The Diffusion of Microelectronics through New Zealand Manufacturing

Robert Bowie and Alan Bollard

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PREFACE AND ACKNOWLEDGEMENTS

In 1984 one of the authors was associated with Britain's Policy Studies Institute (PSI) programme of investigation into the diffusion of microelectronics through European manufacturing industry. Subsequently, the OECD has been encouraging member countries to carry out comparable surveys. In 1986, DFC New Zealand Ltd, the Department of Trade and Industry, the Department of Scientific and Industrial Research, and Fisher and Paykel Allied Products Ltd agreed to fund a parallel investigation of the diffusion of microelectronics through New Zealand manufacturing industry. We thank these organisations for their generosity. In particular we also wish to thank Graham Vickery (OECD), Jim Northcott (PSI), Don Barnes (DSIR), and Martin Kaiser (DSIR) for their contributions. The surveying was carried out by AGB:McNair and the manuscript typed by Rosemary Davis and Raewyn Hodges.

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STUDY HIGHLIGHTS

In little more than a decade, developments in microelectronics technology have made it possible to embody, in a single silicon chip, as much logic and memory capacity as in the early mainframe computers. Furthermore, this new technology comes in a form which is more reliable, very much more compact and commercially appealing. As well, there is wide scope - in numerous fields - for new applications and the urgency and enterprise with which we exploit the new technology may well be of major significance to New Zealand's economic future.

The salient findings from this study (based on 1986 survey data) on the impact of microelectronics on New Zealand manufacturing industry include:

Extent of Application:

- Rapid progression with the incorporation of microelectronics in both products and production processes is apparent. Between 1980 and 1986 the aggregate number of product-users and process-users each increased by a factor of 4.5. There are currently 4.5 times more process-users than product-users in absolute terms.

- In 1984, products incorporating microelectronics componentry accounted for more than one-half of the output of 17 per cent of product-users. By 1986 this figure had grown to 28 per cent.

- Larger establishments are more likely to use microelectronics in their products and production processes. Product-users are concentrated in industries which involve the production of electrical, electronic and engineering type products as well as the chemical, coal, rubber and petroleum industries and non-metallic mineral products. Establishments with process applications are more widely distributed across the spectrum of manufacturing industry, but in particular in fabricated metal products and equipment, food/beverages/tobacco, textiles/wearing apparel/leather goods, and paper/paper products.

Sourcing of Componentry:

- Nearly one-half of all product-users (and intending users) and three-quarters of process-users (and intending users) use standard catalogue items (from outside suppliers) as at least one source of their microelectronics requirements.

For the product-users, the next most commonly cited source (20 per cent) is "designed and made by you in your own factory", while for the process-users it is "made to your own specifications by an outside supplier" (17 per cent). A slightly higher proportion of New Zealand-based firms source their microelectronics from standard catalogue items whereas significantly higher proportions of firms whose parent company is overseas source from origins such as "designed and made by you in your own factory" and "designed specifically for you by an outside supplier".

Integrated Circuitry Used:

- Sixty-seven per cent of all product-users (and intending users) have standard industrial microprocessor applications, 40 per cent have custom integrated circuits developed for their specific application, and 25 per cent have semi-custom integrated circuits. Smaller factories have a relatively higher use of standard microprocessor product applications.

Forms of Process Control:

- The most common forms of use of microelectronics in production processes are for control of individual machines (67 per cent of process-users and intending users), and control of individual items of process plant (51 per cent). The highest incidence of each type of control is within the food, beverages and tobacco industries. Of the more sophisticated forms of automation such as centralised machine control (21 per cent of process-users and intending users) and integrated process control (22 per cent), the highest incidence of usage is also within the food, beverages and tobacco industries (and also paper and paper products). One-third of process-users have microelectronic installations for testing and quality control, while approximately one-quarter have computer-aided design applications and automated handling applications. Automated storage systems (9 per cent) are much less common.

Control Equipment Used:

- Programmable logic controllers, used by 40 per cent of process-users and intending users, are the most commonly used items of control equipment. Next most common usage is computer-aided design units (27 per cent), followed by machine controllers (21 per cent) and then computer numerically controlled machine tools (17 per cent). Robots are used by only 3 per cent of process-users but this is expected to increase to 12 per cent by 1988.

Disadvantages and Difficulties:

- Of the technical problems encountered with the introduction of microelectronics, "lack of people with electronics expertise" is the most important (20 per cent of product-users and intending users and 21 per cent of process-users and intending users). Of the economic difficulties, "high costs of development" is the most commonly cited (22 per cent of product-users and intending users and 19 per cent of process-users and intending users).

- Almost one-half of all product-users (and intending users) believe they are either keeping pace or ahead of their main overseas competitors in applying microelectronics to their products. Little more than one-quarter of process users (and intending users), however, report this situation with respect to their process applications.

Funding Sources:

- For both product-users and process-users (and intending users), internal funding is the most common source of funding, followed by longterm finance from banks or finance houses.

External Assistance:

- It is quite common for establishments to seek technical help from outside agencies in doing research and development work on microelectronics applications. Generally, it is the largest establishments which tend to make most use of outside expertise and by far the most common source of help are the suppliers of microelectronics: their help has been sought by about 70 per cent of both product-users and process-users (and intending users).

Skills:

- The number of engineers with microelectronics expertise employed by user establishments increased markedly in the 1984-1986 period. Establishments with product applications typically employ more microelectronics engineers than establishments with process applications.

Jobs:

- The massive job losses predicted in the past by various groups have not eventuated. In aggregate, 68 per cent of user establishments (and intending users) reported no change, on balance, in the number of jobs, while 13 per cent reported a net increase in jobs and 15 per cent a net decrease in jobs. Establishments employing 50-99 people have experienced the greatest relative net increase in jobs owing to microelectronics introduction, while the largest establishments (employing 200+ people) have experienced the greatest relative net decline in their employment levels. The establishments reporting a net increase in jobs are relatively more concentrated in Wellington and rural areas, while those reporting a net decrease in jobs are relatively more concentrated in Dunedin and the towns and boroughs.

- Over the 1984-1986 period, a higher percentage of establishments increased jobs for women (in net terms) than decreased jobs for women as a consequence of introducing microelectronics, and this trend is expected to continue at least until 1988.

- Microelectronics has resulted in a gain, overall, in the number of factories increasing their number of skilled shop floor jobs (in net terms) over the 1984-1986 period, and again this trend is expected to continue until at least 1988.

- For non-skilled jobs, an overall gain is evident in the number of product-users who have, on balance, increased jobs over the 1984-1986 period, while - among process-users - no change is recorded. Overall, both product-users and process-users foresee little change, on balance, over 1986-1988.

Consultation:

- Just over one-third of user establishments engaged in consultation with the workforce or relevant union(s) at the time of introducing microelectronics to the workplace. Consultation was more frequently carried out in larger establishments.

Labour Productivity, Profitability and Competitiveness:

- Overall, respondents report gains in some key economic variables as a result of introducing microelectronics. Nearly two-thirds of establishments report increases in each of labour productivity, profitability and domestic competitiveness. Two-fifths of establishments report a gain in international competitiveness.

International Comparisons

- In overall terms, it appears that by 1986 New Zealand manufacturers had achieved a similar frequency of application of microelectronics technologies - in both their products and production processes - to that of Britain and France around three years earlier. Of the countries reviewed, Germany and Japan have achieved the most widespread application of the new technologies but there are some European countries (e.g. the Netherlands) which seem to be considerably behind New Zealand.

- The balance of evidence suggests that New Zealand manufacturing industry is reasonably modern with its microelectronics technologies, albeit with relatively lower application of some of the very sophisticated equipment (e.g. robots) now in use in parts of Europe and Japan.

CHAPTER 1

INTRODUCTION

In 1986, the NZ Institute of Economic Research circulated a proposal to instigate a study on the diffusion of microelectronics through New Zealand manufacturing industry. The proposal received considerable support from both industry and Government, and the study was initiated. This topic has not been researched before but it has assumed increased importance, as the thrust of overseas evidence suggests that the intelligent adoption of microelectronics is a key aspect of industrial competitiveness and thus, to some considerable extent, business prosperity and success.

Research in the 1960s (and earlier) culminated in the early 1970s with the development of the microprocessor, which had vast potential for industrial application. In this study we define microelectronics technology as the use of microprocessors or their electronic equivalents (e.g. custom chips or semi-custom chips), normally with LSI or VLSI circuitry, and either in the form of single integrated circuit devices or in small groups of linked devices.

Much debate has centred around the "microchip revolution" - overseas as well as in New Zealand, there being little doubt that this technology has provided the means for much of the advance in automation within industry through the 1970s to the present time. There has been considerable survey-based research conducted overseas to obtain information in areas such as: what is actually happening, whether the promised performance is living up to expectations, whether the growth momentum is being sustained, the origin of the equipment used, the value of annual output in which microelectronics is used in production, how major items of microelectronic equipment have been financed, and various other important aspects. In New Zealand, however, a dearth of material exists. While there is a good body of literature contributed by the DSIR, and others, on the actual New Zealand microelectronics industry (see bibliography), there exists very little information relating to manufacturing industries and aspects of their usage of microelectronics in their products and production processes.

A notable advantage in carrying out a comprehensive survey-based study has been that the OECD is encouraging member nations to conduct work in this area on a comparable basis. In particular the Policy Studies Institute (PSI) in Britain has done considerable pioneering work with respect to developing microelectronics survey methodology. In 1985 the PSI undertook a major survey of 1,200 factories representative of the full range of manufacturing industry. This survey followed similar surveys conducted in 1981 and 1983 and provides a reasonably up-to-date measure of the unfolding pattern of use of the new technology in Britain. As well, similar studies have been undertaken in other OECD countries including France and Germany.

In this study, the PSI sample design and questionnaire design were kept the same wherever possible, so that the results of the overseas experience could be compared with New Zealand evidence. The principal aspects investigated by the NZIER survey can be categorised as:

- the extent of current and prospective microelectronics applications
- the forms of application
- the patterns of diffusion
- the main technical and economic disadvantages and difficulties impeding adoption
- domestic manufacturers' position relative to overseas competition.
- funding sources for major items of equipment
- external assistance including government support
- requisite skills and training
- the effect on jobs, labour productivity, profitability and competitiveness

The survey questionnaire was administered by McNair Surveys New Zealand Ltd (an AGB:McNair company).

1.1 Sample Design, Questionnaire and Interviewing Procedure

A list of 800 New Zealand manufacturing establishments (or "activity units") was drawn up and a representative sample of 387 was obtained. The sample was stratified by size of establishment (number of employees) and by industry.

In each of the following size groupings, 160 establishments were drawn:

1-19 employees
20-49 employees
50-99 employees
100-199 employees
200+ employees

Within each size grouping the 160 establishments were allocated among nine industrial classes according to the national distribution of establishments within that size grouping:

- Food, beverages and tobacco
- Textiles, wearing apparel and leather goods
- Wood, wood and cork products
- Paper and paper products, printing and publishing
- Chemical, petroleum, coal, rubber products
- Non-metallic mineral products
- Basic metal industries
- Fabricated metal products, machinery and equipment
- Other manufacturing industries

Note that the sample was drawn and questions asked in terms of establishments (or activity units), meaning the physical premises where production activities take place. Questions can, therefore, relate to more than one product (where several are made at the same site), but not to activities at more than one site where several establishments at different sites are owned by the same firm.

The aim was to achieve 400 interviews - 80 in each of the five size groupings. Interviews were carried out by trained telephone interviewers speaking to the person in each activity unit most likely to know about the past, present and future application of microelectronics in their products and/or production processes. Up to three call-backs were made in attempting to interview the appropriate person. A total of 614 contacts were made and 387 successful interviews were completed. At least 20 per cent of all interviews were audited. In 147 calls, the selected respondent was out/unavailable/inconvenienced, and in 15 calls the telephone was engaged. Only 65 selected respondents refused to give an interview. A low refusal rate of 10.6 per cent was thus achieved. The interviewing was carried out between 27 October and 14 November, 1986.

The main questions asked in the survey questionnaire are summarised on pages 92-97.[1]

[1] Copies of the actual survey questionnaire are available from the NZIER, on request.

CHAPTER 2

EXTENT OF USE

How great a use is New Zealand manufacturing industry making of microelectronics? Is the promise of the 1970s being matched by current performance? The aim of this chapter is to provide an assessment of the level of adoption.

2.1 Overall Extent of Use

The following table provides a breakdown of the total sample achieved:

Table 2.1.1 USE OF MICROELECTRONICS BY NEW ZEALAND MANUFACTURING INDUSTRY, 1986 [BASE: ALL SURVEY RESPONDENTS]

Total sample	387 [100%]
Product Applications:	
In production	47 [12%]
Under development	5 [1%]
Feasibility investigated	11 [3%]
Total Product Applications	63 [16%]
Process Applications:	
In process	209 [54%]
Under development	18 [5%]
Feasibility investigated	22 [6%]
Total Process Applications	249 [65%]
Non-Users:	
Scope in products	14 [4%]
Scope in processes	36 [9%]
Scope in both products and processes	9 [2%]
No scope in products or processes	90 [23%]
Total Non-Users	131 [34%]

In this survey, in keeping with the internationally accepted classification, establishments in the sample have been grouped into three categories:

A. <u>Product-Users</u> - Establishments using microelectronics in their products (or intending to):

In production now	47
Not yet in production	8
Total product-users (and intending users)	55

B. Process-Users - Establishments using microelectronics in their production processes (or intending to):

In production now	209
Not yet in production	34
Total process-users (and intending users)	243

C. Non-Users - Establishments where neither kind of application is in use nor is intended to be used:

With scope in products	14
With scope in processes	36
No scope in products	117
No scope in processes	95
Total, no scope in products or processes	90
Total, non-users	131

[N.B: The combined number of product-users and process-users totals 256. The total of 256 is lower than 55 and 243 combined because if an establishment is both a product-user and a process-user, it will only be counted once.]

It would naturally be useful to have a handful of figures to provide a concise summary of the level of achievement that has been reached, but caution must be exercised because the figures in Table 2.1.1 above - as with various others contained in this study - are invariably a simplification which may, if read in isolation, conceal as much as they reveal. Among the limitations of the particular figures quoted above, for instance, are that they neglect the sophistication or importance of the applications, of the proportion of a factory's products or processes in which they are used, or of the pattern of diffusion through different sizes of establishments, industries, regions, and types of factories. These aspects are dealt with in subsequent chapters of the study.

This survey reveals that of the 47 product-users in production now (i.e. at the time that the survey was carried out) with a product incorporating microelectronics technology, 6 per cent first went into production prior to 1975, 15 per cent in 1976-1980, and 74 per cent in 1981-1986. (Four per cent did not know/not specified.) The outcome for process-users in production now, with a process incorporating microelectronics technology, is similar: 4 per cent first used microelectronics in a production process prior to 1975, 18 per cent in 1976-1980, and 75 per cent in 1981-1986. (One per cent did not know/not specified.)

In absolute terms, however, there are now nearly 4.5 times as many process-users as product-users.

2.2 Extent of Scope for Further Applications and Overall Extent of Use

The proportion of factories using microelectronics in their products and the percentage using microelectronics in their production processes are obviously, in themselves, deficient measures of the extent of use. Similarly, the percentages of their output in which the users incorporate microelectronics and the percentages of their production processes controlled by microelectronics are also, on their own, an inadequate measure. Viewed together, however, these separate measures can provide an improved indication of the overall extent of use.

The growth in importance of microelectronics in terms of annual output was therefore also surveyed. Two years prior to the survey, 17 per cent of product-users in production at the time of the survey stated that products incorporating microelectronics accounted for 51-100 per cent of their annual output. Now, however, this has grown to 28 per cent while, in two years time, 43 per cent of all product-users (and intending product-users) expect that products incorporating microelectronics will account for 51-100 per cent of their annual output. Furthermore, 53 per cent of all product-users (and intending) consider that products incorporating microelectronics could account for 51-100 per cent of their annual output in the sense of a "perceived maximum potential" (see Appendix 1). This figure compares with 34 per cent of all respondents (or 53 per cent of all process-users in production and intending) who consider that processes controlled by microelectronics could account for 51-100 per cent of all production processes in the sense of a "perceived maximum potential" (see Appendix 2). In contrast, the 1985 PSI survey in Britain reveals that, in 1983, 28 per cent of product-users had their products incorporating microelectronics accounting for 51-100 per cent of their annual output. In 1985, the figure remained much the same (27 per cent), but by 1987 was expected to rise to 35 per cent. Fifty per cent of these British product-users consider that products incorporating microelectronics could account for 51-100 per cent of their annual output in the sense of a "perceived maximum potential".[1]

Of the 14 non-users (in the New Zealand survey) who have scope in products, three believe that 51-100 per cent of the value of their output could potentially

[1] Northcott, J. (1986), **Microelectronics in Industry: Promise and Performance**, PSI, p 106.

be accounted for by products which contain microelectronics. The greatest scope here lies within the chemical/coal/rubber/petroleum and paper products industries (see Appendix 3).

2.3 Other Aspects

The purpose of this chapter has been to provide some general measures of the extent of present usage of microelectronics and the scope for future application. There are limitations, however, in what the information provided can express. As already outlined, it does not take into consideration various other factors such as the pattern of diffusion between different sizes of establishment and different industries and regions.

A further limitation stems from the fact that data of this kind ignore both the extent and quality of use evident in a given application. For example, a microelectronically controlled kitchen toaster counts as a product application - as might a microwave oven; even though the kitchen toaster may be the original product effectively unchanged except for the microelectronic control unit while the latter is a completely new product developed around microelectronic devices. Similarly, two cars may both be included as product applications even though one has a stereo cassette player only, while the other has an electronic dashboard together with four 'on-board' computers controlling various sophisticated mechanical processes such as a fuel injection system. As well, two pocket calculators may both be fully electronic in their operation though one may have a greater range of functions than the other, a more readable display and a print-out facility.

By the same token, with production processes, some applications are very simple while others are relatively sophisticated or for other reasons make more impact on labour productivity or the quality of the output.

It is not appropriate to compare all these types of differences by using one measure, for at least two basic reasons. First, some of the differences are qualitative rather than quantitative, and thus are not easily measurable. Second, the range of products and processes contained within this survey is so widespread that such an approach would be futile.

In the following chapters attention is focused on some of the individual issues of importance.

CHAPTER 3

PATTERNS OF DIFFUSION

The pattern of diffusion of microelectronics through manufacturing industry is in some ways more important than its extent of use. This concept includes such aspects as:

- the time frame for adoption through industry
- the stages of development within establishments
- the differences between establishments of different sizes and categories of ownership
- the distribution between different regions

3.1 Timing

Microelectronics is very much a modern age technology, and the rate of adoption over little more than a decade has been rapid. Prior to 1975, only 6 per cent of the establishments in the sample commenced using it in their products while 4 per cent of these establishments were using it in their production processes. Between 1976 and 1980, more than twice as many establishments commenced using microelectronics in their products as in the pre-1975 era. Between 1981 and 1986, five times as many firms commenced using it in their products as in the 1976-1980 era. For process-users, the progression has been similar: the number which commenced process applications rose by a factor of five through 1976 to 1980 and quadrupled between 1981 and 1986.

It must be remembered, however, that the proportion of establishments with product applications in 1986 (12 per cent) is still quite low relative to process applications (54 per cent) - perhaps because of relatively more limited scope with many products. On the other hand, it is logical to expect that with process applications the rate of increase will now begin to slow down, because of the already considerable degree of penetration and presumably because many of the establishments with more attractive applications have already put them into operation. Further penetration may thus depend on introducing the technology into smaller establishments and less obviously attractive industrial process applications.

3.2 Stages of Development

The introduction of microelectronics to an establishment is not usually an automatic process. First, there is the realisation of potential scope followed by a pragmatical examination. Outside consultants may be called in for an appraisal. Second, once a specific application has been identified, a decision must be made whether or not to proceed and this may involve some fundamental or more complex financial analysis. Third, if the project seems financially feasible, it is usually then necessary to undertake development work to design or re-design the product or process concerned and make prototypes and do testing to ensure its physical/engineering viability. Finally, a decision must be made whether to go into commercial production. If so, a whole range of matters must be attended to: tooling up, factory floor re-design, staff training, and product launch onto the market all being candidates for consideration.

Although not ascertained in this survey, the 1981 survey of the PSI in Britain[1] suggested that with process applications it was common for a period of one year to elapse from the beginning of work on the first application to the commencement of commercial production. With product applications, however, the lead time was typically about two years. This longer period of time reflects the greater complexity and difficulty of many product applications together with the more limited scope for using standard pieces of equipment and software packages (where the development work has mostly been done in advance by an outside supplier). It is likely that a similar time frame is applicable in New Zealand.

In this 1986 survey, 1 per cent of the sample had product applications under development, whereas 3 per cent were investigating their feasibility. With process applications, 5 per cent of the sample had them under development and 6 per cent were investigating their feasibility. The 1985 survey of the PSI in Britain, in comparison, established that 1.3 per cent of the sample had product applications under development while 0.5 per cent were investigating feasibility. For process applications, 1.7 per cent of the PSI sample had them under development, while 2.3 per cent were investigating their feasibility.

3.3 Size of Establishment

The percentage of establishments actually using microelectronics in their products (in 1986) increases steadily with size (measured in terms of the number of people employed per establishment), rising from 5 per cent of those in the smallest size range (1-19 people) to 16 per cent of those in the largest size

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[1] Ibid, p 38.

range (200+ people). With production process applications, the progression is even more marked, rising from 17 per cent in the smallest size range to 86 per cent in the largest (see Table 3.3.1).

Table 3.3.1 EXTENT OF USE BY SIZE [BASE: ALL SURVEY RESPONDENTS]

Numbers employed	Product-users* [%]	Process-users* [%]
1-19	5	17
20-49	7	40
50-99	16	64
100-199	15	61
200+	16	86

* in production only

With product applications, the increase in the proportion of users between 1976 and 1980 was predominantly in factories employing more than 200 people. Specifically, one-third of these larger product-users in production at the time of this survey first commenced a product application between 1976 and 1980. This compares with about one-fifteenth of the smaller establishment (less than 200 employees) product-users in production at the time of the survey which first commenced a product application between 1976 and 1980. Between 1981 and 1986, however, the rate of uptake was relatively faster in the smaller establishments: four-fifths of these smaller establishment product-users first commenced a product application between 1981 and 1986, compared with three-fifths of the larger establishments. Hence the disparity between product-users in the larger size establishments and product-users in the smallest size establishments has diminished over the last five years.

With process-users, this trend of a reduced disparity is also evident, albeit a little less marked. Specifically, one-quarter of the larger process-users in production at the time of the survey first commenced a process application between 1976 and 1980. This compares with about one-eighth of the smaller establishment process-users in production at the time of the survey which first commenced a process application between 1976 and 1980. Again, however, between 1981 and 1986 the rate of uptake was relatively faster in the smaller establishments: five-sixths of the smaller establishment process-users first commenced a process application between 1981 and 1986 compared with five-eighths of the larger establishments.

The differences in rate of use observed between the smaller establishments and the larger establishments may, in part, be because the larger factories tend to have a more comprehensive range of products and numerous production processes, and thus a potentially wider range of possible opportunities for microelectronics use. Also, larger establishments typically have more complex products and/or processes which can often benefit from the more sophisticated control mechanisms that have become available with microelectronics. Another explanation, however, could be that larger establishments have greater knowledge of the potential scope for applications, and have greater financial and technical resources available for their exploitation.

3.4 Company Ownership

It is conspicuous that, with product-users in production at the time of the survey, faster initial growth of product applications occurred with establishments whose parent company is based overseas. The contrast in the rate of adoption here, as shown in Table 3.4.1, is most noticeable in the 1976-1980 period.

Table 3.4.1 NATIONALITY OF ULTIMATE PARENT COMPANY OF PRODUCT-USERS IN PRODUCTION [BASE: PRODUCT-USERS IN PRODUCTION*]

	Total	New Zealand	Overseas
Total [Number of establishments]	33	19	14
Year first started:			
Prior to 1975	9%	11%	7%
1976-1980	18%	11%	29%
1981-1986	67%	68%	64%
Don't know/Not specified	6%	10%	-

* Note that in this table the base size is less than 47 because not all product-users answered this question.

This lower than average initial uptake in New Zealand establishments may be partially accounted for by their smaller average size. Other possible explanations for the differential may include difference in management style or goals (in terms of levels of progressiveness and desire to introduce modern technologies) and, in the case of overseas-linked firms, access to the parent company's product technology.

In the case of process-users in production at the time of the survey, there appears, however, to be no significant difference in uptake according to the nationality of the ultimate parent company.

3.5 Industry

As one would expect, microelectronics applications in products are concentrated within just a few manufacturing industries. Of the 47 product-users in production at the time of the survey, 21 were concentrated in the manufacture of fabricated metal products and equipment which is where one would expect various applications in the electrical, electronic and instrument engineering and related industries. There were a further four product applications within the chemical/coal/rubber/petroleum industries and three applications in non-metallic mineral products. Eight product applications were loosely recorded within the "other manufacturing industries" category. Somewhat surprisingly, eight product applications were quoted in the textiles, wearing apparel and leather goods industries. This apparent anomaly may be explained by the fact that a few firms that are predominantly within this manufacturing category may produce an unrelated range of products which contain microprocessors, perhaps through a subsidiary firm. It is also possible that there are some firms which make, say, leather cases (or covers) for electronic equipment and these finished products have been counted as leather goods. Also, it cannot be discounted that some "hi-tech" sports apparel may contain devices including microelectronics for such purposes as measuring speed and distance. Not surprisingly, there are no product applications recorded within either the food/beverages/tobacco industries or the basic metal industries.

Factories with process applications currently in production are distributed much more widely across the entire range of manufacturing industry but with particularly high percentages of applications in fabricated metal products and equipment, food/beverages/tobacco, textiles/wearing apparel/leather goods, and paper/paper products. The details appear in Table 3.5.1.

The variance between industries in their proportionate level of product applications largely depends, as already mentioned, on the differences in scope for applications in different types of products. The variance between industries with respect to adoption of process applications may often, however, be more associated with different levels of both awareness and technical knowledge. A low level of process application may prevail in industries which have up to the present time been isolated (at varying degrees) from the electronics/microelectronics fields, or which have dealt with suppliers of equipment that have had a lower record of success in incorporating new technology in items of process plant.

Table 3.5.1 INDUSTRY BREAKDOWN OF PRODUCT-USERS AND PROCESS-USERS IN PRODUCTION [BASE: PRODUCT-USERS AND PROCESS-USERS IN PRODUCTION]

	Total	Food/ Beverages/ Tobacco	Textiles/ Wearing apparel/ Leather	Wood/Cork products	Paper/ Paper products	Chemicals/ Coal/ Rubber/ Petroleum	Non-metallic mineral products	Basic metal industries	Fabricated metal products and equipment	Other manufacturing industries
Total Product-Users	47	-	8	1	2	4	3	-	21	8
Total Process-Users	209	37	30	16	25	19	10	5	59	8

In Britain, microelectronics applications in products were, in 1985, concentrated within mechanical engineering, electrical engineering, vehicles and the metal goods industries while process applications were most widespread in the following industries: food and drink, chemicals and metals, mechanical engineering, electrical engineering, vehicles, and paper and printing.[1]

3.6 Region

Since the sample was defined in terms of size and industry, it is less accurately representative in terms of regions. Nonetheless, it is possible to get a broad indication of the main differences on a regional basis. Of the 47 product-users in production at the time of the survey, approximately two-thirds were concentrated in the three largest city areas - Auckland, Wellington and Christchurch. Less than one-quarter were concentrated in the provincial cities. It is also apparent that in Wellington, Auckland, Christchurch and the provincial cities, a relatively high proportion of establishments have product applications in production compared with Dunedin, the towns and boroughs, and rural districts (see Table 3.6.1).

Of the 209 process-users in production at the time of the survey, 61 per cent were concentrated in Auckland, Wellington and Christchurch, but the proportion of establishments using microelectronics in each location is relatively more even

[1] ibid, p 47.

across the country than is the situation with the product-users (see Table 3.6.2).

Table 3.6.1 REGIONAL ANALYSIS - PRODUCT-USERS IN PRODUCTION [BASE: ALL SURVEY RESPONDENTS]

		URBAN AREA				AREA TYPE			
	TOTAL	Auckland	Wgtn	Chch	Dunedin	Metropolitan	Provincial City	Towns/ Boroughs	Rural
Total	387	150	48	44	14	256	64	47	20
Product applications in production	47 [12%]	19 [13%]	7 [15%]	5 [11%]	1 [7%]	33 [13%]	11 [17%]	3 [6%]	0 [0%]

Table 3.6.2 REGIONAL ANALYSIS - PROCESS-USERS IN PRODUCTION [BASE: ALL SURVEY RESPONDENTS]

		URBAN AREA				AREA TYPE			
	TOTAL	Auckland	Wgtn	Chch	Dunedin	Metropolitan	Provincial City	Towns/ Boroughs	Rural
Total	387	150	48	44	14	256	64	47	20
Process applications in production	209 [54%]	78 [52%]	28 [58%]	22 [50%]	8 [57%]	136 [53%]	39 [61%]	23 [49%]	13 [65%]

CHAPTER 4

FORMS OF USE

4.1 Types of Product

In its 1985 survey of microelectronics in industry - the third in a series - the PSI concluded that, "It is not only in the number of user factories and in the proportion of their output that the use of microelectronics has been expanding, but also in the variety of different kinds of product in which it is incorporated".[1]

As the outcome of the 1986 NZIER New Zealand survey reveals, product applications are considerably less common than process applications, one possible explanation being that the former are typically more difficult to develop, often requiring (for instance) more technical expertise, a longer development time, and a higher development budget. A more important constraint, however, may be the unsuitability of many categories of products. Obvious examples here include food, textiles and furniture; products which collectively account for a sizeable proportion of total output of the manufacturing sector. In principle, microelectronics can be applied to almost any product in which there is something to measure, monitor or control. There thus exists a whole range of relatively simple products in which - theoretically - one can think of applications. In a practical sense, however, the scope may be fairly limited if, for instance, there is very little to measure, monitor or control and/or because the extra complexities (and costs) of microelectronic application would not be compensated by comparable gains in product acceptance or performance and/or sales increases.

In spite of the above limitations, a wide range of products now incorporate microelectronics and there still remains much potential scope for further applications. The PSI reports from its 1985 survey that the establishments in its [standard] sample alone are using microelectronics in well over 150 different kinds of product, about twice as many as was recorded in its 1983 survey and about six times as many as was recorded in its 1981 survey.

In this New Zealand survey the products currently in production using microelectronics include:

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[1] ibid, p 47.

Laminated signs	Water pumps
Moulding machines	Motor vehicles/car parts
Knitwear machines	Air conditioning equipment
Data equipment	Timers
Plant controls	Switches
Printing machines	Digital sound equipment
Extrusion machines	Television
Alarms	Audio equipment
Fire extinguishers	Video cassette recording cameras
Motor mowers	

Further applications are planned by establisnments in the following products:

Printing equipment	Water pumps
Alarms	Motor vehicles/car parts
Fire extinguishers	Air conditioning equipment
Motor mowers	

4.2 Types of Process

Microelectronic applications are considerably more common in processes, partly because they tend to be less difficult. In practice, microelectronics often tend to be built into process applications so that it is the equipment supplier rather than the user who requires the technical expertise and directly pays the development costs. Also, with process applications the scope for applications is virtually unlimited, with notable exceptions being where the product's particular appeal relates to it being handcrafted, or where the level of production is too limited to achieve scale economies. Note, however, that with respect to the latter point the frequency with which this is relevant is steadily falling as the various types of process application increase in variety and decrease in cost.

The 1985 PSI survey reveals a very wide variety of production processes - again considerably more than its 1983 survey and substantially more than in the 1981 survey. The PSI notes that in addition to using process applications in the actual making of the product, industry is also using them widely for design, tooling, fault diagnosis, equipment maintenance, quality control and testing, storage and control, as well as for a range of more general production management systems.

It is likely that this growth in process application has followed a broadly similar course in New Zealand over the same time period.

The following is a list of some actual processes already in production incorporating microelectronics mentioned by New Zealand survey respondents:

Computer control of type setting operations
Knitting machines/designing fabrics/monitoring performances
Painting process controls on assembly of cars
Accounting systems
Type setting
Film extrusion
Process control in making gelatine
Sewing machinery automated and semi-automated
Sewing machines - needle positioners
Energy efficiency field
Newspaper - press converted; type setting
Manufacturing programming
Treatment of fruit, producing fruit juices
Injection moulding machines/Blow moulding machines
Mixing of latex, roll up units
Furnace control
Winding transformer bobbins
Sawmill - pressure treatment plant
Machine optimising timber docker
Sewing machines
Newspaper production, imprint side
Dip facility, controls passage of product and plant itself
Automatic paint colour changer
Control of safety systems
Plating department - machinery, forging; tool room department - design
Ticketing; customer orders
Printing plane scanning, ink setting
Measuring field, monitoring
Mixing compounds to make Aakronite
Time control
Inventory control; control some processes in drying and separation
Automatic PVC extruding; automatic copper wire drawing, wire bunching
Cutting steel plate
Processing steel sections
Welding
Wage calculation, costing, invoicing
Test equipment
Automotive assembly equipment
Finishing garments, pressing
Machining of components
Sawmilling
Glueing processes
Finger jointing timber
Temperature control
System controllers, refrigeration, freezer storage loading
Packing, conveyor systems
Design
Dyeing/heat setting
Testing bays

Manufacture of spectacle frames, casing sunglass lenses
Controls part of coffee process, opening and closing valve
Temperature monitoring
Electronic control in hydraulic housing machine
Design
In packaging and storing processes
Computer type setting
In making up (assembling) garments
Production of pulp and paper, and chemicals
Electronic skin measurer
Design of quilting patterns
Tallying up stocks
Computerised weighing equipment
Metal detectors
Monitoring and controlling of machines in processing metal
Weaving and preparation processes
Vaccine production
Primary tobacco processing areas, filter rod area, cigarette handling, case packing, pellet wrapping, heating controls
Canning and refrigeration
Welding controls, brackets resistance, zinc phosphate coating control systems
Monitoring metal treatment condits and using them in automated assembly equipment
Telecommunications purposes
Controlling cold storage
Controlling moulding of food and cooking
Oil refining, oil products manufacture
Manufacture of bricks, piping, tiles etc
Control of routers and drills
Dairy products manufacturing processes
Manufacture of plastic containers
Computer controlled camera
Small goods manufacturing
Sewing machines and associated machinery
Batch making processes
Direct injection moulding
Photo typesetters
Milling machines
Computer cutting machines
Markers and scrolls
Computer aided design unit
Digital read outs on milling machines and cutting lathes
Bonding machine/scales - grading fish fillets; cooker and sensor control
Automatic bar tack machines
Grinding lenses
Logic control
Emission spectograph PC chemical analysis of metals
Smoking machine (time control)
Metal work/sheet metal
Automatic loading and unloading of blast-freezing
Speed controls of freezing chains/chilling cycles
Cooked and canned food manufacturing processes
Processing cheese
Packaging
Printing/speed content/alignment/despatching/conveyor
Refrigeration, temperature and humidity control
Data logging

Power demand centre
Automatic alarm control
Carding machine and dye house
On coal boilers
Drives for speed control around the factory
Guillotine process
Automotive tunnel punches
Automatic bending
Machine stop
Batch weighing/weigh scales
Automatic operation of heat source equipment
Clicking machine/folding machine/top lasting machine (shoes)
Plastics processing
Drying kilns - timber treatment, saw mills
Stock control and all accounting machines
Telex machines
Machine lathe/ machining centre and lathes
Tube bending machines
Tube welding machines
Sanitary napkins and diapers production
Measuring and cutting of paper for filler
Pump parts manufacture
Labelling and packing processes
Design/cutting of metals for air conditioner
Gib-board manufacture
Margarine manufacturing/blending, chilling, packing
Powdered milk manufacture
Assembly of spark plug insulators
Bottling beer
Automatic board testing/active powering up the set or board
Mixing compounds, steel building machines, presses; checking of end product
Boiler house processes providing hot water for other processing, including drier controls
Manufacture of tin cans
Weld gun control/oven temperature control
Testing of electronics produced by AWA
Multi processing for weighing and grading of meat: process in fruit sizing machine
Radio telephone communication system
Wallboard manufacture
Wire extrusion - drawing
Processing logs to timber
Plastic moulding of containers
Process of meat products
All refrigerators - whole process
Zinc baths processes for car body assembly
Control of galvanised rods and sheet steel
Drying ovens, tube making, progressive press tools
Die cutting and printing
Calibration of electrical measuring instruments
Control welding and cutting
CIP sets
Chemical hardening processes for lens/edging machines/computerised tinting machines
Punching of sheets
Guillotine operation

Design of sails/for plotting
Controls of cardboard production
Controls the amount of fabrics, trims, minutes in the production process
Knitwear manufacture
Car painting/oven controls
Garment drying machine
Machining process for turning metal
Manufacture of super phosphate
Spreading of fabric, hemming of garments
Control of transportation of product while cooking; controls the cyclic process of oven; conveyancing; weighing of ingredients
Numerical control; computer control of lathe
Computerised down filling - head - high tech fillers set weights
Beam saw control
Label printer for bar codes etc
Quality control processes
Laboratory quality control processes
Stitching of garments
Control of quantity of water and plaster; compressed air control in drying operation
Cartoning and coding
Leaf processing/manufacturing cigarettes
Refrigeration/processing/pelting machines/effluent plant/rendering most of the plant
Raw material mixing plant processes
Graphic reproduction
Computerised press work, sheet metal

The following is a list of some planned future processes incorporating micro-electronics mentioned by the New Zealand survey respondents:

Manufacture of polyurethane and process control
Automated weighing and packing
Line printer - micro dot printer
Automated filling and packaging
Scouring plant processes
Guillotine and lathe processes
Weaving processes
Bar coding system for tracking the product
All processes for cigarette making and packing
Robotic automated wheel alignment systems
Paint spraying systems
Cooking controls processes (upgrading)
Distribution processes
Wire bending processes
Wire extrusion
Lay planning equipment
Automatic cutting
Monitoring flow systems
Update typesetting and printing processes
Design of quilting patterns
Computerised weighing
Metal manufacture processes
Controls for part of coffee manufacturing process
Logical control of bitumen
Computer cutting

Moulding lines
Manufacturing of whole milk powder products
Panel production
Slicing, packaging
Pattern grading and marker making and fully computerised cutting out of fabric
Colour work processes
Web laminating
Undergarments manufacture
Salt lick blocks for animals
Repetitive manufacture, auto welding system
Adapting present equipment electric motor variable speed controls
Electronic weigh back system
Invoicing, statements, payroll
Whole scouring process will be controlled by microelectronics
Spraying system
Automatic testing: auto component insertion machine "board stuffer"
Preparation of PCP and repair processes
Plastic moulding of containers
Meat product processing
Upgrading of zinc baths for car bodies assembly
Control of galvanised rods and sheet steel
Spot welding
Painting - oven control, temperature monitoring
Metal cutting - sheet metal cutting or press tool replacement
Material handling
Glue setting machine
Update present stitching equipment and expand its ability
Bar coding/control of small production areas
Extension of inventory control and costing
Glueing of cases
Water rights monitoring
Welding and cutting
Computerised camera, in house computer and type setter
Chemical packaging
Upgrading controls of cardboard production
Car painting/oven controls
In new bakery - total microprocessor control, weighing, baking, transporting and packaging
Production planning
Mixing control
Automated testing of light fittings
Pressing operations
Brush making
Automative link-sorting and processing machine for timber
Audio recording
Sanitary napkins and diapers manufacturing processes
Weigh batcher/measuring materials
Effluent control
Freezing food process
Canned and cooked food manufacturing
Energy management systems
Automative filling machines
Manufacture of particle board
Collating system
Quality control processes for cement
Quality control in milk processing

Plate making for printing/slitting/collating
Shoe manufacturing processes
Software systems in replace of manual input
Measuring and cutting of paper for air and oil filters manufacturing
Pump parts manufacturing
Motor mower parts manufacturing
Speed control processes
Conveyor processes
Manufacture of metal components
Colour sorting and harvesting of red and green tomatoes, peas, and other fruit and vegetables
Design cutting of metals for air conditioner
Punch operation for paper

Concerning future production process applications, several establishments commented that they would expect to incorporate microelectronics in all new equipment installed as part of a production process. Some firms suggested that they were always "looking" at possibilities and a few said that an ever increasing number of worthwhile applications seemed to be eventuating. Several mentioned that they were planning to use microelectronics but at the time of the survey could not be specific with details.

4.3 Sourcing of Microelectronics Componentry

Many of the respondents use microelectronics from more than one kind of source and therefore the figures quoted in Appendix 4 provide information in terms of all sources as well as the most important source. It is noticeable that for nearly one-half of all product-users (in production and intending to use), the most common source of microelectronics system used is offered as a standard catalogue item by an outside supplier. For process-users this source is also the most common one, being cited by 76 per cent of respondents.

Appendix 5 provides the breakdown of source used according to size of establishment. (Note that the total [base] here of 256 is lower than 55 and 243 combined because if a respondent is both a product and process-user it is counted once in this total.) Establishments employing 50-100 staff source proportionately more of their microelectronics from standard catalogue items relative to firms of other sizes. Appendix 6 reveals that there is very little variation in the source of microelectronics according to region.

With respect to the nationality of the ultimate parent company, it is noticeable that a slightly higher percentage of the New Zealand-based factories source their microelectronics from standard catalogue items, whereas significantly higher percentages of the overseas-based factories source their microelectronics from origins such as "designed and made by you in your own factory" and "designed specifically for you by an outside supplier" (see Table 4.3.1). This suggests that, on balance, the overseas-based factories may be using more sophisticated applications (and their own designs) where standard catalogue items might tend to be inadequate.

Table 4.3.1 SOURCE OF MICROELECTRONICS SYSTEM USED BY NATIONALITY OF ULTIMATE PARENT COMPANY [BASE: PRODUCT/PROCESS-USERS AND INTENDING COMBINED]*

	NATIONALITY OF ULTIMATE PARENT COMPANY		
	Total	New Zealand	Overseas
Total [Base]	178 [100%]	116 [100%]	61 [100%]
All Sources:			
Designed and made by you in your own factory	21 [12%]	10 [9%]	11 [18%]
Made to your specifications by an outside sub-contractor	33 [19%]	20 [17%]	12 [20%]
Designed specifically for you by an outside company	29 [16%]	15 [13%]	14 [23%]
Offered as standard catalogue item by an outside supplier	127 [71%]	85 [73%]	41 [67%]
Not quite fitting any of these descriptions	9 [5%]	6 [5%]	3 [5%]

* Note that the base here is less than 47 because not all product/process-users answered this question.

4.4 Types of Integrated Circuit Used

Microprocessors are, in essence, standard industrial chips which can be programmed by the user for different applications. There are, however, two other main kinds of integrated circuit which are commonly used as alternatives to them. One of these is custom integrated circuits which are special chips made for specific application. (Their programmes are fixed at the time of manufacture - which limits their flexibility compared with microprocessors, but for larger volume applications they may yield cost advantages.) The other kind is semi-custom integrated circuits (including gate arrays, uncommitted logic arrays, programmable logic arrays and field programmable logic arrays). These are a compromise between standard industrial chips and custom integrated circuits and offer varying degrees of user flexibility and the potential for lower costs in middle volume applications.

Of the 55 product-users in production or intending to use microelectronics in a product(s), 67 per cent now have standard industrial microprocessor application, 40 per cent have custom integrated circuits developed for their specific application, and 25 per cent have semi-custom integrated circuits.[1] In terms of size of establishment, the smallest product-user factories (1-20 employees) have (at 80 per cent) a proportionately high use of standard microprocessor product applications or proposed applications. With factories of 20-49 employees, however, standard microprocessor product applications fall off considerably, with 50 per cent of product-users reporting applications. There is a further sharp rise in use by factories with 50-99 employees. For factories with 100-199 employees, there is another sharp drop-off but for the largest factories (200+ employees) a 74 per cent application rate is recorded. As is evident in Appendix 7, there is also considerable variance in incidence of product application of the other two main types of microelectronic componentry according to the size of establishment.

With respect to region, there is much less variability in type of componentry used, but it is noticeable that the towns and boroughs have proportionately fewer standard industrial microprocessor product applications compared with the cities, while the reverse is true concerning semi-custom integrated circuits (see Appendix 8).

As Table 4.4.1 shows, New Zealand-based establishments have relatively higher usage of standard industrial microprocessors in their products compared with establishments whose parent company is off-shore.

Standard microprocessors are used by a particularly high proportion of establishments producing products within the textiles/wearing apparel/leather industries, paper/paper products, non-metallic mineral products, and fabricated metal products and equipment.

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[1] The 1985 PSI survey in Britain shows that of the 243 product-users surveyed, 65 per cent had standard industrial applications, 48 per cent had custom integrated circuits developed for their specific application, and 31 per cent had semi-custom integrated circuits.

See Northcott (1986), **op.cit.** p 128

Table 4.4.1 TYPE OF MICROELECTRONICS COMPONENTS USED BY PRODUCT-USERS [OR INTENDING] ACCORDING TO NATIONALITY OF ULTIMATE PARENT COMPANY [BASE: PRODUCT-USERS AND INTENDING]*

	Total	New Zealand	Overseas
Total [Base]	40 [100%]	22 [100%]	18 [100%]
All Types:			
Standard industrial microprocessors offered on catalogue	28 [70%]	19 [86%]	9 [50%]
Custom integrated circuits developed for your application	19 [48%]	9 [41%]	10 [56%]
Semi-custom integrated circuits	11 [28%]	6 [27%]	5 [28%]

* Note that the base is less than 55 as not all product-users or intending answered this question

4.5 Forms of Process Control Used

The most common forms of use of microelectronics in production processes are for control of individual machines or control of individual items of process plant. Sixty-seven per cent of the 243 establishments in the sample with process applications (or planned process applications) use microelectronics in their machine control of individual machines, while 51 per cent use them for controlling individual items of process plant.[1] The highest incidence of machine control application is within the food/beverages/tobacco industries, textiles/wearing apparel/leather and wood/cork products, while the highest incidence of process control is within the food/beverages/tobacco industries, wood/cork products, non-metallic mineral products, and basic metal industries.

A more complex and sophisticated form of automation is the use of microelectronics for centralised control of groups of machines or several stages of processes (called integrated process control systems). These offer potentially greater advantages when used effectively in appropriate situations, but normally require much greater specialist expertise and organisational change for successful implementation to be achieved. In New Zealand, 21

[1] The PSI report that, in 1985, 52 per cent of all British establishments surveyed used microelectronics in machine control of individual machines, while 41 per cent used microelectronics in process control of individual items of process plant.

See Northcott (1986), **op.cit**, p 56.

per cent of process-users (and intending process-users) now have microelectronic applications for centralised machine control, while 22 per cent of these establishments have microelectronic applications installed for integrated process control systems. The highest incidence of centralised machine control application and integrated process control application is within the paper/paper products and food/beverages/tobacco industries.

Automated handling of products, materials or components is frequently linked with integrated systems for the control of groups of machines or processes and commonly uses similar control techniques. It also tends to have its usage concentrated in the same kind of factories, and involves the resolving of comparable problems. This survey reveals that 28 per cent of process-users (and intending process-users) currently have automated handling system applications.

Automatic storage systems are currently much less common, with only 9 per cent of these establishments having implemented these process applications.

Design process (computer aided) applications are currently used by 24 per cent of establishments with process applications (and intending), the main concentration being with the wood/cork products, textiles/wearing apparel/leather industries, and paper/paper products.

Thirty-three per cent of process-users (and intending) now have in place microelectronic applications for testing and quality control, these innovations being most prevalent in the food/beverages/tobacco industries, and non-metallic mineral products.

As establishment size grows, the relative incidence of all these process applications tends to increase, as is evident from Appendix 9.

The nationality of the ultimate parent company (New Zealand or overseas) appears to make no significant difference to the relative use of any of the process applications surveyed.

Establishments were also asked if they were "planning to use/continue to use microelectronics within the next two years or so?" As can be seen from Table 4.5.1, the increases recorded according to each category of process application are considerable.

Table 4.5.1 TYPE OF MICROELECTRONIC PROCESS APPLICATIONS IN PRODUCTION AND PLANNED [BASE: ALL PROCESS-USERS AND INTENDING]

	In Production	Planning to Use/Continue to Use Within Next 2 Years
Total [Base]	243 [100%]	243 [100%]
Design	59 [24%]	98 [40%]
Machine control	162 [67%]	186 [77%]
Process control	124 [51%]	147 [60%]
Centralised machine control	51 [21%]	77 [32%]
Integrated process control	54 [22%]	85 [35%]
Automated handling	67 [28%]	108 [44%]
Automated storage	22 [9%]	40 [16%]
Testing, quality control	80 [33%]	115 [47%]
Don't know	2 [1%]	2 [1%]

4.6 Control Equipment Used

Based on the 243 establishments in the survey sample using or planning to use microelectronic-based equipment in their production processes, Table 4.6.1 lists the main types of equipment available, together with the number of establishments now using each category of equipment or planning to use it in two years time.

Table 4.6.1 TYPE OF MICROELECTRONICS - BASED EQUIPMENT USED IN PRODUCTION PROCESSES AND PLANNED TO BE USED IN NEXT TWO YEARS [BASE: ALL PROCESS-USERS AND INTENDING]

	In Production Process Now	Plan to Use in Two Years Time
Total [Base]	243 [100%]	243 [100%]
CAD work stations	65 [27%]	52 [21%]
CNC machine tools	42 [17%]	27 [11%]
PLCs	97 [40%]	31 [13%]
Machine controllers	50 [21%]	32 [13%]
Pick and place machines	15 [6%]	27 [11%]
Robots	7 [3%]	28 [12%]
Flexible manufacturing cells	4 [2%]	14 [6%]

It appears that there has been rapid growth in the diffusion of some of this equipment. For example, in 1982, there were only three robots and 250 numerically controlled metalworking machines operating in New Zealand.[1]

Table 4.6.1 shows that - relative to the number of existing processes - the planned increase in new process applications over the next two years of the first four categories of equipment is relatively low compared with the latter three. At the extremes, the number of establishments with PLC applications is expected to increase by about one-third over the next two years whereas the number of establishments with robots is expected to increase by a factor of five.[2]

As Appendix 10 shows, the use of all kinds of equipment tends to be more common in the larger establishments.

It is also noticeable that use of PLCs, Pick and Place Machines, and Robots is relatively more prevalent in establishments that have an overseas-based parent company. In contrast, use of Machine Controllers is relatively more prevalent in establishments that are based in New Zealand.

There are also significant differences between industries and between regions but the pattern varies with different types of equipment.

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[1] Kaiser, M. (1983), **The Use of Computers for Factory Applications**, paper presented to the New Zealand Computer Society Conference, September 1983.

[2] Regarding the British situation, the PSI found in its 1985 survey that 43 per cent of all establishments surveyed were using PLCs, 24 per cent were using CNC machine tools, 19 per cent were using machine controllers and 17 per cent were using CAD work stations. The British establishments expect, however, a relatively less widespread increase than the New Zealand establishments in the use of this equipment (all types) over the next two years.

See Northcott, J. (1986), **op.cit.** p 132

Key - Chapter 4 [1]

CAD Work Stations:	Computer aided design units with keyboards, visual display units
CNC Machine Tools:	Computer numerically controlled tools
PLCs:	Programmable logic controllers, normally for relatively straightforward control or monitoring of a single piece of equipment
Machine Controllers:	For more complex control application than can be handled by a PLC
Pick and Place Machines:	Like robots, but less expensive, less versatile, for less varied and less complex tasks
Robots:	Industrial robots which can be reprogrammed for a variety of complex tasks, normally cost over $50,000
Flexible Manufacturing Cells:	Group of production machines served by materials handling devices, e.g. robots

[1] A more comprehensive glossary of terms appears on page 98.

CHAPTER 5

DISADVANTAGES AND DIFFICULTIES

There are various reasons traditionally advanced concerning why some factories do not use microelectronics. For example, there may be no scope in their particular kinds of products, and/or in the processes used to manufacture them; or, if scope exists, they may be unaware of it. Alternatively, scope may exist as well as awareness, but there might be specific problems which make it unrealistic or impossible for particular factories.

5.1 Lack of Scope

With many types of product the absence of scope for incorporating microelectronics is obvious (e.g. food and beverages). With process applications, however, the limits to the possibilities may be much less clear and various explanations are made for the supposed absence of scope. These include: small size of company, small scale of operation, short runs, too wide a variety of products, simple labour-intensive processes, products hand-made by skilled craftsmen, and products whose manufacture involves specific technical problems. Often, some combination of the above is given as justification for non-use.

There are, however, many small scale operations where microelectronics can now be effectively used but of which many firms are undoubtedly unaware. Incorporation of microelectronics in such operations can enable batch production of various products to be undertaken with some of the scale economies formerly achievable only with much larger and longer runs.

Many firms depend (and wait) for innovation on the part of their equipment suppliers, and where their suppliers fail to make use of microelectronics some of these firms may tend to be passive in their approach rather than actively seeking new suppliers. Some firms, although mindful of the benefits microelectronics could offer them, are prepared to wait for existing equipment to wear out in the physical sense before modernising. (Older equipment may be unable to be converted.) Economic obsolescence may be a concept they have difficulty in accepting. Lease arrangements (contracts) with suppliers may cause further problems in this regard. The 1985 PSI study suggests that, in some cases, the organisational "culture" may be old-fashioned in its thinking and purposely resist change.[1] Some managements, however, perceive that breaking away from a

[1] Northcott (1986), op.cit, p 62.

time-honoured method of manufacture could have a detrimental effect on the corporate image.

5.2 Relative Importance of Difficulties

The great majority of establishments in the sample are currently using microelectronics or are intent upon introducing it (within the next two years). Many of these have encountered various problems which to some extent have constrained the speed or extent of their use, or reduced the anticipated benefits.

Both users and non-users were asked, therefore, what they saw as the most important disadvantages and problems in the use of microelectronics in their products or processes. They were asked as an open question, "unprompted", to get a spontaneous response on what they considered to be the key issues. The comparative percentages from the PSI survey of the 1985 British experience are also listed, where available, for the various technical and economic difficulties.

5.3 Technical Difficulties

The technical difficulty given as being of most importance is lack of people with microelectronics expertise (see Table 5.3.1). This factor was cited far more frequently than the next most often cited technical factor - problems with software. Problems with suitable sensors, servicing difficulties, opposition from shop floor or unions, and problems with chips are all much less commonly cited factors.

With the exception of "lack of people with microelectronics expertise", the technical difficulties encountered by product-users tend to be concentrated in larger establishments, although there is a wider dispersion across the size ranges with process-users (see Appendices 11 and 12).

Particular technical problems also seem to be associated proportionately more with particular industries, this effect being relatively more marked with product users than process-users. For example, lack of people with microelectronics expertise is not a problem for product-users in the food/beverages/tobacco industries, textiles/wearing apparel/leather, or basic metal products industries (see Appendices 13 and 14).

Nationality of ultimate parent company appears to have some bearing on the dispersion of problem technical factors of importance both within product-users and process-users. Perhaps the most interesting difference is that, within

Table 5.3.1 MAIN PROBLEMS OF MICROELECTRONICS USERS AND NON-USERS WITH SCOPE - TECHNICAL FACTORS: "UNPROMPTED" RESPONSES [BASE: PRODUCT-USERS AND INTENDING/ PROCESS-USERS AND INTENDING/NON-USERS WITH SCOPE]

	PRODUCT USERS		PROCESS USERS		NON USERS WITH SCOPE	
	NZ 1986	Britain 1985	NZ 1986	Britain 1985	NZ 1986	Britain 1985
TOTAL [Base]	55 [100%]	243 [100%]	243 [100%]	629 [100%]	59 [100%]	108 [100%]
Lack of people with micro-electronics expertise	11 [20%]	58 [24%]	50 [21%]	138 [22%]	6 [10%]	18 [17%]
Problems with chips	2 [4%]	5 [2%]	1 [0.2%]	13 [2%]	0 [0%]	1 [1%]
Problems with suitable sensors	3 [5%]	7 [3%]	5 [2%]	13 [2%]	1 [2%]	0 [0%]
Problems with software	4 [7%]	17 [7%]	9 [4%]	19 [3%]	1 [2%]	0 [0%]
Opposition from shop floor or unions	2 [4%]	0 [0%]	7 [3%]	13 [2%]	2 [3%]	0 [0%]
Opposition from management	1 [2%]	0 [0%]	3 [1%]	6 [1%]	0 [0%]	1 [1%]
Difficulties of communication with subcontractors/suppliers	1 [2%]	2 [1%]	5 [2%]	6 [1%]	0 [0%]	1 [1%]
Servicing difficulties	3 [5%]	*	11 [5%]	*	2 [3%]	*
Training staff	1 [2%]	*	1 [0.2%]	*	0 [0%]	*
Others	9 [16%]	*	44 [18%]	*	6 [10%]	*
No technical considerations	23 [42%]	*	79 [33%]	*	21 [36%]	*
Don't know						

* *data unavailable*

process-users (and intending process-users), 23 per cent of New Zealand-based factories cite lack of people with microelectronics expertise as a major disadvantage, whereas with overseas-based factories, only 16 per cent cite this factor.

The differences by region of technical difficulties incurred by both product and process-users appear generally less significant than is the case with the factors discussed above.

Table 5.4.1 MAIN DISADVANTAGES AND PROBLEMS OF MICROELECTRONIC USERS AND NON-USERS WITH SCOPE - ECONOMIC FACTORS: "UNPROMPTED" RESPONSES [BASE: PRODUCT-USERS AND INTENDING/PROCESS-USERS AND INTENDING/NON-USERS WITH SCOPE]

	PRODUCT-USERS		PROCESS-USERS		NON-USERS WITH SCOPE	
	NZ 1986	Britain 1985	NZ 1986	Britain 1985	NZ 1986	Britain 1985
TOTAL [Base]	55 [100%]	243 [100%]	243 [100%]	629 [100%]	59 [100%]	108 [100%]
High cost of development [1]	12 [22%]	12 [5%]	45 [19%]	25 [4%]	14 [24%]	26 [24%]
High production costs	4 [7%]	12 [5%]	15 [6%]	63 [10%]	6 [10%]	8 [7%]
Lack of finance	3 [5%]	7 [3%]	8 [3%]	13 [2%]	2 [3%]	15 [14%]
The tax regime	1 [2%]	*	1 [0.2%]	*	1 [2%]	*
High price of technology	1 [2%]	*	19 [8%]	*	2 [3%]	*
Volatile exchange rates	2 [4%]	*	2 [0.4%]	*	1 [2%]	*
Lack of specific government support programmes	1 [2%]	*	1 [0.2%]	*	0 [0%]	*
Competition from overseas	3 [5%]	*	7 [3%]	*	1 [2%]	*
Lack of volume in NZ	2 [4%]	*	13 [5%]	*	1 [2%]	*
Others	2 [4%]	*	13 [5%]	*	1 [2%]	*
No economic considerations	30 [55%]	*	110 [45%]	*	18 [31%]	*
Don't know						

* *data unavailable*

[1] Note that New Zealand product-users and process-users cite "High cost of development" relatively more often than their British counterparts.

5.4 Economic Difficulties

Of the economic difficulties, high development costs, as shown in Table 5.4.1 above, are the most commonly cited factor (22 per cent of product-users and intending, and 19 per cent of process-users and intending) by respondents. This factor is cited much more frequently than the next most often cited factors, high production costs, lack of finance, competition from overseas, and lack of volume in New Zealand.

As with technical factors, the economic difficulties tend to be concentrated in the large establishments and again this effect is more marked with product-users (see Appendices 15 and 16).

Similarly, particular economic difficulties seem to be associated proportionately more with particular industries - this effect again being more marked with product-users; most notably those within the textiles/wearing apparel/leather industries and fabricated metal products and equipment (where high development costs are a notable factor).

Nationality of ultimate parent company has an effect on the economic considerations of product-users, particularly with respect to high production costs. Eighteen per cent of New Zealand-based product-users (and intending product-users) cite this disadvantage whereas no overseas-based product-users (and intending) mention it. Similarly, 9 per cent of New Zealand-based product-users (and intending) cite lack of volume in New Zealand, whereas this factor is not mentioned by any overseas-based product-users. With process-users the most significant difference occurs with the high cost of development; 15 per cent of New Zealand-based process-users (and intending) cite this factor compared with 25 per cent of overseas-based process-users.

There are generally fewer significant differences in economic disadvantage by region.

5.5 A Note on Acceptance Problems

Problems in getting microelectronics accepted by the people affected was classified in Section 5.3 as a technical factor.

From Table 5.3.1, only about 1-2 per cent of establishments see opposition from management as a very important problem (when asked "unprompted") but since many of the respondents would feel that they are part of management themselves and are thus unlikely to cite their own attitudes as being of concern, the questionnaire is probably not of a form applicable for gleaning a full appreciation of this aspect. It could perhaps be conjectured that, inasmuch as a problem exists with management, it is probably less a matter of blatant opposition than a lack of awareness of the opportunities, or lack of initiative to take advantage of them.

Similarly, only around 3-4 per cent of establishments cite opposition from the shop floor or unions as being a very important problem. In the 1985 PSI survey, the corresponding figure is 6 per cent.[1]

5.6 Position Relative to Overseas Competition

Respondents using microelectronics were also asked if, in general, they believed they were ahead of, or behind, their main overseas competitors in applying microelectronics technology in their products and production processes. The responses are recorded in Table 5.6.1.

Table 5.6.1 POSITION RELATIVE TO MAIN OVERSEAS COMPETITORS IN APPLICATION OF MICROELECTRONICS TO PRODUCTS AND PRODUCTION PROCESSES [BASE: PRODUCT-USERS AND INTENDING/PROCESS-USERS AND INTENDING]

	PRODUCT-USERS [application in products]	PROCESS-USERS [application in processes]
TOTAL [Base]	55 [100%]	243 [100%]
Definitely ahead	6 [11%]	6 [2%]
Probably ahead	6 [11%]	15 [6%]
About level	13 [24%]	46 [19%]
Probably behind	15 [27%]	71 [29%]
Definitely behind	9 [16%]	53 [22%]
Don't know	4 [7%]	8 [3%]
No major competitors	2 [4%]	4 [2%]
Not specified		40 [16%]

With product-users there is little variation according to size of establishment, this applying to all levels of competitiveness with overseas competitors. The same observation is relevant with process-users with the exception of those who say they are definitely behind: a much greater proportion of these establishments are of smaller size. For example, 50 per cent of process-users employing 1-19 people state they are definitely behind their overseas competitors whereas only 6 per cent of process-users employing 200+ people state that they are definitely behind.

Notably, for process applications the establishments that state that they are probably behind their overseas competitors are more concentrated in Dunedin and rural areas relative to other areas - whereas the establishments that are definitely behind are more highly concentrated in Christchurch.

[1] Northcott (1986), op.cit, p 68.

Nationality of parent firm appears to have little bearing on establishments' competitiveness relative to their overseas counterparts.

Establishments which are definitely ahead of their overseas competitors with process applications have proportionately high representation in the wood and wood/cork products industries. Those which are probably ahead have relatively high concentration in the food/beverages/tobacco industry and non-metallic mineral products, while those that are about level are most concentrated in the paper and paper products industries and basic metals.

Non-users of microelectronics with scope in processes were asked whether, as far as they were aware, their main competitors in New Zealand, Australia and elsewhere have already applied microelectronics technology in their production processes. As indicated in Table 5.6.2, considerable proportions of Australian and other overseas competitors have already applied the technology.

Table 5.6.2 WHETHER MAIN COMPETITORS HAVE ALREADY APPLIED MICROELECTRONICS TECHNOLOGY IN THEIR PRODUCTION PROCESSES - NON-USERS WITH SCOPE IN PROCESSES [BASE: NON-USERS WITH SCOPE]

	New Zealand	Australia	Elsewhere
TOTAL	36 [100%]	36 [100%]	36 [100%]
Have applied	11 [31%]	15 [42%]	17 [47%]
Have not applied	17 [47%]	6 [17%]	4 [11%]
No competitors	1 [3%]	-	-
Don't know	6 [17%]	14 [39%]	14 [39%]

CHAPTER 6

SOURCES OF ASSISTANCE

6.1 Funding for Major Items of Microelectronics Equipment

In this survey, establishments were asked how they have financed or are intending to finance the purchase of major items of microelectronics equipment (defined as items costing more than $50,000). The findings are summarised in Table 6.1.1.

Table 6.1.1 HOW MAJOR ITEMS OF CAPITAL EQUIPMENT HAVE BEEN FINANCED/ARE INTENDED TO BE FINANCED BY PRODUCT-USERS AND PROCESS-USERS [BASE: PRODUCT-USERS AND INTENDING/PROCESS-USERS AND INTENDING]

	Product-Users	Process-Users
TOTAL [Base]	55 [100%]	243 [100%]
Internal funds	24 [44%]	101 [42%]
Term finance from bank/finance house /other financial institution	9 [16%]	40 [16%]
Finance from supplier	-	6 [16%]
Equity/venture capital	1 [2%]	10 [4%]
Other	2 [4%]	9 [4%]
Haven't spent/wouldn't spend over $50,000	5 [9%]	12 [5%]
Don't know/not yet decided	11 [20%]	30 [14%]
Not specified	3 [5%]	35 [13%]

For both product-users and process-users, internal funding is the most commonly quoted source of funding, followed by long-term finance from banks or finance houses.[1] A relatively high proportion of both product-users and process-users that cite internal funds as their funding source are concentrated in the largest establishments (i.e. 200+ employees).

It is also apparent that a relatively higher proportion of both product-user and process-user establishments sourcing from internal funds have an overseas-based parent company rather than a New Zealand-based one. The reverse is true for product-users and process-users who source funds from term finance (i.e. from

[1] Other funding alternatives included in the questionnaire were: finance from supplier, and equity/venture capital. Respondents could also answer "haven't spent/wouldn't spend over $50,000", "other", or "don't know/not yet decided".

Table 6.1.2 HOW MAJOR ITEMS OF CAPITAL EQUIPMENT HAVE BEEN FINANCED/ARE INTENDED TO BE FINANCED BY INDUSTRY CATEGORY - PRODUCT-USERS AND PROCESS-USERS [BASE: PRODUCT-USERS AND INTENDING/PROCESS-USERS AND INTENDING]

	TOTAL	Food/ Beverages /Tobacco	Textiles/ Wearing Apparel/ Leather	Wood/ Cork Products	Paper/ Paper Products	Chemicals/ Coal/ Rubber/ Petroleum	Non-metallic Mineral Products	Basic Metal Industries	Fabricated Metal Products & Equipment	Other Manufacturing Industry
PRODUCT USERS										
TOTAL [Base]	55 [100%]	-	8 [100%]	1 [100%]	3 [100%]	4 [100%]	3 [100%]	1 [100%]	27 [100%]	8 [100%]
Internal funds	24 [44%]	-	5 [63%]	-	-	2 [50%]	3 [100%]	1 [100%]	10 [37%]	3 [38%]
Term finance from bank or finance house	9 [16%]	-	2 [25%]	1 [100%]	1 [33%]	-	-	-	4 [15%]	1 [13%]
PROCESS USERS										
TOTAL [Base]	243 [100%]	42 [100%]	31 [100%]	18 [100%]	28 [100%]	26 [100%]	12 [100%]	6 [100%]	71 [100%]	9 [100%]
Internal funds	101 [42%]	20 [48%]	10 [32%]	11 [61%]	12 [43%]	8 [31%]	5 [42%]	5 [83%]	28 [39%]	2 [22%]
Term finance from bank or finance house	40 [16%]	9 [21%]	5 [16%]	5 [28%]	6 [21%]	5 [19%]	-	-	9 [13%]	1 [11%]

banks or finance houses); here proportionately more establishments have New Zealand-based parent companies.

Very marked differences in source of funding according to industry category are evident with both product-users and process-users. This effect is particularly well illustrated with respect to the two main sources of funding: internal funding and term finance from bank or finance house. Table 6.1.2 illustrates this finding.

6.2 External Assistance Including Government Support

Because the introduction of microelectronics can lead to such a wide range of issues to be dealt with and problems to be solved, it is quite common for manufacturing establishments to seek technical nelp and advice from outside agencies.

Overall, it is the largest establishments which tend to make most use of outside sources of technical help. This may seem paradoxical, **prima facie,** since the larger organisations might appear to be the ones with the strongest in-house technical expertise and the least need to look elsewhere for help. The PSI, however - which also noted this effect - suggests that it is probably less a matter of greater need by these larger establishments than of their greater awareness of the benefits of external assistance, a more in-depth knowledge of the types of help available from particular sources, stronger ability to frame specifications and briefs, and higher budgets to cover fees.[1]

By far the most common source of help are the suppliers of the microelectronics equipment. Their help has been sought from 69 per cent of product-users (and intending product-users), and 72 per cent of process-users (and intending process users), as indicated in Table 6.2.1. (The comparative percentage figures from the 1985 PSI survey for Britain are also listed.)

Respondents were also asked how useful they have found each particular outside agency consulted. The responses are summarised in Table 6.2.2. (The comparative percentage figures from the 1985 PSI survey for Britain are again also listed.)

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[1] Northcott (1986), **op.cit,** Chapter 7.

Table 6.2.1 OUTSIDE AGENCIES FROM WHICH HELP SOUGHT IN DOING RESEARCH AND DEVELOPMENT WORK ON MICROELECTRONICS APPLICATIONS - PRODUCT-USERS AND PROCESS-USERS (OR INTENDING)[BASE: PRODUCT-USERS AND INTENDING/PROCESS-USERS AND INTENDING]

	PRODUCT-USERS		PROCESS-USERS	
	NZ 1986	Britain 1985	NZ 1986	Britain 1985
TOTAL [Base]	55 [100%]	243 [100%]	243 [100%]	629 [100%]
Agencies sought help from:				
Equipment suppliers	38 [69%]	165 [68%]	175 [72%]	497 [79%]
Commercial consultancy firms	10 [18%]	70 [29%]	47 [19%]	120 [19%]
Parent or other companies in group	26 [47%]	95 [39%]	80 [33%]	170 [27%]
Other companies	12 [22%]	46 [19%]	47 [19%]	82 [13%]
Professional associations	5 [9%]	36 [15%]	24 [10%]	57 [9%]
Industrial research associations	6 [11%]	41 [17%]	28 [12%]	57 [9%]
Universities	10 [18%]	68 [28%]	25 [10%]	69 [11%]
Technical colleges	2 [4%]	29 [12%]	13 [5%]	57 [9%]
DSIR	14 [25%]	*	44 [18%]	*
Department of Trade and Industry	7 [13%]	*	15 [6%]	*
Development Finance Corporation	2 [4%]	*	11 [5%]	*
Others	4 [7%]	*	20 [8%]	*

* *not applicable for Britain*

Table 6.2.2 SOUGHT HELP AND HOW USEFUL OUTSIDE AGENCIES HAVE BEEN: ALL USERS
[BASE: ALL SURVEY RESPONDENTS]

Agencies sought help from:	SOUGHT HELP NZ 1986	SOUGHT HELP Britain 1985	ESSENTIAL NZ 1986	ESSENTIAL Britain 1985	QUITE USEFUL NZ 1986	QUITE USEFUL Britain 1985	# NOT SO USEFUL NZ 1986	# DON'T KNOW NZ 1986
TOTAL [Base]	387 [100%]	872 [100%]	387 [100%]	872 [100%]	387 [100%]	872 [100%]	387 [100%]	387 [100%]
Equipment suppliers	181 [47%]	663 [76%]	112 [29%]	419 [48%]	58 [15%]	209 [24%]	9 [2%]	2 [1%]
Commercial consultancy firms	48 [12%]	192 [22%]	23 [6%]	70 [8%]	17 [4%]	78 [9%]	7 [2%]	-
Parent or other companies in group	84 [22%]	262 [30%]	42 [11%]	140 [16%]	32 [8%]	105 [12%]	9 [2%]	1
Other companies	48 [12%]	131 [15%]	14 [4%]	35 [4%]	29 [7%]	78 [9%]	5 [1%]	-
Professional associations	25 [6%]	87 [10%]	9 [2%]	26 [3%]	17 [4%]	52 [6%]	1 -	-
Industrial research associations	28 [7%]	96 [11%]	10 [3%]	26 [3%]	15 [4%]	52 [6%]	3 [1%]	
Universities	25 [6%]	140 [16%]	7 [2%]	35 [4%]	10 [3%]	78 [9%]	8 [2%]	-
Technical colleges [Polytechnics]	13 [3%]	87 [10%]	4 [1%]	17 [2%]	8 [2%]	52 [6%]	1 -	-
DSIR	44 [11%]	*	13 [3%]	*	26 [7%]	*	5 [1%]	-
Department of Trade and Industry	16 [4%]	*	4 [1%]	*	9 [2%]	*	3 [1%]	-
Development Finance Corporation	11 [3%]	*	1 -	*	7 [2%]	*	3 [1%]	-
Others	21 [5%]	*	11 [3%]	*	8 [2%]	*	1 -	17 [4%]

* *not applicable for Britain*
\# *not available for Britain*

CHAPTER 7

MICROELECTRONICS AND EMPLOYMENT

In Chapter 6, the lack of personnel with microelectronics expertise was the difficulty quoted far more than any other as a major impediment to the introduction of microelectronics.

7.1 Microelectronics Engineers

Various surveys on microelectronics taken overseas since 1980 reveal microelectronics engineers as the most critical kind of skilled staff in insufficient supply.[1] In this survey, therefore, establishments were asked how many (if any) engineers with specific microelectronics expertise were currently on the staff; on the staff two years ago; and how many more they would like to have on their staff at the present time. They were also asked roughly what percentage of their currently employed engineers with microelectronics expertise are professional engineers.

As can be seen from Table 7.1.1, the number of engineers with microelectronics expertise employed by New Zealand establishments has increased markedly over the last two years. For example, of all product-users (and intending product-users), 25 per cent had at least three engineers two years prior to the survey, whereas this percentage figure has risen to 40 per cent at the time of the survey.

As might be expected, the number of engineers with microelectronics expertise increases directly with the size of the establishment. In fact this effect is very marked. For the product-users, small establishments (1-19 people) currently employ an average 1.2 engineers with microelectronics expertise, whereas the largest establishments (more than 200 people) employ an average of 16.9. Note that the average number of these engineers per establishment (product-users) is 7.3 (see Table 7.1.1). For the process-users, small establishments currently employ an average of 0.6 of these engineers, whereas the largest establishments employ an average of 6.1. Note that the average number of engineers per process-user establishment is 2.9 (see Table 7.1.1).

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[1] For example, see **Microelectronics in Industry: An International Comparison, Britain, Germany, France.** PSI, VDI, BIPE, January 1985 (Chapter 6).

Table 7.1.1 **NUMBER OF ENGINEERS WITH MICROELECTRONICS EXPERTISE - ALL PRODUCT-USERS AND ALL PROCESS-USERS [BASE: ALL PRODUCT-USERS AND INTENDING/ALL PROCESS-USERS AND INTENDING]**

	NUMBER NOW		NUMBER 2 YEARS AGO		HOW MANY MORE WOULD LIKE TO HAVE	
	Product Users	Process Users	Product Users	Process Users	Product Users	Process Users
TOTAL [Base]	55 [100%]	243 [100%]	55 [100%]	243 [100%]	55 [100%]	243 [100%]
Number of Engineers per Establishment:						
at least 1	41 [75%]	137 [56%]	33 [60%]	98 [40%]	28 [51%]	108 [44%]
at least 2	27 [49%]	81 [33%]	20 [36%]	53 [22%]	18 [33%]	60 [25%]
at least 3	22 [40%]	56 [23%]	14 [25%]	30 [12%]	8 [15%]	26 [11%]
at least 4	16 [29%]	34 [14%]	11 [20%]	20 [8%]	7 [13%]	18 [7%]
at least 5	15 [27%]	28 [12%]	10 [18%]	17 [7%]	6 [11%]	13 [5%]
at least 6-10	3 [5%]	9 [4%]	3 [5%]	6 [2%]	1 [2%]	5 [2%]
at least 11-20	4 [7%]	7 [3%]	4 [7%]	6 [2%]	1 [2%]	2 [1%]
at least 21-50	3 [5%]	5 [2%]	1 [2%]	1 -	2 [4%]	2 [1%]
at least 50+	2 [4%]	2 [1%]	1 [2%]	1 -	1 [2%]	2 [1%]
Average number per establishment	7.3	2.9	4.1	1.6	3.4	1.8
Number engineers with microelectronics expertise	13 [24%]	102 [42%]	20 [36%]	141 [58%]	26 [47%]	130 [53%]
Don't know/Not specified	1 [2%]	4 [2%]	1 [2%]	4 [2%]	1 [2%]	5 [2%]

N.B. The PSI reports that in Britain in 1985, the average number of engineers per establishment (all users) in its sample was 2.9, while the average number of professional engineers was 1.3.

The microelectronics engineers are not, however, uniformly distributed across manufacturing industry. As the PSI has also discovered with its surveys, establishments with product applications typically have far more microelectronics engineers than establishments with process applications.[1]

About one-half of the engineers with microelectronics expertise employed by product-users and process-users are professional engineers, that is - they have degrees in engineering and/or are chartered members of one of the engineering institutions.

7.2 Changes in Employment Due to Use of Microelectronics

While many people involved with the new microelectronics technologies are primarily concerned with ensuring that they are adopted as widely and as effectively as possible, there are others whose main concern is over the possible effects if they are adopted - in particular on people and jobs. Over the past decade there has been an on-going controversy regarding whether the introduction of microelectronics will lead to the widespread loss of jobs.

It is usually accepted that to obtain an overview of employment creation effects, it is necessary to measure the indirect effects of introducing microelectronics as well as the direct effects. For instance, while assembly line process workers may be displaced by industrial robots, jobs may in turn be created in areas such as designing, making, selling, delivering, installing, servicing and repairing the robots.

Furthermore, it can be argued that general economic considerations will lead to a situation whereby the indirect effects will tend to offset the direct ones, so that - after allowing for full adjustment - the effects might counterbalance each other. Thus, when an establishment uses microelectronics in a radically improved product, this may increase its market dominance and necessitate the employment of additional staff. On the other hand, other establishments which have not introduced microelectronics may suffer a consequential loss in their market share, which may lead to staff retrenchment.

Another scenario is that, for example, a new process application may increase labour productivity to an extent that fewer staff are needed per unit of output.

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[1] Northcott (1986), op.cit, p 72.

The gains from this higher productivity, however, may well be used for investment in new capital facilities (creating jobs with equipment suppliers); or reducing prices (leading to a real increase in consumers' purchasing power and thus an increase in consumption expenditure and so creating more jobs); or for increasing pay (again leading to more spending and more jobs elsewhere); or for increasing shareholders' dividends (again leading to more spending and more jobs elsewhere); or, more realistically, some combination of these. Hence, no matter which way the gains are used, the effect is likely to stimulate the creation of other jobs, at some other place, in the short, medium or longer term.

Some cautions, however, need to be observed: while a counterbalancing employment effect may occur, other problems may need to be resolved. Medium to longer term adjustment may, for example, be too late for peace of mind, while "some other place" may mean a different type of job, in a different workplace, in a different location, or even in a different country.

To attempt a reliable measure of the full direct and indirect employment effects would, of course, be a very difficult task and well beyond the scope of this study. To measure only the direct effects is a more realistic task in the interim, and still of very considerable benefit because these direct effects indicate where the new technology is perceived to make its impact and show where the changes are coming about.

7.3 Direction of Change in the Number of Jobs

The survey respondents with existing applications were asked what the introduction of the new microelectronics technology in their products and/or production processes has meant so far in terms of changes in the number of jobs - by roughly how many their total numbers increased or decreased overall as a direct result of this in the past two years or so. In aggregate, 68 per cent of establishments reported no change, on balance, in the number of jobs while 13 per cent reported a net increase in jobs and 15 per cent a net decrease. (Five per cent did not know.) Table 7.3.1 summarises the responses in terms of net increases and decreases in jobs for each size of establishment, while Appendix 17 details the results according to the number of jobs gained or lost.

Establishments employing 50-99 people show the greatest proportionate increase in jobs. (Nineteen per cent of these establishments have increased the number of jobs over the past two years due to the effect of microelectronics.) It is the largest establishments (200+ people), however, that show the greatest

Table 7.3.1 CHANGES IN EMPLOYMENT [1984-1986] DUE TO USE OF MICROELECTRONICS: INCREASES AND DECREASES IN JOBS BY SIZE OF ESTABLISHMENT - ALL PRODUCT-USERS AND PROCESS-USERS COMBINED [BASE: PRODUCT-USERS/PROCESS-USERS AND INTENDING COMBINED]

		NUMBER OF PEOPLE EMPLOYED					
	Total	1-19	20-49	59-99	100-199	200+	Don't know
TOTAL [Base]	256 [100%]	20 [100%]	38 [100%]	58 [100%]	50 [100%]	87 [100%]	3 [100%]
Number of Establishments with:							
Increase in jobs *	33 [13%]	3 [15%]	3 [8%]	11 [19%]	5 [10%]	11 [13%]	-
No change in jobs *	173 [68%]	16 [80%]	28 [74%]	39 [67%]	39 [78%]	49 [56%]	2 [7%]
Decrease in jobs *	38 [15%]	1 [5%]	8 [21%]	6 [10%]	3 [6%]	20 [23%]	-
Don't know/Not stated	12 [5%]	-	-	2 [3%]	3 [6%]	6 [7%]	1 [3%]

* net

Table 7.3.2 CHANGES IN EMPLOYMENT DUE TO USE OF MICROELECTRONICS: INCREASES AND DECREASES IN JOBS BY REGION - ALL PRODUCT-USERS AND PROCESS-USERS COMBINED [BASE: PRODUCT-USERS/PROCESS-USERS AND INTENDING COMBINED]

	Total	Auckland	Wgtn	Chch	Dunedin	Metropolitan	Provincial	Towns/ Boroughs	Rural
TOTAL [Base]	256 [100%]	99 [100%]	34 [100%]	28 [100%]	9 [100%]	169 [100%]	46 [100%]	26 [100%]	14 [100%]
Number of Establishments with:									
Increase in jobs *	33 [13%]	9 [9%]	10 [29%]	3 [11%]	1 [11%]	24 [14%]	4 [9%]	2 [8%]	3 [20%]
No change in jobs *	173 [68%]	67 [68%]	21 [62%]	22 [79%]	6 [67%]	116 [69%]	31 [67%]	16 [62%]	10 [67%]
Decrease in jobs *	38 [15%]	17 [17%]	2 [6%]	2 [7%]	3 [33%]	22 [13%]	6 [13%]	8 [31%]	2 [13%]
Don't know/ Not stated	12 [5%]	5 [5%]	1 [3%]	1 [4%]	-	7 [4%]	5 [11%]	-	-

* net

relative decline in their numbers employed due to the effect of microelectronics. (Twenty-three per cent of these establishments report, on balance, such a decline.)

Table 7.3.2 on the previous page summarises the responses in terms of the number of establishments reporting net increases and decreases in jobs by region. Clearly the establishments reporting a net increase in jobs are relatively more concentrated in Wellington and rural areas while those reporting a net decrease in jobs are relatively more concentrated in Dunedin and in the towns and boroughs.

Table 7.3.3 summarises the responses in terms of the number of establishments reporting net increases and decreases in jobs by industry category. Here, establishments reporting a net increase in jobs are relatively more concentrated within the paper and paper products, and textiles/wearing apparel/leather industries. Conversely, establishments reporting a net decline in jobs are relatively more concentrated in food/beverages/tobacco, non-metallic mineral products, and wood and wood/cork products industries.

With respect to the effects of microelectronics on jobs in Britain, the PSI reports the changes as summarised in Table 7.3.4.[1] Here, compared with New Zealand, a relatively more widespread loss of jobs is apparent, particularly with process-users.

7.4 Women's Jobs and Microelectronics

One question in the survey was designed to obtain information on how the introduction of microelectronics has affected women. This question simply asked what, roughly, had been the increase or decrease in the number of women employed as a result of using microelectronics technology in each establishment's products and production processes over the past two years or so, and what change in the number of women employed was expected in the next two years or so. Perhaps the most notable feature of the results here, as illustrated in Table 7.4.1, is the very low proportion of respondents having, on balance, reduced jobs for women or expecting a net reduction in women's jobs. (The comparative British percentage figures from the PSI are also included in this table.)

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[1] Northcott (1986), **op.cit**, adapted from tables on pp 177-179.

Table 7.3.3 CHANGES IN EMPLOYMENT DUE TO USE OF MICROELECTRONICS - INCREASES AND DECREASES IN JOBS BY INDUSTRY CATEGORY: ALL PRODUCT-USERS AND PROCESS-USERS COMBINED [BASE: PRODUCT-USERS/PROCESS-USERS AND INTENDING COMBINED]

	TOTAL	Food/ Beverages /Tobacco	Textiles/ Wearing Apparel/ Leather	Wood/Wood and Cork Products	Paper/ Paper Products	Chemicals/ Coal/ Rubber/ Petroleum	Non-metallic Mineral Products	Basic Metal Industries	Fabricated Metal Products & Equipment	All Manufacturing Industry
TOTAL [Base]	256 [100%]	42 [100%]	32 [100%]	18 [100%]	28 [100%]	26 [100%]	12 [100%]	6 [100%]	79 [100%]	13 [100%]
Number of establishments with:										
Increase in jobs*	33 [13%]	6 [14%]	5 [16%]	-	6 [21%]	2 [8%]	1 [8%]	-	11 [14%]	2 [15%]
No change in jobs*	173 [68%]	25 [60%]	21 [66%]	13 [72%]	19 [68%]	19 [73%]	7 [58%]	6 [100%]	54 [68%]	9 [69%]
Decrease in jobs*	38 [15%]	9 [21%]	5 [16%]	4 [22%]	3 [11%]	3 [12%]	4 [33%]	-	8 [10%]	2 [15%]
Don't know/ Not stated	12 [5%]	3 [7%]	1 [3%]	1 [6%]	-	1 [4%]	-	-	6 [8%]	-

* net

Table 7.3.4 **CHANGES IN BRITISH EMPLOYMENT DUE TO USE OF MICROELECTRONICS - 1983-1985 AND 1985-87 (EXPECTED) [BASE: ALL PRODUCT-USERS AND INTENDING/ALL PROCESS-USERS AND INTENDING]**

	1983-1985			Expected 1985-1987		
	Product users	Process users	All users	Product users	Process users	All users
Base [1985]	243	629	872	243	629	872
Percentage of establishments with:						
Increase in jobs*	13%	6%	8%	18%	8%	11%
No change in jobs*	67%	70%	69%	63%	69%	67%
Decrease in jobs*	17%	18%	18%	14%	16%	16%
Don't know/Not stated	3%	6%	5%	5%	7%	69%

* net

Table 7.4.1 **CHANGES IN JOBS AVAILABLE FOR WOMEN DUE TO USE OF MICROELECTRONICS - ALL PRODUCT-USERS AND PROCESS-USERS [BASE: ALL PRODUCT-USERS AND INTENDING/ALL PROCESS-USERS AND INTENDING]**

	PRODUCT-USERS		PROCESS-USERS	
	NZ 1986	Britain 1985	NZ 1986	Britain 1985
TOTAL [Base]	55 [100%]	243 [100%]	243 [100%]	629 [100%]
Changes in women's jobs over last two years:				
NUMBER OF ESTABLISHMENTS WITH				
Increase in jobs*	7 [13%]	17 [7%]	29 [12%]	19 [3%]
No change*	44 [80%]	197 [81%]	192 [79%]	554 [88%]
Decrease in jobs*	-	22 [9%]	7 [3%]	31 [5%]
Don't know/Not stated	4 [7%]	7 [4%]	14 [6%]	25 [4%]
Expected change in women's jobs over next two years:				
NUMBER OF ESTABLISHMENTS WITH				
Increase in jobs*	4 [7%]	24 [10%]	21 [9%]	19 [3%]
No change*	43 [78%]	187 [77%]	189 [77%]	535 [85%]
Decrease in jobs*	-	22 [9%]	12 [5%]	38 [6%]
Don't know/Not stated	8 [15%]	12 [5%]	20 [8%]	31 [5%]

* net

Table 7.5.1 CHANGES IN SKILLED SHOP FLOOR JOBS AVAILABLE DUE TO USE OF MICRO-ELECTRONICS - ALL PRODUCT-USERS AND PROCESS-USERS [BASE: ALL PRODUCT-USERS AND INTENDING/ALL PROCESS-USERS AND INTENDING]

	PRODUCT-USERS		PROCESS-USERS	
	NZ 1986	Britain 1985	NZ 1986	Britain 1985
TOTAL [Base]	55 [100%]	243 [100%]	243 [100%]	629 [100%]
Changes in skilled shop floor jobs over last two years:				
NUMBER OF ESTABLISHMENTS WITH				
Increase in jobs*	9 [16%]	27 [11%]	42 [17%]	31 [5%]
No change*	39 [71%]	165 [68%]	170 [70%]	453 [72%]
Decrease in jobs*	2 [4%]	41 [17%]	15 [6%]	113 [18%]
Don't know/Not stated	5 [9%]	10 [4%]	14 [7%]	31 [5%]
Expected change in skilled shop floor jobs over next two years:				
NUMBER OF ESTABLISHMENTS WITH				
Increase in jobs*	4 [7%]	27 [11%]	21 [9%]	31 [5%]
No change*	43 [78%]	165 [68%]	189 [78%]	453 [72%]
Decrease in jobs*	-	3 [16%]	12 [5%]	101 [16%]
Don't know/Not stated	8 [15%]	12 [5%]	21 [8%]	44 [7%]

* net

7.5 Skilled Shop Floor Jobs and Microelectronics

One question in the survey, directed towards skilled shop floor jobs, asked how the number of such jobs had changed as a result of using microelectronics over the past two years or so. The results show that, for both product-users and process-users, a higher percentage of establishments report a net increase in jobs than a net decrease in jobs over the past two years and this trend is expected to continue over the next two years. The results appear above in Table 7.5.1.

Table 7.6.1 CHANGES IN OTHER SHOP FLOOR JOBS AVAILABLE DUE TO USE OF MICRO-ELECTRONICS - ALL PRODUCT-USERS AND PROCESS-USERS [BASE: ALL PRODUCT-USERS AND INTENDING/ALL PROCESS-USERS AND INTENDING]

	PRODUCT-USERS		PROCESS-USERS	
	NZ 1984-86	Britain 1983-85	NZ 1984-86	Britain 1983-85
TOTAL [Base]	55 [100%]	243 [100%]	243 [100%]	629 [100%]
Changes in other shop floor jobs over last two years:				
NUMBER OF ESTABLISHMENTS WITH				
Increase in jobs*	6 [11%]	39 [16%]	16 [7%]	38 [6%]
No change*	41 [75%]	153 [63%]	192 [79%]	472 [75%]
Decrease in jobs*	2 [4%]	44 [18%]	18 [7%]	88 [14%]
Don't know/Not stated	6 [10%]	10 [4%]	17 [7%]	31 [5%]
Expected change in other shop floor jobs over next two years:				
NUMBER OF ESTABLISHMENTS WITH				
Increase in jobs*	4 [7%]	41 [17%]	12 [5%]	44 [7%]
No change*	39 [71%]	158 [65%]	189 [78%]	453 [72%]
Decrease in jobs*	3 [5%]	29 [12%]	15 [6%]	88 [14%]
Don't know/Not stated	9 [15%]	12 [5%]	27 [11%]	44 [7%]

* net

7.6 Other Shop Floor Jobs and Microelectronics

A further question in the survey was asked to obtain information on how the introduction of microelectronics had affected other shop floors - that is, other than skilled type shop floor jobs. The results in Table 7.6.1 above show that, for product-users, a higher proportion of establishments report a net increase in jobs than a net decrease in jobs while, for process-users, equal proportions of establishments (7 per cent) report both net increases and net decreases in jobs. Looking ahead two years, the proportion of establishments expecting a net increase in this category of jobs is very similar to the proportion expecting a

Table 7.7.1 CONSULTATION WITH WORKFORCE/UNION WHEN MICROELECTRONICS FIRST INTRODUCED BY SIZE OF ESTABLISHMENT - ALL USERS IN PRODUCTION [BASE: ALL PRODUCT USERS AND PROCESS-USERS IN PRODUCTION COMBINED]

		NUMBER OF PEOPLE EMPLOYED					
	Total	1-19	20-49	50-99	100-199	200+	Don't know
TOTAL [Base]	225 [100%]	17 [100%]	31 [100%]	49 [100%]	42 [100%]	83 [100%]	3 [100%]
Consultation:							
Yes	78 [35%]	5 [29%]	5 [16%]	16 [33%]	17 [40%]	33 [40%]	2 [67%]
No	132 [59%]	11 [65%]	25 [81%]	32 [65%]	23 [55%]	40 [48%]	1 [33%]
Don't know/Not specified	15 [6%]	1 [6%]	1 [3%]	1 [2%]	2 [2%]	10 [12%]	-

Table 7.7.2 CONSULTATION WITH WORKFORCE/UNION WHEN MICROELECTRONICS FIRST INTRODUCED BY REGION - ALL USERS IN PRODUCTION [BASE: ALL PRODUCT-USERS AND PROCESS-USERS IN PRODUCTION COMBINED]

	Total	Auckland	Wgtn	Chch	Dunedin	Metropolitan	Provincial	Towns/Boroughs	Rural
TOTAL [Base]	225 [100%]	86 [100%]	28 [100%]	23 [100%]	8 [100%]	145 [100%]	42 [100%]	25 [100%]	13 [100%]
Consultation:									
Yes	78 [35%]	24 [28%]	8 [29%]	6 [26%]	2 [25%]	41 [28%]	20 [48%]	11 [44%]	6 [46%]
No	132 [59%]	52 [60%]	17 [61%]	17 [74%]	6 [75%]	91 [63%]	22 [52%]	13 [52%]	6 [46%]
Don't know/ Not specified	15 [6%]	9 [10%]	3 [11%]	-	-	13 [9%]	-	1 [4%]	1 [8%]

net decrease; this applies to both product-users and process-users. (Again the comparative British percentage figures are listed.)

7.7 Consultation with Workforce/Union During Introduction of Microelectronics

It is often suggested that change in the workplace will be better accepted and more effectively implemented if consultation with the workforce and union(s) takes place. Respondents were, therefore, asked if there was consultation with the workforce/union(s) when they first introduced microelectronics technology. The results as summarised in Table 7.7.1 above show that just over one-third of all users in production engaged in consultation but relatively more of the larger establishments did so, compared with the smaller establishments.

When the results are tabulated according to region, some further interesting differences become apparent: the establishments which engaged in consultation are relatively less concentrated in the (main) metropolitan areas and relatively highly concentrated in the provincial cities, towns and boroughs, and rural areas.

Note that the PSI survey in Britain reports that, for 1985, 52 per cent of firms surveyed (i.e. all users) engaged in prior consultation, 41 per cent did not, and 8 per cent did not know (or did not answer the question).[1] Hence, it appears that British firms have been engaging in consultation relatively more often than their New Zealand counterparts.

7.8 Labour Productivity, Profitability and Competitiveness

Invariably, when firms introduce new technologies they are interested in monitoring variables such as labour productivity, profitability and competitiveness to ascertain what changes, if any, occur.

A particularly high proportion of establishments - about one-third - have experienced a considerable increase in domestic competitiveness compared with one-fifth who report an increase in international competitiveness. Higher proportions of respondents report a slight increase in labour productivity and profitability rather than a considerable increase. A relatively high proportion of establishments report no increase at all in international competitiveness. The results are summarised in Table 7.8.1.

Table 7.8.1 MAGNITUDE OF INCREASE IN KEY ECONOMIC VARIABLE OVER LAST TWO YEARS DUE TO INTRODUCTION OF MICROELECTRONICS - ALL PRODUCT-USERS AND PROCESS-USERS [BASE: PRODUCT-USERS/PROCESS-USERS AND INTENDING COMBINED]

INCREASE IN:	Considerably	Slightly	Not at all	Don't know/ Not specified
Labour productivity	70 [27%]	94 [37%]	56 [22%]	35 14%]
Profitability	65 [25%]	97 [38%]	57 [22%]	38 [15%]
Domestic competitiveness	82 [32%]	81 [32%]	56 [22%]	35 [14%]
International competitiveness	50 [20%]	53 [21%]	114 [45%]	35 [14%]

[1] Northcott (1986), **op.cit**, p 172.

CHAPTER 8

INTERNATIONAL COMPARISONS

Discussions on the "microchip revolution" tend, sooner or later, to focus on how the experience of a particular country compares with other countries.

In the preceding chapters of this study, reference has been made - where comparable data exist - to the British experience as surveyed by the PSI in London. Most of these data relate to the PSI's 1985 survey of the micro-electronics industry.

As was mentioned in the introduction, surveys in other countries have also been carried out and in 1985 the PSI, in conjunction with the VDI-Technologiezentrum in Berlin and the BIPE in Paris, carried out an international comparison between Britain, Germany and France.[1] The data used for this comparison, however, relate to similar surveys carried out in all three countries in 1983. They are thus not directly comparable with the 1986 New Zealand survey data on a "point in time" basis. This warning is particularly important given the rapid diffusion of microelectronics over time. Nonetheless, the data can be used for the comparison of trends in these countries with New Zealand trends, and this is the approach taken in this chapter.

8.1 Extent of Use

In 1983, the differences in the proportion of total users[2] to all survey respondents in four of the overseas countries was not great; 66 per cent in Germany, 56 per cent in Britain, 61 per cent in France, and 63 per cent in Japan (1982). The corresponding New Zealand figure for 1986 was 57 per cent.[3] The majority of these user establishments (New Zealand and overseas) are using micro-electronics in their production processes but, in each country, the proportion with applications in their products is much smaller: 20 per cent in Germany, 13 per cent in each of Britain, France and Japan (1982), 12 per cent in New Zealand [and 5 per cent in the Netherlands](see Table 8.1.1).

8.2 Patterns of Diffusion

In each of the three overseas countries, the 1983 surveys found one establishment working on the development of a product application for every five or

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[1] **Microelectronics in Industry** (1985), op.cit.

[2] "Users" here means product and process-users (combined) in production.

[3] Estimated indirectly from survey data.

Table 8.1.1 EXTENT OF USE: PERCENTAGE OF SAMPLE ESTABLISHMENTS (1983) [BASE: ALL SURVEY RESPONDENTS]

	Britain	Germany	France	(1982) Japan*	Nether-lands	(1986) New Zealand*
			- percentages -			
PRODUCT-USERS						
in production	13	20	13	13	5	12
under development	2	4	2	na	na	1
feasibility investigated	1	3	1	na	na	3
Total product-users	16	27	16	na	na	16
PROCESS-USERS						
in production	55	63	57	59	30	54
under development	3	6	4	na	na	5
feasibility investigated	3	5	4	na	na	6
Total process-users	61	74	65	na	na	65
NON-USERS	35	17	29	41	na	34

* *Note the different dates for Japan and New Zealand.*

Source: Northcott (1986), **op.cit**, p 103; **National Programmes to Promote Industrial Diffusion of New Technologies: Synthesis Report**, OECD (1987).

six witn one already in production. (In New Zealand the ratio of products under development to products in production, in 1986, was significantly lower.) For process applications under development the overseas ratios are very similar to the New Zealand ones.

In all three overseas countries there is consistency in the way the proportion of users rises steadily with increasing size of establishment. In New Zealand the rise in proportion for product-users (with establishment size) is relatively less marked than was recorded for Britain, Germany and France, while for process-users the rise in the proportion in New Zealand is considerably more marked.

In New Zealand, product applications are most heavily concentrated in the fabricated metal products and equipment, textiles/wearing apparel/leather and non-metallic mineral products industries. Although the industrial classification system for the overseas countries is different, the outcome is broadly similar. In all three countries, product applications are heavily concentrated in three of the ten industry groups: in electrical and instrument engineering (where Britain has the highest percentage of users), in mechanical engineering (where Germany has the highest percentage of users) and in vehicles (where France has the highest percentage of users).

With process applications, the outcome is less comparable. There are, however, particularly high percentages of process applications in food in Britain, in printing in Germany, in vehicles in France, and in paper and paper products as well as basic metal industries in New Zealand.

8.3 Forms of Use

As well as the quantity of use of microelectronics, the type (and quality) of use is also of major importance - for example, the level of sophistication of the control systems, the categories of equipment used, and the extent of reliance on outsiders for supply.

(1) SOURCE OF MICROELECTRONICS - In all three overseas countries, about 40 per cent of the factories with product applications designed and made their own microelectronics systems in 1983, and roughly similar proportions bought in standard units from outside suppliers. In New Zealand, a much lower 20 per cent of product-users designed and made their own microelectronics systems while 45 per cent bought in standard units from outside suppliers.

With process applications, however, only 12-15 per cent of the establishments in the three overseas countries, in 1983, designed and made their own microelectronics systems, compared with over 60 per cent who relied on standard bought-in systems: a course which generally necessitates much less in-house technical expertise. In New Zealand the situation in 1986 was broadly similar. A slightly less 9 per cent of respondents designed and made their own microelectronic systems, compared with a slightly higher percentage (76 per cent) who relied on the standard catalogue systems.

(2) TYPE OF MICROELECTRONICS APPLICATIONS - Microelectronics is being used proportionately more for the control of individual machines than for the other types of process control among process-users in all four countries. The comparative percentages are listed in Table 8.3.1.

Notably, microelectronics is being used for centralised control of groups of machines or several stages of processes in more than two-fifths of the process-user establishments in the sample in Germany, compared with less than one-quarter in Britain, France and New Zealand.

Table 8.3.1 TYPE OF MICROELECTRONICS APPLICATION IN PRODUCTION PROCESSES - PERCENTAGE OF PROCESS USERS [BASE: ALL PROCESS-USERS IN PRODUCTION]

	Britain 1983	Germany 1983	France 1983	New Zealand 1986
Base	578 [100%]	900 [100%]	686 [100%]	209 [100%]
Design	23%	25%	27%	28%
Individual machine control	68%	70%	57%	78%
Centralised machine control	14%	42%	21%	24%
Integrated process control	18%	33%	22%	26%
Automated handling	25%	34%	30%	32%
Automated storage	8%	18%	16%	11%
Testing, quality control	36%	33%	41%	38%

About one-quarter of the establishments in the samples are using microelectronics for design, about one-third for automated handling, about one-third for testing and quality control, but only about one-sixth for automated storage in Germany and France and even fewer in Britain and New Zealand.

Overall, it may be concluded that New Zealand, in 1986, had broadly similar (percentage) rates of process application, form by form, as Britain and France had in 1983. The rates in Germany, with the exception of design, testing and quality control, were significantly higher than in Britain, France and New Zealand.

Finally, a comparison of the (percentage) user rates of microelectronics-based equipment used by process-users (Table 8.3.2) reveals that New Zealand in 1986 was considerably behind France and Germany but similar to Britain in 1983. In particular, New Zealand is noticeably behind the other countries in the usage of CNC machine tools, pick and place machines, and robots. The exception is with the usage of CAD work stations: here New Zealand process-users' percentage rate of usage is a little higher than that of France and Germany and considerably higher than in Britain.

Table 8.3.2 TYPE OF MICROELECTRONICS-BASED EQUIPMENT USED IN PRODUCTION PROCESSES - PERCENTAGE OF PROCESS-USERS [BASE: ALL PROCESS-USERS IN PRODUCTION]

	Britain (1983)	Germany (1983)	France (1983)	New Zealand (1986)
Base	578 [100%]	900 [100%]	686 [100%]	209 [100%]
CAD work stations	17%	29%	25%	31%
CNC machine tools	29%	44%	38%	20%
PLCs	39%	50%	56%	46%
Machine controllers	21%	34%	29%	24%
Pick and place machines	8%	9%	22%	7%
Robots	5%	8%	12%	3%

8.4 Disadvantages and Difficulties

In all three overseas countries, the lack of people with microelectronics expertise is cited as the major difficulty in using microelectronics. Next in importance follow a number of economic difficulties of various kinds. In Britain these rank closely, in importance, behind the lack of people with microelectronics expertise, but in the other two countries they are mostly of relatively less importance.

Technical difficulties with chips, sensors and software are, in Britain and France, of much less importance than the economic problems, but in Germany problems with software are more widely felt.

Shop floor and trade union opposition is seen as a very important obstacle by 16 per cent of French establishments, by 14 per cent of German establishments, but by only 7 per cent of British establishments.

In New Zealand, direct comparisons with Britain, Germany and France are not possible because of both the way in which the survey questions were asked and the way the responses were collated. Nonetheless, New Zealand (in 1986) appears similar to the three overseas countries (in 1983) in that lack of people with microelectronics expertise and various economic difficulties are cited by a proportionately high number of New Zealand establishments.

8.5 Skills and Training

The establishments in the sample in Germany, in 1983, had about one-sixth more engineers with microelectronics expertise than the ones in France, and probably more than the establishments in Britain. The New Zealand establishments - in 1986 - had, on average, significantly fewer engineers with microelectronics experience per establishment, as is illustrated in Tables 8.5.1 and 8.5.2 below. Much of the reason for this difference, however, would be accounted for by the fact that the average size of the establishments (in terms of numbers employed) in the three overseas countries' samples exceeds the average size of the establishments in the New Zealand sample by a factor of about four times.

Table 8.5.1 ENGINEERS WITH MICROELECTRONICS EXPERTISE - ENGINEERS IN SAMPLE OF PRODUCT-USER ESTABLISHMENTS [BASE: PRODUCT-USERS IN PRODUCTION]

	TWO YEARS AGO				NOW			
	Britain 1981	Germany 1981	France 1981	NZ 1984	Britain 1983	Germany 1983	France 1983	NZ 1986
Base [establishments]	198	290	159	55*	198	290	159	55*
Average number of engineers	9	14	14	4	15	18	23	7

* For New Zealand, base includes product-users and intending users

Table 8.5.2 ENGINEERS WITH MICROELECTRONICS EXPERTISE - ENGINEERS IN SAMPLE OF PROCESS-USER ESTABLISHMENTS [BASE: PROCESS-USERS IN PRODUCTION]

	TWO YEARS AGO				NOW			
	Britain 1981	Germany 1981	France 1981	NZ 1984	Britain 1983	Germany 1983	France 1983	NZ 1986
Base [establishments]	578	900	686	243*	578	900	686	243*
Average number of engineers	2	8	7	2	4	10	10	3

* For New Zealand, base includes process-users and intending users

In all four countries, these engineers are heavily concentrated in the larger size establishments, in a few industries - especially fabricated metal products and equipment (which covers electrical engineering and vehicles in the overseas establishments).

There is a relatively high concentration of engineers in establishments with product applications, possibly because these applications tend to require more technical expertise than process applications.

8.6 Jobs

(1) CHANGES IN THE NUMBER OF JOBS - Respondents in the user establishments in all four surveys were asked what, if any, changes there had been in their workforces in the previous two years as a result of their use of microelectronics. The validity of answers to questions of this kind is open to a number of reservations and the comparative figures in Table 8.6.1 should therefore be treated accordingly. In particular, it will involve countries at different stages in their business cycles. Nonetheless, the broad similarities between the four countries in the pattern that emerges suggests that the data give a reasonably reliable indication of what has been occurring.

Several points emerge from the comparison. Firstly, around two-thirds of the factories in the samples in each country report that there has been, on balance, no change in the number of jobs as a result of their using microelectronics. Secondly, where there has been a change, it has not always been a net decrease. Furthermore, in New Zealand, the percentage of establishments reporting net increases almost matches the percentage reporting net decreases, whereas in Germany and France the net decreases are twice as common as the net increases - and in Britain about four times as common.

Table 8.6.1 CHANGES IN EMPLOYMENT DUE TO USE OF MICROELECTRONICS - INCREASES AND DECREASES IN JOBS BY SIZE OF ESTABLISHMENT: PERCENTAGES [BASE: ALL PRODUCT-USERS AND PROCESS-USERS IN PRODUCTION COMBINED]

	Britain 1981-83	Germany 1981-83	France 1981-83	New Zealand 1984-86
Base	776 [100%]	943 [100%]	726 [100%]	256* [100%]
Percentage of establishments with:				
increase in jobs [net]	5%	10%	6%	13%
no changes in jobs [net]	67%	69%	71%	68%
decrease in jobs [net]	21%	20%	12%	15%
don't know/not stated	7%	2%	11%	5%

* for New Zealand, base includes users and intending users combined

Net decreases in job numbers are significantly more common in the larger establishments in all four countries, whereas the percentage of establishments reporting a net increase in jobs shows little variance with size.

There are also differences among industries. In both Britain and Germany between 1981 and 1983, for example, there were noticeably high percentages of establishments reporting net increases in jobs in electrical engineering and particularly low percentages of establishments reporting net increases (and net decreases) in jobs in clothing. In New Zealand, the establishments reporting a net increase in jobs have the highest concentration within the paper and paper products industries, while those reporting a net decrease in jobs have the highest concentration in the non-metallic mineral products industries.

(2) CONSULTATION - The introduction of microelectronics to the workplace can have a major effect on jobs and employees; this raises the question of management consultation with staff and/or unions concerning the introduction of new technology. In fact the practice of consultation is far from universal in all four countries. In New Zealand, 35 per cent of the establishments in the sample engaged in consultation (1986 survey); in Britain (1983 survey) the figure was 51 per cent; in Germany (1983 survey) 40 per cent; and in France (1983 survey) 23 per cent.

CHAPTER 9

CONCLUSION

This study has generated new information and new insights concerning the diffusion of microelectronics into products and production processes in New Zealand manufacturing industry. Until now, much of the comment about such important issues as how modern is the plant used by New Zealand manufacturers, the pressures to innovate, and the effects that the technology has had on employment and productivity, has been largely speculative. This chapter summarises some of the more important results of the study and closes by commenting on some pertinent issues.

The survey showed that, in 1986, just over one-half of the manufacturing establishments in the sample used microelectronics technologies in their process applications, whereas only 12 per cent produced products incorporating microelectronics. Twenty-three per cent of non-users saw no scope for the incorporation of such new technologies in either their products or production processes. New Zealand manufacturers have been surveyed at a time when they have been rapidly updating their technologies. For example, 17 per cent of product-users stated that over one-half of their output contained microelectronic technologies in 1984; by 1986 this figure had risen to 28 per cent and was expected to rise to 43 per cent in 1988. During the five-year period ending in 1986, the number of establishments commencing production of microelectronic-based products was nearly five times the number that commenced in the preceding five-year period, which was more than twice the number in the five-year period before that - in the early 1970s. The number of establishments commencing production with microelectronic-based process technologies between 1981 and 1986 was four times that of the preceding five years, which was five times that of the early 1970s.

In general, the larger the establishment the more likely it is to report the use of microelectronics applications in its products or production processes although this is not surprising because the larger factory would also have a tendency to be carrying out a greater range of activities. Of more significance is the result that establishments with foreign parents have had faster uptake of microelectronic product applications and are more likely to be manufacturing products incorporating microelectronics than are locally owned establishments. It appears that this difference may be associated with a number of factors including easier access to technologies for firms with foreign parents, together with greater ability to market the products. Foreign ownership does not seem to affect the propensity to use microelectronics technologies in production processes.

As found in other countries (in earlier surveys), one-half of the establishments using microelectronics in products are concentrated within the fabricated metal products and equipment industries. Those using microelectronics in their production processes are much more widely dispersed by sector though one-quarter were again to be found in the fabricated metal products and equipment sector.

The survey found a wide range of products in which microelectronics have been incorporated, and also reported on numerous microelectronics production process applications involving fabrication, design, tooling, fault diagnosis, maintenance, testing and quality control, automated nandling and storage, and control of machines and stages of processes. The main source of microelectronics technologies used is from standard catalogue items from outside suppliers, although overseas-based companies are more likely to use custom-designed componentry and systems. Whereas, in 1986, microelectronics applications in production processes were principally utilised in programmable logic controllers, computer aided design units and machine controllers, in two years time there is expected to be relatively more emphasis on industrial robots (that can replace machines in carrying out a variety of complex tasks), pick and place machines and, to a lesser extent, flexible manufacturing cells.

When respondents were asked to indicate the main problems they faced in incorporating microelectronics, they reported that their main technical difficulty is lack of people with microelectronics expertise. They also reported various minor problems: in particular difficulties with software, with servicing and problems with suitable sensors. The main economic difficulty reported is the high development costs of systems. Other economic problems mentioned include high production costs, lack of finance, lack of volume in New Zealand and competition from overseas. Few cited exchange rates or the absence of government support programmes as being crucial. New Zealand establishments are somewhat pessimistic in assessing whether they are in front or behind their competitors. Twenty-two per cent of product-users felt they were ahead and 43 per cent felt they were behind. This compares with only 8 per cent of process-users who felt they were ahead and 51 per cent who felt they lagged behind.

Establishments report that the major source of funding to finance investment in microelectronics comes from internal funds. Less important sources quoted include term finance from banks, finance houses and other financial institutions. Very few firms cited finance from supplier or equity/venture capital. Technical assistance is most commonly received from equipment suppliers and from the parent firm or other companies within the group. Other significant sources of help are the DSIR and commercial consultancy firms, as well as other companies. Fewer establishments receive help from industrial research associations, universities and technical colleges (polytechnics). Respondents generally rate the effectiveness of these agencies highly.

Respondents report that the number of engineers with microelectronics expertise has increased markedly over the 1984-1986 period. Most establishments, however, would still like to see significantly more electronics engineers available.

The effects of microelectronics investment on jobs is a complex and much argued issue encompassing both direct and indirect effects. It appears, however, that in New Zealand's case investment - at least until 1986 - has been reasonably neutral with respect to jobs. Two-thirds of all manufacturers in the sample consider that their investment in microelectronics has had no effect on the number of employees, while the remainder are divided fairly evenly between net job gains and net job losses. Unskilled workers have been, it appears, slightly increased in those establishments where microelectronics have been introduced, whereas both women's jobs and skilled jobs appear more likely to have been boosted, in net terms, by the new technologies. Only 35 per cent of employers claim to have discussed the introduction of these new technologies with the relevant union(s) or their workforce beforehand.

When asked to summarise the effects that the microelectronics technologies have had, a 12 per cent balance of manufacturers reported that the technology has enabled them to increase their domestic competitiveness. In net terms, a few also added that there have been positive effects on their labour productivity and profitability. On balance, however, no manufacturers thought that their international competitiveness has been enhanced by these investments.

We were able to test the validity of the general pessimism concerning international competitiveness by comparing the New Zealand results with those obtained from earlier surveys in Britain, Germany, France and Japan - bearing in mind that the latter surveys were completed around three years earlier (or four years in the case of Japan) than the New Zealand survey. It appears, overall, that New Zealand manufacturers may now (1986) only be marginally behind the stage reached by Britain and France in 1983 with respect to the incidence of both products incorporating microelectronics and the use of microelectronics-based production processes. There are, of course, variations in sectoral specialisation between these countries. The surveys used in our comparison suggest, however, that Germany and Japan have achieved, relatively, the most widespread application of the new technologies.

In New Zealand, however, compared with the other countries, a much lower proportion of microelectronics product-users have designed and built their own systems. Presumably the reason for this is partly because New Zealand manufacturers have, on average, smaller plants. The type of microelectronics equipment used to date in New Zealand has also tended to be less sophisticated with, for example, more widespread usage of programmable logic controllers and computer aided design units rather than robots, pick and place machines, and flexible manufacturing cells. In spite of these differences, similar technical and economic difficulties to those cited in the New Zealand survey were cited in the surveys of overseas countries. In New Zealand, however, firms report that microelectronics technologies are associated with less job shedding, on balance, than in the other countries reviewed.

These results convey an impressionistic yet persuasive picture of New Zealand manufacturing industry as being reasonably up to date with its microelectronics technologies, albeit with relatively less widespread adoption of the very sophisticated equipment in use in parts of Europe and Japan. New Zealand's output of microelectronics products is significantly lower than in some large industrial countries, but this is at least partly attributable to the smaller size of New Zealand firms, their more limited markets, and the fact that in many cases they are domestically-owned rather than owned by foreign (parent) companies. Diffusion of new microelectronics-based products and production processes continues to be fairly rapid in New Zealand - as has been the overseas experience - even over a period of rather stagnant investment. The pressures to innovate appear to have originated from domestic competition and/or the expectation of a foreign parent company as opposed to an intrinsic desire to compete overseas. This revelation may seem to be somewhat contradictory to the current wisdom of the efficient, sophisticated New Zealand exporter competing vigorously in foreign markets. The effects of microelectronics investment on productivity and employment appear to have been generally positive. The indications are that, on balance, over the 1984-1986 period, labour productivity may have increased without a significant net loss of jobs. This is in contrast to the results reported by other countries in which there have been large productivity gains resulting from microelectronics investment, but at the expense of significant net job losses. (A notable exception here is within service sectors overseas, where net job growth has frequently been observed.) In a broad sense, New Zealand manufacturing firms seem prepared to accept responsibility - guided by market signals - for their decisions pertaining to microelectronics investment. In the main tney utilise market institutions and without major government support programmes. This is in striking contrast to the results reported by Stuart and Keir in 1980 when a relatively large proportion of respondents reported that they considered it was a responsibility of government to assist them with such investment programmes.[1] Finally, it is worth noting that in the majority of OECD countries there are a number of selective industry policies aimed at promoting the up-take of microelectronics and/or other high technologies in industry.

[1] Stuart, G.F. and Keir, M. (1979), **Problems and Expectations of the New Zealand Manufacturer**, DSIR, Lower Hutt.

LIST OF APPENDICES

Appendix 1

PRODUCTS INCORPORATING MICROELECTRONICS AS A PERCENTAGE OF ANNUAL OUTPUT OF PRODUCTS [BASE: PRODUCT-USERS IN PRODUCTION NOW (1984, 1986); PRODUCT-USERS AND INTENDING (1988)]

	1984	1986	Expected in 1988	Perceived Maximum Potential
Total	47	47	55	55
Percentage of annual output of products:				
0	10 21%	-	-	-
1-10	9 19%	11 23%	5 11%	4 9%
11-20	5 11%	5 11%	5 11%	2 4%
21-50	11 23%	14 30%	12 26%	13 28%
51-100	8 17%	13 28%	20 43%	25 53%
Don't know/Not specified	4 9%	4 9%	5 11%	3 6%

Appendix 2

PRODUCTION PROCESSES CONTROLLED BY MICROELECTRONICS AS A PERCENTAGE OF PROCESSES [BASE: ALL SURVEY RESPONDENTS (INCLUDING NON-USERS)]

	1984	1986	Expected in 1988	Perceived Maximum Potential
Total	387	387	387	387
Percentage of production processes				
0	238 61%	182 47%	185 48%	180 46%
1-10	44 11%	55 14%	31 8%	8 2%
11-20	23 6%	31 8%	21 5%	10 3%
21-50	42 11%	52 13%	56 14%	41 11%
51-100	27 7%	52 13%	79 20%	130 34%
Don't know/Not specified	13 4%	15 4%	15 4%	18 5%

Appendix 3

SCOPE FOR USING MICROELECTRONICS IN PRODUCTS - PERCENTAGE OF MAXIMUM VALUE OF ANNUAL OUTPUT BY INDUSTRY [BASE: NON-USERS WITH SCOPE IN PRODUCTS]

	TOTAL	Food/ Beverages /Tobacco	Textiles/ Wearing Apparel/ Leather Goods	Wood/ Wood and Cork Products	Paper/Paper Products/ Printing & Publishing	Chemicals/ Coal/ Petroleum/ Rubber Products	Non-metallic mineral Products	Basic Metal Industries	Fabricated Metal Products & Equipment	Other Manufacturing Industry
TOTAL	14	-	2	2	1	3	-	-	5	1
Maximum value of annual output:										
1-9	3 21%	-	-	-	-	1 33%	-	-	2 40%	-
10-19	3 21%	-	1 50%	1 50%	-	-	-	-	1 20%	-
20-49	2 14%	-	-	1 50%	-	-	-	-	1 20%	-
50-100	3 21%	-	-	-	1 100%	2 67%	-	-	-	-
Don't know	3 21%	-	1 50%	-	-	-	-	-	1 20%	1 100%

Appendix 4

SOURCE OF MICROELECTRONICS SYSTEM USED BY TYPE OF USER [BASE: ALL PRODUCT-USERS (AND INTENDING) AND ALL PROCESS-USERS (AND INTENDING)]

	Product-Users	Process-Users
TOTAL	55	243
ALL SOURCES		
Designed and made by you in your own factory	11 [20%]	21 [9%]
Made to your own specifications by an outside sub-contractor	7 [13%]	41 [17%]
Designed specifically for you by an outside company	9 [16%]	30 [12%]
Offered as standard catalogue item by an outside supplier	25 [45%]	184 [76%]
Not quite fitting any of these descriptions	3 [5%]	10 [4%]
MOST IMPORTANT SOURCE		
Designed and made by you in your own factory	3 [5%]	5 [2%]
Made to your own specifications by an outside sub-contractor	5 [9%]	10 [4%]
Designed specifically for you by an outside company	-	7 [3%]
Offered as standard catalogue item by an outside supplier	5 [9%]	23 [9%]
Not quite fitting any of these descriptions	-	2 [1%]

Appendix 5

SOURCE OF MICROELECTRONICS SYSTEM USED BY SIZE OF ESTABLISHMENT [BASE: ALL PRODUCT/PROCESS-USERS (AND INTENDING) COMBINED]

		Number of People Employed					
	TOTAL	1-19	20-49	50-99	100-199	200+	Don't know
TOTAL	256	20	38	58	50	87	3
ALL SOURCES							
Designed and made by you in your own factory	28 11%	2 10%	3 8%	8 14%	5 10%	9 10%	1 33%
Made to your own specifications by an outside sub-contractor	46 18%	2 10%	6 16%	12 21%	8 16%	17 20%	1 33%
Designed specifically for you by an outside company	37 14%	1 5%	7 18%	7 12%	8 16%	14 16%	-
Offered as standard catalogue item by an outside supplier	193 75%	15 75%	27 71%	48 83%	36 72%	66 76%	1 33%
Not quite fitting any of these descriptions	10 4%	1 5%	1 3%	1 2%	1 2%	6 7%	-

Appendix 6

SOURCE OF MICROELECTRONICS SYSTEM USED BY REGION [BASE: ALL PRODUCT/PROCESS-USERS (AND INTENDING) COMBINED]

		Urban Area				Area Type			
	TOTAL	Auck-land	Well-ington	Christ-church	Dunedin	Metro-politan	Provincial City	Towns/ Boroughs	Rural
TOTAL	256	99	34	28	0	169	46	26	15
ALL SOURCES									
Designed and made by you in your own factory	28 11%	13 13%	3 9%	6 21%	2 22%	22 13%	4 9%	2 8%	-
Made to your own specifications by an outside sub-contractor	46 18%	18 18%	6 18%	6 21%	-	30 18%	9 20%	4 15%	3 20%
Designed specifically for you by an outside company	37 14%	12 12%	8 24%	3 11%	1 11%	24 14%	9 20%	3 12%	1 7%
Offered as standard catalogue item by an outside supplier	193 75%	74 75%	25 74%	20 71%	7 78%	124 73%	36 78%	22 85%	11 73%
Not quite fitting any of these descriptions	10 4%	5 5%	1 3%	1 4%	1 11%	8 5%	-	2 8%	-

Appendix 7

TYPE OF MICROELECTRONICS COMPONENTRY USED BY SIZE OF ESTABLISHMENT [BASE: PRODUCT-USERS (AND INTENDING)]

		Number of People Employed					
	TOTAL	1-19	20-49	50-99	100-199	200+	Don't know
TOTAL	55	5	6	11	12	19	2
ALL TYPES							
Standard industrial microprocessors offered on catalogue	37 67%	4 80%	3 50%	8 73%	6 50%	14 74%	2 100%
Custom integrated circuits developed for your specific application	22 40%	2 40%	4 67%	3 27%	4 33%	9 47%	-
Semi-custom integrated circuits	14 25%	1 20%	1 17%	4 36%	2 17%	6 32%	-
MOST IMPORTANT TYPE							
Standard industrial microprocessors offered on catalogue	8 15%	1 20%	1 17%	1 9%	1 8%	4 21%	-
Custom integrated circuits developed for your specific application	5 9%	-	1 17%	1 9%	1 8%	2 11%	-
Semi-custom integrated circuits	2 4%	-	-	1 9%	1 8%	-	-
Don't know	5 9%	-	1 17%	-	-	4 21%	-

Appendix 8

TYPE OF MICROELECTRONICS COMPONENTRY USED BY REGION [BASE: PRODUCT-USERS (AND INTENDING)]

		Urban Area				Area Type			
	TOTAL	Auckland	Wgtn	Chch	Dunedin	Metropolitan	Provincial City	Towns/ Boroughs	Rural
TOTAL	55	21	9	8	1	39	12	4	-
ALL TYPES									
Standard industrial microprocessors	37	14	7	4	1	27	8	2	-
offered on catalogue	67%	67%	78%	50%	100%	69%	67%	50%	
Custom integrated circuits developed	22	7	5	4	-	14	6	2	-
for your specific application	40%	33%	56%	50%		36%	50%	50%	
Semi-custom integrated circuits	14	6	2	3	-	10	2	2	-
	25%	29%	22%	38%		26%	17%	50%	
MOST IMPORTANT TYPE									
Standard industrial microprocessors	8	3	1	2	-	5	2	1	-
offered on catalogue	15%	14%	11%	25%		13%	17%	25%	
Custom integrated circuits developed	5	1	2	-	-	3	2	-	-
for your specific application	9%	5%	22%			8%	17%		
Semi-custom integrated circuits	2	-	-	1	-	1	1	-	-
	4%			13%		3%	8%		
Don't know	5	3	-	1	-	4	1	-	-
	9%	14%		13%		10%	8%		

Appendix 9

TYPE OF MICROELECTRONICS COMPONENTS CURRENTLY USED (OR INTENDING) BY SIZE OF ESTABLISHMENT [BASE: PROCESS-USERS (AND INTENDING)]

		Number of People Employed					
	TOTAL	1-19	20-49	50-99	100-199	200+	Don't know
TOTAL	243	16	36	55	49	85	2
USING NOW							
Design	59 24%	3 19%	5 14%	11 20%	7 14%	33 39%	-
Machine control	162 67%	10 63%	21 58%	33 60%	29 59%	67 79%	2 100%
Process control	124 51%	6 38%	9 25%	23 42%	20 41%	64 75%	2 100%
Centralised machine control	51 21%	2 13%	5 14%	3 5%	10 20%	30 35%	1 50%
Integrated process control	54 22%	1 6%	4 11%	10 18%	8 16%	30 35%	1 50%
Automated handling	67 28%	3 19%	5 14%	10 18%	10 20%	38 45%	1 50%
Automated storage	22 9%	1 6%	-	2 4%	7 14%	11 13%	1 50%
Testing, quality control	80 33%	5 31%	8 22%	12 22%	17 35%	38 45%	-
Don't know	2 1%	-	-	1 2%	-	1 1%	-

Appendix 10

TYPE OF MICROELECTRONICS BASED EQUIPMENT USED BY SIZE OF ESTABLISHMENT [BASE: PROCESS-USERS (AND INTENDING)]

		Number of People Employed					
	TOTAL	1-19	20-49	50-99	100-199	200+	Don't know
TOTAL	243	16	36	55	49	85	2
TYPE OF EQUIPMENT USED							
CAD work stations	65 27%	3 19%	6 17%	6 11%	14 29%	36 42%	-
CNC machine tools	42 17%	3 19%	7 19%	9 16%	6 12%	17 20%	-
PLCs	97 40%	1 6%	5 14%	21 38%	14 29%	55 65%	1 50%
Machine controller	50 21%	1 6%	3 8%	7 13%	5 10%	33 39%	1 50%
Pick and place machines	15 6%	1 6%	-	3 5%	1 2%	10 12%	-
Robots	7 3%	-	-	-	-	7 8%	-
Flexible manufacturing cells	4 2%	-	-	-	-	4 5%	-

Appendix 11

MAIN TECHNICAL DISADVANTAGES AND PROBLEMS IN USE OF MICROELECTRONICS:PRODUCT-USERS BY SIZE OF ESTABLISHMENT - [BASE: PRODUCT-USERS (AND INTENDING)]

		Number of People Employed					
	TOTAL	1-19	20-49	50-99	100-199	200+	Don't know
TOTAL	55	5	6	11	12	19	2
TECHNICAL FACTORS							
Lack of people with microelectronics expertise	11 20%	1 20%	1 17%	2 18%	1 8%	6 32%	-
Problems with chips	2 4%	-	-	1 9%	-	1 5%	-
Problems with suitable sensors	3 5%	-	-	-	-	2 11%	1 50%
Problems with software	4 7%	-	-	-	1 8%	3 16%	-
Opposition from shop floor or unions	2 4%	-	-	-	-	2 11%	-
Opposition from management	1 2%	-	-	-	-	1 5%	-
Difficulties of communications with sub-contractors or suppliers	1 2%	-	-	-	-	1 5%	-
Servicing difficulties	3 5%	-	-	2 18%	-	1 5%	-
Training staff	1 2%	-	-	-	-	1 5%	-
Others	9 16%	4 80%	1 17%	1 9%	1 8%	1 5%	1 50%
No technical considerations/Don't know	23 42%	1 20%	5 83%	4 36%	8 67%	5 26%	-

Appendix 12

MAIN TECHNICAL DISADVANTAGES AND PROBLEMS IN USE OF MICROELECTRONICS - PROCESS-USERS BY SIZE OF ESTABLISHMENT
[BASE: PROCESS-USERS (AND INTENDING)]

		Number of People Employed					
	TOTAL	1-19	20-49	50-99	100-199	200+	Don't know
TOTAL	243	16	36	55	49	85	2
TECHNICAL FACTORS							
Lack of people with microelectronics expertise	59 21%	2 13%	8 22%	12 22%	9 18%	19 22%	-
Problems with chips	1 *	1 6%	-	-	-	-	-
Problems with suitable sensors	5 2%	-	1 3%	1 2%	1 2%	2 2%	-
Problems with software	9 4%	1 6%	-	2 4%	2 4%	4 5%	-
Opposition from shop floor or unions	7 3%	1 6%	1 3%	-	1 2%	4 5%	-
Opposition from management	3 1%	-	-	-	1 2%	2 2%	-
Difficulties of communications with sub-contractors or suppliers	5 2%	-	-	-	2 4%	3 4%	-
Servicing difficulties	11 5%	1 6%	2 6%	3 5%	3 6%	2 2%	-
Training staff	1 *	-	-	-	1 2%	-	-
Others	44 18%	3 19%	6 17%	14 25%	9 18%	12 14%	-
No technical considerations/Don't know	79 33%	7 44%	12 33%	17 31%	16 33%	26 31%	1 50%

Appendix 13

MAIN TECHNICAL DISADVANTAGES AND PROBLEMS IN USE OF MICROELECTRONICS - PRODUCT-USERS BY INDUSTRY CATEGORY [BASE: PRODUCT-USERS (AND INTENDING)]

	TOTAL	Food/ Beverages /Tobacco	Textiles/ Wearing Apparel/ Leather Goods	Wood/ Wood and Cork Products	Paper/Paper Products/ Printing & Publishing	Chemicals/ Coal/ Petroleum/ Rubber Products	Non-metallic Mineral Products	Basic Metal Industries	Fabricated Metal Products & Equipment	Other Manufacturing Industry
TOTAL	55	-	8	1	3	4	3	1	27	8
TECHNICAL FACTORS										
Lack of people with microelectronics expertise:										
	11 20%	-	-	1 100%	1 33%	1 25%	2 67%	-	5 19%	1 13%
Problems with chips:										
	2 4%	-	1 13%	-	-	-	-	-	1 4%	-
Problems with suitable sensors:										
	3 5%	-	1 13%	-	-	-	1 33%	-	1 4%	-
Problems with software:										
	4 7%	-	1 13%	-	1 33%	-	-	-	2 7%	-
Opposition from shop floor or unions:										
	2 4%	-	-	-	-	-	-	-	2 7%	-
Opposition from management:										
	1 2%	-	-	-	-	-	1 33%	-	-	-
Difficulties of communications with sub-contractors or suppliers:										
	1 2%	-	-	-	1 33%	-	-	-	-	-

Appendix 13 (continued)

Servicing difficulties:	3 5%	-	-	-	-	1 25%	-	-	2 7%	-
Training staff:	1 2%	-	-	-	-	-	-	-	-	1 13%
Others:	9 16%	-	1 13%	-	-	1 25%	-	-	5 19%	2 25%
No technical considerations/Don't know:	23 42%	-	5 63%	-	-	1 25%	1 33%	1 100%	12 44%	3 38%

Appendix 14

MAIN TECHNICAL DISADVANTAGES AND PROBLEMS IN USE OF MICROELECTRONICS - PROCESS-USERS BY INDUSTRY CATEGORY
[BASE: PROCESS-USERS (AND INTENDING)]

	TOTAL	Food/ Beverages /Tobacco	Textiles/ Wearing Apparel/ Leather Goods	Wood/ Wood and Cork Products	Paper/Paper Products/ Printing & Publishing	Chemicals/ Coal/ Petroleum/ Rubber Products	Non-metallic Mineral Products	Basic Metal Industries	Fabricated Metal Products & Equipment	Other Manufacturing Industry
TOTAL	243	42	31	18	28	26	12	6	71	9
TECHNICAL FACTORS										
Lack of people with microelectronics expertise:										
	50	11	5	4	6	8	-	1	13	2
	21%	26%	16%	22%	21%	31%		17%	18%	22%
Problems with chips:										
	1	-	-	-	-	-	-	-	1	-
	*								1%	
Problems with suitable sensors:										
	5	1	1	1	-	-	1	1	-	-
	2%	2%	3%	6%			8%	17%		
Problems with software:										
	9	1	1	-	2	2	-	-	3	-
	4%	2%	3%		7%	8%			4%	
Opposition from shop floor or unions:										
	7	2	1	-	-	1	-	1	2	-
	3%	5%	3%			4%		17%	3%	
Opposition from management:										
	3	1	-	1	-	-	-	1	-	-
	1%	2%		6%				17%		
Difficulties of communications with sub-contractors or suppliers:										
	5	-	-	-	2	1	-	-	2	-
	2%				7%	4%			3%	

Appendix 14 (continued)

Servicing difficulties:	11 5%	2 5%	2 6%	-	4 14%	1 4%	-	-	1 1%	1 11%
Training staff:	1 *	-	-	-	1 4%	-	-	-	-	-
Others:	44 18%	8 19%	10 32%	2 11%	7 25%	2 8%	2 17%	2 33%	11 15%	-
No technical considerations/Don't know:	79 33%	13 31%	9 29%	6 33%	10 36%	10 38%	5 42%	1 17%	23 32%	2 22%

Appendix 15

MAIN ECONOMIC DISADVANTAGES AND PROBLEMS IN USE OF MICROELECTRONICS - PRODUCT-USERS BY SIZE OF ESTABLISHMENT
[BASE: PRODUCT-USERS (AND INTENDING)]

		Number of People Employed					
	TOTAL	1-19	20-49	50-99	100-199	200+	Don't know
TOTAL	55	5	6	11	12	19	2
ECONOMIC CONSIDERATIONS							
High cost of development	12	-	2	2	2	5	1
	22%		33%	18%	17%	26%	50%
High production costs	4	-	-	2	-	1	1
	7%			18%		5%	50%
Lack of finance	3	-	-	-	1	1	1
	5%				8%	5%	50%
The tax regime	1	-	-	1	-	-	-
	2%			9%			
High price of technology	1	-	1	-	-	-	-
	2%		17%			5%	
Volatile exchange rates	2	-	1	-	-	1	-
	4%		17%			5%	
Lack of specific government support programmes	1	-	-	-	-	1	-
	2%					5%	
Competition from overseas	3	1	-	-	-	2	-
	5%	20%				11%	
Lack of volume in New Zealand	2	1	-	1	-	-	-
	4%	20%		9%			
Others	2	1	-	1	-	-	-
	4%	20%		9%			
No economic considerations/Don't know	30	4	2	7	6	10	1
	55%	80%	33%	64%	50%	53%	50%

Appendix 16

MAIN ECONOMIC DISADVANTAGES AND PROBLEMS IN USE OF MICROELECTRONICS - PROCESS-USERS BY SIZE OF ESTABLISHMENT
[BASE: PROCESS-USERS (AND INTENDING)]

		Number of People Employed					
	TOTAL	1-19	20-49	50-99	100-199	200+	Don't know
TOTAL	243	16	36	55	49	85	2
ECONOMIC CONSIDERATIONS							
High cost of development	45 19%	4 25%	5 14%	16 29%	11 22%	8 9%	1 50%
High production costs	15 6%	1 6%	4 11%	4 7%	3 6%	3 4%	-
Lack of finance	8 3%	2 13%	1 3%	-	3 6%	2 2%	-
The tax regime	1 *	-	1 3%	-	-	-	-
High price of technology	19 8%	1 6%	3 8%	5 9%	3 6%	7 8%	-
Volatile exchange rates	2 1%	-	-	-	1 2%	1 1%	-
Lack of specific government support programmes	1 *	-	1 3%	-	-	-	-
Competition from overseas	7 3%	1 6%	1 3%	1 2%	-	4 5%	-
Lack of volume in New Zealand	13 5%	-	4 11%	4 7%	5 10%	-	-
Others	13 5%	-	4 11%	4 7%	5 10%	-	-
No economic considerations/Don't know	110 45%	9 56%	15 42%	22 40%	18 37%	46 54%	-

Appendix 17

CHANGES IN EMPLOYMENT DUE TO USE OF MICROELECTRONICS - NUMBER OF JOBS GAINED OR LOST BY INCREASE OR DECREASE IN NUMBER OF JOBS PER ESTABLISHMENT [BASE: ALL PRODUCT AND PROCESS-USERS (AND INTENDING) COMBINED]

Number of People Employed:	TOTAL	1-19	20-49	50-99	100-199	200+	Don't know
TOTAL	256	20	38	58	50	87	3
INCREASES IN JOBS (NET)							
1-4	16	2	2	6	-	6	-
	6%	10%	5%	10%		7%	
5-9	4	1	-	2	1	-	-
	2%	5%		3%	2%		
10-19	5	-	1	2	1	1	-
	2%		3%	3%	2%	1%	
20-29	1	-	-	-	1	-	-
	*				2%		
30-39	3	-	-	-	2	1	
	1%				4%	1%	
40-49	1	-	-	-	-	1	-
	*					1%	
50+	3	-	-	1	-	2	-
	1%			2%		2%	
DECREASES IN JOBS (NET)							
1-4	15	1	7	2	1	4	-
	6%	5%	18%	3%	2%	5%	
5-9	8	-	-	2	2	4	-
	3%			3%	4%	5%	
10-19	4	-	1	-	-	3	-
	2%		3%			3%	
20-29	4	-	-	1	-	3	-
	2%			2%		3%	
30-39	3	-	-	1	-	2	-
	1%			2%		2%	

... continued ...

Appendix 17 (continued)

	TOTAL	1-19	20-49	50-99	100-199	200+	Don't know
40-49	-	-	-	-	-	-	-
50+	4 2%	-	-	-	-	4 5%	-
NUMBER OF ESTABLISHMENTS WITH							
Increase in jobs (net)	33 13%	3 15%	3 8%	11 19%	5 10%	11 13%	-
No change in jobs (net)	173 68%	16 80%	28 74%	39 67%	39 78%	49 56%	2 67%
Decrease in jobs (net)	38 15%	1 5%	8 21%	6 10%	3 6%	20 23%	-
Don't know/Not stated	12 5%	-	-	2 3%	3 6%	6 7%	1 33%

SURVEY QUESTIONNAIRE DETAILS

Q.1 Are you at present using the new microelectronic technology in your products? By new microelectronic technology I mean the use of microprocessors or their electronic equivalents (e.g. custom chips or semi-custom chips), normally with LSI or VLSI circuitry, either in the form of single integrated circuit devices or in small groups of linked devices.

USE IN PRODUCTS MEANS INCORPORATION OF INTEGRATED CIRCUITS IN THE PRODUCT ITSELF.

Q.2 When did you first go into production with a product incorporating microelectronics technology?

Q.3 Do you think there is potentially scope for using microelectronics in your products?

Q.4 Have you started actual development work on it?

Q.5 Have you investigated the feasibility of using it?

Q.6 What was the outcome?

APPLICATION FOUND TO BE NOT FEASIBLE
APPLICATION FEASIBLE, BUT DECIDED NOT TO GO AHEAD AND DEVELOP IT
APPLICATION FEASIBLE, DECIDED TO GO AHEAD AND DEVELOP IT, BUT NOT DOING SO YET
APPLICATION FEASIBLE, BUT NOT YET DECIDED WHETHER OR NOT TO GO AHEAD AND DEVELOP IT
INVESTIGATION NOT YET COMPLETED, NOT YET KNOWN WHETHER APPLICATION IS FEASIBLE
OTHER OUTCOME (Write in)

Q.7 When do you first plan to go into production with a product incorporating the new microelectronics technology?

Q.8 In which of your products are you already using/intending to use the new microelectronics technology?

Q.9 Roughly what percentage of the value of your annual output do the product(s) in which you use microelectronics represent?

Q.10 Roughly what percentage of the value of your annual output did they represent two years ago?

Q.11 Roughly what percentage of the value of your annual output do you expect products incorporating microelectronics will represent in two years time or so?

---

[1] This section summarises the main questions asked in the survey questionnaire. (Copies of the actual survey questionnaire are available from the NZIER, on request.)

Q.12 Roughly what percentage of the value of your annual output do you regard as the very maximum for which there is potentially scope for using microelectronics in your kinds of products?

Q.13 Is the microelectronics system you are using/intending to use in your products mainly ...

DESIGNED AND MADE BY YOU IN YOUR OWN FACTORY
MADE TO YOUR OWN SPECIFICATIONS BY AN OUTSIDE SUB-CONTRACTOR
DESIGNED SPECIFICALLY FOR YOU BY AN OUTSIDE COMPANY
OFFERED AS STANDARD CATALOGUE ITEM BY AN OUTSIDE SUPPLIER
(NOT QUITE FITTING ANY OF THESE DESCRIPTIONS)

IF MORE THAN ONE CATEGORY IS MENTIONED, ASK WHICH IS THE MOST IMPORTANT

Q.14 Is the outside sub-contractor or equipment manufacturer ...

LOCATED IN NEW ZEALAND
LOCATED IN AUSTRALIA
LOCATED ELSEWHERE

IF MORE THAN ONE AREA MENTIONED, ASK WHICH THEY THINK IS THE MOST IMPORTANT

Q.15 What type of microelectronics components are you using/intending to use in your products?

IF MORE THAN ONE PRODUCT ASK WHICH IS MOST IMPORTANT
IF MORE THAN TWO, ALSO CODE WHICH IS SECOND MOST IMPORTANT

STANDARD INDUSTRIAL MICROPROCESSORS OFFERED ON CATALOGUE
CUSTOM INTEGRATED CIRCUITS DEVELOPED FOR YOUR SPECIFIC APPLICATION
SEMI-CUSTOM INTEGRATED CIRCUITS

....

Q.18 (a) As far as you are aware, have your main competitors in New Zealand already applied microelectronics technology in their products?

(b) As far as you are aware, have your main competitors in Australia already applied microelectronics technology in their products?

(c) And again, as far as you are aware, have your main competitors elsewhere already applied microelectronics technology in their products?

....

Q.31 (a) Are you at present using microelectronics in the following operations?

(b) Are you planning to use/continue to use microelectronics within the next two years or so?

DESIGN
MACHINE CONTROL (of individual machines)
PROCESS CONTROL (of individual items of process plant)
CENTRALISED MACHINE CONTROL (of groups of machines)
INTEGRATED PROCESS CONTROL (of several stages of processes)
AUTOMATED HANDLING (of products, materials or components)
AUTOMATED STORAGE
TESTING, QUALITY CONTROL

NOW SOME QUESTIONS ABOUT THE SORT OF EQUIPMENT YOU ARE USING

Q.32 (a) Are you at present using any CAD workstations?

(b) How many?

(c) About how many do you expect to use in two years time?

(d) Do you plan to use any in 2 years time?

(e) About how many?

CAD WORK STATIONS
CNC MACHINE TOOLS
PLCs
MACHINE CONTROLLERS
PICK AND PLACE MACHINES
ROBOTS
FLEXIBLE MANUFACTURING CELLS

....

Q.38 (a) As far as you are aware, have your main competitors in New Zealand already applied microelectronics technology in their production processes?

(b) As far as you are aware, have your main competitors in Australia already applied microelectronics technology in their production processes?

(c) And again, as far as you are aware, have your main competitors elsewhere already applied microelectronics technology in their production processes?

HAVE APPLIED
HAVE NOT APPLIED
NO COMPETITORS
DON'T KNOW

Q.39 In general, do you believe you are ahead of or behind your main overseas competitors in applying microelectronics technology in your products? Would you say that you are:

DEFINITELY AHEAD
PROBABLY AHEAD
ABOUT LEVEL
PROBABLY BEHIND
DEFINITELY BEHIND
(DON'T KNOW)
(NO MAJOR COMPETITOR)

Q.40 What do you see as the most important disadvantages and problems in the use of microelectronics in your products?

Q.41 In your experience are any of the following potential disadvantages or problems "Very Important"?

(a) TECHNICAL FACTORS

Lack of people with microelectronics expertise
Problems with chips
Problems with suitable sensors (or other input/output devices)
Problems with "software" (programming)
Opposition from shop floor or unions
Opposition from management
Difficulties of communications with sub-contractors or suppliers (e.g. difficulty in understanding their technical jargon)
Other technical considerations

(b) ECONOMIC FACTORS

High cost of development
High production costs
Lack of finance
The tax regime
High price of technology
Volatile exchange rates
Lack of specific Government support programmes
Competition from overseas
Other economic considerations

Q.42 How have you financed/are intending to finance the purchase of major items of microelectronic equipment, i.e. items costing more than $50,000? DO NOT PROMPT

INTERNAL FUNDS
TERM FINANCE FROM BANK, FINANCE HOUSE/OTHER FINANCIAL INSTITUTION
FINANCE FROM SUPPLIER
EQUITY/VENTURE CAPITAL
OTHER
NOT YET DECIDED

....

Q.47 How many (if any) engineers with specific microelectronics expertise do you have on your staff?

I.E. PEOPLE WHO CAN DO THE WORK NEEDED, WHETHER OR NOT THEY HAVE BEEN FORMALLY TRAINED IN MICROELECTRONICS

Q.48 And how many (if any) did you have two years ago?

Q.49 And how many more (if any) would you like to have now?

Q.50 Of the engineers with microelectronics expertise that you have now, about what percentage are professional engineers, i.e. have degrees in engineering and/or are chartered members of one of the engineering institutions?

Q.51 What has the introduction of the new microelectronics technology in your products and/or production processes meant so far in terms of changes in the number of jobs - by roughly how many has the total numbers increased or decreased overall as a direct result of this in the past two years or so?

APPROXIMATE INCREASE
APPROXIMATE DECREASE

Q.52 And roughly what change in the number of jobs overall do you expect it to mean in the next two years or so?

APPROXIMATE INCREASE
APPROXIMATE DECREASE

Q.53 And how has it affected women? Roughly what has been the increase or decrease in the number of women employed as a result of using microelectronics in your products and/or production processes in the past two years or so?

APPROXIMATE INCREASE
APPROXIMATE DECREASE

Q.54 And what change in the number of women employed do you expect in the next two years or so?

APPROXIMATE INCREASE
APPROXIMATE DECREASE

Q.55 And skilled shop floor jobs? How has the number of skilled shop floor jobs changed as a result of using microelectronics in the past 2 years or so?

APPROXIMATE INCREASE
APPROXIMATE DECREASE

Q.56 And what change in the number of skilled shop floor jobs do you expect in two years time or so? (As a result of using microelectronics)

APPROXIMATE INCREASE
APPROXIMATE DECREASE

Q.57 And other shop floor jobs? What has been the change in these (as a result of using microelectronics) in the past 2 years or so?

APPROXIMATE INCREASE
APPROXIMATE DECREASE

Q.58 And what change in other shop floor jobs do you expect in two years time (as a result of using microelectronics)?

APPROXIMATE INCREASE
APPROXIMATE DECREASE

Q.59 When the microelectronic technology was first introduced, was there consultation with the workforce/union?

YES
NO

Q.60 As a result of the new microelectronics technology being introduced, have there been any actual redundancies, voluntary or involuntary? If so, roughly how many?

VOLUNTARY REDUNDANCIES
INVOLUNTARY REDUNDANCIES
TOTAL REDUNDANCIES

Q.61 (a) Which kinds of outside agencies have you sought help from in doing research and development work on microelectronics applications?

ASK FOR EACH OUTSIDE AGENCY USED

(b) How useful have the ...... been to you? Were they essential, quite useful or not so useful?

EQUIPMENT SUPPLIERS
COMMERCIAL CONSULTANCY FIRMS
PARENT OR OTHER COMPANIES IN GROUP
OTHER COMPANIES
PROFESSIONAL ASSOCIATIONS
INDUSTRIAL RESEARCH ASSOCIATIONS
UNIVERSITIES
TECHNICAL COLLEGES
D.S.I.R
DEPT OF TRADE & INDUSTRY
DEVELOPMENT FINANCE CORPORATION
OTHER (please specify)

Q.62 Has the introduction of the new microelectronics technology in your products and/or production processes allowed you, over the last two years, to increase your labour productivitiy considerably, slightly or not at all?

CODE BELOW, THEN REPEAT FOR:

... PROFITABILITY
... ABILITY TO COMPETE ON LOCAL MARKETS
... INTERNATIONAL COMPETITIVENESS

....

Q.65 Of the total number of people employed in your establishment, roughly what percentage are women?

Q.66 And roughly what percentage of the total number employed at your establishment are skilled shop floor workers?

Q.67 And roughly what percentage of the total number employed at your establishment are employed in other shop floor jobs?

Q.68 What is the main business activity carried out at this establishment?

Q.69 Is your company independent or part of a group?

Q.70 What is the nationality of the ultimate parent company?

Q.71 And how many employees does your company have at this address?

FINISH OF QUESTIONNAIRE

GLOSSARY*

The following terms are commonly encountered in the literature related to microelectronics in manufacturing industry.

ACTUATOR - a device to translate electrical signals into physical action, e.g. opening or closing a valve.

ANALOGUE - the representation of the behaviour of a system by continuously variable factors, e.g. currents or voltage (the opposite of digital).

CAD - computer aided design (using keyboard/visual display units) system allows the on-line construction of a highly detailed design drawing using a variety of interaction devices and programming techniques.

CAD/CAM - computer aided design/computer aided manufacture. This refers to the integration of computers into the entire design-to-fabrication cycle of a product or plant.

CAE - computer aided engineering. This computer based facility allows analysis of a design for basic error checking or to optimise manufacturability, performance and economy. Information is drawn from CAD/CAM design database.

CAM - computer aided manufacturing. The use of computers to generate manufacturing data. Information from a CAD/CAM data base can assist in or control a proportion or all of a manufacturing process. CAM techniques can be used to produce process plans for manufacturing a complete assembly, to programme robots and to co-ordinate plant operation.

CHIPS - an integrated circuit contained on a small fragment ('chip') of semiconductor material (usually silicon). Different chips can have different functions depending on the circuit, e.g. memory, computing, controlling input and output signals.

CIM - computer integrated manufacturing. The concept of a totally automated factory in which all manufacturing processes are integrated and controlled by a CAD/CAM system. CIM will enable production planners and schedulers, shop-floor foremen and accountants to use the same database as product designers and engineers.

CIRCUIT BOARD - a board on which all necessary electronic components for a system are mounted.

CNC - computer numerical control; a means of controlling machinery by programmed instructions from a small computer or microprocessor.

CONVERTERS - a special electronic arrangement to convert analogue ('real world') type signals into digital ('computer manageable') type signals, and vice versa.

DEDICATED EQUIPMENT - equipment designed or intended for a single function or use.

DNC - direct numerical control. A system in which sets of NC machines are connected to a mainframe computer to establish a direct link between the DNC computer memory and the machine tools, which are directly controlled by the computer without the use of tape. See also NC and CNC.

DIGITAL - type of signal (opposite analogue) in which behaviour of a system is represented by discontinuously variable factors, e.g. an on/off switch.

DOWNTIME - the time when a system (such as a robot system) is not available for production due to breakdown in the hardware, software, ancillary equipment or associated processes and parts, or due to required maintenance.

FMC - flexible machining centre. Usually a multi-robot system that comprises CNC machines with robots loading and unloading parts that are conveyed into and through the system.

FMS - flexible manufacturing system. An arrangement of machines (typically machining centres under numerical control with tool changers) interconnected by a transport system. The transporter carries work to the machines on pallets or other units. A central computer controls machines and transport.

GRIPPER - a robot 'hand' which picks up, holds and releases the part or object being handled.

HARDWARE - the physical components of a computer or microprocessor system.

INTEGRATED CIRCUIT - an electronic analogue or digital circuit constructed in a single semiconductor chip.

INTEGRATED SYSTEM - a CAD/CAM system which integrates the product development cycle (analysis, design and manufacture) so that all processes flow smoothly from concept to production.

MACHINE CONTROLLERS - for more complex control application than can be handled by a PLC.

MINICOMPUTER - originally a computer smaller than a large 'mainframe' one, but nowadays a medium-sized computer larger than the new 'micro' one.

NAKED ROBOT - a robot which is bought 'off the shelf' and then developed, installed and integrated by the user.

NC - numerical control. A technique of operating machine tools or similar equipment in which motion is developed in response to numerically coded commands, usually stored on a tape. See also CNC and DNC.

PICK AND PLACE MACHINES - like robots, but less expensive, less versatile, for less varied and less complex tasks.

PLA - programmable logic array. An integrated circuit having fixed memory cells which can be programmed to customer requirements at a late stage in design process.

PLC - programmable logic controller. Custom integrated circuit devices developed around 1969 as replacements for relay logic in numerically controlled machine tool and process control applications.

PROGRAMMING - robots can be programmed in the following ways: (1) the robot is placed in 'teach' mode of operation and points in space are recorded as the robot is led through the desired sequence of movements; (2) the robot, in teach mode, is manually walked through the sequence of movements and operations; (3) a pre-recorded programme is transferred to the robot's control unit, usually via a magnetic tape, and (4) some robots are directly controlled from a computer running programmes which specify the robots' movements and operations.

ROBOT - the Japanese Industrial Robot Association defines five categories of robot: (1) manipulators - devices controlled directly by an operator; (2) sequential robots - manipulators operated according to a pre-established sequence - (i) a fixed sequence - a sequence that cannot be easily modified, (ii) a variable sequence - a sequence that can be readily modified; (3) playback robots - manipulators which store in their memory a sequence demonstrated by the operator; (4) NC robots - manipulator robots which receive instructions from a numerical controlled station; and (5) intelligent robots - robots capable of understanding the tasks required of them thanks to the capacities of a sensor and means of recognition.

RAM - random access memory. Memory which can be both written into and read from by a microprocessor.

ROM - read only memory. Programmes, once stored in ROM, cannot be altered, and are called firmware as opposed to software.

REAL TIME - refers to a system in which the processing of information occurs simultaneously with the event generating the data.

RELAY LOGIC - control system based upon a series of electromechanical switches called relays.

RETROFITTED - a control system capable of being fitted to an existing machine.

SENSORS - part of a control system concerned with detecting changes in the process under control.

SERIAL DATA LINK - transmission system in which information is passed consecutively in sequence.

SOFTWARE - the collection of analysis, programming, testing, documentation, and so on, required to make a computer system function.

SOFT-WIRED - system in which the various control functions are provided in the form of instructions in a programme.

SOLID STATE - based on the electronic properties of solids (as opposed to valves which are based on properties of gases).

TRANSDUCER - a device which converts physical process information into that required by a controller and vice versa.

ULA - uncommitted logic array. An integrated circuit designed to provide a high number of general purpose functions, some of which may be selected for a particular use.

UP-TIME - time spent in productive operations by a piece of plant.

VDU - visual display unit. Normally a cathode ray tube; used for displaying information.

VALVE LOGIC - based upon the electronic properties of valves.

*
Note:

A number of different sources have been used in compiling this glossary. In particular we wish to acknowledge the assistance of the PSI and its publication, ***Robots in British Industry: Expectations and Experience****, 1986, by Jim Northcott* ***et al.***

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