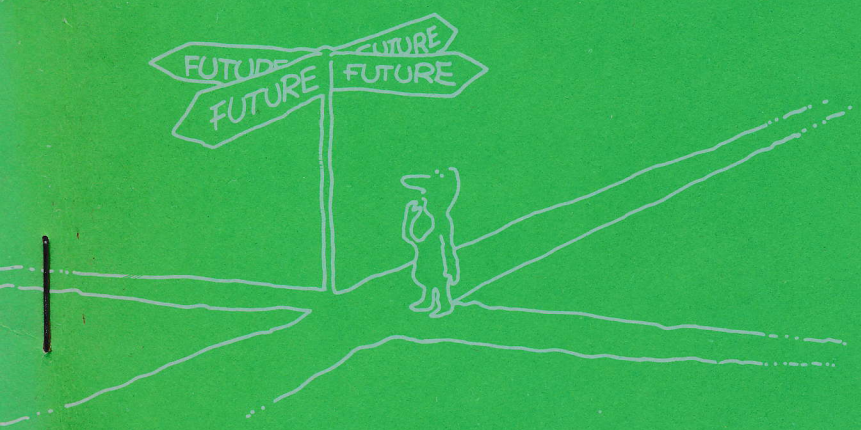
WORK AND THE MICROPROCESSOR

A discussion paper by
JAMES F. DUNCAN



COMMISSION FOR THE FUTURE

REDEPLOYMENT OF THE WORKFORCE CONSEQUENT ON THE INTRODUCTION OF MICROPROCESSORS

A DISCUSSION PAPER BY

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ABSTRACT

The number of people are estimated who are likely to need to be redeployed over the next 30 years in five industries [Manufacturing, Transport and Storage, Communications, Financial Institutions and Insurance]. Assumptions include both high and low fertility and immigration rates and a fraction of 0.50 or 0.75 of those which would otherwise be needed to be so affected by the year 2001. Up to 0.5 M will be redeployed in this period, to support which a growth rate from about 1% p.a. GNP growth in 1981 to 6-7% in 2001 will be required. A similar growth rate in overseas earnings and about double the present productivity rate would, in these industries, be needed by the end of the period.

Much has been said about the major effects likely to arise as a result of the widespread introduction of microprocessors, computers and telecommunications into industry. Usually this is painted as a disaster, but it may just as legitimately be regarded as a great challenge and opportunity - but only if action is taken sufficiently early to take advantage of it. Perhaps the magnitude of the challenge is not sufficiently clearly and widely understood. This paper sets out the dimensions of the matter; and estimates levels of the workforce in five industries who will be displaced, the consequent necessary increases in sector and national output and the resulting distribution of those displaced between productive and service industries. Productive industries are taken to be those which

support their workforce out of earnings; service industries are those such as teaching, medicine, most state departments, and local authority employees who ultimately depend for their salaries and wages on government finance.

METHODOLOGY

It is not the intention to present a detailed economic study, for which very uncertain data would have to be used to cover the time-span discussed - 30 years. Further, to be conservative only five industries have been included - manufacturing, transport, storage, communications, financial institutions, and insurance. The impact of microprocessor technology will be far wider than these, but by restricting the field in this way there is the implication that the number to be redeployed will be considerably greater than calculated. Further, conservative limits have been set for the number of people in these industries who will be displaced over the next 30 years. At the end of this time, it is assumed that at a minimum some 50% of the workforce in these industries and at a maximum some 75% will be so affected. CFF study of this matter suggests that this is likely to be the situation far earlier than 30 years (1). Indeed, already 32,000 German clockworkers in 1970 have been reduced to 18,000 by 1978 (2); 40% of German office workers will do present work by 1990, 30% of French banking and insurance workers now accommodate the work of those earlier years (3); and 95% of U.S. mail (25 billion pieces) are expected to be handled by 25% of the present manpower (4).

Extrapolation to the future is made in two steps. First it is assumed that technology remains sufficiently static for the number of people employed in these industries to be a constant fraction, ϕ, of the

total numbers in the workforce at any time t (N_t) - i.e. the effect of microprocessors is ignored, the growth of numbers in these industries being dependent on the growth of the total workforce and equal to $N_t \phi$. The value of ϕ is estimated from the data of Table 1 for 1971 to be 0.37.

TABLE 1

Estimation of ϕ from 1971 data (6)

Industry	Workforce
Manufacturing	281,110
Transport and Storage	73,816
Communications	29,365
Financial Institutions	18,881
Insurance	13,780
Total in these industries	P = 416,952
Total workforce	T = 1,118,835

$$\phi = P/T = 0.37$$

Next it is assumed that the fraction of the workforce displaced by microprocessors at time t (f_t) varies linearly from zero in 1976 to the maximum assumed in 2001 [0.75 or 0.50]. This leads to a number $N_t \phi f_t$ displaced from the industries concerned at time t. This assumption is certainly only approximate but it is difficult to make any other assumption with the certainty of any better approximation. It should also be noted that this assumption refers to the number of people who would find themselves doing other jobs because they had been displaced by micro-processors. Such redeployment might, or might not occur within the industry concerned. If it did, then after a possible initial fall in manpower as microprocessors were introduced (although not necessarily so), the manpower would continue to grow but at a slower rate than would occur

in the absence of microprocessors.

Finally two population extremes are assumed for the total workforce namely high fertility, with 15,000 p.a. immigration, and low fertility with 5,000 p.a. immigration (6).

RESULTS AND DISCUSSION

The maximum and minimum limits of manpower to be redeployed on the assumptions made are given in Table 2, and plotted in Fig. 1. Over the 25 year period it is estimated that between 337,000 and 595,000 people will be in need of redeployment, representing some 18.6% and 27.7% respectively of the total projected workforce from these industries. With the additional assumption that microprocessors etc. began to have their effect on the industries concerned in 1976 (probably too late a date) then by 1981 some 50-80,000 people will be in need of redeployment.

TABLE 2

Number of people to be redeployed in the industries considered

	High Fertility			Low Fertility		
	15,000 net Immigrants per annum			5,000 net Immigrants per annum		
	f_t = 0.75 at 2001			f_t = 0.5 at 2001		
Year	$N_t(M)$	f_t	$N_t \phi f_t$	$N_t(M)$	f_t	$N_t \phi f_t$
1976	1.268	0	0	1.248	0	
1981	1.420	0.15	78,800	1.368	0.10	50,600
1986	1.566	0.30	174,000	1.485	0.20	110,000
1991	1.724	0.45	287,000	1.596	0.30	177,000
1996	1.921	0.60	426,000	1.712	0.40	253,000
2001	2.145	0.75	595,000	1.822	0.50	337,000

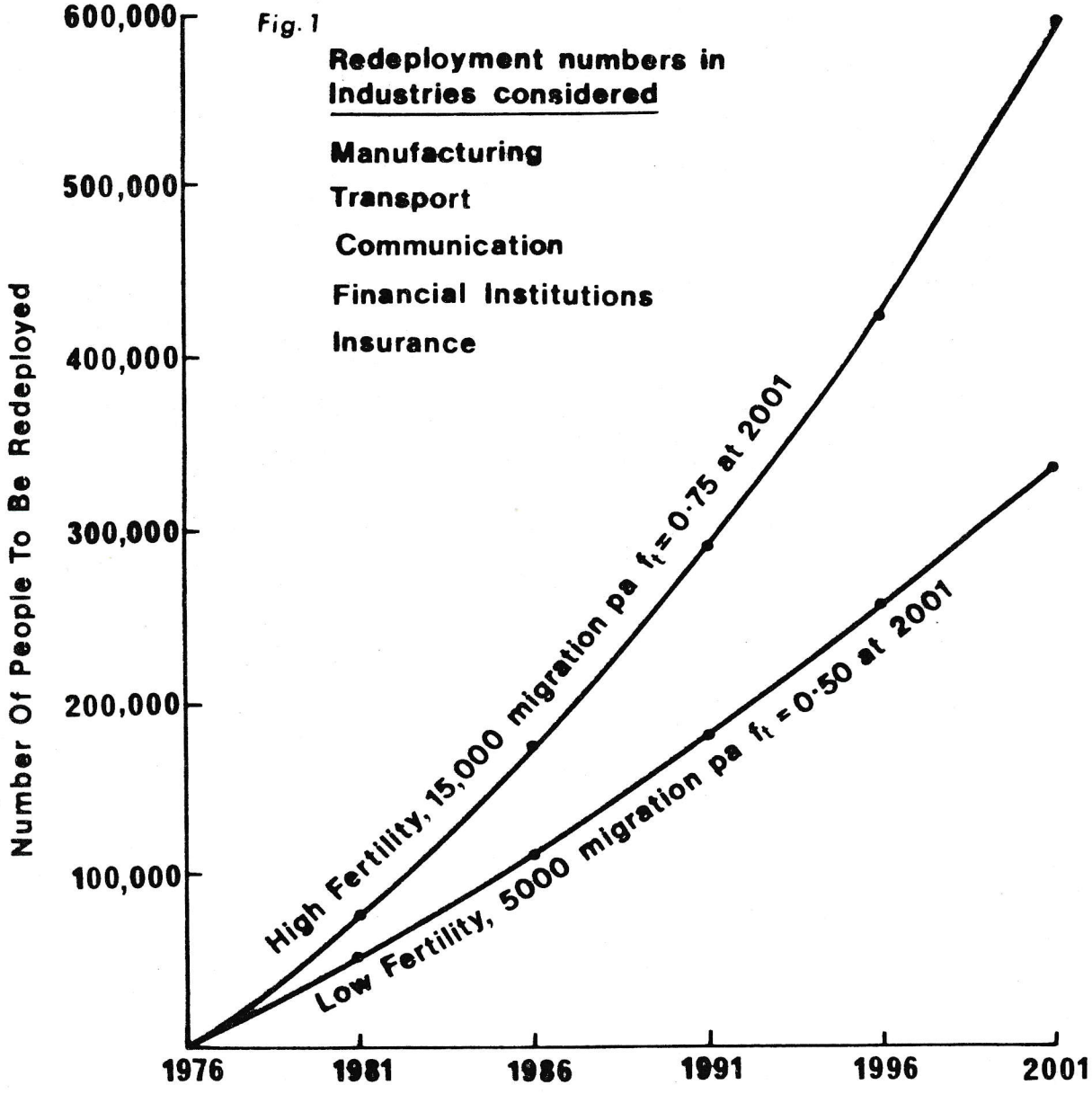
Fig. 1
Redeployment numbers in Industries considered
Manufacturing
Transport
Communication
Financial Institutions
Insurance
Number Of People To Be Redeployed
600,000
500,000
400,000
300,000
200,000
100,000
1976
1981
1986
1991
1996
2001
High Fertility, 15,000 migration pa f_t = 0·75 at 2001
Low Fertility, 5000 migration pa f_t = 0·50 at 2001

Adjustments as big as this over such a long period of time are not abnormal in a dynamic economy. Indeed this is the normal response to changes in technology and in demand. In agriculture, for instance, we have seen the manpower needs fall by a factor of ten over the last fifty years. Redeployment of workers can be achieved in the following ways:

(a) by the employing body providing new work for them.

(b) by the employing body allowing them to work inefficiently at their previous job, or another (i.e. by featherbedding).

(c) by them obtaining new work elsewhere.

(d) by them becoming unemployed.

Because of these different possibilities, it is not possible to determine how many would fall into category (d) or what proportion of the present number who are unemployed or have left New Zealand did so because they were redundant, but there could well be a significant contribution. This is especially so because the three industries chosen do not represent all the fields in which microprocessors etc. can be exploited. Others include wholesale trade, commerce, agriculture, forestry, construction, education, law, medicine, and any office using a typist-secretary. Modern word processors, for instance, can allow one person to do the work of six people.

Option (d) needs further comment since at first sight it would appear to be a relatively simple matter for an industry to achieve maximum efficiency with fewer workers at the same level of output, supporting the displaced workers as if they were employed. This course leads to the following:

(i) Costs of production being maintained at uncompetitively high levels.

(ii) Very high taxation levels of companies to provide governmental support for maintenance of those displaced.

(iii) Loss of incentive by management to maintain profitability.

(iv) Inability to find liquid assets to pay the capital cost of installing the technology proposed.

For these reasons option (d) is not a simple solution but falls in with the others in the general argument below. It is a form of redeployment requiring additional support for those so affected. Redeployment will probably take place in all the four ways given above, and therefore what follows relates to them all.

We now estimate the effect of such redeployment on a number of other parameters.

1. Growth Rate

The people redeployed will have to be paid something, whether they are supported by the state on the dole, in special work schemes, in service industries (e.g. education and health), or otherwise; or whether they are employed in productive industry. If we now assume that in the first instance the increase in contribution to GNP by the industry concerned must be sufficient to support those redeployed from the sector concerned then we may estimate the growth rate in that sector as follows:

The estimates of Table 2 are divided into five yearly increments. We compare the changes between the situation at time t and five years later at time t+5. The number of additional people requiring redeployment in the five year interval between t and t+5 is

$$N_{t+5}\,\phi\,f_{t+5} - N_t\,\phi\,f_t$$

which may be expressed as a fraction of those remaining in the sector

at t+5 as

$$\frac{N_{t+5}\,\phi\,f_{t+5} - N_t\,\phi\,f_t}{N_{t+5}\,\phi\,(1-f_{t+5})}$$

$$\frac{f_{t+5}}{1-f_{t+5}} - \frac{N_t}{N_{t+5}}\left\{\frac{f_t}{1-f_{t+5}}\right\} \qquad \ldots 1$$

In Table 3 the growth rate of the industries considered is calculated from relationship 1. It will be seen that

(a) the growth rate needed increases greatly as the period considered advances.

(b) even the minimum assumptions imply a growth rate of at least 2% p.a. in 1981 rising to 5.0% p.a. in 2001.

Over the next 30 years we might expect the industries considered to contribute a greater amount to the national income, so that many of the jobs lost to microprocessors would be replaced by new productive jobs in these industries. However, since the total population is likely to be only 3.8±0.1 M by the year 2001 compared to 3.1 M in 1979 (8), it seems doubtful if any industry which has not a substantial export market could achieve such a growth rate. In the present context only manufacturing seems to be in this category. Others like financial institutions for example seem most unlikely to be able to retain their displaced manpower by generating enough new business. It follows, therefore, that other export-oriented sectors will need to expand to take up those who cannot be employed in such industries. We may therefore translate the calculated growth rate for the industries concerned to the equivalent GNP growth rate, as is done in Table 4. One cannot be in any way certain about the contribution which these industries will make to GNP growth because of uncertainties about the economic parameters over the next 30 years. Two independent assessments have therefore been made:

TABLE 3

Estimates of growth rate in industries considered to support those redeployed

High Fertility 15,000 immigration $f_t = 0.75$ at 2001

	$\frac{f_t}{1-f_t}$	$A = \frac{N_t}{N_t+5}$	$B = \frac{f_t}{1-f_{t+5}}$	AB	Growth Rate: 5-year fractional increment	Growth Rate: Percent per annum
1976	0					
1981	0.176	$\frac{1.268}{1.420} = 0.893$	$\frac{0}{0.85} = 0$	0	0.177	3.5
1986	0.429	$\frac{1.420}{1.566} = 0.907$	$\frac{0.15}{0.70} = 0.214$	0.1941	0.235	4.7
1991	0.818	$\frac{1.566}{1.724} = 0.908$	$\frac{0.30}{0.55} = 0.545$	0.4950	0.323	6.5
1996	1.500	$\frac{1.724}{1.921} = 0.897$	$\frac{0.45}{0.40} = 1.125$	1.009	0.491	9.8
2001	3.000	$\frac{1.921}{2.145} = 0.896$	$\frac{0.60}{0.25} = 2.400$	2.150	0.850	17.0

Low Fertility 5,000 net immigration $f_t = 0.5$ at 2001

	$\frac{f_t}{1-f_t}$	$A = \frac{N_t}{N_t+5}$	$B = \frac{f_t}{1-f_{t+5}}$	AB	Growth Rate: 5-year fractional increment	Growth Rate: Percent per annum
1976	0					
1981	0.111	$\frac{1.248}{1.368} = 0.912$	0	0	0.111	2.2
1986	0.25	$\frac{1.368}{1.485} = 0.912$	$\frac{0.10}{0.80} = 0.125$	0.1142	0.146	2.9
1991	0.429	$\frac{1.485}{1.596} = 0.930$	$\frac{0.20}{0.70} = 0.285$	0.266	0.163	3.3
1996	0.667	$\frac{1.596}{1.712} = 0.932$	$\frac{0.3}{0.6} = 0.50$	0.466	0.201	4.0
2001	1.000	$\frac{1.712}{1.822} = 0.940$	$\frac{0.4}{0.5} = 0.80$	0.752	0.248	5.0

Workforce estimate. The growth rates calculated above have been reduced in the ratio of the workforce numbers involved in these industries compared to the total workforce, previously assumed to be 0.37. This implies the assumption that the contribution to GNP of different sectors is in the same ratio as the workforce which is of course not realistic, but gives a crude estimate.

Output estimate. It is assumed that the contribution of the industries concerned to GNP is the same constant fraction as at present. From recent data (8) this is estimated as 0.396 (see Table 5) for 1976/7. This may, however, not be constant over the next 30 years but (using the 5-year data of Table 3) it leads to the data calculated in Table 4.

TABLE 4

Percentage Growth in GNP p.a. to support those redeployed

	Industries considered		GNP (workforce estimate)		GNP (output estimate)	
	Low*	High†	Low*	High†	Low*	High†
1976	-	-	-	-	-	-
1981	2.2	3.5	0.92	1.31	0.79	1.40
1986	2.9	4.7	1.08	1.74	1.16	1.86
1991	3.3	6.5	1.21	2.39	1.29	2.56
1996	4.0	9.8	1.49	3.63	1.59	3.89
2001	5.0	17.0	1.84	6.29	1.96	6.73

* Low - Low Fertility, 5,000 net Immigrants per annum, and $f_t = 0.5$ at 2001.

†High - High Fertility, 15,000 net Immigrants per annum, and $f_t = 0.75$ at 2001.

TABLE 5

Gross Domestic Product by Kind of Industry (1976-7)

(Categories refer to those listed in Table 2 of reference 8)

Industry	G.D.P. ($ M)	G.D.P. (%)
Manufacturing (Categories 5-13)	3012	22.1
Transport and Storage (Category 17)	834	6.1
Communications (Category 18)	308	2.3
Financing, Insurance, Real Estate and Business Services (Category 19)	1244	9.1
Total G.D.P. for industries considered	5398	39.6
Total G.D.P. for all industries	13625	100.0

It is reassuring to see that the two estimates of Table 4 are in close agreement. Precise agreement would not be significant, since both are orders of magnitude calculations. Nevertheless they show that a growing proportion of GNP, rising from about 1% in 1981 to 6-7% in 2001, will be needed just to support those people who are redeployed and/or displaced from the industries considered with no allowance being made for other industries. Since many others will also be affected by microprocessors and computers similar conclusions must emerge in any sector which cannot otherwise be competitive. For labour intensive industries, they will remain competitive and can use the displaced manpower only if there is no way of replacing the high cost of labour by automated devices.

2. Growth in Overseas Earnings

Since those redeployed will not be distinguishable from the remainder of the community they will be able to commit overseas exchange in their day-to-day personal purchases. If the proportion of their salaries, wages, or public

maintenance used in this way is the same as at present then we may estimate that this will be in the same ratio as the value of imports to the value of GNP which for 1975-6 were respectively $2,961 M (total merchandise imports) and $10,914 M, giving a ratio of 0.27. It is true that not all of these imports will be directly accounted for by individuals, since some will go for further manufacturing in New Zealand. Some of these will lead to manufactured goods for sale in New Zealand, whilst others will be required for re-exporting to support the New Zealand economy generally. Nevertheless a comparable growth rate in export earnings as indicated for GNP growth in Table 4 will be needed, if those who are redeployed are not to cause a deterioration in our overseas balance of payments. A consequence of this is that some of those who are displaced must enter productive industry earning overseas exchange. The proportion who do will vary from industry to industry. In the case of manufacturing (which currently earns (1975-6) $343.6 M annually in overseas exchange with an annual salaries and wages bill of $1.57 M), if one half of the workforce were displaced by 2001, then in 1975/6 currency it would require 0.23% of them in that industry to maintain the $0.79 M in overseas exchange necessary to meet the purchases of all those redeployed.

It must, however, not be forgotten then microprocessors will only be introduced if foreign exchange is available to purchase them. This factor has been ignored since they are likely to be exceedingly cheap and economic (compared to labour costs) and not to place any greater foreign exchange costs on New Zealand than technology which is currently imported for similar reasons.

3. Manpower and Productivity

Finally it is possible to check the reliability of the primary assumptions as follows. Let us first assume that the present output of the industries considered is the minimum maintained over the next 30 years with the remaining manpower (even though some of those redeployed might be retained to increase the output of the sector beyond this limit). The minimum increase in productivity (specifically labour productivity defined as the ratio of value of output to the cost of labour) can then be calculated from the numbers of people remaining in the industries concerned $[N_t\phi(1-f_t)]$, as listed in Table 6 for the high and low extremes. The minimum increase in productivity necessary for a 5-year period is then equal to the ratio of manpower at t+5 to that at t. This has been given in Table 6 together with the corresponding estimates per annum.

Let us now look at the low estimates. Over the 25-year period, the minimum increase in productivity is only 2.5% [0.1% p.a.] and in fact is negative for the first 5-year period. That is, there would be virtually no increase in productivity over the 25-year period if present output alone were maintained. This is ridiculously unrealistic which means that the number to be redeployed for maintaining current output has been substantially underestimated. More likely they are in error by a factor upwards of the order of 2. If the error were as high as this then the low estimates would conform very closely to those of the high estimates (see Fig. 1), which are therefore more realistic. From Table 6 these imply a minimum of 95.3% increase in productivity for maintaining current output over the 25-year period (an average of 4% p.a.) and a fall in manpower for the same output by a factor of 2.3. The percentage productivity increase rises from about 1% per annum at the beginning of the period to about 8% at the end of the period. In practice of course, the industries would not

TABLE 6

Percentage Increase in Productivity in Industries Concerned

High Fertility, 15,000 net Immigrants per annum, f_t = 0.75 at 2001

Year	$N_t\phi$ (M)	$N_t\phi f_t$ (M)	$N_t\phi(1-f_t)$ (M)	% Increase in Productivity in 5 years	p.a.
1976	0.468	0	0.468	-	-
1981	0.525	0.0788	0.4462	+4.9	+0.98
1986	0.576	0.1740	0.402	+10.9	+2.18
1991	0.638	0.2870	0.351	+14.5	+2.90
1996	0.711	0.4260	0.285	+23.2	+4.64
2001	0.794	0.5950	0.201	+41.8	+8.36

Total over 25 years 95.3%

Low Fertility, 5,000 net Immigrants per annum, f_t = 0.5 at 2001

Year	$N_t\phi$ (M)	$N_t\phi f_t$ (M)	$N_t\phi(1-f_t)$ (M)	% increase in Productivity in 5 years	p.a.
1976	0.468	0	0.468	-	-
1981	0.525	0.050	0.4744	-1.3	-0.26
1986	0.576	0.110	0.466	+1.8	+0.36
1991	0.638	0.177	0.461	+1.1	+0.22
1996	0.711	0.253	0.458	+0.7	+0.14
2001	0.794	0.337	0.457	+0.2	+0.04

Total over 25 years 2.5%

remain static at a constant output, but how far they could expand would depend on the nature of the industry and of the market. But to the extent that new activities are introduced with the manpower projected, additional numbers are effectively redeployed, so that the challenge becomes greater not less than indicated on the assumptions made. The rise in annual productivity increase over the 30 year period actually obtained would thus depend on the closeness reality conformed to the primary assumptions made - especially the linear increase per annum in the numbers to be redeployed, which assumption causes the annual productivity rise to increase so dramatically.

CONCLUSIONS

This analysis serves to illustrate the dimensions of the challenge for redeployment of people displaced from the five industries considered as a result of the introduction of microprocessors. The estimates are not intended to be precise but to give order-of-magnitude indications only. They do not include a large number of other industries on which microprocessors can be expected to have a significant, if not a substantial effect. For this reason, the challenge to New Zealand is that of a great opportunity to create new industries, a diversity of lifestyles and more free time to use one's energies creatively as one wishes, supported by an adequate income to look after creature comforts. In that event, the expansion of industries and occupations catering for the occupation of leisure time would result. But that opportunity will only be seized if conscious thought is given to how the new openings for those redeployed can be created by industry, government and the community at large in such a way that the impact of the world economy in boom periods can be embraced, and in recessions can

be lessened. Failure to meet this challenge must lead to massive unemployment, and social disharmony. Much will depend on the attitudes of organised labour and management. With education and understanding on both sides, the gains in productivity and living standards could be very great indeed. Such a rapid growth rate would certainly make adjustments easier and more effective, especially if exports also grow. This then is the challenge which we would be wise to consider soberly.

ACKNOWLEDGEMENTS

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