes time to achieve the best matching of workers.

The bulk of overseas literature tends to suggest a strong skill premium and rising inequality within industries but between firms and establishments. This pattern is strongly suggestive of returns to adaptability. It implies that some firms have adopted a rapid modernization path, making deeper use of capital and paying premia for staff who can move with the changes and make the new approach worthwhile, while other firms are able to retain a niche in their industry using more traditional equipment and methods.

This pattern would also suggest that globalization effects are relatively secondary, being somewhat correlated through the downstream effect that it is mostly export oriented companies which usually pursue company growth most vigorously.

4.F.2 The present study

The purpose of the present thesis is to investigate the patterns of rising inequality in New Zealand, and to consider these in the light of new technology and the demand for skills within and between different industries. In particular, because the pattern of New Zealand trade is rather different from that in other developed countries, similarities or differences between the New Zealand experience and those found overseas can help to elucidate which forces have been driving the rising inequality of the last twenty years.

This thesis uses data from the Population Census and from unit record files to investigate the patterns of inequality in New Zealand. If rising inequality is inter-sectoral the problems are more likely to be temporary, and adjustment can be expected to take effect automatically, though it may be painful in the short-run. But if the inequalities are between workers of different skill levels and the problem is a general shortage of skills, then it is much less likely that any adjustment will take place automatically.

The extent to which rising inequality is between industries or between groups of workers is therefore an important guide to appropriate public policy. If inequality is within groups and between industries, the best strategy is probably to facilitate adjustment. However the opposite pattern, with inequality between groups and within industries is likely to be more intractable. The only long term answer to this problem is to raise general levels of education and skills, if the country is to avoid greater polarization, and the economic and social problems which that would bring.

I also study the extent to which the rise in inequality was temporary. Most authors have concluded that it was most marked in the late 1980s or early 1990s (Hyslop and Maré, 2001; O'Dea, 2000), and that the rise has substantially eased in recent years and may even have reversed. It is still rather too early for this to be answered with confidence, but it is another important distinction from a policy point of view, as here again, if the inequality is more permanent, it would suggest a more determined policy response.

Chapter 5 following describes the data and methods used to investigate these issues, and Chapters 6 to 9 report the findings.

Chapter 5

Data and Methods

5.A Introduction

It is the hypothesis of this study that recent changes in technology have been skill-biased. In order to test this hypothesis the empirical chapters which follow examine the patterns of inequality change in New Zealand according to industries and the skills and qualifications of workers. To this end we need data sets which reveal worker numbers, and the age, occupations and skill levels of workers in each industry, with the industries as finely divided as possible.

There are two available data sets which provide relevant worker information: The Census of Population and Dwellings, which is conducted every five years, and the New Zealand Income Survey. Each has its strengths and its limitations. The Population Census is only conducted every five years. But it has been maintained for many decades without interruption, and with only minimal changes to the variables collected. The New Zealand Income Survey is annual, and provides more detailed and precise information. However these data have only been collected since 1997, and being unit record data access to them is strictly controlled. Section 5.B describes these data sets in detail.

An indicator of technology uptake is also needed, in order to check whether the new technologies are related in any systematic way to workers skills and changing worker demand in different industries. A number of different technology-uptake measures have been used in different countries, but the analysis which follows uses expenditure on computing hardware and software as reported by Statistics New Zealand in the Input-Output tables. The reasons for this choice are explained in Section 5.D.

5.B Sources of income data

5.B.1 The New Zealand Population Census

For the present study New Zealand Population Census data were purchased for the Census years 1991, 1996 and 2001. The information requested was numbers of workers and average age of workers, broken down:

By gender
By industry (using the 62 industry classification)
By personal income bracket (the 11 income brackets in the Census)
By highest qualification achieved

Census data have the merit of being virtually comprehensive, but they are limited in terms of the range of questions asked, and the way these questions are structured. For one thing, questions on topics such as income are expressed in terms of income brackets, which inevitably give less precision than unit record data would provide. Thus instead of analyzing patterns over individuals, the analysis has to compare averages of workers with certain characteristics in the various industries, and some covariances within unit record data become unobservable.

Secondly, this thesis being an exploration of the wage effects of new technology, it would have been ideal to have information about hourly wages received. However, the only Census question relating to income asks respondents for total income in the last year from all sources. The data purchased were therefore restricted to full-time workers, since these workers can be expected to receive the great bulk of their total incomes from earnings.

The total number of full-time workers rose from some 891 200 in 1991 to some 997 300 in 2001, with the proportion of female workers in the full-time workforce rising from 39.9 percent to 42.6 percent. Table 5.1 gives a summary of worker numbers by gender in each Census year. Appendix 1A provides a more detailed table of the Census data, broken down by worker numbers in each education level and also subdivided by gender. The Population Census uses an 11 step scale for qualifications, but these were grouped up to the 7 step scale used in much previous New Zealand research (Maani, 1997; Winkelmann, 1998).

Table 5.1 : New Zealand Population Census
Full-time workers

1991	Male workers	535 539	60.1%
	Female workers	355 674	39.9%
	Total	891 210	
1996	Male workers	551 718	58.7%
	Female workers	387 447	41.3%
	Total	939 162	
2001	Male workers	572 244	57.4%
	Female workers	425 088	42.6%
	Total	997 332	

In 1991, 10.2 percent of male workers were graduates, compared to 9.1 percent of female workers. By 2001, not only had women increased their share of the workforce, but 18 percent of female workers were graduates compared to only 14.6 percent of male workers.

Just as dramatic is the change in relative numbers for workers who left school with few if any qualifications. In 1991, 40 percent of male workers had no qualifications beyond School Certificate, while for female workers the figure was 42 percent. By 2001, the proportion of males with no qualifications beyond School Certificate had risen to 45.5 percent, while the proportion of female workers had fallen to 40 percent.

Evidently women perceive a greater advantage in pursuing education to higher levels. This may well reflect a greater skill premium for women than for men, if the job opportunities for unskilled women tend to be especially poorly paid. Appendix 1B gives the worker numbers in each of the 62 industries for each Census year.

5.B.2 The New Zealand Income Survey (NZIS)

Since 1997 Statistics New Zealand has conducted an annual New Zealand Income Survey (NZIS) as a supplement to the June quarter of the Household Labour Force Survey (HLFS). The Income Survey collects an extensive array of income information, including hourly, weekly and annual usual and total wages. The NZIS surveys some 30 000 individuals aged 15 or over, and includes information on the industries and occupations those individuals are employed in, their highest level of qualification achieved, and many other details such as marital status and ethnicity.

For confidentiality reasons the full Income Survey data set is carefully controlled, and access to it by outsiders is only possible for approved projects conducted at the Statistics New Zealand Datalab, where all output can be checked before release. However, since 2002 Statistics New Zealand have been putting the NZIS data through a confidentialising process. This involves some top coding of numbers to exclude outliers, and some rounding to make identification of individuals more difficult. It also involves some regrouping into broader categories, such as grouping location of residence from the local government districts into 10 larger regions.

With the risks to confidentiality much reduced, the resulting Confidentialised Unit Record Files (CURFs) are available for use outside Statistics New Zealand offices, and while the loss of some detail is regrettable they are beginning to prove a very useful research tool. In particular, the appearance of IS CURF data every year facilitates the tracking of relatively recent trends in personal incomes. Full details of CURFs available and the confidentilising process are available on the Statistics New Zealand website (Statistics New Zealand, 2004).

As of mid-2006 three years of Income Supplement CURFs had been released. The present chapter uses the 2002 and 2004 CURFs, the earliest and latest currently available, to examine wage inequality between workers in each of those years, and also the inequality trend over this two year period.

The CURF data provide many different income and earnings variables, but because this is a study of the technology and industry effects on wages it focuses on the usual hourly wage from first job. This variable should be the most responsive indicator of the earnings effects of industries and worker characteristics.

5.C Industry information from Statistics New Zealand

The Population Census records each worker as being employed in one of 64 industries. However the following six categories were deleted from the data analyzed, either because there were very small numbers of workers and many empty cells, or (in the case of line 64) because the industries could not be identified:

5	Hunting and Trapping
22	Petroleum Refineries
53	Owning Owner-Occupied Dwellings
61	Domestic Services
63	International And Extra-Territorial Body Operation
64	Unidentifiable/ Not Specified

There were no data supplied for industry 53, and industry 63 was not used in 2001. Industries 5, 22, 61 and 63 had large numbers of empty cells. Moreover, in the case of industry 22 (petrol refining) there is only one firm in New Zealand, so data on wages and education levels of workers is as much firm-specific as it is industry-specific. Appendix 2 gives details of the numbers of workers in the 58 usable industries.

5.D Measures of ICT uptake

There is no generally accepted best proxy for the uptake of new technologies, and two broad approaches to quantifying technology uptake have been used. One approach is to use indicators of level of innovation, usually either R & D expenditure (Allen, 2001; Gregory and Machin, 2000) or use of patents (Bartel and Sicherman, 1998). R & D expenditure is one of the most widely used proxies internationally, but has serious drawbacks. Lundgren (2000) has noted that there is little connection between R&D and innovation, and moreover:

> "The advantage of this variable [the ratio of R&D to net sales] is that it is a direct measure of innovative activity in the industry, but… the innovative activity refers only to the industry in which the innovation originates, not the industry where the innovation is actually used" (Bartel and Sicherman, 1998: 729).

Pilat (2002) points out that Australia and New Zealand are both among the countries with very high levels of ICT diffusion, but Parham (2002) has commented that while Australia is a high user it is low in the league of countries which produce new ICTs, and the same is doubtless true for New Zealand. R&D is therefore an inappropriate measure in the New Zealand context, and number of patents used suffers from the same limitations

The second approach is to use new investment as a proxy for innovation, either using specific technology measures such as computer use (Gittleman and Handel, 2003) or expenditure on ICT equipment and services (Katz and Autor, 1999), or sometimes using broader measures of new investment such as age of capital or capital-labour ratios. A correlation has been found between rising capital-intensity and higher wage dispersion (Caselli, 1999), suggesting a skill-bias related to changing capital-labour ratios. But using a general investment indicator as a proxy for ICT is open to question, since ICT is only one possible area for new investment, and capital-intensity tends to rise in any industry with large economies of scale.

The present study therefore focuses on industry expenditure which is specifically on computers and computer services, using data drawn from the 1996 inter-industry input-output tables compiled by Statistics New Zealand. These tables provide figures for the expenditure by each industry on goods and services purchased from each industry, expressed to the nearest million dollars (Statistics New Zealand, 2002). In addition to inputs from other industries, the input-output tables provide industry expenditure on wages of employees and operating surplus, as well as figures for imports and exports in each industry. These figures facilitate controlling for wage-intensity, for profitability (using operating surplus as a proxy) and for trade effects.

Unfortunately the 1996 input-output tables were an experimental one-off project which has not been repeated, and Statistics New Zealand advise that there is currently (2007) no update planned. It would be very desirable to track changes in the ICT inputs by industry over a period of years, to monitor the consistency of ICT investment over time and as a check whether any particular year such as 1996 was typical. However this appears to be impractical at present.

The 1996 industry expenditure information provides a reasonable ICT-use indicator for the analysis of the Census data between 1991 and 2001. However it is now becoming increasingly out of date, and this source is less satisfactory for the analysis of wage trends in the Income Supplement since 2002. The lack of any more recent source of ICT-uptake data will be an increasingly serious problem for any extension of the present study into later years.

The input-output tables are published at two levels of detail, but the more detailed 126 industry by 210 product version was chosen because it provided separate commodity data for computer hardware, and computer software and services. Statistics New Zealand provide a concordance between their 126 industry groupings and their 49 industry groupings. Neither of these exactly matches the 62 industry division used for the Census data, so a new concordance between the 62 and the 126 industries was created (Appendix 3).

5.E Analysis of Census data

5.E.1 Income inequality trends by industry

The Census data were used to estimate earnings functions for full time workers in each industry and each Census year, with estimated coefficients on each of the seven qualification levels. There are large numbers of workers with bachelors degrees, and also large numbers who only hold School Certificate. These two levels of qualifications were taken as being indicative of workers near the ends of the qualifications spectrum, and the ratio of these coefficients was used as an indicator of the skills premium being paid by employers in each industry and each Census year.

The trend over time is examined by dividing the skills premium in one Census year by the skills premium in the previous Census year. This time trend is then regressed on the industry use of computing, as an estimate of the extent to which any change in the industry skills premium is associated with the use of computer technologies. The analysis is described in detail in Chapter 6, and the regression estimates are reported in Appendix 4.

Within-group inequality trends were also estimated by calculating Gini coefficients for workers' incomes within each industry and qualification level. Changes in the Gini coefficients between one Census year and the next were regressed on the proportion of industry expenditure devoted to computing inputs, as an indicator of the extent to which industry computing was related to trends in within-group inequality.

5.E.2 Employment change by industry

The Population Census data were further used to examine the extent to which workers of different qualifications levels are experiencing increasing or declining work opportunities in different industries. Unemployment is itself a form of inequality, since employment opportunities tend to vary systematically with skill levels. Typically, demand is strongest for the well qualified workers, and weakest for the least-skilled workers. Thus an employment differential across workers of different skill levels is a form of between group inequality, analogous to the skills premium described in the previous section.

The Census data were used to estimate a labour skills demand function for full-time workers of each qualification level, in each industry and over each inter-censal period. The dependant variable is the proportional change in numbers employed in each industry and year, and this was regressed on computer use and other industry variables, to check whether there is any correlation between computer uptake and changing labour demand patterns. The detailed findings of this investigation of employment trends are reported in Chapter 7.

5.F Analysis of New Zealand Income Survey data

5.F.1 Income dispersion in the 2002 Income Survey data

As noted above, the New Zealand Income Survey provides a source of earnings data which are both more up-to-date and more specifically wage information than the Census offers, though as yet they are only available for a few years.

Quantile regression analysis was applied to the hourly wages of workers as reported in the New Zealand Income Survey for 2002. Quantile regression permits the simultaneous estimation of the relationship between wages and computer uptake at different points in the conditional wage distribution. In this study the 10^{th} percentile (P10) and the 90^{th} percentile (P90) were chosen, the

P90:P10 ratio being taken as an indication of the skills premium in each industry.

5.F.2 Trends in the CURF data between 2002 and 2004

For the final phase of the study, industries were divided into two groups, according to whether or not they were significant users of the new technologies. Industry expenditure on computer equipment and services varies from virtually zero in the primary industries up to nearly 4.9 percent of total industry inputs in banking. A cutoff line was drawn at 0.8 percent of total industry inputs. Only 14 industries out of 58 spend a higher proportion than this on computer equipment and services, but these 14 industries are among the largest and provide employment for some 45 percent of all workers. This cutoff point therefore divides the workforce into two groups of approximately equal size. Appendix 2B lists the 58 industries in order of ICT-uptake.

Inequality patterns have shape as well as magnitude, with the consequence that no simple measure of inequality is able to capture nuances in the distribution. For this reason, three inequality measures were used in the analysis: the Theil measure, which is most sensitive to income differences towards the top of the distribution, the Gini coefficient, which is most sensitive to differences around the mode of the distribution, and the Atkinson (A2) measure, which is most sensitive to differences near the bottom of the distribution.

These three inequality measures were calculated for wages in the CURF data for 2002 and 2004, for workers in the high-technology group of industries and the low-technology group. This allows comparison of the inequality between workers in the different industrial groups, as an indicator of the technology effect. It also provides an indication of recent trends over time, though the availability of CURF data for only a two year interval is rather limiting.

DiNardo, Fortin and Lemieux (1996) pioneered a technique for reweighting one set of observations to the characteristics of another, as a method of isolating which variables explain the differences between the two sets. This technique is applied to the workers in the two groups of industries, as a test of the extent to which wage differentials are explained by worker characteristics as against differences intrinsic to the technology.

5.G Empirical contribution of this study

The findings on New Zealand inequality trends outlined above are covered in detail in Chapters 6 to 9 following. The broad facts of rising inequality have already been widely documented elsewhere, but this thesis represents the first major attempt in New Zealand to isolate the underlying causes.

In particular, international literature mostly suggests that inequality has risen because of a rising skills premium associated with new technology. Against this background the present thesis probes the relationship between earnings inequality and the adoption of new technology since 1991. In particular, Chapters 6 and 7 report on the broad trends as revealed in Population Census data between 1991 and 2001. Chapters 8 and 9 use unit record data to probe more deeply into the workers' attributes which are most likely to explain the relationship between new technologies and the trends in wage dispersion, thereby providing an indication of what public policies would be most appropriate.

Chapter 6

Skills differentials and the use of new technology in New Zealand
Patterns across industries

6.A Introduction

Inequality in earnings and in incomes increased considerably in New Zealand in the last quarter of the 20th century (Borland, 2000; Chatterjee, Podder and Mukhopadhaya, 2003), as in many other developed countries (Atkinson, 1997; Freeman, 1999). This rising inequality is coincident with the rapid diffusion of computers and other information technologies, and in other developed countries the rising inequality has also been found in conjunction with a rising skills premium. Skill-biased technical change (SBTC) is therefore one of the most favoured explanations for the growth of inequality (Goldin and Katz, 1998).

When inequality is rising, it may either be between groups of workers with certain characteristics or it may be within such groups, or some combination of the two. If the SBTC theory is correct, we would expect a rise in inequality to be largely between groups of workers with different skills or qualifications, as the premium for acquiring certain skills increases. In this chapter I use Population Census data from 1991, 1996 and 2001 to explore income differentials by level of education and worker experience for full-time workers in 58 industries covering the entire New Zealand economy. In particular I try to determine the extent to which rising inequality is reflected in the skills premium, and therefore a rise in between-group inequality, and the extent to which it is a rise in within-group inequality.

The skills premium in New Zealand industries is estimated by means of the ratio of the marginal wage effect of having a bachelor's degree compared to the marginal wage effect of only having School Certificate. Change over time in the skills premium is examined by comparing this ratio in one Census year with the same ratio in the subsequent Census year, for each of the two inter-censal periods.

In order to estimate changes in within-group inequality, I calculate Gini coefficients for income inequality by industry, within groups of workers with the same level of educational qualifications. These Gini coefficients are calculated for each of the three Census years, in order to estimate the trend in within-group inequality over time. Data on industry use of computers from the 1996 Input-Output tables (as discussed in section 5.C) are used to examine the relationship between new technology and the changes in both within-group and between-group inequality.

6.B Data

6.B.1 The Population Census

This chapter uses data from the New Zealand Population Census for the years 1991, 1996 and 2001, as described in Chapter 5 and summarized in Appendix 1. The Census data were purchased in a disaggregated form which provided worker numbers in each of 63 industries, with the numbers in each industry further broken down into 12 income brackets. These brackets are typically $5 000 wide for incomes below $30 000, and $10 000 wide above that. Within each industry the workers were further divided into seven groups according to their highest qualification held, and the numbers of workers in each industry and qualification group were also broken down by gender. Thus there are 10 584 cells of worker numbers for each Census year:

7 Qualifications * 2 genders * 12 income brackets * 63 industries

Appendix 1A shows the worker numbers by highest qualification, in each of the three Census years. Appendix 1B gives the worker numbers by income bracket, and Appendix 1C gives the worker numbers in each of the 63 industries. Each of these tables is also broken down by gender.

For each cell containing worker numbers there was an additional cell providing the average age of those workers, since age (or an experience measure based on age and years of education) is an important control variable in wage equations. As noted in Chapter 5, unit record data are preferable to tabular data because some information is lost when workers are grouped into cells representing numbers of workers with certain characteristics, and it is a particular limitation of the Census data that average ages of groups of workers are less informative than unit record data would be. However confidentialised unit record data have only been released since 2002, and the Census data remain the best available source of information on the 1990s era, which because of the rapid changes in technology and inequality is of particular interest for this study.

It is a further drawback that the Census data only provide a single figure for total income from all sources, rather than a specific figure for earnings. Some of these income sources are likely to be positively correlated with earnings, such as interest payments, while others may be negatively correlated, such as government benefits, so the use of incomes data may bias the estimated earnings equations in unknown directions. However, in the absence of unit record data until very recently, a number of authors have used Census data on incomes as a proxy for earnings (Morrison and Poot, 1998; Papps, 2001).

To minimize the possible biases from using income data, the data sets were restricted to full-time workers only. For one thing, earnings can be expected to provide the bulk of annual incomes for full-time workers, with income from other sources playing a relatively minor role. Secondly, workers in full-time positions are more likely to have incomes which reflect the market value of their work, whereas part-time workers may be more interested in work for reasons of personal satisfaction or other non-market reasons.

Full-time workers are unlikely to receive benefit income, but highly paid workers are more likely to have investment income in addition to their earnings, compared to workers on low wages. It is therefore most unlikely that earnings will move in the opposite direction from incomes, but there is a risk that the income differentials in the Census data are somewhat greater than the earnings differentials.

The 58 industries which were used for the analysis vary greatly in size. The largest of them, wholesale and retail trade, employed 129 210 full-time workers in 1991, rising to 162 477 in 2001. In 1991 this was followed by public administration and defence (77 409), education (65 652) and business services (56 574). By 2001 this order had changed slightly with business services up to second largest (85 110), followed by education (83 115) and public administration and defence (64 899). At the other end of the scale, the smallest industries are coal mining, petroleum and coal products, and gas manufacture and distribution, each of which has fewer than 1000 full-time workers. Throughout this chapter the estimation methods used employ weighting by worker numbers, to take account of these large differences in industry sizes.

6.B.2 ICT uptake by industry

The 1996 input-output tables provided by Statistics New Zealand were used as an indicator of the extent to which different industries rely on computer hardware and computer software and services. As discussed in Chapter 5, the input-output tables were a one-off project which has not been repeated, and are therefore the only available official tables of this kind. The different industries in New Zealand vary widely in terms of their use of computer equipment and services. Banking and finance are the industries making heaviest use of computing, with expenditure on these inputs more than 4 percent of total industry outlays, including outlay on salaries and dividends.

Of the 58 industries, six have computer expenditure in excess of 2 percent of outlay, and 12 industries have computer expenditure in excess of 1 percent of outlay. At the low end of the scale, 11 industries spend less than 0.1 percent of total outlay on computing, these being mostly primary production such as farming, fishing and forestry. Appendix 2A provides the complete table of computing expenditure by industry in industry sequence, and Appendix 2B gives the same information sorted by computer expenditure as a proportion of total outlay.

6.C Method of analysis

6.C.1 Earnings differentials between skill groups

The Census data were used to estimate earnings functions for full-time workers in each industry and each Census year. The earnings functions are of the form:

$$(6.1) \quad \mathit{l}n\,Y_i = \alpha_i + \beta_{SC}\,\text{School Cert}_i + \beta_{UE}UE_i\ \ \beta_{BURS}\text{Bursary}_i + \beta_{DIP}\text{Diploma}_i + \beta_{BACHi}\text{Bachelor's Degree}_i + \beta_{PG}\,[\text{Post-grad Degree}_i] + \beta_7\,EXP_i + \beta_8\,EXP_i^2 + u_i$$

[i=industry]

where the dependent variable is the natural logarithm of annual income and the data on highest qualifications enable six dummy variables to be defined, distinguishing between School Certificate, University Entrance, Seventh Form/ Bursary, Post-School Diploma, University Bachelor's degree, and Post-graduate degrees. The β_k (*k=SC, .., PG*) coefficients estimate the marginal effect of each level of education, as compared with the excluded group who have no school qualifications.

Thus 58 equations were estimated, one for each usable industry, for each of the three Census years. The estimation results for these 174 equations are reported in Appendix 4A, arranged by Census year and then industry.

The earnings equations also include a quadratic in years of potential labour market experience. A quadratic in age is frequently used in labour equations, but Winkelmann (1998) argues that experience is the more appropriate specification.

Work experience is itself valuable, but the time spent in gaining qualifications means that years of experience are shorter for a worker of given age but higher qualifications[1]. Thus controlling for age and age squared encompasses two variables, and is likely to underestimate the benefits of further education.

There is a problem with the estimation of an earnings function from Census information, in that the data on annual earnings are not continuous but instead fall into unequal intervals. Moreover, the income brackets changed between the 1991 and 1996 Censuses, though the 1996 brackets were retained for 2001. While it is tempting to use Ordinary Least Squares (OLS) estimation on such data (implemented, for example, by using the mid-points of the intervals) such a strategy generally gives inconsistent estimates (Stewart, 1983).

For this reason a consistent maximum likelihood procedure is used here (StataCorp, 2001), which is a generalisation of the Tobit model (See Appendix 11). This model requires the end points of the intervals to be specified (with the exception of the lower end-point for the bottom interval and the upper end-point for the top interval, which are treated as censored). The interval regression model assumes that the distribution of the error term is normal, but this should cause no difficulty since the logarithm of income is being used and it is well-established that earnings distributions are approximately log-normal (Pryor and Schaffer, 1999). Appendix 4A reports the coefficients on the marginal effect of each level of education and for each industry, for each of the three Census years.

The variety of qualification levels distinguished in New Zealand allows several different empirical measures of skills differentials to be calculated. The ratio of the marginal effect of a Bachelor's degree relative to the marginal effect of School Certificate was chosen because these two qualifications are close to the ends of the qualification spectrum, and there are large numbers of workers at each of these qualification levels.

Within each industry and year this ratio is interpreted as the premium paid for gaining a university level qualification. Appendix 4B gives these ratios for each of the 58 industries and each of the three Census years.

The skills premia revealed by these ratios of marginal effects of qualifications vary considerably between industries. For example, the 2001 weighted mean skills premium was 2.25 and the industry median was 2.08. However the lowest ratio is just 1.43 (rubber products, industry 24) and 10 industries have a skills premium below 1.8. At the other end of the scale the highest ratio is 4.23 (petroleum and coal products, industry 23), but only 18 of the 58 industries have a premium for skills which is greater than 2.4. Eric Wanner (2004) notes that the wage premium enjoyed by a graduate in the USA over a worker with only high school qualifications is about 85 percent, so a premium of 110 percent over School Certificate in New Zealand appears to be quite comparable.

6.C.2 Time trends in the skills premium

The trend over time is examined by dividing the skills premium in one Census year by the skills premium in the previous Census year. The skills differential that is calculated for each industry and Census interval, and then related to industry use of computers, therefore takes the form:

(6.2) $$\frac{\left(\hat{\beta}_{BACH} / \hat{\beta}_{SC}\right)_{t+5}}{\left(\hat{\beta}_{BACH} / \hat{\beta}_{SC}\right)_{t}} = f\,(computer\ use,\ other\ industry\ controls).$$

Where t = 1991, 1996.

Equation (6.2) implies a causal relationship, with the income differential due to skills modelled as depending on computer use. However this is not the only plausible explanation for a correlation between a skills premium and computer use. It could be the reverse relationship, with industries raising the premium for skills in order to attract or retain higher quality workers, and then equipping those workers with computers. Or, following Nelson and Phelps (1966) and Schultz (1975), it could be that industries undergoing rapid change are paying a premium for adaptability and simultaneously introducing new technology. The evidence for a correlation is examined in Section 6.D, but an attempt to tease out the path of causality will be left to Chapter 9.

6.C.3 Earnings differentials within skill groups

To examine earnings differentials within skill groups, inequality in annual incomes amongst full-time workers with the same level of highest qualification was measured, using the Gini coefficient:

$$G = \sum_i \sum_j \frac{|x_i - x_j|}{2N^2\mu} \qquad (6.3)$$

where x_i is the income of the ith person, μ is the mean income and N is the total number of persons. To deal with the problems created by interval data, the midpoints were used for the closed intervals (e.g., $10,001-$15,000). Unlike the regression case, where such a procedure can cause bias, simulations suggest that no bias is introduced by using midpoints to estimate the data for Lorenz curves, from which the Gini coefficient is derived (Chen, Datt and Ravallion, 1991)[2].

For each Census year Gini coefficients were computed for workers at each of the seven educational levels, and for all workers grouped together. In order to see whether the change in within-group inequality was related to computer use the inter-censal change in these Gini coefficients was regressed on the computer-uptake measure and other industry controls.

6.D Trends in income inequality

6.D.1 Earnings differentials between groups of workers

Over the ten years from the Population Census of 1991 to the Census of 2001 it appears that the skills premium for gaining a bachelor's degree increased significantly. Of the 58 industries analyzed, 43 industries, or 74 percent, showed a rising skills premium over those 10 years. But because the larger industries were more likely to show rising returns to skills than the smaller industries, the number of workers involved was 897 054 in 2001, or 89.95 percent of all full-time workers.

Table 6.1 below provides a summary of the skills premium over all industries for the three Census years, together with the ratio over the whole decade 1991 to 2001, as defined in equation 6.2, showing the generally upward trend. Appendix 4B gives detailed figures for the trends in each industry, over each of the inter-censal periods.

Table 6.1: Changes in the skills premium
Full-time workers 1991-1996-2001

	$\left(\hat{\beta}_{BACH}/\hat{\beta}_{SC}\right)$ 1991	1996	2001	$\dfrac{\left(\hat{\beta}_{BACH}/\hat{\beta}_{SC}\right)_{2001}}{\left(\hat{\beta}_{BACH}/\hat{\beta}_{SC}\right)_{1991}}$
Median	1.910	1.840	2.078	1.088
Unweighted mean	1.951	1.928	2.208	1.132
1996 employment-weighted mean	1.881	1.993	2.249	1.196
Industries with rising skills premium, 1991-1996	30 of 58			(51.7%)
Industries with rising skills premium, 1996-2001	52 of 58			(89.7%)
Industries with rising skills premium, 1991-2001	43 of 58			(74.1%)
Numbers of workers in these 43 industries, 2001	897 054 of 997 332 (89.95%)			

Over the decade as a whole, the skills premium rose from a factor of 1.88 to a factor of 2.25, an increase of almost 20 percent. But the 5 years of the early 1990s contributed only 6 percent to the rise, whereas the second 5 year period contributed more than 13 percent.

Moreover, in the first five years the rise in between-groups inequality was markedly concentrated in certain industries, while in the second five years it was much more general. In the five years from 1991 to 1996, between-group inequality rose in only 30 of the 58 industries (51.7 percent). In the 5 years after 1996 the skills premium rose in 52 of the 58 industries (89.7 percent).

When unweighted industry data are used the return to skills even appears to have fallen slightly in the first period, though weighted industry data show a rise. Evidently the rising between-group inequality was concentrated in the larger industries in that period, with those 30 industries employing 68.6 percent of the workers in 1991. However this selective pattern did not continue into the late 1990s, when between-group inequality was rising more rapidly, and affected 90 percent of the industries. Because of the small size of the six unaffected industries, rising between-group inequality was experienced by more than 95 percent of the full-time workforce.

6.D.2 Earnings inequality within groups

In addition to this rise in inequality between skill groups, there has also been a rise in inequality amongst workers who have the same highest qualification. This change in within-group inequality is reported in two ways:

(1) the change in the weighted mean Gini coefficient, $\overline{G}_{96} - \overline{G}_{91}$ for each level of highest qualification (weighted by the numbers in each industry), and

(2) the mean of the changes in the Gini coefficient, $\overline{\Delta G}$, where in any particular industry, $\Delta G = G_{96} - G_{91}$.

Appendix 5 reports the within-group Gini coefficients for each level of qualifications and for each of the three Census years. It also shows the findings on changes in the Ginis, using both the above methods. For most workers the rise in within-group inequality over the whole 10 years is about 8 percent in the Gini coefficient, though the figure is rather less for postgraduates and substantially greater for those with no qualifications. The percentage changes are summarized in Table 6.2.

For holders of a postgraduate qualification the overall increase in the Gini coefficient is only 5.2 percent. This probably reflects the fact that this group is one of the smallest, making up only 5.3 percent of full-time worker numbers in 2001, and probably relatively homogeneous. However there was a marked difference between the two periods. In 1991 – 1996 the university graduates experienced an exceptionally large increase in within-group inequality, but after 1996 there was a significant reduction. Thus, by the end of the 10 years the overall rise in within-group inequality for these workers was quite modest. At the other end of the scale, the workers with no formal qualifications experienced rising within-group inequality in both periods. Over the whole 10 years their within-group inequality rose 14.1 percent, a much greater increase than within any other group.

Table 6.2 : Changes in within-group income inequality by highest education level : Full time workers

	1991-1996	**1996-2001**
Qualification level	Mean %-age Change in Gini	Mean %-age Change in Gini
No qualifications	9.3%	4.0%
School Cert	4.6%	2.6%
UE/6th form	2.7%	4.3%
Bursary	5.8%	3.5%
Diploma	4.6%	2.4%
Bachelor	10.9%	-2.9%
Postgraduate	11.2%	-5.1%
Total	7.4%	2.2%

6.E Computer use and changes in income inequality

6.E.1 Computer use and between group inequality

A variety of regressions were estimated to see whether the rise in inequality between skill groups that is documented in the previous section is related in any way to the importance of computers in each of the various industries. The initial estimates used a bivariate version of equation (6.2), with industry computer use measured in three ways: the ratio of hardware purchases to total outlay (which includes wage payments and operating surplus); the ratio of software purchases to total outlay; and the ratio of all computer purchases to outlay.

Industry spending on software and computer services appears to have been significantly related to the rise in between-group inequality that occurred in the 1991-1996 period (Table 6.3), with an estimated coefficient on the ratio of software spending to industry total outlay in that period of approximately 2.2. In other words, in an industry where software and computer services spending relative to total outlay is one percentage point higher, the skills premium for a Bachelor's degree relative to School Certificate would have risen by 2.2 percentage points between 1991 and 1996. However in the period 1996 to 2001, while the coefficients continue to be positive they are considerably smaller and they have low statistical significance.

The increase in the weighted mean skills premium in the period 1991-1996 was 3.6 percent. The predicted rise in between-groups inequality associated with computing expenditure (at some 2.2 percent) therefore represents more than the half the mean increase, signalling the potential importance of industry computer use to this source of inequality at that time. The bivariate regression results also show that purchases of computer hardware have a positive effect on between-groups inequality, but this effect is not statistically significant. This stronger apparent effect of software and services spending may reflect the fact that measured expenditure on this input is nearly four times that on hardware, making it easier to observe statistically significant effects.

By contrast, in the period 1996 – 2001 the correlations were much weaker. The coefficient on total computer outlay dropped to about 1.6, and the coefficient on software alone to about 1.9. But in this later period the results had little statistical significance.

Table 6.3: Bivariate relationships between industry computer use and the change in between-groups inequality All full time workers, 1991-1996-2001

	Independent variables		
	Hardware	*Software*	*All Computing*
All workers	*Total Outlay*	*Total Outlay*	*Total Outlay*
(i) 1991 - 1996	3.174	2.243	2.061
	(0.90)	(2.90)**	(2.67)**
(ii) 1996 - 2001	0.867	1.867	1.569
	(0.21)	(1.27)	(1.15)
(iii) 1991 - 2001	4.581	4.722	4.142
	(0.63)	(2.13)*	(1.92)

Note: The values in the table are coefficients from bivariate regressions. The dependent variable for each regression is the ratio of the marginal effect of a Bachelor's degree relative to the marginal effect of School Certificate in the later year, relative to the value of the same ratio in the previous year. The independent variables are, alternately, the ratio of industry spending on computer hardware to total industry outlay, the ratio of software spending, and the ratio of all computer expenditures to total industry outlay. Each regression is estimated on the sample of 58 industries, and is weighted by industry size. In Table 6.2 all missing values are set to zero. Heteroscedastically-robust *t*-statistics in parenthesis; * significant at 5% level; ** significant at 1% level.

One problem with the information reported in the inter-industry tables is that values less than one million dollars are suppressed. Of the 58 industries, there were 11 with software and computer services expenditure and 25 with hardware purchases below this threshold in 1996 (Appendix 2B). In the base case reported above these missing data were set to zero, but to test the robustness of the findings the model was re-estimated using three alternative assumptions. The first alternative was to set the missing values to $0.5 million (and then divide by total industry outlays), under the assumption that any larger figure would have been rounded up to $1M and reported. In contrast to adjustments which operate only on the numerator of the ratio between computer spending and total industry outlay, the other two approaches operate on the ratio itself. One of these is to set the ratio to the lowest non-missing ratio and the other is to use the mean of the non-missing ratios.

The results for these four different approaches to the missing data are reported in Appendix 6. The coefficients for the bivariate relationships are very similar, regardless of which method is used. In the 1991 – 1996 period the coefficients on computer use were slightly over 2 and highly statistically significant. In the period 1996 – 2001 the coefficients dropped to approximately 1.5 but the statistical significance was low in every case except the coefficient on software expenditure when the mean of the non-missing values was used.

To test whether these bivariate relationships between industry use of computers and changes in between-group inequality are robust, a variety of additional control variables were added to the model. These additional variables included: profitability (proxied by operating surplus), wages, and trade effects (exports and imports) each expressed as a proportion of total industry outlay.

A measure of employment change over each five year period was also included. This final control variable was defined two different ways:
(1) As a general employment change measure, based on the change in employment levels in each industry as a whole, and

(2) As a targeted measure, based on the ratio of numbers of workers at the bachelor’s degree level to the number with only school certificate. This change in skilled relative to unskilled employment can be seen as a quantity change in the demand for skills, corresponding to the price change that is being measured by the skills premium for a Bachelor’s degree relative to School Certificate.

Because the results in the previous section (Appendix 6) show that the measured effect of industry computer spending is robust to the assumptions about missing values, only one approach was used with the augmented model: Computer spending was set to zero for those industries where it was less than \$1million. The results for this augmented model are reported in Appendix 7A for the period 1991 – 1996, and Appendix 7B for 1996 – 2001.

The relationship between industry spending on computing and the rise in the skills premium appears robust to the inclusion of the control variables. The addition of the control variables results in almost no change in either the magnitude or the statistical significance of the variables that proxy for industry use of computers, as reported in Table 6.3 above.

Amongst the control variables, in the period 1991-1996 it appears that the rise in the returns to skill was smaller in industries which relied heavily on imports. However there was no significant import effect in the period following 1996. In the five years 1996-2001 there was a positive coefficient on operating surplus, with strong statistical significance, even though there had been no significant effect in the earlier period. Neither the general employment change nor the ratio of skilled to unskilled employment changes appears to have a significant effect on the change in the skills premium.

6.E.2 ICT and changes in inequality within groups

Bivariate and multivariate OLS regressions were estimated to see whether the rise in the Gini coefficient between 1991 and 1996 for each educational level is associated with the spending on computing in each industry. These regressions take the general form:

$$(6.3) \qquad d\_Gini_{edlev} = f(computer\ use,\ other\ industry\ controls).$$

Where edlev = highest qualification held

Eight regressions were estimated for each model, one for each of the seven educational levels, and one for all levels grouped. The coefficients on computer use for both the bivariate and the multivariate models are reported in Appendix 8. The multivariate regressions use the same controls as were used in the between-group estimates in the previous section, and again the results are robust to the inclusion of the controls.

For poorly educated workers (those whose highest qualification is School Certificate or less) greater spending on computers by an industry is associated with a significant fall in income inequality between 1991 and 1996. In contrast, spending on computers is associated with a substantial rise in inequality amongst the most skilled workers, which is those who hold at least Bachelor's degrees.

6.F Summary and Implications

The results reported here suggest there was a rise in both between-group and within-group income inequality for full-time workers, both between 1991 and 1996, and further between 1996 and 2001. Earnings make up much the greater part of incomes for people who are employed full-time, so the most likely cause is a rise in earnings inequality.

There was a marked difference between the general trends in inequality over the period 1991 – 1996 and the period 1996 – 2001. The skills premium, represented by the inequality between those with only School Certificate and those with a bachelor's degree, rose by about 6 percent in the first period, but unevenly between industries. In the five years following 1996 the overall between-group inequality rose by more than 13 percent, and this rise was spread over 90 percent of industries and affected 95 percent of full-time workers.

In the case of within-group inequality there was also an important difference between the two periods. Overall there was a fairly general rise of about 8 percent in within-group inequality, with the least skilled workers experiencing the greatest rise and the most highly skilled workers experiencing the least. However the workers with university degrees experienced a very sharp rise in within-group inequality in the first 5 years, which dropped back again in the later period. Other groups of workers experienced within-group inequality rising more steadily over the whole 10 years.

The patterns of between-group and within-group inequality can be seen as complementary, and are therefore not surprising. If some industries are paying greater returns to skills than other industries, it would be expected that graduates in the industries with the higher skills premium would be widening their gap from other graduates who are in the industries where there is less change.

The late 1980s and early 1990s were a period of considerable industrial change. This was partly brought about by the widespread adoption of new technologies, especially in some industries, and was compounded by a more open economic philosophy which ended the protection of many industries and led to a number of industries being more exposed to imports than previously.

Thus it is not surprising that the period 1991 – 1996 saw considerable differentials between different industries. The global changes inevitably affected some industries more than others, and the pattern of between-group inequality growing only in some industries during that period is therefore quite understandable. During the early 1990s the premium for skills appears to have been associated with higher levels of computer expenditure, and in that period the industries with high levels of imports also showed a small negative effect on the returns to skills. These associations tend to support the idea that the early 1990s were a period of major adjustment, in which particular skills were very well rewarded, and there were substantial if sometimes temporary advantages for workers of certain skills in certain industries.

In contrast the period from 1996 – 2001 was a time of persistently rising inequality which affected all industries, and the between-industry effects of the early 1990s disappeared. In particular, the association with computer expenditure, which had been significant in the earlier period, was insignificant after 1996.

As noted in Chapter 3, earnings inequality is not only a matter of wage inequality for those who are working, but also involves access to work. The inequality measured in this chapter at the end of each time period is for surviving workers, and will not tell the whole story unless unemployment is felt equally by workers of all skill levels and in all industries. Chapter 7 continues the analysis of data from the Population Census by examining the changes in employment by groups of workers, and relating those changes to the computer-intensity of industries.

Footnotes:

[1] To construct the potential experience variable it was necessary to assign standardised years to each of the seven qualification levels. I follow the concordance used by Winkelmann (1998), which is: no qualification (8 years), school certificate (11 years), sixth form certificate (12 years), Bursary (13 years), Diploma (14 years), Bachelor’s Degree (16 years), Postgraduate degree (18 years).

[2] For the open-ended interval at the top of the income distribution (either >$70,000 in 1991 or >$100,000 in 1996) the mean income for the interval was set at 30 percent above the lower bound, while for the lowest income interval it was set at 80 percent of the upper bound. Both of these values are recommended by Chen, Datt and Ravallion (1991) for use with interval data.

Chapter 7

Employment change in New Zealand industries

7.A Introduction

7.A.1 Employment Opportunities as a Form of Inequality

The previous chapter examined patterns of wage inequality by industry, but hourly wage rates or annual incomes are only one dimension of inequality. Many studies have confirmed that being unemployed has serious non-pecuniary costs (Clark and Oswald, 1994; Winkelmann and Winkelmann, 1998). People need jobs, not only for the money but also for the sense of self-worth and the sense of being needed that having a job confers (Layard, Nickell and Jackman, 1991; Freeman and Soete, 1994).

Job security therefore has value (Killick, 1995, Osberg, 2002). "Jobs differ in the amenities they offer" (Borjas, 2005: 206), and the payment of a higher wage in recompense for some undesirable feature of a job is referred to as a compensating differential. Since some jobs have greater security (and some employers offer greater security), workers are less willing to take employment where job security is seen to be a worry. Thus for many workers a somewhat lower wage in a secure job may be worth more than a higher wage with weaker long-term prospects.

However. many studies have shown that workers of different skill levels have systematically different levels of job security, with the less skilled more likely to be unemployed, employed casually, or forced to change jobs (Topel, 1993; Booth, 1999):

> "People without skills are much more likely to be out of work, and, if in work, low paid" (Layard, 2006: 175).

These different patterns of job security therefore represent a form of systematic inequality, which exacerbates the inequality of wages. The least skilled workers command the lowest wages, but it is precisely those workers who also enjoy the lowest job security. Thus they tend to be doubly disadvantaged.

In the middle years of the 20th century, there was little unemployment in the OECD countries, but by the mid-1990s unemployment had risen significantly in New Zealand (Gobbi and Rea, 2000; Statistics New Zealand, 2000) and in other developed countries (Martin, 1994; Nickell and Bell, 1995), and it particularly afflicts workers at the lower end of the skills range (Kruse, 1998). This decline in employment opportunities is coincident with the rapid diffusion of computers and other information technologies. Skill-biased technological change is therefore one of the leading explanations, not only for the changing wage distribution for those who still have jobs (Goldin and Katz, 1998), but also for the changing pattern of employment opportunities (Phelps, 1997).

This chapter examines the link between computer use and employment change across different industries. Worker numbers in the Census of Population from 1991, 1996 and 2001 are used to estimate trends in employment change by educational level for full-time workers in 56 industries covering the entire New Zealand economy. To explore the role of technical change, I again use data on industry use of computers from the 1996 Input-Output tables as described in Chapter 5, in this chapter relating them to the changes in employment levels for workers at different levels of education.

7.A.2 The Theoretical Framework

The present chapter examines the demand for workers of different educational levels in terms of industry computer use, the underlying theory being the assumption that the demand for labour at each skill level is a function of the price of labour and the price of other inputs. The cost of computer power fell dramatically in the late 20th century (Jorgensen and Stiroh, 1999), and as the cost of computer inputs fell it was to be expected that the pattern of demand for different sorts of labour would also change. In industries with high levels of ICT uptake, both wages and employment growth are expected to be strongest for workers at those skill levels which are complementary to the new technology (Autor, Levy and Murnane, 2003; Katz, 2000). Conversely, for those workers for whom the new technology is a substitute, wages are likely to be weak and employment trends to be flat or negative

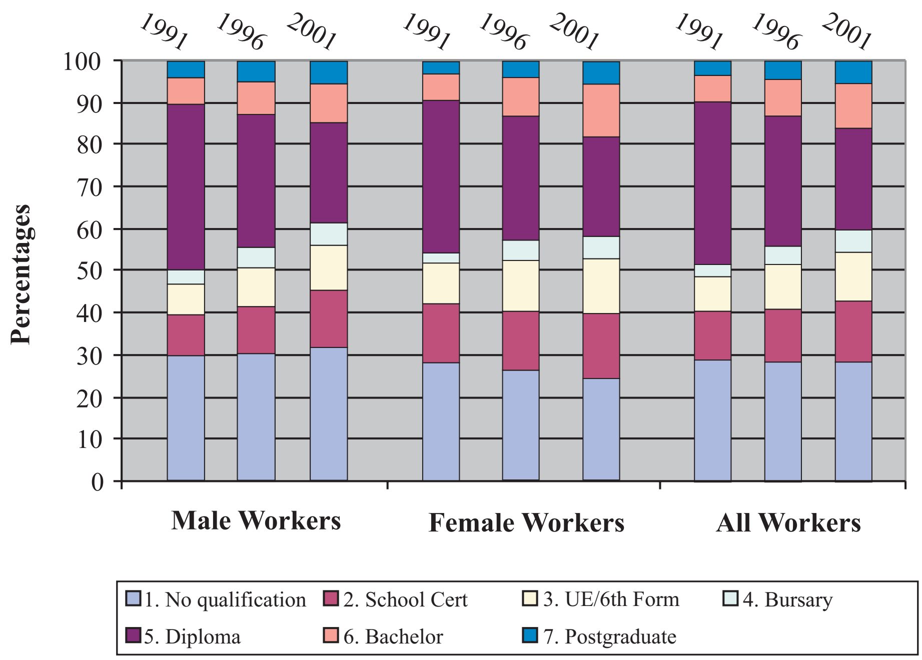
7.B Data and Methods

7.B.1 The Population Census

Appendix 1A gives the numbers of full-time workers by gender and highest qualification achieved from the New Zealand Census of Population for 1991, 1996 and 2001, together with the proportions of workers at each qualification level by gender and year. The sample was again restricted to full-time workers, in part because the previous chapter looked at changes in annual incomes for full-time workers, and comparison between the wage effects and the unemployment effects are more meaningful if the same data specification is used. Secondly, part-time work is more often associated with casual work than is full-time work, and casual work tends to change systematically with unemployment. Thus, while the following results do not cover the full working population they do relate to the largest group in the New Zealand workforce, and the group which is least like the unemployed.

Female workers increased their share of the full-time workforce from 39.9 percent in 1991 to 42.6 percent in 2001. But working women also overtook men in terms of qualifications achieved at every level except postgraduate. The distribution of full-time workers by highest qualification achieved for each Census year is displayed in Graph 7.1, and shows the general trend over this ten year period in which women's educational attainment levels continued to rise while men's levels tended to fall. The proportion of female workers who were university graduates had overtaken that of male workers by 1996, and by 2001 was ahead by more than 3 percentage points. At the lower end of the qualification scale female workers also displayed significantly higher qualification rates than males, with only 24.3% of female workers lacking even School Certificate in 2001, compared to 31.7% of male workers.

Graph 7.1: Proportions of full-time workers by highest qualifications



The figures show a broad trend toward more workers with university degrees, both at the bachelor's and at the post-graduate levels. Workers holding degrees rose from 9.8 percent of the full-time workforce in 1991 to 12.9 percent in 1996 and 16.1 percent in 2001. However this rise was entirely achieved at the expense of other post-secondary qualifications, and the proportion of workers with no qualification beyond the University Entrance/6th form level increased from 48.9 percent in 1991 to 54.7 percent in 2001.

One problem affecting the estimation of a skills demand function from self-reported qualifications lies in the changing use of terminology and the expansion of degree-level polytechnic courses. Many qualifications such as accountancy are today recognized with university degrees, where in earlier years qualifications were granted by professional bodies or non-degree granting institutions. In primary teaching for example, since 1990 the six colleges of education have all amalgamated with local universities, and the standard qualification has become a BA or BTeaching degree, where in the past the teachers colleges awarded their own diplomas. Thus the decline in numbers of workers with vocational diplomas and the rise in numbers with bachelor's degrees is partly explained by changing the names of qualifications which in reality are quite similar.

In theory a decline in the employment of low-skill workers could be explained by declining demand for these workers, or by a declining supply if increasing numbers of school leavers were proceeding to further qualifications. However the second explanation is implausible in the New Zealand context in view of the overall rise in the proportion of school leavers with no qualifications beyond the school level. Thus it seems clear that declining employment of low-skill workers is entirely a function of declining demand.

7.B.2 Industrial Classification

Of the 58 industries analyzed in Chapter 6, 56 were used to track employment change. Prior to 1997, Statistics New Zealand used the New Zealand Standard Industrial Classification (NZSIC) to differentiate industries, but since then they have adopted the Australian and New Zealand Standard Industrial Classification (ANZSIC). The Census data from 1991 and 1996 are therefore directly comparable, but the design of the ANZSIC classification results in a number of regroupings which complicate some industry comparisons between 1996 and 2001.

Translation between the classifications is relatively straightforward for 54 of the 58 industries, covering some 94% of the full-time workforce. Of the remaining four industries, two industries (banking and other financial services) have been redefined in such a way that some 5000 workers classified as banking under NZSIC are now included in other financial services. For the purpose of comparison between 1996 and 2001, these two industries have therefore been combined into a single financial services industry of 32 073 full-time workers. A further two industries (manufacture of professional equipment and sanitary and cleaning services) have been regrouped in such a fundamentally different manner as to make comparison of worker numbers invalid. These two industries were therefore dropped from the analysis in this chapter, but together they only account for 28 122 workers in 2001, or 2.8% of the full-time workforce.

7.B.3 Industry Use of Information and Communications Technologies (ICT)

As a measure of ICT uptake, the present chapter again uses industry expenditure on computers and computer services, drawn from the 1996 inter-industry tables compiled by Statistics New Zealand. As noted in Chapter 6, in the inter-industry tables values less than $1M are suppressed. Four alternative ways of handling the missing data were tested and found to make no significant difference to the results of the wage equations. The same four methods were tested for the following labour-skills demand equations, but again there were no significant differences in the results. The results reported in this chapter are those with missing values set to zero.

7.B.4 Method of analysis

The Census data were used to estimate a labour-skills demand function for full-time workers of each qualification level, in each industry and over each inter-censal period, where the dependent variable is the proportional change in numbers employed (E) in each industry (i) and year (t), which is regressed on computer use and other industry variables:

$$\text{(7.1)} \qquad \frac{\left(E_{i\,(t+5)} - E_{i\,t}\right)}{\left(E_{i\,t}\right)} = f\,(\textit{computer use},\ \textit{other industry controls}).$$

The base-line case examines the bivariate relationship between ICT expenditure and the demand for labour at different skill levels. In the second phase controls are brought into the model as proxies for other inputs which could be alternatives to labour. Operating surplus and wage costs as proportions of total industry expenditure are controlled for as proxies for the price of capital and the capital-to-labour ratio. Industry use of imports is introduced as a proxy for the extent to which industries may be able to substitute foreign sourced fabrication as an alternative to local labour. The proportion of female workers is also controlled for, as the rising proportion of women in the workforce has been advanced as a possible explanation for the changing labour demand patterns.

The same caveats apply to equation (7.1) as for equation (6.2) in the previous chapter. As written, equation (7.1) posits a causal relationship, with changing employment patterns modelled as dependant on computer use, but it is quite possible that the causality runs in another direction. A greater proportion of high-skill workers could theoretically be the exogenous variable, with the changed workforce needing to be equipped with computers. Or more fundamental changes in certain industries could be simultaneously driving both the increased use of computing and a different pattern of labour demand.

7.C Computer use and Changes in Employment

7.C.1 Bivariate Relationship : Computer use and changes in employment between skill groups

Table 7.1 shows the proportional change in numbers of workers at each skill level over each of the two intercensal periods. There are overall trends in employment, which grew 5.4 percent from 1991 to 1996 and 6.2 percent from 1996 to 2001 (as well as being higher for female workers than male), so to focus on the changing demand by skill level the employment changes in Table 7.1 have been calculated relative to the change in total employment, using equation (7.2), where E_s is the number of workers E at each skill level s:

$$\left\{ \frac{\left(E_{s(t+5)} - E_{st}\right)}{\left(E_{st}\right)} \right\} \Big/ \left\{ \frac{\left(E_{(t+5)} - E_{t}\right)}{\left(E_{t}\right)} \right\} \qquad (7.2)$$

t=1991, 1996

Table 7.1: Employment change by educational level as a proportion of overall change

Highest Qualification	1991 – 1996 Male	1991 – 1996 Female	1991 – 1996 Total	1996 – 2001 Male	1996 – 2001 Female	1996 – 2001 Total
No qualification	1.88	0.11	0.72	2.28	0.21	0.98
School Cert	3.72	1.23	2.06	8.01	2.04	4.04
UE/6th Form	11.59	4.22	6.74	4.44	1.71	2.68
Bursary	18.41	9.17	12.12	5.46	2.79	3.72
Diploma	-5.87	-1.16	-2.78	-5.96	-1.28	-2.95
Bach’s degree	10.78	6.98	8.18	5.29	5.72	5.69
Postgrad degree	7.18	4.97	5.47	4.24	4.78	4.44
Total	1.00	1.00	1.00	1.00	1.00	1.00

In Table 7.1 ratios greater than 1 indicate categories of worker with numbers rising faster than the overall trend, those with ratios which are positive but less than 1 are growing more slowly than the overall trend, and those which are negative are categories in absolute decline. These figures highlight the rapid increase in the proportions of the workforce with university degrees, and the steadily declining proportions of workers, both male and female, whose highest qualification is a vocational training diploma, though as noted in Section 7.B.1 above this is partly explained by the trend towards replacing vocational courses with degrees.

A variety of regressions were estimated to see whether the changing proportions of workers at each educational level were related in any way to the importance of computers in each of the various industries. The initial estimates used a bivariate version of equation (7.2), with industry computer use measured as the ratio of all computer expenditure (including hardware, software and computer services to total industry outlay. The regressions were estimated for all workers together, and also for male and female workers separately. Table 7.2A shows the coefficients from the bivariate reressions, for all workers grouped. Appendix 9A gives the full table of coefficients, showing male and female workers separately as well as grouped together.

The proportion of industry expenditure devoted to computing appears to be significantly related to the changes in the demand for skills. There is a strong and statistically significant negative correlation between industry computer expenditure and the proportionate change in the number of workers with no qualification beyond school level. This is particularly true for workers with no qualifications beyond 6th form or bursary, for whom the coefficients are between minus 15 and minus 18 over the 1991-1996 period. The implication of these findings is that for workers with no qualifications beyond upper secondary school level, between 1991 and 1996 there would have been a 15% to 18% decline in employment in the i-th industry, for every one percentage point increase in the ICT share of total industry expenditure. (Though the entire range in the computer expenditure measure is only 0-4.8%, so a 1 percentage point difference in this measure is a full one-fifth of the range.) The same trend is apparent over the 1996-2001 period, though the coefficients are reduced to below 10 percent. In contrast, there was very little effect of computer spending on rates of industry-level employment change for workers who had completed post-school qualifications.

Table 7.2A: Bivariate relationships between employment change and industry computer use, by educational level

No Qual's	School Cert	UE 6th form	Bursary	Diploma	Bach's degree	Post-grad	All Levels
1991-1996							
-4.18	-6.26	-15.26	-18.05	-2.26	-0.71	1.67	**-2.31**
(2.03)*	(3.42)**	(6.58)**	(5.93)**	(1.89)	(0.17)	(0.32)	**(1.23)**
1996-2001							
-3.44	-7.83	-9.71	-4.66	1.14	-6.66	-0.94	**-2.01**
(0.89)	(3.07)**	(3.72)**	(1.44)	(0.41)	(1.28)	(0.26)	**(0.72)**

Table 7.2B: Multivariate relationship between employment change and industry computer use, by educational level.

No Qual's	School Cert	UE 6th form	Bursary	Diploma	Bach's degree	Post-grad	All Levels
1991-1996							
-5.84	-9.52	-19.47	-21.94	-3.38	-1.08	0.98	**-3.79**
(2.32)*	(4.33)**	(6.65)**	(4.81)**	(2.25)*	(0.51)	(0.38)	**(1.78)**+
1996-2001							
-6.54	-11.46	-14.96	-10.50	-0.32	-7.98	-3.55	**-4.05**
(1.66)+	(2.71)**	(2.87)**	(1.78)+	(0.12)	(1.25)	(0.64)	**(1.47)**

Robust t-statistics in parentheses

+ significant at 10% level; * significant at 5% level; ** significant at 1% level

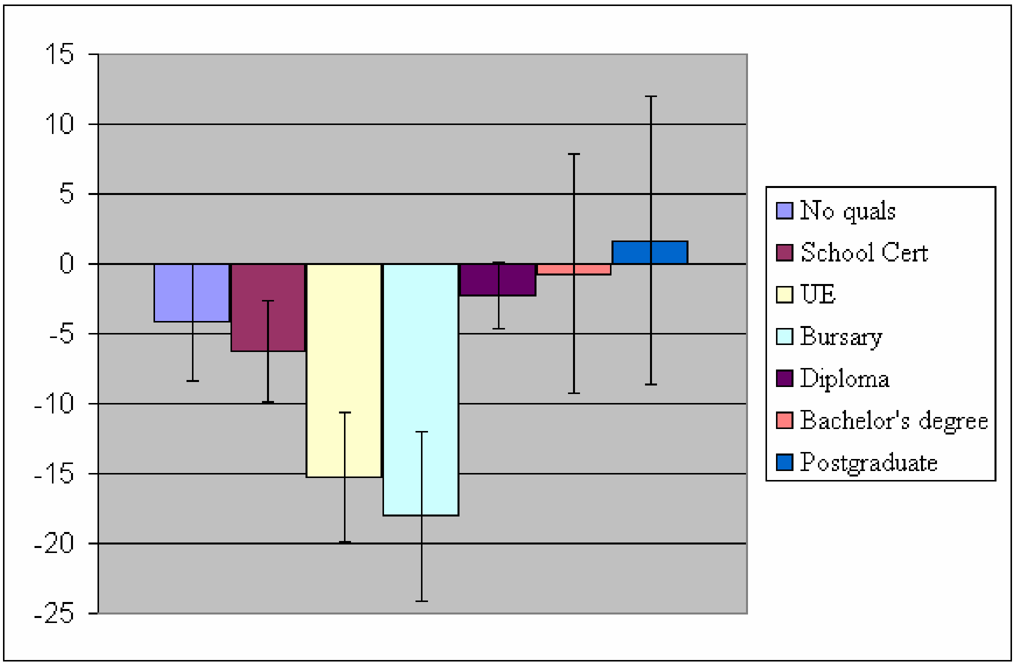
Graph 7.2A (for the 1991-1996 period) and Graph 7.2B (for 1996-2001) illustrate the relationship between employment change and industry expenditure on ICT at each of the seven educational levels. In the five years 1991-1996 there was a strongly negative relationship between industry use of computers and employment opportunities for those workers with no more than school qualifications, and this relationship had a high statistical significance. For those workers with any post-school qualifications the relationship was closer to zero, and the statistical significance was weak, especially for the university graduates.

In the five-year period following 1996 the coefficients were generally smaller, and were rather more uniform across all educational levels. However, as in the earlier period, the negative relationship had strong statistical significance for workers who did not proceed beyond 6th form, and low statistical significance for workers with post-school qualifications.

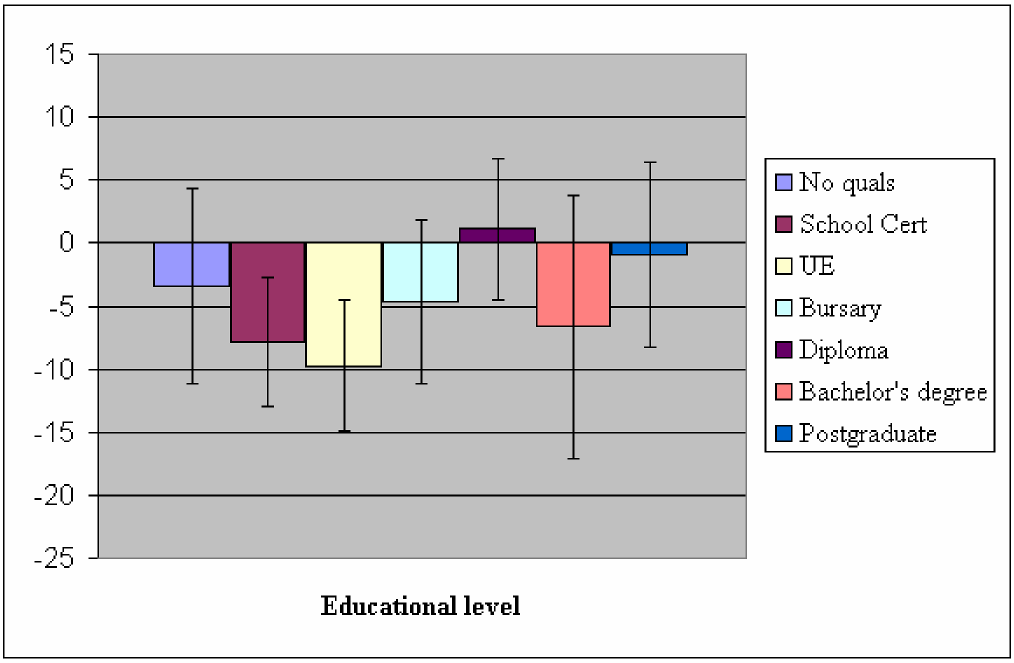
When male and female workers are considered separately, the same patterns are evident in the 1991-1996 period, suggesting that declining demand for less skilled workers was very general at that time. In the following five years, the pattern is again similar for male workers, but for female workers the statistical significance drops to very low levels (Appendix 9A). This finding suggests that the low-skill work in predominantly female industries was less affected by new technology than in industries which traditionally employed significant numbers of low-skilled male workers.

The regressions were also estimated for the effects of hardware purchases and software and services purchases separated, each expressed as a proportion of industry total expenditure. In the case of software and services purchases, both the coefficients and the levels of statistical significance are very similar to those for all computing purchases combined. However, for hardware purchases there are no statistically significant findings at any educational level, except for workers with postgraduate degrees for whom the coefficients are substantial and positive. The findings with computing inputs separated are reported in Appendix 9B.

Graph 7.2A: Relationship between employment change and industry computer use at each educational level : 1991 – 1996



Graph 7.2B: Relationship between employment change and industry computer use at each educational level : 1996 – 2001



Note : Y bars indicate 95% confidence intervals

The stronger apparent effect for software and services may reflect the fact that expenditure on this input is nearly four times as great as expenditure on hardware, making it easier to observe statistically significant effects. The increasing trend toward outsourcing computer services also raises questions about the validity of the hardware figure from the input-output tables, since the purchase of computer services necessarily hides a substantial hardware component, which then appears as a purchase by the computer services industry instead of the end-user industry.

7.C.2 Multivariate relationships

Several additional control variables were added to the model to test whether these bivariate relationships between industry use of computers and changes in employment patterns are robust. These additional variables included: profitability (proxied by operating surplus), wages, and trade effects (proxied by exports and imports). Industries vary widely in the extent to which they are involved in exporting, or experience import penetration, and also in their proportions of labour costs, and it might therefore have been expected that the relationship between computing expenditure and labour demand would be muted once these control variables were brought into the model. The data for these variables were again drawn from the 1996 inter-industry tables and were again expressed as proportions of total industry expenditure.

A gender variable was also included, being the ratio of female workers to total workers in each industry, as at the start of each five year period. There is a marked tendency for male and female workers to cluster in specific industries. In 1996, for example, mining and quarrying were more than 90% male, while clothing manufacture or health care and care of the elderly were over 70% female. It is therefore also plausible that controlling for the female proportion of employment in each industry could have produced different coefficients for the computing effect.

The coefficients on computing expenditure in the multivariate model are given in Table 7.2B. When these controls are included the coefficient for computing expenditure changes little from the bivariate model, with the magnitude of each coefficient almost invariably increased. Moreover, in the multivariate model the statistical significance of the results for the computing variable also remains high for the coefficients on workers with only school level qualifications, as was the case in the bivariate model. In the multivariate model the statistical significance is again low for workers with university degrees, confirming that in the industries with high levels of ICT uptake the better-qualified workers were less vulnerable to employment decline.

The full results for this augmented model are reported in Appendix 10A for the 1991-1996 period, and Appendix 10B for 1996-2001. Most of the control variables had very little effect, and few of these effects were statistically significant. In particular the gender variable had no significant effect in either five year period. Evidently the tendency of men and women to cluster in different industries has no significance once other factors such as qualifications have been allowed for.

In the 1991-1996 period there was a small tendency for openness to trade to lower the employment prospects. Import penetration appears to have had a negative effect on workers with at least school certificate, and especially on those with postgraduate qualifications. This finding suggests that more skilled workers were to some extent disadvantaged during the period of rapid restructuring after the mid-1980s, when import restrictions were relaxed and it would have been easier for firms to substitute imports for local skilled labour.

As might be expected, exactly the opposite pattern applies to industries with higher levels of exports, where employment decline was exacerbated for workers who lacked post-school qualifications, and there was no significant effect on the better qualified workers. Firms which are involved in exporting tend to be the more innovative firms (Dosi and Fabiani, 1994), and it is therefore plausible that more export-oriented industries will have labour demand skewed toward the better qualified. But the import and the export effects evaporated in the period following 1996, suggesting that they were both features of the period of rapid restructuring.

In the 1991-1996 period there was also a small negative effect on wages for workers at the two ends of the skills spectrum. This probably also relates to the widespread changes taking place in that period, as the trend did not continue after 1996. Operating surplus had no significant effect in the earlier period, but after 1996 it does show a positive correlation with the postgraduates. This finding is very similar to the finding on income inequality noted in Chapter 6, where again operating surplus had insignificant effects in the earlier period, but after 1996 was associated with higher earnings.

A regression specification test (RESET) was run following each regression. The regression specification test is designed to find evidence of excluded relevant variables and incorrect functional form, by included powers of the fitted values in the model. Only in the regression for workers with postgraduate degrees, and only in the 1991-1996 period did the RESET test find any significant evidence of misspecification. The relationship between industry spending on computing and the change in demand for workers of each skill level therefore appears to be reasonably robust.

7.D Summary and Implications

In New Zealand, the late 20th century saw a marked decline in demand for less skilled workers, a pattern which is common to many of the developed countries and especially to the English-speaking countries. This period has also been one of rapid technological change, notably with regard to the adoption of Information and Communication Technologies and the widespread workplace reorganization which new technologies have facilitated.

The results reported here suggest a strong correlation between changing patterns of labour demand and the ICT-intensiveness of industries. The industry-level demand for well qualified workers does not appear to be significantly affected by industry ICT use. However the findings show a substantial and statistically significant decline in demand for workers with no qualifications beyond school level, and this decline is strongly correlated with the uptake of ICT. The trend was most marked between the Censuses of 1991 and 1996, and continued between 1996 and 2001 although at a reduced level.

The reduced demand for less-qualified workers in ICT-intensive industries parallels the wage dispersion noted in Chapter 6. It was found there that between-group inequality had risen substantially over the 10 years 1991 – 2001, and that the rise in inequality was correlated with ICT-uptake. In particular, the skills premium in ICT-intensive industries showed a major jump in the first five years, which is also the period when the demand for worker numbers was in steepest decline for the less-skilled workers. In the five years after 1996 the skew in the skills premium toward the ICT-intensive industries was more muted, as was the decline in demand for less skilled workers.

This pattern is consistent with the complementarity of computers with skilled workers and the substitutability of computers for unskilled workers. The international literature suggests that this complementarity is partly a direct effect of computers replacing workers in routine tasks, but more importantly the indirect effect that automation facilitates workplace reorganization, which in turn leads to a changing pattern of labour demand (Brynjolfsson and Hitt, 2000; Wolff, 2002). The findings from the Census data reported here tend to support the returns to adaptability theory. The greatest shift in both between-group wage inequality and labour-skills demand occurred during the period of rapid change in the early 1990s, suggesting that the process of adjustment had more effect on inequality than computerization per se.

The latest New Zealand Census of Population was held in March 2006. No data from this Census are available at the time of writing (August 2006), but it will be interesting to study the ongoing trends in labour demand when the next batch of Census data are released early in 2007. However the relevance of the 1996 input-output tables becomes increasingly tenuous with time. In the context of

ICT uptake, any further study of Census data should probably be delayed until a more recent indicator of industry inputs becomes available.

The analysis of Census data has therefore been taken as far as is currently possible, but since the 1990s Statistics New Zealand have been collecting earnings information through the Income Supplement to the Household Labour Force Survey. As explained in Chapter 5, unit record data have a number of advantages over Census data, both in terms of reliability and especially in terms of separating earnings from other forms of income. Too few years are available yet for long term trends to be studied, but Chapter 8 following uses the 2002 Income Supplement data for a more up-to-date view of earnings inequality than is possible from the Census, and one which is more earnings specific.

Chapter 8

Technological change and the demand for skills in New Zealand : Evidence from Unit Record Data

8.A Introduction

8.A.1 Skill-biased technological change

During the 1980s and 1990s inequality in earnings and incomes increased considerably in New Zealand, as in many of the industrialized countries, and this rising inequality was coincident with the rapid diffusion of Information and Communications Technologies (ICT). This is most unlikely to be mere coincidence, since a number of overseas studies have established that the industries with the greatest ICT uptake have been leaders in the trend toward greater wage inequality (Allen, 2001; Bell, 1996; Machin, 2001), and the earlier chapters of this thesis confirm that this is also the pattern in New Zealand.

Many commentators believe that the latest phase of technological developments has been biased in favour of more-skilled workers, and that the rise in inequality reflects the associated premium for skills (Katz, 2000; Green, Felstead and Gallie, 2003). But the exact path of causality is not clear. In particular, the number of experts in computing and related fields in New Zealand has been estimated at no more than four percent of the workforce (Engelbrecht, 2000b; Blumenfeld and Thickett, 2003), and it therefore seems implausible that the increasing inequality can be explained by the wages of ICT specialists alone.

For skill-biased technological change to be the cause of rising wage inequality, a much more general demand for higher skills throughout industries with rapid uptake of new technology would seem to be necessary. Computers have automated many specific tasks, and this has doubtless changed the proportions of workers of different skill levels that are needed in firms. But again, the extent to which cheaper technology alters the skills demand through direct displacement of low-skilled workers appears too small to explain the observed shift in labour demand (Acemoglu, 2002; Aguirregabiria and Alonso-Borrego, 2001).

However various studies around the world have identified an effect with a deeper groundswell. New technology only appears to have really far-reaching effects when it is combined with rather general workplace reorganisation (David, 2000; Wolff, 2002a):

> " Much of the previous discussion of IT impact has focused on the substitution of IT for labor, yet much of the managerial literature has recently stressed the importance of finding complementarities between IT and other organizational practices" (Hitt and Snir, 1999)

A large proportion of the New Zealand workforce is employed in industries which have experienced substantial reorganisation, in part associated with the adoption of new technologies, and it is therefore plausible that widening earnings dispersion reflects the increased returns to the knowledge and skills required to maximize the potential of the new workplace. This chapter reports the findings of an investigation into the extent to which wage inequality is related to new technology and the extent to which it is correlated with skills and qualifications. Specifically it uses unit record data collected by Statistics New Zealand in the June 2002 Income Supplement to the Household Labour Force Survey to estimate wage differentials in the New Zealand economy.

To explore the role of technical change I relate data on the industry use of computers from the 1996 Input-Output tables to the earnings dispersion. Quantile regression was used to estimate how the proportion of industry spending on computing affects workers at the 10^{th} and 90^{th} percentiles of the conditional log wage distribution, and whether that log wage gap is wider in industries making more intensive use of computers. These regressions include tests for the effects of occupations, qualifications and skills, in order to estimate how much any difference in inequality is explained by worker characteristics, and how much the difference is ICT-specific.

8.B Data and Methods

8.B.1 The Household Labour Force Survey – Income Supplement

Statistics New Zealand (SNZ) conducts a quarterly Household Labour Force Survey (HLFS), to which they add an annual Income Supplement each year in June[1]. This chapter uses the Income Supplement for June 2002, which contains extensive detail on the various sources of income, including income from wages, for a cross-section of some 29 000 New Zealanders aged 15 and over.

As noted in Chapter 5, unit record data contain large amounts of personal information, and for confidentiality reasons access to the IS data is therefore limited to approved users working at an office of Statistics New Zealand. The empirical work described in this chapter was carried out in the controlled environment of the Statistics New Zealand Datalab, and all analyses were checked by SNZ staff for conformity with the confidentiality requirements of the Statistics Act (1975).

In order to focus on wage effects, those respondents were excluded who reported no income from earnings, or unrealistic earnings (less than $4.00 per hour), reducing the sample size to 12 919. Not only does the Income Supplement distinguish between earnings and other forms of income, it also provides information on normal hours of work per week and earnings derived from those hours. One of the derived values provided by SNZ is the usual hourly wage from the primary job. This figure provides a robust basis for the analysis of industry, occupation and skill level effects on wage dispersion, since it is hourly wage rates which most accurately reflect the willingness of employers to pay for particular skills.

8.B.2 Occupations, qualifications and skill levels of workers

For occupations and skill levels of workers this paper draws on the work of Nick Pappas (2001), which itself was based on the classification of occupations developed in the U.S. Department of Labor (1991) *Dictionary of Occupational Titles* (DOT). Pappas provides estimates of cognitive skills, interpersonal skills and motor skills for each occupation (Pappas, 2001: 213-217).

The occupation classification used by Pappas is the Australian Standard Classification of Occupations (ASCO) revision 1. A concordance was created to translate the ASCO categories into their equivalents in the New Zealand Standard Classification of Occupations (NZSCO),[2] and were then grouped up to the two digit occupation level. Appendix 12 provides a summary table of the skill measures.

The HLFS Income Supplement includes information on the highest qualification attained for each of the workers sampled. There are ten levels identified in the HLFS, but levels 9 and 10 together represent less than 0.6 percent of the sample, and some qualifications levels (eg. 5 and 8) are rather ill-defined, so for the purposes of the present study the groupings were compacted into five, as detailed in Table 8.1. The very small, totally unspecified level 10 was merged with level 6, as that is both the most numerous class and it straddles the median[3].

Table 8.1: Qualification levels in the HLFS

HLFS		Regrouped	
1	No qualification	1	No qualification
2	School certificate	2	School certificate
3	Sixth form certificate	4	
4	Higher school qualification	4	Higher school qualification
5	Other school qualification	4	
6	Vocational / trade qualification	6	Vocational / trade qualification
7	Bachelor or higher degree	7	Bachelor or higher degree
8	Other post-school qualification	6	
9	Post-school not specified	6	Post-school not specified
10	Not specified	6	

8.B.3 Method of analysis

As in Chapter 6, this phase of the investigation studied both within group and between group inequality. To study within group inequality, quantile regression (QR) was used (Buchinsky, 1998; Koenker and Hallock, 2001), the θ-th quantile (0< θ<1) of the log wage (w) distribution for the i-th individual being specified as:

$$Quant_{\theta}(w_i|x_i) = \alpha(\theta) + x_i'\beta(\theta)$$

While OLS relates the conditional mean of a dependent variable to the explanatory variables, QR permits estimation of the conditional median (θ = 0.5) or any other quantile. By comparing changes in the log wage at the 10^{th} percentile with changes in the log wage at the 90^{th} percentile it is possible to see whether wage dispersion is increasing or decreasing as an explanatory variable such as the computing share of industry inputs changes. Such a comparison may reveal whether wage dispersion for otherwise similar workers (according to the observable characteristics included as controls in X) is greater for more computer intensive industries.

To investigate the extent to which the computing effect differs between groups of similar workers, the set of 58 industries was split into two groups. Each industry was flagged as ICT-intensive or not ICT-intensive, according to whether industry spending on computing exceeded 0.8% of total industry expenditure. Appendix 2B shows the 58 industries ranked by computer inputs as a proportion of total inputs, and marks the 0.8 percent cutoff line. While only 14 of the 58 industries lie above this line, these industries include several of the largest, including wholesale and retail trade which employs nearly one-sixth of the full-time workforce. These 14 industries together employed 45.2 percent of the workforce as at the 2001 Census (Table 9.3), so the cutoff chosen divides the workforce into two approximately equal groups.

OLS regressions of log wages on the interaction of this computing intensity dummy with the five qualification level dummies were estimated, to see whether computer intensive industries show higher returns to qualifications. These OLS regressions were also estimated controlling for characteristics such as occupation and cognitive skills. Where Qi is the qualification dummy and HiTech is the computer expenditure dummy, the specification is:

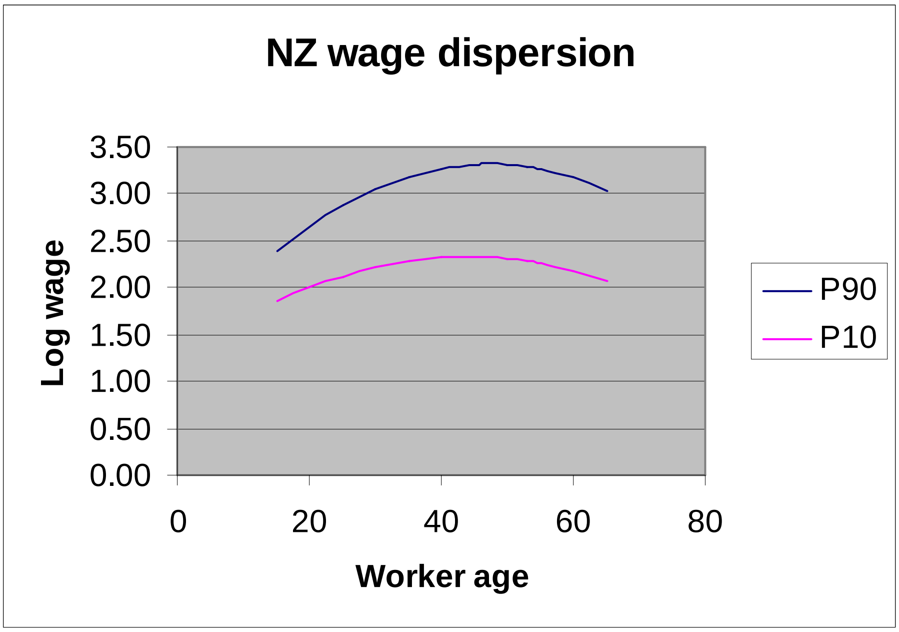
$$\ln wage = \Sigma diQi + \Sigma \beta i(Qi*HiTech) + Ui$$

8.C Findings

8.C.1 Quantile regression estimates for New Zealand workers in 2002

Graph 8.1 presents quantile regression estimates for the 10th percentile of the workforce (P10) and the 90th percentile (P90), simply regressing log wage on age and age squared, without any controls for industry or skill effects. The graph shows the characteristic concave curves for log wages over the working life cycle. As would be expected, the estimated earnings for those at the 90th percentile are rising more steeply than for those at the 10th percentile over most of the working age range, and the 90th percentile curve peaks several years later. The P10 to P90 gap is widest at age 53, with a log wage gap of 1.02 representing an hourly wage difference of 2.76 times. In dollar terms, across all industries, occupations, qualification groups, and other relevant characteristics, a 53 year old worker at the 10th percentile of the wage distribution typically earns $9.75 per hour, while a worker of the same age at the 90th percentile earns $26.89 per hour.

Graph 8.1 : Wage dispersion by worker age



8.C.2 Computing effects

The dispersion was then estimated between the 10th percentile and the 90th percentile with the proportion of industry expenditure on computing included as an additional explanatory variable (Appendix 2A). A number of different specifications were tested, but following Winkelman (1998) all included controls for experience and experience squared[3], this specification being preferred to a quadratic in age for the reasons outlined in Section 6.C (P. 95). The simplest specification included only experience, experience squared and the variable indicating the proportion of computer inputs in the industry where the worker has their primary job. This reveals a marked tendency for wage dispersion in New Zealand to be wider in those industries which are significant users of new technology, than it is within industries which make little use of new technology, and the statistical significance of the computer use coefficient is very high (Table 8.2).

Table 8.2: Relationship between wage dispersion and industry use of computing, controlling only for experience and experience squared.

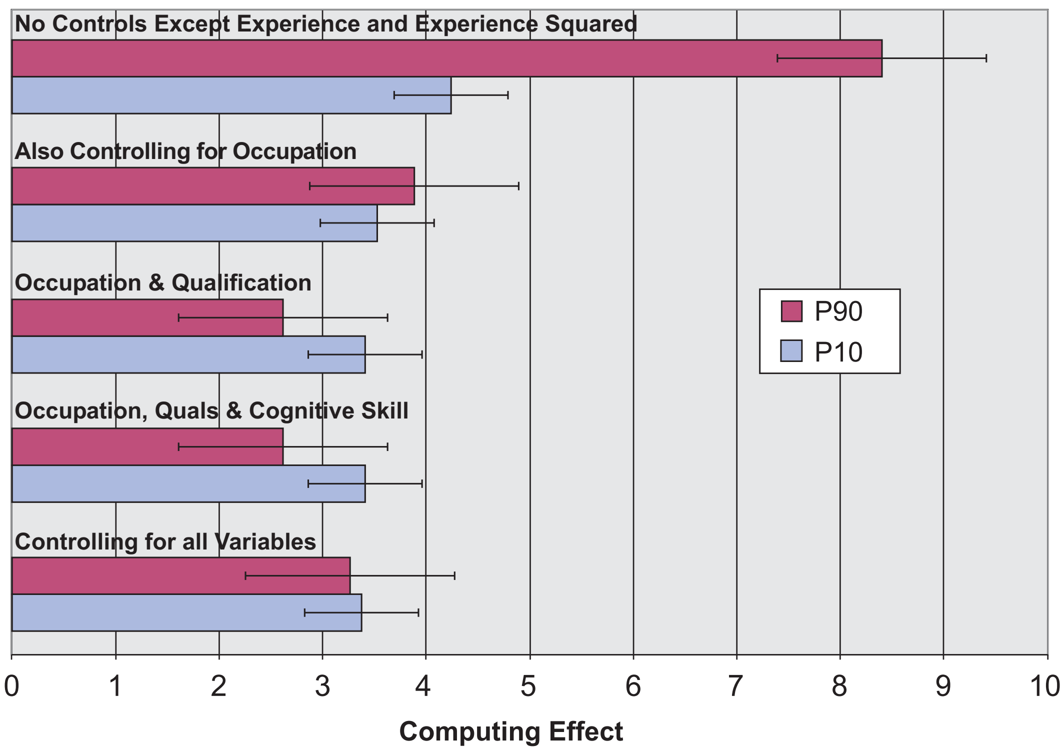
Variable	P10	P90	Difference
Computing/total expenditure	4.24 (8.78)**	8.41 (8.81)**	4.17
Experience	0.03 (25.9)**	0.079 (19.43)**	
Experience squared	-0.0005 (24.0)**	-0.001 (16.06)**	
Constant	1.894 (150.9)**	1.484 (20.54)**	
R^2 = 0.11			
Robust t-statistics in parentheses * significant at 5%; ** significant at 1%			

The difference of 4.17 in the coefficient on computing expenditure means a greater log wage dispersion of 0.20 log points between those industries which have negligible computing expenditure and those which are the most computer intensive (4.8% of total expenditure). This log wage difference of 0.20 represents a 22 percent difference in P90:P10 dispersion.

However, once the regression was re-estimated incorporating controls for occupation, qualifications and cognitive skill, the apparent dispersion due to computer spending disappeared. Of these three sets of controls, occupation was found to have the strongest explanatory power, with the coefficient on computing expenditure becoming almost the same at the 10^{th} percentile as it is at the 90^{th} percentile. This implies that the wage dispersion over industries which is correlated with computer expenditure is in fact largely explained by the occupations of the workers. When a dummy variable for qualifications is also incorporated into the equations the coefficient on computer expenditure actually becomes smaller at the 90^{th} percentile than it is at the 10^{th} percentile.

Graph 8.2 shows the coefficients on the variable measuring the industry proportion of computing expenditure in the quantile wage regressions, at the 10th and 90th percentiles, for five different specifications of the control variables. The first pair of bars reports the estimation when no control variables are added apart from experience and exprience squared, and shows the large difference between the estimated coefficients at the 10th and 90th percentiles. The second pair of bars incorporates a dummy variable for occupation, with the P90 coefficient only fractionally larger than the P10 coefficient. The third pair incorporates a further control for qualifications and the fourth pair is the third with the addition of controls for cognitive skills. The fifth pair is the fourth with the incorporation of variables for marital status, sex, ethnicity, local government region of residence, and a dummy variable indicating whether or not the respondent was a migrant to New Zealand. The error bars indicate one standard error plus or minus.

Graph 8.2: P10 and P90 comparisons of the computing effect, controlling for experience and experience squared, with and without the inclusion of other control variables.



Controlling for occupation and qualifications reveals exactly the same pattern whether or not the control for cognitive skill is also incorporated (specifications 3 and 4 in Graph 8.2). Additional controls were brought into the model for interpersonal skills and motor skills as calculated by Pappas (2001), but the coefficients on computer expenditure remained the same as they were in the simpler specification. The coefficients on interpersonal skills and motor skills are negligible, while the small positive coefficients on cognitive skills are offset by reduced positive coefficients on the dummies for qualifications and occupation.

Table 8.3: Relationship between wage dispersion and industry use of computing, including all control variables.

Variable	P10	P90	Difference
Computing/total expenditure	3.38 (5.79)**	3.27 (3.92)**	0.11
Experience	0.020 (13.50)**	0.028 (14.21)**	
Experience squared	-0.00034 (11.7)**	-0.0046 (12.06)**	
Constant	1.95 (30.4)**	2.31 (16.57)**	
R^2 = 0.23			
Robust t-statistics in parentheses ** significant at 1% level			

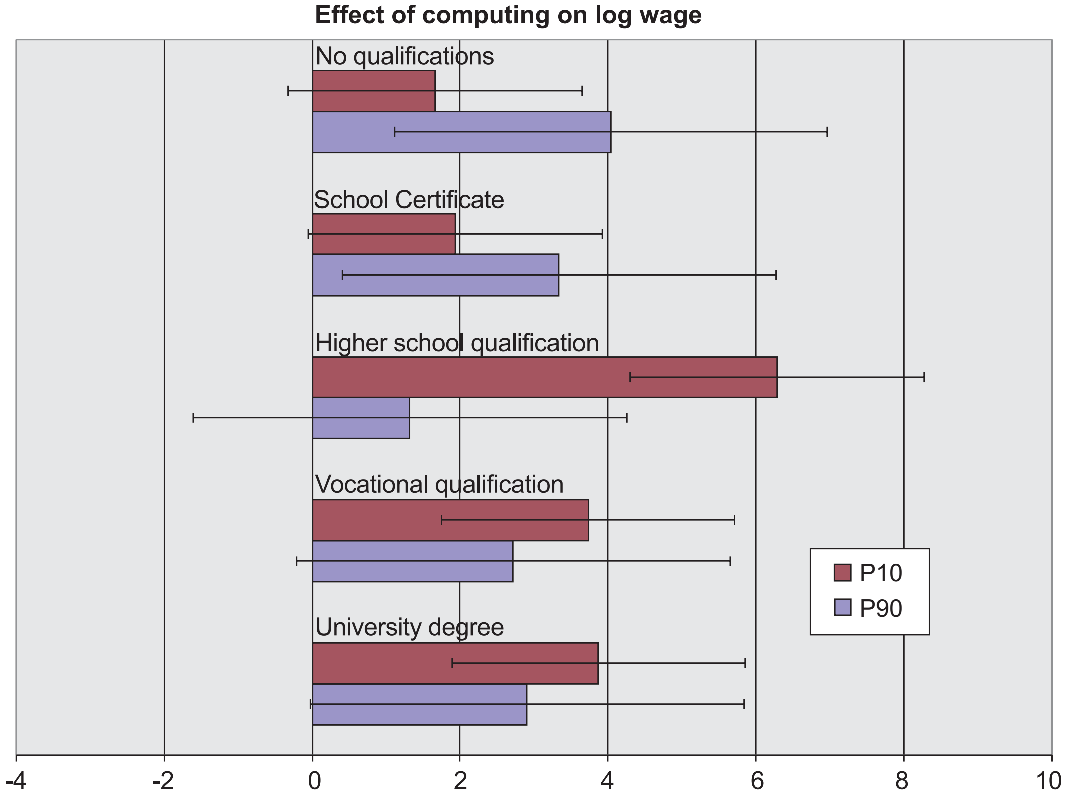
A number of additional control variables were introduced into the model, for worker characteristics which could possibly have significance: sex, ethnicity, marital status, migrant status and local government region of residence (specification 5 in Graph 8.2). When all these control variables are included the coefficients on computing expenditure become almost identical, suggesting that there is no direct technology effect as such. It appears that the characteristics of the workers fully explain the rising inequality associated with new technology, and in particular it is very largely occupations and qualifications which determine the difference. Table 8.3 shows the revised coefficients and t-statistics for the most complete specification[4].

8.C.3 Within group inequality

The study of Census data reported in Chapter 6 found a tendency for the computer intensity of industries to be associated with higher within-group inequality for workers with higher qualifications in the period from 1991 to 1996, but in the period 1996 to 2001 there was hardly any significant relationship between computer use and within-group inequality (Appendix 8). In order to double check this finding using the 2002 unit record data, the sample was divided into five groups by level of qualification, and quantile regressions were estimated at the 10^{th} and 90^{th} percentiles for each qualification level in turn.

In the simplest specification, controlling only for age and age squared, QR estimates show a substantial increase in wage dispersion associated with computer intensity, for those workers with no qualifications or only school certificate. However, for those workers who have higher schooling or vocational or university qualifications computer intensity is associated with compression of the wage differential. The same pattern is apparent when cognitive skill is also controlled for, but the coefficients on computing are somewhat muted (Graph 8.3. Error bars show one standard error plus or minus).

Graph 8.3: The effect of computing intensity on within-group inequality, by highest qualification achieved, controlling for cognitive skill.



<u>*8.C.4 Between group inequality*</u>

Finally, in order to examine changes in between-group inequality, industries were divided into two groups according to whether their expenditure on new technology exceeds 0.8% of total industry expenditure (Appendix 2B). OLS wage regressions on the interaction of qualifications and technology were estimated, to see whether the return to qualifications was greater in the more computer intensive industries.

These regressions were run separately for male and female workers. For male workers the higher technology industries were associated with greater returns to qualifications at all qualification levels, with the effect most marked at the middle levels. For example, a male worker with School Certificate gains a premium of 6.78% over a male worker with no qualifications, but if they also work in a high technology industry that premium is enhanced by a further 8.34%. This difference is statistically significant (t=2.42).

Table 8.4 reports the coefficients on the interaction effects between the indicator that an industry is higher-technology and the independent variables age and age squared. For female workers the pattern was similar to the male pattern up to the middle levels, but for university graduates the relationship was reversed, with high technology industries associated with a lower return to qualifications. The regressions were re-estimated including a control for the interaction of high-technology with cognitive skills, and the patterns were found to be similar to the base case specification. However for male degree holders the wage premium was greater, and for female degree holders the reduction in wage premium was halved.

Table 8.3: Effect of higher technology uptake on returns to education at different qualification levels.

	Controlling only for high-technology dummy		**Further controlling for cognitive skill**	
	Male	Female	Male	Female
School Cert	0.0834 (2.42)*	0.0917 (2.69)**	0.0827 (2.42)*	0.0905 (2.72)**
Higher school	0.1822 (5.02)**	0.0886 (2.78)**	0.1575 (4.58)**	0.0669 (2.08)*
Vocational	0.0929 (3.37)**	0.0052 (0.19)	0.0861 (3.25)**	0.0514 (1.84)
Degree	0.0754 (1.77)	-0.1053 (2.56)*	0.1144 (2.55)*	-0.0582 (1.37)

Heteroscedastically robust t-statistics in parentheses
* significant at 5% level; ** significant at 1% level

8.D Summary and Conclusions

In New Zealand, the more computer intensive industries show significantly greater wage dispersion than industries which make little use of new technology, a pattern which has also been found in other countries (Allen, 2001; Katz, 2000). The most technology-intensive industries in New Zealand are associated with an increase of 0.20 in the log wage gap between the 10th percentile and the 90th percentile, representing an hourly wage premium of 22%.

However the relationship between wage dispersion and industry use of new technology is fully explained when controls for educational qualifications and occupation are introduced into the equations. Evidently it is not so much the industry use of technology as such that is driving the wage dispersion, as the industry need for a better educated and more appropriately qualified workforce. This finding tends to support the hypothesis that new technology is just one manifestation of the new industrial workplace, and that rising inequality reflects returns to the skills which are most in demand as the workplace evolves.

There appears to be within group wage compression associated with industry computer use for workers at the higher educational levels, suggesting that rapid change and new technology have little effect on those who have higher skills. But for those workers with no qualifications beyond School Certificate the use of technology is associated with a marked widening of the P10:P90 wage gap, tending to confirm the intuitively plausible idea that workers with few qualifications enjoy only weak demand in technology intensive industries.

Testing whether computer intensive industries show higher returns to qualifications also revealed a softening of the technology effect at the top of the qualification range. For male workers there was a higher return to education at all levels, but for female workers this was only true in the mid range, and for women university graduates high technology industries are associated with wage compression.

In line with the conclusions of Chapter 7, this finding tends to support the idea of the complementarity of computers with skilled workers and the substitutability of computers for unskilled workers. The returns to skill are correlated with those industries which are major users of new technology, implying that the general level of education in New Zealand is likely to be a constraint on the speed at which new technology can be further expanded.

The trends in the Population Census data, described in Chapter 6, revealed a widespread rise in between group inequality, especially in the later 1990s. The present chapter provides a more detailed view of this between-group inequality, and suggests that the gaps between the bottom and the middle of the qualification range are now more significant than between the middle and the top, with the workers who have no qualifications beyond School Certificate being the most disadvantaged. It therefore seems likely that an increased commitment to public education could be expected to have beneficial outcomes, if it were aimed at raising the standards of the least educated.

In this context it is particularly troubling that the numbers of young adults entering the workforce with no formal qualifications continue to make up nearly 30 percent of the New Zealand workforce, and are only trending downwards very slowly (Graph 7.1) While greater numbers of women are completing at least some qualifications, and the general level of women's education is trending upwards, the proportion of men with no qualifications beyond School Certificate rose to 45 percent in the 1990s.

If inequality is exacerbated by changing labour demand rewarding the well-positioned, there is a serious risk of self perpetuating polarisation. Moreover it has been argued that within-group inequality tends to be temporary while between-group inequality is more permanent (Aghion and Howitt, 2002). If this is correct, and the Census findings in Chapter 6 strongly suggest that this has been the case in New Zealand, there would seem to be a strong argument for an increased public commitment to lifting the workers at the bottom of the qualification range.

Footnotes:

1. In recent years the HLFS Income Supplement has been restyled the New Zealand Income Survey (NZIS).

2. The ASCO : NZSCO occupation concordance is available from the author on request, with two-digit level detail.

3. Because only five qualification levels were usable from this data it was necessary to modify the Winkelmann (1998) experience measure described in Chapter 6 (P. 108). The values used in this chapter are: No qualification (8 years), school certificate (11 years), higher school qualification (13 years), vocational/trade qualification (14 years), university degree (16 years),

4. The complete results showing coefficients on every qualification level, every occupation etc. are available from the author on request.

Chapter 9

Inequality decomposition using unit record files

9.A Introduction

The pattern of rising inequality at the same time as rising demand for skills and increased use of technology is now widely recognized, both in New Zealand and rather generally around the English speaking world. But the path of causality is by no means clear.

The existence of these parallel trends of rising demand for skills and uptake of new technology has prompted many commentators to speculate that the new technologies are driving the demand for skills, which in turn is lifting wage inequality, and this is a plausible explanation which accords with the basic facts. But it could also be that the industries which are undertaking automation are the ones in which change is generally most rapid, for example through workplace reorganization, and that these industries reward certain worker characteristics. In this case the highly technologized industries would tend to be the ones which paid a skills premium, without necessarily paying a return to computerization per se.

As noted in Chapter 6, some industries have been affected much more by the ICT revolution than others, and so it is natural to compare wage inequality in the more ICT-intensive industries with inequality in the less ICT-intensive industries. A finding of higher inequality in the ICT-intensive industries may indicate an unpalatable tradeoff between faster productivity growth from spurring ICT-uptake, and widening inequality. However, inequality may differ between these two groups of industries for reasons that are not directly related to the industry's investment in new technology, especially if there are systematic differences in the characteristics of workers in each industry which account for any inequality differences.

In this chapter I address this issue by dividing the industries into two groups, high-tech and low-tech, according to their expenditure on ICT inputs as a proportion of total industry purchases. Using wage data from the Statistics NZ Confidentialized Unit Record Files for 2002 and 2004 the comparative wage distributions in the two groups of industries are examined, controlling for gender, highest qualification and other attributes. Using the reweighting technique pioneered by DiNardo, Fortin and Lemieux (1996), counterfactual wage distributions are constructed to estimate the extent to which the different wage distributions reflect industry differences, and the extent to which different industries are rewarding worker characteristics.

9.B Data

9.B.1 The Income Survey CURF data

Since 1997 Statistics New Zealand has conducted an annual Income Supplement to the Household Labour Force Survey, now known as the New Zealand Income Survey (NZIS). The NZIS provides an extensive range of earnings information such as hourly and annual wage rates, in addition to information about incomes from other sources.

The Income Supplement (IS) data are a very rich source, but because they contain extensive detail about private individuals use of the full data set is understandably very strictly controlled, and access to it is only possible for approved projects conducted at the Statistics New Zealand Datalab. However since 2002 the IS data have been put through a confidentialising process. This involves some top coding of numbers to exclude outliers, and some rounding to make identification of individuals more difficult. It also involves some regrouping into broader categories, such as grouping location of residence from the local government districts into 10 larger regions.

With the risks to confidentiality much reduced, Statistics New Zealand are willing to make these Confidentialised Unit Record Files (CURFs) available for use outside Statistics New Zealand offices, and while the loss of some detail is regrettable they are beginning to prove a very useful research tool. Full details of CURFs available and the confidentialising process are available on the Statistics New Zealand website (Statistics New Zealand, 2004).

Some 30 000 individuals aged 15 or over are surveyed, establishing information on the industries and occupations those individuals are employed in, their highest level of qualification, and many other details such as marital status and ethnicity. However, for the purpose of this study approximately half of these observations are dropped, almost always because earnings are zero or trivial, but in a few cases because industries or occupations were not identified in the data.

As at mid-2006 three years of Income Supplement CURFs had been released. The present chapter uses the 2002 and 2004 CURFs, the earliest and latest years currently available, to examine wage inequality between workers in each of those years, and also the inequality trend over this two year period. Table 9.1 shows the total numbers of observations in each of these two CURF data sets, and the numbers which were usable for the present study.

Table 9.1 : Income Supplement CURF Data

Descriptive statistics	**2002**	**2004**
Total CURF sample	29356	27847
No earnings	14923	13975
Industry or occupation not identified	50	61
Usable sample	**14383**	**13811**
Female workers	7233	6912
Male workers	7150	6899

The CURF data provide many different income and earnings variables, but because this is a study of the technology and industry effects on wages it focuses on the usual hourly wage from first job. This variable should be the indicator most responsive to the earnings effects of industry and worker characteristics.

9.B.2 Industry Use of Information and Communications Technologies (ICT)

This chapter again makes use of the industry expenditure on computers and computer services drawn from the 1996 inter-industry tables compiled by Statistics New Zealand.

Industry expenditure on computers and computer services ranges from virtually zero in the primary industries such as farming, fishing and forestry, up to 4.8 percent of total industry expenditure in banking and finance, and over 3 percent in public administration. As in Chapter 8, industries were divided into two groups, according to whether expenditure on computers and computing services was greater or less than 0.8 percent of total industry expenditure. This threshold divides the labour force approximately in half. (Description in 8.B.3 Page 126)

The overall proportion of workers in the technology-intensive industries has remained close to 45.5 percent over the two years, but there is a marked tendency for the proportion of female workers in the technology-intensive industries to be rising while the proportion of male workers in the technology-intensive industries is declining. Table 9.2 gives the split between the two groups (labeled hi_comp and low_comp) for male and female workers separately and together.

Unfortunately the CURF data only provide single-digit industry indicators, whereas the NZIS data contain industry information to the two-digit level. However the proportions of workers in each group are very similar, whether single-digit or two-digit data are used. For comparison, Table 9.2 includes the data from the 2001 Population Census, which provide industry data to the two-digit level.

While the proportions are very similar, the single-digit industry groupings do not correspond exactly to the two-digit industries. In some groups one or two technology-intensive industries are swamped by a generally low-technology group, and vice versa. However, while a finer division of industries would be desirable in the CURF data, it is probable that the single-digit industry grouping will tend to diminish the differences between groups rather than distorting the direction of findings.

Table 9.2	Census	CURF	CURF
Hi_comp/Low_comp split	**2001**	**2002**	**2004**
Usable sample	1 005 825	14 383	13 811
Female workers	431 589	7 233	6 912
Male workers	574 236	7 150	6 899
Low-comp group			
Low_comp group (male)	317 343	4 077	4 017
Proportion in low_comp group (male)	55.3%	57.0%	58.2%
Low_comp group (female)	233 955	3 774	3 500
Proportion in low_comp group (female)	54.2%	52.2%	50.6%
Low_comp group (all workers)	551 298	7 851	7 517
Proportion in low_comp group (all)	54.8%	54.6%	54.4%
High-comp group			
High_comp group (male)	256 893	3 073	2 882
Proportion in high_comp group (male)	44.7%	43.0%	41.8%
High_comp group (female)	197 634	3 459	3 412
Proportion in high_comp group (female)	45.8%	47.8%	49.4%
High_comp group (all workers)	454 527	6 532	6 294
Proportion in high_comp group (all)	45.2%	45.4%	45.6%

9.B.3 Occupations and skills

For skill levels of workers this chapter again uses the skills factors estimated by Nick Pappas (2001) for each occupational group, as described in Chapter 8 (Section 8.B.2 Page 125) and Appendix 12. As with the industry information, the CURF data only provide single digit occupation indicators, so for the present study the cognitive skill estimate has been grouped up to that level.

9.C Method of Analysis

9.C.1 The base line case

The base line case for the analysis examined the wage inequality patterns for male workers only, since male workers are less prone to sample bias. Both full-time and part-time male workers were included.

Three inequality measures were used in the analysis:

1. The Theil inequality measure (which is a member of the Generalized Entropy family with an income difference sensitivity parameter equal to two), $I_T = \frac{1}{N}\sum_{i=1}^{N}\frac{x_i}{\mu}\ln\left(\frac{x_i}{\mu}\right)$ where x_i is the income of the *i*th person, μ is the mean income and N is the total number of persons. The Theil index is sensitive to income differences towards the top of the distribution.

2. The Gini coefficient, $G = \sum_i \sum_j \frac{|x_i - x_j|}{2N^2\mu}$, which is most sensitive to income differences around the mode of the distribution.

3. The Atkinson inequality measure, $A = 1 - \left[\sum_{i=1}^{N}(x_i/\mu)^{1-\varepsilon}\right]^{1/(1-\varepsilon)}$ with the coefficient of relative inequality aversion, ε=2 making the index sensitive to income differences at the bottom of the distribution.

The CURF data for 2002 and 2004 were combined, and inequality measures were compared both between the workers in the two groups of industries and also between the two years.

Every observation in the CURF data has a weight attached, since:

> "Each record represents a number of people in the population. The number of people represented is indicated by the weight held on the record" (Statistics NZ, 2004).

Thus the weights need to be taken into account when using these samples, in order to obtain reliable estimates for the total working population.

The inequality analysis was initially performed using the replication weights provided by Statistics New Zealand, to show the difference in inequality between the workers in the two groups of industries. Using the technique pioneered by DiNardo, Fortin and Lemieux (1996), hereafter DFL, the data were then reweighted. A reweighting factor was estimated from a logit which captures the characteristics of workers, including age, age squared, sex, ethnicity, marital status, local government region, whether or not a migrant, highest qualification achieved, whether working fulltime, occupation and cognitive skill level.

The weights for workers in the high-comp industries are multiplied by the reweighting factor, and the inequality decomposition is recalculated. This technique achieves the separation of industry effects from the effects of worker characteristics. Lorenz curves display the differences in overall inequality between the two groups of workers and the two years, and when redrawn to reflect the reweighted workers in the high_comp industries they show the extent to which the inequality reflects the value of the worker characteristics. Kernel density graphs show the shape of the wage distribution under each specification.

The inequality decomposition program provides Gini coefficients, Atkinson indices and Theil indices. As noted above, these different measures of inequality are sensitive to changes in different parts of the distribution, and reporting all three measures provides some understanding of which part of the distribution is most affected.

9.C.2 Sensitivity analysis

Two sets of sensitivity analyses were also performed, in order to test the robustness of the base line specification. Firstly, sensitivity to sample selection was checked by re-estimation four ways: all workers (male and female) full-time only or full-time and part-time, and male workers only, full-time only or fulltime and part-time.

Secondly, in an attempt to understand which worker characteristics are most significant, the estimates were also tested for sensitivity to the respecification of the logit which determines the reweighting factor. Using only the male workers the inequality decompositions were reestimated without the measure of cognitive skill or the indicators of occupation or highest qualification, or combinations of these.

The two sets of sensitivity analyses were only run on the 2002 data, as the inequality differences were substantially more pronounced in that year compared to 2004.

9.D Results

9.D.1 Results using original weights

Table 9.3 gives the mean and median hourly wages for the two different categories of workers in both years, using the original Statistics New Zealand weights. It is significant that the median wage in 2002 is exactly the same across the two groups of workers, and in 2004 it is fractionally lower in the technology-intensive industries, despite the means being substantially higher. Thus the difference between the two groups of industries is entirely one of levels of inequality, and there is no difference in the general level of wages paid in each group.

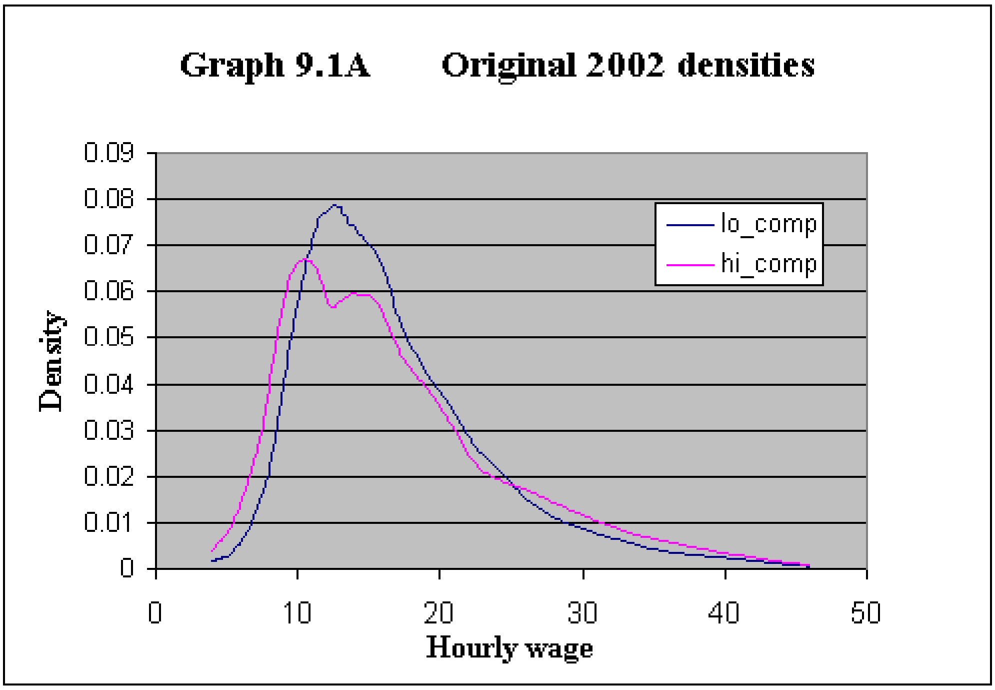
Table 9.3 also reports the Atkinson A(2) indices, Gini coefficients and Theil GE(2) indices. These three inequality indicators are more sensitive to movements at the bottom, the middle and the top of the distribution respectively, and a comparison of them therefore reveals which part of the distribution is most affected.

Table 9.3 : Hourly wages and inequality measures — **Original weights**

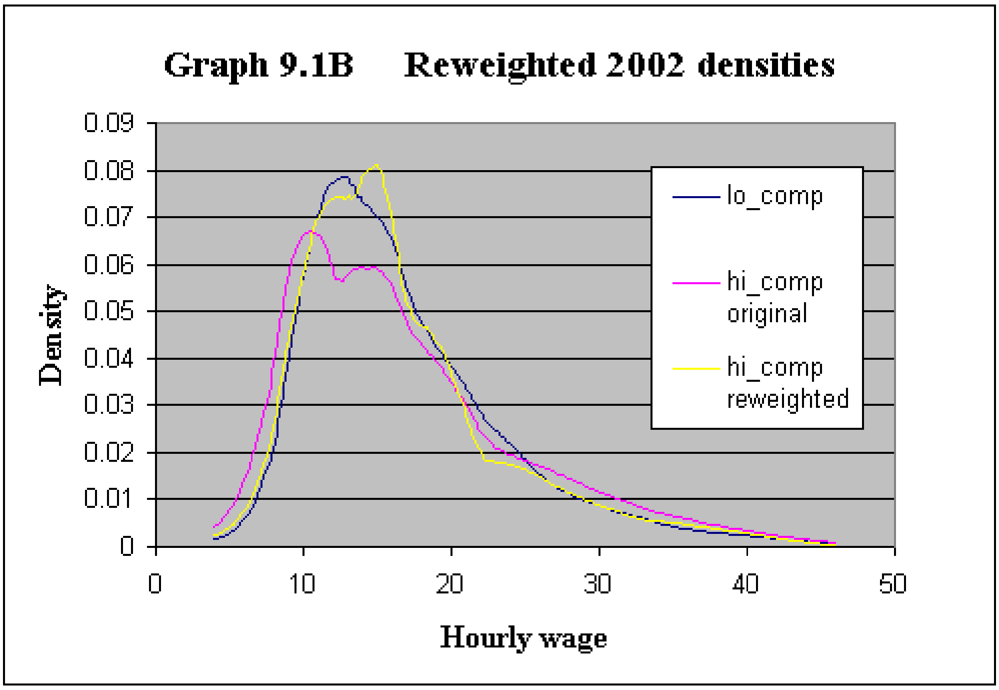
2002	Mean wage (hourly)	Median wage	Atkinson A(2)	Gini	Theil GE(2)
Overall			0.2681	0.3194	0.90071
Low-comp	18.26	15.30	0.2245	0.2788	0.59578
High_comp	20.13	15.30	0.3162	0.3632	1.20094
Difference	1.87	0.00	40.89%	30.25%	101.57%
2004	Mean wage	Median wage	Atkinson A(2)	Gini	Theil GE(2)
Overall			0.2136	0.2833	0.2186
Low-comp	19.30	16.70	0.1901	0.2599	0.1855
High_comp	20.15	16.40	0.2413	0.3096	0.2555
Difference	0.85	-0.30	26.90%	19.11%	37.75%

Inequality is markedly greater in the technology-intensive group, with the Gini coefficient on wages in the hi-comp group being some 30 percent higher in 2002, and more than 19 percent higher in 2004. However, in both 2002 and 2004 the Gini coefficients show less difference in wage inequality between the two groups of industries than is found at either end of the distribution, suggesting that the difference in inequality is largely a feature of the two tails rather than workers near the median.

Of the three inequality indicators, it is the Theil index which shows the greatest difference in both years. Indeed, in 2002, the Theil index for wage inequality in the technology-intensive industries was fully double the value for the less technologized industries. Graph 9.1A is a kernel density graph showing the density of worker numbers against wage rates for workers in the low-comp and high-comp groups in 2002. The curve for the workers in the low-tech industries is taller and narrower, illustrating the greater concentration of worker numbers near the mode of the distribution. The substantially greater inequality in the right hand tail of the high-tech curve is also clearly visible, echoing the higher value of the Theil index noted above.



Graph 9.1A Original 2002 densities
Density
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
0
10
20
30
40
50
Hourly wage
lo_comp
hi_comp



Graph 9.1B Reweighted 2002 densities
Density
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
0
10
20
30
40
50
Hourly wage
lo_comp
hi_comp original
hi_comp reweighted

9.D.2 Effect of reweighting

The DFL reweighting technique adjusts the weight attached to the workers in the high-technology industries to allow for worker characteristics. Thus, the more closely the reweighted figures approach the figures for the workers in the low-tech industries, the more we can see the difference as being explained by worker characteristics and the less it relates to anything intrinsic to the industries themselves.

When the workers in the high-comp group are reweighted to reflect the attributes of the workers, the difference largely disappears. Table 9.4 shows the comparable figures after reweighting, and Graph 9.1B presents the 2002 kernel density graphs with the reweighted hi-comp group showing a distribution much closer to the low-comp group than it is to the unadjusted hi-comp group.

In 2002 both the Atkinson index and the Gini coefficient drop to about a quarter of their original values. The Theil index, sensitive to income differences at the top of the distribution where the wage difference between the two groups is most marked, drops by more than 40 percent. Graph 9.2 displays the Lorenz curves for the 2002 workers, with the low-comp group dominant and the hi-comp group with the original weights much the most unequal.

9.D.3 Trend over time: 2002 - 2004

By 2004 there was apparently less inequality overall in New Zealand wages, with all the three measures showing considerably lower figures than two years earlier. Graph 9.3 shows the Lorenz curves for the hi-comp workers in each year, with and without reweighting. Within each year the reweighted curve is dominant, while the pair for 2004 is markedly less unequal than the 2002 pair.

It could be suggested that this merely reflects an ongoing adjustment of the labour market to new industrial labour demand patterns. But the reweighted figures in 2004 show an even larger proportion of the difference explained by adjustment for worker characteristics. This suggests that the worker characteristics are particularly important in explaining the industry wage differentials, and it is not merely an adjustment issue.

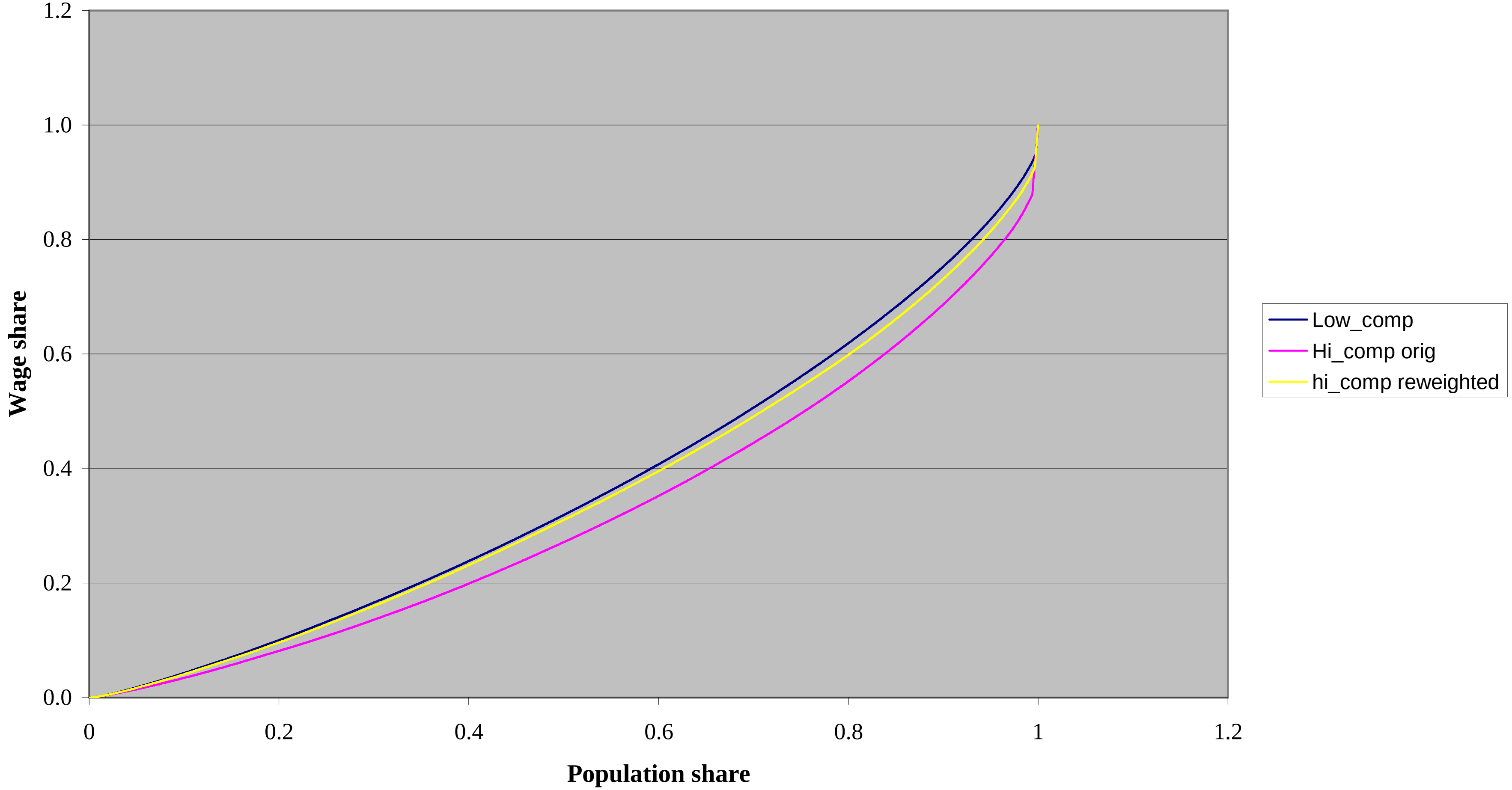
Both the mean wage and the Atkinson index in the reweighted high-comp group actually fall below their counterparts in the low-comp group, suggesting that the lower end of the distribution is totally explained by worker characteristics. And at the top of the distribution, more than six sevenths of the difference in the Theil index is also explained by the worker characteristics.

Table 9.4 **Inequality in high-comp and low-comp Industries : Male workers only** **Adjusted weights**

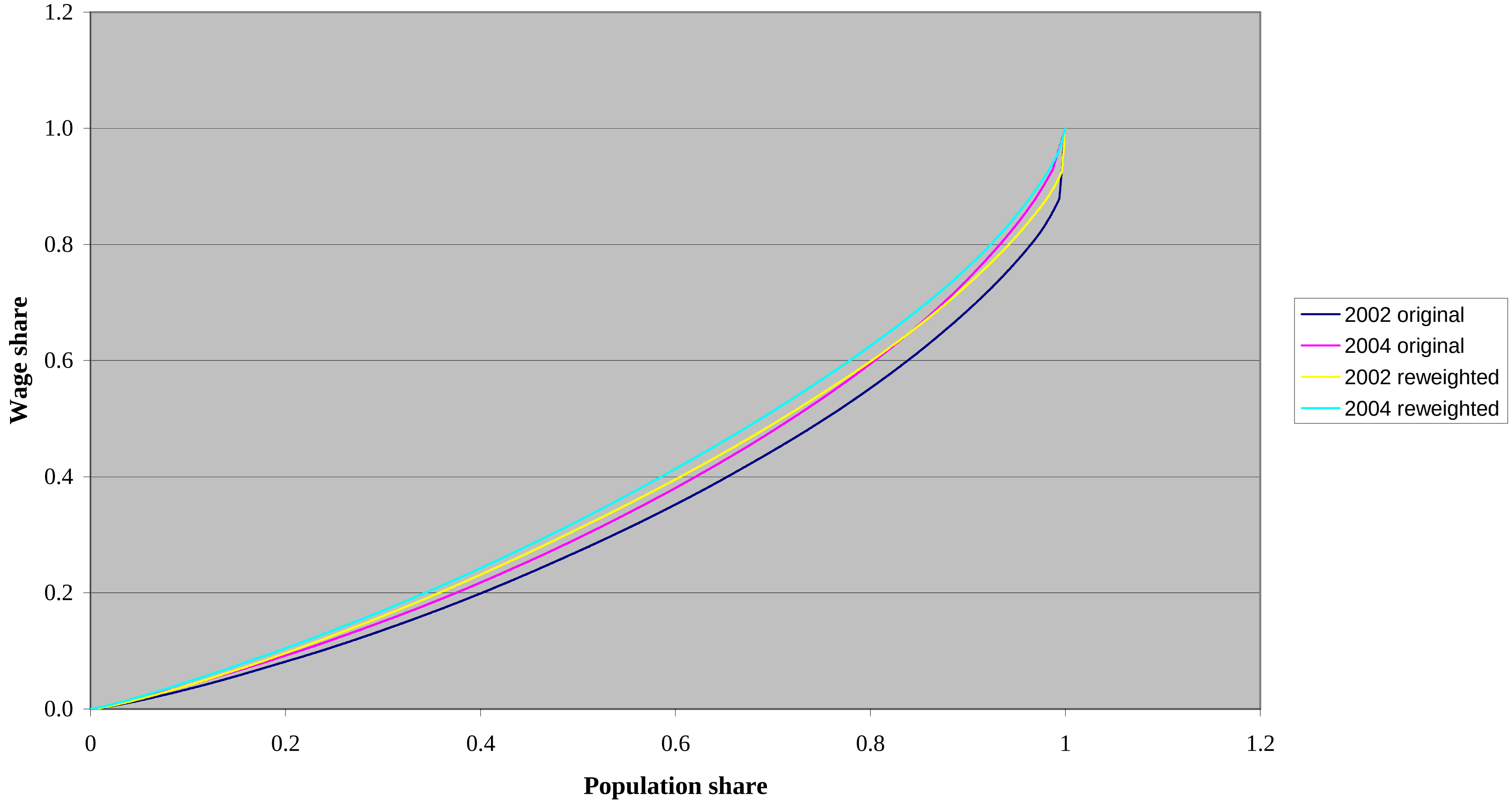
2002	Mean wage (hourly)	Atkinson A(2)	Gini	Theil GE(2)
Overall		0.233	0.2886	0.7013
Low-comp	18.263	0.224	0.2788 (0.0117)	0.5958
High-comp	18.473	0.244	0.3001 (0.0153)	0.8264
Difference	0.210	8.54%	7.63%	38.71%
Original difference	1.870	40.89%	30.25%	101.57%
Explained proportion	88.79%	79.11%	74.79%	61.89%
2004	Mean Wage	Atkinson A(2)	Gini	Theil GE(2)
Overall		0.1899	0.2632	0.1899
Low-comp	19.303	0.1901	0.2599 (0.0117)	0.1855
High-comp	18.570	0.1889	0.2666 (0.0153)	0.1952
Difference	-0.733	-0.66%	2.57%	5.22%
Original difference	0.85	26.90%	19.11%	37.75%
Explained proportion	186.24%	102.44%	86.57%	86.16%

Standard errors in brackets

Graph 9.2 2002 Lorenz curves



Graph 9.3 Hi_comp 2002 and 2004



9.E Sensitivity analysis

9.E.1 Sensitivity to sample selection

The base line case above considers only male workers, but includes both full-time and part-time workers. In order to check the sensitivity to sample selection the 2002 CURF data were also analyzed including both male and female workers. They were further checked using only the fulltime workers, both including and excluding the female workers. The comparative findings are reported in Table 9.5.

Inclusion of the female workers makes very little difference to the overall pattern. As we would expect, mean wages are somewhat lower when women are included in the sample. But whereas the difference in the mean wage is less than 5 percent in the low-tech group it is over 14 percent in the high-tech group with the original weights. Reweighting for worker characteristics produces very similar results whether or not female workers are included, with the worker characteristics explaining the overwhelming proportion of the difference.

Not only do mean wages drop when women are included. Compared to the male only samples the inequality is also lower, by any of the three inequality measures, and especially in the Theil index. In the most extreme case, considering full-time workers only in the technology-intensive industry group, the Theil index drops by 20 percent when female workers are added to the sample. This finding, combined with the significantly lower mean wages when women are included, implies that women are much more bunched toward the low end of the wage spectrum than are men.

Inclusion of part-time workers also makes very little difference to the general pattern. When part-time workers are included the mean wage drops, but only by some 6 percent in the high-comp group and one-third of that in the low-comp group. Part-time workers tend to be concentrated toward the low end of the wage distribution, as would be expected.

Table 9.5 — **Sensitivity analysis**
Various samples

Low-comp group	Mean	Atkinson A(2)	Gini	Theil GE(2)
Full-time and part-time				
Male only	18.26	0.224	0.279	0.596
Male and female	17.45	0.217	0.275	0.582
Full-time only				
Male only	18.45	0.199	0.263	0.489
Male and female	17.80	0.188	0.253	0.418
High-comp group Original weights	Mean	Atkinson A(2)	Gini	Theil GE(2)
Full-time and part-time				
Male only	20.13	0.316	0.363	1.201
Male and female	17.58	0.269	0.326	1.005
Full-time only				
Male only	21.31	0.272	0.332	0.976
Male and female	19.12	0.234	0.298	0.775
High-comp group Reweighted	Mean	Atkinson A(2)	Gini	Theil GE(2)
Full-time and part-time				
Male only	18.47	0.244	0.300	0.826
Male and female	17.53	0.230	0.290	0.755
Full-time only				
Male only	18.67	0.214	0.283	0.706
Male and female	17.91	0.198	0.268	0.573

Rather more surprising, inclusion of part-time workers increases the dispersion, and this is reflected in all three inequality measures. While part-time workers are lower paid on average, the spread of their wages is evidently higher. Thus the base case, considering only male workers but including those working part-time and full-time, is the case which shows the most marked inequality patterns.

9.E.2 Sensitivity to the weighting factor specification

As outlined in Section 9.C above, the DFL technique for estimating the extent to which inequality reflects worker characteristics uses a reweighting factor based on a logit estimate designed to capture the characteristics which are likely to be relevant. Respecifying this logit with certain characteristics included or excluded provides a test of the sensitivity of the reweighting to those particular characteristics.

The base line specification of male workers from the 2002 CURF, including both full-time and part-time workers, was re-estimated excluding the occupation and highest qualification variables and the cognitive skill measure, singly and in combination, in order to check the sensitivity of the analysis to these characteristics. The results are reported in Table 9.6.

Dropping the cognitive skill indicator on its own from the logit results in no change to any of the estimates, suggesting that the effects of this measure are fully captured by the other variables already included. Dropping the occupation variable reduces the reweighting effect significantly, but simultaneously dropping occupation and cognitive skill reduces the reweighting effect on the Gini by some 38 percent.

Table 9.6 **Sensitivity analysis : Various logit specifications**

2002 **Adjusted weights**

		Mean wage (hourly)	Atkinson A(2)	Gini	Theil GE(2)
Low-comp		18.263	0.224	0.279	0.596
High_comp	**Original weights**	20.130	0.316	0.363	1.201
	Reweighted				
High_comp	All variables	18.473	0.244	0.300	0.826
High_comp	Without occupation	18.583	0.259	0.315	0.913
High_comp	Without cog_skill	18.473	0.244	0.300	0.826
High_comp	Without either	19.224	0.271	0.324	0.959
High_comp	Without qualifications	18.622	0.242	0.300	0.816
High_comp	No quals or occ	18.790	0.256	0.314	0.887
High_comp	No quals, no cog_skill	18.622	0.242	0.300	0.816
High_comp	None of these three attributes	19.972	0.277	0.331	0.977

Evidently occupation and cognitive skill are worker qualifications of particular value in the more ICT-intensive industries, though workers in the desired occupations appear to have the required skills, and the cognitive skill dummy contributes nothing extra if occupation has already been included. Dropping the highest qualification variable by itself produces results very similar to dropping the occupation variable, while dropping both these simultaneously makes hardly any difference. It would therefore appear that qualifications and occupations are very closely correlated, and, as would be expected, that these two variables largely proxy for each other and for an important set of worker characteristics.

If all these three worker characteristics are dropped from the logit two thirds of the reweighting effect disappears from all the inequality indices, and the mean hourly wage returns to within $0.16 of the figure in the high-comp industries without reweighting. Evidently, the worker characteristics captured in the occupation and highest qualifications variables and in the cognitive skill measure are the characteristics of particular importance in determining which workers will be of greatest value in the industries which are undertaking new technologies.

9.F Conclusions

Two conclusions can be drawn from this examination of wage data by industry. Firstly, especially in the 2002 data, wage inequality is substantially higher in the industries which are more technology-intensive than it is in the less technology-intensive industries. But this difference in inequality reflects differences in worker characteristics much more than differences which are intrinsic to the industries themselves.

The implication of this finding is that increasing use of ICT should not be a direct cause of wider inequality. Once we adjust for worker attributes there is almost no difference in inequality between ICT-intensive and other industries. However workers lacking the relevant characteristics are little valued in the technology-intensive industries. Not only are they not pulled forward by generally higher industry wages, they tend to be rewarded even less well than they would be in the less technology-intensive industries. This finding is strongly supportive of the theory that new technology is complementary to skills and a substitute for the less-skilled (Goldin and Katz, 1998; Krueger, 1993).

A second significant finding is that wage inequality fell very generally between 2002 and 2004. This was not specifically an inter-industry decline, but was spread across all groups of workers in both technology-intensive and less technologized industries, with the gap between industries continuing to be explained overwhelmingly by worker characteristics.

A two year period is too short to be taken as signifying a major trend. But following the rapid rise in inequality that was recorded in the 1990s it suggests a distinct break with the previous decade. This lends support to the theories of Nelson and Phelps (1966) and Schultz (1975), that firms pay a premium for adaptability which is highest during periods of rapid change. As Acemoglu (2001) suggested, it may now be that the period of most rapid change is past, and with much of the adjustment accomplished the worst phase of rising inequality may be over.

Chapter 10

Conclusions, Policy Implications and Possible Future Research

10.A Summary of existing knowledge

10.A.1 Inequality and its recent trends

Inequality matters. It has long been appreciated that, for a given level of production, greater inequality means a lower standard of living for most people. Moreover, in the last 20 years it has also come to be widely accepted that inequality has a marked tendency to impede growth (Osberg, 1995).

Prior to the 1970s it was widely accepted that the rich would save and invest more, and that inequality was therefore a necessary precursor to growth. But the availability of extensive new data has brought this theory seriously into question (Aghion, Garcia-Penalosa and Caroli, 1998). It now seems reasonably certain that the problems of polarization, distorted incentives and misdirection of government spending which result from inequality (Easterly, 2001b; Snower, 1998) far outweigh the very doubtful extent to which the rich are growth-promoting. And high levels of inequality are also strongly associated with social exclusion and crime (Borjas, Grogger and Hanson, 2006; Thorbecke, and Charumilind, 2002).

Over a long period from the late 19th century to the late 20th century, inequality of incomes was stable or trending downwards. Growth was shared, and the majority of citizens in the more developed countries benefited from growth. This trend showed an abrupt reversal in the mid-1970s, or a few years later in New Zealand. Not only did growth slow down, but it came to be largely captured by the few (Rosenthal, 2004). The average income grew faster than the median, which was static in the United States (Freeman, 1999; Wolff, 2001), and in New Zealand actually declined by some 3 percent between 1988 and 1998 (Gregory, 1999; Hyslop and Maré, 2005).

10.A.2 Possible explanations for recent trends in inequality

A number of possible explanations have been advanced for the recent trends in inequality, falling into four broad categories. The first of these is based on labour supply considerations: Increased numbers of unskilled migrants or the higher proportions of women entering the workforce, presumably flooding the market for less-skilled jobs. However the case for this is weak worldwide, and fits the New Zealand data particularly badly. Women in New Zealand are better educated than men, and most migrants are required to be well-qualified before they are allowed entry.

The second theory is centred on labour market institutions. The late 20th century was a period when many governments moved to deregulate labour markets and reduce union power. But since the pioneering work of Blanchflower and Oswald (1990, 1994) it has become increasingly appreciated that low wages and unemployment are not alternatives, but tend to go hand in hand (Conceição, Ferreira and Galbraith, 2001; Glyn and Salverda, 2000b). The idea that propping up minimum wages raised unemployment therefore looks relatively weak (Simonazzi and Villa, 1999) and this undermines the plausibility of labour market institutions being at the heart of rising inequality.

The third theory is based on rising inequality being coincident with the relaxation of trade restrictions in many countries. It is assumed that cheap goods from low-wage countries have displaced low-skill workers from routine jobs in the developed countries, but have had less impact on high-skill workers. This explanation found strong support in the past (Wood, 1995). In recent years it has largely fallen out of favour because rich countries mostly trade with other rich countries, and the quantities of trade with the third world do not appear large enough to have the effects which have been detected (Blanchflower and Slaughter, 1999; Burtless, 1998; Freeman, 1995b, 1999). Also this theory fits particularly poorly with the New Zealand experience, where the greatest rises in inequality tend to be in industries such as banking, financial services and public administration, which are not traded at all (Chapter 6, this thesis).

The final theory, and currently the most widely accepted, is that inequality is driven by some form of skill-biased technological change (Berman, Bound and Machin, 1998). Technology is constantly evolving (Gregory and Machin, 2000), and every development is likely to affect inequality, though at any particular time the direction of that effect can only be determined empirically. If technological change replaces human skills, then less-skilled workers become more useful and demand for them would be expected to rise. On the other hand, if new technology is a substitute for less-skilled workers and a complement to the better-skilled, then demand for the less-skilled is likely to decline, with poor job prospects for the less-skilled and rising wage inequality as the low-paid workers get left behind (Krueger, 1993). In the international literature the skill-biased technological change theory has been consistently the most favoured in recent years (Chennells and van Reenen, 1997, Galor and Moav, 2000), and the findings of the present study strongly support this in the New Zealand context. I review the evidence in Section 10.B.

10.A.3 Inequality and productive systems

Methods of production are constantly changing. New methods may promote or inhibit inequality, depending on whether new technology is more of a complement or a substitute for worker skills, and it is easy to think of examples of each (Berman, Bound and Griliches, 1994). For over 100 years it appears that evolving methods of production have been somewhat skill-biased (Acemoglu, 2002). However, the 20th century witnessed extensive skills upgrading, as universal primary education was followed up with comprehensive secondary schooling and steadily expanding tertiary programmes (Goldin and Katz, 1996). So long as the demand for skills was not rising very fast, and the supply was rising faster, the wage gap between the skilled and the less-skilled workers was stable or narrowing.

After the mid-1970s the demand for skills began to outstrip supply. In many of the developed countries, but especially in the English-speaking world, the skills premium began to widen. Not only did the wage dispersion increase, but the employment situation became increasingly precarious, and it was precisely those workers with the fewest qualifications, those who were falling behind in the wages race, who were also most vulnerable to job insecurity, casualisation and unemployment (Nickell, 1998).

The increasing skills premium and declining work opportunities for the less-skilled were also highly correlated with the uptake of new technologies, lending strong support to the idea that skill-biased technological change is the primary source of rising wage inequality in the late 20th century. But the exact path of causality is less clear, and this effect could have come about through a variety of different mechanisms.

One possible explanation is that new machines require skilled staff to develop, maintain and upgrade them, and that these new skills forced up the wage premium. This theory might be plausible in countries with substantial new technology industries, but it is hard to believe in the New Zealand context. While many industries have adopted new technology extensively, only a very small proportion of their staff are high technology experts. Blumenfeld and Thickett (2003) and Engelbrecht (2000b) have both estimated the number of ICT experts at no more than 4 percent of the total workforce, and it is inconceivable that such a small number of workers could have the effects that are observed.

The second possibility is that new technology has taken over tasks that were previously performed by less-skilled workers, while the better-skilled have been less vulnerable to displacement (Bauer and Bender, 2002). To some extent this has doubtless happened, but again it does not seem likely to have had the far-reaching effects that are seen in the real world. The marked tendency for enhanced returns to ability suggests an effect running right through the workplace, rather than simply declining demand for workers at the low end of the skills range (Bartel and Sicherman, 1999).

Overseas literature has found a strong correlation between new technology and workplace reorganization (Bresnahan, Brynjolfsson and Hitt, 2002; Green, Felstead and Gallie, 2003), and this appears to underlie the most plausible explanation for the correlation between the rising skills premium and the industries which are most affected by new technology (Bresnahan, 1999). Ultimate and proximate causes are hard to disentangle, but many authors have noted that new technology and workplace organization are closely intertwined, and the full potential of the one can only be realized in the presence of the other (Askenazy, 2000; Wolff, 2002).

New technology affects every aspect of the modern firm (David, 2000; Freeman, 2001) and the effective adoption of new ICTs therefore depends on new ways of structuring and managing the work of an organisation (Pilat, 2002; Piva, Santarelli and Vivarelli, 2003). As such it requires staff at every level who are adaptable and quick to learn, and:

> “it is not enough for the ‘elite’ to be competent and innovative” (Lundgren, 2000: 161).

This changing nature of the workplace undermines the traditional Fordist structure and encourages the involvement of all workers, implying the need for a generally better skilled workforce and a reduced role for middle management (Black and Lynch, 2003; Caroli and van Reenen, 2001). In line with the ideas of Nelson and Phelps (1966) and Schultz (1975), the observed rise in the returns to skills strongly supports the idea of increasing returns to adaptability during periods of rapid change.

10.B Findings of the present study

10.B.1 Inequality patterns in New Zealand

The last 15 years of the 20th century saw a widespread rise in inequality in New Zealand, which has already been extensively documented (Chatterjee, Podder and Mukhopadhaya, 2003; Hyslop and Maré, 2005). The principal aim of the present study was to investigate the underlying patterns of inequality in terms of skills demand and the uptake of new technology, in the hope of revealing some of the forces behind the rise. In particular, if inequality has mostly risen between groups of workers with different characteristics it can be seen as driven by a general skill-bias in the way productive systems are evolving. On the other hand, if inequality is rising within groups of workers who have similar characteristics, it would give stronger support for the theory that changing patterns of industrialization were responsible, possibly affected by increased trade touching some industries more than others.

It was the hypothesis of this study that new Information and Communications Technology is a General Purpose Technology, and moreover that it is skill biased. That is to say it is a pervasive technology affecting patterns of industrial organization in a wide range of industries, and one which rewards skilled workers out of proportion to the unskilled, thereby driving up earnings inequality.

Whether ICT should be considered a GPT is not a matter to be determined within New Zealand or any particular economy. The defining characteristic which most authors use as their guideline for a GPT is that it is an enabling technology (Bertschek, 2003). As such it is pervasive and has many applications beyond those first imagined. Moreover it spawns a wide range of complementary products (Bresnahan and Trajtenberg, 1995) so that there will be a marked time lag before major benefits begin to accrue (David, 2000), and its ultimate effects are very slow to be realised (Helpman, 1998; Jovanovic and Rousseau, 2005). A few authors consider the computer revolution to have been relatively brief and already largely complete (Gordon, 2000). But many believe that new ICT developments still stretch far into the future, as applications become increasingly diverse and computing and complementary products continue to evolve in ways which are still largely unforeseeable (Lipsey, Bekar and Carlaw, 2005). In view of this ever increasing diversity of ICT use it seems entirely valid to consider it as a GPT.

The second part of the hypothesis was to assess whether ICT has been skill-biased. In common with findings from other developed countries, the data studied in this thesis strongly support the skill-biased technological change (SBTC) theory. Neither the labour supply theory nor the labour market institutions theory fits the facts of inequality in New Zealand. The trade theory does find some support, especially in conjunction with deindustrialization following the removal of protection. But the evidence for this effect suggests that it was relatively temporary. By contrast, the SBTC theory fits the facts well, and in particular it looks to be the most plausible with regard to the longer term effects. This trend was especially evident from the Census findings discussed in Chapters 6 and 7.

10.B.2 New Zealand Census findings, 1991 to 1996

The data from the five-yearly Population Census show marked differences between the inequality trends in the period 1991 – 1996 and those in the period 1996 – 2001. In the earlier period there was an increase of 6 percent in between-group wage inequality, as measured by the ratio of the margin for holding a bachelor's degree compared to the margin for holding only school certificate. This increase was unevenly distributed across industries, with workers in some industries being much more affected than others, and there was a marked tendency for the industries most affected to be those with high ICT-uptake. There was also an increase of 8 percent overall in within-group inequality as measured by the Gini coefficient, but with the increases concentrated at each end of the distribution. The implication of these findings is that inequality was changing both because of changed industrial patterns and also because of a general skill-bias in labour demand.

Rising within-group inequality in the early 1990s is not surprising, since in the decade from the mid-1980s to the mid-1990s New Zealand was subjected to a particularly abrupt transition from relatively high protection to an almost completely open regime. In particular, the relaxation of import controls and the abandonment of tariff barriers dramatically changed the operating conditions for industries which had previously been protected, while making little difference to many others. It was therefore fully to be expected that there would be a period of extensive readjustment between industries at that time, and that there would be rather high income inequality between industries (and therefore within groups of similar workers) as the labour force adjusted to the new circumstances.

But while changing industrial patterns doubtless played a role in the early 1990s, it is unlikely that this was the whole story, as the rising inequality was also strongly associated with the industries which are heavy users of new technology. It is a feature of the New Zealand economy that the most technology-intensive industries, such as banking, business services and public administration, are among the least traded, so to the extent that technology was correlated with rising inequality it seems necessary that it was driven by skill bias in the demand for labour within those industries.

Moreover, unemployment is now widely seen as an important manifestation of inequality (Galbraith, 2000). Traditionally, high wages were assumed to reduce employment opportunities, and unions and collective bargaining were blamed for penalising the unemployed (Hutton, 1995). Many commentators continue to hold this position, but opposition to it has grown steadily since 1990, as data from many countries provide convincing evidence that unemployment is higher where wages are lower, rather than low wages being a tradeoff for unemployment (Blanchflower and Oswald, 2005; Glyn and Salverda, 2000a; Papps, 2001).

As Chapter 7 of this thesis shows, in New Zealand the early 1990s saw a significant decline in job opportunities for workers with few qualifications, but no significant change in opportunities for the well-qualified. Since the ease of getting a job is itself something of value, a decline in employment opportunities at the bottom of the qualifications scale can be seen as a form of increasing between-groups inequality, analogous to a rise in the skills premium. And like the rise in the skills premium, the declining employment opportunities for the less skilled workers were strongly correlated with the technology-intensive industries. Thus, when viewed over both the wage and the employment dimensions, the rise in between-group inequality was more substantial than might be assumed from income trends alone.

10.B.3 New Zealand Census findings, 1996 to 2001

In contrast to the early 1990s, the period following 1996 shows a less complex pattern. Between-group inequality increased by 13 percent and almost all industries were affected. This finding is strongly supportive of the original hypothesis of this study, that there has been a skill bias in the latest technological phase, and this bias in favour of more skilled workers has been pervasive through a wide range of industries. Within-group inequality, which had been a distinct feature of the earlier period, was more muted, and mostly affected workers with few qualifications. In particular, the sudden rise before 1996 in within-group inequality for the well-qualified workers was reversed, and at the top of the qualifications scale the within-group inequality returned to more modest levels. This strongly suggests that the earlier findings were episodic rather than permanent, and were at least partly driven by the abrupt policy changes of that particular period.

Looking at the whole decade from 1991 to 2001, the overall trend has been one of substantial and ongoing increases in between group inequality, both in terms of incomes and in terms of employment opportunities. The rise in income inequality was particularly marked in the later part of the period while the declining job opportunities for the less-skilled workers were most marked in the earlier period. But overall the trends have been persistent and seriously damaging to workers with few qualifications.

Within-group inequality only rose persistently for the workers at the low end of the qualifications scale. It has been suggested that within-group inequality is likely to be transitory, while between-group inequality is likely to be more permanent (Aghion and Howitt, 2002), and this theory accords closely with the observed facts in New Zealand in the 1990s. For most workers the rising within-group inequality was a passing phase, very probably a by-product of the sudden shocks to the industrial pattern. It was only the least-skilled workers who experienced a significant increase which continued through the whole ten years.

10.B.4 The causes of rising inequality

Skill biased technological change can therefore be isolated with reasonable confidence as the explanation for the more persistent changes in New Zealand earnings inequality. But this finding leaves open the question of what particular skills have become more desirable in the latest phase of technological progress, and therefore what public policies are likely to be most cost-effective in minimizing higher inequality and its undesirable effects.

As described in Chapter 8, quantile regression was used to estimate the changes in wage inequality which accompany changes in other variables, such as the level of ICT-uptake or the skills of the labour force. In common with the findings from other developed countries (Autor, Katz and Krueger, 1998; Chennells and van Reenen, 1997), New Zealand shows a pattern of higher wage inequality strongly associated with ICT-uptake. However this increased wage dispersion is fully explained by worker occupations and qualifications. Moreover, the demand for workers with few qualifications is especially depressed in the more ICT-intensive industries, whereas the technology effect is rather weak for workers near the top of the skills range. This finding strongly suggests that it is not so much the technology which is driving the wage dispersion as the qualifications and skills which are useful in the industries which happen to be more ICT-intensive.

Using the Income Supplement CURF data for 2002 and 2004, workers were divided into two groups according to whether or not they were employed in industries making significant use of new technologies. Kernel density graphs (Chapter 9) clearly indicate the wider wage dispersion in the technology-intensive industries. However the DiNardo, Fortin and Lemieux (DFL) technique was used to investigate further how much the higher inequality was intrinsic to the technology, and how much it related to the characteristics of the workers. When the workers in the high-technology group are reweighted to allow for worker characteristics the distribution graph is very to similar to that for the workers in the low-technology group. This finding strongly supports the controlled quantile regression estimates of Chapter 8, in isolating the worker characteristics as being the important factor, rather than anything intrinsic to the new technology. Evidently, in the recent phase of technological change, firms reward workers who have certain qualifications and occupational skills. This can be seen as confirmation of the Nelson and Phelps (1966) theory of returns to ability, and the Bresnahan, Brynjolfsson and Hitt (2002) theory that changing workplaces create new patterns of skills demand rather than technologies per se requiring technological specialists.

10.B.5 Recent trends in inequality

A number of previous studies found that income inequality was rising in New Zealand in the 1990s (Chatterjee, Podder and Mukhopadhaya, 2003; O’Dea, 2000). The Population Census data strongly suggested that income inequality in New Zealand had been rising steadily throughout the 1990s. However the

Income Supplement data, which focuses specifically on wage inequality, suggests that between 2002 and 2004 inequality has been declining again, confirming the finding of Hyslop and Yahanpath, 2006). A two-year period is too short to establish a trend with any certainty, but when CURF data are released for the next year or two it should be possible to trace the trend in the present decade with greater confidence. Also customized data from the 2006 Population Census are due for release by early 2007, and their availability will facilitate a cross check between trends in wages reported in the Income Supplement and the overall income trends revealed by the Census.

10.C Policy implications

10.C.1 Technology and inequality

Technological change is crucial to any rise in productive efficiency, and therefore any real rise in living standards. But earnings inequality can be seriously affected by changing technology, including the labour force skill levels which are a part of the productive system. In New Zealand, as in other countries in the developed world, there is strong evidence to suggest that the technological changes of the late 20th century have been complementary to skilled workers while reducing the opportunities for the less skilled, and this trend raises important public policy issues.

In particular, a higher rate of adoption of new technology requires a higher general level of skills in the workforce. The changes of the last 15 years strongly support the Nelson-Phelps theory of returns to adaptability, since workers with a good level of general education have generally done well, while the workers with little education have been penalized. Evidently, at least during the 1990s the supply of skills in the New Zealand labour force was not keeping up with demand, and this phase has opened up a gap between the workers who were well-placed to take advantage of the new opportunities and those who were ill-prepared and have found themselves left behind.

In terms of skill acquisition women have been making steady progress, and by the early 1990s women had overtaken men. But it is a concern that the numbers of men not going beyond basic schooling are on the increase. Greater numbers of both men and women are completing university qualifications, but the numbers taking tertiary vocational courses are dropping faster and the pool of low-skilled workers is actually on the increase. Thus recent years have seen little overall upskilling in New Zealand.

The recent Income Supplement data suggest that the latest period of rising wage inequality may be over. But the greater polarization of the community is likely to leave a legacy of problems. Firstly, as noted at the start of this chapter, it now seems clear that inequality is growth impeding. Polarization distorts investment patterns as well as being anti-democratic and socially disruptive (Easterly, 2001b; Galbraith, 2000). The resulting social problems, ranging from unemployment through to alienation and crime, are likely to mean continuing costs to government, which could therefore be constrained in its ability to pay for improved education which might help the less well-placed workers to achieve in the new environment. Secondly, there is a high level of intergenerational transmission in education (Cameron and Heckman, 2001; Shea, 2000), and the children of the workers who were worst hit by the recent changes are themselves likely to be ill-prepared for the workplace of the future.

10.C.2 The future of work and workforce skills

It is therefore important to make whatever efforts are cost-effective in terms of giving the next generation an equal start. Even if the pace of change eases somewhat, it is most unlikely that there will be any return to the large, hierarchical firms of yesteryear. The real costs of ICT will almost certainly continue to decline, facilitating new combinations of workers and equipment, as well as reorganized and possibly dispersed workplaces.

In many workplaces, adaptation to new technology has meant an end to the days when large numbers of process workers with minimal skill levels could be given useful employment. It therefore seems probable that the workplace of the future will only reward workers who are sufficiently skilled and flexible to be effective in a world with flat structures, high levels of delegation and minimal supervision. Unless a greater proportion of the workforce is given suitable preparation for the new working environment, New Zealand faces the probability that substantial numbers of workers will enjoy only minimal rewards and low job security, with all the damaging economic and social consequences that this would entail.

Internationally, many commentators have noted that the countries which raised the supply of skills have lower inequality (Katz, 1994). In this respect, the Continental European countries have generally done better than Britain or the United States, with education reaching the children of less well-off households to much greater effect (Jencks, 2005; Nickell, 1998). The rise in inequality in New Zealand is one unfortunate manifestation of a general move toward a more user pays approach to the provision of education. Without strong government commitment to improving the opportunities of all the next generation of workers, New Zealand is likely to find itself trapped in a low-growth, high-inequality path, lacking the workforce skills which will be needed to make the most of whatever opportunities present themselves in the future.

The New Zealand Government has stated its wish to encourage ICT upgrading as a growth promoting strategy (Clark, 2002). But given the now well-established link between new technology and workforce skills it seems unlikely that such a strategy would realize its full potential unless there is an increased commitment to raising skill levels. Moreover, since adaptability appears to be particularly valuable during times of change, the rate of change itself is likely to be constrained by the general level of labour force skills

Some 40 percent of young New Zealanders are entering the workforce with minimal education. In view of the general purpose nature of new technology, and the high proportion of the workforce which has now been touched by changing workplace structures, it seems almost certain that this is seriously out of balance with the likely future needs. An increased commitment to raising skill levels of the less qualified members of the workforce is almost certainly necessary if the New Zealand economy is to take advantage of the opportunities which arise in the future, and if undesirable divisions in society are to be kept to a minimum.

10.D Directions for future research

10.D.1 Extensions to the present study

The provision of New Zealand Income Survey Confidentialised Unit Record Files (CURFs) has greatly facilitated research into income trends in New Zealand, with data on both wages and other forms of income. Income Survey CURFs only became available from 2002, but over the next few years this resource will provide a powerful tool for the analysis of trends in all forms of income, including inequality trends.

The 2006 Census was held in March, and when customized data are released this will also allow a useful extension of the present study beyond 2001. In particular, it should help to clarify whether the recent reversal of the rising inequality trend was only a minor dip, or whether it represents a more significant change of trend. Moreover, once the Income Survey CURFs are available up to 2006 it will be possible to compare much of the latest inter-censal period between the two sets of data. The Population Census information is limited, both by having only a single variable for income and through the reliability issues surrounding a self-reported survey. An overlap of several years between the CURF and the Census should reveal how much trust can be placed in Census income figures as a proxy for earnings.

Any further investigation into the relationships between economic outcomes and industry use of technology will need a more up to date source of information on technology uptake. The inter-industry tables from Statistics New Zealand were a one-off project in 1996, and as at September 2006 no update is planned. It is unlikely that patterns of industry use of technology would change very rapidly, as some industries naturally lend themselves to new technology more than others. Nonetheless, using a source which is now 10 years old will become increasingly questionable.

10.D.2 Wider research questions

The present thesis has concentrated on wage inequality within and between groups of workers of different skills and qualifications. However inequality has many dimensions, and unequal outcomes along gender or ethnic lines are two which merit more attention than was possible in this study.

Over the last 50 years the proportion of women in the workforce has risen steadily (Statistics New Zealand, 2000), partly through choice, but partly also because the two-earner household has become increasingly necessary to maintain satisfactory household incomes (Martin, 1998). In parallel with rising participation, women workers have also overtaken men in their formal qualifications (Graph 7.1, page 110). That women are investing more in education is not surprising, since Sholeh Maani notes that women enjoy higher returns to education (Maani, 1997). This implies that women are well aware that their workplace opportunities are even more dependent on qualifications than are the opportunities for men.

Male and female workers continue to cluster strongly in different industries (Section 7.C.2, p. 118), but the ICT-intensive industries are one area where women's participation has increased very markedly, and Engelbrecht notes that:

> "By 1996 about 55% of the female work force was employed in information occupations, compared to 40% of the male work force" (Engelbrecht, 2001: 135).

The other important fault line of inequality in New Zealand is the ethnic divide. It is widely recognized that Maori are generally less well qualified than non-Maori, and are disproportionately unemployed or found in low paid jobs

(Stevenson, 2004). Just as male and female workers tend to cluster into distinct areas of employment, so do Maori workers often seek employment in certain industries (Chapple, 1999).

It was noted in Chapter 7 that the restructuring era of the early 1990s saw a sharp rise in unemployment, as some workers were well placed to take advantage of the new opportunities while others were seriously disadvantaged. The concentration of Maori (especially Maori men) in the secondary sector and manual work meant they were particularly hard hit (Engelbrecht and Mahon, 2003), and their employment rates "remained depressed in the late 1990s" (Statistics New Zealand, 2000).

The world will continue to change, and new ways of working and workplace arrangements are likely to continue rewarding the well-educated, as the workers who are best placed to cope with and benefit from change. It seems probable that New Zealand already has too many young adults entering the work force inadequately prepared for the working world of the future, and that an increased public commitment to raising educational standards of school leavers is desirable. If young Maori are particularly concentrated in this group there is a serious risk of rising alienation and social problems. Moreover, given the strong intergenerational transmission effect noted in Section 3.D, unequal opportunities are likely to persist for a long time unless their sources are understood and addressed. There are many dimensions of inequality to be studied, but we ignore them at the risk of ever widening social divisions, impaired economic performance, and a poorer country for the majority of citizens.

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Appendix 1A : Summary Details from New Zealand Population Census

Full-time worker numbers by highest qualification

Highest Qualificaton	1991 Males	1991 Females	1991 Total	1996 Males	1996 Females	1996 Total	2001 Males	2001 Females	2001 Total
No qualification	158142	100308	258450	167130	101283	268416	181296	103347	284643
School Cert	54690	50007	104697	60831	55485	116316	78966	66483	145449
UE/6th Form	38949	33909	72858	52590	46677	99267	61278	54438	115719
Bursary	16812	9705	26517	26160	17652	43815	31470	22443	53913
Diploma	211926	129612	341541	174363	116157	290523	135684	101727	237411
Bachelor	33939	21204	55140	44988	34416	79404	53841	53538	107382
Postgraduate	21081	10926	32007	25656	15774	41430	29706	23106	52815
Total	535539	355674	891210	551718	387447	939162	572244	425088	997332

Proportions by highest qualification

Highest Qualificaton	1991 Males	1991 Females	1991 Total	1996 Males	1996 Females	1996 Total	2001 Males	2001 Females	2001 Total
No qualification	29.53%	28.20%	29.00%	30.29%	26.14%	28.58%	31.68%	24.31%	28.54%
School Cert	10.21%	14.06%	11.75%	11.03%	14.32%	12.39%	13.80%	15.64%	14.58%
UE/6th Form	7.27%	9.53%	8.18%	9.53%	12.05%	10.57%	10.71%	12.81%	11.60%
Bursary	3.14%	2.73%	2.98%	4.74%	4.56%	4.67%	5.50%	5.28%	5.41%
Diploma	39.57%	36.44%	38.32%	31.60%	29.98%	30.93%	23.71%	23.93%	23.80%
Bachelor	6.34%	5.96%	6.19%	8.15%	8.88%	8.45%	9.41%	12.59%	10.77%
Postgraduate	3.94%	3.07%	3.59%	4.65%	4.07%	4.41%	5.19%	5.44%	5.30%
	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%

Appendix 1B : Worker numbers by income bracket

	1991			1996			2001		
	Male	Female	Total	Male	Female	Total	Male	Female	Total
Nil Income or Loss	0	0	0	330	186	513	1458	864	2325
$1 - $5,000	6,525	9,726	16,251	11916	13881	25794	11196	10926	22122
$5,001 - $10,000	19,206	24,375	43,578	19014	21612	40623	16221	17322	33546
$10,001 - $15,000	40,023	49,095	89,121	30423	35226	65649	24573	28320	52890
$15,001 - $20,000	70,821	65,892	136,713	45351	51069	96420	36972	43032	80004
$20,001 - $25,000	84,387	67,755	152,142	68061	62901	130959	54486	54366	108852
$25,001 - $30,000	81,204	58,749	139,950	81816	66906	148719	73491	61992	135483
$30,001 - $40,000	109,335	54,429	163,764	119037	79404	198441	122850	98058	220911
$40,001 - $50,000	63,318	15,249	78,567	74955	28581	103536	82539	51393	133932
$50,001 - $70,000	38,052	5,157	43,212	54450	12039	66492	77997	35256	113256
$70,001 and Over	17,163	1,557	18,720	32109	4605	36714	55251	12762	68013
Not Specified	5,502	3,687	9,192	14259	11040	25299	15204	10794	25998
Total	535,539	355,674	891,210	551718	387447	939162	572244	425088	997332
		Proportion			Proportion			Proportion	
Nil Income or Loss	0.0%	0.0%	0.0%	0.1%	0.0%	0.1%	0.3%	0.2%	0.2%
$1 - $5,000	1.2%	2.7%	1.8%	2.2%	3.6%	2.7%	2.0%	2.6%	2.2%
$5,001 - $10,000	3.6%	6.9%	4.9%	3.4%	5.6%	4.3%	2.8%	4.1%	3.4%
$10,001 - $15,000	7.5%	13.8%	10.0%	5.5%	9.1%	7.0%	4.3%	6.7%	5.3%
$15,001 - $20,000	13.2%	18.5%	15.3%	8.2%	13.2%	10.3%	6.5%	10.1%	8.0%
$20,001 - $25,000	15.8%	19.0%	17.1%	12.3%	16.2%	13.9%	9.5%	12.8%	10.9%
$25,001 - $30,000	15.2%	16.5%	15.7%	14.8%	17.3%	15.8%	12.8%	14.6%	13.6%
$30,001 - $40,000	20.4%	15.3%	18.4%	21.6%	20.5%	21.1%	21.5%	23.1%	22.2%
$40,001 - $50,000	11.8%	4.3%	8.8%	13.6%	7.4%	11.0%	14.4%	12.1%	13.4%
$50,001 - $70,000	7.1%	1.4%	4.8%	9.9%	3.1%	7.1%	13.6%	8.3%	11.4%
$70,001 and Over	3.2%	0.4%	2.1%	5.8%	1.2%	3.9%	9.7%	3.0%	6.8%
Not Specified	1.0%	1.0%	1.0%	2.6%	2.8%	2.7%	2.7%	2.5%	2.6%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Appendix 1C
Worker numbers by industry

Code	Industry	1991 Worker numbers	1996 Worker numbers	2001 Worker numbers
1	Dairy Farming	6,552	8,181	9,765
2	Sheep and Beef Farming	9,333	8,799	8,223
3	Other Farming	19,458	19,755	18,027
4	Agricultural Services	6,021	8,196	8,085
5	Hunting and Trapping	156	210	147
6	Forestry and Logging	3,909	6,408	6,453
7	Fishing	1,602	2,139	1,803
8	Coal Mining	789	642	522
9	Exploration and Extraction of Oil and Gas	786	555	264
10	Other Mining and Quarrying	2,325	2,355	2,028
11	Slaughtering and Preserving Meat	23,100	18,591	19,416
12	Dairy Products	6,807	6,039	5,370
13	Other Food Preparation	17,391	17,898	16,497
14	Beverages and Tobacco	3,105	2,910	3,381
15	Textiles	7,737	7,557	6,513
16	Wearing Apparel and Footwear	14,376	11,589	8,328
17	Wood and Wood Products	16,314	18,060	20,226
18	Paper and Paper Products	8,226	6,753	5,415
19	Printing and Publishing	14,478	13,377	15,033
20	Industrial Chemicals	3,678	3,423	3,411
21	Other Chemicals	4,335	4,488	2,667
22	Petroleum Refineries	870	609	174
23	Petroleum and Coal Products	252	378	216
24	Rubber Products	1,848	1,377	1,209
25	Plastic Products	5,565	5,934	6,285
26	Non Metallic Industries	4,890	4,593	4,545
27	Iron and Steel Products	3,177	2,715	2,280
28	Non-Ferrous Metals	2,847	2,571	2,517
29	Fabricated Metal Products	14,901	16,179	14,952
30	Machinery nec.	11,790	13,059	12,591
31	Electrical Machinery	7,974	8,859	8,853
32	Transport Equipment	9,504	9,147	8,244
33	Professional Equipment	486	570	1,983
34	Other Manufacturing	3,000	2,664	2,808

Continued…

Appendix 1C - Continued
Worker numbers by industry

Code	Industry	1991 Worker numbers	1996 Worker numbers	2001 Worker numbers
35	Electricity	9,141	5,943	3,636
36	Gas Manufacture and Distribution	840	567	465
37	Water Works and Supply	762	1,074	741
38	Building and Ancillary Services	32,943	37,623	43,833
39	Other Construction	11,904	11,658	12,405
40	Wholesale and Retail Trade	129,210	138,483	162,477
41	Restaurants and Hotels	25,896	33,759	36,585
42	Rail Transport	3,300	2,331	2,070
43	Road Passenger Transport	4,854	4,305	4,296
44	Road Freight Transport	10,341	12,240	13,776
45	Water Transport	5,871	3,960	1,155
46	Air Transport	7,986	7,893	7,098
47	Services to Transport	11,376	13,905	20,184
48	Communication	22,587	15,909	14,541
49	Banking	24,687	19,767	15,705
50	Other Financial Institutions and Services	9,897	11,025	16,368
51	Insurance	10,608	9,837	9,897
52	Owning and Leasing Real Estate	9,162	12,597	12,738
53	Owning Owner-Occupied Dwellings	0	0	0
54	Business Services	56,574	69,417	85,110
55	Public Administration and Defence	77,409	69,207	64,899
56	Sanitary and Cleaning Services	4,383	5,259	26,139
57	Education	65,652	71,604	83,115
58	Social and Community Services	24,477	31,293	40,119
59	Health Services	52,692	46,290	56,664
60	Recreational and Cultural Services	14,553	18,147	21,006
61	Domestic Services	810	516	222
62	Personal Services	25,125	26,502	22,359
63	Internat'l And Extra-Territorial Body Operation	588	384	0
64	Unidentifiable/ Not Specified	0	21,093	16,197
65	Total	891,210	939,162	997,332

Appendix 2A : Computing Proportion of Industry Inputs

Industry code	Industry	Inputs $M Computing	Total Inputs	Computing proportion
1	Dairy Farming	0	3590	0.00%
2	Sheep and Beef Farming	0	2909	0.00%
3	Other Farming	0	2885	0.00%
4	Agricultural Services	4	949	0.42%
6	Forrestry and Logging	5	2633	0.19%
7	Fishing	0	807	0.00%
8	Coal Mining	0	241	0.00%
9	Exploration and Extraction of Oil and Gas	1	944	0.11%
10	Other Mining and Quarrying	0	696	0.00%
11	Slaughtering and Preserving Meat	26	5363	0.48%
12	Dairy Products	9	4925	0.18%
13	Other Food Preparation	47	4887	0.96%
14	Beverages and Tobacco	4	1636	0.24%
15	Textiles	10	1385	0.72%
16	Wearing Apparel and Footwear	5	1443	0.35%
17	Wood and Wood Products	8	2835	0.28%
18	Paper and Paper Products	13	2886	0.45%
19	Printing and Publishing	27	3086	0.87%
20	Industrial Chemicals	23	1759	1.31%
21	Other Chemicals	6	1659	0.36%
23	Petroleum and Coal Products	0	79	0.00%
24	Rubber Products	1	336	0.30%
25	Plastic Products	10	1497	0.67%
26	Non Metallic Industries	5	1436	0.35%
27	Iron and Steel Products	5	1691	0.30%
28	Non-Ferrous Metals	5	1691	0.30%
29	Fabricated Metal Products	8	2883	0.28%
30	Machinery nec.	13	1929	0.67%
31	Electrical Machinery	48	1993	2.41%
32	Transport Equipment	8	2325	0.34%
33	Professional Equipment	2	197	1.02%
34	Other Manufacturing	8	1352	0.59%

Continued ….

Appendix 2A : Computing Proportion of Industry Inputs - Continued

Industry code	Industry	Inputs $M Computing	Total Inputs	Computing proportion
35	Electricity	21	4611	0.46%
36	Gas Manufacture and Distribution	0	469	0.00%
37	Water Works and Supply	0	374	0.00%
38	Building and Ancillary Services	20	10147	0.20%
39	Other Construction	4	2835	0.14%
40	Wholesale and Retail Trade	367	27475	1.34%
41	Restaurants and Hotels	6	3534	0.17%
42	Rail Transport	2	1507	0.13%
43	Road Passenger Transport	1	580	0.17%
44	Road Freight Transport	3	2581	0.12%
45	Water Transport	2	1507	0.13%
46	Air Transport	21	4960	0.42%
47	Services to Transport	21	4960	0.42%
48	Communication	52	4761	1.09%
49	Banking	255	5236	4.87%
50	Other Financial Institutions and Services	273	6488	4.21%
51	Insurance	41	1948	2.10%
52	Owning and Leasing Real Estate	7	6484	0.11%
54	Business Services	266	11881	2.24%
55	Public Administration and Defence	176	4605	3.82%
56	Sanitary and Cleaning Services	0	720	0.00%
57	Education	14	4823	0.29%
58	Social and Community Services	41	3700	1.11%
59	Health Services	34	6345	0.54%
60	Recreational and Cultural Services	66	3506	1.88%
62	Personal Services	1	1510	0.07%

Appendix 2B : Industries Ranked by Computing Inputs

Industry code	Industry	Inputs $M Computing	Total Inputs	Computing proportion
49	Banking	255	5236	4.87%
50	Other Financial Institutions and Services	273	6488	4.21%
55	Public Administration and Defence	176	4605	3.82%
31	Electrical Machinery	48	1993	2.41%
54	Business Services	266	11881	2.24%
51	Insurance	41	1948	2.10%
60	Recreational and Cultural Services	66	3506	1.88%
40	Wholesale and Retail Trade	367	27475	1.34%
20	Industrial Chemicals	23	1759	1.31%
58	Social and Community Services	41	3700	1.11%
48	Communication	52	4761	1.09%
33	Professional Equipment	2	197	1.02%
13	Other Food Preparation	47	4887	0.96%
19	Printing and Publishing	27	3086	0.87%
15	Textiles	10	1385	0.72%
30	Machinery nec.	13	1929	0.67%
25	Plastic Products	10	1497	0.67%
34	Other Manufacturing	8	1352	0.59%
59	Health Services	34	6345	0.54%
11	Slaughtering and Preserving Meat	26	5363	0.48%
35	Electricity	21	4611	0.46%
18	Paper and Paper Products	13	2886	0.45%
46	Air Transport	21	4960	0.42%
47	Services to Transport	21	4960	0.42%
4	Agricultural Services	4	949	0.42%
21	Other Chemicals	6	1659	0.36%
26	Non Metallic Industries	5	1436	0.35%
16	Wearing Apparel and Footwear	5	1443	0.35%
32	Transport Equipment	8	2325	0.34%
24	Rubber Products	1	336	0.30%
27	Iron and Steel Products	5	1691	0.30%
28	Non-Ferrous Metals	5	1691	0.30%
57	Education	14	4823	0.29%
17	Wood and Wood Products	8	2835	0.28%
29	Fabricated Metal Products	8	2883	0.28%
14	Beverages and Tobacco	4	1636	0.24%

Continued ….

Appendix 2B : Industries Ranked by Computing Inputs - Continued

Industry code	Industry	Inputs $M Computing	Total Inputs	Computing proportion
38	Building and Ancillary Services	20	10147	0.20%
6	Forestry and Logging	5	2633	0.19%
12	Dairy Products	9	4925	0.18%
43	Road Passenger Transport	1	580	0.17%
41	Restaurants and Hotels	6	3534	0.17%
39	Other Construction	4	2835	0.14%
42	Rail Transport	2	1507	0.13%
45	Water Transport	2	1507	0.13%
44	Road Freight Transport	3	2581	0.12%
52	Owning and Leasing Real Estate	7	6484	0.11%
9	Exploration and Extraction of Oil and Gas	1	944	0.11%
62	Personal Services	1	1510	0.07%
1	Dairy Farming	0	3590	0.00%
2	Sheep and Beef Farming	0	2909	0.00%
3	Other Farming	0	2885	0.00%
7	Fishing	0	807	0.00%
8	Coal Mining	0	241	0.00%
10	Other Mining and Quarrying	0	696	0.00%
23	Petroleum and Coal Products	0	79	0.00%
36	Gas Manufacture and Distribution	0	469	0.00%
37	Water Works and Supply	0	374	0.00%
56	Sanitary and Cleaning Services	0	720	0.00%

Appendix 3 : Industry mapping in the Inter-industry Study 1996 - Concordance P.1

49 industry tables		126 industry tables		62 industry tables
Industry grouping	Reference Number	**Industry grouping**	Reference Number	Reference Number
Horticulture and fruit growing	1	Other horticulture	1	3
		Apple and pear growing	2	3
		Kiwifruit growing	3	3
		Other fruit growing	4	3
Livestock and cropping farming	2	Mixed livestock and cropping	5	3
		Sheep and beef cattle farming	6	2
Dairy cattle farming	3	Dairy cattle farming	7	1
Other farming	4	Other farming	8	3
Services to agriculture, hunting and trapping	5	Services to agriculture, hunting and trapping	9	4
Forestry and logging	6	Forestry	10	6
		Services to forestry	11	6
		Logging	12	6
Fishing	7	Fishing	13	7
Mining and quarrying	8	Coal mining	14	8
		Services to mining	15	10
		Other mining and quarrying	16	10
Oil & gas exploration & extraction	9	Oil & gas extraction	17	9
		Oil & gas exploration	18	9
Meat and meat product manufacturing	10	Meat processing	19	11
		Poultry processing	20	11
		Bacon, ham and smallgood manufacturing	21	11
Dairy product manufacturing	11	Dairy product manufacturing	22	12

Appendix 3 : Industry mapping in the Inter-industry Study 1996 - Concordance P.2

49 industry tables		126 industry tables		62 industry tables
Industry grouping	Reference Number	**Industry grouping**	Reference Number	Reference Number
Other food manufacturing	12	Fruit and vegetable, oil and fat, cereal and flour manufacturing	23	13
		Bakery, sugar and confectionery manufacturing	24	13
		Seafood processing	25	13
		Other food manufacturing	26	13
Beverage, malt and tobacco manufacturing	13	Soft drink, cordial and syrup manufacturing	27	14
		Beer, wine, spirit and tobacco manufacturing	28	14
Textile and apparel manufacturing	14	Textile manufacturing	29	15
		Clothing manufacturing	30	16
		Footwear manufacturing	31	16
		Other leather product manufacturing	32	16
Wood product manufacturing	15	Log sawmilling and timber dressing	33	17
		Other wood product manufacturing	34	17
Paper and paper product manufacturing	16	Paper and paper product manufacturing	35	18
Printing , publishing & recorded media	17	Printing and services to printing	36	19
		Publishing and recorded media manufacturing	37	19
Petroleum and industrial chemical manufacturing	18	Petroleum refining	38	22
		Petroleum & coal product manufacturing nec	39	23
		Fertiliser manufacturing	40	20
		Other industrial chemical manufacturing	41	20

Appendix 3 : Industry mapping in the Inter-industry Study 1996 - Concordance P.3

49 industry tables		126 industry tables		62 industry tables
Industry grouping	Reference Number	**Industry grouping**	Reference Number	Reference Number
Rubber, plastic and other chemical product manufacturing	19	Medicinal, detergent and cosmetic manufacturing	42	21
		Other chemical product manufacturing	43	21
		Rubber manufacturing	44	24
		Plastic product manufacturing	45	25
Non-metallic mineral product manufacturing	20	Glass and glass product and ceramic manufacturing	46	26
		Other non-metallic mineral product manufacturing	47	26
Basic metal manufacturing	21	Basic metal manufacturing	48	27, 28
Structural, sheet, and fabricated metal product manufacturing	22	Structural, sheet and fabricated metal product manufacturing	49	29
Transport equipment manufacturing	23	Motor vehicle and part manufacturing	50	32
		Ship and Boat Building	51	32
		Other transport equipment manufacturing	52	32
Machinery & equipment manufacturing	24	Photographic and scientific equipment manufacturing	53	33
		Electronic equipment and appliance manufacturing	54	31
		Agricultural machinery manufacturing	55	30
		Other industrial machinery and equipment manufacturing	56	30
Furniture and other manufacturing	25	Prefabricated building manufacturing	57	38
		Furniture manufacturing	58	34
		Other manufacturing	59	34

Appendix 3 : Industry mapping in the Inter-industry Study 1996 - Concordance P.4

49 industry tables		126 industry tables		62 industry tables
Industry grouping	Reference Number	**Industry grouping**	Reference Number	Reference Number
Electricity generation and supply	26	Electricity Generation	60	35
		Electricity Transmission	61	35
		Electricity Supply	62	35
Gas supply	27	Gas supply	63	36
Water supply	28	Water supply	64	37
Construction	29	Residential building construction	65	38
		Owner builders	66	38
		Non-residential building construction	67	38
		Non-building construction	68	39
		Site preparation services	69	38
		Building structure services	70	38
		Plumbing services	71	38
		Installation trade services	72	38
		Building completion services	73	38
		Other construction services	74	39
Wholesale trade	30	Wholesale trade	75	40
Retail trade	31	Retail trade	76	40
Accommodation, restaurants and bars	32	Accommodation	77	41
		Bars, clubs, cafes and restaurants	78	41

Appendix 3 : Industry mapping in the Inter-industry Study 1996 - Concordance P.5

49 industry tables		126 industry tables		62 industry tables
Industry grouping	Reference Number	**Industry grouping**	Reference Number	Reference Number
Road transport	33	Road Freight transport	79	44
		Road passenger transport	80	43
Water and rail transport	34	Water and rail transport	81	42,45
Air transport, services to transport and storage	35	Air transport, services to transport and storage	82	46,47
Communication services	36	Communication services	83	48
Finance	37	Finance	84	49,50
Insurance	38	Life insurance	85	51
		Superannuation fund operation	86	51
		Health insurance	87	51
		General insurance	88	51
Services to finance and investment	39	Services to finance and insurance	89	50
Real estate	40	Residential property operators	90	52
		Commercial property operators	91	52
		Real estate agents	92	52
Ownership of owner-occupied dwellings	41	Ownership of owner-occupied dwellings	93	53
Equipment hire and investors in other property	42	Investors in other property	94	52
		Vehicle and equipment hire	95	54

Appendix 3 : Industry mapping in the Inter-industry Study 1996 - Concordance P.6

49 industry tables		126 industry tables		62 industry tables
Industry grouping	Reference Number	**Industry grouping**	Reference Number	Reference Number
Business services	43	Scientific research	96	54
		Technical services	97	54
		Computer services	98	54
		Legal services	99	54
		Accounting services	100	54
		Advertising and marketing services	101	54
		Business administrative and management services	102	54
		Employment, security and investigative services	103	54
		Pest control and cleaning services	104	56
		Other business services	105	54
Central government administration, defence, public order and safety services	44	Central government administration	106	55
		Defence	107	55
		Public order and safety services	108	58
Local government administration services and civil defence	45	Local government administration services and civil defence	109	58
Education	46	Pre-school education	110	57
		Primary and secondary education	111	57
		Post school education	112	57
		Other education	113	57

Appendix 3 : Industry mapping in the Inter-industry Study 1996 - Concordance P.7

49 industry tables		126 industry tables		62 industry tables
Industry grouping	Reference Number	**Industry grouping**	Reference Number	Reference Number
Health and community services	47	Hospitals and nursing homes	114	59
		Medical, dental and other health services	115	59
		Veterinary services	116	59
		Child care services	117	59
		Accommodation for the aged	118	59
		Other community care services	119	59
Cultural and recreational services	48	Motion picture, radio and TV services	120	60
		Libraries, museums and the arts	121	60
		Horse and dog racing	122	60
		Lotteries, casinos and other gambling	123	60
		Other sport and recreational services	124	60
Personal and other community services	49	Personal and other community services	125	62
		Waste disposal, sewerage and drainage services	126	56

Appendix 4A (1991) : Wage Effects of Qualifications, by Industry

1991	Industry 1	Industry 2	Industry 3	Industry 4	Industry 6	Industry 7
School cert	0.805 (61.47)	1.401 (89.49)	1.502 (128.90)	1.388 (68.19)	0.758 (47.20)	0.941 (25.66)
UE	1.160 (64.91)	1.950 (93.20)	2.369 (142.20)	1.936 (68.43)	1.165 (50.45)	1.165 (23.39)
Bursary	1.117 (38.01)	1.720 (60.28)	2.175 (107.11)	1.768 (44.20)	1.187 (30.45)	0.692 (9.62)
Diploma	1.125 (94.63)	1.597 (102.90)	1.792 (158.08)	1.578 (82.42)	0.944 (76.65)	1.051 (42.32)
Bachelor	1.597 (52.02)	2.131 (71.99)	2.623 (122.54)	2.283 (58.59)	1.713 (63.18)	1.561 (22.60)
Postgrad	1.733 (27.62)	1.772 (31.49)	1.989 (57.92)	2.143 (36.37)	1.579 (33.07)	1.209 (12.48)
Experience	0.163 (51.22)	0.113 (32.58)	0.239 (80.69)	0.115 (20.25)	0.203 (48.83)	0.184 (17.67)
Expersq	-0.001 (14.24)	0.001 (8.30)	-0.002 (26.23)	0.001 (7.56)	-0.003 (21.78)	-0.001 (4.03)
Chi2	8442.3	10085	20768.8	6271.1	6030.7	1995.4
Observations	6429	9165	18948	5892	3837	1572
t-statistics in parentheses						

1991	Industry 8	Industry 9	Industry 10	Industry 11	Industry 12	Industry 13
School Cert	0.578 (12.38)	0.626 (9.04)	1.231 (34.12)	1.336 (268.77)	1.307 (113.99)	1.080 (134.53)
UE	1.400 (16.25)	1.434 (15.19)	1.655 (34.83)	1.995 (265.18)	1.961 (124.90)	1.706 (138.85)
Bursary		1.065 (9.93)	1.348 (19.28)	1.645 (168.26)	1.848 (93.83)	1.288 (82.07)
Diploma	0.559 (16.96)	1.117 (20.84)	1.231 (42.36)	1.310 (317.77)	1.338 (144.22)	1.259 (188.87)
Bachelor	1.604 (21.87)	1.966 (24.31)	2.364 (43.11)	2.289 (192.06)	2.307 (127.87)	2.183 (148.04)
Postgrad	1.047 (7.42)	1.848 (20.91)	2.132 (34.39)	1.990 (102.88)	2.212 (104.74)	1.897 (76.75)
Experience	0.169 (20.22)	0.151 (12.91)	0.078 (9.43)	0.142 (92.09)	0.143 (57.23)	0.140 (66.92)
Expersq	-0.003 (15.53)	-0.001 (3.14)	0.001 (6.05)	0.000 (2.31)	0.000 (4.19)	0.000 (6.16)
Chi2	507.2	800.2	2104.3	48597	12861	26088
Observations	759	777	2307	22830	6759	17070
t-statistics in parentheses						

Appendix 4A (1991) : Wage Effects of Qualifications, by Industry

1991	Industry 14	Industry 15	Industry 16	Industry 17	Industry 18	Industry 19
School cert	1.179 (50.20)	1.438 (104.59)	1.532 (170.56)	0.914 (161.94)	1.369 (138.78)	1.304 (135.05)
UE	1.826 (59.94)	1.991 (100.22)	2.277 (155.28)	1.168 (148.70)	1.806 (139.17)	1.801 (162.60)
Bursary	1.775 (43.70)	1.610 (69.96)	1.342 (84.75)	0.845 (69.47)	1.401 (84.23)	1.661 (122.59)
Diploma	1.305 (64.52)	1.551 (126.87)	1.541 (197.47)	0.877 (205.80)	1.409 (186.19)	1.578 (177.84)
Bachelor	2.449 (74.67)	2.385 (85.82)	2.676 (130.62)	1.488 (108.68)	2.263 (140.18)	2.061 (145.69)
Postgrad	2.363 (56.65)	2.083 (39.49)	2.036 (54.56)	1.343 (54.78)	2.050 (83.93)	2.220 (128.11)
Experience	0.082 (16.44)	0.090 (24.83)	0.159 (58.96)	0.114 (101.04)	0.062 (28.79)	0.067 (35.86)
Expersq	0.001 (8.03)	0.001 (14.71)	0.000 (4.44)	0.000 (15.25)	0.002 (33.43)	0.001 (27.41)
Chi2	3917	10560.5	22250	32402	17697	24070
Observations	3099	7629	14133	16107	8139	14367
t-statistics in parentheses						

1991	Industry 20	Industry 21	Industry 23	Industry 24	Industry 25	Industry 26
School Cert	0.887 (60.40)	1.014 (60.70)	1.039 (17.73)	0.660 (30.06)	1.127 (99.25)	0.827 (74.97)
UE	1.380 (70.50)	1.640 (76.64)	1.336 (19.75)	1.110 (32.05)	1.566 (103.83)	1.130 (70.59)
Bursary	1.109 (45.40)	1.562 (56.71)	1.959 (12.04)	0.690 (14.57)	1.200 (65.18)	0.778 (34.74)
Diploma	1.100 (96.36)	1.357 (88.84)	0.782 (19.50)	0.863 (46.08)	1.221 (138.49)	0.892 (106.96)
Bachelor	1.985 (98.11)	2.195 (99.56)	2.752 (23.05)	1.428 (34.84)	2.144 (105.55)	1.575 (72.83)
Postgrad	1.584 (64.33)	2.133 (83.60)	2.415 (17.51)	1.479 (24.76)	2.109 (63.42)	1.496 (39.84)
Experience	0.054 (14.09)	0.079 (23.20)	0.171 (14.99)	0.045 (7.83)	0.111 (46.48)	0.106 (37.85)
Expersq	0.001 (13.26)	0.001 (8.82)	-0.001 (4.80)	0.001 (6.26)	0.000 (4.18)	0.000 (3.51)
Chi2	6290	6471.4	473.6	2245	10931.4	8763
Observations	3633	4281	249	1830	5484	4860
t-statistics in parentheses						

Appendix 4A (1991) : Wage Effects of Qualifications, by Industry

1991	Industry 27	Industry 28	Industry 29	Industry 30	Industry 31	Industry 32
School cert	1.398 (62.87)	1.149 (49.88)	0.879 (147.33)	0.917 (111.10)	1.172 (108.23)	0.929 (100.93)
UE	2.030 (75.04)	1.410 (45.79)	1.312 (152.30)	1.309 (119.73)	1.678 (115.72)	1.247 (99.03)
Bursary	1.373 (40.64)	1.105 (26.24)	0.871 (71.44)	1.095 (72.70)	1.186 (70.90)	1.086 (60.85)
Diploma	1.625 (87.53)	1.311 (68.76)	0.913 (205.82)	1.121 (167.31)	1.236 (152.88)	1.052 (159.52)
Bachelor	2.508 (84.23)	2.074 (59.33)	1.556 (122.29)	1.756 (126.99)	2.169 (144.90)	1.702 (98.64)
Postgrad	2.244 (54.02)	1.612 (33.23)	1.591 (65.72)	1.606 (69.13)	2.044 (91.87)	1.504 (57.71)
Experience	0.106 (22.33)	0.049 (10.83)	0.123 (91.41)	0.099 (81.93)	0.114 (50.41)	0.066 (39.52)
Expersq	0.001 (8.95)	0.002 (14.52)	-0.001 (18.54)	0.000 (4.56)	0.000 (1.36)	0.001 (17.30)
Chi2	5170	3770	29657	22511	14566	16953
Observations	3144	2826	14700	11685	7851	9408
t-statistics in parentheses						

1991	Industry 33	Industry 34	Industry 35	Industry 36	Industry 37	Industry 38
School Cert	0.537 (12.03)	0.919 (50.75)	0.877 (76.46)	0.544 (11.62)	0.649 (11.41)	0.871 (161.77)
UE	1.183 (19.90)	1.302 (50.11)	1.437 (101.43)	1.042 (19.64)	0.819 (10.72)	1.203 (168.93)
Bursary	1.129 (12.49)	1.245 (34.12)	1.069 (52.97)	1.135 (12.53)	0.145 (0.73)	0.934 (85.28)
Diploma	0.773 (21.42)	1.044 (68.21)	1.199 (123.89)	0.763 (20.81)	0.580 (18.19)	0.954 (240.65)
Bachelor	1.419 (20.67)	1.772 (48.77)	1.857 (130.59)	1.252 (22.67)	1.358 (19.56)	1.442 (127.23)
Postgrad	1.160 (11.73)	1.526 (29.47)	1.953 (94.24)	1.250 (15.63)	1.326 (9.60)	1.384 (61.93)
Experience	0.078 (10.32)	0.106 (26.28)	0.064 (36.74)	0.086 (11.06)	0.103 (11.32)	0.123 (141.65)
Expersq	0.000 (1.08)	0.000 (3.17)	0.001 (11.19)	0.000 (1.99)	-0.001 (5.99)	-0.001 (34.31)
Chi2	547.1	4258	14658	831.3	509	56307
Observations	486	2964	9072	825	762	32517
t-statistics in parentheses						

Appendix 4A (1991) : Wage Effects of Qualifications, by Industry

1991	Industry 39	Industry 40	Industry 41	Industry 42	Industry 43	Industry 44
School cert	1.582 (172.13)	1.230 (553.89)	1.650 (187.97)	1.275 (48.64)	1.731 (46.95)	1.439 (144.96)
(UE)	2.130 (171.31)	1.819 (663.64)	2.533 (230.44)	1.933 (54.25)	2.636 (51.59)	1.907 (138.47)
Bursary	1.619 (109.19)	1.674 (469.80)	2.595 (204.21)	1.598 (40.10)	1.682 (37.52)	1.679 (94.04)
Diploma	1.575 (210.04)	1.435 (700.23)	2.327 (257.82)	1.417 (58.07)	1.958 (53.28)	1.563 (160.22)
Bachelor	2.416 (165.27)	2.309 (627.45)	2.827 (192.78)	2.466 (53.22)	3.404 (49.26)	1.995 (71.61)
Postgrad	2.423 (93.63)	2.182 (389.13)	2.498 (127.24)	2.465 (28.97)	3.172 (35.56)	2.478 (46.81)
Experience	0.062 (28.78)	0.123 (309.18)	0.158 (100.38)	0.085 (15.52)	0.124 (9.94)	0.066 (21.28)
Expersq	0.002 (38.52)	0.000 (6.16)	0.000 (2.78)	0.001 (6.85)	0.001 (3.91)	0.003 (31.18)
Chi2	23093	286433	38882	3090	2884.6	16026
Observations	11724	128004	25446	3261	4788	10212
t-statistics in parentheses						

1991	Industry 45	Industry 46	Industry 47	Industry 48	Industry 49	Industry 50
School Cert	1.221 (82.87)	0.984 (81.74)	1.003 (97.83)	1.246 (141.35)	0.797 (111.88)	1.222 (93.41)
UE	1.702 (91.49)	1.610 (114.63)	1.522 (132.04)	1.902 (175.14)	1.263 (163.21)	1.873 (137.84)
Bursary	1.562 (70.53)	1.583 (96.53)	1.383 (97.74)	1.653 (129.15)	1.311 (144.78)	1.915 (123.99)
Diploma	1.380 (105.72)	1.488 (121.38)	1.297 (134.42)	1.684 (195.11)	1.084 (139.24)	1.531 (123.80)
Bachelor	2.297 (94.92)	2.100 (119.57)	1.682 (107.82)	2.394 (194.25)	1.725 (166.15)	2.375 (164.57)
Postgrad	2.149 (68.33)	1.908 (78.61)	1.800 (68.19)	2.415 (140.00)	1.811 (127.22)	2.397 (137.05)
Experience	-0.011 (3.35)	0.068 (30.74)	0.074 (44.12)	0.128 (74.59)	0.091 (89.04)	0.088 (48.22)
Expersq	0.003 (35.63)	0.001 (16.54)	0.001 (14.36)	0.000 (6.20)	0.000 (11.23)	0.001 (10.14)
Chi2	9061	14401	17317	29957	34062	18659
Observations	5793	7941	11262	22458	24582	9831
t-statistics in parentheses						

Appendix 4A (1991) : Wage Effects of Qualifications, by Industry

1991	Industry 51	Industry 52	Industry 54	Industry 55	Industry 56
School cert	1.104 (79.96)	1.426 (82.21)	1.175 (202.65)	1.099 (229.27)	1.480 (67.91)
UE	1.690 (113.72)	2.241 (106.40)	1.921 (296.20)	1.718 (325.79)	2.132 (69.20)
Bursary	1.696 (100.31)	2.095 (80.29)	1.874 (250.89)	1.727 (275.63)	1.622 (46.47)
Diploma	1.368 (102.14)	1.506 (99.36)	1.590 (281.94)	1.264 (289.98)	1.535 (87.84)
Bachelor	2.121 (126.62)	2.949 (128.81)	2.474 (384.24)	1.861 (332.90)	2.386 (52.34)
Postgrad	2.103 (95.59)	2.584 (88.49)	2.300 (301.90)	1.813 (310.50)	2.284 (38.01)
Experience	0.076 (38.92)	0.121 (30.75)	0.120 (147.21)	0.073 (92.23)	0.093 (14.58)
Expersq	0.000 (7.53)	0.001 (5.90)	0.000 (0.85)	0.001 (33.05)	0.002 (9.94)
Chi2	15527	11600	102512	110418	5272
Observations	10566	9075	56223	76896	4329
t-statistics in parentheses					

1991	Industry 57	Industry 58	Industry 59	Industry 60	Industry 62
School Cert	0.825 (96.77)	1.318 (103.29)	1.322 (181.48)	0.961 (106.74)	0.801 (135.76)
UE	1.561 (147.24)	1.966 (117.89)	2.491 (257.23)	1.750 (176.60)	1.084 (144.43)
Bursary	1.702 (123.64)	1.912 (96.68)	2.383 (202.04)	1.868 (159.15)	1.008 (83.95)
Diploma	1.449 (247.73)	1.437 (144.58)	1.889 (281.86)	1.371 (175.03)	1.031 (217.91)
Bachelor	2.189 (329.90)	2.289 (163.63)	3.273 (354.49)	2.054 (191.08)	1.235 (69.40)
Postgrad	2.159 (320.38)	2.266 (178.46)	2.757 (326.41)	1.900 (169.09)	1.320 (53.36)
Experience	0.092 (69.48)	0.079 (22.34)	0.181 (130.00)	0.180 (103.31)	0.105 (123.43)
Expersq	0.000 (11.05)	0.001 (16.12)	-0.001 (24.88)	-0.001 (29.70)	0.000 (14.66)
Chi2	95669	25037	87416	28779	42798
Observations	65238	24243	52233	14406	24789
t-statistics in parentheses					

Appendix 4A (1996) : Wage Effects of Qualifications, by Industry

1996	Industry 1	Industry 2	Industry 3	Industry 4	Industry 6	Industry 7
School cert	0.927 (117.12)	1.336 (117.12)	1.920 (190.63)	1.399 (112.04)	0.865 (93.19)	1.232 (42.76)
UE	1.284 (126.89)	1.958 (143.13)	2.837 (219.54)	2.182 (130.44)	1.243 (104.87)	1.710 (49.28)
Bursary	1.382 (97.04)	2.104 (119.37)	3.192 (192.62)	2.377 (106.09)	1.216 (67.52)	1.817 (35.66)
Diploma	1.269 (165.16)	1.678 (146.62)	2.369 (223.19)	1.575 (129.64)	1.040 (131.06)	1.419 (56.94)
Bachelor	1.693 (102.54)	2.381 (129.77)	3.226 (199.19)	2.401 (120.34)	1.609 (118.05)	1.963 (45.87)
Postgrad	1.344 (43.43)	2.138 (85.98)	2.998 (136.61)	2.683 (86.58)	1.799 (78.20)	1.791 (31.65)
Experience	0.185 (110.85)	0.121 (56.63)	0.190 (76.11)	0.162 (46.91)	0.182 (77.47)	0.147 (16.10)
Expersq	-0.002 (41.49)	0.000 (7.79)	0.000 (6.57)	0.000 (2.46)	-0.002 (26.39)	0.001 (2.57)
Chi2	16670.8	16231	33451	13986.7	12832.4	3288
Observations	7965	8604	18969	7884	6120	2082
t-statistics in parentheses						

1996	Industry 8	Industry 9	Industry 10	Industry 11	Industry 12	Industry 13
School Cert	0.681 (8.09)	0.920 (13.11)	1.489 (39.86)	1.067 (242.41)	1.417 (104.20)	1.295 (236.64)
UE	0.868 (8.55)	0.979 (11.50)	1.923 (39.42)	1.660 (271.47)	2.054 (122.49)	1.996 (281.12)
Bursary	0.494 (4.68)	1.171 (9.62)	2.020 (32.58)	1.735 (206.16)	2.382 (114.73)	2.226 (231.00)
Diploma	0.673 (9.39)	1.034 (16.47)	1.413 (45.12)	1.055 (268.75)	1.681 (130.00)	1.491 (295.47)
Bachelor	1.565 (13.26)	1.641 (20.41)	2.657 (46.40)	2.077 (213.93)	2.646 (138.40)	2.554 (294.98)
Postgrad	1.707 (10.10)	1.970 (21.27)	2.700 (43.09)	1.847 (106.66)	2.675 (119.72)	2.524 (187.64)
Experience	0.127 (11.07)	0.059 (6.33)	0.084 (11.89)	0.137 (121.63)	0.099 (37.29)	0.149 (105.96)
Expersq	-0.001 (4.45)	0.001 (2.24)	0.001 (7.25)	0.000 (13.28)	0.001 (18.93)	0.000 (4.48)
Chi2	404.5	574.8	2184.7	45746.4	11020.4	41938.3
Observations	618	549	2304	18015	5919	17244
t-statistics in parentheses						

Appendix 4A (1996) : Wage Effects of Qualifications, by Industry

1996	Industry 14	Industry 15	Industry 16	Industry 17	Industry 18	Industry 19
School cert	1.070 (43.56)	1.566 (141.04)	1.751 (165.59)	1.041 (228.33)	1.266 (119.20)	1.364 (146.58)
UE	1.651 (57.43)	2.291 (151.25)	2.592 (175.62)	1.491 (258.18)	1.753 (138.24)	1.930 (184.72)
Bursary	2.045 (54.40)	2.262 (120.32)	2.683 (133.15)	1.586 (187.80)	1.735 (104.51)	2.099 (175.74)
Diploma	1.412 (61.22)	1.638 (155.92)	1.972 (186.08)	1.050 (269.25)	1.384 (164.39)	1.734 (189.20)
Bachelor	2.455 (78.23)	2.476 (130.85)	2.791 (155.44)	1.545 (171.86)	2.214 (146.38)	2.334 (187.43)
Postgrad	2.420 (60.61)	2.614 (80.02)	2.791 (82.01)	1.558 (94.72)	2.355 (109.90)	2.266 (140.38)
Experience	0.104 (24.55)	0.059 (20.32)	0.081 (29.92)	0.131 (137.11)	0.079 (40.97)	0.084 (56.70)
Expersq	0.000 (3.92)	0.002 (31.39)	0.002 (31.79)	0.000 (17.38)	0.001 (22.33)	0.001 (24.58)
Chi2	3893.1	14191.6	19648.7	42965.5	14791	26085.6
Observations	2841	7320	11133	17493	6594	13104
t-statistics in parentheses						

1996	Industry 20	Industry 21	Industry 23	Industry 24	Industry 25	Industry 26
School Cert	1.014 (66.48)	0.960 (66.97)	0.668 (13.73)	0.755 (29.29)	1.214 (106.24)	0.960 (82.98)
UE	1.460 (77.44)	1.512 (88.09)	1.152 (16.94)	1.139 (32.58)	1.753 (126.34)	1.431 (93.59)
Bursary	1.845 (68.62)	1.684 (75.05)	1.215 (15.08)	1.018 (22.72)	2.030 (105.43)	1.243 (60.41)
Diploma	1.204 (95.47)	1.283 (95.73)	0.760 (17.18)	0.849 (37.60)	1.382 (140.20)	0.957 (98.67)
Bachelor	1.964 (97.21)	2.086 (116.44)	1.832 (23.76)	1.380 (31.07)	2.017 (119.22)	1.780 (89.22)
Postgrad	1.823 (66.59)	2.159 (100.86)	1.904 (20.37)	1.410 (21.30)	2.191 (69.95)	1.934 (58.10)
Experience	0.071 (19.97)	0.077 (24.81)	0.117 (12.12)	0.127 (25.52)	0.106 (40.54)	0.100 (39.24)
Expersq	0.001 (12.06)	0.001 (12.10)	-0.001 (3.65)	-0.001 (8.99)	0.001 (10.07)	0.000 (1.97)
Chi2	6320.6	7455.7	525.2	2039.6	11579.1	8726
Observations	3333	4383	372	1329	5730	4443
t-statistics in parentheses						

Appendix 4A (1996) : Wage Effects of Qualifications, by Industry

1996	Industry 27	Industry 28	Industry 29	Industry 30	Industry 31	Industry 32
School cert	1.391 (58.95)	0.903 (49.07)	1.057 (176.70)	1.040 (145.85)	1.214 (122.94)	1.044 (141.86)
UE	1.788 (62.97)	1.252 (56.67)	1.532 (199.34)	1.595 (189.08)	1.730 (150.45)	1.444 (157.73)
Bursary	1.870 (52.04)	1.367 (40.21)	1.533 (138.13)	1.746 (152.81)	1.882 (125.53)	1.603 (122.45)
Diploma	1.549 (76.28)	1.070 (71.74)	1.076 (219.55)	1.284 (205.79)	1.324 (165.36)	1.149 (188.46)
Bachelor	2.520 (76.81)	1.863 (61.60)	1.778 (171.46)	1.863 (178.94)	2.162 (180.98)	1.780 (142.94)
Postgrad	2.207 (48.43)	1.790 (48.09)	1.718 (100.29)	1.978 (120.03)	2.186 (131.94)	1.987 (83.73)
Experience	0.072 (15.11)	0.056 (14.25)	0.126 (95.99)	0.121 (107.47)	0.127 (68.56)	0.101 (71.85)
Expersq	0.002 (13.31)	0.001 (13.45)	0.000 (11.03)	0.000 (11.31)	0.000 (5.87)	0.000 (1.87)
Chi2	4334	4215.3	32660	28869.4	17092	20912.7
Observations	2643	2514	15633	12702	8601	8916
t-statistics in parentheses						

1996	Industry 33	Industry 34	Industry 35	Industry 36	Industry 37	Industry 38
School Cert	0.723 (12.72)	1.154 (72.01)	1.358 (68.47)	0.662 (14.89)	1.029 (25.17)	0.992 (256.29)
UE	1.323 (18.04)	1.578 (78.73)	2.141 (89.84)	1.253 (21.54)	1.346 (30.92)	1.466 (310.69)
Bursary	1.420 (10.48)	1.718 (64.36)	2.281 (87.53)	1.380 (18.58)	1.181 (23.34)	1.547 (240.90)
Diploma	0.983 (19.51)	1.240 (86.18)	1.749 (91.14)	1.070 (23.42)	1.148 (35.16)	1.058 (339.10)
Bachelor	1.572 (20.64)	1.463 (49.41)	2.684 (112.90)	1.777 (31.42)	1.779 (42.76)	1.465 (181.56)
Postgrad	1.871 (18.32)	1.914 (32.30)	2.873 (108.58)	1.308 (20.17)	1.965 (38.04)	1.364 (97.23)
Experience	0.117 (10.18)	0.136 (39.15)	0.049 (16.66)	0.116 (19.62)	0.010 (1.63)	0.162 (217.10)
Expersq	-0.001 (2.78)	-0.001 (6.21)	0.002 (23.28)	-0.001 (5.97)	0.002 (11.76)	-0.001 (65.54)
Chi2	499.1	4925.1	10122.9	873.1	1444.4	83132
Observations	555	2589	5826	546	1059	36441
t-statistics in parentheses						

Appendix 4A (1996) : Wage Effects of Qualifications, by Industry

1996	Industry 39	Industry 40	Industry 41	Industry 42	Industry 43	Industry 44
School cert	1.388 (177.10)	1.254 (593.77)	1.231 (217.08)	1.278 (64.40)	1.961 (51.59)	1.542 (186.50)
UE	1.901 (196.29)	1.978 (805.99)	2.087 (317.21)	1.789 (70.32)	3.001 (59.04)	2.144 (205.02)
Bursary	2.049 (156.73)	2.298 (782.99)	2.548 (331.43)	1.710 (55.38)	2.983 (51.48)	2.244 (174.56)
Diploma	1.379 (207.04)	1.618 (755.53)	1.990 (346.44)	1.444 (76.65)	2.272 (56.43)	1.702 (200.06)
Bachelor	2.214 (185.87)	2.490 (834.92)	2.280 (293.93)	2.207 (63.44)	3.576 (55.91)	2.580 (152.12)
Postgrad	2.047 (112.23)	2.487 (567.95)	1.943 (246.92)	2.652 (57.96)	3.226 (40.20)	2.848 (106.27)
Experience	0.099 (55.83)	0.135 (376.22)	0.175 (192.47)	0.045 (12.49)	0.049 (5.05)	0.063 (30.42)
Expersq	0.001 (22.64)	0.000 (2.15)	-0.001 (35.30)	0.002 (19.47)	0.003 (14.38)	0.003 (49.77)
Chi2	24956.6	356493	72791	3736.3	3026.8	24183
Observations	11319	135003	32490	2280	4185	11862
t-statistics in parentheses						

1996	Industry 45	Industry 46	Industry 47	Industry 48	Industry 49	Industry 50
School Cert	0.935 (52.82)	0.917 (79.39)	1.016 (106.42)	1.476 (152.58)	1.121 (103.58)	1.279 (105.75)
UE	1.630 (71.97)	1.597 (121.41)	1.623 (151.93)	2.250 (192.47)	1.971 (150.30)	1.993 (150.98)
Bursary	1.640 (53.82)	1.891 (126.21)	1.762 (136.89)	2.822 (202.68)	2.317 (169.66)	2.194 (150.51)
Diploma	1.182 (77.82)	1.543 (133.29)	1.500 (158.21)	2.154 (203.47)	1.950 (148.40)	1.812 (141.70)
Bachelor	2.164 (81.44)	2.191 (139.83)	1.899 (148.24)	3.279 (238.32)	2.751 (197.00)	2.642 (194.24)
Postgrad	1.874 (49.86)	2.359 (100.22)	1.880 (97.97)	3.307 (202.90)	2.881 (178.60)	2.847 (181.31)
Experience	0.080 (27.18)	0.104 (58.02)	0.088 (55.80)	0.162 (92.58)	0.123 (78.73)	0.096 (53.20)
Expersq	0.001 (8.00)	0.000 (2.77)	0.001 (13.10)	0.000 (3.75)	0.000 (0.80)	0.001 (14.98)
Chi2	6203	15965.7	21710.8	29457.7	31661.7	22605
Observations	3870	7782	13605	15612	19488	10815
t-statistics in parentheses						

Appendix 4A (1996) : Wage Effects of Qualifications, by Industry

1996	Industry 51	Industry 52	Industry 54	Industry 55	Industry 56
School cert	0.975 (79.72)	1.178 (124.06)	1.150 (229.44)	1.273 (221.14)	1.794 (92.11)
UE	1.685 (122.91)	1.936 (175.27)	1.981 (341.23)	1.961 (302.13)	2.486 (99.11)
Bursary	1.941 (130.20)	2.123 (157.16)	2.266 (357.74)	2.186 (303.80)	2.639 (85.63)
Diploma	1.446 (114.90)	1.501 (168.23)	1.771 (330.20)	1.580 (272.57)	1.967 (104.68)
Bachelor	2.247 (151.51)	2.554 (217.99)	2.658 (454.34)	2.273 (338.16)	3.049 (97.35)
Postgrad	2.271 (122.66)	2.345 (158.76)	2.740 (423.99)	2.330 (335.64)	3.016 (65.72)
Experience	0.089 (53.73)	0.106 (56.76)	0.119 (173.27)	0.073 (72.93)	0.034 (6.73)
Expersq	0.000 (5.82)	0.001 (11.83)	0.000 (13.69)	0.001 (42.41)	0.004 (27.78)
Chi2	17316.5	24555.3	140887	99984	8194.9
Observations	9693	12318	68271	68208	5079
t-statistics in parentheses					

1996	Industry 57	Industry 58	Industry 59	Industry 60	Industry 62
School Cert	0.728 (114.65)	1.190 (161.57)	1.511 (199.89)	1.064 (129.78)	1.099 (232.92)
UE	1.284 (178.05)	2.049 (228.37)	2.721 (269.68)	1.757 (198.35)	1.582 (286.77)
Bursary	1.531 (170.75)	2.377 (206.80)	3.191 (279.28)	2.146 (218.76)	1.780 (257.30)
Diploma	1.281 (258.27)	1.629 (240.73)	2.413 (282.54)	1.613 (200.37)	1.335 (315.43)
Bachelor	1.974 (357.66)	2.438 (292.30)	3.699 (358.84)	2.221 (237.70)	1.577 (167.37)
Postgrad	1.953 (343.75)	2.722 (334.68)	4.036 (385.09)	2.186 (209.84)	1.548 (96.64)
Experience	0.078 (83.69)	0.082 (42.23)	0.137 (104.92)	0.136 (104.61)	0.146 (185.12)
Expersq	0.000 (17.75)	0.001 (31.69)	0.001 (23.50)	0.000 (3.88)	-0.001 (30.88)
Chi2	118522	55287.3	94121	39652	61095
Observations	70557	30582	45321	17745	25554
t-statistics in parentheses					

Appendix 4A (2001) : Wage Effects of Qualifications, by Industry

2001	Industry 1	Industry 2	Industry 3	Industry 4	Industry 6	Industry 7
School cert	0.892 (103.37)	1.327 (80.45)	1.795 (166.09)	1.780 (129.33)	0.737 (105.29)	1.111 (24.48)
UE	1.280 (114.62)	1.967 (97.17)	2.705 (195.72)	2.453 (146.83)	1.139 (125.19)	1.616 (28.47)
Bursary	1.597 (98.04)	2.370 (94.38)	3.209 (192.73)	2.804 (126.63)	1.392 (97.08)	1.891 (23.29)
Diploma	1.387 (145.5)	2.024 (103.6)	2.646 (199.24)	2.280 (147.29)	1.030 (150.49)	1.758 (36.2)
Bachelor	1.674 (98.45)	2.477 (92.01)	3.359 (201.51)	2.989 (135.39)	1.614 (126.27)	2.195 (24.33)
Postgrad	1.348 (56.47)	2.346 (70.32)	3.103 (163.2)	3.201 (99.91)	2.085 (95.81)	2.352 (20.88)
Experience	0.182 (86.65)	0.110 (32.98)	0.108 (45.71)	0.117 (32.22)	0.207 (91.55)	0.142 (11.19)
Expersq	-0.002 (28.82)	0.001 (9.02)	0.002 (36.36)	0.002 (21.93)	-0.002 (36.02)	0.000 (1.22)
Chi2	16022	11421	35838	17668	16531	1524
Observations	9492	7977	17367	7743	6183	1707

2001	Industry 8	Industry 9	Industry 10	Industry 11	Industry 12	Industry 13
School Cert	1.277 (15.82)	0.603 (3.90)	1.437 (30.23)	1.130 (310.09)	1.187 (104.54)	1.315 (281.65)
UE	1.684 (16.57)	0.647 (3.46)	1.831 (31.06)	1.588 (338.18)	1.793 (126.67)	2.044 (338.23)
Bursary	1.457 (11.53)	0.697 (2.58)	1.834 (25.93)	1.874 (290.98)	2.289 (126.59)	2.588 (301.18)
Diploma	1.466 919.24)	0.850 (4.74)	1.596 (35.78)	1.295 (336.67)	1.667 (136.41)	1.802 (345.92)
Bachelor	2.354 (19.74)	1.704 (8.11)	2.759 (39.34)	2.203 (290.63)	2.652 (152.60)	2.826 (357.30)
Postgrad	2.626 (19.97)	1.926 (8.26)	2.675 (32.91)	2.443 (202.01)	2.681 (127.42)	2.994 (269.41)
Experience	0.029 (2.14)	0.073 (4.22)	0.031 (3.29)	0.109 (124.72)	0.113 (49.59)	0.150 (118.31)
Expersq	0.002 (5.58)	0.000 (0.07)	0.002 (10.19)	0.000 (17.13)	0.001 (10.32)	0.000 (13.24)
Chi2	414.9	191.9	1549.8	56530	11354	48273
Observations	504	270	1977	18705	5229	15798

Interval regression of Census income brackets, by industry.
Independent variables are highest qualification achieved, experience and experience squared. t-statistics in parentheses

Appendix 4A (2001) : Wage Effects of Qualifications, by Industry

2001	Industry 14	Industry 15	Industry 16	Industry 17	Industry 18	Industry 19
School cert	1.255 (62.96)	1.738 (119.42)	1.729 (95.21)	1.091 (232.01)	1.053 (108.77)	1.492 (145.12)
UE	2.098 (84.66)	2.538 (137.09)	2.778 (110.66)	1.512 (252.63)	1.646 (131.05)	2.253 (181.81)
Bursary	2.556 (85.35)	2.771 (121.67)	3.093 (95.95)	1.773 (202.13)	1.712 (108.45)	2.582 (185.71)
Diploma	1.988 (89.97)	2.164 (134.83)	2.635 (113.75)	1.267 (268.59)	1.370 (153.94)	2.301 (190.48)
Bachelor	3.116 (110.52)	2.996 (130.95)	3.217 (108.46)	1.868 (213.79)	2.339 (148.38)	3.062 (220.13)
Postgrad	3.227 (94.79)	3.174 (87.40)	3.621 (73.04)	1.931 (131.05)	2.476 (108.33)	2.956 (193.63)
Experience	0.131 (33.97)	0.039 (11.80)	0.025 (5.09)	0.121 (106.45)	0.096 (37.28)	0.062 (33.91)
Expersq	0.001 (6.31)	0.003 (35.67)	0.004 (30.48)	0.000 (4.27)	0.001 (11.10)	0.002 (42.81)
Chi2	6404.3	11586.2	10377.1	44117.6	12138.6	29685.4
Observations	3255	6285	8004	19482	5256	14724
t-statistics in parentheses						

2001	Industry 20	Industry 21	Industry 23	Industry 24	Industry 25	Industry 26
School Cert	1.069 (77.92)	0.988 (54.60)	0.337 (3.69)	1.004 (32.40)	1.218 (131.67)	1.060 (90.31)
UE	1.583 (93.17)	1.616 (70.11)	0.927 (7.45)	1.400 (35.37)	1.805 (158.17)	1.443 (96.46)
Bursary	1.780 (76.67)	2.095 (62.20)	1.177 (7.20)	1.092 (20.05)	1.902 (124.96)	1.612 (74.94)
Diploma	1.502 (112.12)	1.599 (76.71)	0.495 (5.44)	1.113 (37.22)	1.590 (172.98)	1.207 (103.59)
Bachelor	2.302 (118.12)	2.174 (85.38)	1.427 (9.15)	1.438 (25.04)	2.215 (161.83)	1.959 (101.45)
Postgrad	2.378 (94.54)	2.478 (70.55)	1.134 (6.80)	0.938 (10.79)	2.164 (95.59)	2.001 (77.68)
Experience	0.051 (15.88)	0.067 (13.98)	0.073 (4.82)	0.045 (6.20)	0.095 (38.75)	0.098 (31.30)
Expersq	0.002 (22.05)	0.001 (12.11)	-0.001 (1.58)	0.001 (6.99)	0.001 (16.89)	0.000 (4.35)
Chi2	7201	4171	91.4	1430	13720.2	8693
Observations	3318	2598	198	1179	6066	4386
t-statistics in parentheses						

Appendix 4A (2001) : Wage Effects of Qualifications, by Industry

2001	Industry 27	Industry 28	Industry 29	Industry 30	Industry 31	Industry 32
School cert	1.115 (48.73)	1.002 (63.16)	1.066 (202.08)	1.258 (138.01)	1.254 (114.43)	0.912 (99.34)
UE	1.574 (54.40)	1.499 (72.12)	1.571 (235.15)	1.796 (165.54)	1.873 (144.24)	1.341 (120.59)
Bursary	1.958 (47.06)	1.670 (57.94)	1.721 (177.38)	1.865 (133.42)	2.286 (141.42)	1.521 (95.33)
Diploma	1.571 (69.31)	1.331 (86.92)	1.282 (254.28)	1.592 (177.43)	1.708 (161.66)	1.215 (138.01)
Bachelor	2.082 (56.99)	2.108 (79.99)	1.892 (199.04)	2.144 (167.47)	2.507 (180.27)	1.634 (93.01)
Postgrad	2.090 (43.55)	2.457 (64.12)	1.785 (114.60)	2.300 (127.97)	2.654 (156.70)	1.726 (54.04)
Experience	0.073 (17.54)	0.067 (18.38)	0.131 (103.38)	0.085 (53.44)	0.120 (51.38)	0.084 (44.65)
Expersq	0.001 (11.43)	0.001 (14.05)	0.000 (12.84)	0.001 (18.75)	0.000 (6.70)	0.000 (7.10)
Chi2	3539.3	4744	33754.8	23171	16515.9	14950.6
Observations	2199	2439	14436	12210	8637	7998
t-statistics in parentheses						

2001	Industry 33	Industry 34	Industry 35	Industry 36	Industry 37	Industry 38
School Cert	0.865 (29.74)	1.192 (66.03)	0.905 (34.49)	0.670 (7.88)	0.557 (11.40)	0.943 (275.27)
UE	1.377 (39.22)	1.855 (81.02)	1.541 (48.80)	1.101 (10.62)	0.891 (14.03)	1.431 (338.85)
Bursary	1.720 (36.06)	2.089 (66.30)	1.956 (54.46)	1.981 (15.49)	1.196 (15.82)	1.629 (275.05)
Diploma	1.502 (48.82)	1.564 (80.18)	1.416 (55.93)	1.254 (12.63)	0.858 (18.39)	1.174 (372.26)
Bachelor	2.212 (59.56)	1.887 (62.73)	2.426 (74.40)	2.195 (18.74)	1.520 (26.02)	1.515 (217.55)
Postgrad	2.282 (56.83)	2.047 (33.09)	2.549 (70.83)	2.687 (20.76)	1.724 (25.09)	1.578 (128.37)
Experience	0.091 (16.87)	0.093 (23.21)	0.107 (27.16)	0.151 (15.35)	0.093 (12.60)	0.137 (194.99)
Expersq	0.000 (3.22)	0.001 (8.61)	0.000 (0.94)	-0.001 (4.22)	-0.001 (3.03)	-0.001 (42.15)
Chi2	2543	4855.6	5372.3	611.9	798.6	92336
Observations	1944	2658	3591	444	708	42366
t-statistics in parentheses						

Appendix 4A (2001) : Wage Effects of Qualifications, by Industry

2001	Industry 39	Industry 40	Industry 41	Industry 42	Industry 43	Industry 44
School cert	1.289 (142.71)	1.257 (617.99)	1.245 (254.40)	1.215 (36.63)	2.229 (52.85)	1.653 (232.26)
UE	1.831 (162.00)	2.101 (829.36)	2.160 (362.45)	1.824 (41.03)	3.259 (57.29)	2.313 (252.56)
Bursary	2.173 (140.47)	2.609 (867.71)	2.668 (393.78)	1.812 (35.58)	2.927 (50.89)	2.455 (210.24)
Diploma	1.654 (181.90)	1.921 (815.67)	2.242 (393.94)	1.535 (41.55)	2.868 (56.72)	1.955 (242.09)
Bachelor	2.390 (169.64)	2.736 (912.29)	2.532 (354.48)	2.392 (44.17)	4.031 (58.19)	3.037 (207.58)
Postgrad	2.551 (116.28)	2.733 (682.04)	2.424 (275.98)	2.638 (37.86)	3.705 (44.05)	3.062 (117.14)
Experience	0.086 (38.25)	0.133 (372.97)	0.158 (212.24)	0.041 (7.26)	-0.124 (12.15)	0.093 (42.65)
Expersq	0.001 (19.90)	0.000 (26.65)	0.000 (13.14)	0.002 (11.08)	0.006 (28.74)	0.002 (40.19)
Chi2	21262.6	428051	89323	2129	2862.3	28893.7
Observations	12018	158010	35133	2016	4143	13284
t-statistics in parentheses						

2001	Industry 45	Industry 46	Industry 47	Industry 48	Industry 49	Industry 50
School Cert	0.683 (16.61)	0.747 (74.70)	0.958 (142.60)	1.537 (100.09)	1.103 (83.19)	1.188 (117.70)
UE	1.420 (27.81)	1.359 (116.47)	1.647 (210.12)	2.533 (130.00)	2.162 (117.05)	2.212 (171.07)
Bursary	1.691 (27.01)	1.779 (128.96)	2.041 (211.97)	3.434 (156.14)	3.012 (145.91)	2.892 (199.17)
Diploma	1.159 (27.86)	1.653 (144.90)	1.702 (233.42)	2.662 (139.20)	2.629 (132.48)	2.291 (176.78)
Bachelor	1.773 (30.77)	2.079 (147.86)	2.239 (230.22)	3.878 (176.95)	3.478 (166.24)	3.224 (229.71)
Postgrad	1.869 (21.59)	2.210 (116.27)	2.258 (158.47)	3.923 (165.09)	3.471 (155.18)	3.368 (219.20)
Experience	0.076 (11.09)	0.098 (61.72)	0.097 (69.37)	0.167 (63.04)	0.143 (67.07)	0.095 (52.69)
Expersq	0.000 (1.02)	0.000 (1.50)	0.001 (15.63)	0.000 (5.60)	0.000 (4.09)	0.001 (27.16)
Chi2	1340.8	15929.9	35856.4	25372.3	24852.2	34198
Observations	1107	6978	19704	14271	15579	16119
t-statistics in parentheses						

Appendix 4A (2001) : Wage Effects of Qualifications, by Industry

2001	Industry 51	Industry 52	Industry 54	Industry 55	Industry 56
School cert	0.973 (77.06)	1.289 (141.67)	1.140 (247.59)	1.337 (172.49)	1.689 (227.13)
UE	1.836 (115.90)	2.220 (194.08)	2.136 (364.54)	2.093 (223.06)	2.762 (293.29)
Bursary	2.323 (133.28)	2.849 (202.60)	2.807 (427.24)	2.468 (249.23)	3.525 (322.36)
Diploma	1.911 (122.54)	1.929 (191.39)	2.184 (381.07)	1.978 (220.52)	2.490 (286.85)
Bachelor	2.653 (154.21)	3.251 (252.71)	3.169 (507.43)	2.601 (267.95)	3.775 (358.71)
Postgrad	2.734 (138.54)	2.987 (196.65)	3.337 (500.90)	2.732 (272.53)	3.765 (326.91)
Experience	0.082 (42.04)	0.132 (66.28)	0.136 (177.54)	0.033 (25.45)	0.129 (79.73)
Expersq	0.001 (14.75)	0.001 (13.33)	0.000 (19.68)	0.002 (59.78)	0.002 (35.70)
Chi2	17405.5	27844.2	178617	78474	59885.7
Observations	9786	12444	83709	64164	25356
t-statistics in parentheses					

2001	Industry 57	Industry 58	Industry 59	Industry 60	Industry 62
School Cert	0.851 (143.90)	1.471 (229.20)	1.402 (155.28)	1.053 (133.05)	1.063 (208.62)
UE	1.491 (217.85)	2.425 (294.77)	2.600 (201.91)	1.759 (190.84)	1.615 (264.08)
Bursary	1.935 (237.46)	3.098 (319.94)	3.325 (220.83)	2.448 (233.63)	1.893 (244.67)
Diploma	1.672 (307.40)	2.266 (312.79)	2.403 (212.12)	1.853 (205.13)	1.471 (283.74)
Bachelor	2.464 (407.16)	3.306 (386.34)	4.187 (287.18)	2.603 (254.49)	1.792 (194.69)
Postgrad	2.368 (391.94)	3.533 (415.26)	4.318 (290.31)	2.510 (225.50)	1.545 (103.11)
Experience	0.029 (31.04)	0.078 (46.65)	0.141 (76.37)	0.143 (111.47)	0.146 (154.61)
Expersq	0.002 (76.34)	0.002 (55.37)	0.001 (22.53)	0.000 (4.27)	-0.001 (25.45)
Chi2	132799	83030	81766	45235.5	52036.8
Observations	82149	39192	55635	20553	21507
t-statistics in parentheses					

Appendix 4B : Skills premium in each industry and Census year, and change in premia between Census years

Code	Industry	1991 bach/sc	1996 bach/sc	2001 bach/sc	ratio 1996:1991	ratio 2001:1996	ratio 2001:1991
1	Dairy Farming	1.983	1.827	1.877	0.921	1.027	0.946
2	Sheep and Beef Farming	1.521	1.781	1.866	1.171	1.047	1.227
3	Other Farming	1.606	1.680	1.872	1.046	1.114	1.165
4	Agricultural Services	1.645	1.717	1.679	1.043	0.978	1.020
6	Forestry and Logging	2.261	1.861	2.189	0.823	1.176	0.968
7	Fishing	1.659	1.593	1.977	0.960	1.241	1.192
8	Coal Mining	2.777	2.298	1.844	0.828	0.802	0.664
9	Oil & Gas Exploration	3.139	1.783	2.825	0.568	1.584	0.900
10	Other Mining and Quarrying	1.920	1.784	1.920	0.929	1.077	1.000
11	Slaughtering and Preserving Meat	1.713	1.946	1.949	1.136	1.002	1.138
12	Dairy Products	1.766	1.868	2.234	1.058	1.196	1.265
13	Other Food Preparation	2.021	1.973	2.149	0.976	1.090	1.064
14	Beverages and Tobacco	2.076	2.296	2.483	1.106	1.082	1.196
15	Textiles	1.658	1.581	1.724	0.953	1.090	1.040
16	Wearing Apparel and Footwear	1.747	1.594	1.861	0.912	1.168	1.065
17	Wood and Wood Products	1.627	1.485	1.712	0.912	1.153	1.052
18	Paper and Paper Products	1.653	1.749	2.222	1.058	1.271	1.344
19	Printing and Publishing	1.581	1.712	2.053	1.083	1.199	1.298
20	Industrial Chemicals	2.239	1.936	2.154	0.865	1.112	0.962
21	Other Chemicals	2.164	2.174	2.201	1.005	1.012	1.017
23	Petroleum and Coal Products	2.650	2.743	4.234	1.035	1.544	1.598
24	Rubber Products	2.164	1.828	1.432	0.845	0.783	0.662
25	Plastic Products	1.903	1.661	1.818	0.873	1.095	0.955
26	Non Metallic Industries	1.904	1.855	1.848	0.975	0.996	0.971
27	Iron and Steel Products	1.794	1.812	1.867	1.010	1.031	1.041
28	Non-Ferrous Metals	1.805	2.064	2.103	1.143	1.019	1.165

29	Fabricated Metal Products	1.770	1.683	1.776	0.951	1.055	1.003
30	Machinery nec.	1.916	1.791	1.704	0.935	0.952	0.889
31	Electrical Machinery	1.852	1.781	1.999	0.962	1.123	1.080
32	Transport Equipment	1.832	1.706	1.791	0.931	1.050	0.977
33	Professional Equipment	2.640	2.173	2.557	0.823	1.177	0.969
34	Other Manufacturing	1.929	1.268	1.582	0.657	1.248	0.820
35	Electricity	2.118	1.977	2.681	0.933	1.356	1.266
36	Gas Manufacture and Distribution	2.303	2.686	3.278	1.166	1.220	1.423
37	Water Works and Supply	2.093	1.728	2.727	0.826	1.578	1.303
38	Building and Ancillary Services	1.656	1.477	1.606	0.892	1.088	0.970
39	Other Construction	1.527	1.595	1.854	1.045	1.163	1.215
40	Wholesale and Retail Trade	1.878	1.986	2.177	1.057	1.096	1.159
41	Restaurants and Hotels	1.713	1.853	2.035	1.082	1.098	1.188
42	Rail Transport	1.934	1.727	1.968	0.893	1.140	1.018
43	Road Passenger Transport	1.967	1.824	1.809	0.927	0.992	0.920
44	Road Freight Transport	1.386	1.674	1.837	1.207	1.098	1.325
45	Water Transport	1.881	2.313	2.595	1.230	1.122	1.380
46	Air Transport	2.135	2.390	2.784	1.119	1.165	1.304
47	Services to Transport	1.677	1.870	2.337	1.115	1.250	1.394
48	Communication	1.921	2.221	2.523	1.156	1.136	1.313
49	Banking	2.163	2.453	3.153	1.134	1.285	1.458
50	Other Financial Services	1.942	2.066	2.714	1.063	1.314	1.397
51	Insurance	1.922	2.306	2.727	1.200	1.183	1.419
52	Owning and Leasing Real Estate	2.068	2.167	2.521	1.048	1.163	1.219
54	Owning Owner-Occupied Dwellings	2.106	2.311	2.781	1.097	1.203	1.320
55	Business Services	1.694	1.785	1.946	1.054	1.090	1.149
56	Public Administration and Defence	1.612	1.700	2.235	1.054	1.315	1.386
57	Sanitary and Cleaning Services	2.655	2.710	2.896	1.021	1.069	1.091
58	Education	1.736	2.048	2.247	1.179	1.097	1.294
59	Social and Community Services	2.475	2.449	2.987	0.989	1.220	1.207
60	Health Services	2.137	2.088	2.472	0.977	1.184	1.157
62	Recreational and Cultural Services	1.542	1.435	1.686	0.931	1.175	1.094

Appendix 5 : Changes in within-group income inequality by highest education level
Full-time workers, 1991-1996 and 1996-2001

				1991-1996			**1996-2001**		
Education level	Gini 1991 (1)	Gini 1996 (2)	Gini 2001 (3)	d_Gini 1991-1996 (2) - (1)	Mean absolute change in Gini	Mean %-age change in Gini	d_Gini 1996-2001 (3) - (2)	Mean absolute change in Gini	Mean %-age change in Gini
No qualificat's	0.231	0.255	0.267	0.024	0.021	9.3%	0.013	0.010	4.0%
School Cert	0.243	0.256	0.264	0.013	0.011	4.6%	0.008	0.006	2.6%
UE/6th form	0.261	0.274	0.289	0.013	0.006	2.7%	0.015	0.011	4.3%
Bursary	0.309	0.330	0.345	0.022	0.015	5.8%	0.015	0.012	3.5%
Diploma	0.242	0.255	0.263	0.013	0.011	4.6%	0.008	0.006	2.4%
Bachelor	0.274	0.308	0.299	0.033	0.030	10.9%	-0.008	-0.008	-2.9%
Postgraduate	0.258	0.292	0.276	0.033	0.028	11.2%	-0.015	-0.016	-5.1%
Total	0.267	0.289	0.298	0.022	0.019	7.4%	0.009	0.006	2.2%

Appendix 6: Bivariate relationships between industry computer use and the change in between-groups inequality for all full time workers, 1991-1996

	Independent variables		
	Hardware	*Software*	*All Computing*
Missing values set to:	*Total Outlay*	*Total Outlay*	*Total Outlay*
(i) Zero	3.174	2.243	2.061
	(0.90)	(2.90)**	(2.67)**
(ii) ($0.5m/total outlay)	3.060	2.242	2.060
	(0.85)	(2.90)**	(2.66)**
(iii) Lowest non-missing ratio	3.229	2.248	2.072
	(0.89)	(2.90)**	(2.67)**
(iv) Mean of non-missing ratios	3.159	2.307	2.162
	(0.75)	(2.89)**	(2.67)**

Bivariate relationships between industry computer use and the change in between-groups inequality for all full-time workers, 1996-2001

	Independent variables		
	Hardware	*Software*	*All Computing*
Missing values set to:	*Total Outlay*	*Total Outlay*	*Total Outlay*
(i) Zero	0.868	1.865	1.568
	(0.21)	(1.27)	(1.14)
(ii) ($0.5m/total outlay)	1.029	1.887	1.585
	(0.25)	(1.28)	(1.15)
(iii) Lowest non-missing ratio	1.189	1.909	1.602
	(0.29)	(1.29)	(1.16)
(iv) Mean of non-missing ratios	1.672	1.617	1.291
	(0.85)	(1.98)*	(1.85)

Note: The values in the table are coefficients from bivariate regressions. The dependent variable for each regression is the ratio of the marginal effect of a Bachelor's degree relative to the marginal effect of School Certificate in Census year t, relative to the value of the same ratio in Census year (t-5). The independent variables are, alternately, the ratio of industry spending on computer hardware to total industry outlay, the ratio of software spending, and the ratio of all computer expenditures to total industry outlay. Each regression is estimated on the sample of 58 industries, and is weighted by industry size in the first year of each interval

Heteroscedastically-robust *t*-statistics in parenthesis;

* significant at 5% level; ** significant at 1% level.

Appendix 7 : Multivariate relationships between change in the skills premium and industry proportion of expenditure on computing, with controls for profitability, wages and trade effects

Appendix 7A **1991-1996**	**General employment change**		**Targeted employment change**	
	ICT purchases separated	ICT purchases grouped	ICT purchases separated	ICT purchases grouped
Hardware/Total	2.954 (0.91)		2.823 (1.01)	
Software/Total	2.208 (2.22)*		2.019 (2.35)*	
All computing/Total		2.312 (2.94)**		2.123 (2.78)**
Op. surplus/Total	0.149 (0.62)	0.151 (0.62)	0.174 (0.7)	0.176 (0.71)
Wages/Total	0.047 (0.35)	0.048 (0.36)	0.039 (0.28)	0.04 (0.28)
Exports/Total	0.135 (1.1)	0.137 (1.14)	0.139 (1.18)	0.14 (1.21)
Imports/Total	-0.349 (1.92)	-0.339 (1.83)	-0.371 (2.05)*	-0.361 (1.95)
Change in employment	0.005 (0.05)	0.007 (0.08)	-0.002 (1.2)	-0.002 (1.23)
Constant	0.989 (10.55)**	0.988 (10.56)**	0.997 (10.16)**	0.996 (10.19)**
R-squared	0.1745	0.1739	0.2015	0.2008
F-test	0.0041 F(7,50)	0.0023 F(6,51)	0.0009 F(7,48)	0.0005 F(6,49)

Note: The values in the table are coefficients from multivariate regressions. The dependent variable for each regression is the ratio of the marginal effect of a Bachelor's degree relative to the marginal effect of School Certificate in 1996, relative to the value of the same ratio in 1991. The independent variables are the ratio of industry spending on all computer inputs, plus control variables for operating surplus, wages, imports, exports, and the extent of employment change. Each regression is estimated on the sample of 58 industries, and is weighted by industry size in 1991.

Robust t-statistics in parentheses
* significant at 5% level; ** significant at 1% level

Appendix 7 : Multivariate relationships between change in the skills premium and industry proportion of expenditure on computing, with controls for profitability, wages and trade effects

Appendix 7B **1996-2001**	**General employment change** ICT purchases separated	 ICT purchases grouped	**Targeted employment change** ICT purchases separated	 ICT purchases grouped
Hardware/Total	-0.948 (0.32)		-1.137 (0.38)	
Software/Total	1.848 (2.09)*		1.841 (2.31)*	
All computing/Total		1.419 (1.73)		1.417 (1.80)
Op. surplus/Total	0.523 (3.40)**	0.514 (3.32)**	0.535 (3.42)**	0.525 (3.35)**
Wages/Total	0.120 (1.25)	0.113 (1.18)	0.122 (1.26)	0.117 (1.18)
Exports/Total	0.032 (0.39)	0.026 (0.31)	0.040 (0.49)	0.036 (0.43)
Imports/Total	0.005 (0.03)	-0.035 (0.19)	0.013 (0.07)	-0.025 (0.14)
Change in employment	-0.012 (0.17)	-0.021 (0.31)	-0.001 (0.91)	-0.001 (0.92)
Constant	1.011 (20.02)**	1.017 (20.19)**	1.011 (21.88)**	1.015 (21.47)**
R-squared	0.260	0.253	0.2769	0.2655
F-test	0.00 F(7,50)	0.0036 F(6,51)	0.0004 F(7,48)	0.0018 F(6,49)

Note: The values in the table are coefficients from multivariate regressions. The dependent variable for each regression is the ratio of the marginal effect of a Bachelor's degree relative to the marginal effect of School Certificate in 1996, relative to the value of the same ratio in 1991. The independent variables are the ratio of industry spending on all computer inputs, plus control variables for operating surplus, wages, imports, exports, and the extent of employment change. Each regression is estimated on the sample of 58 industries, and is weighted by industry size in 1996.

Robust t-statistics in parentheses
* significant at 5% level; ** significant at 1% level

Appendix 8 : Relationship between industry computer use and the change in within-group inequality for full-time workers

	1991 - 1996		1996 - 2001	
	Bivariate	Multivariate	Bivariate	Multivariate
No qualifications	-0.285 (2.93)**	-0.284 (3.14)**	0.316 (1.08)	0.217 (1.05)
School Certificate	-0.281 (3.44)**	-0.280 (1.86)	0.006 (0.02)	0.095 (0.8)
UE / 6th Form	-0.156 (1.06)	0.027 (0.11)	0.190 (0.54)	0.247 (1.31)
Bursary / 7th Form	0.008 (0.04)	-0.072 (0.20)	-0.449 (1.58)	-0.542 (2.27)*
Other post-school	-0.028 (0.15)	0.128 (1.05)	-0.004 (0.02)	0.085 (0.79)
Bachelor’s degree	0.342 (1.83)	0.332 (2.35)*	0.189 (1.11)	0.106 (0.78)
Postgraduate	0.759 (5.24)**	0.833 (3.99)**	0.035 (0.1)	-0.058 (0.26)
ALL SKILL GROUPS	-0.030 (0.26)	0.045 (0.54)	0.053 (0.39)	0.096 (1.03)

Dependent variable is the change in the Gini coefficient within each qualifications level. Independent variable is proportion of computer expenditure by industry. Multivariate model includes control variables for profitability, wages, and trade effects.
Each regression is estimated on the sample of 58 industries and is weighted by industry size.
Heteroscedastically robust t-statistics in parentheses

Appendix 9A: Bivariate relationships between employment change and industry computer use, by educational level

	All workers		Male workers		Female workers	
	1991 -1996	**1996 -2001**	**1991 -1996**	**1996 -2001**	**1991 -1996**	**1996 -2001**
All levels	-2.31 (1.23)	-2.01 (0.72)	-2.70 (1.12)	-0.06 (0.50)	-2.82 (1.21)	5.12 (0.48)
No qualification	-4.18 *(2.03)	-3.44 (0.89)	-5.34 (1.67)	-0.11 (0.34)	-2.98 (1.49)	4.06 (0.45)
School Certificate	-6.26 **(3.42)	-7.83 **(3.07)	-7.97 **(3.85)	-0.95 **(4.43)	-5.46 *(2.26)	8.31 (0.55)
U.E./6th Form	-15.26 **(6.58)	-9.71 **(3.72)	-14.85 **(5.45)	-0.82 **(6.05)	-17.00 **(7.60)	5.07 (0.32)
Bursary	-18.05 **(5.93)	-4.66 (1.44)	-18.30 **(6.47)	-0.52 **(4.10)	-18.23 **(3.80)	9.04 (0.60)
Diploma	-2.26 (1.89)	1.14 (0.41)	-2.46 (1.25)	0.49 **(2.94)	-2.68 (1.70)	1.58 (0.22)
Bachelor's degree	-0.71 (0.17)	-6.66 (1.28)	0.18 (0.04)	-0.11 (0.74)	-0.06 **(5.00)	-4.86 (0.39)
Postgraduate degree	1.67 (0.32)	-0.94 (0.26)	1.34 (0.21)	0.21 (1.38)	3.40 (0.70)	-1.29 (0.18)

Coefficients from labour-skills demand equation.
Dependent variable is proportional change in employment at each skill level.
Independent variable is industry outlay on all computer inputs grouped together.

Heteroscedastically robust t-statistics in parentheses
* significant at 5% level; ** significant at 1% level

Appendix 9B: Bivariate relationships between employment change and industry computer use, by educational level, with hardware expenditure separated from software and services

	1991-1996		1996-2001	
	<u>**Hardware**</u> **Total**	<u>**Software/Serv's**</u> **Total**	<u>**Hardware**</u> **Total**	<u>**Software/Serv's**</u> **Total**
All levels	2.40 (0.22)	-2.94 (1.57)	-3.32 (0.34)	-1.81 (0.71)
No Qualification	-4.33 (0.49)	-4.16 (1.96)	-10.73 (1.06)	-2.02 (0.50)
School Certificate	-2.51 (0.26)	-6.61 **(3.44)	-13.06 (1.48)	-7.15 **(2.99)
U.E./6th Form	-0.38 (0.05)	-16.06 **(8.50)	-8.51 (1.02)	-9.84 **(4.36)
Bursary	-11.64 (0.95)	-18.53 **(6.66)	4.19 (0.41)	-5.73 *(2.09)
Diploma	-4.32 (0.44)	-1.91 (1.14)	-3.65 (0.40)	2.05 (0.72)
Bachelor's degree	-2.80 (0.28)	-0.37 (0.08)	-20.58 (1.28)	-4.43 (1.16)
Postgraduate degree	37.97 (1.78)	-4.25 (0.75)	21.30 *(2.06)	-4.80 (1.18)

Coefficients from labour-skills demand equation.
Dependent variable is proportional change in employment at each skill level.
Independent variables are industry outlays on computer hardware and computer software and services

Heteroscedastically robust t-statistics in parentheses
* significant at 5% level; ** significant at 1% level

Appendix 10A: Relationship between employment change and industry computer use by educational level. Multivariate results including controls for profitability, wages, trade effects and gender. 1991-1996.

1991-1996	All Levels	No Qualificat's	School Certificate	U.E./ 6th form	Bursary	Diploma	Bach's Degree	Postgrad Degree
Computing expenditure	-3.79 (1.78)+	-5.84 (2.32)*	-9.52 (4.33)**	-19.47 (6.65)**	-21.94 (4.81)**	-3.38 (2.25)*	-1.08 (0.51)	0.98 (0.38)
Imports	-0.46 (1.14)	-0.30 (0.96)	-0.68 (1.83)+	-0.46 (0.81)	-1.44 (1.7)+	-0.34 (0.87)	-0.82 (1.07)	-2.31 (1.97)*
Exports	-0.34 (1.74)+	-0.48 (2.74)**	-0.50 (2.33)*	-0.64 (1.96)+	-0.92 (1.66)+	-0.20 (1.11)	0.64 (1.5)	1.18 (0.98)
Wages	-0.55 (1.92)+	-0.52 (1.48)	0.08 (0.18)	0.05 (0.07)	-0.81 (0.91)	-0.43 (1.72)+	-0.81 (2.45)*	-0.72 (1.93)+
Operating surplus	-0.50 (1.01)	-0.38 (0.79)	-0.42 (0.79)	-0.75 (1.15)	-0.39 (0.44)	-0.70 (1.42)	0.04 (0.09)	0.85 (1.1)
Proportion of female workers	0.24 (1.2)	0.13 (0.81)	0.010 (0.03)	0.18 (0.65)	0.09 (0.17)	0.24 (1.48)	0.42 (1.2)	-0.01 (0.01)
F-test	1.39	2.26+	4.18**	13.08**	9.06**	1.15	4.45**	3.35**
R^2	0.15	0.23	0.38	0.62	0.44	0.17	0.30	0.28
RESET (F)	1.42	0.99	1.48	1.07	0.52	1.43	0.90	3.28*

Number of observations = 58

Degrees of freedom for F test are usually 6, 51

The Regression Specification Test (RESET) is distributed as F with 3 and 48 degrees of freedom

Coefficients from multivariate labour-skills demand equation.
Dependent variable is proportional change in employment at each skill level.
Independent variables are industry outlays on computer hardware and computer software and services, imports, exports, wages and operating surplus, all expressed as proportions of total industry inputs; and proportion of female workers in each industry in 1991.

Robust t-statistics in parentheses

+ significant at 10% level; * significant at 5% level; ** significant at 1% level

Appendix 10B 1996 – 2001

Relationship between employment change and industry computer use by educational level. Multivariate results including controls for profitability, wages, trade effects and gender.

1996-2001	All Levels	No Qualificat's	School Certificate	U.E./ 6th form	Bursary	Diploma	Bach's Degree	Postgrad Degree
Computing expenditure	-4.05	-6.54	-11.46	-14.96	-10.50	-0.32	-7.98	-3.55
	(1.47)	(1.66)+	(2.71)**	(2.87)**	(1.78)+	(0.12)	(1.25)	(0.64)
Imports	-0.44	-0.71	-0.62	-0.24	-0.04	-0.21	1.02	0.62
	(0.98)	(1.38)	(1.26)	(0.52)	(0.06)	(0.56)	(0.94)	(0.53)
Exports	-0.26	-0.31	-0.35	-0.21	-0.23	-0.32	-0.86	-0.89
	(1.12)	(1.09)	(1.24)	(0.76)	(0.76)	(1.63)+	(1.42)	(1.05)
Wages	0.16	0.07	0.53	1.34	1.56	-0.03	0.40	0.99
	(0.29)	(0.1)	(0.58)	(1.13)	(1.22)	(0.08)	(0.44)	(2.04)*
Operating Surplus	0.60	0.39	0.37	1.05	1.48	0.13	1.79	2.24
	(0.73)	(0.48)	(0.39)	(0.9)	(1.1)	(0.19)	(1.39)	(2.27)*
Proportion of female Workers	0.21	0.23	0.00	0.01	0.17	0.23	0.96	-0.86
	(0.92)	(0.99)	(0.01)	(0.03)	(0.39)	(1.08)	(1.01)	(1.28)
F-test	2.46*	1.27	2.84*	6.12**	2.87*	2.10+	0.96	1.23
R^2	0.08	0.13	0.13	0.13	0.11	0.06	0.08	0.04
RESET (F)	0.11	0.13	0.38	1.02	1.36	0.44	1.00	0.14

Number of observations = 57

Degrees of freedom for F test are usually 6, 50

The Regression Specification Test (RESET) is distributed as F with 3 and 47 degrees of freedom.

Coefficients from multivariate labour-skills demand equation.
Dependent variable is proportional change in employment at each skill level.
Independent variables are industry outlays on computer hardware and computer software and services, imports, exports, wages and operating surplus, all expressed as proportions of total industry inputs; and proportion of female workers in each industry in 1996..

Robust t-statistics in parentheses
+ significant at 10% level; * significant at 5% level; ** significant at 1% level

Appendix 11 : Extention of the Tobit Model (intreg in *Stata*)

Each of the *j* observations comes from one of four possible subsets of the data:

For $j \in C$ the actual earnings (i.e., y_j) are observed, giving standard point data.

For $j \in L$ the data are left-censored, where the unobserved y_j is only known to be less than or equal to the threshold y_{Lj} e.g. ≤$4,999).

For $j \in R$ the data are right-censored, with the unobserved y_j only known to be greater than or equal to the threshold y_{Rj} (e.g. ≥$70,000).

The other $j \in I$ observations are intervals, where all that is known is that the unobserved y_j is in the interval $[y_{1j}, y_{2j}]$. The log likelihood function is:

$$L = -\frac{1}{2}\sum_{j \in C} w_j \left[\left(\frac{y_j - x\beta}{\sigma} \right)^2 + \log 2\pi\sigma^2 \right] + \sum_{j \in L} w_j \log \Phi\left(\frac{y_{Lj} - x\beta}{\sigma} \right)$$

$$+ \sum_{j \in R} w_j \log\left[1 - \Phi\left(\frac{y_{Rj} - x\beta}{\sigma} \right) \right] + \sum_{j \in I} w_j \log\left[\Phi\left(\frac{y_{2j} - x\beta}{\sigma} \right) - \Phi\left(\frac{y_{1j} - x\beta}{\sigma} \right) \right]$$

Appendix 12: Skill levels from Pappas (2001) regrouped to the

N Z Standard Classification of Occupations

Occupation		Cognitive Skill	Interactive Skill	Motor Skill
1	Legislators, Administrators & Managers	8.52	6.41	5.44
2	Professionals	8.52	6.41	5.44
3	Technicians and associate professionals	7.39	4.44	4.38
4	Clerks	4.76	2.12	5.17
5	Service and sales workers	4.21	3.00	3.37
6	Agricultural and fisheries workers	3.85	2.44	5.25
7	Trades workers	5.45	1.61	8.34
8	Plant and machine operators and assemblers	3.72	1.94	5.64
9	Elementary occupations (incl residuals)	2.57	1.22	1.94

Skill levels from Pappas (2001) translated from ASCO to NZSCO.
The Pappas list of occupations has no equivalent to NZSCO occupation 1, so figures for occupation 2 were assumed to be comparable.