IMPACT OF DEMOGRAPHIC CHANGE ON INDUSTRY STRUCTURE IN AUSTRALIA

A joint study by the Australian Bureau of Statistics, the Department of Employment and Industrial Relations, the Department of Environment, Housing and Community Development, the Department of Industry and Commerce and the Industries Assistance Commission

Paper Presented to a Workshop on
TECHNOLOGY ASSESSMENT AND FUTURE STUDIES IN
NATIONAL AND CORPORATE PLANNING

Department of Science
Canberra
July 4 - 6, 1978

TECHNOLOGY SCENARIOS : THEIR ROLE IN THE IMPACT PROJECT

by

D. P. Vincent
Industries Assistance Commission

General Paper No. G-13 Melbourne July 1978

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

IMPACT Project, Industries Assistance Commission, 608 St. Kilda Road, Melbourne, Victoria 3004 Australia
Area Code 03 Telephone 51 8611

Dixon, Peter B., J.D. Harrower and D.P. Vincent, "Validation of the Economics of the SNAPSHOT Model", Impact of Demographic Change on Industry Structure in Australia, Industries Assistance Commission, 1978 (forthcoming).

Powell, Alan A., The iMPACT Project : An Overview, March 1977 -- First Progress Report of the IMPACT Project, Vol. 1 (Canberra : Australian Government Publishing Service, August, 1977).

Tulpule, Ashok and M.K. McIntosh, "BACHUROO - An Economic - Demographic Module for Australia", Impact of Demographic Change on Industry Structure in Australia, Working Paper No. B-02, Industries Assistance Commission, Melbourne, May, 1976.

5. REFERENCES

Allen, R.G.D., Macro-Economic Theory : A Mathematical Treatment, St. Martins, New York, 1967.

Australian Bureau of Statistics, Australian National Accounts Input-Output Tables 1968-69, Canberra 1977.

Berndt, E.R. and M.S. Khaled, "Energy Prices, Economies of Scale and Biased Productivity Gains in U.S. Manufacturing, 1947-71", Discussion Paper No. 77-23 University of British Columbia, August, 1977.

Carter, A.P., Structural Change in the American Economy, Harvard University Press, 1970.

Chapman, D. and A.J. Wood, "Technological Update of Input-Output Industries to 1990/91", Internal Working Document, Bureau of Industry Economics, February, 1978(a).

Chapman, D. and A.J. Wood, "Technology in 1990/91; an Analysis of Selected Industries", Internal Working Document, Bureau of Industry Economics, February, 1978(b).

Chapman, D. and A.J. Wood, "Less Detailed Technological Updates of Input-Output Industries to 1990/91", Internal Working Document, Bureau of Industry Economics, April, 1978(c).

Dixon, Peter B., John Harrower and Alan A. Powell, "SNAPSHOT, A Long Term Economy-Wide Model of Australia : Preliminary Outline", Impact of Demographic Change on Industry Structure in Australia, Preliminary Working Paper No. SP-01, Industries Assistance Commission, Melbourne, February, 1976.

Dixon, Peter B., B.R. Parmenter and John Sutton, "Some Causes of Structural Maladjustment in the Australian Economy", Economic Papers, 57, January 1978.

Dixon, Peter B., John D. Harrower and Alan A. Powell, "Long Term Structural Pressures on Industries and the Labour Market", Australian Bulletin of Labour, Vol. 5, June 1977.

Dixon, Peter B., B.R. Parmenter, G.J. Ryland and John Sutton, ORANI, A General Equilibrium Model of the Australian Economy : Current Specification and Illustrations of Use for Policy Analysis -- First Progress Report of the IMPACT Project, Vol. 2 (Canberra : Australian Government Publishing Service, August, 1977).

Dixon, Peter B., "Additions to the ORANI Model : Current Work in Progress", Impact of Demographic Change on Industry Structure in Australia, Research Memorandum, Industries Assistance Commission, Melbourne, January, 1978.

CONTENTS

SNAPSHOT imply in principle (2 x 109x109 + 9x109 ≒ 25,000) cells of coefficients to be updated. Clearly, the full specification of technology scenarios for IMPACT is impractical. The best that can be reasonably expected is for a comprehensive treatment of key industries in the economy selected according to size and propensity to undergo technological change. For the remaining industries for which it is not practical to undertake detailed analyses, it would seem reasonably satisfactory to incorporate technological change by modifying the labour requirements matrix to reflect anticipated changes in labour productivity. The detailed study of selected industries together with the labour productivity analysis of remaining industries, is in fact the approach followed by the Department of Industry and Commerce in formulating technology scenarios for IMPACT.

authors considered that the experts' forecasts were fairly robust in terms of possible relative prices scenarios. They gave what were considered the most likely forecast value and were not able to assess quantitatively the effect of different relative prices of the various inputs.

Results have been reported for twelve industries : iron ore mining, other metallic minerals, coal and crude petroleum, petroleum and coal products, other basic metals, motor vehicles and parts, plastic and related products, motor vehicle repairs, road transport, residential buildings, building and construction and communication. The detailed study covers about 22 per cent of the economy.

A less detailed analysis has been prepared for the remaining industries. This analysis concentrates heavily on the labour requirements matrix. For each I-O industry, projections of average rates of labour productivity growth have been undertaken on the basis of historic trends in labour productivity. In constructing the 1990/91 labour matrix from these projections it has been assumed that the proportional composition of the workforce is the same as in the base year. Further adjustments have also been made to the materials coefficients matrix to account for anticipated differential rates of growth of different industries.

4. CONCLUSION

Both IMPACT'S long term models are at the stage of development where information on technological scenarios can be readily incorporated. The technology requirements for both models are however immense. For example, the dimensions of the three technology coefficients matrices in

TECHNOLOGY SCENARIOS : THEIR ROLE IN THE IMPACT PROJECT

D. P. Vincent

1. THE IMPACT PROJECT [1]

IMPACT is an inter-agency applied economic research project which originated in the Industries Assistance Commission (IAC) in 1975. Its initiation represented a response to an increasingly felt need at the time for improved policy information facilities in the IAC and other departments advising the government on a wide range of inter-related economic and social issues. Within its field of primary responsibility, namely protection policy, the IAC was acutely aware of the conflicts that could arise in the piece-meal approach which had traditionally been followed in Australia.

From the IAC's particular viewpoint, it was clear that reliable policy advice on the consequences for employment and industry structure of alternative options in protection policy would require a comprehensive economy-wide framework of analysis. The framework would need to be detailed enough to give useful information on particular industries, and on different categories of labour. It would also need to take explicit account of the likely growth and composition of the workforce and pay due attention to the role of immigration and fertility in these issues. In order to fulfil these requirements, the IMPACT project was initiated.

The focus of IMPACT is heavily on Australian industry composition and its relationship to international trade, the domestic labour market, and

---

1. The purpose history and framework of the project are described in a comprehensive non-technical monograph. See Powell (1977).

population characteristics. For example, some medium run questions to which IMPACT could be addressed include;

(a) the effects on Australian industry structure and the pattern of employment of international trade developments including changes in the relative prices of traded commodities, tariff changes by Australia or exchange rate changes between Australia and its trading partners,[1]

(b) the long term living standards compatible with the adoption of a particular strategy towards Australia's economic development, and,

(c) the implications of changing fertility patterns for development of Australian industry.

1.1 The IMPACT Models

The project involves the development of a framework containing four models related to different aspects of the Australian economy together with the data bases necessary to support this framework for policy analysis. The four models are:

(i) a small macro-economic model MACRO,

(ii) an industry composition model ORANI,

(iii) an economic-demographic and labour force model BACHUROO,

(iv) a long term model SNAPSHOT.

---

1. Applications of IMPACT'S inter-industry model reported to date have included analyses of the effects on Australia's industrial structure of changes in the exchange rate, changes in levels of protection, changes in real wages, changes in wage relativities, changes in foreign currency import and export prices and changes in the level of Australia's mineral exports. Those applications are reported in Dixon, et al, (1977a), Dixon, Harrower and Powell (1977), Dixon, Parmenter and Sutton (1977) and Industries Assistance Commission (1977).

technological change is expected to take place. The updating is carried out in consultation with Australian industry "experts". This is the procedure being adopted by the Department of Industry and Commerce (DIC) for the IMPACT project.

3.5 Progress to Date in the IMPACT technology Scenarios

Briefly, the procedure adopted has been as follows.[1] Detailed studies of selected industries were conducted via interviews with industry experts. Each expert was asked to update his industry's columns in the A, K and L matrices to 1990/91. The experts were supplied with statistical information on their industries, including:

(i) the base period coefficients which they were being asked to project to 1990/91;

(ii) a breakdown of their industry to the 4-digit ASIC level. Where available, information was given at this level on occupational composition of the work forces, total wages, total materials usage, and trends in output levels.

Experts were also given a general macro scenario for 1990/91. This scenario was not very explicit. The experts were told to assume that wage costs would continue to rise relative to capital costs, government assistance to investment (depreciation allowances, etc.) would continue as at present, and that there would be large increases in crude oil and related product prices. In industries where tariffs and quotas could have an important influence on technology (e.g. motor vehicles), it appears that the experts assumed that current levels of protection and the resulting industry market structures are to be maintained. For example the

---

1. A detailed account of the procedure followed, the coverage of industries and the projection scenarios developed is contained in D. Chapman and A.J. Wood (1978 a, 1978 b and 1978 c.)

As noted earlier, the results of the Carter Study suggest that a detailed trend analysis of labour productivity on an I-O industry basis might be almost as good as a trend analysis based on I-O tables.[1] Supporting evidence is provided by Berndt and Khaled (1977) who have compiled gross output, quantity and various I-O coefficients in USA manufacturing for the period 1947 to 1971. Their figures show that over the period considered, the capital stock/output ratio has risen only very slightly whereas the labour/output ratio has fallen sharply.

3.3 International Comparisons

In this approach future technology for Australia would be assumed to reflect current best practice overseas. Technology scenarios based on such an assumption would however need to be compatible with Australian trade policy scenarios on protection. If for example it was envisaged that the Australian industry would remain heavily protected in relation to its overseas counterparts, then scale limitations brought about by the small size of the domestic market may make it impossible for the Australian industry to take advantage of the technology associated with large scale operations in overseas countries.

3.4 Judgemental - Business Survey Approach

This approach involves the updating of base period technology matrices with the researcher concentrating on industries judged to be of substantial size in the future economy[2] and in which significant

---

1. Preliminary simulations for 1990/91 have been undertaken with SNAPSHOT. In these simulations, the A and K technology is that of the base year (1971/72). The ℓ matrix however reflects the projected increase in labour productivity for each I-O industry based on trend analysis of labour productivity over the 1962/63 to 1972/73 period.
2. It is useful to establish which cells in the coefficients matrices have the greatest impact on the results. Estimates of intermediate demand for example will be more sensitive to changes in some cells in the A matrix than in others. If the more important cells can be identified, the quality of the projections can be improved by devoting resources to studying their movements over time.

MACRO is concerned with determining the size of the aggregates of national income, in particular real private consumption and investment expenditure and real government expenditure. The role of monetary and financial markets is also handled exclusively within MACRO.[1]

ORANI disaggregates the economic aggregates into 109 Input-output[2] (I-O) categories.[3] It also deals with relative prices of commodities, imports and exports, and occupationally disaggregated employment demand. ORANI can be used in short run mode in which case capital stocks are fixed and rates of return are endogenous or in long run mode in which case rates of return are treated as exogenous and capital stocks are allowed to adjust.

BACHUROO is designed to endogenise labour supply for the nine categories of labour recognized by IMPACT[4] by modelling, inter alia, educational and retraining programmes, occupational mobility and workforce

---

1. The MACRO model is based heavily on the macro-econometric model developed by the Reserve Bank of Australia. See Bacon and Johnston (1976) for details.
2. The I-O classification is that of the Australian Bureau of Statistics (ABS (1977)).
3. An outline of the model's theoretical structure as at mid 1977 is contained in Dixon et al. (1977a).
4. The nine occupational groups distinguished by IMPACT are; 1. Professional White Collar, 2. Skilled White Collar, 3. Semi and Unskilled White Collar, 4. Skilled Blue Collar (metal and electrical), 5. Skilled Blue Collar (building), 6. Skilled Blue Collar (other), 7. Semi and Unskilled Blue Collar, 8. Rural Workers and 9. Armed Services.

participation.[1] BACHUROO when linked with MACRO and ORANI will form IMPACT's annual medium term model.

SNAPSHOT is specifically a long term model.[2] It is designed to provide long term projections of the economy 15,20 or 25 years ahead. SNAPSHOT abstracts from the dynamics of adjustment paths of variables between the base year and the snapshot year in which projections are made. Its task is to identify the long run consequences of changes in technology, demography and international trade on the industrial structure of the Australian economy, on the skill composition and manpower requirements of the workforce, and on living standards. Technology, demography and external trade patterns are exogenous to SNAPSHOT -- that is, they form the scenarios on which the SNAPSHOT projections are made.

2. TECHNOLOGICAL CHANGE VARIABLES IN IMPACT'S LONG TERM MODELS

Information on technology is required by the ORANI model when run in long term mode and by SNAPSHOT. Although they enter the models in different ways, the basic informational requirements on technology are essentially the same for ORANI and SNAPSHOT with both models based on the 109 industry I-O classification.

2.1 Technological Information Required for SNAPSHOT

The user is required to specify the demographic scenario, (size of workforce and the number of persons in each of the nine different types of households identified by the model), the international trade scenario (the relative international prices of imports and exports, the level of exports and the extent of import penetration to be permitted),

1. The BACHUROO model is outlined in Tulpule and McIntosh (1976).
2. See Dixon, Harrower and Powell (1976).

distinguishing between technological improvements which are Australia-specific and those which are expected to be world-wide. For both SNAPSHOT and ORANI it is necessary to specify the trade scenario in terms of the vector of foreign prices of internationally traded commodities. This scenario needs to be consistent with the technology scenario. Consider for example, a technological change that occurred in overseas countries but which could not be applied in Australia. This change would be reflected in a lowering of the internationally traded price of the commodities produced in the industry benefiting from the change. The Australian industry would therefore become less competitive in international trade. On the other hand, Australia-specific improvements in technology would increase Australia's international competitiveness. In such a situation, changes would be made to the Australian technology matrix but not to the world price.

3.2 Extrapolative Approaches to Forecasting Technology

Various types of trend curves (for example linear of logarthmic) can be fitted to historic data on coefficients. The ideal data base would be a time series of comparable input-output coefficient matrices for the A, K and ℓ matrices. However such a data base is simply not available for Australia. Even if it were, the time series approach has a number of inherent problems. Coefficient changes over time can be attributed, in addition to the pure technology effect, to changes in relative prices and changes in the proportionality between components within individual I-O cells. In turn, changes in relative prices may be the result of technological change. On the data side, it is inevitable that the underlying product mix of a sector in the coefficient matrix will change over time causing changes in the coefficents purely as a result of the aggregation decisions made when constructing the I-O classification.

light of analyses of trend movements in U.S. input-output coefficients (Carter (1970)) that the dominant features of technological change are embodied in the labour coefficients matrix. If this were the case, we would expect the model to perform reasonably satisfactorily provided that we could establish the correct movement in labour productivity over the snapshot period. Getting the technology right for the A and K matrices should prove of less critical importance.

The Melbourne based IMPACT team has no special expertise in compiling technology scenarios. Hence the list of methods which follows is both short and lacking in detail. It is meant to encompass only those methods being considered for the IMPACT study.

3.1 Some Issues in the Development of Technology Scenarios for IMPACT

Before mentioning these methods it is worthwhile to mention several issues that need to be kept in mind when formulating technology scenarios for SNAPSHOT and ORANI. The first relates to the fact that changes in technology are due in part to changes in the relative price of inputs where these relative prices are themselves determined by the models. Hence there is a problem of achieving internal consistency between the exogenous technology and the endogenous prices. Ideally, the technology scenarios need to be assembled assuming a relative price scenario which is broadly consistent with that which the model will generate. If for example a technology scenario is assembled under an anticipated relative price scenario that is vastly different to that subsequently generated by the model then the original scenario would have to be reformulated and the model rerun.

The second issue concerns the importance, in the case of those industries which are extensively involved in international trade, of

and the technology scenario for the snapshot year. The technology requirements refer to intermediate input technology, technology for capital formation and labour input technology. The technology scenarios are written in terms of conventional input-output coefficients. SNAPSHOT requires the specification of the following three matrices of input-output technology coefficients;

(i) a 109 x 109 intermediate input coefficients matrix (A)

(ii) a 109 x 109 capital requirements coefficients matrix (K)

(iii) a 9 x 109 labour requirements matrix (ℓ).

In terms of the I-O tables, A is the basic values, indirect allocation of imports, materials usage matrix expressed in base year prices. That is, a_{ij} is the number of base year dollars worth of output from industry i required per base year dollars worth of ouput in industry j in the snapshot year.[1]

Similarly, a typical element of K the capital coefficients matrix is the number of base year dollars worth of good i required in the capital stock necessary to support the production of one base year dollar's worth of output from industry j in the snapshot year.

A typical element of the labour matrix (ℓ) represents the number of workers in IMPACT occupation i required per base year dollar's worth of output from industry j in the snapshot year. Consider for example a technological scenario for the snapshot year (say 1990/91) compared with the known technology for 1971/72. The technology for a particular industry might be expressed as follows :

---

1. Ideally, all I-0 technology coefficients are expressed in terms of physical units of inputs and outputs hence the use of base year dollar values for the numeraire. That is, coefficient changes over time refer to input volume/output quantity changes which conceptually are independent of changes that might occur in input prices.

(i) labour inputs of type 1 (Professional) per unit of output 10% lower than in 1971/72, labour inputs of type 7 (Semi and Unskilled) per unit of output 20% lower, all other categories of labour inputs 5% lower;

(ii) accumulated fixed capital stock per unit of output supplied by the building and construction industry 20% lower than in 1971/72, accumulated fixed capital stock per unit of output supplied by the motor vehicles industry 10% lower, with capital coefficients for the remaining capital supplying industries unchanged;

(iii) inputs of the plastic products industry per unit of output 5% higher, inputs of the fabricated metal products industry per unit of output 5% lower and with all other materials input-output coefficients unchanged.

It is readily apparent that because of the high level of industry disaggregation recognized in the model, a vast amount of information on technology is required to fully specify the technology scenario.

2.2 Technological Information Required for ORANI[1]

The data requirements to completely specify a technology scenario for ORANI are even more demanding than is the case with SNAPSHOT because of ORANI'S detailed treatment of commodity flows from both domestic and imported sources and its extensive treatment of margins on these flows. Consider for example the ORANI I-O data base of figure 1.

The figure shows that ORANI uses information on

1. This section borrows heavily from Peter B. Dixon (1978).

change the scenario writer was attributing to a change in relative factor prices. The extent to which explicit price scenarios are required depends on the substitution possibilities already specified within ORANI. Therefore, scenario writers should be familiar with the model.

3. APPROACHES TO COMPILING TECHNOLOGICAL CHANGE SCENARIOS

To date ORANI model simulations have been mainly in short run mode with base period technology fixed. Similarly, the major research effort with SNAPSHOT to date has been to evaluate its economic performance by assessing how accurately the model projects the industrial and workforce structure of the 1971/72 economy given the production technology, demographic and trade conditions that actually were realised in the 1971/72 snapshot year. The model has performed to a high degree of accuracy in this situation where all components of the exogenous data base are known with certainty.[1] Long run projections with the model are planned from a starting base of 1971/72 to a snapshot year 1990/91. Hence scenarios on technology, trade and demography are currently being developed for 1990/91.

One additional task currently being undertaken with SNAPSHOT involves using trend analysis to project the technology, trade and demography scenarios for 1971/72 from the vantage point of 1962/63. The aim of the exercise is to assess the impact each component of the data base projected in this way has on the accuracy with which the model projects the endogenous variables in the 1971/72 economy. In terms of the three matrices of technology coefficients, we might anticipate in the

1. Details of the validation experiment and results are contained in Dixon, Harrower and Vincent (forthcoming 1978).

$$X = f\left(\frac{Y_1}{A_1}, \frac{Y_2}{A_2}, \ldots, \frac{Y_n}{A_n}\right)$$

where f is a non-decreasing function of each of its arguments, and where X is an industry output, the Y s are inputs and the A s are exogenous technological change variables. A decrease in A_i is a input-i-augmenting technological change - - if as the result of a technological advance A_i declines by 5 per cent, then an input of 100 units of i becomes the equivalent of an input of 105 units of i under the old technology.

Although the percentage changes in the A_i s are required for ORANI computations, it is quite satisfactory to compile the technological change scenarios in terms of the SNAPSHOT style input-output coefficients. With reference to the example given in the previous section, the scenario outlined would be written in terms of the percentage changes in the input-output coefficients formed from the $\tilde{A}$, $\tilde{F}$, $\tilde{B}$, $\tilde{G}$, and the primary factor input matrices. One further complication in ORANI concerns the need to separate the technological change element from the price induced substitution element of projected technology input-output coefficients for labour and capital. (The ORANI model permits substitution among the primary factor inputs (labour, capital and land) in response to changes in their relative prices. SNAPSHOT however, allows no such substitution. Capital and labour input-output coefficients are fixed.) This exercise however need present no difficulties provided the price scenarios (in which the technology scenarios are written) are specified. Via the price scenarios, we can net out substitution effects from total changes, leaving the technological changes, i.e. the changes in the A s. For example, if a technological change scenario specified a 10 per cent increase in the use of capital per unit of output and a 5 per cent decrease in labour per unit of output, it would be important to calculate what proportion of this

Figure 1 : I-O Data Base for ORANI

		Intermediate users	Final Demand: Capital formation	Final Demand: Current consn.	Final Demand: Exports	Final Demand: Other	
		← g →	← g →	← 1 →	← 1 →	← 1 →	
Domestic		g ↑↓ $\tilde{A}$	$\tilde{B}$	$\tilde{C}$	$\tilde{D}$	$\tilde{E}$	Row sums = total direct usage of domestic production
Imports		g+1 ↑↓ $\tilde{F}$	$\tilde{G}$	$\tilde{H}$	$\tilde{I}$	$\tilde{J}$	- Duty - $\tilde{Z}$; Row sums = total imports (c.i.f.)
Margin type 1	on domestic flows	g ↑↓ $\tilde{K}_1$	$\tilde{L}_1$	$\tilde{M}_1$	$\tilde{N}_1$	$\tilde{O}_1$	Row sums = total margin (type 1) on sales of each type of domestic output
	on imports flows	g+1 ↑↓ $\tilde{P}_1$	$\tilde{Q}_1$	$\tilde{R}_1$	$\tilde{S}_1$	$\tilde{T}_1$	Row sums = total margin (type 1) on sales of each type of import
Continues through margin types 2 to g + 1							
Margin type g+1 (tax)	on domestic flows	g ↑↓ $\tilde{K}_{g+1}$	$\tilde{L}_{g+1}$	$\tilde{M}_{g+1}$	$\tilde{N}_{g+1}$	$\tilde{O}_{g+1}$	Row sums = total margin (tax) on sales of each type of domestic output
	on imports flows	g+1 ↑↓ $\tilde{P}_{g+1}$	$\tilde{Q}_{g+1}$	$\tilde{R}_{g+1}$	$\tilde{S}_{g+1}$	$\tilde{T}_{g+1}$	Row sums = total margin (tax) on sales of each type of imports
Primary inputs	Labour	M ↑↓ $\tilde{U}$	0	0	0	0	
	Capital	1 ↑↓ $\tilde{V}$					
	Land	1 ↑↓ $\tilde{W}$					
	Other Costs	1 ↑↓ $\tilde{X}$					
		Column sums = domestic outputs at basic values	Column sums = investment expenditure by each industry				

(i) intermediate commodity flows from domestic and foreign sources for current production ($\hat{A}$ and $\hat{F}$),

(ii) commodity flows for fixed-capital creation ($\hat{B}$ and $\hat{G}$),

(iii) commodity flows to households ($\hat{C}$, $\hat{H}$),

(iv) exports ($\hat{D}$, $\hat{I}$),

and

(v) "other" demands (mainly government consumption).

Associated with each "direct" commodity flow is a set of markup flows. The ij th element of $\hat{K}_t$ is the use of good t as a margin in facilitating the ij th flow in $\hat{A}$, i.e., the flow of good i from domestic sources to industry j for use as a current input. The elements of the $\hat{P}$ matrices are margin flows on imported intermediate inputs and the elements in the $\hat{L}$ and $\hat{Q}$ matrices are margin flows associated with domestic and imported inputs into capital creation, etc.[1]

Finally, the $\hat{U}$, $\hat{V}$, $\hat{W}$ and $\hat{X}$ matrices show primary factor inputs into current production.[2] The labour input matrix, $\hat{U}$, is disaggregated into 9 labour-types or occupations (M = 9).

---

1. Although the data base allows for margins uses of any of the 109 commodities, in practice the only margin supplying industries are wholesale trade, retail trade, road transport, rail transport, water transport, air transport, other insurance, and hotels.
2. ORANI follows the convention that primary factors are used in current production only. Primary factors enter capital creation via their role in current production in the construction and machinery industries.

In ORANI 78 there is a technological change variable attached to every commodity and factor[1] flow in figure 1 with the exceptions of the vectors[2] $\hat{C}$, $\hat{H}$, $\hat{D}$, $\hat{I}$, $\hat{E}$, and $\hat{J}$. For example, the technological change variable attached to the ij th element of $\hat{A}$ refers to improvements in the technology for producing good j associated with the use of input i from domestic sources. The technological change variable associated with the ij th element of $\hat{Q}_t$ refers to savings in the margins use of good t required per unit of good i delivered from imported sources to industry j for capital creation in that industry. The technological change variables attached to the elements of $\hat{U}$ refer to improvements associated with the use of various types of labour, and the technological change variables attached to the elements of $\hat{M}_t$ allow simulation of the effects of improvements in the margins use of good t associated with the delivery of domestic commodities to households.[3]

Each of the ORANI technological change variables allows for "factor augmentation".[4] In general, the production functions are written as

---

1. The tax and tariff flows X, K_{g+1}... O_{g+1},... T_{g+1} are not included.
2. These vectors refer to "final" uses of commodities. The flows are not inputs into a production process and thus technological change is not applicable. However, "change in taste parameters" are attached to the household consumption vectors $\hat{C}$ and $\hat{H}$.
3. For example a lowering of the input of retail trade services in the delivery to consumers of vegetables, would be handled via the technological change variables attached to $\hat{M}_t$.
4. See, for example, Allen (1967) pp. 234-57.