The steel industry
Productivity in the Australian Basic Iron and
The long term effects of improved labour

By
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-53-

30. (cont.)

\[
\sigma'(g+1,1,63) \left[ P(g+1,1,63) - S^*(g+1,1,63) \right. \\
\left. - (1 - S^*(g+1,1,63)) \left[ P(g+1,2,63) - P(g+1,1,63) \right] \right] \\
= \sigma'(g+1,1,63) \left[ 1 - S^*(g+1,1,63) \right] \left[ P(g+1,1,63) - P(g+1,2,63) \right].
\]

With the values given for \( \sigma'(g+1,1,63) \) and \( S^*(g+1,1,63) \) in sub-section 2.1, the last expression becomes \( \sigma'(g+1,1,63) \) and \( S^*(g+1,1,63) \) in sub-section 2.1, the last expression becomes

\[
0.299 \left[ P(g+1,1,63) - P(g+1,2,63) \right].
\]

In the long-run environment adopted here labour is assumed to be fully employed, while the capital stock in each industry is allowed to adjust to exogenous shocks. As a result of the labour-augmenting technical change in the basic iron and steel sector there is an increase in the industry wage rate (projected to be \( P(g+1,1,63) = 1.01\% \)) relative to the rental price for a unit of capital in the industry (projected to be \( P(g+1,2,63) = 0.54\% \)). Thus the effect on employment of labour in the sector is:

\[
0.299[1.01 - 0.54] = 0.14\%.
\]

31. Note that while the ORANI theory allows for CRETH technology on the input side and CRETH technology on the product side (see DPSV, Chapter 3), in the present version only three agricultural industries are modelled as having CRETH transformation prospects.


33. SNAPSHOT is a programming model of the Australian economy. The economy is viewed as if it maximizes an objective function subject to a set of production possibilities, a balance of payments constraint and additional constraints ensuring adequate diversification of investment and employment across sectors, satisfactory income distribution, etc. See Dixon and Vincent (1980) for a description of the SNAPSHOT model.
employment or occupation, additional real wages, real domestic absorption.

2. In addition to product productivity growth, the impact of output on income is considered.

This paper attempts to quantify the long-term effects of the

productive impact of Japanese steel workers on Japan's Gross Domestic Product. The productive impact is measured in terms of output and income. The marginal productivity of labour is defined as the increase in output resulting from an additional unit of labour. The paper considers the impact of productivity on income and output, and the effects of changes in productivity on the economy. The model of the 1990 productivity increase and the resulting economic effects are also examined.
aggregate exports, aggregate imports and the aggregate capital stocks. To simulate the responses of these indicators the ORANI model of the Australian economy will be used in long-run mode. Hagan and Smith (1980) used an earlier version of the ORANI model to simulate the inter-industry effects of labour-saving technical change. ORANI is a multisectoral model distinguishing 113 industries and including a facility for imposing technical change either neutral or augmenting of specific inputs. In section 2 the relevant parts of the ORANI production theory and the implementation of technical change are reviewed. As the emphasis of this study is on the long-term implications of technical change, section 3 is devoted to discussion of the use of ORANI in long-run mode. The results of the ORANI simulation of a labour-augmenting technical change in the production of basic iron and steel are presented in section 4. Finally, in section 5 two problems with the ORANI long-run facility are discussed, and conclusions are offered.

23. (cont.)

\[
x = \frac{X}{(\partial f/\partial X)} \ k + \frac{N}{(\partial f/\partial N)} \ n + \frac{L}{(\partial f/\partial L)} \ l_0 \\
+ \frac{O}{(\partial f/\partial O)} \ (t_6^3 - a_{(g+1,1)63}) .
\]

(4)

For details of the next step the interested reader is referred to P.B. Dixon, S. Bowles and D. Kendrick, Notes and Problems in Microeconomic Theory, 1980 (Amsterdam: North Holland), pp.224-226. Provided that factor rentals are equated with their marginal products and that the aggregate production function (1) is homogenous of degree 1 then, by taking as numeraire the price of a unit of aggregate output, (4) may be rewritten as:

\[
x = s_k'x + s_n'x + s_0'x + s_{63}'x - s_{63} a_{(g+1,1)63} .
\]

(5)

where

\[s_k + s_n + s_0 + s_{63} = 1,
\]

and \(s_k, s_n, s_0\) and \(s_{63}\) may be interpreted as factor shares in aggregate output. The expression \(s_0'x + s_{63}'x\) appearing in (5) may be written as \(s_k'x\) so that equation (5) may be converted into (4.2) by using this result and by equating gdp with \(x\).

24. This adjustment mechanism is analogous to that advanced by Gregory (1976) and Dixon, Farmenter and Sutton (1978).

25. To see this note that, \(l_6\), the percentage change in employment of the skilled blue collar (other) occupation is given by DFSV, Table 23.1 as:

\[
l_6 = \sum_{j=1}^{h} B_{(g+1,1,6)} x_{(g+1,1,6)} .
\]

(6)

where \(B_{(g+1,1,6)}\) is the share of the economy wide employment in occupation 6 which is accounted for by industry \(j\), and \(x_{(g+1,1,6)}\) is the percentage change in employment of occupation 6 by industry \(j\). The ORANI equation for \(x_{(g+1,1,6)}\) is given in (2.5). By substituting (2.6a) into (2.5) the equation for \(x_{(g+1,1,6)}\) becomes:

\[\]
production function. Thus, in the short run, the production function in a particular industry is specified by a set of factor proportions that define the relationship between inputs and outputs. This relationship is often expressed in the form of a production function, which shows the maximum output that can be produced with a given set of inputs.

In the long run, the production function is determined by the technology available, the size of the plant, and the level of capital investment. The production function in the long run is often expressed in the form of a production function, which shows the maximum output that can be produced with a given set of inputs. This relationship is often expressed in the form of a production function, which shows the maximum output that can be produced with a given set of inputs.

In summary, the production function in the short run is determined by the factor proportions available, while the production function in the long run is determined by the technology available and the size of the plant. The production function in the short run is often expressed in the form of a production function, which shows the maximum output that can be produced with a given set of inputs. This relationship is often expressed in the form of a production function, which shows the maximum output that can be produced with a given set of inputs.

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and Vincent (hereafter DPSV) (1982, sub-section 11.1). Here the formation of a unit of activity in industry \( j \), denoted \( Z_j \), is summarized in Figure 2.1. The figure shows all possible inputs to current production that can be purchased by each of the \( h \) ORANI industries. These consist of \( g \) commodities (\( g \) domestically produced and \( g \) imported), \( n \) occupational categories of labour, \( i \) industry fixed capital and land inputs, and inputs of other cost tickets. The ORANI production functions depicted in Figure 2.1 are of a three level nested form, and exhibit constant returns to scale. At level 3 effective units of labour are constructed as CES\(^{6}\) composites of labour from the \( n \) different occupational groups. At level 2 effective units of material input \( i \) are defined as CES\(^{7}\) combinations of domestic and imported supplies of the \( i \)th commodity classification, and effective units of primary factors are constructed as CES\(^{8}\) combinations of capital, agricultural land and effective inputs of labour. A technological change in the overall use of labour can be introduced at this point. Finally, at level 1 a given level of activity in industry \( j \) is generated using, in fixed proportions, effective units of produced inputs, effective units of primary factors, and inputs of other costs.

The Leontief technology used to combine inputs at level 1 in Figure 2.1, precludes the possibility of substitution between effective units of primary factors and effective inputs of produced commodities or other costs as a result of relative price movements between these groups. Solution of each producer's cost minimization problem using the technological constraints shown in Figure 2.1 can be carried out in stages. For example, at levels 2 and 3 industry \( j \) will choose the

13. The percentage reduction in total primary factor input costs to basic iron and steel production, denoted by \( c \), is given by:

\[
c = aS(g+1,1)63 + \beta S(g+1,2)63
\]

where \( a \) and \( \beta \) are the reductions in demands for inputs of labour and fixed capital, respectively, by industry 63 for a fixed level of activity and with constant primary factor rentals. In the text \( a \) and \( \beta \) are computed using

\[
a = a_{g+1,1,63} [1 - \alpha(g+1,1,63) (1 - S(g+1,1,63))]
\]

and

\[
\beta = a_{g+1,1,63} \alpha(g+1,1,63) S(g+1,1,63).
\]

Using the fact that \( S(g+1,2,63) = 1 - S(g+1,1,63) \) it can be shown that \( c \) is given by

\[
c = a_{g+1,1,63} S(g+1,1,63),
\]

and so when \( a_{g+1,1,63} = -22 \) the reduction in primary factor costs in basic iron and steel production is:

\[
c = -22(0.766)
\]

\[
= -16.85%.
\]


15. The basic value of each domestically produced good is the price received by the producer.

16. The balance of trade may pass through zero, and so this variable appears in the model in change form (rather than percentage change form).

17. See DPSV, Section 50, pp. 344-353.


21. See DPSV, pp. 143-144.

Figure 2.1. Input technology for current production in ORANI

ACTIVITY LEVEL

FIXED COEFFICIENTS

LEVEL 1

EFFECTIVE INPUT OF GOOD 1

EFFECTIVE INPUT OF GOOD 8

EFFECTIVE INPUT OF PRIMARY FACTORS

"OTHER COSTS"

LEVEL 2

CES

DOMESTIC GOOD 1

IMPORTED GOOD 1

DOMESTIC GOOD 8

IMPORTED GOOD 8

LEVEL 3

CR E S H

CR E S H

CR E S H

CAPITAL

AGRIC. LAND

LABOUR OF OCCUPATION 1

LABOUR OF OCCUPATION 2
combination of capital, land and labour of each occupational type to minimize the costs of providing the effective input of primary factors required to sustain any given activity level.

In percentage change form the complete solution for the cost minimizing selection of primary factors is given by the following equations:

\[
x_{(g+1,1,q)j} - x_{(g+1,1,q)j} = \sigma_{(g+1,1,q)j} \left( p_{(g+1,1,q)j} - \sum_{q=1}^{M} s_{(g+1,1,q)j} p_{(g+1,1,q)j} \right) \\
+ s_{(g+1,1,q)j} - \sigma_{(g+1,1,q)j} \left( a_{(g+1,1,q)j} - \sum_{q=1}^{M} s_{(g+1,1,q)j} a_{(g+1,1,q)j} \right) \\
q=1,2,\ldots, M, j=1,2,\ldots, h \tag{2.1}
\]

\[
x_{(g+1,v)j} = z_{j} - \sigma_{(g+1,v)j} \left( p_{(g+1,v)j} - \sum_{t=1}^{3} s_{(g+1,t)j} p_{(g+1,t)j} \right) \\
+ s_{(g+1,v)j} - \sigma_{(g+1,v)j} \left( a_{(g+1,v)j} - \sum_{t=1}^{3} s_{(g+1,t)j} a_{(g+1,t)j} \right) \\
+ s_{j} + a_{g+1,j} \quad v=1,2,3, \quad j=1,2,\ldots, h \tag{2.2}
\]

\[
p_{(g+1,q)j} = \sum_{q=1}^{M} p_{(g+1,q)j} s_{(g+1,q)j} + \sum_{q=1}^{M} a_{(g+1,q)j} s_{(g+1,q)j} \tag{2.3}
\]

where all lower case arabic symbols are percentage changes in the variables indicated below.
the shape of total output of agro in the country, a
of the production process of industry, if
between labor force and output of other factors in the
a CASH parameter reflecting the degree of substitutability
is external production process.
between agro sector and other industry sectors in industry
a CASH parameter reflecting the degree of substitutability
The parameters are:
(a\',1.1+3)\,\,d
place to industry, a net of effective demand
(a\',1.1+3)\,\,d
context of change vector, v=x
\n\nCASH parameter reflecting the degree of substitutability
\[ (a',1.1+3) \]
\n\n\n\]
$S_{(g+1,1,q)j}$: the modified occupation q cost share arising from the CRRESH formation of effective labour inputs, defined as:

$$S_{(g+1,1,q)j} = \frac{\sigma_{(g+1,1,q)j} S_{(g+1,1,q)j}}{\sum_{k=1}^{N} \sigma_{(g+1,1,4)j} S_{(g+1,1,4)j}}$$

$S_{(g+1,v)j}$: the modified share of total primary factor costs in industry j accounted for by primary factor v, defined as:

$$S_{(g+1,v)j} = \frac{\sigma_{(g+1,v)j} S_{(g+1,v)j}}{\sum_{k=1}^{3} \sigma_{(g+1,1)j} S_{(g+1,1)j}}$$

where

$S_{(g+1,v)j}$ = share of primary factor v in the total costs of primary factors in industry j.

Dixon and Vincent stress that they are drawing their conclusion from employment results based on a 9-order occupational classification (which is identical to the classification used here). By moving to a more disaggregated occupational classification of the workforce some groups may be seen to experience high levels of unemployment (indicating a need for re-training programmes for workers in those occupations), while at the same time revealing likely shortages of workers with specific skills. A method for decomposing ORANI employment projections into occupation-specific changes for 71 categories is described in Cook and Dixon (1982).

In ORANI simulations of the effects of exogenous technical change the "a" variables in equations (2.1) - (2.3) are set exogenously. Labour-augmenting technical change can be simulated via suitable choices of values for these variables. For example, a 1 percent occupation-q-augmenting technical change in industry j requires

$$\sigma_{(g+1,1,q)j} = -1,$$

with all the other a's set to zero. For a 1 percent labour-augmenting technical change in industry j which is occupation-neutral we would set
The occupational changes observed in the workforce shown in Table 1.4.2 are expressed as occupational shares, which show the proportion of the total workforce in each occupational category. The changes are calculated using the formula:

\[ S_i = \sum_j a_{ij} S_j \]

where:
- \( S_i \) is the share of occupation \( i \) in the total workforce,
- \( a_{ij} \) is the transition rate from occupation \( j \) to occupation \( i \), and
- \( S_j \) is the share of occupation \( j \) in the total workforce.

The occupational changes observed in the workforce shown in Table 1.4.2 are expressed as occupational shares, which show the proportion of the total workforce in each occupational category.
\[ x_{(g+1,v)j} = 2_j - \sigma_{(g+1,v)j} \left( p_{(g+1,v)j} - \sum_{k=1}^{3} s_{(g+1,k)}j \right) p_{(g+1,k)j} \]
\[ + \delta_{63,j} \sigma_{(g+1,v)j} s_{(g+1,1)j} a_{(g+1,1)j} \]
\[ v=2,3 \quad (2.6b) \]

\[ p_{(g+1,1)j} = \sum_{q=1}^{M} p_{(g+1,1,q)j} s_{(g+1,1,q)j} \]  \quad (2.7)

where

\[ \delta_{63,j} = \begin{cases} 
0 & \text{if } j \neq 63 \\
1 & \text{if } j = 63 
\end{cases} \]

According to equation (2.5) industry j's demand for labour of skill q varies proportionately with j's demand for labour in general if occupational wage relativities do not change. But if the wage of occupation q falls relative to a weighted average of all occupational wage rates in industry j, then that industry will substitute skill group q in place of other occupations in its labour force. In (2.6a) the variable \( p_{(g+1,1)j} \) is the percentage change in the costs to industry j of a unit of labour and, with \( a_{(g+1,1,q)j} = 0 \) for each q, this is given by (2.7) as a weighted average of the percentage changes in occupational wage rates in that industry.

Interpretation of equations (2.6a and b) is now straightforward. For the moment suppose that \( a_{(g+1,1)63} = 0 \). Then each industry's demands for labour in general (via (2.6a)), capital and agricultural land (via (2.6b)) vary proportionately with activity in the sector provided relative factor prices in the industry do not change. Alternatively, an increase in the cost to industry j of any one factor relative to the other two, leads to substitution away from that factor.

The second problem is that in long-run mode ORANI suffers from a mild form of the overspecialization or "flip-flop" problem with respect to export-oriented activities. The elasticities of foreign demand curves for the products whose export levels are endogenous in ORANI are quite high, but are less than infinity, thus providing some restraints on the projected movements in export volumes. Nevertheless, as may be seen in Table 4.2, activity in the coal industry, for example, decreases by 9.46%. However, the pastoral zone, the wheat/sheep zone, and the high rainfall zone activities experience a much smaller contraction in activity. Two features of this current version of ORANI reduce the tendency of these three agricultural activities to overspecialize:

(i) as pointed out by Vincent (1980), the own price elasticity of output of each commodity by industry j under the ORANI CRESH-CRETH production technology depends inversely on the share of fixed factor costs \( W_{F} \) in that industry. If \( W_{F} \) is zero then the supply curve for that industry is horizontal. In long-run simulations where labour markets are slack and capital is mobile only those industries which use land (namely, those in the agricultural sector) have non-horizontal supply schedules.

(ii) the ORANI treatment of agriculture permits only limited transformation possibilities between the commodities produced by each of the pastoral, wheat/sheep, and high rainfall zones.

One line of research into the flip-flop behaviour displayed by the ORANI mining industries (which are single product activities, have no fixed-factor usage in long-run mode, and which usually show the greatest variation of
The potential advantage of the CMOS product comes from the fact that the product of the two input signals, which is a function of the product of the two signals, can be expressed as:

\[ E_9(1^{1+8})_d = E_9(1^{1+8})_p \cdot E_9(1^{1+8})_x \]

where \( E_9(1^{1+8})_d \) is the product of the two input signals, and \( E_9(1^{1+8})_p \) and \( E_9(1^{1+8})_x \) are the product of the two signals, respectively.

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\[ E_9(1^{1+8})_d = E_9(1^{1+8})_p \cdot E_9(1^{1+8})_x \]

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the use of CES functions only. With the CES production technology specified for industry $j$ the parameter $\sigma_{(g+1,1)j}$ is the elasticity of substitution between labour and all other primary factor inputs, and $s_{(g+1,1)j}$ simplifies to be the share $s_{(g+1,1)j}$ of labour in industry $j$'s primary factor costs. Following the work of Caddy (1976), (1977) the values chosen for the primary factor substitution elasticities in each sector for the long-run simulation reported here were

$$\sigma_{(g+1,v)j} = 1.276, \quad v = 1, 2, 3, \quad j = 1, 2, \ldots, h.$$  

This implies that the pairwise substitution elasticities between land, labour and capital in each of the land using industries is 1.276; while for those sectors which do not use land, the elasticity of substitution between capital and labour is also 1.276.

Base period data for the simulation was obtained from the Australian Bureau of Statistics (ABS) 1974-75 input-output tables for Australia. From this data, $s_{(g+1,1)63}$ was computed as:

$$s_{(g+1,1)63} = 0.766, \quad (2.9)$$

and so a 22% labour-augmenting technical change in the basic iron and steel industry induces substitution towards labour in general of

$$1.276 \times (1 - 0.766) \times 22.0 = 6.58\%$$

The overall reduction in demand for labour under conditions of fixed activity level and fixed factor price relativities is then $-22.0 + 6.58 = -15.42\%.$

The term involving $a_{(g+1,1)j}$ in equation (2.6b) quantifies the degree of substitution away from capital and land inputs into current production by industry $j$ when labour becomes relatively more efficient. In our example the

This percentage change is close to the increase in activity reported in Table 4.3 for the ship and boat building industry. Expansion in the water transport sector is due to a large increase in demand for the use of water transport to facilitate the flow of intermediate inputs to basic iron and steel producers.

4.3 Employment in the basic iron and steel industry

Recall that at any given output level the labour-augmenting technical change implies that 22% less labour is required to produce a unit of output in the industry. But as labour has become more efficient iron and steel producers tend to substitute labour for capital in their manufacturing process, so that, if the level of output in the industry had been held constant at the level prior to the introduction of the technical change, and if relative factor prices had remained constant, demand for labour overall by the basic iron and steel sector would have declined by 15.42% (see subsection 2.1). But as a result of the 22% labour-augmenting technical change in the basic iron and steel industry, activity in the sector is projected to expand by 30.40% (see Table 4.3). Therefore exclusive of the effect of changes in relative factor prices, employment in the manufacture of basic iron and steel increases by $30.40 - 15.42 = 14.98\%.$

In the ORANI simulation, where both relative factor prices and output in the basic iron and steel sector are allowed to fluctuate to accommodate the labour-augmenting technical change, employment in the industry is projected to grow by 14.84%. Thus the effect of also allowing the wage-rental ratio to adjust to the labour-augmenting technical change, is to reduce the employment of labour in the industry by only $14.98 - 14.84 = 0.14\%.$
The increase in activity in the ship and port building industry is due to the increase in actual activity to ship and port building due to the expansion of both investment and operation by the water transport industry. The expansion of both investment and operation by the water transport industry is also due to the increased activity to ship and port building due to the expansion of both investment and operation by the water transport industry. The increase in activity to ship and port building is due to the increased activity to ship and port building due to the expansion of both investment and operation by the water transport industry.
\( P(63,1) \): basic value of a unit of production by the basic iron and steel sector,

\( P(16)63 \): price to the basic iron and steel producers of a unit of commodity \( i \) from source \( s \) used in current production,

\( a(63) \): a weighted sum of the technical change terms affecting the production function for the basic iron and steel industry,

\( P_{g+2,63} \): price of other cost tickets to industry 63.

\( H_{(v=63)} H_{(g+1, v=63)} H_{(g+1, q=63)} \) and \( H_{g+2,63} \) are the shares of industry 63's costs accounted for by inputs of commodity \( i \) from source \( s \), by inputs of capital \((v=2)\) and land \((v=3)\), by inputs of labour of skill \( q \), and by purchases of other cost tickets.

With the assumptions made in (2.5), \( a(63) \) becomes

\[
a(63) = a_{(g+1,1)63} H_{(g+1,1)63} = -22(0.247) = -5.43,
\]

where the value of \( H_{(g+1,1)63} (0.247) \) is calculated from the data base. For the moment assume that prices are held constant. So, from a state in which (2.10) is satisfied with \( a(63) = 0 \) the imposition of technical change in the basic iron and steel sector reduces the left hand side of (2.10) by 5.43%. That is, basic iron and steel producers make a cost saving of 5.43% per unit produced.

In summary, there are 3 equations in the ORANI system which are affected directly by the technical change (that is, by setting \( a_{(g+1,1)63} = -22 \)). These are the equations modelling demands by basic iron and steel producers for labour in general and capital inputs to current production, and also the pricing equation, or zero pure profits condition, for the sector. The appearance of

---

Figure 4.3: Location of a new equilibrium (OE) in the market for Australian iron ore once the initial domestic supply curve SS to D2, domestic demand from D1 to D2, and the foreign demand curve T2O. The resultant new equilibrium demand curve for Australian iron ore is given by the intersection of SS and T2O, and the resultant new equilibrium is represented by the new equilibrium price and quantity of Australian iron ore.

---
to the basic iron and steel sector. The cost of ferrous materials and the production of capital goods and machinery will expand outward by more than the increase in the level of aggregate real product. The cost of output increases by the increase in the costs of the imported parts necessary for successful production. The output function for non-traded commodities can thus be written as:

\[ y = f(K, L, N, I) \]

where \( K \) is capital, \( L \) is labor, \( N \) is non-traded goods, and \( I \) is the output function for iron, steel, and coal.

With no expectation of future in the price of coal, the export market is not expected to suffer significant output reductions.

Importance are projected by only the shift away from coal, which reduces the output of export-related activity in coal.

The output function for non-traded commodities is:

\[ y_{NT} = f(K_{NT}, L_{NT}, N_{NT}, I_{NT}) \]

where \( K_{NT} \) is capital, \( L_{NT} \) is labor, \( N_{NT} \) is non-traded goods, and \( I_{NT} \) is the output function for non-traded commodities.
3. ORANI IN LONG-RUN MODE

3.1 Algebraic representation of the ORANI model and the neo-classical short-run environment.

ORANI is a computable general equilibrium model in the Johansen class, and so it can be written as a system of linear equations involving percentage changes in its variables. In matrix notation ORANI may be represented by:

\[ Ax = 0, \]

where \( A \) is an \( m \times n \) rectangular matrix, and \( z \) is an \( n \times 1 \) column vector.

The number of variables \( n \) exceeds the number of equations \( m \), and the model is closed by declaring \( n-m \) variables to be exogenous. If \( z_2 \) is the \( (n-m) \times 1 \) vector of exogenous variables and \( z_1 \) is the \( m \times 1 \) vector of endogenous variables then (3.1) may be re-written as:

\[ A_1 z_1 + A_2 z_2 = 0, \]

where \( A_1 \) and \( A_2 \) are sub-matrices formed from the columns of \( A \) corresponding respectively to the endogenous and exogenous variables. Given values for \( z_2 \) the solution of ORANI is:

\[ z_1 = -A_1^{-1} A_2 z_2. \]

With the exception of the variable modelling balance of trade fluctuations, all of the components of \( z_1 \) and \( z_2 \) are percentage changes in ORANI variables, and therefore, so long as neither \( i \) nor \( j \) correspond to the balance of trade, the \((i,j)\)th element of \(-A_1^{-1} A_2\) may be interpreted as the...
calculator the interaction of the solution period is about 2 years.

The use of the method involves subtracting from the total amount of the cash flows the discount factor for each year to determine the present value of the cash flows. The present value is then used to calculate the internal rate of return (IRR) for the project. If the IRR is greater than the required rate of return, the project is considered acceptable.

In the context of the current project, the expected cash inflows are as follows:

- Year 1: $100,000
- Year 2: $150,000
- Year 3: $200,000
- Year 4: $250,000
- Year 5: $300,000

The required rate of return is 10%. Using a financial calculator or spreadsheet, the IRR can be calculated as follows:

1. Enter the cash flows into the calculator or spreadsheet.
2. Set the interest rate to 10%.
3. Calculate the IRR.

The IRR for this project is approximately 20%. Since the IRR is greater than the required rate of return, the project is acceptable.

In summary, the IRR method provides a useful tool for evaluating the acceptability of investment projects. It allows for the comparison of projects with different cash flow profiles and different time horizons. However, it is important to note that the IRR method does not take into account the timing of cash flows or the opportunity cost of capital. Therefore, additional analysis is required to make a final decision.
The following macroeconomic assumptions are usually made in short-run simulations:

1. the real values of domestic expenditure aggregates (that is, aggregate real investment, consumption and government spending) are exogenous; and
2. occupational labour markets are slack with exogenous real wage rates.

By placing the real components of domestic expenditure on the exogenous list the assumption is that these aggregates are controlled independently of the other exogenous variables by policy makers using macro instruments, an explanation of which is not included in ORANI. Alternatively users could replace the components of domestic absorption on the exogenous list by the balance of trade. Then ORANI would project the change in the level of domestic absorption needed to maintain a given level for the balance of trade when, say, tariffs are reformed. The current version of ORANI does not explain the allocation of this changed level of domestic absorption between investment and consumption, but rather this must be imposed exogenously.

The reason for setting real wage rates exogenously is that institutional factors are seen as preventing their adjustment in the short-run. Thus, producers can employ as much labour as they require in all occupations at fixed real wages. This implies that the level of employment is demand determined, which is appropriate in conditions of general unemployment.

3.2 The snapshot approach to long-run simulations with ORANI.

For the simulation reported in section 4, ORANI has been solved with industries' capital stocks for the solution year endogenous and

curve. This is represented in each figure by the transition from supply schedule SS to supply schedule $S_1S'_1$. If this had been the only change then the ORANI results would show a large loss of activity in the extraction of iron ore. This is demonstrated in Figure 4.1 where $F_0$ represents the foreign demand curve, DD represents the domestic demand schedule, and the schedule $Dq$ is the (horizontal) aggregation of the foreign and domestic demand curves.

Prior to the increase in costs, the domestic iron ore industry operates on supply curve SS, with equilibrium in the global market for Australian iron ore occurring at the price and quantity combination $E_1$. At the initial equilibrium price (denoted $P_1$) the domestic market absorbs quantity $N_1$, and the level of foreign demand for Australian iron ore is given by $L_1$. After the increase in costs the industry shifts to supply schedule $S_1S'_1$ which intersects the aggregate demand curve at the new price (denoted by $P_2$) the level of demand contracts to $N_2$, while the level of foreign demand contracts to $L_2$. To maintain consistency with the (percentage) change notation used in (4.4), the change in exports of iron ore, the contraction from $N_2$ to $N_1$ in domestic demand is denoted by $\Delta X_{(14,1)}$ (i.e., the actual change in exports of iron ore), the contraction from $N_2$ to $N_1$ in domestic demand is denoted by $\Delta X_{(14,1),03}$, and the overall change in activity in the domestic iron ore industry is given in Figure 4.1 as $\Delta Z_{14}$. Because the foreign demand curve is quite elastic the reduction $\Delta X_{(14,1)}$ in the quantity sold on international markets is large (while there is also a small contraction $\Delta X_{(14,1),03}$ in the quantity sold on the domestic market). Thus the supply curve shift causes a large contraction $\Delta Z_{14}$ in activity by iron ore miners. This explanation is not consistent with the ORANI projection of only a slight (0.33%) contraction in iron ore mining. The feature missing from Figure 4.1 is the influence of a shift in domestic demand.
through the snapshot period. These points can be demonstrated using
Figure 3.1 which has been borrowed from Parmeter. In this diagram
time is plotted on the horizontal axis, and the levels attained by an
endogenous ORANI variable $X_j$ are recorded on the vertical axis. The
solid curve in the figure shows the path which the variable $X_j$ might be
assumed to follow in the absence of the shock imposed at $t = 0$. (For
this work $t = 0$ corresponds to a view of the Australian economy obtained
from the 1974-75 ABS input-output tables.) The value $a$ represents the level
$X_j$ would attain in the snapshot year (that is, at $t^*$). When a shock is imposed
at $t = 0$ (like a labour-augmenting technical change) the path of $X_j$ is
represented by the broken line in Figure 3.1. From the point of view of the
snapshot approach the only important point on this curve is $(t^*, b)$, where $b$
is the value of $X_j$ in the snapshot year when the shock has been applied in the base
year, $t = 0$. The percentage change in $X_j$ from its ceteris paribus value $a$ at
t* is given by:

$$x_j = \frac{b-a}{a} \times 100.$$ 

It is this percentage change which is obtained as part of the solution
$z_1$ of the ORANI model given by (3.3).

An alternative to the snapshot methodology would be to generate a long-
run solution over 10 years by accumulating changes in the endogenous variables,
including next period capital stocks, over a number of 1 to 2 year short-run
solutions. This would allow the time paths of endogenous variables to be traced
from period to period. In each of these short-run solutions the availability of
capital to each industry in the next period depends on the exogenously

simulation reported here), agricultural exporters tend to show considerably
less output volatility than do other exporting activities. One mining
based export industry undergoes only a small loss in activity and so does
not appear in Table 4.2. This is the iron industry, which in the base year
supplied 75.6% of its output to international markets and 21.2% to the basic
iron and steel sector. The expanded demand for iron by the booming basic
iron and steel sector nearly matches the loss of sales of iron on
international markets. An approximation to the net effect on the iron
industry can be obtained as follows. Estimate $z_{14}$, the percentage change in
output of iron mining (ORANI industry 14) by:

$$z_{14} = B^{(4)}(14,1) x^{(4)}(14,1) + B^{(14,1)63} x^{(4)}_{63}$$

(4.4)

where $x^{(4)}(14,1)$ and $B^{(14,1)63}$ are the shares (given above in percentage
form) of total sales of domestically produced iron to exports and to the
basic iron and steel industry as an input to current production, and
$x^{(4)}_{14}$ is the percentage change in exports of iron ore. The simulation
gives $x^{(4)}(14,1) = -8.96$ and $z^{(14)}_{63} = 30.40$, hence:

$$z_{14} = 0.756 \times (-8.96) + 0.212 \times 30.40$$

$$= -6.77 + 6.45$$

$$= -0.32.$$ 

This agrees closely with the output contraction of 0.33% projected for
the iron industry by ORANI.

The operation of the market for Australian iron ore can be
explained using Figures 4.1 and 4.2. Due to an increase in costs in the
extraction of iron ore there is an upward shift in the industry's supply
when no such change occurs (solid line) and when an exogenous technological change occurs (broken line), and

Figure 3.1: Time path of development of endogenous variable X.

<table>
<thead>
<tr>
<th>Rank</th>
<th>Main Product Category</th>
<th>Proportion (percent)</th>
<th>Proportion (percent)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Basic Iron and Steel</td>
<td>63</td>
<td>113</td>
</tr>
<tr>
<td>1</td>
<td>Clay products</td>
<td>98</td>
<td>111</td>
</tr>
<tr>
<td>2</td>
<td>Non-metallic minerals (coal)</td>
<td>77</td>
<td>111</td>
</tr>
<tr>
<td>3</td>
<td>Iron and steel products (coal)</td>
<td>74</td>
<td>110</td>
</tr>
<tr>
<td>4</td>
<td>Mining, petroleum</td>
<td>56</td>
<td>110</td>
</tr>
<tr>
<td>5</td>
<td>Textiles</td>
<td>1.5</td>
<td>100</td>
</tr>
<tr>
<td>6</td>
<td>Ship and boat building</td>
<td>93</td>
<td>100</td>
</tr>
<tr>
<td>7</td>
<td>Commerce of furniture</td>
<td>69</td>
<td>100</td>
</tr>
<tr>
<td>8</td>
<td>Commerce of transport</td>
<td>59</td>
<td>100</td>
</tr>
</tbody>
</table>

Table 4.3: Experiences of the outcomes of innovation which
determined industrial capital endowments at the commencement of the 10 year period, and net investment generated endogenously by the previous short-run solutions. This accumulation approach relies heavily on ORANI's short-run investment mechanism for the long-run determination of the relative sizes of industries' capital stocks.

3.3 The long-run scenario

For the ORANI simulation reported in section 4 partial lists of exogenous and endogenous variables are given in Table 3.1. The choices of other exogenous variables for this work are the same as those made by DPSV and shown in their Table 23.3.1 In this sub-section the assignment of those variables shown in Table 3.1 to the exogenous category is discussed.

As has already been noted the inclusion of industry rates of return on the exogenous list embodies the idea that, in the long run, these rates are unaffected by the 22% labour-augmenting technical change. Adjustment to the shock occurs via industry capital stocks, with industries favoured by the change growing relative to other sectors. Similarly, the economy is seen as operating as a small country in an open world market, so that in the long term, the average rate of return in the domestic economy is exogenous, and the percentage change \( k \) in the aggregate ORANI capital stock is allowed to adjust. This accounts for the inclusion of the variables \( r_j(0) \) on the exogenous list in Table 3.1.

The second variable on the exogenous list is aggregate employment \( \ell \). With the focus on long-run developments in this paper it is appropriate to assume that changes in aggregate employment are independent of the labour-augmenting

Table 4.2: ORANI projections of the outputs of industries which suffer the heaviest output losses as a result of a 22% labour-augmenting technical change in the basic iron and steel industry

<table>
<thead>
<tr>
<th>Rank</th>
<th>ORANI industry</th>
<th>Description</th>
<th>Projection (percent)</th>
<th>Trade Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>14</td>
<td>Coal</td>
<td>-9.46</td>
<td>E</td>
</tr>
<tr>
<td>2</td>
<td>17</td>
<td>Services to mining</td>
<td>-6.14</td>
<td>ER</td>
</tr>
<tr>
<td>3</td>
<td>25</td>
<td>Food products (sec)</td>
<td>-5.08</td>
<td>E</td>
</tr>
<tr>
<td>4</td>
<td>4</td>
<td>Northern beef</td>
<td>-4.80</td>
<td>ER</td>
</tr>
<tr>
<td>5</td>
<td>13</td>
<td>Other metallic minerals</td>
<td>-4.73</td>
<td>E</td>
</tr>
<tr>
<td>6</td>
<td>6</td>
<td>Other farming export</td>
<td>-3.70</td>
<td>ER</td>
</tr>
<tr>
<td>7</td>
<td>64</td>
<td>Other basic metals</td>
<td>-3.68</td>
<td>E</td>
</tr>
<tr>
<td>8</td>
<td>22</td>
<td>Flour and cereal products</td>
<td>-3.53</td>
<td>E</td>
</tr>
<tr>
<td>9</td>
<td>18</td>
<td>Meat products</td>
<td>-2.71</td>
<td>E</td>
</tr>
<tr>
<td>10</td>
<td>3</td>
<td>High rainfall zone</td>
<td>-2.05</td>
<td>E</td>
</tr>
<tr>
<td>11</td>
<td>1</td>
<td>Pastoral zone</td>
<td>-2.09</td>
<td>E</td>
</tr>
<tr>
<td>12</td>
<td>30</td>
<td>Prepared fibres</td>
<td>-1.91</td>
<td>E</td>
</tr>
<tr>
<td>13</td>
<td>2</td>
<td>Wheat–Sheep zone</td>
<td>-1.84</td>
<td>E</td>
</tr>
<tr>
<td>14</td>
<td>49</td>
<td>Chemical fertilizers</td>
<td>-1.84</td>
<td>ER &amp; IC</td>
</tr>
<tr>
<td>15</td>
<td>9</td>
<td>Services to agriculture</td>
<td>-1.65</td>
<td>ER</td>
</tr>
<tr>
<td>16</td>
<td>76</td>
<td>Agricultural machinery</td>
<td>-1.34</td>
<td>IC &amp; ER</td>
</tr>
<tr>
<td>17</td>
<td>31</td>
<td>Man-made fibres</td>
<td>-1.25</td>
<td>IC</td>
</tr>
<tr>
<td>18</td>
<td>8</td>
<td>Poultry</td>
<td>-1.16</td>
<td>ER</td>
</tr>
<tr>
<td>19</td>
<td>32</td>
<td>Cotton, silk, flax</td>
<td>-1.01</td>
<td>IC</td>
</tr>
<tr>
<td>20</td>
<td>94</td>
<td>Railway transport</td>
<td>-0.98</td>
<td>ER</td>
</tr>
</tbody>
</table>
The selection of other econometric variables is the same as the 2.

### Table 2: Partial List of Econometric and Other Controls

<table>
<thead>
<tr>
<th>Category</th>
<th>Variable</th>
<th>Description</th>
</tr>
</thead>
</table>

The table above summarizes the econometric controls used in the analysis.

(continued)
The remaining exogenous variables are the change in the balance of trade $\Delta B$, and $f_R$, the percentage change in the ratio of real consumption ($C_R$) to real investment ($I_R$). In this configuration ORANI will simulate the change in real domestic absorption in the snapshot year which must accompany a technical change, say, given a constant balance of trade. The current version of ORANI does not explain the distribution of the change in domestic absorption amongst its components (aggregate consumption, aggregate investment, and aggregate government spending). Hence $f_R$ appears on the exogenous list, and the changes in domestic absorption will be allocated according to the initial shares of its components. (Hagan and Smith (1980) assume that real domestic absorption is fixed.)

In long-run simulations it would be better to treat $C_R$ and $f_R$ as well as $\Delta B$ and $f_R$ as endogenous for the following reason: ORANI may report that $k = 10$ as the result of a labour-augmenting technical change. That is, there is a 10% growth in aggregate capital stocks at the beginning of the snapshot year, over that which would have occurred if the technical change had not arisen. The effect of the technical change on the components of domestic absorption and the balance of trade will depend on the manner in which the expansion of the capital stock was financed over the snapshot period.

If the extra capital was purchased by foreign investors, then the income accruing from it in the snapshot year would be reflected in an increased balance of trade surplus corresponding to additional profit repatriation. However, if the extra capital was owned domestically, then in the snapshot year this would emerge as real increases in domestic spending. In the current version of ORANI there is no explicit theory of the ownership of capital, although the inclusion of such a theory into a miniature version of ORANI has been recently completed. Implementation of a similar theory for ORANI is currently underway.

percentage as aggregate consumption, and an increasing nominal wage level, which is due to the competition for labour in an environment of fixed labour supply. This is detrimental to exporters (although in the case of basic iron and steel producers not sufficiently detrimental to offset completely the direct effects of the technical change) who face increasing production costs, while the selling prices of their international competitors are largely independent of domestic developments. Moreover import-competing industries are unable to pass on cost increases as their customers will substitute (albeit, imperfectly) imported goods (from the same commodity classification) if the price of the domestic product rises. An additional cause of the rise in imports is the direct increase in demand for imports flowing from the increase in domestic absorption. There is a redistribution of resources between the traded and non-traded sectors, which leads to changes in the occupational composition of the workforce.

Table 4.1 reveals that seven of the nine ORANI occupations experience small gains with two occupational groups suffering declines in employment. Rural workers are primarily employed in agricultural activities, and demand for this group declines in line with the cost-price squeeze experienced by agricultural export industries. In the 1974-75 input-output database 18.8% of employment in the skilled blue collar (other) category is concentrated in the export-oriented meat products industry. It is contraction of the output of this sector which accounts for nearly all of the fall in employment in the occupation. The fourth occupation, skilled blue collar (metal and electrical), experiences the largest net increase in employment. This is predominantly due to the growth in the non-traded sector (which accounted for 48.3% of the
The productivity of labor in the form of total output and total production would increase. The reduction in production costs (result that the increased

wages, the economy's efficiency capital stock will be lower by 0.2%, the the introduction of new knowledge of certain state in the new productive capital.

level of employment, the efficiency of the economy is significantly higher at the beginning of the year. The result is that the economy is able to operate a 0.6% higher

to this work, it was assumed that labor is only employed to the maximum

capacity, labor is operated to the maximum capacity. The increased

productivity, by improving the economy's output of goods and services, the increased

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In the table below, the results of the economic simulation of the economy are presented.
Table 4.1: Projections of the long-run effects on macroeconomic and employment variables of a 22 per cent labour-augmenting technical change in the basic iron and steel industry

<table>
<thead>
<tr>
<th>Variable</th>
<th>Projection (per cent)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Absolute real wage</td>
<td>0.66</td>
</tr>
<tr>
<td>Aggregate real consumption</td>
<td>0.32</td>
</tr>
<tr>
<td>Aggregate capital stock</td>
<td>0.37</td>
</tr>
<tr>
<td>Consumer price index</td>
<td>1.01</td>
</tr>
<tr>
<td>Aggregate imports</td>
<td>1.17</td>
</tr>
<tr>
<td>Aggregate exports</td>
<td>1.16</td>
</tr>
<tr>
<td>Employment by occupation:</td>
<td></td>
</tr>
<tr>
<td>Professional white collar</td>
<td>0.15</td>
</tr>
<tr>
<td>Skilled white collar</td>
<td>0.15</td>
</tr>
<tr>
<td>Semi- and un-skilled white collar</td>
<td>0.15</td>
</tr>
<tr>
<td>Skilled blue collar (metal and electrical)</td>
<td>0.36</td>
</tr>
<tr>
<td>Skilled blue collar (building)</td>
<td>0.24</td>
</tr>
<tr>
<td>Skilled blue collar (other)</td>
<td>-0.56</td>
</tr>
<tr>
<td>Semi- and un-skilled blue collar</td>
<td>0.05</td>
</tr>
<tr>
<td>Rural workers</td>
<td>-2.16</td>
</tr>
<tr>
<td>Armed services</td>
<td>0.31</td>
</tr>
</tbody>
</table>

otherwise stimulate exports and also provide import-competing industries with a competitive advantage over imports, thus generating a balance of trade surplus. (For example, see the results in Tables 2 and 4 of the work on input-augmenting technical change by Hagan and Smith (1980).)

A check on the aggregate capital and aggregate absorption results is available via the national income identity. The percentage change in gross domestic product (GDP), denoted $\Delta p$, is given by:

$$
\Delta p = S_A^a + \Delta B/GDP,
$$

(4.1)

where $a$ is the percentage change in real domestic absorption, $S_A$ is the share of domestic absorption in GDP, and $\Delta B$ is the change in the balance of trade. The percentage change in GDP can also be measured as a weighted average of percentage changes in the employment of primary factors and technical changes which occur, that is,

$$
\Delta GDP = S_k \Delta k + S_n \Delta n + S_L \Delta L - S_{63} \Delta (g+1)63
$$

(4.2)

where $k$, $n$ and $L$ are percentage changes in the employment of capital, land and labour; $\Delta (g+1)63$ denotes the variable modelling labour-augmenting technical change in the basic iron and steel sector (ORANI industry 63); and $S_k$, $S_n$, $S_L$ and $S_{63}$ are the shares of returns to capital, land, all labour, and labour employed by industry 63 in GDP. For the long-run simulation

$$
\ell = n = 0,
$$

(4.3)

$k = 0.37$ (see Table 4.1) and $\Delta (g+1)63 = -22.0$.

The values of $S_k$ and $S_{63}$ in the data base are 0.22 and 0.01, so that (4.2) and (4.3) realise a value for $\Delta GDP$ of about 0.31. The distribution of domestic absorption between consumption and investment is exogenous,