JUNE 1997

8121.0

New Issue

INNOVATION IN MINING

AUSTRALIA

EMBARGO: 11:30AM (CANBERRA TIME) FRI 11 SEPT 1998

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■ For further information about these and related statistics, contact John Ovington on Canberra 02 6252 5189, or any ABS office shown on the back cover of this publication.

NOTES

ABOUT THIS PUBLICATION

This publication presents the results of a survey of mining businesses which was designed to measure the extent to which they had undertaken technological innovation during the three-year period from July 1994 to June 1997. The survey, which was the first of its kind conducted by the Australian Bureau of Statistics (ABS) for the Mining sector, was based on concepts and standard questions for the collection of innovation data prepared jointly by the Organisation for Economic Co-operation and Development (OECD) and the statistical office for the European Community (Eurostat). The concepts have been published by the OECD in *Proposed Guidelines for Collecting and Interpreting Technological Innovation Data* (OECD, Paris, 1997), known as the Oslo Manual.

The ABS has previously conducted two surveys of manufacturing businesses to measure the extent of innovation in that sector. The latest results are published in *Innovation in Manufacturing, Australia, 1996–97* (Cat. no. 8116.0).

DEFINING TECHNOLOGICAL INNOVATION IN MINING

The Oslo Manual (p. 47) describes technological innovation to:

> ...comprise implemented technologically new products and processes and significant technological improvements in products and processes. An innovation has been implemented if it has been introduced on the market (product innovation) or used within a production process (process innovation). Innovations therefore involve a series of scientific, technological, organisational, financial and commercial activities. An innovating business is one that has implemented technologically new or significantly technologically improved products or processes during the period under review.

Based on the Oslo Manual, the ABS has defined technological innovation in mining businesses to include:

- *Product innovation,* which occurs if any *new* minerals or energy sources result from the exploration, extraction, mineral processing, smelting or refining activities of the businesses; and
- *Process innovation*, which involves the use of any *new* technologies, techniques or processes in the exploration, extraction, mineral processing, smelting or refining activities of the businesses.

As in the innovation surveys of the Manufacturing industry conducted previously, *new* is defined as being new to the businesses selected in the survey.

T.J. Skinner
Acting Australian Statistician

RATE OF TECHNOLOGICAL INNOVATION

TOTAL

Of the estimated 1,650 mining businesses operating in Australia, 42% had undertaken technological innovation during the period 1 July 1994 to 30 June 1997. By way of comparison, the proportion of manufacturing businesses undertaking technological innovation was 26% for the same period.

TYPE

Process innovation was the most prevalent type of technological innovation in mining, occurring in 39% of businesses. Product innovation was considerably less common, occurring in 11% of mining businesses. This contrasts with manufacturing businesses where product innovation was the more common type of technological innovation, occurring in 23% of businesses, while process innovation occurred in 18% of businesses.

INDUSTRY

As shown in table 1, the industry with the highest proportion of businesses undertaking technological innovation during the three years from July 1994 to June 1997 was 'Coal and gas extraction' (96% of businesses). The industries with the next highest proportions were 'Metal ore mining' and 'Coal mining' with 78% and 68% respectively. 'Services to mining', at 35%, was the second lowest and 'Other mining' (predominantly mining of gravel, sand and construction material) recorded the lowest proportion at 31%.

1 BUSINESSES UNDERTAKING TECHNOLOGICAL INNOVATION BY INDUSTRY

		Type of technological innovation		
		Product	*Process*	*Total*
ANZSIC code/ Industry subdivision		*%*	*%*	*%*
11	Coal mining	11.0	68.0	68.0
12	Oil and gas extraction	44.9	88.0	96.0
13	Metal ore mining	35.3	67.7	78.1
14	Other mining	**3.8	30.3	30.7
15	Services to mining	*7.4	33.0	35.1
11–15	**All mining**	**10.5**	**39.2**	**41.8**

QUALITATIVE ASPECTS OF TECHNOLOGICAL INNOVATION

INTRODUCTION

Businesses which had undertaken technological innovation were asked to indicate which were the important objectives, sources of ideas and information, and barriers to undertaking technological innovation.

OBJECTIVES OF UNDERTAKING TECHNOLOGICAL INNOVATION

The results show that the objectives of 'Reducing environmental impact', 'Safety of staff' and 'Increase production output' were most frequently identified as important objectives in undertaking technological innovation. About 75% of mining businesses which had undertaken technological innovation in the three-year period identified these objectives as important while around 20% indicated that these objectives were not applicable to their businesses.

The objectives that were next most frequently considered as important were 'Lower labour costs', 'Improve production flexibility' and 'Lower wastage costs'. These were identified as important by between 68% and 70% of all mining businesses undertaking technological innovation.

The objective that was least frequently identified as important was 'Increase export levels'. While this objective was important for only 27% of mining businesses that had undertaken technological innovation, 67% indicated that it was not applicable to their business.

2 OBJECTIVES OF UNDERTAKING TECHNOLOGICAL INNOVATION

		Importance of the objective	
	Not applicable	*Not important*	*Important*
Objective	*%*	*%*	*%*
Cost reduction			
Lower labour costs	20.4	*10.1	69.5
Lower energy consumption costs	32.2	*10.5	57.3
Lower material consumption costs	32.1	*10.0	57.9
Lower capital equipment costs	26.7	*9.7	63.6
Lower wastage costs	22.9	*9.1	68.1
Production process			
Increase production output	22.1	**3.2	74.6
Decrease cycle times	36.6	*13.5	49.9
Maximise recovery rates	28.6	**4.8	66.6
Improve production flexibility	28.6	*2.9	68.5
Replace machinery or equipment	29.8	14.5	55.7
Environmental issues			
Reduce environmental impact	21.0	**3.3	75.6
Develop cleaner operating techniques	26.2	*9.3	64.5
Habitat management	27.5	*13.8	58.7
Land rehabilitation including waterways	26.2	*10.5	63.3
Recycling or reusing	26.7	21.9	51.4
Market share			
Maintain market share	34.3	*12.1	53.6
Increase market share	37.2	*8.1	54.6
Open new domestic markets	41.8	*8.1	50.1
Open new overseas markets	61.5	*8.4	30.2
Increase export level	66.5	*6.9	26.6
Other objectives			
Attracting staff	44.6	25.0	30.4
Improve working conditions	35.9	*10.8	53.3
Safety of staff	24.3	1.0	74.8

SOURCE OF IDEAS AND INFORMATION

Businesses undertaking technological innovation were also asked to identify which were the important sources of ideas at two stages of their innovation projects. They were asked what were the important sources for the initial idea and what were the important sources for ideas at other stages of the project. They also identified the sources of technical information and advice used throughout these projects.

Internal (or in-house) sources were utilised by a higher proportion of businesses than external sources for both the initial idea and at other stages of the project. The source which was most often identified as important by businesses undertaking technological innovation was 'Management' (58% of businesses). This source was identified over twice as often as any other for the initial idea for innovation. Internal sources such as 'Management', 'Production staff' and 'Technical staff' were the main sources of ideas for other stages of the project, being identified by about two-thirds of businesses undertaking technological innovation.

For technical information and advice, the source identified most often was 'Consultants' at 42% of innovative businesses, followed by 'Technical staff' (40%) and 'Management' 33%. The proportion of businesses that used 'Consultants' and 'Universities and government organisations' as the source of ideas, and for technical information and advice was considerably higher for mining than for manufacturing businesses.

3 SOURCE OF IDEAS AND INFORMATION USED FOR TECHNOLOGICAL INNOVATION

	Technological innovators using source for		
	Initial idea	*Ideas at other stages of the project*	*Technical information and advice*
Source	%	%	%
Internal sources			
Management	57.6	65.2	33.3
Production staff	21.0	68.8	23.6
Technical staff	27.8	57.4	40.3
R&D staff	15.5	19.6	20.2
Marketing staff	*12.1	*10.9	*10.3
Parent company etc.	15.6	22.6	17.7
Market/commercial sources			
Joint venture	17.0	15.2	15.4
Competitors, clients etc.	17.5	*19.2	*15.9
Consultants	*11.8	34.1	42.2
Suppliers	*9.8	16.7	21.5
Educational/government			
Universities, government organisations	*15.2	*13.9	19.4
Generally available information			
Government standards, regulations, patents etc.	*11.6	*14.1	*16.0
Computer information systems	**4.3	*9.0	*12.5
Conferences, fairs etc.	21.5	12.8	21.5
Internal sources subtotal	69.8	89.7	61.7
External sources subtotal	49.0	58.7	65.4
Any source	81.2	95.2	81.8

BARRIERS TO TECHNOLOGICAL INNOVATION

Just over three-quarters of all mining businesses felt that there were one or more important barriers that inhibited them from starting technological innovation projects. A higher proportion (95%) of businesses that had already undertaken technological innovation felt there were barriers that inhibited them from starting innovative projects than those businesses that had not previously undertaken any technologically innovative activity (67%).

The barriers which were most frequently identified as important by all mining businesses were 'Current economic climate not conducive to innovation' (49%), 'Costs too high or too hard to control' (48%) and 'Government policy and taxation' (44%). By way of comparison the two barriers most frequently identified by manufacturing businesses were 'Government policy and taxation' (41%) and 'Current economic climate' (41%).

For mining businesses which had undertaken technological innovation, 'Costs too high or too hard to control' (63%) and 'Government policy and taxation' (62%) were the two most frequently identified barriers which inhibited businesses from starting innovation projects. For businesses which had not undertaken technological innovation, 'Current economic climate not conducive to innovation' (40%) and 'Costs too high or too hard to control' (38%) were the two most frequently identified barriers.

4 BARRIERS TO STARTING TECHNOLOGICAL INNOVATION

	Importance of the reason		
	Not applicable	*Not important*	*Important*
Barriers	*%*	*%*	*%*
Economic factors			
Current economic climate not conducive to innovation	40.9	10.6	48.5
Excessive economic risk perceived by the business or parent company	49.5	*9.1	41.3
Excessive economic risk perceived by financier/investors	61.3	8.5	30.2
Costs too high or too hard to control	39.6	12.0	48.4
Expected low returns	50.2	*7.5	42.3
Payback period too long	54.1	*8.0	37.9
Market factors			
Development period too long	60.5	13.4	26.1
Competitor activity in same market	50.8	16.2	33.0
Unable to satisfy customer's specifications	67.9	11.4	20.7
External market pricing	58.9	9.9	31.2
Business factors			
Competing resources priorities	50.2	9.7	40.1
Parent company directive	74.7	13.3	11.9
Outside 'core' business activity	73.0	11.1	15.9
Unable to obtain suitably skilled staff	63.8	15.7	20.5
Lack of commitment within business	68.6	16.6	14.8
Failure of cooperation agreement	80.5	8.7	10.8
Other factors			
Unable to resolve technical difficulties	69.1	11.3	19.7
Resistance to change from staff or unions	71.9	18.0	10.0
Unacceptable environmental impact	62.3	11.2	26.4
Government standards and regulations	46.9	10.5	42.5
Government policy and taxation	48.0	*7.8	44.2
Any factor	n.a.	n.a.	78.5

IMPACT OF TECHNOLOGICAL INNOVATION

TOTAL

Businesses that had undertaken technological innovation were asked to indicate whether undertaking innovative activities had either increased or decreased their employment, production activities and profitability.

Overall more businesses reported that undertaking technological innovation had positive, rather than negative, effects on the employment, production activities and profitability of the business.

EMPLOYMENT LEVELS

About 41% of businesses reported that undertaking technological innovation had an impact upon the labour usage of the business during the period 1 July 1994 to 30 June 1997; 21% reported that in-house staff levels had increased while 12% reported a decline in in-house staff. In terms of businesses use of contractors, 11% reported increased use and 11% reported decreased use.

PRODUCTION ACTIVITIES

Over 57% of businesses reported that undertaking technological innovation had an impact upon some aspect of their production activities. About 45% of businesses reported that undertaking technological innovation increased their 'Production levels' during the period 1 July 1994 to 30 June 1997. In contrast only 3% reported that undertaking technological innovation decreased their 'Production levels'. 'Capital utilisation' was the next most significant impact, with 29% of businesses reporting an increase while only 3% reported a decrease.

PROFITABILITY

Of the businesses which had undertaken technological innovation, 45% reported that their profitability had changed during the period 1 July 1996 to 30 June 1997. While 20% of businesses which had undertaken technological innovation reported that their innovative activities had helped increase the businesses profits, only 2% reported that their innovative activities had decreased their profits.

5 EFFECT OF TECHNOLOGICAL INNOVATION

	Proportion of technological innovators	
	Decreased	*Increased*
Impact on	*%*	*%*
Employment levels		
In-house labour	*11.5	20.6
Contractors	*10.5	*10.6
Production activities		
Production levels	**3.4	44.9
Materials consumption	7.6	*12.3
Energy consumption	16.1	*14.5
Capital utilisation	*3.4	28.8
Maintenance support	*8.7	*9.3
Fly in/fly out	0.6	*6.8
Profitability	**1.6	19.9

EXPENDITURE ON TECHNOLOGICAL INNOVATION

TOTAL

The total amount spent by businesses on technological innovation during 1996–97 was $8.5 billion. This represented approximately one-third of the total operating expenses of mining businesses during 1996–97. Most innovation expenditure was on 'Mine development and construction costs' (36%), followed by 'New technology and capital replacement' (28%) and 'Exploration' (21%).

INDUSTRY

'Metal ore mining' spent the most on technological innovation ($3,880m). This was more than double the second largest amount spent by 'Oil and gas extraction' ($1,652m). 'Other mining' spent the least on technological innovation ($243m).

The average expenditure per business which had undertaken technological innovation was highest in 'Oil and gas extraction' ($67m). This average was more than twice as large as the average amount spent by businesses in 'Coal mining' ($25m) and 'Metal ore mining' ($24m).

6 EXPENDITURE ON TECHNOLOGICAL INNOVATION, BY INDUSTRY

Type of innovation activity	*Coal mining* $m	*Oil and gas extraction* $m	*Metal ore mining* $m	*Other mining* $m	*Services to mining* $m	*Total* $m
Exploration	24.4	581.3	748.5	*21.1	439.8	1 815.0
Feasibility studies	37.0	37.0	150.6	1.5	**40.4	266.6
Research and development	71.5	34.6	*305.8	*20.2	27.2	459.3
Mine development and construction costs	534.7	740.5	1 059.8	**59.4	686.2	3 080.6
New technology and capital replacement	629.6	207.6	1 384.3	*111.1	72.3	2 405.0
Environmental assessment, management and rehabilitation	70.4	24.9	113.8	6.5	31.0	246.7
Marketing	52.6	19.2	72.6	19.7	6.4	170.4
Training and further education	29.4	6.7	44.5	3.3	12.0	95.9
Total	**1 449.6**	**1 651.7**	**3 879.9**	**242.8**	**1 315.5**	**8 539.4**
Average expenditure per business	25.1	67.2	23.8	1.5	5.7	13.4

USE OF ADVANCED MINING TECHNOLOGIES

INTRODUCTION

Presented below are data on the use within industries, of the main types of advanced mining technologies. The data has been compiled in respect of management units (primarily legal entities) and as such the detail may not be directly comparable with similar data previously published in ABS *Mining Technology Statistics, Australia, 30 June 1994* (Cat. no. 8413.0) which was based on a collection from establishments. For further details about the specific technologies included, please see paragraph 14 of the Explanatory Notes or contact the ABS.

TOTAL

Of all businesses in the Mining sector, 48% had acquired at least one of the advanced mining technologies. Another 5% were currently installing advanced technologies or planned to acquire advanced technologies within the next two years.

Of businesses in the Mining sector which had undertaken technological innovation between 1 July 1994 and 30 June 1997, approximately three-quarters had acquired at least one of the nominated advanced mining technologies. Only one-quarter of businesses which had not undertaken technological innovation in the same period had acquired at least one of the nominated advanced mining technologies.

More businesses had exploration technologies (37%) than any other type of advanced mining technology.

INDUSTRY

'Oil and gas extraction' had the highest proportion of businesses with advanced technologies (92%). 'Other mining' had the lowest proportion, at 30%.

7 BUSINESSES WITH TECHNOLOGY, BY BROAD TECHNOLOGY CATEGORY—BY INDUSTRY

ANZSIC code/ Industry subdivision		*Exploration technologies*	*Mining or extraction technologies*	*Mineral and energy processing technologies*	*Engineering technologies*	*Environmental technologies*	*Any AMT(a)*	*Expected by 1998–99*
		%	%	%	%	%	%	%
11	Coal mining	63.0	64.6	56.4	39.8	63.2	71.9	75.7
12	Oil and gas extraction	85.1	84.6	46.5	14.9	51.8	92.0	92.0
13	Metal ore mining	62.0	58.0	46.5	33.3	63.9	75.4	75.4
14	Other mining	*12.2	*9.8	*11.8	*7.9	24.0	27.3	29.9
15	Services to mining	44.9	*16.6	*7.5	**4.8	*9.4	50.8	58.4
11–15	**All mining**	**37.4**	**23.2**	**17.2**	**11.5**	**24.9**	**47.6**	**52.2**

(a) Advanced mining technologies.

EXPLANATORY NOTES

DESCRIPTION

1 The Innovation in Industry Survey collected information about businesses' innovative activities during the period 1 July 1994 to 30 June 1997. This publication presents information for the Mining sector.

SURVEY METHODOLOGY

2 A questionnaire was mailed to approximately 425 businesses in the Mining sector. The sample was drawn from the ABS' Business Register. The sample was chosen to produce reliable estimates at Australian and New Zealand Standard Industrial Classification subdivision level.

SCOPE AND COVERAGE

3 The survey included businesses of all sizes operating in the Mining sector, regardless of whether those businesses had undertaken innovative activities during the period. Data contained in this publication relate to all businesses that were operational at 30 June 1997. If a business ceased operations before that date it has been excluded from the scope of the survey.

STATISTICAL UNIT

4 The business unit from which the information was collected and published is the management unit, which is the highest-level accounting unit within a business, having regard to industry homogeneity. In nearly all cases it coincides with the legal entity owning the business (i.e. company, partnership, trust, sole operator, etc.). In the case of large diversified businesses, however, there may be more than one management unit, each coinciding with a 'division' or 'line of business'. A division or line of business is separately identified where separate and comprehensive accounts are maintained.

5 Unincorporated joint ventures (UJVs) operate within the Mining sector. The UJV allows for the risk associated with the development of mineral deposits to be spread, through participation by many businesses as an investment (know as 'participants'), or as an operator which carries out the mining operation. This survey has only included responses from the operators.

CLASSIFICATION BY INDUSTRY

6 The statistics in this publication are classified by industry in accordance with the 1993 edition of the ABS *Australian and New Zealand Standard Industrial Classification (ANZSIC)* (Cat. no. 1292.0). Each management unit is classified to a single industry. The industry allocated is the one which provides the main source of income for the management unit irrespective of whether a range of activities or a single activity is undertaken by the unit.

RELIABILITY OF ESTIMATES

7 The estimates presented in this publication are subject to non-sampling and sampling error.

Non-sampling error

8 Non-sampling error may result from deficiencies in the register of businesses, non-response, imperfections in what is reported and errors in the process of aggregating the results. Non-sampling error can occur in any type of collection. The extent to which non-sampling error affects the results of the survey is unknown. Efforts were made to minimise this type of error, in particular by developing and testing the questionnaires with a variety of mining businesses.

9 Any errors in the estimates caused by non-response is expected to be negligible since 91% of businesses returned completed questionnaires.

Sampling error

10 The estimates in this publication are derived from the responses from a sample of businesses in the Mining sector. These estimates are likely to differ from estimates derived from responses from all businesses in this sector. One measure of that difference is the standard error.

11 There are about two chances in three that a sample estimate will differ by less than one standard error from the figure that would have been obtained if all units had been included in the survey, and approximately 19 chances in 20 that the difference will be less than two standard errors.

12 The following table contains estimates of the standard errors for only a selection of the statistics presented in this publication. Standard errors for other tables will generally be higher than those presented below and are available upon request from the ABS.

STANDARD ERRORS ASSOCIATED WITH PROPORTION OF BUSINESSES UNDERTAKING INNOVATION ACTIVITIES, BY INDUSTRY

		Type of technological innovation activity		
		Product	*Process*	*Technological*
ANZSIC code/ Industry subdivision		*%*	*%*	*%*
11	Coal mining	1.4	7.4	7.4
12	Oil and gas extraction	9.3	2.4	1.3
13	Metal ore mining	8.4	8.3	7.8
14	Other mining	1.9	6.3	6.3
15	Services to mining	2.8	6.1	6.2
11–15	**All mining**	**1.9**	**3.7**	**3.8**

13 The rate of process innovation is 39.2% and this estimate has a standard error of 3.7%. There are two chances in three that the true rate of process innovation lies in the range 35.5% to 42.9%, while there are 19 chances in 20 that the true rate lies in the range 31.8% to 46.6%.

ADVANCED TECHNOLOGIES

14 Data in table 7 are presented by five broad technology categories: Exploration technologies; Mining or extraction technologies; Mineral and energy processing technologies; Engineering technologies; and Environmental technologies. The tabulated data have been compiled by combining more detailed categories as shown below:

Exploration technologies	Aerial photography
	Satellite/airborne scanner
	Airborne geophysics
	Ground geophysics
	Geochemical techniques
	Image processing
	Analytical techniques
	Global positioning systems
Mining or extraction technologies	Computer modelling and simulation systems
	Blasting analysis
	Ground reinforcement design
	Truck despatch technology
	In-mine data transfer
	Automated ground movement sensors
	Drill rig monitoring
	In-seam drilling
	Guidance control mechanisms
Mineral and energy processing technologies	In-mine rock crushing
	Automated material handling-particulate
	Automated material handling-slurries
	On-stream analysis
	On-stream size analysis
	Programmable logic controller(s)
	Supervisory control and data acquisition
	Interactive expert systems for process supervision
	Material characterisation and liberation analysis
Engineering technologies	Condition monitoring systems
	Welding technology
	Energy conservation
Environmental technologies	Air quality monitoring
	Meteorological monitoring
	Water quality monitoring
	Biological monitoring
	Rehabilitation design
	Waste disposal design

RELATED STATISTICS

15 Other statistics relevant to innovation are contained in the following publications:

Innovation in Manufacturing, Australia, 1996–97 (Cat. no. 8116.0)—released in June 1998

Manufacturing Technology Statistics, Australia, 31 December 1991 (Cat. no. 8123.0)

Mining Technology Statistics, Australia, 30 June 1994 (Cat. no. 8413.0)

Research and Experimental Development, Business Enterprises, Australia, 1996–97 (Cat. no. 8104.0)—released in July 1998.

ADDITIONAL DATA

16 This publication contains only a selection of the information from the survey. More detailed information is available, at a cost, from the ABS. Copies of the collection form used in the survey are also available.

SYMBOLS AND OTHER USAGES

ABS	Australian Bureau of Statistics
ANZSIC	Australian and New Zealand Standard Industrial Classification
billion	thousand million
n.a.	not available
OECD	Organisation for Economic Co-operation and Development
R&D	Research and development
UJV	Unincorporated joint venture
*	estimate has a relative standard error greater than 25%
**	estimate has a relative standard error greater than 50%

Where figures have been rounded, discrepancies may occur between the sum of component items and the total.

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POST Client Services, ABS, PO Box 10, Belconnen, ACT 2616

EMAIL client.services@abs.gov.au

2812100007968
ISBN 0 642 25683 7

RRP $15.50

Produced by the Australian Bureau of Statistics