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MODELLING THE ECONOMY-WIDE IMPLICATIONS OF TECHNICAL CHANGE : RESPONSE TO CRITICISM OF THE APPROACH ADOPTED BY THE IMPACT PROJECT

by

Peter B. Dixon, La Trobe University
D.P. Vincent and Alan A. Powell
IMPACT Research Centre, University of Melbourne

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The views expressed in this paper do not necessarily reflect the opionions of the participating agencies, nor of the Commonwealth government.

IMPACT PROJECT RESEARCH CENTRE 153 Barry Street, Carlton 3053
Postal Address: Impact Centre, University of Melbourne, Parkville, Vic., 3052, Australia
Phones: (03) 345 1844 extensions 7417 & 7418
After hours (03) 341 7417 or 341 7418.

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Peter B. Dixon, D.P. Vincent and Alan A. Powell*

1. Introduction

At the Eighth Conference of Economists (La Trobe University, 1979) we presented a detailed report (Dixon and Vincent [1979]) on our development at the IMPACT Project of the SNAPSHOT model. As an illustrative application we used the model in a discussion of the economy-wide implications of technical change. We summarized our results in a second paper (Powell [1979]) at the same conference. The primary objective of the present paper is to give a short overview of that earlier material.

Our immediate reason for writing such a paper is to provide a response to criticisms of our work by Thomas Mandeville, Stuart Macdonald and Don Lamberton (hereafter MML). In their article in the January/February issue of <u>Search</u>, MML claim that the contribution of the SNAPSHOT model to the understanding of the consequences of

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* The authors are engaged in the IMPACT Project. This is a Commonwealth Government inter-agency project in co-operation with the University of Melbourne, to facilitate the analysis of the impact of economic, demographic and social changes on the structure of the Australian economy. The views expressed here do not necessarily reflect the opinions of the participating agencies, nor of the Commonwealth government.

technical change is "not just worthless but actually negative", (MML [1980, p. 14]). Among other things, MML accuse us of perverting definitions, of misunderstanding the nature of technical change, of being completely ignorant of the relevant body of literature and of adopting unscholarly research methods. They imply that we are not serious scholars (MML [1980, p. 15]), that we write on subjects with which we have no familiarity (MML [1980, p. 15]) and that we "assault logic and common sense" (MML [1980, p. 17]). They describe aspects of our work as "quite ludicrous", "fatuous", "beyond belief", and "clearly absurd".

From all of this we can conclude only that MML have misunderstood our earlier papers. Certainly the bulk of our SNAPSHOT documentation is written in technical language which understandably acts as a barrier to communication with the non-specialist. Consequently the main part of this paper is devoted to a less technical description of both the theory of the SNAPSHOT model and its application to the study of the implications of technical change.

The paper is organized as follows. In section 2 we build a simple two commodity model. This is used to illustrate the general equilibrium method employed in the SNAPSHOT model. We also explain how input-output coefficients are used to describe production techniques. Then in section 3 we review the important features of our SNAPSHOT application exercise. In section 4 we reply to specific criticisms by MML and section 5 contains some concluding remarks.

2. General Equilibrium Models and Input-Output Coefficients in the Study of the Implications of Technical Changes

The specification of a general equilibrium model of a country's economy can be divided into two parts : the description of the production possibilities and the description of the demand conditions. The production possibilities depend on production techniques and resource availabilities. The demand conditions depend on consumer preferences, the distribution of disposable income across consumers (including the government) and on the world trading situation. The two parts are interrelated. Because production possibilities are determinants of income and its distribution, they are a determinant of demand. Because demand conditions (e.g., the world trading situation and consumer preferences for savings) influence capital accumulation, they also influence production possibilities. A general equilibrium model tries to bring together the description of production possibilities and demand conditions, taking into account the relationships between them. What emerges from the model is a set of conditional forecasts (conditional on the underlying assumptions about production possibilities and demand conditions) concerning, among other things, the level and industrial composition of GDP, the distribution of factor income, the occupational composition of the workforce and the level of real wages.

In the present paper it would not be appropriate to set out anything beyond the most elementary general equilibrium model. This will be sufficient, however, to illustrate the essential ingredients of our approach to the study of the implications of technical change.

Consider a society which produces just two products, cloth and wine. The techniques currently in use for the production of these products are described by "input-output" coefficients in table 1. The production of one gallon of wine uses up 0.2 yards of cloth and one hour of labour. The production of one yard of cloth uses just one hour of labour.

Table 1 Current Production Techniques : Input-Output Coefficients

	Wine (1 gallon)	Cloth (1 yard)
Wine		
Cloth	0.2 yds	
Labour	1 hour	1 hour

We assume that the society's resource endowment for a year is 100 labour hours. Given this resource endowment and the production techniques set out in table 1, we can derive the society's production possibilities set. This is shown graphically in figure 1. It can be constructed by doing a few calculations. For example, if 50 labour hours are devoted to wine and 50 to cloth, then society's net annual output will be 50 gallons and 40 yards (10 yards of cloth is used up in wine production). If all of the 100 labour hours is devoted to cloth, then the net output will be 100 yards of cloth and no wine. On the other hand, if all the labour were devoted to wine production we would end up with 100 gallons of wine and a deficit of

20 yards of cloth. Perhaps this could be made up by drawing on accumulated stocks or through international trade. But for simplicity we will assume that there are no accumulated stocks and that there is no international trade. Thus, the annual production possibilities available to our society are restricted to the shaded area OAB in figure 1.

What about demand conditions? We consider the simplest possible case by assuming that our society always consumes wine and cloth in fixed proportions : 5 gallons of wine to 4 yards of cloth. In terms of figure 1, consumption will occur somewhere along the line OC.

Now we make two assumptions which will bring together our descriptions of the production possibilities and demand conditions. We assume that there is full employment[1] and that production is geared to satisfy demands. Under these assumptions, it is apparent that consumption and net production will be 40 yards of cloth and 50 gallons of wine, point E_1 in figure 1. Half the workforce (50 labour hours) will be used in cloth production and the other half in wine production. It is also apparent from table 1 that if we fix the wage per labour hour at \$1, then the price for a yard of cloth will be \$1 and the price of a gallon of wine will be \$1.2.[2] Thus the hourly wage rate will buy a bundle containing 0.4 yards of cloth plus 0.5 gallons of wine.

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1. This is a particularly contentious assumption and is discussed in some detail under point (6) in section 4.

2. All that is important here is the price of wine and cloth relative to that of labour. It is simply convenient to assign labour a price of one.

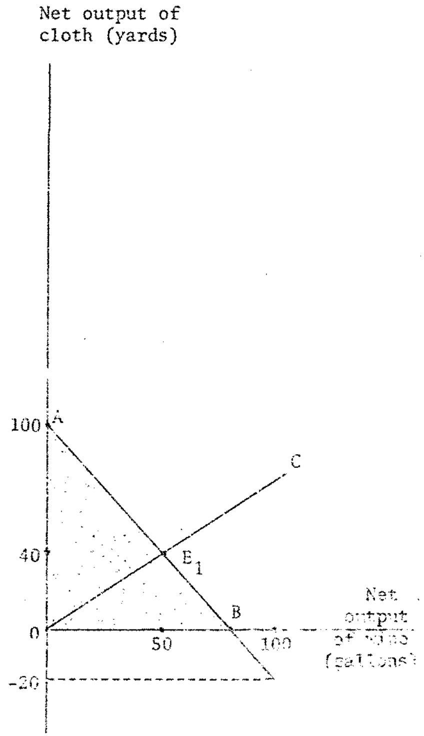

Figure 1 : Annual net production possibilities under the initial production techniques.

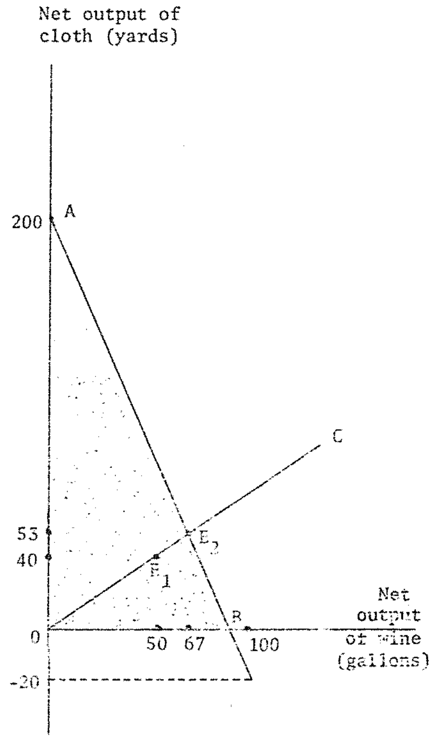

Figure 2 : Annual net production possibilities after the improvement in the technique for producing cloth.

How will our economy be affected by a change in production techniques? For example what will happen if there is a dramatic improvement in the technique for producing cloth so that 1 yard requires an input of only 0.5 hours of labour? Assuming that society's resource endowment remains at 100 labour hours per year and that the technique for producing wine is unchanged, then the production possibilities set will be expanded to that shown in figure 2. If we continue to assume that there is full employment, that society consumes wine and cloth in the ratio 5 gallons to 4 yards and that production is geared to satisfy demands, then consumption and net production will be $66^2/_3$ gallons of wine and $53^1/_3$ yards of cloth (point E_2 in figure 2). Employment in wine production will be $66^2/_3$ hours and employment in cloth production will be $33^1/_3$ hours. The price of cloth will be \$0.5 per yard and the price of wine will be \$1.1 per gallon where we again use the convention that the wage rate is \$1 per hour.

In summary, the improvement in the technique for producing cloth has increased net production and consumption of both wine and cloth by $33^1/_3$ per cent. It has also allowed the real wage rate to increase by $33^1/_3$ per cent. (Notice that the wage for one hour of labour now buys a bundle containing 0.53 yards of cloth and 0.67 gallons of wine rather than 0.4 yards and 0.5 gallons.) Finally, we note that the proportions of the total labour force in cloth and wine production have changed from (.5, .5) to (.33, .67), that is, $16^2/_3$ per cent of the labour has been reallocated from cloth production to wine production.

3. The SNAPSHOT Exercise

Apart from a multitude of details, the SNAPSHOT exercise on the effects of changes in production techniques was very much like the one we have just described. SNAPSHOT, of course, divides the economy into many sectors, 109, rather than 2. SNAPSHOT includes capital not just labour as a primary factor and models investment in its roles both as a component of demand and as a determinant of future production possibilities. SNAPSHOT allows for the effects of commodity demands by the government and divides the household sector into 9 consuming groups. SNAPSHOT models various taxes, tariffs and subsidies and includes the effects of changes in international trading conditions. It is with respect to international trade, however, that we feel our current work is most deficient. The problems in this area, and what we hope to do about them are discussed in detail in Dixon and Vincent [1979, especially pp. 18-23].

In our exercise with SNAPSHOT, we specified two alternative sets of input-output coefficients. One set described production techniques as they were in 1971/72.[1] The other was a forecast of what production techniques will be in 1990/91. The forecast was based partly on work by the Bureau of Industry Economics (BIE) and partly on work done at IMPACT. The BIE selected industries which appeared to be undergoing rapid technical change and asked industry experts to forecast the changes in the input-output coefficients to 1990/91. At the time that we wrote our SNAPSHOT paper, the BIE's work was complete

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1. This is the most recent year for which we could assemble the required data.

for 12 industries accounting for 22 per cent of GDP in 1971/72. For the remaining industries, we relied mainly on our own trend projections applied to labour productivity figures over periods between the early sixties and the mid-seventies. Our reliance on trend projections will be reduced as BIE results for more industries become available.

Having assembled our two sets of input-output coefficients, we made some comparisons. The central computation was designed to answer the following question : how much difference do the projected technical changes make to one's picture of how the economy will be in 1990/91? In terms of figures 1 and 2 we computed the points E_1 and E_2 where E_1 refers to the levels which will be achieved in 1990/91 for commodity outputs, prices, real wages, etc., if production techniques remain as they were in 1971/72 and E_2 refers to the situation which will emerge if production techniques are consistent with our forecast. The comparison between E_1 and E_2 was, therefore, the basis for a discussion of the effects of technical change.

What did we conclude about the effects of technical change? Given the preliminary nature of our work and a number of deficiencies which we were careful to emphasize, our conclusions were cautious. In fact, we offered little more than the following :

> "The overwhelming impression from table 4.6 [reproduced here as table 2] is that the occupational composition of the workforce at the 9-order level in 1990/91 is unlikely to be radically different from that in 1971/72

> and that it will be determined largely independently of technical change. Certainly, the present simulations do not pinpoint any likely difficulties in the areas of labour mobility and manpower training." (Dixon and Vincent [1979, p. 52].)

> "Subject to the qualifications expressed throughout the paper, our results indicate that rapid technical progress is particularly important for the future well-being of those Australian industries which are closely connected with international trade. At the macro level, our results support the view that technical progress is vital for securing increased GDP, increased consumption and higher real wages. Technical progress may also affect macroeconomic management. In the absence of technical progress, we found that the "full-employment" level of real wages would decline. Under such conditions, it is difficult to imagine that Australia could achieve even a tolerable approximation to full employment." (Dixon and Vincent [1979, p. 54].)

Perhaps in this first conclusion we should have underlined the words "at the 9-order level". It is possible that technical change to 1990/91 may render redundant certain very specific skills. This, of course, does not necessarily imply any serious difficulties. Australian workers exhibit a high degree of occupational mobility, even between occupations defined at the 9-order level (see for example, Dixon, Powell and Parmenter [1979, p. 63]). The second conclusion is

Table 2 Occupational Shares in the Workforce[a]

	I Actual 1971/72	II 1990/91 Innovative Economy[b],[c]	III 1990/91 Luddite Economy[b],[c]
1. Professional White Collar	3.3	3.9 (3.1)	4.0 (3.2)
2. Skilled White Collar	12.8	14.3 (2.7)	13.6 (2.5)
3. Semi- and Unskilled White Collar	26.9	30.5 (2.9)	29.0 (2.6)
4. Skilled Blue Collar (Metal & Electrical)	10.9	9.0 (1.2)	9.1 (1.3)
5. Skilled Blue Collar (Building)	5.1	3.9 (0.8)	4.1 (1.0)
6. Skilled Blue Collar (Other)	2.6	2.7 (2.5)	2.7 (2.5)
7. Semi- and Unskilled (Blue Collar)	32.0	30.5 (1.9)	30.6 (1.9)
8. Rural Workers	4.8	3.6 (0.5)	5.1 (2.4)
9. Armed Services	1.6	1.6 (2.2)	1.8 (2.7)
Total	100.0	100.0 (2.2)	100.0 (2.2)

(a) Source : Dixon and Vincent [1979, p. 51].

(b) Innovative and Luddite were the labels used in Dixon and Vincent [1979]. Luddite refers to the projections for 1990/91 generated by SNAPSHOT with the input-output coefficients set at their 1971/72 values. Innovative refers to the projections where the input-output coefficients were set at the values forecast for 1990/91. The differences between columns II and III were interpreted as being attributable to technical change.

(c) Figures in parentheses show annual percentage growth rates over the period 1971/72 to 1990/91. For example, professional white collar employment grows at an average annual rate of 3.1 per cent on the path to the Innovative Economy of 1990/91.

unexceptional and seems acceptable to our critics. They comment that "We do not doubt that the Australian economy of 1990/91 will be much healthier with technological change than without ......" , (MML [1980, p. 17]).[1]

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1. It is only fair to complete the quotation. It continues " ... but technological change is not something an economy either has or does not have." A generous interpretation of this clause is that it is connected with the objection of MML to our failure to explain technical change. We consider this issue in section 4 under point (2).

4. The MML Criticisms

The question arises as to why our SNAPSHOT paper has drawn such a savage response from MML. In attempting to provide an answer, it will be useful to consider their criticisms in two categories. First, they deny the validity of our underlying theoretical assumptions. That is, they deny the appropriateness of the path we have taken from our data (observations about the state of the world) to our conclusions about the likely implications of technical change. Second, they are dissatisfied with the quality of our data.

We do not propose to devote much space to the second category. Chapman [1980] has dealt capably with the various misconceptions of MML in this area. Only two points remain for us to make. First, we know of no data base which would be superior for our purposes to the one we used. None was suggested by MML. Second, in our opinion, the BIE's work on forecasting production techniques is of high professional quality. It is to be commended and encouraged. The refusal of our critics (see MML [1980, p. 15]) to cooperate with the BIE on this project is not to their credit.

With regard to theory, MML make a large number of criticisms of our work. Perhaps the easiest way to organize our response is to quote from their conclusion and then to comment on each of the points raised. Their conclusion (MML [1980, p. 17]) starts "It is difficult to offer constructive criticism of a paper which purports to forecast the effects of technological change in 1990/91 and which[1] (1) isolates the main effects of technological change to

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1. The numbering of the points has been added by us.

the industry in which it emerged, (2) which ignores entirely the process of technological change as opposed to the change itself, (3) which works within an ossified industrial classification, (4) which relies on research methods which are unscholarly, and (5) which displays a cavalier disregard for other work on technological change." Later in their conclusion, MML (6) question our use of the full employment assumption, (7) claim that "it may be less than responsible to indulge in such abstract musing", and (8) that the operation of technological change is complex and that it is virtually impossible to measure its effects by input-output techniques.

(1) Isolation of effects. The comment by MML on this issue is surprising. The point of our general equilibrium approach is to avoid precisely the problem to which they allude. Recall the results in section 2 where we considered the effects of a technical change (a halving of the labour input per unit output) in the cloth industry in our hypothetical two commodity economy. We found that there would be a $33^1/_3$ per cent increase in the net output of wine, a $33^1/_3$ per cent increase in real wages, a $33^1/_3$ per cent increase in employment in the wine industry and a small reduction in the price of wine relative to labour. All of these are effects of the technical change outside the industry in which it emerged. Nevertheless, the model of section 2 does miss some potential sources of interindustry linkage. For example, the improvement in the technique for producing cloth has generated a sharp reduction in the price of cloth relative to that of labour. Perhaps this will generate some substitution of cloth for labour in the production of wine. In terms of table 1,

what we are saying is that we should allow for the cloth input co-efficient to the wine industry to increase from 0.2 while the labour coefficient decreases from one. There may also be some substitution of cloth for wine in consumption, that is the consumption point may move off OC (see figures 1 and 2) towards the cloth axis. The SNAPSHOT model includes price-induced substitution in consumption but not in production. The practicalities of modelling substitution in production are discussed in our original paper. We concluded that "attempts to model input substitution in response to changes in relative prices are likely to have only minor payoffs". (Dixon and Vincent [1979, p. 16].)

(2) The process of technical change. We have taken changes in production techniques as exogenous. Consequently, in section 2 we did not give a story about the process by which the input coefficient for cloth was halved. This process would involve a scientific discovery, a period of engineering experimentation and finally a period in which the new technique gradually was adopted throughout the cloth industry. While the process of technical change provides an interesting and important area for economic study, it was not the subject of our research. We were concerned with some of the implications of technical change, not with how it comes about.

The failure by MML to appreciate this distinction probably explains their strange insistence that we should have been discussing technological change rather than technical change. They go as far as to cite our use of the word technical as evidence of a "complete ignorance of the literature on technological change" (MML [1980, p. 15]).

As one of them pointed out in an earlier paper, "technology is defined as the science of the industrial arts", (Macdonald [1979, p. 1]). But we were not concerned with changes in knowledge concerning production techniques. We were concerned with the effects of changes in the techniques themselves, i.e., with technical change.[1]

(3) Ossified industrial classification. The problem here is with new products. What happens in our model of section 2 if we wish to analyse the implications of the introduction of a new product, radio for example. The technical change is not a modification of the production techniques for wine and cloth, but involves the addition of an entirely new column to our production techniques table. In theory, there is no obvious difficulty. If we know the production technique for radios and the consumer preferences for wine, cloth and radios, then we simply expand our model from two sectors to three. We can then derive conclusions regarding the extent to which employment will be switched into the new radio industry and out of wine and cloth, the implications for real wages, the effect on relative commodity prices, etc. In practice, of course, it is very difficult in a forecasting exercise to allow realistically for new products and industries. Even if we have heard about radios (perhaps they have been introduced in a more advanced country) it is obviously difficult to forecast production techniques and demand conditions for a product for which there is currently no local experience.

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1. Despite the distinction made here, we realize that the words technical and technological are often used interchangeably. Nevertheless, the distinction, which was brought to our attention by Professor Frank Davidson, seems to us to be a useful one.

Closely related to the problem of allowing for new products is the problem of allowing for changes in the quality of existing products. Perhaps the technical change under consideration is the introduction of a new type of cloth having twice the durability of existing cloth. At this stage it is apparent that "yards" is an inappropriate unit for measuring cloth production. What we need is a measure of cloth service, yard-years say. Then the introduction of the new durable cloth can be seen as halving the labour input per yard-year of cloth output. Of course, where the quality change is multidimensional, the problem of finding a unit for measuring output will have no straightforward solution. For example, how do we proceed if the new type of cloth is not only more durable but is also more comfortable to wear?

The specific solutions adopted by the BIE to the problems of new products and quality changes are described in Chapman [1978]. Chapman [1980] provides some further comment. Because it is not clear from the MML paper, it is important to note that these problems plague all researchers interested in the economy-wide implications of technical change. They are certainly not specific to the SNAPSHOT model.

(4) Unscholarly research methods. We feel obliged to point out that the research methods adopted with respect to the SNAPSHOT model (and in all other aspects of the IMPACT Project) are carefully documented in publicly available papers. IMPACT papers are regularly published in refereed scholarly journals. A slightly abridged version of the paper which is the subject of MML's criticisms is forthcoming in the Economic Record.

(5) Cavalier disregard of other work on technical change. MML [1980, p. 15] cite a long list of authors (not cited by us) who have written on the causes of technical change. As explained in (2), this was not the topic of our research. Early in our work on technical change we did, of course, check the literature. A research memorandum (Harrower [1976]) was prepared surveying much of the material mentioned by MML as well as various other pieces.

(6) The full employment assumption. In section 2 we simply assumed that the halving of the labour coefficient for cloth would not affect the aggregate level of employment. At both E_1 and E_2 in figures 1 and 2, employment is 100 hours of labour. There is no need to interpret this as literally full employment. Perhaps 105 hours of labour were available. The assumption is that technical change is not an important determinant of the aggregate level of employment. What technical progress does is to allow society to achieve any given level of employment with higher real wages. At any point of time, however, the level of employment depends principally on fiscal and monetary policy and on the real wage rate in relation to labour productivity.

Reassuring as this may be, some readers will still want to know how the displaced workers in the cloth industry will find a job. Starting at E_1, the halving of the labour input coefficient for cloth will mean that only 25 labour hours (rather than 50) are required in the industry. Now, cloth will be cheaper and the real incomes of employed workers will expand. These workers will demand more wine and cloth, thus providing employment for the previously displaced workers. This will set us on the happy path to E_2.

What if capitalists prevent the reduction in the real price of cloth and take an enormous increase in profits? But don't capitalists consume wine and cloth too? Perhaps not, perhaps capitalists spend on imported luxuries and overseas holidays. But what will the foreigners do with the Australian dollars they receive from our capitalists? They will buy our wine and cloth! But what happens if everyone has had enough wine and cloth? This would be a blissful state -- we could simply do less work. Unfortunately a state in which all our material wants are satisfied seems very far away, even in the world's wealthiest countries.

What about adjustment problems along the path from E_1 to E_2? Recall that the shift from E_1 to E_2 involved the transfer of $16^2/_3$ per cent of the labour force out of cloth and into wine. What if the skills required of wine workers differ from those of cloth workers? Then might not the move from E_1 to E_2 cause excessive periods of unemployment for surplus cloth workers? Certainly this is a possibility. It is important, therefore, in comparing E_1 and E_2 to consider the feasibility of the implied rates of shift of resources between different activities. This is what we did in our SNAPSHOT exercise. For example, on examining table 2, we concluded that technical change to 1990/91 could be accommodated without rapid transfers of labour between the broadly defined occupational groups.

(7) Less than responsible abstract musing. In summarizing some results from Dixon and Vincent [1979], Powell commented that

> "Using the 1990-91 technology the same final bill of goods and services could have been produced with a

> workforce of 3.6 million. In this sense, the technology envisaged for 1990-91 is "labour displacing" to the extent of 1.6 million jobs." Powell [1979, p.20].

In terms of figure 2, Powell's comment could be paraphrased as follows : using the improved production technique for cloth, the original bill of final goods (point E_1) could have been produced with a workforce of 75 labour hours. In this sense, the new technique is "labour displacing" to the extent of 25 labour hours.

This type of computation is a convenient and standard way (see for example, Carter [1970]) of describing the expansion in the production possibilities set associated with technical change. As Powell makes clear in the paragraph following the above quotation, the computation has nothing to do with the implications of technical change for the actual level of employment. MML (p. 17) quote Powell out of context as speaking of technology as being "'labour displacing' to the extent of 1.6 million jobs". They make no attempt to report the meaning of Powell's statement but simply dismiss it as "abstract musing" which "may be less than responsible", MML [1980, p. 17].

(8) Inappropriateness of input-output techniques. Under point (3) we considered the major objections by MML to the use of input-output analysis in projecting the effects of technical change. Our only additional comment concerns MML's attempted use against us of the authority of W.W. Leontief, winner of the 1973 Nobel Prize for economics and pioneer of input-output analysis. MML [1980, p. 15] attribute the following view of exercises such as SNAPSHOT to Leontief :

> "Great mathematical skill and imagination go into setting up such hypothetical problems and solving

> them.... At best, the contribution will be marginal. Unfortunately, it produces a semblance of scientific advance, when actually there is none.... [It reflects only] the properties of the system of linear differential equations into which its authors choose to pour the scanty empirical evidence on which they based their deductions." (Leontief [1967].)

When placed in their original context, it is clear that Leontief's remarks were directed against the then contemporary developments in two-sector growth models (i.e., they had nothing whatsoever to do with input-output modelling or with models of the type to which SNAPSHOT belongs). In the same article Leontief does, however, express an opinion about how prospective changes in production techniques should be incorporated into a view of the likely future development of the overall economy :

> "Or, consider the information on technological change. Here again, large technical consulting firms are prepared and what is even more important, are being asked to supply a detailed and systematic analysis of the so-called technical input coefficients and the capital coefficients in various industries. They do it by contacting directly the foremost technical experts in particular industries. Inserted in an

> appropriate framework, these data gradually will replace doubtful technical assumptions. These, of course, are only the beginning but, as the practical results come in, more resources will flow into this new large scale fact-finding enterprise and the economist will find himself in possession of the data which he so badly needs."

Thus the work by the BIE on technical coefficients is exactly the approach whose utility Leontief was promoting. His faith in the appropriateness of the input-output framework for integrating the available information is reaffirmed by his recently published study for the U.N. (Leontief et al. [1977]).

5. Concluding Remarks

To us, the most important idea in economics is that of linkages. Every part of the economy is linked with every other part. Thus, in thinking about the implications of any economic change (including a change in production techniques) we must look beyond the initial effect.

In section 2 of this paper we showed how economists quantify linkage effects by using input-output data in a general equilibrium framework. Our application of this method to the analysis of the implications of technical change was discussed in section 3. Then in section 4 we turned to a detailed consideration of MML's criticisms.

The condemnation by MML of our work stems from several misunderstandings. Perhaps the most basic of these was explained in section 4 under point (2). Apparently MML were unable to accept that our concern was with the implications of technical change, not with the causes of technical change. It is unfortunate that they did not feel it worthwhile to check their ideas with us before finalizing their paper. It is surprising that the editorial board of Search did not seek any comment from us before publishing an article which casts rather serious aspersions on our professional standards.

It is equally surprising that Search's referees did not realize that MML quoted Leontief so completely out of context as to put into his mouth words whose meaning is diametrically opposite to his clearly stated position.

References

Carter, A.P. (1970) Structural Change in the American Economy, Harvard University Press, Cambridge, Massachusetts.

Chapman, D. (1978) "Forecasting Technological Coefficients", Bureau of Industry Economics, Working Paper No. 1, Canberra.

Chapman, D. (1980) "Why telling fortunes is better than telling fairy tales : a reply to a Grimm view of SNAPSHOT", Search, vol. 11, June (forthcoming).

Dixon, Peter B., Alan A. Powell and B.R. Parmenter (1979) Structural Adaptation in an Ailing Macroeconomy, Melbourne University Press, Melbourne.

Dixon, Peter B. and D.P. Vincent (1979) "The SNAPSHOT model : underlying theory and an application to the study of the implications of technical change in Australia to 1990", IMPACT Preliminary Working Paper No. SP-14, Industries Assistance Commission, Melbourne, October.

Harrower, J. (1976) "Some economic approaches to technological change - an overview", Workshop on forecasting technological change, IMPACT Project, Industries Assistance Commission, Melbourne, October.

Macdonald, S. (1979) "The governance of technological change in Australia", Occasional Paper No. 3, Science Policy Research Centre, Griffith University.

Mandeville, Thomas, Stuart Macdonald and Don Lamberton (MML) (1980) "The fortune teller's new clothes : a critical appraisal of IMPACT's technological change projections to 1990/91", Search, vol. 11, no. 1-2, Jan/Feb, pp. 14-17.

Leontief, W. (196) "The new outlook in economics", Sir Ellis Hunter Memorial Lecture, University of York, also published in Indian Economic Journal, vol. 16, July/ Sept, 1968, pp. 71-77.

Leontief, Wassily, Anne P. Carter and Peter A Petri (1977) The Future of the World Economy, Oxford University Press for the United Nations, New York.

Powell, Alan A. (1979) "Employment prospects for Keynes' grandchildren : some popular fallacies" IMPACT General Paper No. G-24, Industries Assistance Commission, Melbourne, August.