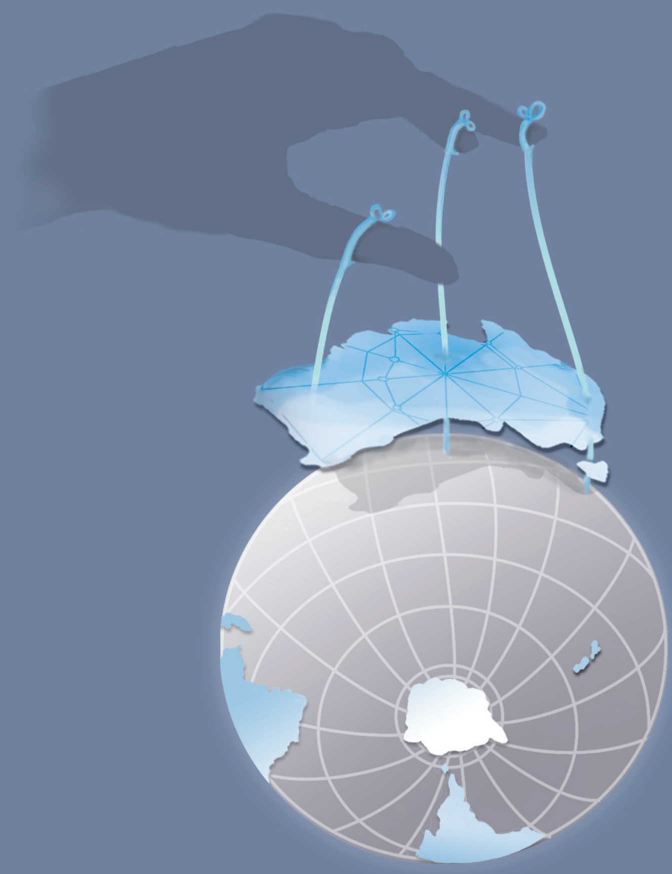

Balancing Act

A TRIPLE BOTTOM LINE ANALYSIS

OF THE AUSTRALIAN ECONOMY

VOLUME 1

The University of Sydney

CSIRO

Barney Foran
Resource Futures Program
CSIRO Sustainable Ecosystems
GPO Box 284
CANBERRA ACT 2601

Manfred Lenzen and Christopher Dey
School of Physics A28
University of Sydney
SYDNEY NSW 2006

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In large complex tasks such as this one has proven to be, it is inevitably our families who bear the brunt of spouses and fathers who are perplexed, frown often, are always tired and who work too many late nights. We can only thank them and promise it will never happen again, knowing that it probably will. Along the way, we hope that whole-economy analyses like this one will help underpin Australia’s eventual transition to sustainability, whatever path that may take. In the end, we aspire to happy, safe and healthy lives for our children’s children.

Barney Foran

Manfred Lenzen

Christopher Dey

April 2005

Structure of This Report

This report is organised into four volumes.

Volume ONE contains three chapters. Chapter 1 is a general introduction to sustainability assessment and the notion of the triple bottom line (TBL). The focus is on the methodologies used for TBL assessment and reporting. It places the remainder of this report in the context of current TBL practices.

Chapter 2 provides the methodological details of the generalised input-output framework from which all results reported in this work have been calculated. Readers who do not wish to read the technical detail should proceed to Chapter 3.

Chapter 3 describes how the analytical results for each economic sector are presented in the forms of tables, graphs, and descriptions.

Volume ONE also contains a table of sector abbreviations, and summary charts showing the results for every sector against each indicator.

The main results are given in **Volumes TWO, THREE and FOUR.** These volumes contain five-page descriptions with data compilations for each of 135 sectors that comprise the Australian economy. These start with Sector 1, ‘Sheep, lambs and shorn wool’, and finish with Sector 135, ‘Police, interest groups, religious organisations, student unions, fire brigade, corrective and other services’.

Volume TWO contains the agriculture, fishing, forestry and food, and the mining and metals industry sectors.

Volume THREE contains the manufacturing sectors.

Volume FOUR contains the public and private services sectors, including utilities, construction, wholesale and retail trade, transport and communications.

Executive Summary

1. A numerate 'Triple Bottom Line' account

This report *Balancing Act*, uses the well developed analytical approach of 'generalised input-output analysis' to develop a numerate triple bottom line account of the Australian economy for three financial, three social and four environmental indicators. For each of 135 economic sectors, every indicator is developed as an intensity, that is, per one dollar of final demand or per one dollar spent for consumption in everyday life. The indicators are generated with a supply chain approach where all activities are included or 'embodied' in the final indicator number. Taken together, these ten indicators provide a macro-landscape against which many management issues can be benchmarked.

The analysis seeks to underpin broader societal calls for industry, government and institutions to make decisions on a broader basis than just the financial bottom line. At an international level, these concerns drive initiatives such as the Global Reporting Initiative (or GRI) for corporate reporting, and the Equator Principles for development project financing. At a national level many firms now report on a triple bottom line basis, while socially or ethically responsible investment guidelines are now used by the financial investment industry.

While the methodology used in this analysis is already well established, the scale and depth of this analysis represents a first nationally, if not internationally. Subsequent work could extend the range of reporting indicators and produce a time series for the last thirty years. Because the indicators are referenced against one dollar of final demand, there is a potential for numerate triple bottom line accounting to become routine in traditional accounting practices. The report has three sections as follows:

- Three chapters of background and methodology
- Detailed reports on 135 economic sectors
- Appendices of summarised data

2. Interpreting the results

Balancing Act provides a snapshot of the triple bottom line performance of the Australian economy in the mid 1990s. While this may appear 'old', the data was the most recent available when the study commenced, as input-output tables are published many years after the relevant accounting period. Nevertheless, other studies indicate the structure of the economy changes relatively slowly, so we would not expect to observe significant differences in the indicator values in the short term. In addition, where relevant the sectoral reports highlight recent major structural changes which may affect the results.

Care needs to be taken in drawing conclusions from the results. A 'below average' indicator (eg high water use, low employment, low surplus) does not necessarily indicate a problem or inefficiency. Different sectors perform different functions in the economy and all sectors have a mix of above and below average results. The report provides a static description of these results for a point in time. Dynamic modelling would need to be used to quantify changes in TBL factors that would occur if conditions changed (eg shifts in demand or supply, or in corporate or government policies). Thus the results cannot by themselves identify problems or appropriate policy and management responses, nor tell us whether Australia's environmental, economic and social performance is sustainable or not. Information on the state of Australia's environment, society and economy must also be considered in determining the efficiency and acceptability of a sector's performance.

Balancing Act should not be viewed in isolation: it informs and is informed by the broader context of TBL accounting and reporting (and indeed sustainable development). In addition to presenting the sectoral results, the report draws on a range of external information sources to identify technological opportunities and future trends affecting each sector. It is hoped this will provide a starting point and stimulus for further investigation and development of policies and programs to improve Australia's TBL performance.

3. Environmental indicators

Four environmental indicators are used: greenhouse gas emissions, primary energy use, managed water use and land disturbance. From an environmental perspective, we interpret that a sector performing 'above average' in triple bottom line accounting terms will have lower than average intensity values for each of these indicators. The indicators or intensities are referenced against one dollar of final demand. Average values for the economy as a whole are 1 kg of CO_2 equivalent greenhouse gas emissions per dollar, 7.7 Megajoules (MJ, one million J) of primary energy use per dollar, 41 litres of managed water use per dollar, and 3.2 square metres of land disturbance per dollar.

Clearly, the primary sectors in agriculture and mining will, by their nature, have higher environmental intensities than service sectors such as banking, education and health. Nevertheless one of the insights emerging from this analysis is that the prices consumers pay for primary production items do not reflect the full value of the natural resources embodied in their production chains. This physical reality is reflected in the current debate on national water resources reform with calls for consumption-based pricing, full cost recovery pricing for water services, and the implementation of pricing that, where feasible, includes externalities (CoAG 2004) which, if acted upon, would inevitably work its way through to the basic prices of agricultural commodities.

4. Social indicators

Three social indicators are used: employment generation, income and government revenue. From a social perspective we interpret that a sector performing 'above average' will have higher employment generation, higher income and higher government revenue. The indicators or intensities are referenced against one dollar of final demand in a sector. Average values across the economy are 1.75 minutes of employment generation, 34 cents of income and 21 cents of government revenue per dollar.

No sector should be 'expected' to equal the economy wide average given the diversity of sectoral structure and function throughout the economy. Sectors such as petroleum, alcohol, tobacco and gambling give government revenue intensities that are substantially above average, and to some extent these 'sin taxes' subsidise the function of governance. Conversely service sectors such as banking, insurance and finance have lower than average employment generation while retail trade and restaurants have above average employment generation. Also the capital intensity and scale of the mining and metals industries results in lower than average social returns. These industries compete in an intense globalised marketplace and domestic social returns have to be balanced against the export income required to balance our international trading accounts.

5. Financial indicators

Three financial indicators are used: the gross operating surplus (or profits), the export propensity and the import penetration. In general we assume that a sector performing 'above average' has a higher than average surplus and export propensity and a lower than average import penetration. Each of these indicators or intensities is referenced against one dollar of final demand and is expressed in terms of dollars per dollar. In national average terms, the operating surplus is 38 cents per dollar, the export propensity is 16 cents per dollar, and the import penetration is 19 cents per dollar.

The imbalance between exports and imports is a long running one in the Australia economy and leads to deficits in our international trading accounts (the balance of payments) and increases in our indebtedness to international financiers. Commodity exports from the farm and the mine, together with manufactured goods and contributions from some service sectors, provide most of Australia's exports. This report views tourism activities more as a physical sector than a service sector, due to the embodiment of energy and food in the totality of its outputs.

6. Scope of the triple bottom line accounting

With only ten indicators, this triple bottom line account provides depth but lacks the breadth of some corporate triple bottom line accounts which extend to fifty or sixty indicators covering a broad range of issues. The macro-viewpoint provided for each of the 135 sectors that make up the economy allows a distillation of the key issues at a glance. While using more indicators would tell a fuller story and capture some aspects otherwise overlooked, it could create confusion so we can't see the 'forest for the trees'.

Segmenting each indicator or intensity into its direct and indirect effects helps indicate whether efforts to improve performance should focus on the sector's own affairs within house, or whether the sector should start managing its supply chain in a more concerted way. In addition, the dissection of each indicator into its main contributors helps focus on whether key innovations in several key industrial processes are needed, or whether the supply chain requires a revolutionary redesign. The sector specific analysis provides guidelines for individual products and firms and gives a benchmark against which individual firms and institutions may measure their own performance.

7. How might this report be used?

The first year after the release of this report will reveal where its primary usefulness lies. Preliminary discussions have suggested uses in six areas. Firstly, it helps make the intent and practice of 'triple bottom line' approaches more numerate and defensible and gives a bottom line that is broader than the traditional focus on financials alone. Secondly, it will give policy analysts a wider view of their subject areas and will help identify where a more thorough analysis is required. Thirdly, preliminary views from the investment industry suggest that the report will help highlight sector issues for firms, which if they are responding to them, will confer higher ratings particularly from social or ethical investment funds.

The fourth area is for technical and science direction, which is often constrained in its oversight because it has to be narrowly focused and reductionist in order to generate fundamental innovations. The broad TBL view of a sector might show that a proposed research activity brings few social or environmental rewards and the research may need to be reassessed. The fifth is for non-government organisations and community groups who frequently lack the analytical budget and organisation of the institutions with whom they have differences. Having the capacity to view the economy at a glance will help NGOs to decide whether their activity should focus on the product, the factory or somewhere in the production chain. Lastly, the general public, the media and educational organisations could develop many information products from this report.

8. A life cycle analysis of the Australian economy

An alternative way to view this triple bottom line report is as a boundary-free lifecycle analysis of the Australian economy. The analysis bridges the concept of the multiplier effects of project development, and traditional life cycle analysis which usually focuses on a discrete factory or a product. The structural path analyses shown at the end of the data analysis section for each sector, allow an analyst to make a stepwise trace of the main effects that make up any of the nine TBL indicators. In many cases it shows that significant effects occur in the production chains that supply the factory or the office.

Since the analysis includes the whole chain - theoretically up to many thousands of suppliers - it often shows that within factory efficiency improvements, while well meaning, can be relatively insignificant. This brings opportunities for a beyond the horizon view of procurement policies and the chance to locate, choose or develop procurement chains that have for example, lower environmental impacts and higher social returns. This will challenge some contemporary management decisions that are based principally on price. It will also lay down the gauntlet to worthy statements on 'the triple bottom line' that are without much analytical substance in the context of the full production chain.

9. Future issues

While this analysis is static and performed for one point in time, its context has used both historical and futures studies to highlight important trends for each sector. The CSIRO Australian Stocks and Flows Framework, a future orientated model of Australia's physical economy, has been used to gauge important trends driven by issues such as population growth, technological innovation, industry development and export trends. In addition, many future orientated studies on both global and national issues have been examined, and key issues have been included in each sector report.

Four future issues stand out. The first is the demographic shift to a more mature and stabilising population structure. For many sectors, the implications of this shift are poorly understood and the greater than 65 year old population cohort, that will eventually represent one quarter of the consumer and political power, is largely ignored. The second issue is the declining availability of cheap oil and after 2040, natural gas. While energy is still a relatively minor cost in most sectors, high quality fuels are more than just a cost. Without fluent and constant supplies of oil and gas, the finely balanced economies of today may face ongoing shocks for which they are ill prepared, as there are few viable substitutes on line.

The third emerging issue is that of industrial ecology, a view that industrial processes will one day be all interconnected to virtually eliminate wastes. This will require the co-location of many firms and processes to maximise the recycling of materials, energy and heat. Organisational and planning aspects of this trend are especially challenging for Australia. The fourth issue relates human health and happiness to the increasing complexity of life in general, and specifically to the increasing numbers of industrial substances that underpin our everyday lives, and become embodied in the human food chain. Restructuring this complexity may require an organised simplification of entire production chains and the transition to a simpler material composition of our everyday lifestyle. This will not be easy given humankind's belief in robust and ongoing technological 'progress'.

10. Technological opportunities

The analysis for each sector includes the distillation of key opportunities for technological improvement. These have been distilled for each sector report. In an overall sense, five technological issues stand out. For basic primary production (agriculture, forestry and fishing), substantial reductions in the embodiment of water, greenhouse emissions and land disturbance will most likely come from redesigning production processes. In mining and metals, increasing the capacity for successive recycling or reuse stages can progressively lower the lifecycle material and greenhouse content, and transfer this advantage to the consumer product or service. In manufacturing, Australia cannot compete across the board with the scale and low cost of countries such as China. It must therefore focus on a high embodiment of skills and design in its production, and develop niche positions in complex materials, the carbohydrate economy, green chemistry and renewable energies. The services sectors in general have low export earnings and are perhaps less open to simple technological solutions to rectify this. A possible solution could emerge if private services acquired a deep and ongoing technical understanding of the primary and secondary sectors, and then led investment decisions strategically, rather than on a case by case and short term returns basis. The mix of investments may then shift to those with higher environmental and social returns.

11. Interactions between indicators and trade-offs

The analysis reveals the many trade offs already made in triple bottom line performance during the evolution of the current Australian economy. Some suggestions are given for possible changes that could improve social indicators while reducing environmental loadings. In some chemical sectors for example, high levels of import penetration mean that the energy and greenhouse intensities are lower than expected because the manufacturing process occurs overseas. However the employment and income indicators are also low for the same reason. Thus policies to make Australia more self sufficient in basic chemicals would add to the national energy use and greenhouse emissions, but may also improve the social indicators of employment generation and income while reducing the import penetration indicator.

Deciding whether such a policy is advantageous is thus more complex than that assumed by more limited methods such as cost-benefit analysis. Indeed a single integrative metric, or new decision making tools, may help in this. However, armed with new understanding, the well tested traditional policy process, which is both discursive and iterative, may still be the most appropriate way forward.

12. The issue of ideology

Both the presentation and interpretation of the results carry a number of value judgements that could be considered as ideological positions. The authors have taken the aspirations of triple bottom line analysis as given. For the financial indicators, high operating surplus, high export propensity and low import penetration are viewed positively. For the social indicators, high employment generation, income and government revenue are all viewed positively. For the environmental indicators, low energy use, greenhouse emissions, water use and land disturbance are viewed positively.

Nevertheless the authors acknowledge these interpretations could create tensions in the established world of single bottom line (ie financial) performance. For example high operating surplus might result from replacing labour with capital, resulting in lower employment generation and higher energy use. Judgements on the 'correct' interpretation of TBL imbalances can be prone to bias depending on the analyst's world view and knowledge of key issues that contribute to the indicators. The data and supporting material provided enable readers to produce their own perspectives on these issues.

13. Agriculture, fishing, forestry and food

For each dollar of final demand, primary production and its value added food and fibre products, have greenhouse, water and land disturbance intensities that are many times the average. These sectors are by definition physically intensive, but the prices we pay for the products reflect the marginal cost of production, rather than the full resource and environmental costs of production. There are many opportunities for innovation and better management to reduce the land, water and greenhouse intensities, but few will significantly moderate the unbalanced triple bottom line outcomes shown by this analytical method. Moves to internalise the full costs of production in the final price of the market product may mean substantial price increases. This would give rise to a number of social equity issues and does not seem feasible in today's society where the market price of food continues to decline.

14. Mining and metals

The mining sector reveals excellent financial and environmental outcomes, but below average employment and income indicators for each dollar of final demand. The substantial resource royalties that flow to state and federal governments from mining are not included in the national input-output tables due to international accounting conventions. The government revenue indicator may therefore be understated. The capital intensity of mining operations required for them to remain price and quality competitive in an international marketplace, drives these lower social returns. However many regional areas assert that resource booms provide them with few long term opportunities for human capital development, and the underpinnings for resilient regional economies. Instead urban areas and overseas owned companies benefit from the resource flows from these regions. This analysis provides few answers at the regional level, but the accounting approach highlights the issue.

15. Manufacturing

Not withstanding the traditional smokestack image of the manufacturing sectors, its overall TBL performance is reasonably balanced. Energy use and greenhouse emissions are above average while employment generation and income are below average. Many of the manufacturing sectors currently face strong competition from countries with lower wages and larger scale, and effective solutions are difficult to define. Nevertheless three issues emerge from this analysis. Industry strategies which aim to increase value adding in Australia bring with them the social returns of increased employment and possibly increased use of resources such as energy and water. If these products can be developed with environmentally advanced production chains, then this may give an advantage in affluent countries where markets are concerned with sustainability issues. Finally, meeting the environmental challenges may require industrial processes and material fabrication skills that are currently under-developed in Australian industry. Overall, there does not seem much advantage in Australia relying solely on being a cost efficient producer of average quality materials and products.

16. The services sectors

Both private services (eg banking and insurance) and public services (eg health, education and community services) are characterised by environmental indicators that are well below the national averages. Commentators often use this profile to suggest the likely sustainability end point for the Australian economy, dominated by private service sectors which are essentially 'light, dry and cool' compared to the 'heavy, wet and hot' structure we have today. There are several important caveats highlighted by our analysis. While private services generate more than one quarter of GDP in this analysis, their intensities of employment generation, income and export propensity are well below average. Balancing our trade account and maintaining full employment in a future economy where possibly three quarters of our GDP comes from private services may therefore be difficult. The second issue is that while private services are themselves 'light, dry and cool', they finance and underwrite most of the resource intensive activities in the Australian economy. Increasingly, their financing decisions may come under scrutiny with the expectation that social and environmental returns match the expected financial returns.

17. Future developments

Future activity for this form of numerate triple bottom line accounting will be guided by the response from the markets for corporate reporting and for policy and philosophical ideas. At this stage, it seems logical that these boundary-less reporting approaches should implement as far as possible, the protocols set out in the Global Reporting Initiative (for corporate and government reporting) and also some of the issues highlighted by The Equator Principles (for the social and environmental implications of major project financing).

The analytical approach must also extend beyond the boundary of the Australian economy to include the impacts in other countries, of many of our imported goods and services. This requires a similarly structured analysis for our most important trading partners. It is also possible to extend the indicator set so that each financial, social and environmental account could have more appropriate indicators, accompanied by a deeper more focused interpretation.

From an analytical perspective, development of this indicator set for all the national input-output tables back to 1969 would provide a time series of triple bottom line performance for the 135 sectors in this report. This could be particularly important for water, energy and greenhouse policy development in the near future.

Chapter 1: Background and Motivation

Abstract

This opening chapter sets the context for the work described in this report. Firstly, a background to triple bottom line reporting in Australia is given and the motivations and drivers are outlined. Current approaches to TBL assessment, typically based on an audit process, are described. Economic indicators are usually calculated from existing financial records, compiled using accepted accounting standards. Social indicators are usually determined by a local audit of the entity's operations, primarily covering employee conditions, health and safety. Environmental indicators, presently the most well developed component of TBL assessment, are also usually determined by an audit process at the "micro" level. The major restriction of an audit approach is that in order to make the audit manageable, an arbitrary boundary has to be set, inevitably leading to inconsistencies within and between assessments. The audit approach is exemplified by the Global Reporting Initiative's Sustainability Reporting Guidelines. These Guidelines contain a large reporting scope or breadth, meaning the range of different indicators. However, due to the restricted boundary, audit approaches to TBL assessment have limited depth, meaning the extent to which effects in the entity's supply chain are captured. Four examples are given of the inconsistencies that result from the boundary problem inherent in the local audit approach to TBL assessment.

In the approach developed in this report, the principle of the triple bottom line is applied at a national economic sector level for 135 sectors of the Australian economy. These Australian sectoral TBL accounts contain information on the aggregate and average performance of each economic sector for ten TBL indicators. These indicators can be best termed "macro" indicators in the sense that they encompass the total, economy-wide effects of the operation of a particular sector, complete with all the economic interdependencies. An internationally accepted method for dealing with economic interdependencies is input-output analysis (IOA). IOA is an accounting procedure that documents all monetary flows to and from industrial sectors. Generalised IOA, the basis of the method employed here, describes the inclusion of non-monetary flows into the economic accounting framework. Physical flows between sectors can therefore be assessed. Synthesis of disparate data sources is a major component of the development of a generalised IOA framework. An input-output approach is at the core of most economic models because it is the main method for dealing with inter-industry effects that are the signature of the circular, interdependent nature of modern economies. The increasing specialisation and compartmentalisation of business units makes assessment of boundary issues more important.

The micro or audit approach, and the macro or IOA approach, therefore address different aspects of TBL assessment. Specificities and breadth of effects covered in a traditional TBL audit are complemented by the macro approach which gives depth of coverage. This hybrid assessment approach removes the boundary problem whilst including the local audit information. Some indicators are common to both the micro and macro approaches, whereas others are only meaningful at a particular level. A combination of the micro (audit) and macro (IOA) approaches and indicators therefore provides scope and depth to sustainability assessment.

Given the above context, there are five important applications of National TBL Accounts calculated using a generalised IOA approach. Firstly, it provides the consistency required for meaningful comparisons to be made between indicators within a sector (eg. employment level and energy use). Secondly, it requires the consistency required for meaningful comparisons to be made between sectors. Thirdly, the results represent quantitative benchmarks for the individual economic entities making up the economic sectors. Fourthly linkages between indicators in different sectors can be identified, significantly increasing the scope and depth of policy analysis. Finally, the sectoral analyses inform the reporting standards and practices of companies placed within the sectors.

1.1 Concepts of Sustainability and the Triple Bottom Line

Governments at all levels, corporations, non-governmental organisations and the general public are all engaging with the concept of sustainability. The environmental movement first brought the issue of tensions between economic development and environmental quality to the attention of the public about 30 years ago. More recently, the developed world has been struggling with expanding the original concept of sustainable development - meeting environmental concerns whilst maintaining economic development - to a more holistic concept where economic, environmental and social considerations are given more weight and clear choices are made between them.

The broadly agreed definition of sustainability is ‘practices and development that meet the needs of the current generation without compromising the ability of future generations to meet their needs’.[1] Although this definition has been widely accepted, applying it in a meaningful way to all levels of society is a major intellectual and governance challenge. Sustainability is ultimately an absolute condition: a country, community or company is either sustainable or it is not. However, unsustainability may be less recognisable over immediate or short time scales that are at odds with the accepted principle of sustainability defined in terms of future generations. Therefore, in an operational sense and with our current limited knowledge, sustainability is best viewed as a process. It is likely therefore that the sustainability ‘goal posts’ will be moved continually as our understanding of the importance of social and natural capital increases. However there are calls for sustainability assessments to move beyond directional judgements to the definition of sustainability principles and the implementation of numerate criteria.[2] While it is difficult to make an absolute assessment of what sustainability means, proxy indicators of sustainability, many of which are currently in use, are required for determining relative performance.

Corporations are beginning to apply the concept of sustainability at a practical level in terms of corporate citizenship or corporate social responsibility (CSR). CSR is currently dominated by the notion of the triple bottom line. Triple bottom line (TBL) was a termed originally coined by John Elkington in 1994 to describe corporations moving beyond reporting only on their financial ‘bottom line’ to assessing and reporting on the three spheres of sustainability: economic, social and environmental.[3] The notion of the triple bottom line has many meanings to many people, and can be applied at different levels in society by different stakeholders. However, there is general agreement that the triple bottom line principle is a useful approach for examining the operations of an entity, from a local council to a major corporation, to a nation.[4]

Importantly, there are strong interactions between economic, social and environmental factors. Environmental degradation can become an economic liability to a company, similarly poor social performance, such as high work place injuries, can have economic impacts. Indeed, this is one approach to sustainability assessment: convert an impact, for example an environmental emission, to a dollar cost and include this in the overall balance sheet.[5] Another approach is to assess the economic risk of environmental and social factors. In all approaches, the first requirement is accounting for the impacts by using indicators (preferably quantitative, but sometimes qualitative) within a framework, to make a comprehensive and accurate TBL report. Subsequent conversion of these indicators to other factors can then occur, but is more likely to involve subjectivity. In the following section we examine TBL assessment and reporting issues and methodologies in Australia.

1 World Commission on Environment and Development 1987, *Our Common Future.* Oxford, UK.

2 J Pope, D Annandale, A Morrison-Saunders, 2004, ‘Conceptualising sustainability assessment’, *Environmental Impact Assessment Review,* vol. 24, 2004, pp. 595-616.

3 J Elkington, ‘Enter the Triple Bottom Line’ in Henriques & Richardson (eds), *The Triple Bottom Line: does it all add up*?, Earthscan, London, 2004. Elkington continues to be active in this area through the *SustainAbility* consulting firm (http://www.sustainability.com).

4 There are many other indicators and concepts for sustainability assessment, but not all of them encompass all the economic/social/environmental aspects. For example, Genuine Progress Indicators are designed to be an alternative to gross domestic product, the quantity generally aimed to be maximised in a more traditional economic view. Also, ecological footprints aim to assess the ecological sustainability of a population, but do not include social or economic aspects directly. At a national level, the Australian Bureau of Statistics’ *Measuring Australia’s Progress* publications do include indicators that could be considered to cover the three pillars of sustainability.

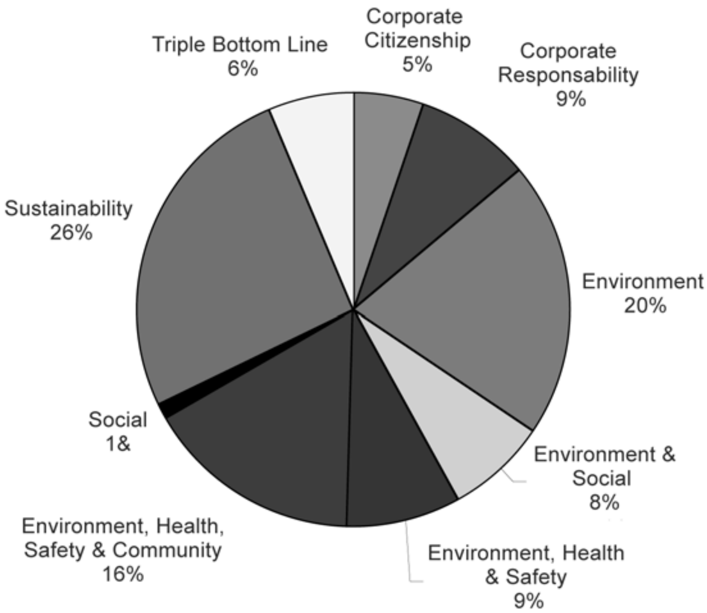
5 In the UK Trucost (www.trucost.com) has a comprehensive global input-output model based on the US input-output structure that is used to analyse a company’s environmental impacts, both direct and indirect. The impacts are then converted to a financial cost based on taxation, regulation costs, resource depletion costs, and externalities in general.

1.2 Issues in Australian Triple Bottom Line Reporting

Types of sustainability reports

A recent survey of sustainability reporting in Australia covering 509 companies found that 23% produced a wide range of reports that could be categorised as sustainability reports (Figure 1.1).[6] Interestingly, almost all reports contained environmental information and only a minority could be considered as reporting on TBL principles, with only 6% using the TBL title directly. The dominance of environmental reports is also seen internationally,[7] which along with health and safety, have been on the corporate agenda for longer than the broader idea of TBL sustainability.

Figure 1.1: Categories of sustainability reports in Australian in 2003 [6]



Drivers for TBL assessment

In a report by The Allen Consulting Group to the Prime Minister’s Community Business Partnership,[8] public drivers for change in business priorities, reflected in increased interest in triple bottom line activity, were identified as:

- community, shareholder and employee expectations rising beyond financial success as the only measure of a company’s operations[9]
- strong growth in socially responsible investment (SRI) although it is still a small part of the total investment market[10] [11]
- environmental and social risk assessment of businesses and investors
- reputation ranking of businesses, though the methods are subjective[12]

6 Department of the Environment and Heritage, *The State of Sustainability Reporting in Australia 2004*, 2004.

7 KPMG Global Sustainability Services, *KPMG International Survey of Corporate Sustainability Reporting 2002*, The Netherlands, 2002.

8 The Allen Consulting Group, *Triple bottom line measurement and reporting in Australia: making it tangible,* Prime Minister’s Community Business Partnership, 2002.

9 S Mays, *Corporate Sustainability – an investor perspective* (The Mays Report), Department of the Environment and Heritage, 2003 (http://www.deh.gov.au/industry/finance/publications/mays-report/).

10 Deni Greene Consulting Services, *A Capital Idea: realising value from environmental and social performance,* 2001.

11 The State Chamber of Commerce (NSW), Taking the First Steps: an overview, corporate social responsibility in Australia, 2001.

12 Reputex Reputation Measurement 2003, http://www.reputex.com.au.

- pressure from the non-government or not-for-profit sector
- regulatory and certification requirements such as the SRI disclosure requirements of the *Financial Services Reform Act 2001*

Characteristics of companies engaging in TBL activities

According to the Allen Consulting Group report, the core characteristics displayed by companies embracing the triple bottom line notion are:

- acceptance of accountability and commitment to transparency;
- integration of planning and operations that is consistent with a triple bottom line philosophy;
- commitment to internal and external stakeholders; and
- commitment to multi-dimensional measurement and reporting.

These characteristics alone do not ensure that a company will realise an improvement in their sustainability performance. Some of the most important reasons for this relate to companies perceiving difficulties in the part of the TBL process mainly considered in this work: assessment and reporting.[13]

TBL assessment and reporting issues in the investment community

There is as yet no consensus on the methodology or standard for the assessment and reporting of non-financial aspects of a company's operations. In regard to one of the drivers for TBL reporting in Australia, the new Financial Services Act, the Australian Securities and Investments Commission (ASIC) is the body charged with the responsibility for defining these standards. ASIC has recently released guidelines for the inclusion of information relating to labour standards and environmental, social and ethical factors in the product disclosure statements (PDSs) of investment products.[14] ASIC has adopted a "non-prescriptive, principles-based approach, as this [SRI] is a relatively new area of investing where product design must be able to develop freely in a flexible environment".

A recent report examined the issue of the materiality of, or significance of information on, environmental risk in the finance sector.[15] The key findings of this report were an increasing need for the finance sector to better incorporate environmental risk in investment decision-making, the subjectivity of the assessment of risk (problems with suitable tools, accounting standards, and reporting regulations), and the large variation across the finance sector in the perceived importance of the materiality of environmental risk.

In another initiative, the considerable publicity from the release of the Good Reputation Index (previously Ruputex) ranking scheme for 100 of Australia's major companies has highlighted community interest in the triple bottom line concept.[16] Despite the assertion in Reputex's literature that the reputation rating will 'provide an independent, transparent and publicly available system which measures the social responsibility performance of business organisations', as yet there does not appear to be any evidence showing this has been achieved.[17] Indeed, there is some frustration in business circles at the lack of rigour and transparency in TBL ranking, assessment and reporting schemes. In 2002 a prominent business commentator wrote:

> 'Even in this narrowest of definitions [of voluntary TBL reporting], it is apparent that it is impossible to come up with a standardised measure of environmental and social outcomes that would apply across all corporations'.[18]

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13 The relationships between different TBL processes such as assessment, reporting, planning, management and standards are discussed further below (see for example Figure 1.2).

14 ASIC Section 1013DA Disclosure Guidelines to product issuers for disclosure about labour standards or environmental, social and ethical considerations in Product Disclosure Statements (PDS), December 2003.

15 Ernst and Young 2003, *The materiality of environmental risk to Australia's finance sector*, prepared for the Department of the Environment and Heritage.

16 Reputex Reputation Measurement 2003, http://www.reputex.com.au. Results released 13th October 2003.

17 The non-governmental organisations The Australian Conservation Foundation, Oxfam Australia and the Australian Consumer's Association have together conducted their own ranking: CORP RATE - an assessment of Australia's top 50 listed companies in 2003, released April 2004.

Socially responsible investment (SRI), referring generally to the consideration of more than financial performance in investment decision-making, is an identifiable sub-set of the investment industry. Along with ranking schemes such as Reputex, SRI funds and practitioners use screening criteria (both positive and negative) and other preference strategies to inform investing. In June 2003, the Australian SRI industry amounted to over $20 billion.[19] Major companies that are prominent in SRI have generally developed their own assessment tools[20] (for example, AMP Henderson and Sustainable Assessment Management). Although some aspects of the development of these tools have been made public, there is a general lack of transparency and consensus on accepted methodology for making assessments on triple bottom line principles in the investment arena.

Principles and requirements for TBL assessment and reporting

The Allen Consulting Group report states (page 3):

> 'A triple bottom line is not a quest for a new bottom-line metric but rather an approach to management and performance assessment that stresses the importance and interdependence of economic, environmental and social performance'.

We agree that it is not possible to distil three single metrics covering economic, social and environmental performance. However, it is highly desirable to strive for equal prominence to be given to the three components of sustainability, rather than social and environmental concerns being given less importance, or ignored altogether. This would require greater emphasis on establishing quantitative environmental and social indicators that enable consistent and meaningful comparisons to be made between organisations and at regular intervals. Indicators and methodologies are discussed in the next section.

Globally, the Sustainability Reporting Guidelines of the Global Reporting Initiative (GRI)[21] have emerged as the most commonly adopted framework for triple bottom line reporting, with environmental reporting being the most developed. The Institute of Social and Ethical Accountability focus on the social and ethical side of sustainable development.[22] An extensive list of other quasi-standards and guideline frameworks is given in Table 1.2. Whilst the Global Reporting Initiative is the most high profile overall triple bottom line framework, companies generally chose a mixture of guidelines that are more specific to their business or industry (for example the Institution of Chemical Engineers and the Greenhouse Gas Protocol Initiative[23]). More recently, the GRI has been developing sectoral supplements for some major industries, such as the automotive, telecommunications, and mining and resource industries.

The GRI defines eleven TBL reporting principles (*in italics*) that are used to inform four aspects of reporting (**in bold**):[24]

- **reporting framework** (*transparency, inclusiveness, auditability*);
- **report contents** (*completeness, relevance, sustainability context*);
- **report quality** (*accuracy, neutrality, comparability*); and
- **report accessibility** (*clarity and timeliness*).

18 M Walsh, 'The Bottom Line', *The Bulletin*, September 3 2002.

19 Deni Greene Consulting Services, *Socially Responsible Investment in Australia – 2003*, Ethical Investment Association, 2003.

20 Mays Report, p. 17.

21 Global Reporting Initiative, *Sustainability Reporting Guidelines 2002*, 2002, see http://www.globalreporting.org

22 *AccountAbility,* http://www.accountability.org.uk

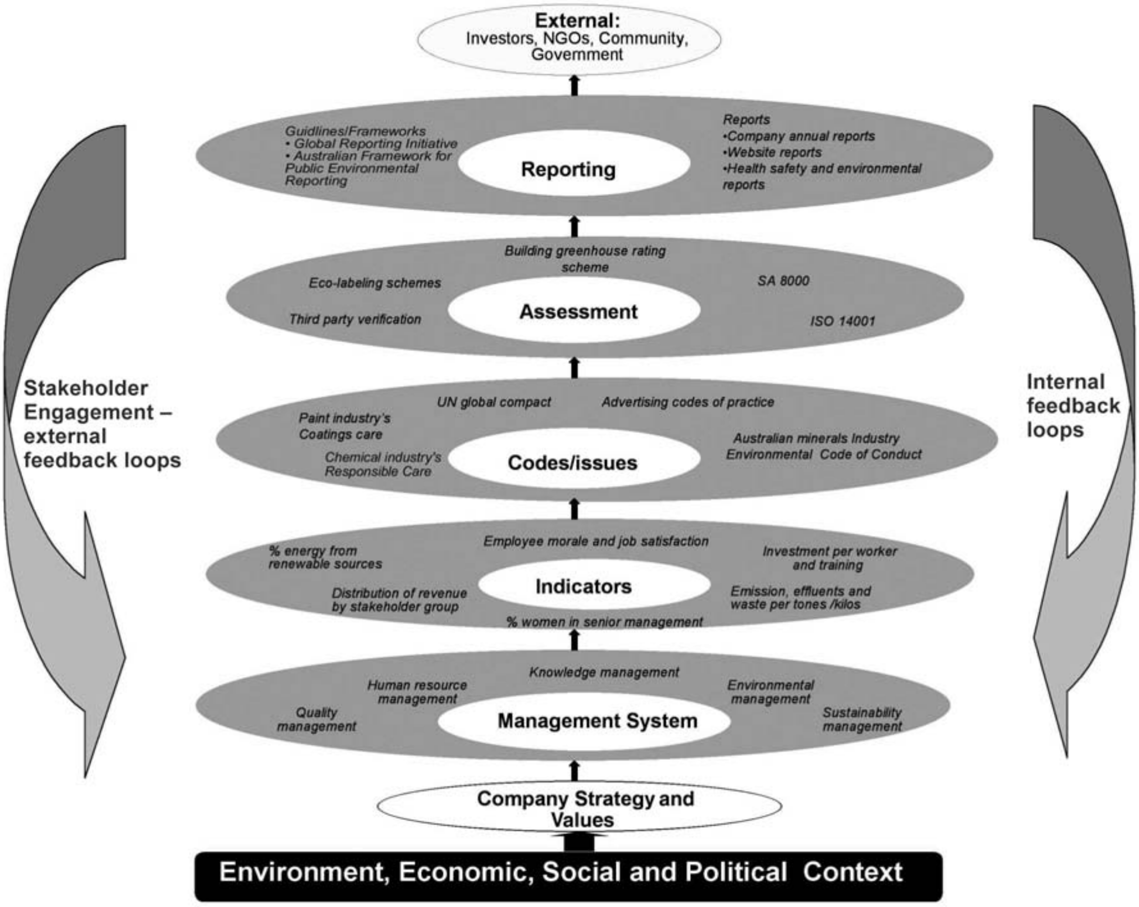
23 Institution of Chemical Engineers, *Sustainable Development Progress Metrics - recommended for use in the process industries*, 2002, see http://www.icheme.org/sustainability/metrics.pdf. Or for example, the Greenhouse Gas Protocol (http://www.ghgprotocol.org/) of the World Business Council for Sustainable Development.

24 Global Reporting Initiative, *Sustainability Reporting Guidelines* 2004, 2004, see http://www.globalreporting.org/guidelines/sectors.asp, accessed 26-11-04

The methods and results described in this report relate directly to the reporting principles grouped under report quality, but are also highly relevant to principles of transparency, completeness and clarity.

The Allen Consulting Group developed a useful visual framework describing the relationships between the business decision elements of the triple bottom line concept (see Figure 1.2). The framework represents the elements linking a company's strategy and values with its external stakeholders. Although this is depicted as a linear process, the understanding is that many of the individually identified elements (such as indicators, reporting and assessment) are closely linked and will occur in parallel.

Figure 1.2: A visual framework relating triple bottom line reporting to complementary institutional activities[25]



This report fits primarily into the Indicators and Reporting categories of this visual framework. However, this work has important implications for the wider environmental, economic, social and political context, as will become apparent from the sectoral descriptions in later chapters. There are also implications in terms of Assessment (verification) and Codes/issues, which arise from the lack of transparency and the use of non-standard assessment methods, as mentioned earlier. Standards and codes are discussed briefly at the end of this chapter.

25 The Allen Consulting Group, p. 7.

1.3 Triple bottom line Assessment Methodologies

Sustainability *indicators*, or *performance measures*, are the elements used within an assessment and reporting framework. The vast range of business types and operating conditions have led to the development of a large array of indicators. Organisations and industry groups continue to develop their own sets of indicators relevant to their operations and stakeholder concerns. An important consideration for these indicators is that they must be able to inform strategic planning and decision making, not just TBL reporting activities.[26] More recently, the GRI and other reporting frameworks have facilitated some standardisation of indicators, but no one set of indicators, however complete, is meaningful across the full range of organisations. In this report, we are most concerned with quantitative indicators, though qualitative indicators which capture aspects of organisational performance that cannot be described meaningfully by numbers, are also of great importance.

Quantitative indicators can be classed into two types: absolute (or systemic) and relative.[27] Absolute indicators describe the size or significance of an impact, usually in physical units per time period (eg. energy consumption over a year). Relative or ratio indicators, sometimes called cross-cutting indicators and metrics, are combinations of absolute indicators. Relative indicators are useful for comparing, ranking and benchmarking reporting entities. Importantly, they are often combinations of absolute indicators across economic, social and environmental categories and therefore assist in integrating and linking performance measures across the three TBL areas. The GRI Guidelines further classify relative indicators into three types: *productivity/efficiency* ratios relating value to impact (eg. production volume per volume of waste), multiplier (or *intensity*) ratios relating impact to value (eg. emissions per $ turnover), and *percentages* relating similar absolute indicators (eg. female employees to total employees). The importance of consistent and accurate calculation of absolute indicators is therefore clear, since the somewhat more revealing operationally-relevant indicators are based on them.

The typical method for compiling a generic organisational report is via a local audit or inventory. This approach could be termed a micro approach. For each indicator, physical or financial information is assembled and placed in a reporting framework. In Australia, the GRI Sustainability Reporting Guidelines (and indicator guidelines) have formed the basis of the Department of the Environment and Heritage's Environmental Indicators Guidebook.[28] These guidelines provide detailed methodologies for identifying and selecting two *classes* of indicators (contrasted with the types of indicators described above). The first class is *environmental management indicators* that describe an organisation's response to environmental issues (which are primarily qualitative in nature) such as implementing an environmental management system (EMS) and integrating this in the general management process. Secondly, *environmental performance indicators* that describe the impacts of the organisation's operations, many of which can be quantitative (such as levels of emissions, energy and water use, and so on).

The *boundary* of environmental management indicators is generally identifiable as the extent over which the company can directly influence its own environmental management:

> 'It is critical [that] the boundaries adopted for the purposes of reporting are clearly defined and obvious to readers of reports. Careful boundary definition also ensures a report can be verified and meaningful comparisons can be made between information from different reporting periods.'[29]

26 The Allen Consulting Group, p. 15.

27 Global Reporting Initiative 2002, *Sustainability Reporting Guidelines*, Annex 5.

28 Department of the Environment and Heritage, *Triple bottom line reporting in Australia: a guide to reporting against environmental indicators*, 2003, see http://www.deh.gov.au/industry/finance/publications/indicators/ accessed 29-11-2004.

29 Department of the Environment and Heritage 2003, p. 8, also contains a wider discussion about the issue of boundaries.

The boundary for environmental performance indicators however is much more difficult to define than for environmental management indicators. This is due to the complexity of the modern economies in which organisations operate, as depicted in Figure 1.3. In a full life cycle view there are an infinite number of upstream suppliers that feed into the organisation of interest, with associated triple bottom line impacts. Most audit approaches do not extend above the first level of suppliers, and identifying a clear boundary for the analysis that is consistent across all indicators is impossible. Whilst important local or on-site effects are captured by audits, the considerable economy-wide effects are not accounted or reported, since assessment of the wider implications of operations is not tractable using the audit approach.

The method described in this report accounts for impacts of the full upstream supply chain of an economic entity such as a company or sector. Downstream impacts, for example those associated with the use of the products sold by a company, are beyond the scope of the present work, but it is feasible to include them in enhanced analytical methods that are currently under development at the University of Sydney.[30] Some downstream impacts can be accounted for in an audit approach, such as the energy consumption footprint of organisations (GRI Indicator EN18).[31] However, the same boundary issue of consistency across indicator sets is involved with a downstream analysis.

Boundary issues are also relevant to social reporting. Again drawing heavily on the GRI Guidelines are the draft guidelines which had limited released in 2003, by the federal Department of Family and Community Services (FACS).[32] The GRI is aware of the importance of boundary issues and currently has a working group and research activities aimed at developing a Boundaries Protocol to be incorporated into the new GRI Guidelines due to be released in 2005.[33] Public consultation on this draft GRI Boundaries Protocol was called in October 2004. The CSIRO/University of Sydney team made a submission on boundaries during the development of the 2002 GRI Guidelines and will continue to be active in the development of this protocol.[34]

30 B Gallego & M Lenzen, 'A consistent formulation of shared producer and consumer responsibility', submitted to *Economic Systems Research* (paper in draft, 2004).

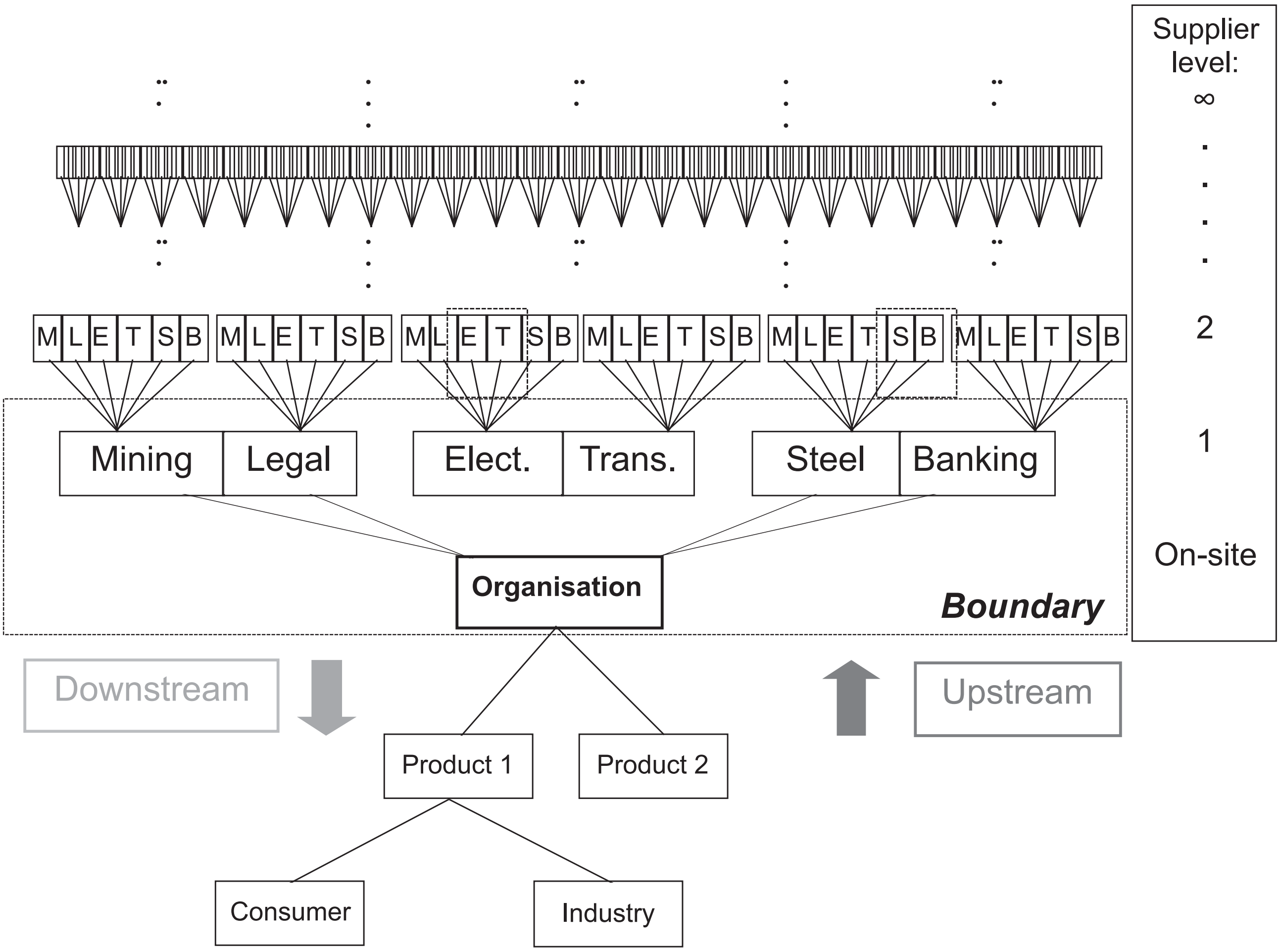
31 Note this use of the term footprint differs from its meaning in "ecological footprint" where it is used to imply all upstream impacts.

32 Department of Family and Community Services, *Triple bottom line reporting in Australia: a practitioner's guide to reporting against social indicators.* Draft-in-discussion, May 2003.

33 GRI Boundaries Working Group, see http://www.globalreporting.org/guidelines/prototcols/boundaries.asp

34 C Dey, M Lenzen, B Foran & M Bilek, Addressing boundary issues in the Global Reporting Initiative: comments on the Draft 2002 Sustainability Reporting Guidelines, 2002, see http://www.globalreporting.org/guidelines/protocols/Boundaries/UniversityofSydneyCSIRO.pdf.

Figure 1.3: A depiction of the complexities of industrial dependencies in a modern economy as a "tree" of upstream suppliers (shown at different levels). For illustration only, six types of suppliers are shown. Each supplier will have TBL impacts that can be assessed with TBL indicators. An arbitrary boundary for an audit approach is also depicted (with a dotted boundary line) demonstrating how the full upstream supply chain is not taken into account. An example of a downstream effect is also shown where there is consumption by a consumer and another industry. However, this practice is unusual, with most companies using the supply chain to mean a more limited boundary.[35]



TBL reporting organisations are also trying to deal with the issue of impacts from their supply chain (more generally termed indirect effects), but this is done in an ad-hoc fashion. For example a telecommunications company's sustainability report refers to its supply chain and "indirect effects associated with its mobile phone base stations", but not other indirect effects such as the energy embodied in the manufacture of the vehicles used to service them.[36] However, further indirect effects are recognised through the use of the term 'sub-supply chain', roughly corresponding to the 2nd order supplier level of Figure 1.3. Indirect effects are relatively more important for secondary (eg aluminium smelting) and tertiary industries (accommodation, cafes and restaurants) whose core business is further 'downstream' in the economy.

Indirect effects also appear to have been taken into account in the annual report of a pharmaceutical company which estimates indirect employment effects.[37] In this case the indirect effects in the country of origin have been estimated using the industry sector production and consumption multipliers estimated by the national statistics body.

35 Volvo Corporate Citizenship Report, 2003, see http://www.volvocars.com/AboutVolvo/CorporateCitizenship/Reports/. Here, the term supply chain appears to be taken to mean the suppliers of finished products that are directly incorporated into their cars, and not to mean the more general case of any supplier, such as the steel supplier whose products they transform into car panels.

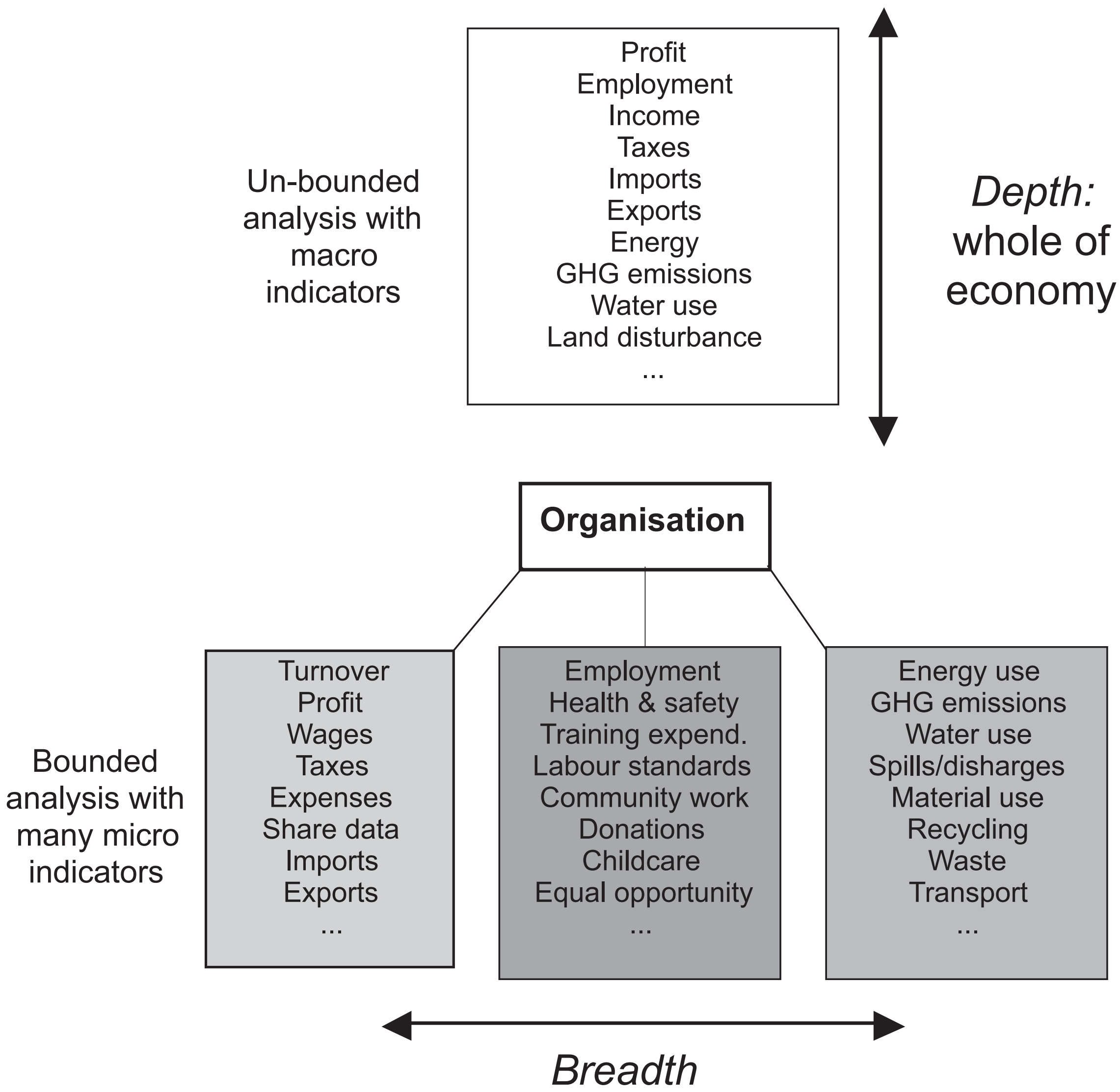
36 Vodafone Group Plc, *Corporate Social Responsibility Report 2003/04*, see http://www.vodafone.com, pp. 12 & 16.

37 Novo Nordisk, *What does being there mean to you? Sustainability Report 2003*, 2003, p. 14, see http://www.novonordisk.com.

The only process/framework that the authors are aware of that does attempt to deal with indirect effects is the Trucost company in the UK, as described briefly earlier (see footnote 5). The fundamental methodology of Trucost is similar to the methodology forming the basis of the work here.

We can summarise the different approaches to TBL assessment and reporting using the notion of assessment *breadth* and *depth* (Figure 1.4). Audit approaches are specific and flexible and generally use many micro indicators in a broad analysis. IOA approaches use fewer macro indicators in a deep assessment that extends through the supply chain. Both approaches have merit and are best used in combination: a practice known in other fields as hybrid analysis, and applicable here.

Figure 1.4: A simple comparison between bounded audit approaches with large indicator *breadth*, compared with input-output approaches with *depth* from macro indicators extending through the full supply chain (economy). Some indicators in these sets (illustrative only here) are common to both approaches.

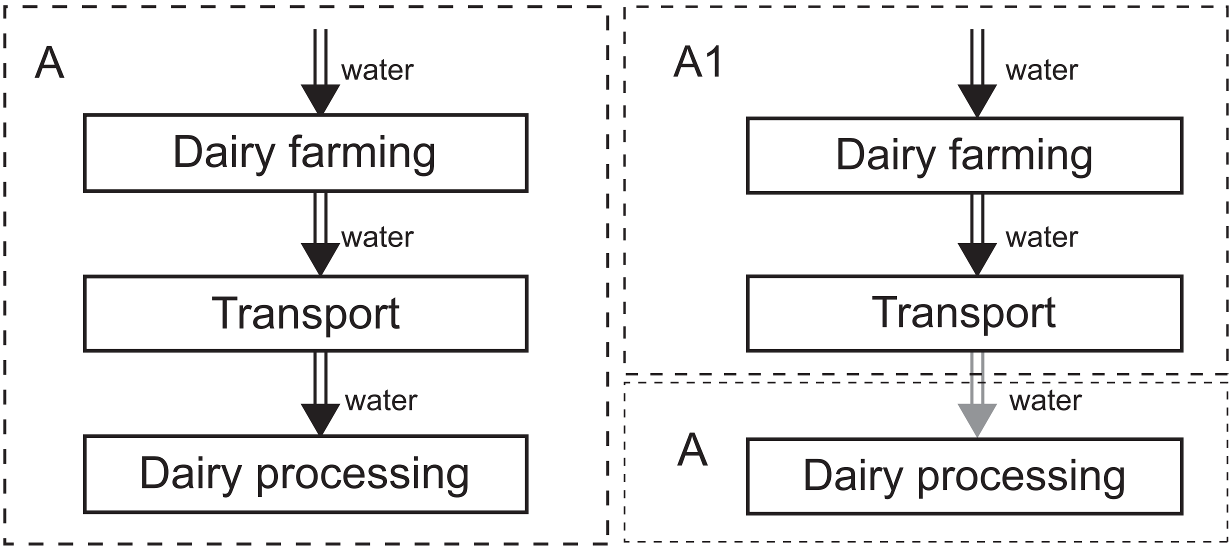


The next section provides some examples of the inconsistencies that result from the requirement to draw a boundary for TBL assessment in audit-only approaches. Then in the following sections we briefly describe some additional requirements of TBL assessment schemes, then introduce input-output analysis (IOA), and finally describe how IOA can be used to enhance traditional audit schemes by removing the boundary problem.

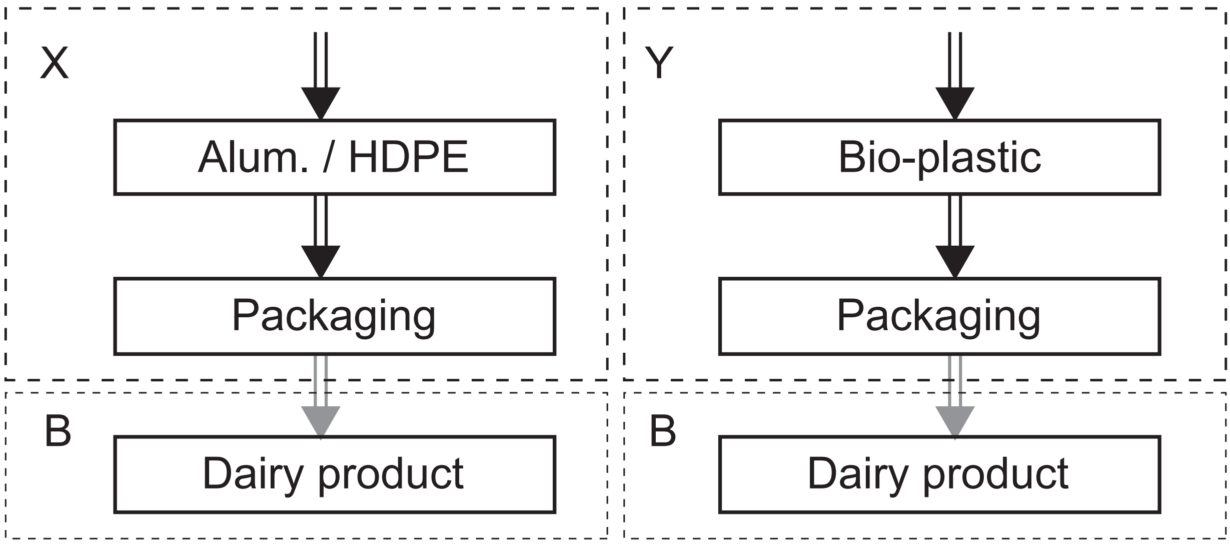
1.4 Examples of Inconsistencies in Current Reporting Frameworks

A *hybrid approach*, combining audit and IOA approaches, is preferable because audit only approaches do *not* take TBL impacts of the upstream supply chain into account and can lead to inconsistencies and loopholes. For example:

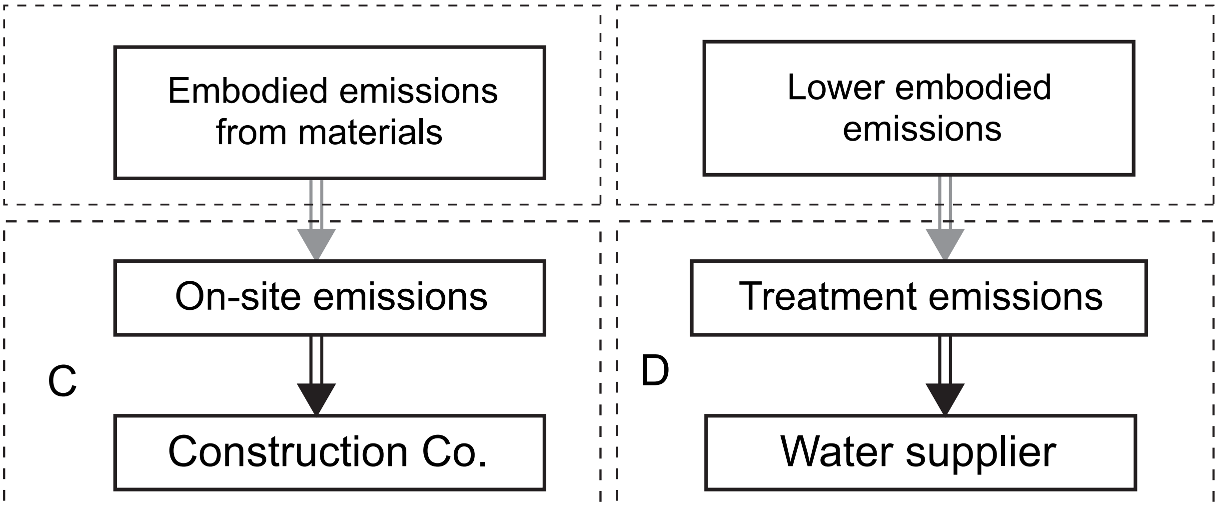
1) *Size and structure of a company:* Assume an Australian dairy company 'A' owns the entire production chain, i.e. production of raw milk at the farm, transport logistics from farm to factory, and the manufacturing site. This company has significant water usage (mainly at the farm). Assume that the same company 'A' demerges into two companies 'A1' and 'A', with A1 consisting of the farm and transport logistics, while the 'new A' is responsible only for dairy manufacturing. As shown below, in a conventional (on-site only – no upstream impacts) TBL reporting regime, 'A' can improve its TBL (water) performance significantly but artificially, as the supply chain – and hence the impact of the product 'processed milk' – is exactly the same. Unless a method is capable of differentiating between companies with differing degrees of vertical integration, the company with the smaller (external) supply chain will be disadvantaged. Benchmarking over time (trend analysis) will also be inaccurate as structures change.



2) *Green supply chain*: A dairy manufacturing company 'B' uses large quantities of packaging materials for their yogurt (supplied by company X). The packaging material consists of HDPE and aluminium. Both materials are energy-, greenhouse gas - and water-intensive. The management of company B decides to replace the packaging material with starch-strengthened biodegradable plastic (supplied by company Y) that is less energy, greenhouse gas and water intensive. Under conventional (on-site-only) TBL reporting, this shift to more sustainable packaging is not recognised. However, by incorporating supply chain effects the improved environmental performance can be quantified thereby providing more incentive for action. Recycling programs can further improve this supply chain.



3) *Risk and liability*: A manager of an ethical investment fund is assessing the risk posed to a construction company 'C' and a water supplier 'D' when faced with a carbon tax. The manager decides to incorporate C into the ethical portfolio, because C's carbon emissions from on-site construction machinery are lower than D's emissions from water treatment processes. However, C may face much higher additional, indirect risks than D, which arise out of price increases of carbon-intensive inputs such as aluminium frames and cement. These risks are beyond the scope of current audit or bounded TBL approaches but nonetheless can represent a general risk to consumers down the supply chain.



1.5 Additional Requirements for TBL Assessment: Guidelines/standards

Whilst the Global Reporting Initiative TBL reporting principles given in Section 1.2 are concise and make good sense, the discussion and examples highlight some important considerations for putting these principles into practice in the form of guidelines and/or standards. We therefore suggest that key requirements for guidelines describing assessment and reporting along triple bottom line principles should also include the following:

- methods should ensure a consistent boundaries across different indicators;
- methods should report the on-site effects of a particular sector or company, as well as all the upstream effects that account for the goods or services obtained from other sectors or companies (the complete supply chain);
- some indicators should be common to a number of levels such as economic sectors, individual firms or government institutions;
- these indicators should include multipliers (unit per $) as relative indicators, so that absolute indicators can be obtained, and compared across economic, social and environmental spheres;
- whilst retaining simplicity, methods should reflect the complexity of modern economic systems and be rigorous enough to be defensible;
- methods and indicators should provide a stimulus for management change and innovation if the particular sector or company report details issues that are at odds with economy-wide expectations or norms; and
- indicators and underlying data should be of archival and benchmark value.

1.6 Introduction to Input-output Assisted Triple Bottom Line assessment

In the approach developed in this report, the principle of the triple bottom line is examined using *input-output analysis* (IOA). IOA is an internationally accepted method for dealing with economic *interdependencies*. It is an accounting procedure that documents all monetary flows to and from discrete economic sectors and covers all traditional economic activity in an economy. Input-output *tables*, the data part of IOA, also forms the core of most economic models, such as computable general equilibrium models. Sectoral studies using IOA have been part of standard economic planning for many years. Of all the methods used in the national accounts, the Australian Input Output Tables compiled by the Australian Bureau of Statistics (ABS) represent the most comprehensive 'snap-shot' of the size and structure of the economy.

Generalised IOA, the basis of the method employed here, describes the inclusion of non-monetary flows into the economic accounting framework. Physical flows between sectors can therefore be assessed. The interdependency between sectors that is a characteristic of the economies of all developed countries, translates into social and environmental interdependencies between sectors. Input-output theory was pioneered by Nobel Prize winning economist Wassily Leontief in the 1940s. It was Leontief's intention that IOA be extended from purely financial considerations to a range of social and physical elements. There has been a great deal of research interest shown in generalised IOA, as is evident in the literature list provided at the end of Chapter 2. The most developed initiatives have been environmentally extended input-output tables[38] most common in Europe.[39] These have also been considered at the level of the United Nations.[40] However, such methods have not been widely employed by economists in government planning and policy circles. One can only speculate as to why this is the case, but it may partly be due to fashion: with the increase in computing power over the last 30 years, input-output analysis has been somewhat superseded by more complex techniques.[41] Nevertheless, the fundamental value and elegance of IOA remains.

The methods used here integrate the structure and function of the financial economy (as described by the national input-output tables) with national social and physical accounts such as energy, greenhouse emissions, water, land disturbance, employment and so on (see Figure 1.5). We have compiled national economic sector level data for 135 sectors of the Australian economy, using input-output tables and additional data from the ABS. These Australian sectoral TBL accounts contain information on the absolute and average performance of each economic sector for ten TBL indicators. These are listed in Table 1.1, together with their main data sources. The synthesis of disparate data sources is a major component of the development of a generalised IOA framework. As well as providing a complete sum (over an infinite number of supply chains) over all indicators, the indicators can also be broken down into contributions from the sector of interest, and sequentially from all sectors suppling the sector. As introduced earlier, these indicators can be best termed "macro" indicators in the sense that they encompass the total, economy-wide effects of the operation of a particular sector, complete with all the economic interdependencies.

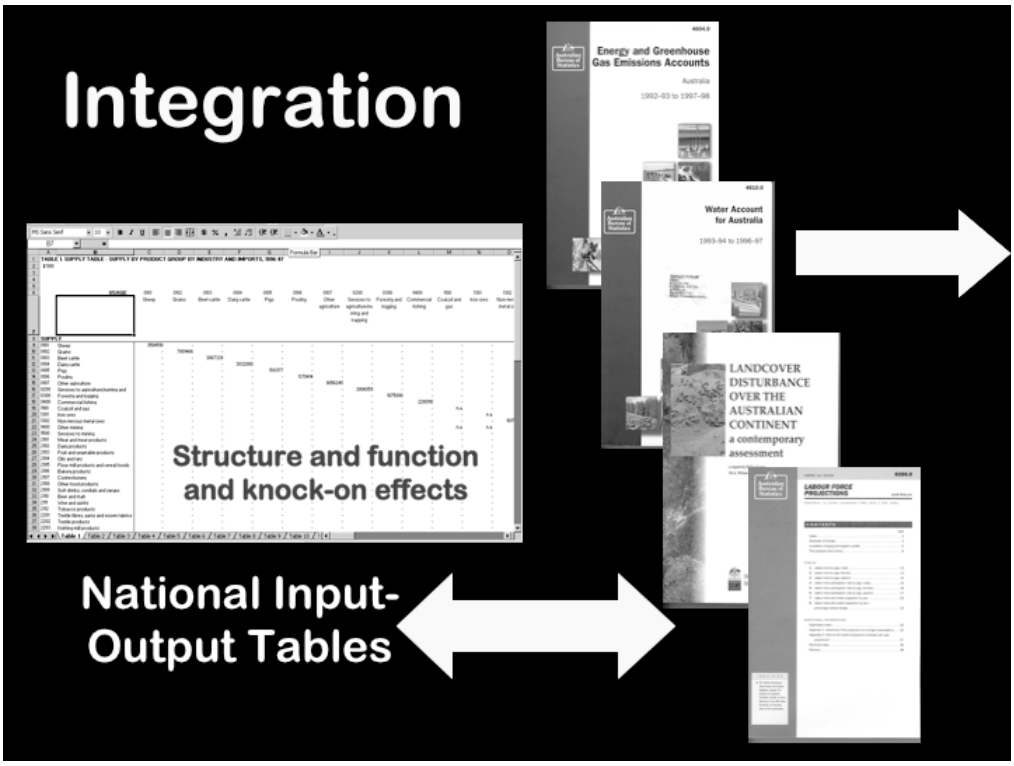
38 ML Lo Cascio & MR Virdis, 'The input-output system extended to environmental accounting', in I Musu & D Siniscalco (eds), *National Accounts and the Environment*, Kluwer, Dordrecht, The Netherlands, 1996, pp. 65-86.

39 Briefly, this is typified by the developed of *NAMEA* - National Accounting Matrix including Environmental Accounts, by various national statistical bodies, including the Dutch body.

40 For example, P Bartelmus, *Greening the National Accounts: approach and policy use,* Department of Economic and Social Affairs Discussion paper (DESA Paper No. 3), Statistical Division, United Nations, 1999. Also UN Statistics Division publication Integrated Environmental and Economic Accounting 2003 (SEEA 2003).

41 M Augusztinovics , 'What Input-Output is about', *Structural Change and Economic Dynamics*, vol. 6, no. 3, 1995, pp. 271-277.

Figure 1.5: A schematic of the process of integrating the national input-output tables with various national social and environmental accounts. Sample data sources are shown for illustrative purpose.



By doing this we are able to describe in hard numbers a number of economic, social and environmental outcomes against a common unit of **one dollar of final demand** (a relative indicator). The latter constitutes a convenient and meaningful numeraire, because (1) it is the destination of GDP, the common measure of sectoral economic performance, and (2), as Adam Smith concluded in 1776, it is ‘the sole end and purpose of all production’. Thus economic entities of surplus, exports and imports can be reported as ‘dollars of surplus per dollar of final demand’. Social entities such as employment, wages and government revenue can be described as ‘the minutes of employment generated per dollar of final demand’. Environmental entities such as greenhouse gas emissions, water requirement and land disturbance can be described as ‘kilograms of carbon dioxide equivalent emissions per dollar of final demand’ or the like. The quantities reported here are referred to as *multipliers* or *intensities*, and can be described and discussed for each of the 135 sectors analysed.

Table 1.1: Brief list of the 10 macro TBL indicators developed in this work and their data sources. Full details are given in Chapters 2 and 3.

Macro indicator (and unit)	Brief description	Data source
Primary energy (MJ)	Combustion of all non-renewable fuels	ABARE Energy Statistics
Greenhouse gas emissions (kg CO_2-e)	Carbon dioxide equivalent impact of all gases affecting climate	National Greenhouse Gas Inventory
Water use (L)	Consumption of all mains and self-extracted surface water	ABS Australian Water Accounts
Land disturbance (hectares – ha)	Land use, weighted by intensity of impact	Various, including CSIRO
Imports (m$)	Value of all goods and services purchased from foreign residents	ABS Input-Output Tables
Exports (m$)	Australian production destined for consumption outside Australia	ABS Input-Output Tables
Surplus (m$)	Operating profits and expenditure on fixed capital	ABS Input-Output Tables
Government revenue (m$)	All taxes less subsidies	ABS Input-Output Tables
Employment (hours)	Full time equivalent employment	ABS Australian Labour Statistics
Income (m$)	Total compensation for employees	ABS Input-Output Tables

There is a well-known precedent for input-output analysis techniques improving assessment methodologies. In life cycle assessment (LCA), which aims to calculate the total impacts associated with a product, the same boundary issue arises as in TBL assessment. In parallel, IOA has for 30 years been used to calculate the full energy requirements of products and services (see for example many of the studies listed in Appendix 2.1). The most recent LCA research has been on 'IO assisted' LCA.[42] For LCA, and equally applicable to TBL, '..from a systems modelling perspective, an IO-based model preserves the fundamental relationships of the economy, preventing uninformed practitioners from overlooking otherwise important impacts'.[43] In the LCA community, IOA is increasingly being recognised[44] and is now being considered in standards.[45]

42 S Joshi, 'Product environmental lifecycle assessment using input-output techniques', *Journal of Industrial Ecology,* vol. 3, nos. 2&3, 1999, pp. 95-120.

43 HS Matthews & MJ Small, 'Extending the boundaries of life-cycle assessment through environmental economic input-output models', *Journal of Industrial Ecology,* vol. 4, no. 3, 2001, pp.7-10.

44 S Suh et al.,System boundary selection in life cycle inventories using hybrid approaches, *Environmental Science & Technology*, vol. 38, no. 3, 2004, pp. 657-664.

45 For example, the Life Cycle Initiative of UNEP/SETAC: LCI Task Force 3, Life Cycle Inventory Methodological Consistency, headed by Dr Sven Lundie (UNSW).

This report documents the TBL performance of 135 Australian economic sectors. At the sector and national level there is no *double counting* in this approach. This is because each TBL account refers to a particular portion of final demand, and these portions add up to total final demand. In generalised IOA, TBL indicator amounts (eg. water use by the dairy sector) are re-allocated and re-distributed from producers first to industrial consumers of goods and services, and finally to final demanders. At no stage in the input-output calculus do indicator flows leak out of the system, or are indicator flows added.

For companies: because the indicators are in terms of *multipliers* that have the common metric of one dollar of final demand they can be applied to the financial balance sheets of companies and institutions. This allows TBL reporting at the company level that is commensurate with sectoral and national reporting. In a simplified application, double counting **does** occur for companies, but is not regarded technically as being an inherent deficiency of the IOA TBL method. On the contrary it demonstrates the *shared responsibility* of suppliers and consumers.

In summary, Input-output analysis is a well developed quantitative method that facilitates the understanding of economic activity in a full production life-cycle context. Moreover, input-output analysis is politically and ideologically neutral, and does not incorporate any specific behavioural conditions for the individual, companies or the state, except that an economy behaves in a consistent manner. Finally, an input-output approach to TBL can be reproduced in every country, for almost any base year, by any institution, since input-output tables are generated and published in regular intervals by many statistical bureaux around the world.

1.7 Input-output Assisted TBL Assessment and Other Schemes

As introduced above, the approach developed in this report, where input-output analysis is applied to TBL assessment, enhances audit type approaches that mainly report on-site impacts. This hybrid method removes the boundary problem, but still contains local detail. The top-down IOA approach thus complements the bottom-up audit approach. In the GRI Guidelines, the term 'scope' is used in the same sense as we use the term breadth. With respect to depth, or the assessment boundary, the GRI Guidelines note:[46]

> 'Defining boundary conditions for reporting on economic, environmental, and social performance is a complex challenge. Complicating factors include the diverse nature of the information and the intimate relationship between the organisation and the larger economic, environmental, and social systems within which it operates. Boundary research is a high priority in GRI's work programme. Discussion papers, exposure drafts and testable protocols will appear during 2002–2003, leading to more systematic and precise treatment of this critical reporting issue.'

The Draft GRI Boundary Protocol was released for public comment in September 2004.[47] This draft protocol clearly explains the issues surrounding the setting of the reporting boundary for TBL auditing of an entity, including the definition of some important terms, discussion of principles which apply to sustainability reporting that are not just an extension of financial reporting, and finally addressing some practical issues in setting reporting boundaries and presenting them in reports. The related concepts of Control (*the power to govern the financial and/or operating principles of an entity*) and Influence (*the power to participate in the operating policy decisions and practices of an entity …*) are used as one aspect of the boundary selection process (Figure 1.6). This is a similar representation to the one shown in Figure 1.3 depicting the complexities of the economy within which the entity's full supply chain is embedded. IOA is the tool by which the all upstream and downstream impacts can be evaluated.

46 Global Reporting Initiative 2002, *Sustainability Reporting Guidelines*, p. 26.

47 Global Reporting Initiative, *GRI Boundary Protocol*, Draft for Public Comment, 2004.

Figure 1.6: The depiction of the reporting boundary concept in the GRI Draft Boundary Protocol (Figure 1, page 7). The entities listed are examples only. The concepts of Control/Influence are shown as diminishing both upstream and downstream of the reporting entity.

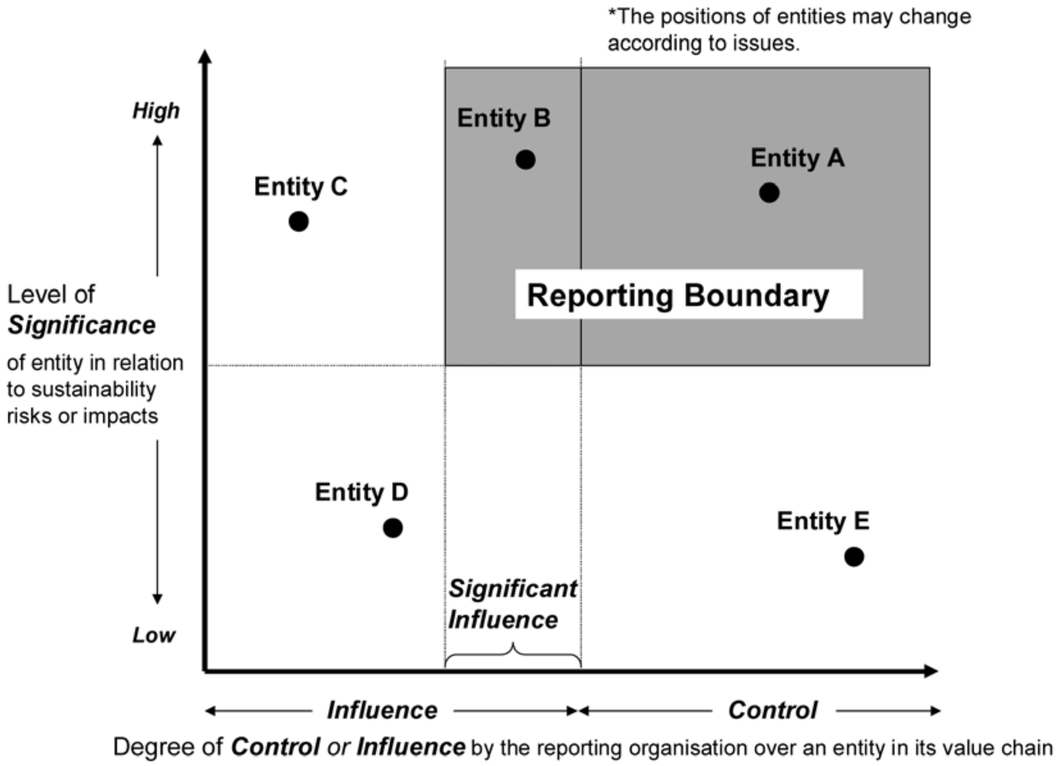
The other aspect that the GRI identifies is *level of significance* – of *risks* or *impacts*. According to these aspects, the Draft Boundary Protocol has a visual representation of the process of determining reporting boundaries in an audit-type report (Figure 1.7). The reporting boundary may indeed be different for different indicators, since the level of significance is of indicators does not change in the same way through the supply chain. Hence "… reporting strictly on entities within the boundaries used for financial reporting may fail to tell a balanced and reasonable story of the organisation's sustainability performance".[48]

In these *extended* audit approaches with an expanded reporting boundary, the boundary selection could be quite an involved task, both to determine and to explain in reports. In this regard the GRI recommends the use of a *reference boundary* that is "… common to most indicators and therefore minimises the need to explain deviations".[49]

48 Global Reporting Initiative 2004, *GRI Boundary Protocol*, Draft for Public Comment, p. 6.

49 Global Reporting Initiative 2004, *GRI Boundary Protocol*, Draft for Public Comment, p. 13.

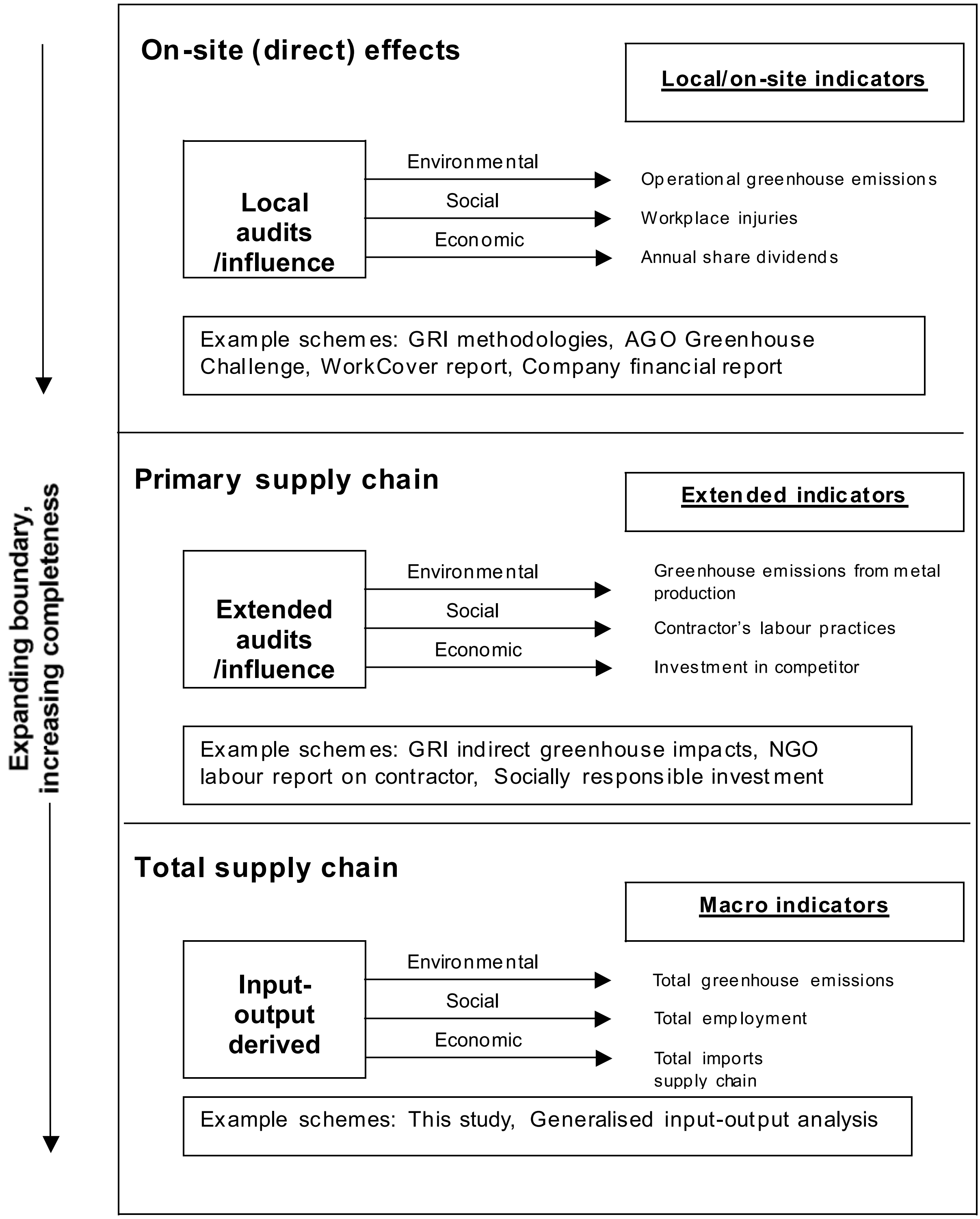
Figure 1.7: GRI Draft Boundary Protocol visual tool showing the relationship between significance and control/ influence (Figure 2, page 8). Entity B has been has been included in the reporting boundary because the significance of its impacts is high AND the reporter has significant influence over its operations.



For audit approaches to TBL reporting, typified by the GRI guidelines, clearly the selection of an appropriate boundary, or *boundaries* for different indicators, is involved and subjective, and can lead to some of the inconsistencies outlined in Section 1.4. The value of the input-output approach to reporting is that in a hybrid analysis it can sit on top of an extended audit approach, thus removing the boundary issue entirely, as discussed in Section 1.3.

In Figure 1.8 we outline the relationship between TBL reporting approaches using the language of the GRI guidelines as much as possible.

Figure 1.8: A generalised scheme depicting the hierarchy of approaches to TBL assessment, together with sample indicators. The audit approach, providing on-site impacts, is depicted with the smallest boundary. An extended boundary indicates a primary supply chain analysis, obtained from an extended audit, such as is involved in the boundary selection procedure in the Draft GRI Boundaries Protocol. The total supply chain, or accounting for all indirect effects, is derived using input-output analysis to yield true macro indicators. Indicators may, but not necessarily, be common to the different levels of assessment.



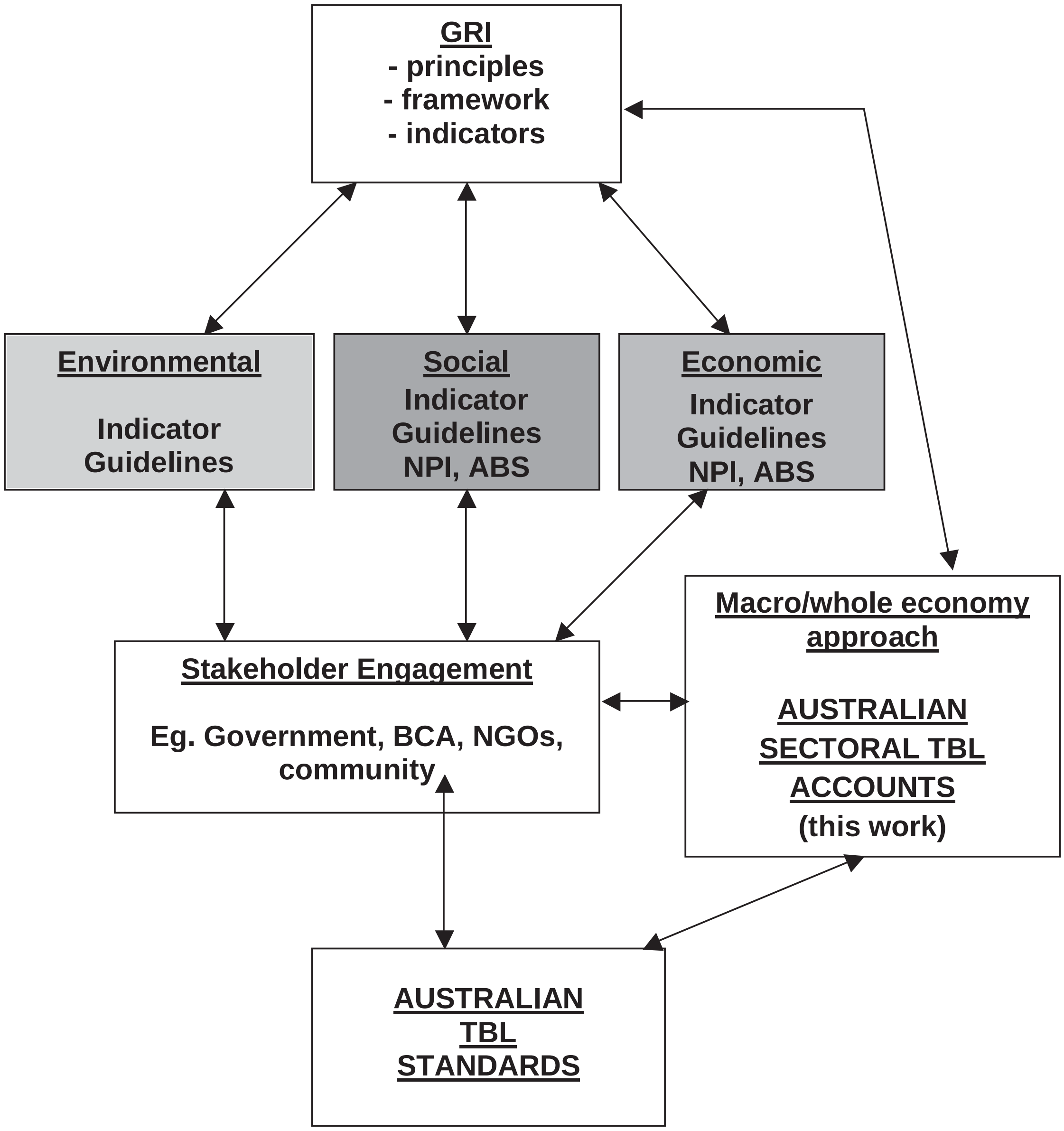
1.8 Conclusion - The Meaning of this Report

The TBL data and results contained in this report have relevance at many different levels in the economy, in addition to the TBL reporting of organisations for different stakeholders. We list some of these in this section:

- The TBL factor multipliers are immediately applicable to organisations wishing to report on their wider impacts. We have employed them extensively in our consulting work to date.
- The detail of the linkages between different sectors makes clear what are the most urgent issues to address, and demonstrates that they can be addressed at a number of levels. Quite often indirect effects in the supply chain overwhelm local issues within the organisation or factory.
- The results represent benchmarks for sectors (and organisations) that can be compared with future analyses undertaken with the same methodology and new input-output tables. Current research in the team aims to develop a full time series of indicators from the first input output tables of the late 1960s.
- Management of supply chains and procurement policies will become more important as the structural path analysis reveals how organisations can better quantify their supply chains, and hence reduce their impact by choosing materials or suppliers with certain qualities.
- The input-output approach used here fits on top of traditional audit type TBL analyses, and should not be seen as a substitute.
- The input-output approach reveals the social and environmental risk through the full supply chain. If greenhouse- or water-related litigation becomes more common, then these kind of data will assume primary importance in the legal context of most business activities.
- The report provides consistent and verifiable indicators for high level policy issues that are relevant to all sectors.
- The report should inform the development and refinement of international non-financial reporting standards (ISAE 3000), particularly for indirect reporting.
- Australia has for some time been involved in implementing international accounting standards (the SNA or ‘System of National Accounts’) focused mainly, but not entirely, on financial issues. It is now apparent that these standards are entering a new era of multi-level reporting and assessment.
- Two important steps would be (1) setting standards around the reporting of sustainability data (in the same way that financial data is standardised) and (2) developing an index of listed companies’ sustainability performance so that environmental and social issues become as routinely assessed in the market as financial success.

As with the GRI methodologies, the reporting guidelines that have been developed by the Department of the Environment and Heritage and the Department of Family and Community Services are complemented by the top-down approach reported here (the Australian Sectoral TBL Accounts: see Figure 1.9). However further institutional discussion and agreement is required so that methodological competition does not collapse TBL reporting to the lowest common denominator, and analytical complexity does not cloud the higher level challenges sectors may face in meeting future societal expectations.

Figure 1.9: Potential relationships and information flows between the GRI, the Australian TBL Indicator Guidelines under development by the Australian Government, and the input-output whole-economy approach developed here



The Mays Report sums it up well suggesting that:

> ‘A shift towards a common framework for sustainability dialogue offers a company and investor win-win. Perhaps some common standards for reporting of social and environmental data should be established along the same lines as the accounting standards. A successful example of such an initiative was the development of standards around the reporting of mining reserves. A similar development would help companies understand what is required and provide the investor with a consistent basis for assessing sustainability performance’.[50]

The next chapter presents the full details of the detailed scientific methodology employed to produce the sectoral results forming the bulk of this work.

If the reader is interested only in the practical interpretation of the data, they should go directly to Chapter 3: ‘How to Interpret Data Sheets’.

50 S Mays 2003, *Corporate Sustainability – an investor perspective* (Section 5 Conclusions), Department of the Environment and Heritage, see http://www.deh.gov.au/industry/finance/publications/mays-report/ accessed 29-11-2004

Table 1.2: Standards, guidelines, activities and other useful resource material[51]

Organisation/Initiative	Summary	Website	Content
Global Reporting Initiative Sustainability Reporting Guidelines	**Guidelines** from a multi-stakeholder body affiliated with the United Nations	www.globalreporting.org	The 2002 GRI Guidelines provide a framework for reporting on the linked aspects of sustainability: the economic, the environmental and the social. It promotes comparability between reporting organisations while recognising the practical considerations of collecting and presenting information across diverse reporting organisations. Some specific industry sector supplements exist, and more are under development.
Australian Department of the Environment & Heritage	Australian **guidelines** for **environmental** reporting of organisations	www.deh.gov.au/industry/corporate/reporting	Triple bottom line reporting in Australia: a guide to reporting against environmental indicators (2003). This report provides a comprehensive framework that provides simple and effective guidance on how to develop an environmental report for Australian organisations. The methodology draws heavily on the Global Reporting Initiative Guidelines.
Institute of Social and Ethical Accountability (United Kingdom) *AccountAbility 1000 (AA1000)*	International, non-profit, professional institute promoting **social**, ethical and organisational accountability **standards**	www.accountability.org	AA1000 (1999) is a standard developed by the Institute of Social and Ethical Accountability covering the *assurance* processes of social accounting, auditing and reporting, and it is focused on the quality of dialogue and overall stakeholder participation; for example, in the development of indicators. Because the standard is process based, it does not deal directly with reporting and disclosure issues. It does, however, provide useful insights into the social audit process that supports indicator selection.
Institution of Chemical Engineers (IChemE)	Sustainability reporting **guidelines** for the chemical industries	www.icheme.org/sustainability	Sustainable Development Progress Metrics (2002) are recommended for use in the process industries. These have been provided by the chemical engineers professional body and are regarded as complementary to the GRI guidelines.
The Equator Principles	A collection of banks establishing principles for social and environmental assessment for the financing of **projects**	www.equator-principles.com www.ifc.org	The Equator Principles are an industry approach for financial institutions in determining, assessing and managing environmental & social risk in project financing. They are based on International Finance Corporation and World Bank guidelines (eg. Pollution prevention, http://lnweb18.worldbank.org/ESSD/envext.nsf/51ByDocName/PollutionManagement)
PERI guidelines	Early (1993) company **environmental guidelines**, largely superseded by the GRI	www.ibm.com/ibm/environment/initiatives/peri_bkgd.shtml	The Public Environmental Reporting Initiative (PERI) was established in 1993 by a group of North American companies. PERI issued reporting guidelines to help organisations improve their environmental reporting.

51 Updated from The Allen Consulting Group, *Triple bottom line measurement and reporting in Australia: making it tangible,* Prime Minister's Community Business Partnership, 2002.

Organisation/Initiative	Summary	Website	Content
The Global Compact	The Global Compact is a voluntary **corporate citizenship** initiative aiming to advance key TBL **principles** in business activities and to support UN goals	www.unglobalcompact.org	The Global Compact is not a regulatory instrument or code of conduct, but a value-based platform designed to promote institutional learning. It utilises the power of transparency and dialogue to identify and disseminate good practices based on universal principles. The Compact encompasses ten such principles, drawn from the Universal Declaration of Human Rights, the ILO's Fundamental Principles on Rights at Work and the Rio Principles on Environment and Development. It asks companies to act on these principles in their own corporate domains. Thus, the Compact promotes good practices by corporations; however, it does not endorse companies.
World Business Council for Sustainable Development (WBCSD)	WBCSD is a coalition of 160 international companies with a shared commitment to sustainable development, producing reports and **business guides**	www.wbcsd.org	WBCSD's report, *Sustainable Development Reporting: Striking the balance* (2003). This report is both a guide to help companies produce reports and a policy document offering insights into the reporting standardization debate. It also aims to help companies understand the added value reporting can bring. WBCSD's report, *Measuring Eco-Efficiency: A Guide for Companies to Report Performance* (2000), encourages the use of the eco-efficiency concept by proposing a common measurement framework that can guide companies. It is intended to enable company managers and external stakeholders to use eco-efficiency indicators as a means of making and measuring progress towards economic and environmental sustainability. The environmental indicators in the GRI Guidelines are closely aligned with these.
Greenhouse Gas Protocol Initiative (GhgProtocol) – **Standards/Guidelines**	Multi-stakeholder group including NGOs and governments, co-convened by World Resources Institute (WRI) and the WBCSD	www.ghgprotocol.org	The Greenhouse Gas Protocol Initiative is working in partnership to design, disseminate and promote the use of an international standard for company reporting on greenhouse gas emissions. Modelled on the GRI process, it brings together many leading experts from business, governments and non-governmental organisations. The resulting protocol (revised in March 2004) provides implementation tools and supporting guidance for the greenhouse gas indicator listed in the GRI Guidelines.
Carbon Disclosure Project (CDP)	Investors requesting major companies to disclose their emissions	www.cdproject.net	The Carbon Disclosure Project provides a coordinating secretariat for a group of institutional investors. This group has written to the 500 largest companies in the world by market capitalisation on 31 May 2002 (CDP 1) and 1st November 2003 (CDP 2) asking for the disclosure of investment-relevant information concerning their greenhouse gas emissions.

Organisation/Initiative	Summary	Website	Content
Caux Round Table **Principles**	“ a network of principled business leaders working to promote a moral capitalism ”	www.cauxroundtable.org	*The Caux Round Table* serves as a stimulus for implementation of its *Principles for Business*, conducts global, regional and national dialogues, and publishes position papers on key global issues.
Global Environmental Management Initiative (GEMI Guidelines)	Business based organisation providing **tools** for environmental health and safety assessment	www.gemi.org	GEMI is US-based organisation of companies dedicated to fostering global environmental, health and safety (EHS) excellence through the sharing of tools and information to help their member businesses improve EHS. GEMI has published a primer and a program for self-assessment. It outlines an environmental self-assessment program (ESAP) that is intended mainly as an internal management tool, and not a source of public information.
SIGMA Project - Sustainability - Integrated Guidelines for Management	UK based partnership providing **guidelines and toolkits** for examining TBL themes	www.projectsigma.com/	SIGMA Project was launched in 1999 with the support of the UK Department of Trade and Industry. It is a partnership between the British Standards Institution, Forum for the Future (a sustainability charity), and AccountAbility (see above). The SIGMA Project draws together the various activities and tools that are involved in sustainable development (eg. assessment, guidelines, standards, reporting, business strategies, etc).
Social Accountability International	SAI is a US-based, non-profit organization developing voluntary verifiable social accountability **standards**	www.cepaa.org	In response to the inconsistencies among workplace codes of conduct, SAI developed a standard for workplace conditions and a system for independently verifying factories’ compliance. The standard, Social Accountability 8000 (SA8000), and its verification system draw from established business strategies for ensuring quality (such as those used by the international standards organisation for ISO 9000), and add several elements that international human rights experts have identified as essential to social auditing.
International Federation of Accountants (IFAC)	IFAC is the global organisation for the accountancy profession, and these are **standards** for **non-financial** auditing	www.ifac.org/iaasb/	International Standard on Assurance Engagements (ISAE) 3000, ‘Assurance Engagements other than Audits or Reviews of Historical Financial Information’ developed by the International Auditing and Assurance Standards Board (IAASB) and released in early 2004.

Organisation/Initiative	Summary	Website	Content
International Accounting Standards Board (IASB), International Accounting **Standards** (IAS)	The IASB is an independent, privately-funded accounting standard setter based in London.	www.iasb.org.uk	The objective of the IASB is to achieve uniformity in the accounting principles that are used by businesses and other organisations for financial reporting around the world. IASB publishes its Standards in a series of pronouncements called International Accounting Standards (IAS). As of June 2000, IASs are recognised globally by the International Organisation of Securities Commissions (IOSCO), and as of 2005 all listed companies in the European Union will be required to apply IASs. IAS 37 is the only international accounting standard to deal directly with environment-related issues: liabilities, provisions, contingent liabilities and long term decommissioning costs. IAS 14 provides a standard for identifying geographical or business line segments of an organisation.
International Organization for Standardization (ISO) ISO 14031 Corporate Social Responsibility	ISO is a network of the national **standards** institutes of 148 countries, but is a non-governmental organisation.	www.iso.ch	ISO 14031 is part of the ISO 14000 series that provides a standard framework for environmental management. ISO 14031 deals with Environmental Performance Evaluation. It is a process guide to measuring, analysing, assessing and describing an organisation's environmental performance against agreed internal targets. ISO 14031 contains a number of generic environmental performance indicators designed for internal management reporting and control purposes, as well as guidance on the process for indicator selection. As yet, the ISO 14000 series of environmental management standards contains no requirements relating to external reporting. ISO is also to develop an International Standard for social responsibility. The objective is to produce "a guidance document, written in plain language which is understandable and usable by non-specialists" and not intended for use in certification.
Organisation for Economic Cooperation and Development (OECD) (North American) Commission for Environmental Cooperation (CEC) UN Economic Commission for Europe (UNECE)	**Pollutant Release** and Transfer **Registers** (PRTRs) – various schemes promoting public reporting on industrial pollution.	www.oecd.org www.cec.org www.unece.org/env/pp National Pollutant Inventory (NPI) www.npi.gov.au	OECD: guidance manual, reports on estimating releases, presenting and using data, workshop and conference reports. CEC: annual reports on PRTRs in Canada, the United States and Mexico. UNECE: PRTR Task Force under the Convention on Access to Information, Public Participation in Decision-making and Access to Justice in Environmental Matters. These websites also provide links to resources prepared by national government (such as Australia's NPI) and non-governmental organisations. Work under this initiative, also known as the Aarhus Convention, most directly addresses facility-level reporting in contrast to the GRI's organisation-level reporting. Maximum harmonisation between these two levels is a goal of the GRI.

Chapter 2: Methodology

Abstract

Input-output analysis forms the methodology behind the 'triple bottom line' accounting approach taken in this report. In its original form, input-output analysis charts the financial flows and inter-dependencies between the different sectors that make up the economic structure of a nation. It was developed originally to help plan the war effort by the USA in World War II by a Russian émigré, Wassily Leontief. In the 50 years since, it has been used to help analyse a wide range of policy issues in economic, social and environmental areas. In this report, the input-output tables developed by the Australian Bureau of Statistics, as part of the International System of National Accounts, have been merged with a range of social and environmental data to develop indices that relate different forms of activity to the generation of one dollar of final demand. This chapter describes the methodology from its origin in the system of national accounts, through the two key mathematical approaches that are used to implement it (the Leontief and Ghosh Inverses), to the system of valuation used (farm or factory gate prices), to the concept of forward and backwards linkages and finally to charting the chain of influence throughout the economy (structural path analysis). To conclude, an extensive list of appropriate literature is presented together with a table showing topics of input-output analysis relevant to energy and environmental issues.

2.1 Introduction

The sectoral 'triple bottom line' accounts (hereafter TBL) presented in this report were obtained using *generalised input-output analysis*. Underlying this technique is a closed-economy, static, short-term model of the Australian economy in which, under equilibrium conditions at a given point in time, goods and services flows are balanced. This model was conceived by Nobel Prize laureate Wassily Leontief in the 1930s and 1940s (Leontief 1936; 1941).

Input-output analysis (IOA) relies only on National Accounts that are regularly published by statistical bureaux, and has therefore been described by Nobel Prize laureate Richard Stone as "neutral from both an analytical and ideological point of view" (as cited by Hewings and Madden 1995, p.1, see also Rose 1995, p. 297). Elements of input-output analysis can be found in many analytical streams within economics, and have been applied during the past four decades in numerous studies of both market and planned economies, with little modification. "Moreover, [input-output analysis] does not incorporate any specific behavioural conditions for the individual or the state [...], except that an economy behave in a consistent manner" (Rose *et al.* 1988, p. 12). Being an accounting procedure, and therefore static, IOA in its basic form is distinct from general equilibrium economic models that incorporate, amongst other aspects, prices and marginal effects, but for which the economic structure (number of sectors) are usually much less detailed.

As Leontief (1986, p. 19) himself put it, 'the economic system to which [input-output analysis] is applied may be as large as a nation or even the entire world economy, or as small as the economy of a metropolitan area or even a single enterprise' (compare Leontief 1974; Hirsch 1963 and Farag 1967). The fact that IOA is applicable across these scales, as well as it being a 'snap-shot' of the economy, means that it is a very useful approach to *reporting* and static analysis of the complex linkages within the economy.

The history of development of IOA has been reviewed by Stone (1984), Polenske (1989), Carter and Petri (1989), Forssell and Polenske (1998), and Rose and Miernyk (1989). Introductions to input-output theory can be found in work by Leontief (1953), Stone (1972), Leontief (1986), Duchin (1992) and Dixon (1996).

Following a classification by Miller and Blair (1985), *generalised* input-output models incorporate additional information on inputs of *production factors* into intermediate demand. The term "production factors" shall here be understood in a very general sense as *additive indicators and quantities that are in any way associated with industrial production*. By additive indicators we mean that the quantities associated with production are cumulative across many different levels in the economy. They can be for example:

- economic parameters such as income, capital, or imports
- social factors such as employment, income disparity or occupational health and safety
- natural resources such as water, land, forest, minerals, metals and fuels
- environmental emissions of greenhouse gases and other air pollutants, general waste, toxic compounds in soil and water and effluent discharge into the ocean
- other physical production- and consumption-related quantities such as transport flows or sustainability indicators

As long as a factor is additive in its impacts, it can be treated with the input-output formalism. Generalised input-output techniques have been described in detail by Forssell and Polenske (1998), Isard et al. (1972), Polenske (1976), Cumberland and Stram (1976), Miller and Blair (1985), Førsund (1985), and Hawdon and Pearson (1995). They have been applied extensively since the late 1960s (see Table 2.2).

The first author to suggest incorporating an environmental component into an input-output system was Cumberland (1966). While this author merely drew attention to the possibility of extending the traditional accounting framework, Isard et al. (1967) and Daly (1968) added mathematical rigour to the formulation and proposed a module containing interactions *within* the ecological system in addition to flows between the environment and the economy. Of this work, only Isard and Langford (1971) and Isard et al. (1972) have attempted to apply the concept to the real world, using comprehensive regional data. Like Isard and Daly, Ayres and Kneese (1969) recognised the fundamental importance of the material balance principle in formulating an ecological-economic framework. These authors extend Walras' general equilibrium model to mass flows in and out of the environment. Dealing with reconciling "ecological" inputs and outputs of the economic system and the condition of material balance, the previous authors encountered the problem of incommensurability of flows because of their different physical units. This proved to be an obstacle for analytical operations which was overcome by Leontief and Ford (1970). A review and critique of these early models is provided by Victor (1972, pp. 25-52).

Many extensions have since been added to the concept. The numerous variants and applications of generalised input-output models have been reviewed in the literature (Dixon and Permenter 1979), and can be summarised as follows:

- Make-use frameworks for industry or commodity technology (Rosenbluth 1968; Gigantes 1970; Schinnar 1978; Flaschel 1982; Hannon et al. 1983).
- Endogenisation and feedback of final demand (private, government and exports) technological change and projections.
- Structural Decomposition Analysis (Rose 1984).
- Regional and multi-regional models (Isard 1951; Moore & Petersen 1955; Polenske 1980).
- Social Accounting Matrices (SAMs) (Stone 1961; Stone 1986; Pyatt *et al.* 1977; Pyatt and Round 1977; Roland-Holst 1990; Pyatt 1991; Hewings & Madden 1995; Xie 2000; Lenzen & Schaeffer 2004).
- Economic-energy-environment (E3) models.
- Socio-demographic models (Stone 1966; Stone et al. 1968; Stone 1970; Schinnar 1976; 1977; Madden & Batey 1983; Batey 1985; Batey et al. 1987; Batey et al. 1988; Batey & Weeks 1989).
- Generalised (non-linear) production functions.
- Cost-price circles; general equilibrium (Rose 1995).
- Linear Programming and optimisation (Leung & Hsu 1984; James et al. 1986).

- Distribution of income.
- Stochastic models, uncertainty calculus (Bullard & Sebald 1977, 1988; Harada et al. 2000; Ii 2000; Sakai et al. 2000; Lenzen 2001; Nansai et al. 2001; Yoshida et al. 2001; Hondo et al. 2002, Yoshida et al. 2002).
- Ecological-economic models (Isard et al. 1967; Isard 1969; Isard & Langford 1971; Isard et al. 1972; Isard 1975).
- Price models.
- Linkage and key sector analysis (Rasmussen 1956; Hirschman 1958; Jones 1976; West 1982; Cella 1984; Hewings et al. 1989; Clements 1990; Clements & Rossi 1991; Sonis & Hewings 1991; Sonis et al. 1995; Lenzen 2003).
- Dynamic, differential-equation formulation.
- Expenditure on environmental abatement (Leontief & Ford 1970; Lo Cascio & Virdis 1996).

Another application of the input-output technique is in life-cycle assessment (LCA), where conventional process analyses of goods or services become overwhelmed with the complexity of resource flows through the production system of a modern economy (Treloar 1997). As mentioned in Chapter 1, input-output-assisted *hybrid LCA* (Lave et al. 1995; Weber 1995; Hendrickson et al. 1998; Hondo & Sakai 2000; Joshi 2001; Suh & Huppes 2005) avoids significant and systematic truncation errors by avoiding the setting of a finite system boundary (Lenzen & Dey 2000; Lenzen 2001, Suh et al. 2004).

As an historical note, sets of input-output tables in physical units were compiled for Australia by Burgess Cameron for the years 1946-47 (Cameron 1957), 1953-54 (Cameron 1958), 1955-56 (Cameron 1960), and as a 6-year forecast for 1965 (Cameron 1959). This author described the underlying theory (Cameron 1954) and applications (Cameron 1955).

2.2 National Accounting

Input-output tables are constructed in many countries for one particular year from surveys of monetary transactions between classified industry sectors. These provide a ‘snapshot' measure of economic interdependence at a particular stage of development. The Australian input-output tables are published annually or biannually by the Australian Bureau of Statistics (ABS).

Since 1993 the System of National Accounts (SNA93) has benchmarked National Income, National Expenditure and National Product on input-output tables. The ABS employs the commodity flow method, which is an input-output approach for compiling National Accounts (Barbetti & De Zilva 1998). The characteristic feature of the commodity flow method is that it balances total supply and use for each commodity while simultaneously balancing total production and input for each industry. In practice, the reconciliation of the three GDP estimates based on income, expenditure and production is achieved by an iterative confrontation and balancing process involving approximately 1000 commodities and 100 industries. As a result of this approach, previously common discrepancies within the National Accounts and between input-output tables and the National Accounts, no longer occur. Furthermore, an Economic Activity Survey incorporating taxation statistics has been specifically designed by the ABS (Australian Bureau of Statistics 1999b) to support the input-output approach from 1994-95 onwards by expanding and detailing the industry data collection, and by facilitating the production of annual input-output tables (previously triennial).

The basic input-output tables contain matrices describing the monetary amounts of supply, use, import, and margins (eg. transaction mark ups) of commodities in the Australian economy. Commodities and industries are distinguished in the published tables. A measure for the homogeneity of industries is the *supply matrix* **V**, which shows the total output of domestically produced commodities (columns j) by domestic industries (rows i). Characteristically, the largest entry in each commodity column belongs to the industry to which the respective commodity is primary. The *market share matrix* **D** (with elements D_{ij} showing the share of industry i in producing commodity j) is derived from the supply matrix by dividing each entry by the total commodity output: $D_{ij} = V_{ij}/\Sigma_i V_{ij}$.

The *use matrix* **U** (Figure 2.1) shows how commodities (rows i) are absorbed in industries (columns j). The use matrix contains both domestically produced and imported commodities without distinction. Competing imports are allocated indirectly, that is, to the supplying sector that they are primary to, rather than directly to the sectors that use them. Complementary imports are excluded from intermediate demand, since there is no domestic sector that they are primary to (as they are not produced domestically). Excluded also are re-exports, that is commodities which are imported into Australia and then exported without having been used or transformed.

The layout of the complete use table (Figure 2.2) reflects the National Accounting Identity:

$$\text{GDP} + m = \text{GNE} + e = \text{GNT} \qquad (1)$$

with the *Gross Domestic Product* (GDP) and imports (m) arranged in rows and the *Gross National Expenditure* (GNE) and exports (e) arranged in columns around a central square table of inter-industrial intermediate transactions (Figure 2.1). Both sums add up to *Gross National Turnover* (GNT). In the input-output terminology, GDP + m is called *primary input*, or *value added* (v), and GNE + e is called *final demand* (y). Adding *intermediate demand* (U) yields *total output*:

$$x = U + v = U + y \qquad (2)$$

Final demand consists of gross fixed capital expenditure (k), government and private domestic final consumption (c_{gv}, c_{pr}), changes in inventories (i) and exports (e), while primary inputs are wages and salaries (w), gross operating surplus (s), net taxes on products and production (t) and complementary and competing imports (m):

$$w + s + t + m = k + c_{gv} + c_{pr} + i + e \qquad (3)$$

Figure 2.1: Structure of intermediate demand in the use table

Industries / Commodities	Agriculture, forestry and fishing	Mining	Food	Other manufac-turing	Utilities	Construc-tion	Trade	Transport and communication	Admini-stration, services
Agriculture, forestry and fishing Mining Food Other manufacturing Utilities (electricity, gas, water) Construction Trade (wholesale, retail) Transport and communication Administration and services				Use of commodities by industries in A$m					

	Intermediate demand	+ Private Final Consumption	+ Government Final Consumption	+ Private Gross Final Consumption	+ Public Enterprise Gross Final Consumption	+Government Gross Final Consumption	+ Changes in Inventories	+ Exports	= Total Supply	
Intermediate demand	443 611	264 333	88 507	81 031	12 129	11 562	1 767	83 364	*986 308*	
+ Wages & salaries	226 904								226 904	
+ Operating surplus	191 809								191 809	GDP
+ Taxes on production	16 408			2 690					19 098	473 463
+ Taxes on products	12 973	17 970		2 948	73	90	133	1 461	***35 651***	
+ Imports, complem.	355	91		123		2	6		579	
= Australian Production	*892 062*	*282 395*	*88 507*	*86 793*	*12 202*	*11 655*	*1 907*	*84 825*	***1 460 351***	GDP+M
+ Imports, competing	94 246							2 828	***97 075***	571 117
= Total Use	*986 309*	***282 395***	***88 507***	***86 793***	***12 202***	***11 655***	***1 907***	***87 654***	***1 557 426***	
				GNE	483 462			**GNE+E**	***571 117***	**GNT**

Figure 2.2: Aggregate quantities in the 1994-95 Australian National Accounts (after Australian Bureau of Statistics 1999a).

All figures in A$m, subtotals in italics, totals and aggregates in bold italics.

GNE = Gross National Expenditure, GDP = Gross Domestic Product, GNT = Gross National Turnover, E = exports, M = imports

Disaggregating Equation 2 into M commodities (expenditure side) and N industries (production side) yields:

$$\{x'_i\}_{i=1,...,M} = \{\Sigma_j\, U_{ij}\}_{i=1,...,M} + \{y'_i\}_{i=1,...,M} \quad \text{and} \qquad (4a)$$

$$\{x_j\}_{j=1,...,N} = \{\Sigma_i\, U_{ij}\}_{j=1,...,N} + \{v_j\}_{j=1,...,N} \qquad (4b)$$

Equations 4a and 4b are basically accounting equations, showing the production and usage balances of all commodities and industries in the economy. In the following, a prime (') will denote a column vector, while unprimed variables are arranged in rows. Note that sums over commodities and industries must equal the scalar totals:

$$\Sigma_i\, x'_i = \Sigma_j\, x_j = x \quad \text{and} \quad \Sigma_i\, y'_i = \Sigma_j\, v_j = v = y \qquad (5)$$

Commodity and industry formulations can be converted into each other using the market share matrix **D**:[52]

$$x'_i = \Sigma_j\, D_{ji}\, x_j \quad \text{and} \quad x_j = \Sigma_j\, D_{ji}\, x'_i \quad \Leftrightarrow \quad \boldsymbol{x}' = \mathbf{D}^t\, \boldsymbol{x}^t \quad \text{and} \quad \boldsymbol{x} = \boldsymbol{x}'^t\, \mathbf{D}^t \qquad (6)$$

where industry totals are in a 1×N row vector $\boldsymbol{x}$, commodity totals in a M×1 column vector $\boldsymbol{x}'$, and the superscript ^{t} denotes transposition.

2.3 Input-output Theory

This subsection gives details of the two input-output formalisms that are combined with the national accounts described in the previous section to yield the TBL results contained in this report. The basic assumptions of input-output analysis are stated briefly. The consequences of the assumptions are addressed in detail in Section 2.7 which presents a justification for the choice of an input-output model.

The Leontief model

The most commonly used input-output model assumes a market economy (as opposed to a centrally planned economy) that is driven by demand. Accordingly, using Equation 4a, substituting $B_{ij} = U_{ij} / x_j$, and adopting matrix notation leads to:

$$\{x'_i\}_{i=1,...,M} = \{\Sigma_j\, B_{ij}\, x_j\}_{i=1,...,M} + \{y'_i\}_{i=1,...,M} \quad \Leftrightarrow \quad \boldsymbol{x}' = \mathbf{B}\, \boldsymbol{x}^t + \boldsymbol{y}' \qquad (7)$$

B is called a *direct requirements* matrix. Similar to use matrix **U**, it shows commodities in its rows and industries in its columns. In most generalised input-output applications, production technology is assumed to be a characteristic of industries, as opposed to commodities.[53] Using Equation 6, Equation 7 can be transformed into industry formulation:

$$\boldsymbol{x}'^t\, \mathbf{D}^t = \boldsymbol{x}\, \mathbf{B}^t\, \mathbf{D}^t + \boldsymbol{y}'^t\, \mathbf{D}^t \quad \Leftrightarrow \quad \boldsymbol{x}^t = \mathbf{A}\, \boldsymbol{x}^t + \boldsymbol{y}^t \qquad (8)$$

where **A** = **DB** is an industry-by-industry direct requirements matrix. Its coefficients A_{ij} describe the intermediate demand of industries j=1,...,N for output from industries i=1,...,N per unit for total output of industry j. 'Industry formulation' means that the whole accounting system is expressed in industry output terms, across all commodity types. This is in contrast to 'commodity formulation', which maps commodity-to-commodity flows. The industry formulation has an important practical advantage for generalised input-output models, since in many countries including Australia, most auxiliary (eg social and environmental) statistics are in industry terms. **A** is the central element of the classical input-output relationship:

$$\boldsymbol{x}^t = (\,\mathbf{I} - \mathbf{A}\,)^{-1}\, \boldsymbol{y}^t \qquad (9)$$

which follows directly out of solving Equation (8) for $\boldsymbol{x}$. **I** denotes the N×N unity matrix, and:

$$\mathbf{L} = (\,\mathbf{I} - \mathbf{A}\,)^{-1} \qquad (10)$$

52 The market share matrix is normalised according to $\Sigma_i\, D_{ij} = 1$ and $\Sigma_j\, D^t_{ji} = 1$. Combining this normalisation with Equation 6, the sum requirement in Equation 5 can be seen as $\Sigma_i\, x'_i = \Sigma_j\, D^t_{ji}\, \Sigma_i\, x'_i = \Sigma_i\, \Sigma_j\, D_{ij}\, x_j = \Sigma_j\, x_j = x$.

53 This condition is sometimes imposed because the available production factor data is in industry, rather than commodity, terms.

is called the *total requirements* matrix or *Leontief inverse*. An element L_{ij} describes the total "content" or "embodiment" of output produced by industry *i* per unit of final demand from industry *j*.

A *generalised* Leontief model features a 1×*N* vector $\boldsymbol{Q}$ of *total factor multipliers*, that is total requirements of production factors per unit of final demand from *N* industry sectors. $\boldsymbol{Q}$ can be calculated from a 1×*N* vector $\boldsymbol{q}$ containing (direct) sectoral production factor usage per unit of total output:

$$\boldsymbol{Q} = \boldsymbol{q} \, (\mathrm{I} - \mathrm{A})^{-1} = \boldsymbol{q} \, \mathrm{L} \qquad (11)$$

The total factor requirement *Q* (scalar) of a final demand bundle $\boldsymbol{y}$ can then be written as:

$$Q = \boldsymbol{Q} \, \boldsymbol{y}^{t} = \boldsymbol{q} \, \mathrm{L} \, \boldsymbol{y}^{t} = \boldsymbol{q} \, \boldsymbol{x}^{t} \qquad (12)$$

These equations state that factor inputs $\boldsymbol{q}\mathbf{L}$ are required in order to satisfy a final demand bundle $\boldsymbol{y}$ (in monetary terms). Special cases are primary input multipliers calculated via:

$$y = v = (\boldsymbol{w} + \boldsymbol{s} + \boldsymbol{t} + \boldsymbol{m}) \, \boldsymbol{x}^{t} = (\boldsymbol{w} + \boldsymbol{s} + \boldsymbol{t} + \boldsymbol{m}) \, \mathbf{L} \, \boldsymbol{y}^{t} = (\boldsymbol{W} + \boldsymbol{S} + \boldsymbol{T} + \boldsymbol{M}) \, \boldsymbol{y}^{t} \qquad (13)$$

where $\boldsymbol{w}$, $\boldsymbol{s}$, $\boldsymbol{t}$ and $\boldsymbol{m}$ are 1×*N* vectors of sectoral primary inputs (wages, surplus, taxes and imports) into industries 1,...,*N* per unit of total output, and $\boldsymbol{W}$, $\boldsymbol{S}$, $\boldsymbol{T}$ and $\boldsymbol{M}$ are total primary input multipliers (1×*N*), respectively. It follows from Equation 13 that these total multipliers form a complete decomposition of the primary input content of final demand, since:

$$y = (\boldsymbol{W} + \boldsymbol{S} + \boldsymbol{T} + \boldsymbol{M}) \, \boldsymbol{y}^{t} \quad \Leftrightarrow \quad \boldsymbol{W} + \boldsymbol{S} + \boldsymbol{T} + \boldsymbol{M} = (1,...,1) \qquad (14)$$

The technical approach taken in this work for generalisation of the standard input-output framework is to include TBL factors $\boldsymbol{q}$ in their respective units into the direct requirements matrices **A** and **A*** as additional rows below primary inputs. The Leontief and Ghosh inverses (discussed further below) contain total multipliers of these factors in the same rows. This procedure follows the solution of Leontief and Ford (1970) to the problem of internal consistency.[54]

The Leontief input-output system represents an economic situation that is characterised by (1) a linear relationship between inputs and output, or in other words, zero fixed costs and constant returns to scale, (2) no factor scarcity and perfectly quantity-elastic supply, (3) idle capacity, and (4) fixed prices that are unaffected by changes in final demand. This situation is dominated by consumers' demand, with producers adjusting to an optimal input structure reflected by the fixed requirements coefficients A_{ij}. Some of these assumptions are not restrictive for accounting purposes such as in TBL benchmarking reporting. However for modelling change over time (see Section 2.7) some of these assumptions do not hold.

The Leontief model can be constructed using two types of use matrices: one that covers only domestic production, and one that includes the use of imported commodities. The direct requirements matrices resulting from these use matrices are called the *domestic requirement* and *technology* matrix, respectively. Only the latter matrix describes the technical production 'recipe', hence its name. Since the present study focuses on national policy issues such as employment, income, territorial greenhouse gas emissions, and water use, the domestic requirements matrix (excluding imports) has been used throughout all analyses. This means that all TBL impacts associated with domestic production, whether destined for export markets or for local consumption, are included. TBL impacts in other countries associated with imports into Australia are not included.[55] It is possible to deal with the import issue if TBL analyses, with the same discrimination and detail, were undertaken for our most important trading partners.

54 Early input-output models, such as by Daly (1968) and Isard et al. (1967), incorporated pollution as outputs of industries, assembled in additional columns of the interindustry table, leading to incompatible units and summation problems across rows (see Forssell & Polenske 1998, p. 92). The solution of Leontief and Ford (1970) to reverse the position of environmental inputs and outputs (ie to assemble generated pollutants as inputs in rows) made this type of model operational.

55 It is possible to include TBL impacts of most imports by assuming they are produced using the domestic economy's production characteristics. Further, more detailed treatment of trade is possible in the input-output formalism by developing trade matrices between major trading partners.

The Ghosh model

The primary input balance (4b) can be used to develop the alternative cost-push formulation of the input-output model as suggested by Augustinovics (1970). Substituting $B^*_{ij} = U_{ij} / x'_i$, Equations 8 to 12 read:

$$\boldsymbol{x} = \boldsymbol{x}'^{\mathrm{t}}\mathbf{B}^* + \boldsymbol{v} = \boldsymbol{x}\mathbf{D}\mathbf{B}^* + \boldsymbol{v} = \boldsymbol{x}\mathbf{A}^* + \boldsymbol{v} = \boldsymbol{v}\,(\,\mathbf{I} - \mathbf{A}^*\,)^{-1} = \boldsymbol{v}\,\mathbf{L}^* \qquad (15)$$

where $\mathbf{B}^*$ and $\mathbf{A}^* = \mathbf{D}\mathbf{B}^*$ are the commodity-by-industry and industry-by-industry *direct sales* matrices, and $\mathbf{L}^*$ is called the *Ghosh inverse*. The coefficients A^*_{ij} describe the intermediate demand of industries j=1,...,N for output from industries i=1,...,N per unit of total sales of industry i. The L^*_{ij} measure the total output of industry j required to utilise a unit of primary input into industry i. The total production factor usage Q accompanying this output is (compare Equation 12):

$$Q = \boldsymbol{v}\,\mathbf{L}^*\,\boldsymbol{q}^{\mathrm{t}} = \boldsymbol{q}\,\mathbf{L}\,\boldsymbol{y}^{\mathrm{t}}\ . \qquad (16)$$

Equation 16 states that factor uses $\mathbf{L}^*\boldsymbol{q}^{\mathrm{t}}$ occur throughout the economy in order to utilise a primary input bundle $\boldsymbol{v}$ (in monetary terms) for final demand.

An interesting feature of the Ghosh formulation is that the sales coefficients A^*_{ij} are independent of prices and valuation (Ghosh 1958). A special case are final demand multipliers calculated via:

$$v = y = \boldsymbol{x}'^{\mathrm{t}}\,(\,\boldsymbol{c}' + \boldsymbol{k}' + \boldsymbol{i}' + \boldsymbol{e}'\,) = \boldsymbol{x}\,\mathbf{D}\,(\,\boldsymbol{c}' + \boldsymbol{k}' + \boldsymbol{i}' + \boldsymbol{e}'\,) = \boldsymbol{x}\,(\,\boldsymbol{c} + \boldsymbol{k} + \boldsymbol{i} + \boldsymbol{e}\,)^{\mathrm{t}}$$

$$= \boldsymbol{v}\,\mathbf{L}^*\,(\,\boldsymbol{c} + \boldsymbol{k} + \boldsymbol{i} + \boldsymbol{e}\,)^{\mathrm{t}} = \boldsymbol{v}\,(\,\boldsymbol{C} + \boldsymbol{K} + \boldsymbol{I} + \boldsymbol{E}\,)^{\mathrm{t}} \qquad (17)$$

where $\boldsymbol{c}$, $\boldsymbol{k}$, $\boldsymbol{i}$ and $\boldsymbol{e}$ are N×1 vectors of sectoral final demand (final consumption, gross fixed capital expenditure, changes in inventories and exports) from industries 1,...,N per unit of total output, and $\boldsymbol{C}$, $\boldsymbol{K}$, $\boldsymbol{I}$ and $\boldsymbol{E}$ are total final demand multipliers (1×N), respectively. It follows from Equation 17 that these total multipliers form a complete decomposition of the final demand content of primary input[56], since:

$$v = \boldsymbol{v}\,(\,\boldsymbol{C} + \boldsymbol{K} + \boldsymbol{I} + \boldsymbol{E}\,)^{\mathrm{t}} \quad \Leftrightarrow \quad \boldsymbol{C} + \boldsymbol{K} + \boldsymbol{I} + \boldsymbol{E} = (1,\ldots,1)^{\mathrm{t}} \qquad (18)$$

There has been considerable debate on the correct economic interpretation of the Ghosh model. The author himself (Ghosh 1958) imagines a monopolistic or centrally planned market with scarce resources, where allocation rather than production functions govern, and where shortages lead to price increases and rationing. Although Ghosh perceived the A^*_{ij} as value coefficients, these were subsequently employed as quantity coefficients, such as by Bon (1988) for multi-regional analysis, and in Giarratani's (1976), Cella's (1988) and Oosterhaven's (1988) studies of potential impacts of supply constraints in energy and water resources, respectively. This conception in turn was heavily criticised, including on the grounds that a situation where all inputs are non-essential, where production recipes can vary, and input substitution can occur perfectly, depending on the availability of supply, is implausible (Cronin 1984) and cannot be derived from any economic theory of production or optimisation behaviour (Cronin 1984).[57]

The perception of the sales matrix as a price model to be used for analysing cost-push inflationary processes was revived by Oosterhaven (1996) and Dietzenbacher (1997). In their interpretation, primary input *prices* change exogenously, are entirely passed on to price-taking purchasers, and change only output *values*, while quantities are fixed. As a consequence, supply is perfectly price-elastic, while demand is perfectly price-inelastic. Oosterhaven (1988) shows that the Ghosh and Leontief price models yield the same results, as do their dual quantity models.

Therefore, Equation 16 cannot be interpreted in a physical, causal sense: supply-side multipliers L^*_{ij} do not quantify the amount of output *generated* by an injection of primary inputs, but instead indicate how primary inputs depend on further processing. The consensus seems that the Ghosh model is justified as a descriptive tool for international comparative studies, and for linkage and key sector identification, but not suitable for impact studies (Oosterhaven 1988). In the present report the Ghosh model is used primarily to calculate *forward linkages*, or the downstream connections in the economy (see Section 2.5).

56 Augustinovics (1970) uses the balance equation $(\boldsymbol{v}\hat{\boldsymbol{x}}^{-1})\mathbf{L}\,\boldsymbol{y} = \boldsymbol{v}\,\mathbf{L}^*\,(\boldsymbol{y}\hat{\boldsymbol{x}}^{-1})$ to present the primary inputs structure of final demand, and the final allocation structure of primary inputs for the Hungarian economy.

57 Note that the matrices of requirements and sales coefficients are extreme cases of the constant-elasticity-of-substitution production function for zero and infinite elasticity, respectively.

2.4 Valuation

In the representation of Equation 2 in the Australian input-output tables, all quantities and intra-industrial transactions are valued in "farm or factory gate" prices, so-called *basic prices* (bp). These are also referred to as *net producers' prices*, because they differ from *producers' prices* (pp) by taxes on final demand t_f, so that:

$$y_{(bp)} = y_{(pp)} - t_f \tag{19}$$

Insertion of Equation 19 into Equation 3 yields:

$$w + s + t + t_f + m = y_{(pp)} \tag{20}$$

Note that t and t_f are not the only sources of tax earnings for the government, since the wages w contain income tax t_w. In contrast to the primary inputs, t_f is not paid by intermediate producers, but only by final purchasers, and must therefore not be treated with the input-output formalism.

Most input-output studies are carried out in terms of basic prices, because coefficients in basic prices valued in producers' prices can be subject to large fluctuations due to changes in taxation. All multipliers and TBL measures presented in this study therefore refer to basic prices. Final demand taxes are reported under the TBL indicator 'government revenue' as intensities $t_f / y_{(bp)}$.

Most input-output tables are expressed in monetary units, in terms of the currency of the respective country. However, intersectoral flows can in principle be represented in physical units, such as data on production factors included in generalised input-output frameworks, which are always measured in their own physical units. These systems are then called *mixed-units* input-output tables.

2.5 Linkages

The row averages (over outputs) $L_{i\cdot} = \Sigma_j L_{ij} / N$ and the column averages (over inputs) $L_{\cdot j} = \Sigma_i L_{ij} / N$ of the Leontief inverse **L** form the elements of the forward and backward linkages ($U_{i\cdot}$ and $U_{\cdot j}$) suggested by Rasmussen (1956) and Hirschman (1958). For normalisation, and to allow inter-industry comparisons, Hazari (1970) suggests relating these row and column sums to the global average $\overline{L} = \Sigma_{ij} L_{ij} / N^2$

$$U_{i\cdot} = \frac{L_{i\cdot}}{\overline{L}} \quad , \quad U_{\cdot j} = \frac{L_{\cdot j}}{\overline{L}} \tag{21}$$

$U_{i\cdot} > 1$ indicates strong forward linkages, or "sensitivity of dispersion", of sector i, meaning that a unit change in all sectors' final demand would cause an above-average production increase in sector i, that is sector i's products would be in greater demand. $U_{\cdot j} > 1$ indicates strong backward linkages, or "power of dispersion", of sector j, meaning that a unit change in the final demand of sector j would create an above-average increase in the activity of the whole economy, that is sector j would draw more heavily on the rest of the system. A key sector is characterised by $U_{i\cdot} > 1 \wedge U_{\cdot j} > 1$, and exhibits both above-average dependence on, and influence on, other sectors. The $U_{i\cdot}$ and $U_{\cdot j}$ are normalised to $\Sigma_i U_{i\cdot} / N = 1$ and $\Sigma_j U_{\cdot j} / N = 1$.

Bharadwaj (1966) and Hazari (1970) recommend taking into account column and row *coefficients* of *variation*:

$$V_{i\cdot} = \frac{\sqrt{\mathrm{Var}_j (L_{ij})}}{L_{i\cdot}} \quad \text{and} \quad V_{\cdot j} = \frac{\sqrt{\mathrm{Var}_i (L_{ij})}}{L_{\cdot j}}$$

$$\text{with Var}_{i/j}(L_{ij}) = \frac{1}{N-1} \sum_{i/j=1}^{N} \left(L_{ij} - \sum_{m/n=1}^{N} L_{mn} / N \right)^2 \tag{22}$$

because high linkage values can result from either many high L_{ij} (reflected in low $V_{i\cdot}$ and $V_{\cdot j}$), or only a few very high L_{ij} (reflected in high $V_{i\cdot}$ and $V_{\cdot j}$). An example for the latter is the Korean rice sector as cited by Jones (1976). Intermediate rice deliveries were a mere 14% of total output, but formed a large fraction for a few small industries, hence exaggerating the key role of the rice sector. An additional criterion for key sectors is therefore that coefficients of variation are relatively low (see also Hazari 1970).

Considering the criticism of the Ghosh model described in the previous section, it must be concluded that a forward-looking model is only plausible if formulated as a price model, with quantities fixed. In a causal sense, such a model only captures price effects of an exogenously specified cost-push, but not quantity effects (which are examined as an exogenously specified demand-pull under fixed prices, using the Leontief model). This has implications for the interpretation of forward quantity-linkages: the Ghosh inverse can only be employed as a descriptive *ex-post* static device that measures the amount of output that is necessary to utilise or absorb, or that accompanies primary inputs. The same (non-causal) interpretation must be applied to environmentally extended forward linkages. These qualifications are not a limitation for the current use of the Ghosh model as a reporting and benchmarking tool aiming to document the detailed interactions between TBL indicators for the economy at one time in the recent past.

Given these qualifications, and using row averages $L^*_{i\cdot} = \sum_j L^*_{ij} / N$ and global averages $\bar{L}^* = \sum_{ij} L^*_{ij} / N^2$ of the Ghosh inverse, forward linkages and their variances can be readily defined by following equations 9-11

$$U^*_{i\cdot} = \frac{L^*_{i\cdot}}{\bar{L}^*} \quad \text{and} \quad V^*_{i\cdot} = \frac{\sqrt{\mathrm{Var}_j (L^*_{ij})}}{L^*_{i\cdot}} \qquad (23)$$

2.6 Structural Path Analysis

The decomposition of multipliers into paths was introduced into economics and regional science by Defourny, Crama, and co-workers (Crama et al. 1984; Defourny & Thorbecke 1984). In order to systematically determine environmentally important input-output paths, the total factor multipliers as in Equation 11 can be decomposed by “unravelling” the Leontief inverse using its series expansion:

$$\boldsymbol{q} \, (\mathbf{I} - \mathbf{A})^{-1} = \boldsymbol{q} + \boldsymbol{q}\mathbf{A} + \boldsymbol{q}\mathbf{A}^2 + \boldsymbol{q}\mathbf{A}^3 + \ldots \qquad (24)$$

Expanding Equation 24, total factor multipliers Q_i as in Equation 12 can be written as:

$$\begin{aligned} Q_i &= \sum_{j=1}^{N} q_j \left(\delta_{ji} + A_{ji} + (\mathbf{A}^2)_{ji} + (\mathbf{A}^3)_{ji} + \ldots \right) \\ &= \sum_{j=1}^{N} q_j \left(\delta_{ji} + A_{ji} + \sum_{k=1}^{N} A_{jk} A_{ki} + \sum_{l=1}^{N} \sum_{k=1}^{N} A_{jl} A_{lk} A_{ki} + \ldots \right) \\ &= q_i + \sum_{j=1}^{N} q_j A_{ji} + \sum_{k=1}^{N} q_k \sum_{j=1}^{N} A_{kj} A_{ji} + \sum_{l=1}^{N} q_l \sum_{k=1}^{N} A_{lk} \sum_{j=1}^{N} A_{kj} A_{ji} + \ldots \end{aligned} \qquad (25)$$

where i, j, k, and l denote industries, and $\delta_{Ij} = 1$ if $I = j$ and $\delta_{ij} = 0$ otherwise. Q_i is thus a sum over direct factor inputs Q_i occurring in industry i itself, and higher-order input paths. An input path from industry j (domestic or foreign) into industry i of first order is represented by a product $Q_j A_{ji}$, while an input path from industry k via industry j into industry i is represented by a product $Q_k A_{kj} A_{ji}$, and so on. There are N input paths of first order, N^2 paths of second order, and, in general, N^n paths of n^{th} order. An index pair (ij) shall be referred to as a vertex.

In this work Equation 25 was evaluated by sequential backwards scanning of the production chain tree from final demand to the various locations of production factor usage. The result of one execution of this algorithm for a particular production factor is a ranking of input paths for each of the N (135 in this work) sectors in terms of their contribution to the total factor budget.

The same decomposition technique can be applied to the direct sales matrix and the Ghosh inverse. In this work, we employ an algorithm for scanning, extracting, and ranking input paths. This algorithm evaluates Equation 25 by sequential backwards scanning of the production chain tree from final demand to the various locations of production factor usage.

2.7 Justification for the Choice of Model

We chose an *input-output* model because it is the simplest model that allows economic activity to be analysed in a production life-cycle context. Moreover, an input-output model is politically and ideologically neutral, and does not incorporate any specific behavioural conditions for the individual, companies or the state, except that an economy behave in a consistent manner. Finally, an input-output approach to TBL can be reproduced in every country, for almost any base year, by any institution, since input-output tables are generated and published in regular intervals by statistical bureaux around the world.

We chose a *static*, *short-term* model because the purpose of this TBL study is reporting and accounting for a particular base year, and not temporal modelling of structural change, or modelling of demographic, technological and policy scenarios. Using static input-output analysis, it is impossible to precisely quantify changes in TBL factors which would occur under real-economy shifts in demand or supply, or under corporate or government policies. The difference between calculated TBL factor embodiments of two alternative scenarios would be equal to real TBL factor changes caused by the corresponding shift from the current to the alternative scenario only if during that shift four assumptions held. These are that all commodity prices stayed constant, that there were no changes in technology and no input substitution and hence no change in production factor intensities, that there were no constraints on production factors, such as a rigid labour supply and that production costs were linear functions of production output (as inherently assumed in input-output analysis). The latter condition applies to production situations where there are no economies of scale, and where average costs equal variable costs, that is, fixed costs are zero. Since none of the above conditions is satisfied in practice, the difference in TBL factor embodiments is only *indicative* of the effect that real-economy demand or supply shifts, or corporate and government policies would have on TBL factors (compare Laitner et al. 1998, p 431). As mentioned above, the static nature of the model used here is appropriate to the present task: benchmarking the TBL performance of a large number of sectors of the Australian economy at a particular time. The same methodology can be used, and more importantly is consistent with, input-output tables from other years.

Structural change, or demographic, technological and policy scenarios can be dealt with using other model types, such as general equilibrium models (Bhattacharyya 1996), marginal or dynamic input-output models (Tilanus 1967), sequential inter-industry models (Romanoff & Levine 1981; Mules 1983; Romanoff & Levine 1986), or iterative physical models (Foran & Crane 1998). Some of these models feature an input-output table in their core. While this core is based only on neutral accounting identities, the model becomes analytical when assumptions are made about the behaviour of economic agents, which then enter into demand and production functions. In order to estimate econometrically these functions a (sometimes prohibitively) large amount of data is required. Analytical models thus often operate at a high level of aggregation, and/or borrow elasticities and other functional parameters from literature studies of previous years and different regions.

In any case, any analytical model relies on its assumptions about the functioning of the economy, and stands and falls together with their validity. This is not the case for static input-output systems that are applied to *ex-post* accounting, since interactions between economic agents are not modelled.

2.8 Description of TBL Factors Chosen for this Study

The following paragraphs describe the ten TBL factors chosen for this study. Due mainly to the availability of suitable data, there is a slight emphasis on environmental TBL factors. These data are taken from various sources including national *physical* accounts, which are in addition to the monetary accounts. The four environmental TBL factors are primary energy consumption, greenhouse gas emissions, water use, and land disturbance. The three financial TBL factors are gross operating surplus (profit), export propensity and import penetration. The three social TBL factors are employment, income, and government revenue. Many more indicators will be possible in the future due to the increase in national data collection by such bodies as the ABS. However, greater numbers of factors/indicators *per se* does not necessarily lead to greater clarity if the depth of analysis is not sufficient to reveal the structure and connections between factors.

Environmental factors

Primary energy consumption (megajoules per dollar)

Primary energy consumption is the combustion of non-renewable fossil fuels, in units of megajoules (MJ). This definition covers, for example, coal, natural gas, fuel oil, petrol, diesel, and kerosene. Items such as crude oil for refinery feedstock and wood are not included, since they are either not combusted, or renewable. The main data source is ABARE's annual energy consumption statistics broken down into more than 30 fuels (Australian Bureau of Agricultural and Resource Economics 1997). The use of the accepted term *primary* energy removes the problem that sometimes occurs in comparing electrical energy with other forms of energy, since the conversion efficiencies are included. It is recognised that renewable energy forms do have impacts, not the least of which is embodied fossil energy in the associated construction. However, renewable energy makes up only about 5% of Australian energy use (DPMC 2004). Also, there is limited information about the consumption of renewable electricity in the economy. Hence we do not include these sources in the factor primary energy. Since energy is a direct cost to most businesses, compared with greenhouse gases which at present have no direct cost, it has further value as a TBL indicator.

Energy consumption serves as a good proxy for a wide range of other pollutants such as emissions of SO_2 and NO_x. As the oil crises in the 1970s and more recent conflicts in the Middle East have shown, fossil energy fuels as energy carriers are undoubtedly one of the most essential resources for the functioning of today's human society. This TBL factor therefore reflects, probably like no other, our profound dependence on the Earth's natural capital such as non-renewable resources.

Greenhouse gas emissions (kilograms per dollar)

The combined effect of all greenhouse gases (CO_2, CH_4, N_2O, SF_6, hydrofluorocarbons, perfluorocarbons and others) in the atmosphere is expressed in terms of the equivalent amount of carbon dioxide which would produce the same effect. In accordance to guidelines set out by the Intergovernmental Panel on Climate Change (IPCC), greenhouse gas emissions are expressed in CO_2-equivalents (CO_2-e), and calculated as a weighted sum of nominal emissions of various gas species using gas-specific global warming potentials of 1 (CO_2), 21 (CH_4), 310 (N_2O), 6500 (CF_4), 9200 (C_2F_6), 1300 (HFC-134a), 2800 (HFC-125), 3800 (HFC-143a), 11700 (HFC-23) and 23900 (SF_6) (IPCC 1997). The data source is the National Greenhouse Gas Inventory (Australian Greenhouse Office 1999).

Climate change and its effects are one of the most pressing issues currently facing Australia. The Intergovernmental Panel on Climate Change has reported that "there is now new and stronger evidence that most of the warming observed over the last 50 years is attributable to human activities" (IPCC 2001). Climate change is now considered to be one of the most serious threats to the environment (Watson, Zinyowera & Moss 1996). The concentrations of atmospheric greenhouse gases such as carbon dioxide (CO_2) and methane (CH_4) are projected to increase, resulting in an average global warming of 1.4 to 5.8 °C over the next century (IPCC 2001). In the same period, a rise in sea level of about half a metre is expected, threatening millions of people living on low-lying islands and in coastal regions around the world. Moreover, the geographic distribution of many ecosystems will shift, causing reductions in biodiversity. The supply of water and food is likely to deteriorate drastically in some regions. The spread of vector-borne infectious diseases such as malaria, dengue and yellow fever will directly affect human health. Finally, many countries will suffer from more extreme weather patterns, and the increase in frequency and intensity of severe floods and droughts will adversely affect agriculture, particularly in countries as vulnerable as Australia (Colls 1993; Smith 1993). Climate models suggest that stabilisation of atmospheric CO_2 concentrations at 550ppm, with a global temperature rise of 1.5 to 2.9 °C, can only be achieved through a reduction in net emissions of 50% by 2100 (CSIRO 2002) and further reductions thereafter. Even then, a global sea level rise of more than 25 cm must be expected over the next 100 years (Houghton et al. 1997).

The 20% of the world's population in the wealthiest countries cause about three-quarters of the global greenhouse gas emissions (Winkler et al. 2002). Average per-capita emissions in North America, Australia, Europe or Japan are about six times higher than those in South Asia or China (United Nations 1996). To date, the key factor accounting for the level, distribution, and increase of global greenhouse gas emissions and for environmental degradation in general has been the increasing material standard of living in the industrialised world (World Commission on Environment and Development 1987). The influence of population growth in the developing world on emissions has been considerably lower (Parikh 1996).

The (environmental) TBL factor of greenhouse gas emissions measures a key driver of climate change. With its particular national circumstances, including the continuing importance of natural resource development to the economy, the strong dependence on coal fired electricity, the absence of nuclear electricity, and the relatively large distances between population centres, Australia has a distinctive profile of greenhouse gas emissions. Non-energy related emissions such as from agriculture, land use change and forestry are also significant in Australia, in contrast with most other developed countries. With these issues in mind, the factor of greenhouse emissions can be used as a guide to the 'carbon risks' (including the risk of future constraints on carbon emissions) faced by sectors, including via their supplying sectors.

Water use (litres per dollar)

Managed water use denotes the consumption of self-extracted water (water from rivers, lakes and aquifers, mainly extracted by farmers for irrigation) as well as mains water, in units of litres (L). Collected rainfall, such as in livestock dams on grazing properties is not included in these figures. The data source is the Australian Water Account (Australian Bureau of Statistics 2000). Water quality issues have not yet been introduced as an indicator in the current work, mainly due to the complexity of allocating impacts and the corresponding lack of data. However the concept is feasible and causes of water quality problems have been examined in a Spanish study and attributed to parts of the production chain (Duarte et al. 2002).

Apart from being one of the driest continents, Australia experiences a spatially and temporally variable climate that includes periodic drought, leading to a relatively unpredictable water supply. On the other hand, Australia's water demand increased 19% between 1994 and 1997, mainly due to increased use on pastures, and to a lesser extent for cotton and rice, resulting in water being a very limited resource in some Australian agricultural and urban areas. For example in the Murray-Darling Basin, which accounts for more than 50% of Australian water use, water resources are already fully committed, and State and Commonwealth governments have agreed to cap water diversions from all sources. Nevertheless, significant environmental damage has occurred because of considerable water diversion from the Murray and Snowy Rivers, with widespread soil and water salinisation. In this 'water-stressed' region, irrigation-based industries are likely to face further environmental degradation, as well as income losses, as a greater price is placed on a scarce resource. Water use is of particular importance in an Australian context, and in contrast, is often not represented in environmental accounts in other countries. Recently the water issue has been elevated in national importance with the formation of a *National Water Initiative* (CoAG 2004).

Land disturbance (square metres per dollar)

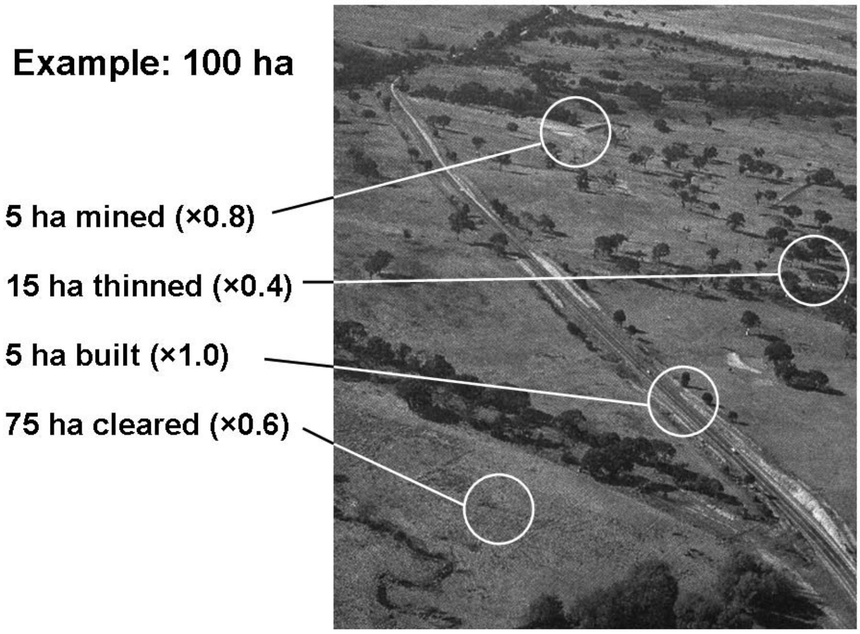
The land disturbance factor summarises recent efforts to incorporate land use into life-cycle assessment, not only in area terms, but also in terms of its environmental impact. Few authors have yet quantified impacts of different types of land use, but most recent approaches consider effects on 'ecosystem quality' or 'condition', expressed in terms of bioproductivity or biodiversity, for example as the species diversity of vascular plants (Lindeijer 2000a, 2000b; Swan and Pettersson 1998; Köllner 2000; van Dobben et al. 1998). Accordingly, the measure of land disturbance D used in this work is expressed as a weighted sum $D = \Sigma_i A_i \times C_i$ of land use areas A_i, with weights C_i (Table 2.1; see also Lenzen & Murray 2001). The weights reflect the *land condition*, the degree of alteration of land from its natural state (weight equal to zero).

Table 2.1: Basic weighting factors for land use, reflecting land condition in Australia

LAND USE TYPE	LAND CONDITION
CONSUMED	
Built, flooded	1.0
DEGRADED	
Degraded pasture or crop land	
Eroded, clearfelled and mined land	0.8
REPLACED	
Cleared pasture and crop land	
Non-native plantations	0.6
SIGNIFICANTLY DISTURBED	
Thinned pasture	
Urban parks and gardens	
Native plantations	0.4
PARTIALLY DISTURBED	
Partially disturbed grazing land	0.2
SLIGHTLY DISTURBED	
Reserves and unused Crown land	
Slightly disturbed grazing land	0.0

For Australia, the degree of landcover disturbance may be a useful proxy for land condition at a very broad scale as it indicates processes such as biotic erosion that lead to land degradation. A comprehensive survey of landcover disturbance over the Australian continent has been conducted by Graetz et al. (1995) using satellite imagery of the current coverage of vegetation and comparing this to estimates of the 'natural' state, taken to be that of 1788. Based on these authors' disturbance categories and a compilation of land use categories from a wide range of sources, Lenzen and Murray (2001) derived a list of weightings for different types of land use ranging from 0 (undisturbed or slightly disturbed) to 1 (completely disturbed), as shown in Table 2.1.

Figure 2.3: Example showing an assessment of land disturbance (Photo courtesy of Glanznig 1995, p. 4)



To obtain a disturbance-based land-use indicator, each area of land is multiplied by its land condition factor. An example of this procedure is provided in Figure 2.3: the 100-hectare area shown in the photo includes a road (5 ha), a quarry (5 ha), cleared land (75 ha), and some less intensively cleared (thinned) land (15 ha). In earlier land use calculations, these areas would all be treated as equivalent, and simply be added to give 100 ha. In a disturbance-based approach, however, each area is weighted with a land condition factor, yielding 5 ha × 1.0 = 5 ha disturbance on built land, 5 ha × 0.8 = 4 ha on mined land, 75 ha × 0.6 = 45 ha on cleared land and 15 ha × 0.4 = 6 ha on thinned land. Thus the total disturbance is 60 ha within a total area of 100 ha. These figures demonstrate the effect of weighting: each part of the land receives a value that reflects both its area and its condition.

Due to a lack of data, the indicator of land disturbance does at present not incorporate the following impact types: land contamination, toxic compound discharges, fragmentation, ecosystem resilience, biodiversity of organisms other than vascular plants, marine impacts, time of usage, and stock depletion. Furthermore, the relative bioproductivity or biodiversity of different ecosystems in different locations within Australia is not distinguished. However augmenting the land disturbance indicator with some nuance of biodiversity quality is however on the workplan for the group and may be available within the next few years. The status of the 310 000 square kilometre region of South West Western Australia may for example attract a higher weighting for land disturbance due to it status as one of the world’s top twenty five biodiversity hotspots (DEH 2004).

Financial factors

Gross operating surplus (dollars per dollar)

Gross operating surplus is defined as the residual of an industry’s total inputs, after subtracting all intermediate inputs, compensation of employees, and net taxes and subsidies. It consists of (a) operating profits, and (b) consumption of fixed capital, in value units of A$ million. Fixed capital consumption is the value, at current replacement cost, of the reproducible fixed assets used up during a period of accounting as a result of normal wear and tear, or accidental damage. The data source is the Australian input-output tables (Australian Bureau of Statistics 1999a).

Gross operating surplus is a positive TBL factor, since it indicates the capacity of an industry to invest in innovation and technological progress through turnover of the capital stock, as well as the capacity for expansion and investment in other sectors.

Export propensity (dollars per dollar)

The export propensity represents the Australian production of primary commodities that are destined for final demand outside Australia, in value units of A$ million. The data source is the Australian input-output tables (Australian Bureau of Statistics 1999a).

With similar reasons to those mentioned for import penetration below, the level of export propensity positively reflects the comparative economic advantage and resource availability of Australian industries. This indicator however requires further comment and explanation on a sector-by-sector basis, because there is evidence to suggest that Australia's export profile is generally heavily reliant on primary goods that cause resource depletion and possibly environmental stress. Moreover, unlike all other TBL factors, there is no causal relationship between the output of an industry sector and the export of upstream industry sectors. This is because exports are not an input into domestic production and are therefore not needed to increase output. For example, an expansion of the fisheries sector requires, or *causes* an increase in the economic activity (and hence energy consumption, water use, employment, imports etc) in key upstream sectors such as ship building. It does not however cause an increase in upstream exports. For this reason, in the commodity sheets in this report, we describe upstream exports as *accompanying* a sector's output, but not to be *required* for this output.

Import penetration (dollars per dollar)

Import penetration represents the value of goods and services purchased from foreign residents. They consist of any commodity needed for the domestic production of commodities, in value units of A$ million. The data source is the Australian input-output tables (Australian Bureau of Statistics 1999a).

All imports, irrespective of commodity, are allocated to the industry that uses them. Almost all imports are of a competitive nature, so that in principle, any Australian industry can substitute between imported and domestically produced inputs. However, items such as sophisticated equipment and passenger aircraft are possibly outside this generalisation due to historical binding (sophisticated industries often stay near their historical origins) and scale (while Australia might make aircraft parts and even engines, currently it does not have the scale to rival Boeing or Airbus in the manufacturing of whole aircraft).

An assessment of the degree of import penetration is important in TBL terms for a variety of reasons. Firstly, in economic terms, the levels of import penetration in a sector has a bearing on the degree to which the sector is affected by changes in exchange rates and trade conditions such as tariffs. In social terms, dependence on imports relates to the degree of self-sufficiency of a nation and its vulnerability to issues such as international resource depletion. For strategic analysis, structural path information can highlight effects due to single purchases from foreign suppliers, perhaps suggesting areas where local economic development is required. In environmental and social terms, imports from economies with poor sustainability records, for example with different labour standards, are a useful indicator of global equity issues. Despite the existence of comparative advantage of foreign industries (even in TBL terms) for some commodities, we regard reducing imports *overall* as being positive. This is because it allows (a) stimulation of domestic production, (b) employment increases in the Australian workforce, and (c) the pursuit of policies aimed at reducing environmentally intensive primary exports (such as from beef and aluminium production) without affecting the overall trade balance. Nevertheless we note there will always be specific commodities for which there are clear advantages in importing goods and services, and indeed, in TBL terms it may, on-the-whole, be beneficial to phase out Australian production of some commodities.

As discussed in Section 2.3, imports still involve environmental and social impacts in their country of origin. While these are not taken into account in the current analysis (which has a focus on Australian impacts only) they can be, to various levels of sophistication. Internationally, there is already recognition of greenhouse gas emissions embodied in trade flows, even without the existence of a global carbon trading scheme. Environmental and social accounting of trade flows is likely to become a mainstream activity in the foreseeable future (Lenzen et al. 2002).

Social factors

Employment (minutes per dollar)

Employment means full-time-equivalent employment, measured as full-time employment plus an assumption of 50% of part-time employment of employees, including employers, own account workers and contributing family workers. Both employment-years (e-y) and employment-minutes (min) are used as units. The data source is the Australian labour statistics (Australian Bureau of Statistics 1999a).

Employment is a critical TBL factor with its widespread implications in areas such as social cohesion, government transfer payments, international credit ratings, and taxation. It is clearly a positive TBL factor and one for which there are demonstrable trade-offs with material and energy use (see for example Lenzen & Dey 2000).

Income (dollars per dollar)

Income, or more technically compensation of employees, involves estimates for each industry wages and salaries, as well as employers' social contributions, in units of A$ million. The data source is the Australian input-output tables (Australian Bureau of Statistics 1999a).

This TBL factor is positive, but distinct from the factor employment, since it does not reflect the workforce as such, but the *level* of work carried out, in monetary terms. For example, two sectors with equal performance with respect to the employment factor can exhibit different ratings with respect to the income factor if direct and upstream wages and salaries are different. Income in an economy impinges directly on purchasing and private investment power, thus closing the loop between production, earning, spending, and again production.

Government revenue (dollars per dollar)

Government revenue consists of (a) taxes less subsidies on products for intermediate demand, (b) other net taxes on production, and (c) net taxes on products for final demand (incorporated within the sales price), in units of A$ million. The data source is the Australian input-output tables (Australian Bureau of Statistics 1999a).

Government revenue was taken in this study as a positive TBL factor, since it is available to support the national commons, such as health, education, defence, social benefit payments, public transport and other infrastructure. Hidden subsidies are not included due to a lack of consistent data available at an economy wide scale.

The following Chapter 3 describes the format and meaning of the presentation of the sectoral TBL accounts forming the bulk of the remainder of this report.

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Table 2.2: Selected generalised input-output studies, with a focus on energy and environmental issues

Factors	Region	Reference	Topic
Water[b]	USA	Isard & Romanoff 1967	
Many[e]	USA	Leontief & Ford 1971	
Many[i]	Maryland	Cumberland & Stram 1972	Residual flows
Energy	USA	Folk & Hannon 1973	Energy-employment relation
Energy	USA	Herendeen 1973	
Energy	USA	Herendeen & Sebald 1973	Energy and employment of consumer options
Many[c]	USA	Just 1973	Energy technology impacts
Waste, employment	Maryland	Cumberland & Korbach 1973	Also primary inputs examined
Energy	USA	Bezdek & Hannon 1974	Government spending
Energy	UK	Chapman et al. 1974	Fuels
Energy	USA	Hannon & Puleo 1974	Energy and employment for transportation options
Energy	USA	Herendeen 1974	Household consumption
Energy	USA	Wright 1974	
Energy	USA	Bullard & Herendeen 1975a	
Energy	USA, UK	Pick & Becker 1975	Materials policy and systems optimisation
Energy	USA	Bullard & Herendeen 1975b	Consumption decisions
Energy	Germany	Denton 1975	
Energy	USA	Hannon et al. 1975	Energy and employment for transportation options
Energy	USA	Herendeen & Sebald 1975	Energy and employment of consumer options
Energy	UK	Wright 1975	
Energy	USA	Herendeen & Tanaka 1976	Household consumption
Energy		Icerman 1976	Hydrothermal energy
Residuals[k]	Norway	Førsund & Strøm 1976	
Energy	USA	Pilati 1976	Electricity supply and energy conservation options
Energy	USA	Hannon et al. 1978	Energy and employment in construction
Energy	Norway	Herendeen 1978	Household consumption
Energy	Scotland	Al-Ali 1979	
Energy	USA	Penner et al. 1979	

Factors	Region	Reference	Topic
Transport flows	Brazil	Echenique 1979	
Energy	USA	Costanza 1980	Energy theory of value
Energy	USA	Hannon et al. 1980	Energy and employment for coal-electric fuel cycle options
Energy	Australia	James 1980	
Energy	Canada	Rogers 1980	LCA of solar heating system
Energy	Canada	Bush 1981	
Energy		Herendeen & Plant 1981	Geothermal technologies
Energy	USA	Herendeen et al. 1981	Household consumption
Energy	UK	Common & McPherson 1982	
Energy	Germany	Hannon 1982	Mixed units
Energy	USA	Beutel & Stahmer 1982	SD
Energy	USA	Hannon et al. 1983	Make-use framework; 1963, 1967, 1972
Energy	Hawaii	Leung & Hsu 1984	
Energy	USA	Costanza & Herendeen 1984	Energy theory of value
Energy	USA	Hannon & Blazeck 1984	Marginal energy intensities
Energy	Many[f]	Proops 1984	SD, Energy-output ratio
Occupational health and safety	USA	Yokell & Ricci 1985	Energy technologies
Discharges[j]	Norway	Førsund 1985	
Energy	Saskatchewan	Gould & Kulshreshtha 1986	
Energy	Australia	James et al. 1986	Energy technology impacts
Energy	New Zealand	Peet 1986	
Energy	USA	Gowdy & Miller 1987	SD
Energy		Herendeen & Brown 1987	Woody biomass
Energy	Many[f]	Proops 1988	SD
Energy	Taiwan	Wu & Chen 1989	
Energy	Taiwan	Chen & Rose 1990	SD
CO_2		Kreith et al. 1990	LCA of electricity generation
Energy	USA	Rose & Chen 1991	SD
CO_2	Australia	Common & Salma 1992	SD
SO_2, NO_x	France	Breuil 1992	
Energy	Australia	Shariful Islam & Morison 1992	SD
Energy	USA	Strauss & Grado 1992	Woody biomass

Factors	Region	Reference	Topic
Energy, carbon	New Zealand	Peet 1993	Intensities
CO_2	Japan	Yasukawa et al. 1992	LCA of electricity generation
CO_2	UK	Gay & Proops 1993	
GHG	USA	Heyes & Liston-Heyes 1993	Demilitarisation
CO_2	UK, Germany	Proops et al. 1993	SD
Energy	Germany	Weber & Fahl 1993	Household consumption
Electricity	Taiwan	Chen & Wu 1994	
Energy	Japan	Han & Lakshmanan 1994	SD
CO_2	Many[h]	Wyckoff & Roop 1994	Imports embodiments
Energy	China	Lin & Polenske 1995	SD
Toxic releases, electricity	USA	Lave et al. 1995	Automobile and paper cup demand
GHG	Japan	Uchiyama 1995	LCA of electricity generation
Energy	Japan	Nishimura et al. 1996	Material content
CO_2, SO_2, NO_x	UK	Proops et al. 1996	LCA of electricity generation
CO_2	India	Murthy et al. 1997	CO_2 reduction potentials
CO_2, SO_x	Japan	Hayami et al. 1997	SD, public policy analysis
Landa	Indonesia	Hamilton 1997	Dynamic
Energy	Australia	Treloar 1997	Embodiment path extraction
CO_2	Taiwan	Chang & Lin 1998	SD
Energy, GHG	Australia	Lenzen 1998b	
Energy, CO_2, SO_2, NO_x	Denmark	Wier 1998	SD
Energy, GHG	Australia	Lenzen 1998a	Household consumption
Hazard. waste	USA	Hendrickson et al. 1998	LCA of concrete
Land	New Zealand	Bicknell et al. 1998	Ecological footprint
Manyd	Indonesia	Lange 1998	Dynamic
GHG	Germany	Marheineke et al. 1998	LCA of a road freight task
Energy	Germany	Weber & Schnabl 1998	Main contributions identification
CO_2	Austria	Kratena & Schleicher 1999	CO_2 reduction impacts
Energy	India	Mukhopadhyay & Chakraborty 1999	SD
CO_2	Netherlands	Nakamura 1999	Influence of waste recycling
Energy, GHG	Australia	Lenzen 1999b	Transportation system
Sustainability	World	Proops et al. 1999	Sustainability criteria

Factors	Region	Reference	Topic
Energy, GHG		Lenzen 1999a	Solar-thermal electricity
Nitrogen	Denmark	Wier & Hasler 1999	SD
Energy		Lenzen & Dey 2000	Basic iron and steel
Waste	Japan	Nakamura 2000	Waste management
Energy, CO_2	Many[g]	Weber & Perrels 2000	Lifestyle impacts
Land disturbance	Australia	Lenzen & Murray 2001	Ecological footprint
CO_2	Spain	Labandeira & Labeaga 2002	Carbon taxes
Water	Spain	Duarte et al. 2002	Hypothetical extraction method

Notes: [a] Land use, soil erosion, deforestation; [b] Use and pollution; [c] Energy, particulates, hydrocarbons, SO_2, CO, NO, steel use, water use; [d] CO_2, SO_2, NO_x, Water use, BOD, COD, suspended solids, land use, soil erosion; [e] Particulates, SO_x, HC, CO, NO_x; [f] U.K., Philippines, India, Netherlands, Yugoslavia, Japan; [g] Germany, France, Netherlands; [h] Canada, France, Germany, Japan, U.K., U.S.A.; [i] Air pollutants, waterborne waste, BOD, solid waste, pesticides; [j] Heavy metals, acids, hydrocarbons, CO, NO_x, SO_x, oil, solvents, toxic compounds and others; [k] mercury, lead, cadmium, zinc, copper, iron, chrome, sulphur and nitrogen oxides, hydrochloric and other acids, fluorine, cyanide, arsenic, CO, mine tailings, pesticides, plastic, oil, solvents, waste and others, discharged into air, water, land;
SD = Structural decomposition; GHG = Greenhouse gases; LCA = Life Cycle Assessment.

Chapter 3: How to Interpret Data Sheets

Abstract

Inevitably a ‘triple bottom line’ (TBL) analysis of 135 sectors Australian economy using the methods described in Chapters 1 and 2 produces a wide range of outputs that may be difficult for the non-specialist to comprehend. This chapter describes the use of the information and the way it should be interpreted by a policy or investment analyst, or a member of the general public. The data are presented both as tables and as graphical figures. The first graphical method brings together all the TBL multipliers in a ‘spider diagram’ that relates each multiplier to the economy-wide average. This allows a quick scan to be made of potential advantages and disadvantages for each sector. The second of the graphical methods, a set of nine column graphs, shows each of the TBL multipliers in relation to the economy wide average and how much of the effect is due to the sector itself (the direct effect), or due to its chain of suppliers (the indirect effect). The first result table for each sector gives an extract from the national accounts that shows its size in relation to the national total. The next two tables document the TBL factors both in absolute terms and as multipliers (a ratio to one dollar of final demand). Finally a ‘structural path analysis’ is presented which reveals where in the production chain a particular advantage might be enhanced or a disadvantage dealt with. The commentary for each sector in the report will describe important issues for that sector, but this chapter may help an analyst focus on the data treatment that is most attuned to a particular policy or investment question.

3.1 Introduction

This chapter serves as an instructive manual to guide the reader through the TBL data sheets using the commercial fishing industrial sector as an example.

Data Sheet 1

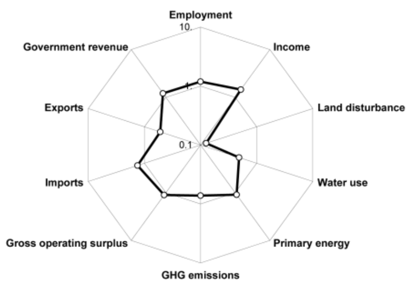
Data sheet header

Sector **Commercial fishing** **(Fi)**

Commercial fishing, fresh seafood

Spider diagram

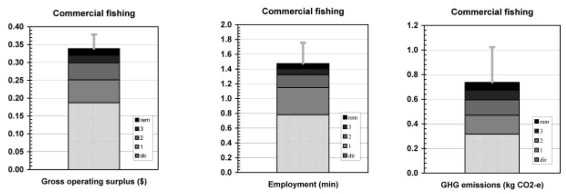
Spider diagram



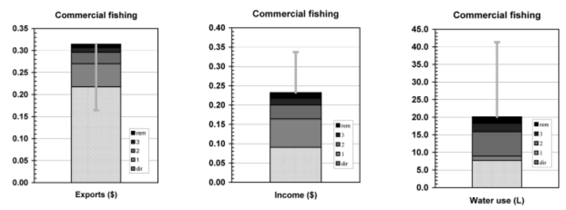
Bargraphs of TBL accounts #1 and #2

Bar graphs

Account #1



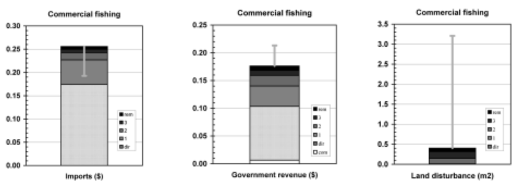
Account #2



Data Sheet 2

Bargraphs of TBL account #3

Account #3



National account extracts

National Accounts extracts			
Receipts: GNT(E) - commodities			
Private final consumption	$m 922.4	(0.35% of total)	($m 887.9 domestically produced)
Government final consumption	$m 102.2	(0.12% of total)	($m 102.2 domestically produced)
Gross fixed capital expenditure	$m 0.0		
Net changes in stocks	$m 2.4	(0.14% of total)	($m 2.3 domestically produced)
Sectoral GNE	**$m 1,027.0**	**(0.22% of GNE)**	**($m 992.4 domestically produced)**
Exports	$m 467.9	(0.56% of total)	($m 467.9 domestically produced)
Final demand	**$m 1,494.9**	**(0.28% of GNT)**	**($m 1,460.3 domestically produced)**
Costs: GNT(I) - industries			
Wages and salaries	$m 195.1	(0.11% of total)	
Gross operating surplus	$m 402.4	(0.21% of total)	
Taxes less subsidies	$m 208.7	(0.24% of total)	
Sectoral GDP*	**$m 806.1**	**(0.18% of GDP)**	
Imports	$m 375.3	(0.38% of total)	
Primary inputs	**$m 1,181.4**	**(0.22% of GNT)**	

* Sectoral gross value added + net taxes on products

TBL factors

TBL factors	in supplying industry	(% of national)	embodied in commodity GNT direct	(% of national)	total	(% of national)
Gross operating surplus ($m)	$m 402.4	(0.21%)	$m 273.2	(0.14%)	$m 494.6	(0.26%)
Exports ($m)	$m 467.9	(0.56%)	$m 317.7	(0.38%)	$m 459.4	(0.55%)
Imports ($m)	$m 375.3	(0.38%)	$m 254.8	(0.26%)	$m 373.6	(0.38%)
Employment (e-y)	13,463 e-y	(0.19%)	9,140 e-y	(0.13%)	17,252 e-y	(0.24%)
Income ($m)*	$m 195.1	(0.11%)	$m 132.4	(0.08%)	$m 339.1	(0.20%)
Government revenue ($m)†	$m 218.0	(0.20%)	$m 151.0	(0.14%)	$m 257.5	(0.24%)
GHG emissions (kt CO_2-e)	680 kt	(0.13%)	462 kt	(0.09%)	1,077 kt	(0.21%)
Water use (ML)	16,487 ML	(0.08%)	11,193 ML	(0.05%)	29,356 ML	(0.14%)
Land disturbance (kha)	1 kha	(0.00%)	0 kha	(0.00%)	59 kha	(0.04%)
Primary energy (TJ)	9,713 TJ	(0.25%)	6,594 TJ	(0.17%)	12,277 TJ	(0.32%)

*excludes income tax † includes net commodity taxes on final demand and income tax

TBL multipliers

TBL multipliers - commodities	per $ of GNE/GNT* direct	total	Nation-wide average total
Gross operating surplus ($)	0.19	0.34	0.38
Exports ($)	0.22	0.31	0.16
Imports ($)	0.17	0.26	0.19
Employment (min)	0.78	1.47	1.75
Income ($)	0.09	0.23	0.34
Government revenue ($)	0.10	0.18	0.21
GHG emissions (kg CO_2-e)	0.32	0.74	1.02
Water use (L)	7.66	20.10	41.32
Land disturbance (m^2)	0.00	0.40	3.21
Primary energy (MJ)	4.52	8.41	7.65

*refers to GNE/GNT produced in the actual year, excludes decreases in stocks

Data Sheet 3

Structural Paths (intensities - commodities)

Gross operating surplus ($/$)			Employment (min/$)			GHG emissions (kg CO_2-e/$)		
Fi	0.187	(0; 55.%)	Fi	0.781	(0; 53.%)	Fi	0.316	(0; 43.%)
Wt Fi	0.0165	(1; 4.9%)	Wt Fi	0.119	(1; 8.1%)	El Fi	0.0396	(1; 5.4%)
Fd Fi	0.00575	(1; 1.7%)	Eq Fi	0.0285	(1; 1.9%)	Fd Fi	0.0379	(1; 5.1%)
Oi Fo Fi	0.00521	(2; 1.5%)	Ma Fi	0.0248	(1; 1.7%)	Fo Fi	0.0366	(1; 5.%)
Rv Fi	0.00462	(1; 1.4%)	Rh Fi	0.013	(1; 0.88%)	Wt Fi	0.0165	(1; 2.2%)
St Wt Fi	0.00315	(2; 0.93%)	Fd Fi	0.0128	(1; 0.87%)	Bc Mp Fd Fi	0.0113	(3; 1.5%)
Eq Fi	0.00289	(1; 0.85%)	Om Fi	0.0127	(1; 0.86%)	Oi Fo Fi	0.011	(2; 1.5%)
Bk Fi	0.00267	(1; 0.79%)	Rv Fi	0.0124	(1; 0.84%)	Is Ma Fi	0.00679	(2; 0.92%)
Ms Wt Fi	0.00239	(2; 0.71%)	Ms Wt Fi	0.0107	(2; 0.73%)	Ap Fi	0.00581	(1; 0.79%)
Rh Fi	0.00213	(1; 0.63%)	Bk Fi	0.0106	(1; 0.72%)	Is Sh Fi	0.00508	(2; 0.69%)
Fo Fi	0.00201	(1; 0.59%)	Sh Fi	0.0104	(1; 0.71%)	El Wt Fi	0.00496	(2; 0.67%)
Pt Fi	0.002	(1; 0.59%)	Pl Fi	0.00986	(1; 0.67%)	Is Eq Fi	0.00423	(2; 0.57%)
Pd Wt Fi	0.0019	(2; 0.56%)	Mv Fi	0.00907	(1; 0.62%)	Ch Pl Fi	0.00412	(2; 0.56%)
Ma Fi	0.00187	(1; 0.55%)	Rd Fi	0.00833	(1; 0.57%)	Nf Fi	0.00366	(1; 0.5%)
Pl Fi	0.00185	(1; 0.55%)	Ps Fi	0.00832	(1; 0.56%)	Oi Ap Fi	0.00301	(2; 0.41%)
Sh Fi	0.00175	(1; 0.52%)	Ee Fi	0.00688	(1; 0.47%)	Bc Mp Fi	0.00299	(2; 0.41%)
Mv Fi	0.00167	(1; 0.49%)	Su Fd Fi	0.00577	(2; 0.39%)	El En Fi	0.00248	(2; 0.34%)

Exports ($/$)			Income ($/$)			Water use (L/$)		
Fi	0.218	(0; 69.%)	Fi	0.0907	(0; 39.%)	Fi	7.66	(0; 38.%)
Wt Fi	0.0135	(1; 4.3%)	Wt Fi	0.0255	(1; 11.%)	Su Fd Fi	4.58	(2; 23.%)
Fd Fi	0.0104	(1; 3.3%)	Eq Fi	0.00503	(1; 2.2%)	Vf Fd Fi	0.364	(2; 1.8%)
Eq Fi	0.00508	(1; 1.6%)	Ma Fi	0.00465	(1; 2.%)	Ws Fi	0.352	(1; 1.8%)
Ma Fi	0.00364	(1; 1.2%)	Fd Fi	0.00301	(1; 1.3%)	Dc Dp Fi	0.329	(2; 1.6%)
Oi Fo Fi	0.00356	(2; 1.1%)	Bk Fi	0.00262	(1; 1.1%)	Bc Mp Fd Fi	0.298	(3; 1.5%)
Nf Fi	0.00268	(1; 0.85%)	Ms Wt Fi	0.0025	(2; 1.1%)	Wh Fd Fi	0.246	(2; 1.2%)
En Fi	0.00233	(1; 0.74%)	Sh Fi	0.00206	(1; 0.89%)	El Fi	0.219	(1; 1.1%)
Sb Fi	0.00195	(1; 0.62%)	Pl Fi	0.00199	(1; 0.86%)	Wa Fi	0.212	(1; 1.1%)
Om Fi	0.00164	(1; 0.52%)	Rv Fi	0.00199	(1; 0.86%)	Sc Cg Su Fd F	0.125	(4; 0.62%)
Fo Fi	0.00149	(1; 0.47%)	Pd Wt Fi	0.00171	(2; 0.74%)	Dc Dp Fd Fi	0.112	(3; 0.56%)
Ee Fi	0.00111	(1; 0.35%)	Mv Fi	0.00157	(1; 0.68%)	Wo Tx Fi	0.0791	(2; 0.39%)
Mv Fi	0.0011	(1; 0.35%)	Rd Fi	0.00143	(1; 0.62%)	Bc Mp Fi	0.0788	(2; 0.39%)
Oi Ap Fi	0.000971	(2; 0.31%)	Rh Fi	0.00142	(1; 0.61%)	Ri Ws Fi	0.0787	(2; 0.39%)
St Wt Fi	0.00078	(2; 0.25%)	Om Fi	0.00132	(1; 0.57%)	Vf Ws Fi	0.0714	(2; 0.36%)
At Wt Fi	0.000639	(2; 0.2%)	Ee Fi	0.00132	(1; 0.57%)	Ri Fc Fi	0.0669	(2; 0.33%)
Wh Fd Fi	0.00062	(2; 0.2%)	St Wt Fi	0.00131	(2; 0.57%)	Wt Fi	0.0665	(1; 0.33%)

Imports ($/$)			Government revenue ($/$)			Land disturbance (m^2/$)		
Fi	0.174	(0; 68.%)	Fi	0.097	(0; 57.%)	Bc Mp Fd Fi	0.0823	(3; 20.%)
Fo Fi	0.012	(1; 4.7%)	Wt Fi	0.0119	(1; 7.%)	Wo Tx Fi	0.0587	(2; 15.%)
Ma Fi	0.0043	(1; 1.7%)	Eq Fi	0.00249	(1; 1.5%)	Wh Fd Fi	0.0359	(2; 8.9%)
Wt Fi	0.00384	(1; 1.5%)	Ma Fi	0.00224	(1; 1.3%)	Bc Mp Fi	0.0217	(2; 5.4%)
Eq Fi	0.00336	(1; 1.3%)	Fd Fi	0.00146	(1; 0.86%)	Wo Tx Tp Fi	0.0128	(3; 3.2%)
Ap Fi	0.00327	(1; 1.3%)	Bk Fi	0.00145	(1; 0.85%)	Wo Mp Fd Fi	0.00929	(3; 2.3%)
Mv Fi	0.00275	(1; 1.1%)	In Fi	0.00132	(1; 0.78%)	Bc Mp Ho Fi	0.00745	(3; 1.8%)
En Fi	0.00271	(1; 1.1%)	Rv Fi	0.00123	(1; 0.72%)	Su Fd Fi	0.00733	(2; 1.8%)
Pt Fi	0.00219	(1; 0.86%)	Ms Wt Fi	0.00119	(2; 0.7%)	Wo Tx Cl Fi	0.00607	(3; 1.5%)
Sb Fi	0.00204	(1; 0.8%)	Pd Wt Fi	0.00112	(2; 0.66%)	Ba Fd Fi	0.00493	(2; 1.2%)
Pl Fi	0.0019	(1; 0.74%)	Sb Fi	0.00104	(1; 0.61%)	Wo Tx Wt Fi	0.00423	(3; 1.%)
Fd Fi	0.00173	(1; 0.68%)	Rd Fi	0.00102	(1; 0.6%)	Fi	0.00298	(0; 0.74%)
Ru Fi	0.00165	(1; 0.64%)	Sh Fi	0.000911	(1; 0.54%)	Wo Mp Fi	0.00246	(2; 0.61%)
Sh Fi	0.00121	(1; 0.47%)	Pl Fi	0.00087	(1; 0.51%)	Bc Mp Ho Wt	0.00244	(4; 0.6%)
Rh Fi	0.0011	(1; 0.43%)	St Wt Fi	0.0007	(2; 0.41%)	Wo Tx Ru Fi	0.00232	(3; 0.57%)
Ee Fi	0.00108	(1; 0.42%)	Mv Fi	0.000674	(1; 0.4%)	Wo Tx Pl Fi	0.0019	(3; 0.47%)
Om Fi	0.000773	(1; 0.3%)	En Fi	0.000672	(1; 0.4%)	Dc Dp Fi	0.00171	(2; 0.42%)

Structural path analysis

Linkages (average = 1)

	Value	C.o.V.
Upstream	0.995 ±0.016	(±1.6%)
Downstream	0.451 ±0.021	(±4.7%)

Linkages: upstream and downstream

3.2. Data Sheet Header

This work disaggregates the output of the Australian economy into 135 commodities, and 135 industries that are primary (ie the main) producers of these commodities (ABS 2002). In the following we will refer to both commodities and their primary industries as sectors (Figure 3.1). The first header row contains the 4-digit or 8-digit code of the standard Input-Output Product Classification (IOPC), and the commodity group name as used by the Australian Bureau of Statistics (1999) (here: 0400 – 'Commercial fishing'). 'Rem.' in these titles means 'Remainder'. The second header row contains a more detailed description of the main commodities included in the commodity group. For ease of reference, the 135 sectors have been given abbreviated codes (eg. Bc for beef cattle, Fw for footwear), with the complete list given in Appendix 3.1.

Figure 3.1: Data sheet header

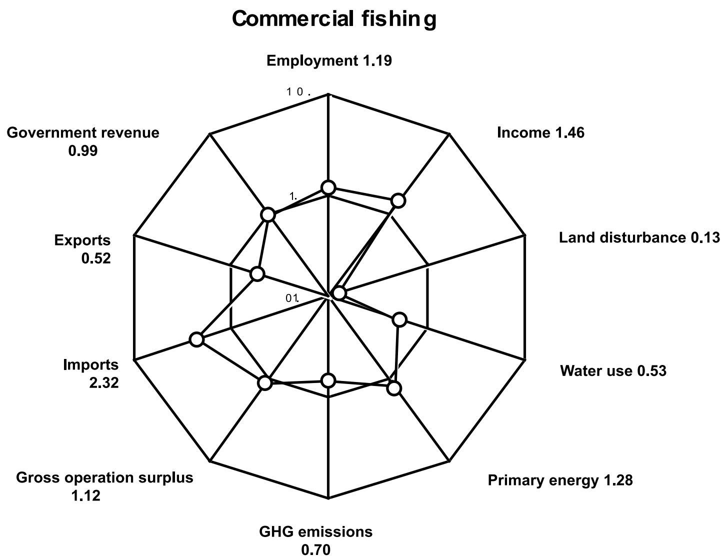
Commodity 0400 **Commercial fishing**

Commercial fishing, fresh seafood

3.3. Spider Diagram

A convenient visualisation of all TBL multipliers for a given sector is provided in a spider diagram (Figure 3.2). All data have been normalised in terms of quantity per $ of final demand. As a guide to the eye, the bold line links the circles depicting the total (direct and upstream) requirements for each factor. For each factor, the lighter line that forms the polygon in the centre (n = 1) represents the economy-wide averages for the requirements of all sectors. Positions inside the economy-wide average represent a better than average performance against the associated factor and positions outside the centre line are worse than average. Note that *above average* performance for some indicators (specifically land disturbance, water use, primary energy, greenhouse gas emissions, and import penetration) implies a reduction in the magnitude of the factors' value, and an increase in the magnitude for other factors (employment, income, gross operating surplus, exports and government revenue). The greenhouse gas emissions performance of the commercial fishing sector, for example, is slightly above average with *lower* emissions than the economy-wide average, while exports accompanying fisheries products are above average with *higher* exports. Note that the scale of the spider diagram is logarithmic in order to accommodate indicator ranges that are many times the economy wide average. To illustrate logarithmic scaling, the values are also shown in Figure 3.2.

Figure 3.2: TBL spider diagram for the commercial fishing sector



For further illustration of the spider diagram, a sector with more extreme TBL indicators is shown in Figure 3.3. The aluminium sector has primary energy factor usage (MJ/$) nearly 7 times the average primary energy factor usage across the economy. The related factor of greenhouse gas emissions (kg CO_2-e/$) is similarly 5 times the economy-wide average. For exports and land disturbance though, the aluminium sector is approximately 6 times and 10 times better than the economy-wide averages respectively. In contrast, a sector which displays almost average performance for all factors is shown in Figure 3.4.

Figure 3.3: The aluminium sector as an example of a sector with more extreme or outlying indicators in the TBL spider diagram

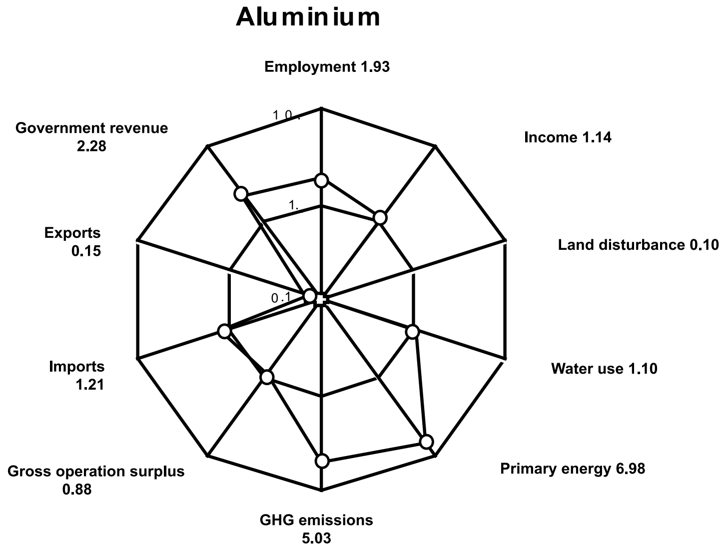
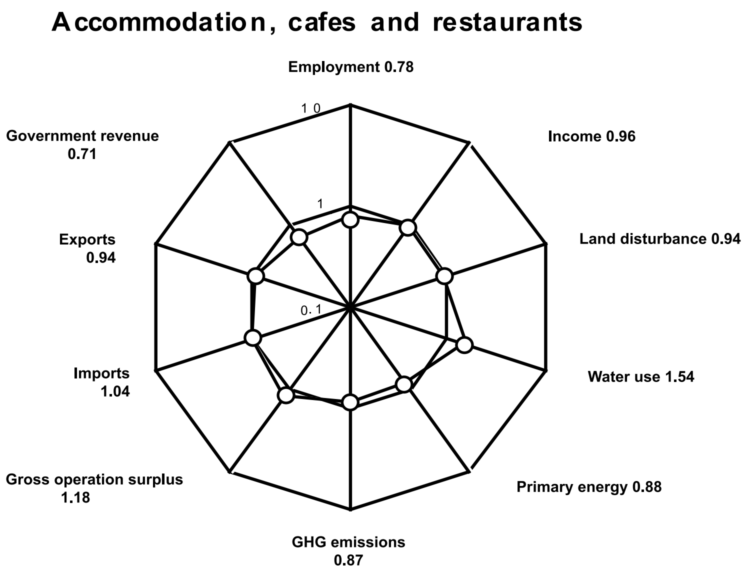


Figure 3.4: The TBL spider diagram for the accommodation, cafes and restaurant sector as an example of a sector with virtually average performance across all factors

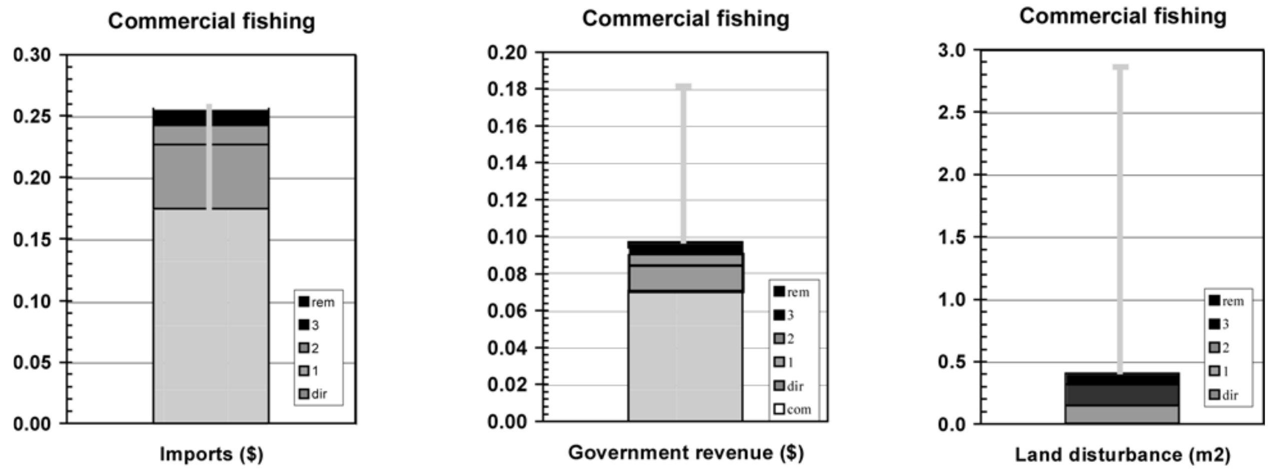


3.4 Bar Graphs

The nine bar graphs accompanying the TBL data tables (see example of three bar graphs in Figure 3.5) visualise the total multipliers listed in the second column at the bottom of Data Sheet 2 (given in Section 3.1) and also later in Figure 3.10. In addition, a breakdown into direct, 1st-order, 2nd-order, 3rd-order and higher-order requirements are shown using different shades. Direct requirements occur on-site (for example within a company in that sector), 1st-order requirements at suppliers of the respective sector, 2nd-order requirements at suppliers of suppliers, and so on (see the visual representations shown in Figure 1.3 and Figure 1.8 of Chapter 1). This so-called *production layer breakdown* is determined by evaluating Equation 24. The grouping of three by three bar graphs are known as TBL accounts 1, 2 and 3. For ease of presentation, the bar graph for primary energy use is omitted. As an example of the meaning of the bar graphs, the imports bar graph in Figure 3.5 shows that direct imports to the commercial fishing sector (eg. boat engines) are about two-thirds of the total import requirement for the sector, which is about 50% above the economy-wide average for imports (in this case the units are $ of imports per $ of final demand).

In the bar graph for the government revenue indicator, for some sectors that pay a direct commodity tax to government (eg petroleum, alcohol, tobacco and gambling), there is an unshaded portion labelled ‘com’ representing this direct payment.

Figure 3.5: Three TBL multiplier bar graphs for the commercial fishing sector. The contribution from direct, 1st, 2nd, 3rd and remaining orders are shown in the shaded regions. The vertical line with the short horizontal bar at the end depicts the economy-wide average. The abbreviation ‘com’ in the government revenue indicator represents direct payments to government such as excise levies on alcohol and tobacco.



3.5 National Accounts Extracts

The National Accounts extracts distinguish the *expenditure calculation* and the *income calculation* of gross national turnover (GNT). Following the National Accounting Identity (Equation 1), the rows and columns in Figure 2.2 of Chapter 2 disaggregate final demand of commodities and primary inputs (value added) of industries into their constituents (Equation 3). Note that final demand and primary inputs balance for the whole economy, not for single sectors. For the latter, the balance is of sectoral total input and output, which includes intermediate demand (Equations 2, 4a and 4b). Note also that GDP is strictly speaking a whole-economy measure, corresponding to ‘gross value added plus net taxes on products’ at the sectoral level. Nevertheless, we have chosen to use the term “Sectoral GDP” for the sake of simplicity in the presentation.

The first column in Figure 3.6 lists the final demand and primary input components (Equation 3). The second column contains the monetary volumes of these components for the respective sector, with (sub-) totals in bold. Column three shows these volumes as a percentage of the economy-wide total, providing an indication of the sector’s size in the entire economy. Finally, column four indicates to what extent final demand is produced in Australia, or is imported.

Figure 3.6: National Accounts extracts for commercial fishing sector

National Accounts extracts			
Receipts: GNT(E)			
Private final consumption	$m 922.4	(0.33% of total)	(96.3% domestically produced)
Government final consumption	$m 102.2	(0.12% of total)	(100.0% domestically produced)
Gross fixed capital expenditure	$m 0.0	(0.00% of total)	
Net changes in stocks	$m 2.4	(0.13% of total)	(96.4% domestically produced)
Sectoral GNE	**$m 1,027.0**	**(0.21% of GNE)**	**(96.6% domestically produced)**
Exports	$m 467.9	(0.53% of total)	(100.0% domestically produced)
Final demand	**$m 1,494.9**	**(0.26% of GNT)**	**(97.7% domestically produced)**
Costs: GNT(I)			
Wages and salaries	$m 251.2	(0.11% of total)	
Gross operating surplus	$m 402.4	(0.21% of total)	
Taxes less subsidies	$m 152.5	(0.28% of total)	
Sectoral GDP*	**$m 806.1**	**(0.17% of GDP)**	
Imports	$m 375.3	(0.38% of total)	
Primary inputs	**$m 1,181.4**	**(0.21% of GNT)**	

* Sectoral gross value added + net taxes on products

3.6 TBL Factors

As introduced in the previous chapter, ten TBL factors were chosen for this study: three economic (gross operating surplus, exports, imports); three social (employment, income, government revenue); and four environmental (greenhouse gas emissions, water use, land disturbance, energy consumption). These factors are described in Chapter 2 and were selected because they address broad, macro-scale objectives, such as alleviation of environmental burdens, employment and income creation, balanced trade, surplus, investment and profits, etc. Note that for particular companies and industries more detailed TBL factors could be chosen (such as toxic compounds in effluents as a TBL indicator for the water supply industry). Additional factors can be readily incorporated into the input-output framework simply by extending the respective matrix in the calculus.

The relationship between factor input and output flows will be described below by reference to the dairy products industry. Each industry sector requires these *directly* or *on site*, in order to produce their total output. A part of this total output is supplied as intermediate demand to other industry sectors, and the other part into final demand. Final demand of a particular commodity entails factor use in the respective primary sector, but also factor use in other sectors that are upstream suppliers of that sector. The sum of on-site and upstream factors embodied in final demand of a commodity is called the *total requirement*.[58] In volumetric terms, over four fifths of the water embodied in dairy

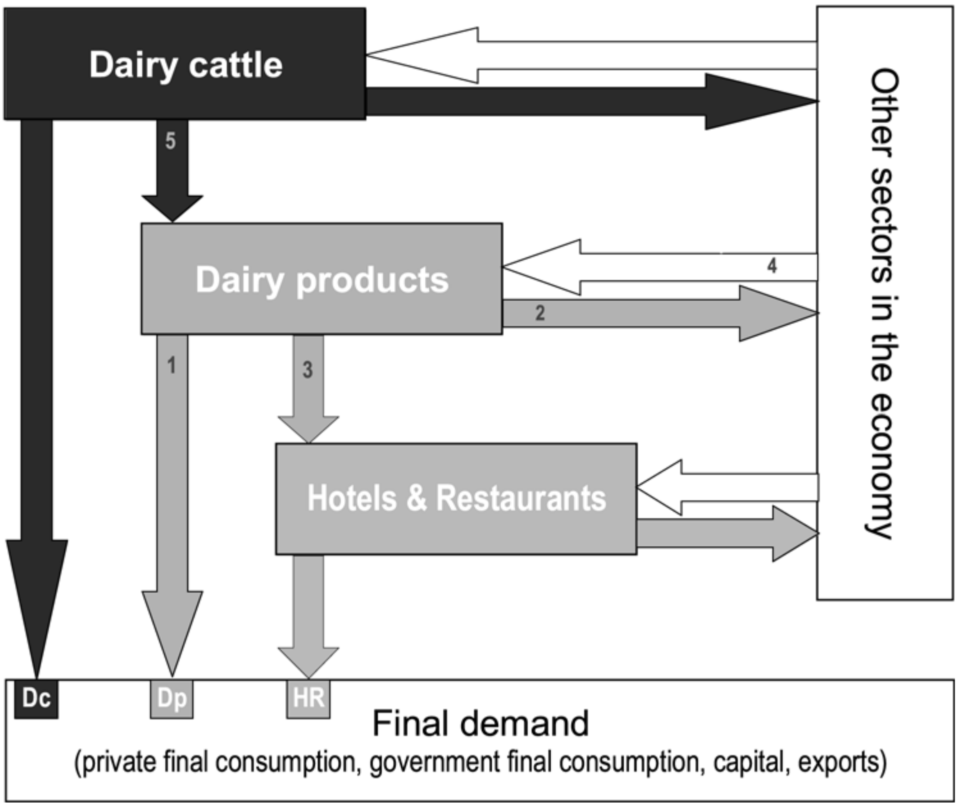
58 According to Equation 12, the three types of requirements can be written as $q_i x_i$, $q_i y_i$, and $\{qLy\}_i$.

products are transferred from the primary sector of ‘dairy cows and whole milk’. Most of this water is for pasture irrigation with minor amounts for stock water and dairy shed cleaning.

In the case of the Australian dairy products *industry* for example (Figure 3.7), this industry needs water directly (large box entitled ‘Dairy products’) in order to produce its outputs. These outputs are (1) for the final demand of the *commodity* ‘dairy products’ (small box entitled ‘Dp’), (2) for other industry sectors (white vertical box), from which (3) the ‘Hotels and Restaurants’ industry (large bottom horizontal box) has been singled out for illustration. Accordingly, the water used directly in the dairy products industry leaves the industry embodied in its outputs (arrows 1, 2 and 3). The content of arrows 1, 2 and 3 is water used in the dairy products industry for all purposes.

A part of the water used in the dairy products *industry* is used to produce the final demand *commodity* ‘dairy products’ (arrow 1). However, in order to produce this commodity, the dairy products industry needs other inputs, and these inputs have embodied water. These inputs are from other sectors of the economy (arrow 4), from which (5) the dairy cattle industry has been singled out for illustration. Accordingly, the whole water embodiment of the final demand *commodity* ‘dairy products’ is contained in arrows 1, 4 and 5.

Figure 3.7: Input and output flows for the example of the dairy products industry



The flows described above are documented in the tables on TBL factors (Figure 3.8).

Figure 3.8: TBL factor requirements of final demand from the dairy products industry

TBL factors	in supplying industry	(% of national)	embodied in GNT direct	(% of national)	total	(% of national)
Gross operating surplus ($m)	$m 634.5	(0.33%)	$m 443.5	(0.23%)	$m 2,013.5	(1.05%)
Exports ($m)	$m 1,515.7	(1.82%)	$m 1,059.3	(1.27%)	$m 1,622.9	(1.95%)
Imports ($m)	$m 117.7	(0.12%)	$m 82.3	(0.08%)	$m 479.5	(0.49%)
Employment (e-y)	14,375 e-y	(0.20%)	10,047 e-y	(0.14%)	63,297 e-y	(0.89%)
Income ($m)*	$m 593.4	(0.26%)	$m 414.7	(0.18%)	$m 1,536.4	(0.68%)
Government revenue ($m)	$m 76.5	(0.14%)	$m 53.5	(0.10%)	$m 245.7	(0.45%)
GHG emissions (kt CO_2-e)	594 kt	(0.11%)	415 kt	(0.08%)	10,321 kt	(1.99%)
Water use (ML)	17,919 ML	(0.09%)	12,524 ML	(0.06%)	2,861,116 ML	(13.66%)
Land disturbance (kha)	2 kha	(0.00%)	1 kha	(0.00%)	1,711 kha	(1.05%)
Primary energy (TJ)	8,046 TJ	(0.21%)	5,624 TJ	(0.14%)	35,278 TJ	(0.91%)

*includes income tax

The contents of arrows 1, 2 and 3 (total factor use in the industry) are listed in the first column. In the case of the dairy products industry, arrows 1, 2 and 3 together contain 17 919 megalitres (ML) of water. Arrow 1 alone – water used in the dairy industry alone for the final demand commodity dairy products – contains 12 524 ML, as listed in the second column. Arrows 1, 4 and 5 – water used for the final demand commodity dairy products from the whole supply chain – is documented in the third column as 2 861 116 ML. A lot of this difference is conveyed via arrow 4, which contains the irrigation water for dairy pastures.

In another example (Figure 3.9), the commercial fishing sector uses 9 713 TJ of primary energy on site, 6 594 TJ of which are used to produce directly for final demand ("embodiment in GNT"), and the remainder supplied to other sectors. However, 6 594 TJ is not all the energy required to produce the final demand of fishing products. A total of 12 295 TJ is needed for this purpose in the commercial fisheries themselves and other sectors supplying fisheries (eg. ships, refineries etc).

Figure 3.9: TBL factor requirements of final demand from the commercial fishing industry

TBL factors	in supplying industry	(% of national)	embodied in commodity GNT direct	(% of national)	total	(% of national)
Gross operating surplus ($m)	$m 402.4	(0.21%)	$m 273.2	(0.14%)	$m 494.6	(0.26%)
Exports ($m)	$m 467.9	(0.56%)	$m 317.7	(0.38%)	$m 459.4	(0.55%)
Imports ($m)	$m 375.3	(0.38%)	$m 254.8	(0.26%)	$m 373.6	(0.38%)
Employment (e-y)	13,463 e-y	(0.19%)	9,140 e-y	(0.13%)	17,252 e-y	(0.24%)
Income ($m)*	$m 195.1	(0.11%)	$m 132.4	(0.08%)	$m 339.1	(0.20%)
Government revenue ($m)†	$m 218.0	(0.20%)	$m 151.0	(0.14%)	$m 257.5	(0.24%)
GHG emissions (kt CO_2-e)	680 kt	(0.13%)	462 kt	(0.09%)	1,077 kt	(0.21%)
Water use (ML)	16,487 ML	(0.08%)	11,193 ML	(0.05%)	29,356 ML	(0.14%)
Land disturbance (kha)	1 kha	(0.00%)	0 kha	(0.00%)	59 kha	(0.04%)
Primary energy (TJ)	9,713 TJ	(0.25%)	6,594 TJ	(0.17%)	12,277 TJ	(0.32%)

*excludes income tax † includes net commodity taxes on final demand and income tax

3.7 TBL Multipliers

TBL multipliers describe how much of a TBL factor is required to generate one dollar value unit of final demand (GNT or GNE) of a particular commodity. As with factor requirements or embodiments, we distinguish direct and total effects: direct effects refer only to on-site use of factors in the respective industry, while total effects cover all upstream suppliers (Figure 3.10).

Figure 3.10: Commercial fishing's TBL Multipliers

TBL multipliers	per $ of GNE/GNT*		Economy-wide average
	direct	total	total
Gross operating surplus ($)	0.19	0.34	0.34
Exports ($)	0.22	0.31	0.15
Imports ($)	0.17	0.26	0.17
Employment (min)	0.78	1.48	1.56
Income ($)	0.12	0.31	0.40
Government revenue ($)	0.08	0.10	0.18
GHG emissions (kg CO_2-e)	0.32	0.74	0.91
Water use (L)	7.66	20.12	36.68
Land disturbance (m^2)	0.00	0.41	2.85
Primary energy (MJ)	4.52	8.42	6.79

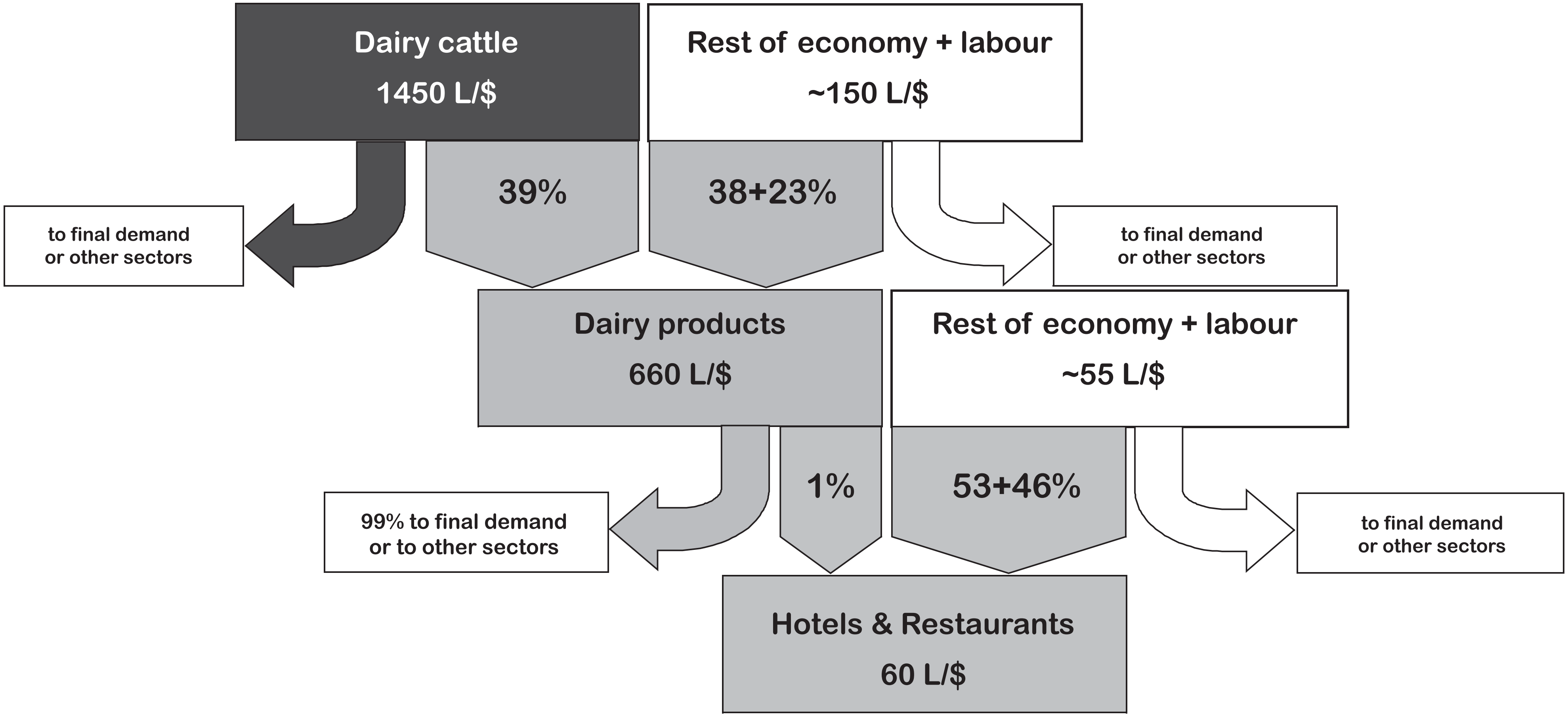
*refers to GNE/GNT produced in the actual year, excludes decreases in stocks

For example, in order to generate one dollar of final demand (GNT, GNE, ...), fisheries need directly about 4.5 MJ of primary energy. About another 3.9 MJ have to be consumed by upstream suppliers (ships, refineries etc). In total, the commercial fishing sector consumes slightly more energy to generate one dollar of final demand (8.4 MJ) than the average Australian sector (6.8 MJ).

Once again, TBL multipliers can be illustrated in terms of supply chain flows. In the case of the Australian dairy products industry (Figure 3.11), the water multiplier is 660 L/$. This water intensity comes about through combining the water-intensive flow from the dairy cattle industry (1 450 litres/$; 39% of the dairy products industry's inputs), and a less water-intensive flow from a basket of other commodity inputs, and primary inputs such as labour (about 150 litres/$; 38% and 23% of the dairy products industry's inputs, respectively).

The dairy products industry itself delivers dairy products to the hotels and restaurants industry. The latter sector combines 1% of water-intensive inputs from the dairy products industry (660 L/$) with a basket of other commodities and labour (53% + 46%, 55 L/$) to yield a water intensity of about 60L/$. This cascade illustrates the "dilution" of TBL factor intensities "down the supply chain", as the value added increases, mainly through addition of labour and capital.

Figure 3.11: Water multipliers in the dairy supply chain



As a further example, the commercial fishing sector requires 17¢ of imported products to generate $1 of final demand (Figure 3.10). The suppliers of the fishing sector require another 6¢ of imports, the suppliers of the suppliers another 1.5¢, and so on. The overall imports requirement of the commodity ‘commercial fishing’ is 26¢/$, which is higher than the economy-wide average of 17 ¢/$.

Note that the bar graph for government revenue shows additional commodity taxes such as fuel, tobacco and alcohol excises, levied on final demand (see Section 3.4 above).

3.8 Structural Path Analysis

The algorithm described in Section 2.6 was run in order to obtain a decomposition of TBL multipliers according to Equation 25. In the following, each path will be characterised by a code, consisting of (see Figure 3.12):

(1) A description of the path vertices

(2) The path value

(3) The path order

(4) The path coverage, that is, the relative contribution (in %) to the total TBL factor multiplier referring to the final demand from the sector in the last vertex.

In the presentation of the results, vertices are assigned the codes listed in Appendix 3.1. For example:

(1) The structural path Oi Fo Fi 0.011 (2; 1.5%) for greenhouse gas emissions describes the emissions caused during crude oil (Oi) extraction (for example flaring at rigs) for refining into diesel fuel oil (Fo) used by the fishing fleet (Fi)

(2) The path value is 0.011 kg CO_2-e per $ of final demand

(3) The path order is of 2nd order (see Figure 1.3)

(4) The path constitutes 1.5% of the total greenhouse gas multiplier of the commercial fishing sector

Figure 3.12: Results of a ‘Structural Path Analysis’ for commercial fishing (Fi) ranked by contribution. Not all paths are listed, since there are many individual paths diminishing in size.

Gross operating surplus ($/$)			Employment (min/$)			GHG emissions (kg CO_2-e/$)		
Fi	0.187	(0; 55.%)	Fi	0.781	(0; 53.%)	Fi	0.316	(0; 43.%)
Wt Fi	0.0165	(1; 4.9%)	Wt Fi	0.119	(1; 8.1%)	El Fi	0.0396	(1; 5.4%)
Fd Fi	0.00575	(1; 1.7%)	Eq Fi	0.0285	(1; 1.9%)	Fd Fi	0.0379	(1; 5.1%)
Oi Fo Fi	0.00521	(2; 1.5%)	Ma Fi	0.0248	(1; 1.7%)	Fo Fi	0.0366	(1; 5.%)
Rv Fi	0.00462	(1; 1.4%)	Rh Fi	0.013	(1; 0.88%)	Wt Fi	0.0165	(1; 2.2%)
St Wt Fi	0.00315	(2; 0.93%)	Fd Fi	0.0128	(1; 0.87%)	Bc Mp Fd Fi	0.0113	(3; 1.5%)
Eq Fi	0.00289	(1; 0.85%)	Om Fi	0.0127	(1; 0.86%)	Oi Fo Fi	0.011	(2; 1.5%)
Bk Fi	0.00267	(1; 0.79%)	Rv Fi	0.0124	(1; 0.84%)	Is Ma Fi	0.00679	(2; 0.92%)
Ms Wt Fi	0.00239	(2; 0.71%)	Ms Wt Fi	0.0107	(2; 0.73%)	Ap Fi	0.00581	(1; 0.79%)
Rh Fi	0.00213	(1; 0.63%)	Bk Fi	0.0106	(1; 0.72%)	Is Sh Fi	0.00508	(2; 0.69%)
Fo Fi	0.00201	(1; 0.59%)	Sh Fi	0.0104	(1; 0.71%)	El Wt Fi	0.00496	(2; 0.67%)
Pt Fi	0.002	(1; 0.59%)	Pl Fi	0.00986	(1; 0.67%)	Is Eq Fi	0.00423	(2; 0.57%)
Pd Wt Fi	0.0019	(2; 0.56%)	Mv Fi	0.00907	(1; 0.62%)	Ch Pl Fi	0.00412	(2; 0.56%)
Ma Fi	0.00187	(1; 0.55%)	Rd Fi	0.00833	(1; 0.57%)	Nf Fi	0.00366	(1; 0.5%)
Pl Fi	0.00185	(1; 0.55%)	Ps Fi	0.00832	(1; 0.56%)	Oi Ap Fi	0.00301	(2; 0.41%)
Sh Fi	0.00175	(1; 0.52%)	Ee Fi	0.00688	(1; 0.47%)	Bc Mp Fi	0.00299	(2; 0.41%)
Mv Fi	0.00167	(1; 0.49%)	Su Fd Fi	0.00577	(2; 0.39%)	El En Fi	0.00248	(2; 0.34%)

(1) Vertices (2) Value (3) Order (4) Coverage

3.9 Linkages

All linkages shown in this work are *domestic* linkages that indicate the transmission and dispersion of economic stimulus throughout associated sectors within Australia (Figure 3.13).

Figure 3.13: Upstream and downstream linkages of the commercial fishing sector and their coefficients of variation (C.o.V.)[59]

Linkages (average = 1)

	Value	C.o.V
Upstream	0.987 ±0.016	(±1.6%)
Downstream	0.446 ±0.021	(±4.7%)

A downstream linkage value greater than one for a sector indicates that above-average total output is necessary to utilise, absorb or accompany a unit (one dollar) of primary inputs injected into that sector. In other words: the sector disperses more per dollar of input into the rest of the economy than other sectors.

Low downstream linkage values indicate that a substantial amount of the sector's output is not utilised by other sectors, but exits the system into final demand (domestic final consumption or exports). For example, consumer products and services (fruit and vegetable products, sport and recreational services) or export commodities (eg. alumina, aluminium, ores) have low downstream linkages. The opposite is true for commodities that are mainly taken up by domestic intermediate users (eg. financial and business services, structural metal products).

While the linkage itself describes the *transmission* of economic dependence, its coefficient of variation describes the *dispersion* of that transmission. A high coefficient of variation indicates the existence of only a few, strongly absorbing downstream sectors (eg. alumina). A low coefficient of variation indicates that dependence is spread relatively evenly across the economy (eg. banking).

An upstream linkage value greater than one for a sector indicates above-average activity is required in the whole economy per dollar of final demand from that sector. In other words: *the sector draws more heavily on the rest of the economy than others*.

Low upstream linkage values indicate that a substantial amount of the sector's requirements are labour (eg health services) or investment (eg water supply), or have to be imported (eg aircraft). The opposite holds for commodities that are mainly produced using other domestic intermediate products (eg meat and leather products, non-ferrous metal products).

Once again, a high coefficient of variation for a particular sector indicates the existence of only a few, but important supplying sectors, while a low coefficient of variation indicates that the sector require inputs that are spread relatively evenly across the economy. A low coefficient of variation means that an increase in final demand for a commodity with a certain upstream linkage, will be dispersed more widely across the economy than an increase in the final demand for another commodity with the same upstream linkage, but higher coefficient of variation.

59 Note that in the technical literature, 'forward' and 'backward' are used instead of 'downstream' and 'upstream'.

3.10 Other Parts of the Sectoral Results Presentation

In addition to the data tables, graphs and their descriptions outlined in the sections above, the sectoral results also contain the following commentaries.

Sector Description: a brief description of the main activities in the sector, particularly if these are not obvious from the sector title. This usually includes such aspects as the turnover of the sector, the approximate number of enterprises involved, and the main trade issues associated with the sector. The information contributing to this section came from about 20 sources including many products from the Australian Bureau of Statistics, the Australian Bureau of Agricultural and Resource Economics (ABARE), Geoscience Australia, IBIS Consulting, the Department of Industry Tourism and Resources , the Productivity Commission, and many industry websites and press releases.

Future Trends in Sector: a brief statement of the likely changes in the sector out to the year 2050. A key resource for this section is the *Australian Stocks and Flows Framework* used in CSIRO futures studies such as *Future Dilemmas* (Foran and Poldy, 2002), *Fish Futures to 2050* (Kearney et al., 2003) and *Decision Points* (Dunlop et al., 2004). In addition, a wide range of government reports were accessed such as the *Intergenerational Report* by the Department of Treasury (2002). For specific sectors such as textiles, aluminium, printing, automobile making and so on, a wide range of future orientated analyses were accessed via scientific literature and structured searching on the internet.

Innovation and Technical Opportunities: this section summarises some technological responses to the key issues raised for the sectors. Information for this section has been collected through structured searches of thousands of on-line scientific journals available through CSIRO's electronic library service and selective reference to reputable industry web sites.

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Appendix 1:

Codes assigned to 135 industry sectors specified in the Australian input-output classification.

Symbol	No.	Short title
Wo	1	Sheep and shorn wool
Ba	2	Barley
Ri	3	Rice
Wh	4	Wheat & other grains
Bc	5	Beef cattle
Dc	6	Dairy cattle & milk
Pg	7	Pigs
Pe	8	Poultry and eggs
Su	9	Sugar cane
Sc	10	Cotton
Vf	11	Vegetable and fruit
Cg	12	Services to agriculture
Sw	13	Softwoods
Hw	14	Hardwoods
Fr	15	Forestry
Fi	16	Commercial fishing
Bl	17	Black coal
Oi	18	Crude oil
Ng	19	Natural gas
Lg	20	LNG, LPG
Br	21	Brown coal
Io	22	Iron ores
Bx	23	Bauxite
Co	24	Copper
Gl	25	Gold and lead
Sz	26	Silver and zinc
Uo	27	Other non-ferrous metal ores
Sg	28	Other mining
Mn	29	Services to mining
Mp	30	Meat products
Dp	31	Dairy products
Fp	32	Fruit and vegetable products
Of	33	Oils and fats
Fc	34	Flour and cereal foods
Bp	35	Bakery products
Cn	36	Confectionery
Fd	37	Other food products
Bv	38	Soft drinks, cordials and syrups
Bm	39	Beer and malt
Ws	40	Wine and spirits
To	41	Tobacco products
Tx	42	Fibres, yarns, fabrics
Tp	43	Textile products
Kn	44	Knitting mill products
Cl	45	Clothing
Fw	46	Footwear
Lp	47	Leather products
Ti	48	Sawmill products
Wp	49	Other wood products
Pp	50	Pulp, paper and paperboard
Pa	51	Paper containers and products
Pr	52	Printing
Ne	53	Publishing
Ap	54	Automotive petrol
Ke	55	Kerosene and aviation jet fuel
Fo	56	Gas oil, fuel oil
Pc	57	Other petroleum and coal products
Fe	58	Mixed fertilisers
Ch	59	Basic chemicals
Pt	60	Paints

Symbol	No.	Short title
Ph	61	Pharmaceuticals
Ac	62	Agricultural chemicals
De	63	Soap and other detergents
Ct	64	Cosmetics and toiletry preparations
Oc	65	Other chemical products
Ru	66	Rubber products
Pl	67	Plastic products
Gp	68	Glass products
Cr	69	Ceramic products
Ce	70	Cement
Lm	71	Lime
Cc	72	Concrete and mortar
Cp	73	Plaster and other concrete products
Mi	74	Other non-metallic mineral products
Is	75	Basic iron and steel
Ao	76	Alumina
Al	77	Aluminium
Nf	78	Other basic non-ferrous metal products
Sm	79	Structural metal products
Sh	80	Sheet metal products
Fm	81	Fabricated metal products
Mv	82	Motor vehicles and parts
Sb	83	Ships and boats
Rw	84	Railway equipment
Ai	85	Aircraft
Oe	86	Scientific equipment
En	87	Electronic equipment
Hh	88	Household appliances
Ee	89	Electrical equipment
Ma	90	Agricultural and other machinery
Eq	91	Other machinery and equipment
Bu	92	Prefabricated buildings
Fu	93	Furniture
Om	94	Other manufacturing
El	95	Electricity supply
Ga	96	Gas production and distribution
Wa	97	Water supply, sewerage and drainage
Rb	98	Residential building
Nb	99	Non-residential construction
Wt	100	Wholesale trade
Rt	101	Retail trade
Rv	102	Mechanical repairs
Rh	103	Other repairs
Ho	104	Accommodation, cafes and restaurants
Bt	105	Bus and tramway transport
Ta	106	Taxi and hired car with driver

Symbol	No.	Short title
Rd	107	Road freight
Rp	108	Railway passenger transport
Pi	109	Pipeline transport
Ot	110	Other transport
Rf	111	Railway freight
Sp	112	Water transport
At	113	Air and space transport
St	114	Other services to transport
Cm	115	Communication
Bk	116	Banking
Fn	117	Non-bank finance
In	118	Insurance
Sf	119	Services to finance
Dw	120	Ownership of dwellings
Pd	121	Property services
Ts	122	Scientific and technical services
Ms	123	Business management services
Bs	124	Other business services
Gv	125	Government administration
Df	126	Defence
Ed	127	Education
Hs	128	Health services
Cs	129	Community care
Et	130	Motion picture, radio and TV
Cu	131	Libraries, museums, arts
Rs	132	Sport and recreation
Ps	133	Personal services
Gd	134	Sanitary and garbage disposal
Os	135	Other services

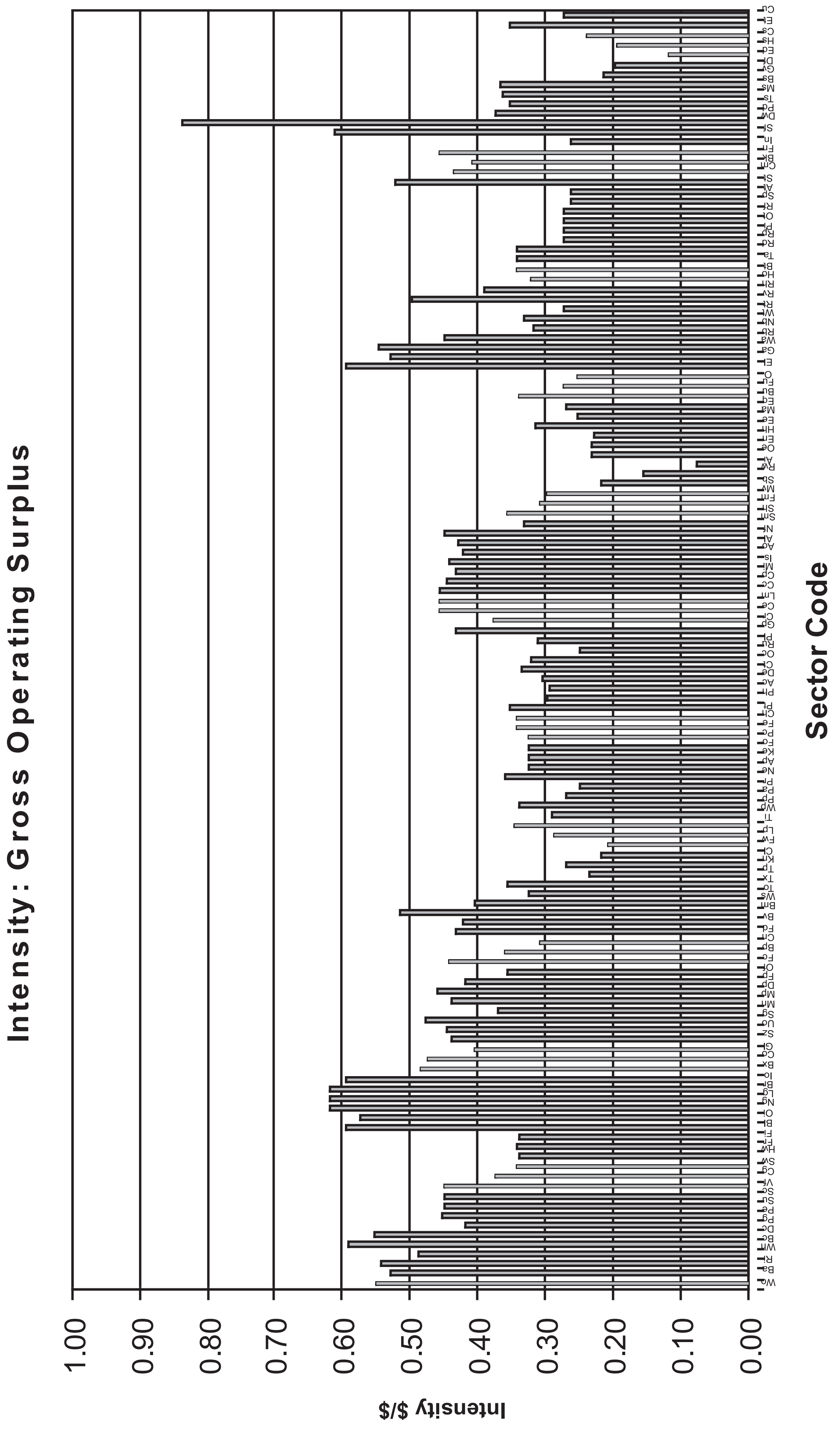
Symbol	Industry
Ac	Agricultural chemicals
Ai	Aircraft
Al	Aluminium
Ao	Alumina
Ap	Automotive petrol
At	Air and space transport
Ba	Barley
Bc	Beef cattle
Bk	Banking
Bl	Black coal
Bm	Beer and malt
Bp	Bakery products
Br	Brown coal
Bs	Other business services
Bt	Bus and tramway transport
Bu	Prefabricated buildings
Bv	Soft drinks, cordials and syrups
Bx	Bauxite
Cc	Concrete and mortar
Ce	Cement
Cg	Services to agriculture
Ch	Basic chemicals
Cl	Clothing
Cm	Communication
Cn	Confectionery
Co	Copper
Cp	Plaster and other concrete products
Cr	Ceramic products
Cs	Community care
Ct	Cosmetics and toiletry preparations
Cu	Libraries, museums, arts
Dc	Dairy cattle & milk
De	Soap and other detergents
Df	Defence
Dp	Dairy products
Dw	Ownership of dwellings
Ed	Education
Ee	Electrical equipment
El	Electricity supply
En	Electronic equipment
Eq	Other machinery and equipment
Et	Motion picture, radio and TV
Fc	Flour and cereal foods
Fd	Other food products
Fe	Mixed fertilisers
Fi	Commercial fishing
Fm	Fabricated metal products
Fn	Non-bank finance
Fo	Gas oil, fuel oil
Fp	Fruit and vegetable products
Fr	Forestry
Fu	Furniture
Fw	Footwear
Ga	Gas production and distribution
Gd	Sanitary and garbage disposal
Gl	Gold and lead
Gp	Glass products
Gv	Government administration
Hh	Household appliances
Ho	Accommodation, cafes and restaurants
Hs	Health services
Hw	Hardwoods
In	Insurance
Io	Iron ores
Is	Basic iron and steel
Ke	Kerosene and aviation jet fuel
Kn	Knitting mill products

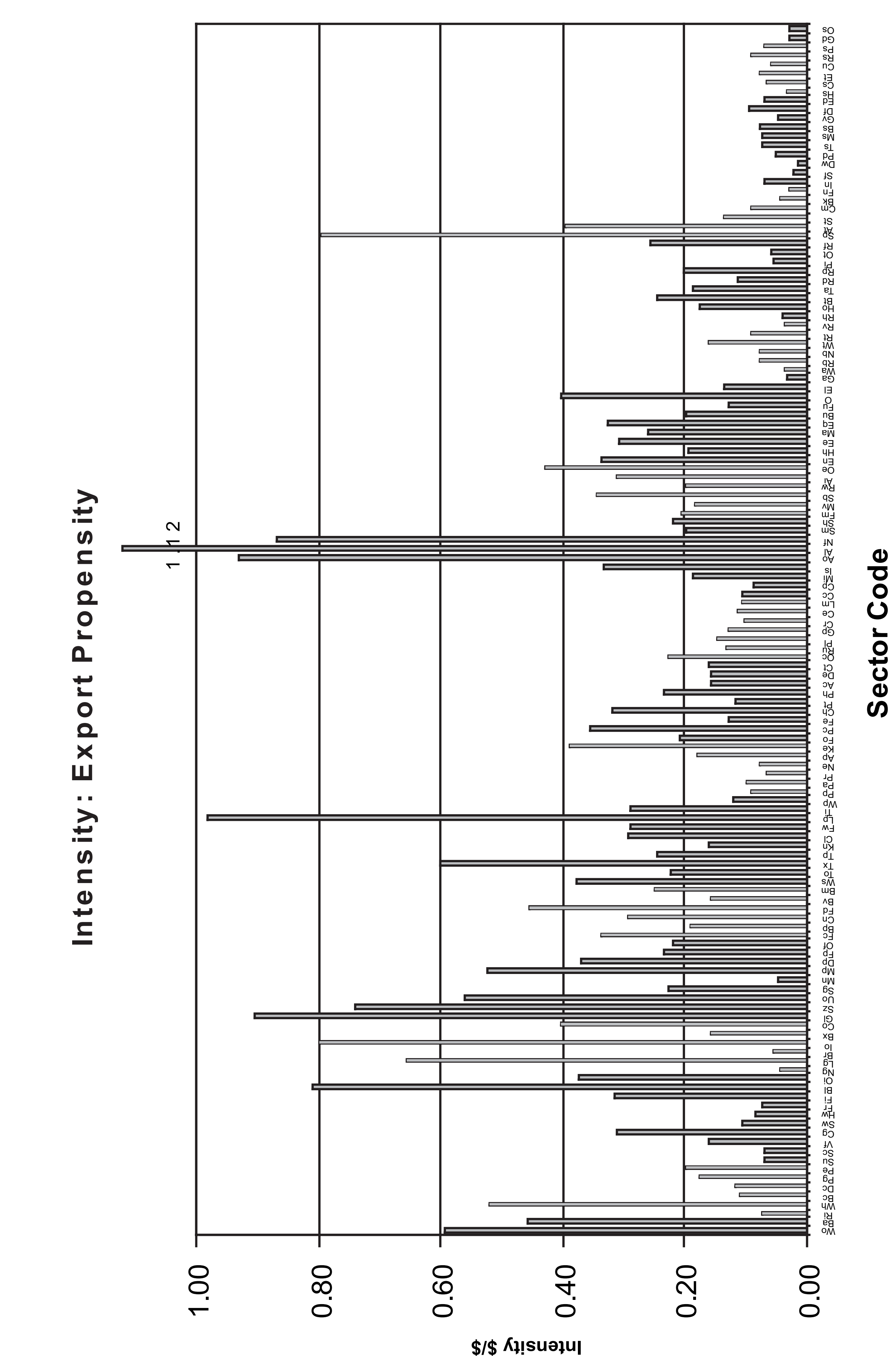
Symbol	Industry
Lg	LNG, LPG
Lm	Lime
Lp	Leather products
Ma	Agricultural and other machinery
Mi	Other non-metallic mineral products
Mn	Services to mining
Mp	Meat products
Ms	Business management services
Mv	Motor vehicles and parts
Nb	Non-residential construction
Ne	Publishing
Nf	Other basic non-ferrous metal products
Ng	Natural gas
Oc	Other chemical products
Oe	Scientific equipment
Of	Oils and fats
Oi	Crude oil
Om	Other manufacturing
Os	Other services
Ot	Other transport
Pa	Paper containers and products
Pc	Other petroleum and coal products
Pd	Property services
Pe	Poultry and eggs
Pg	Pigs
Ph	Pharmaceuticals
Pi	Pipeline transport
Pl	Plastic products
Pp	Pulp, paper and paperboard
Pr	Printing
Ps	Personal services
Pt	Paints
Rb	Residential building
Rd	Road freight
Rf	Railway freight
Rh	Other repairs
Ri	Rice
Rp	Railway passenger transport
Rs	Sport and recreation
Rt	Retail trade
Ru	Rubber products
Rv	Mechanical repairs
Rw	Railway equipment
Sb	Ships and boats
Sc	Cotton
Sf	Services to finance
Sg	Other mining
Sh	Sheet metal products
Sm	Structural metal products
Sp	Water transport
St	Other services to transport
Su	Sugar cane
Sw	Softwoods
Sz	Silver and zinc
Ta	Taxi and hired car with driver
Ti	Sawmill products
To	Tobacco products
Tp	Textile products
Ts	Scientific and technical services
Tx	Fibres, yarns, fabrics
Uo	Other non-ferrous metal ores
Vf	Vegetable and fruit
Wa	Water supply, sewerage and drainage
Wh	Wheat & other grains
Wo	Sheep and shorn wool
Wp	Other wood products
Ws	Wine and spirits
Wt	Wholesale trade

Appendix 2:

Charts of TBL Intensities

Chart 1	**Intensity: Operating Surplus $/$**
Chart 2	**Intensity: Export Propensity $/$**
Chart 3	**Intensity: Import Penetration $/$**
Chart 4	**Intensity: Employment minutes/$**
Chart 5	**Intensity: Income $/$**
Chart 6	**Intensity: Government Revenue $/$**
Chart 7	**Intensity: Greenhouse Gas Emissions kg CO_2-e/$**
Chart 8	**Intensity: Managed Water Use litres/$**
Chart 9	**Intensity: Land Disturbance square metres/$**
Chart 10	**Intensity: Primary Energy Use megajoules/$**


Intensity: Gross Operating Surplus
Sector Code
Intensity $/$
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00



Intensity: Export Propensity
Intensity $/$
Sector Code
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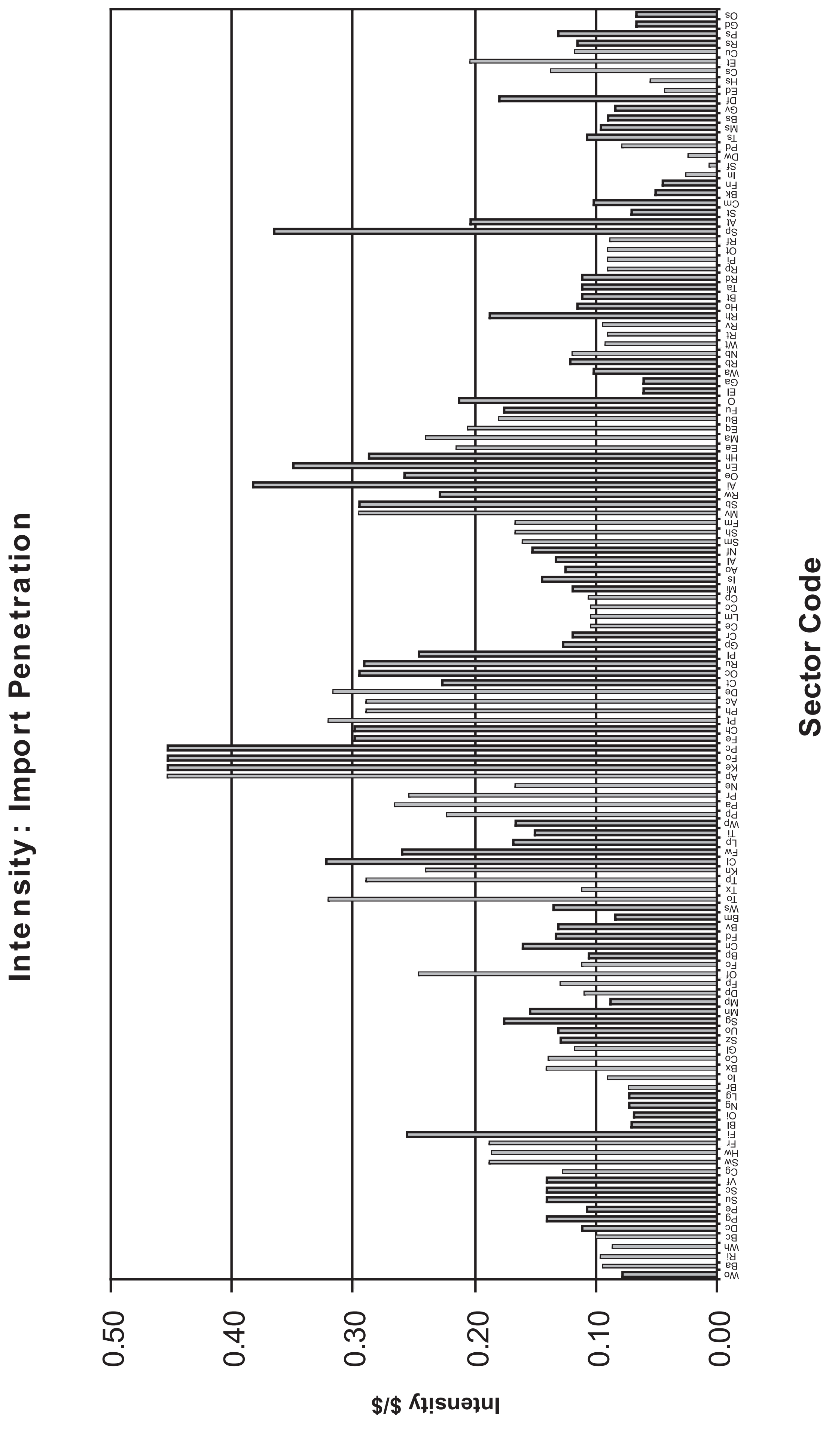
0.80
0.60
0.40
0.20
0.00
1.12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Intensity $/$
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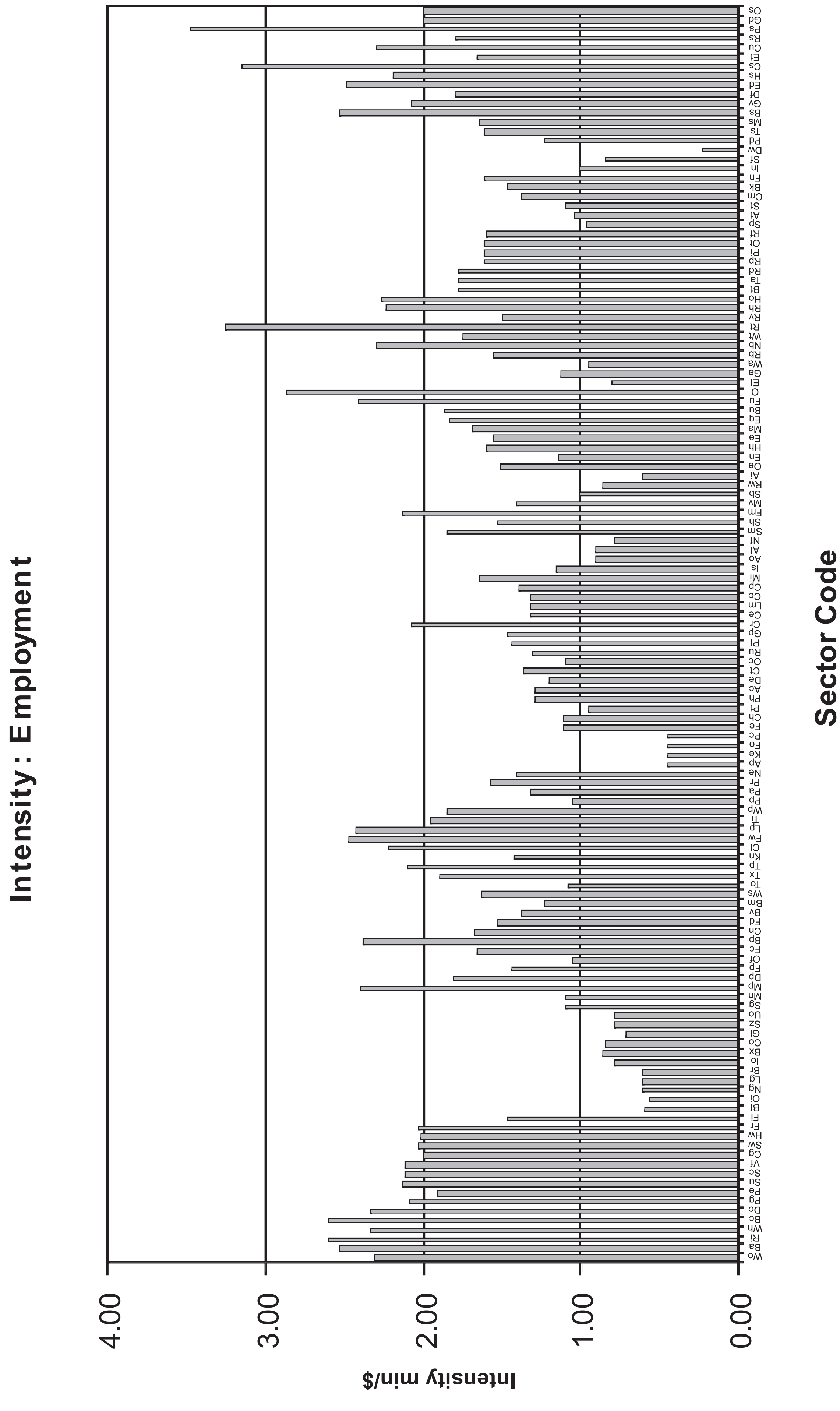
0.30
0.20
0.10
0.00
Sector Code


Intensity : Employment
Intensity min/$
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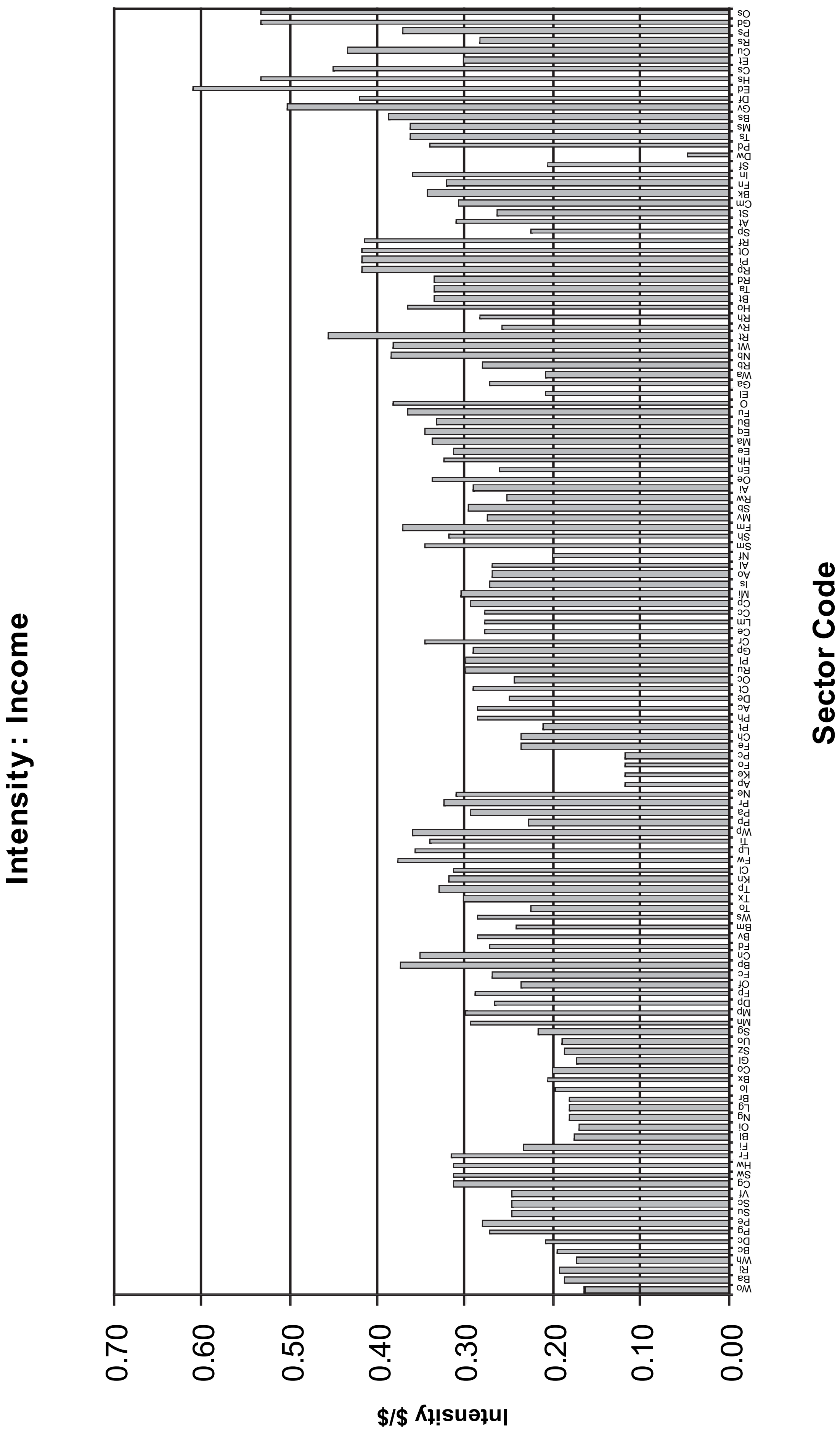
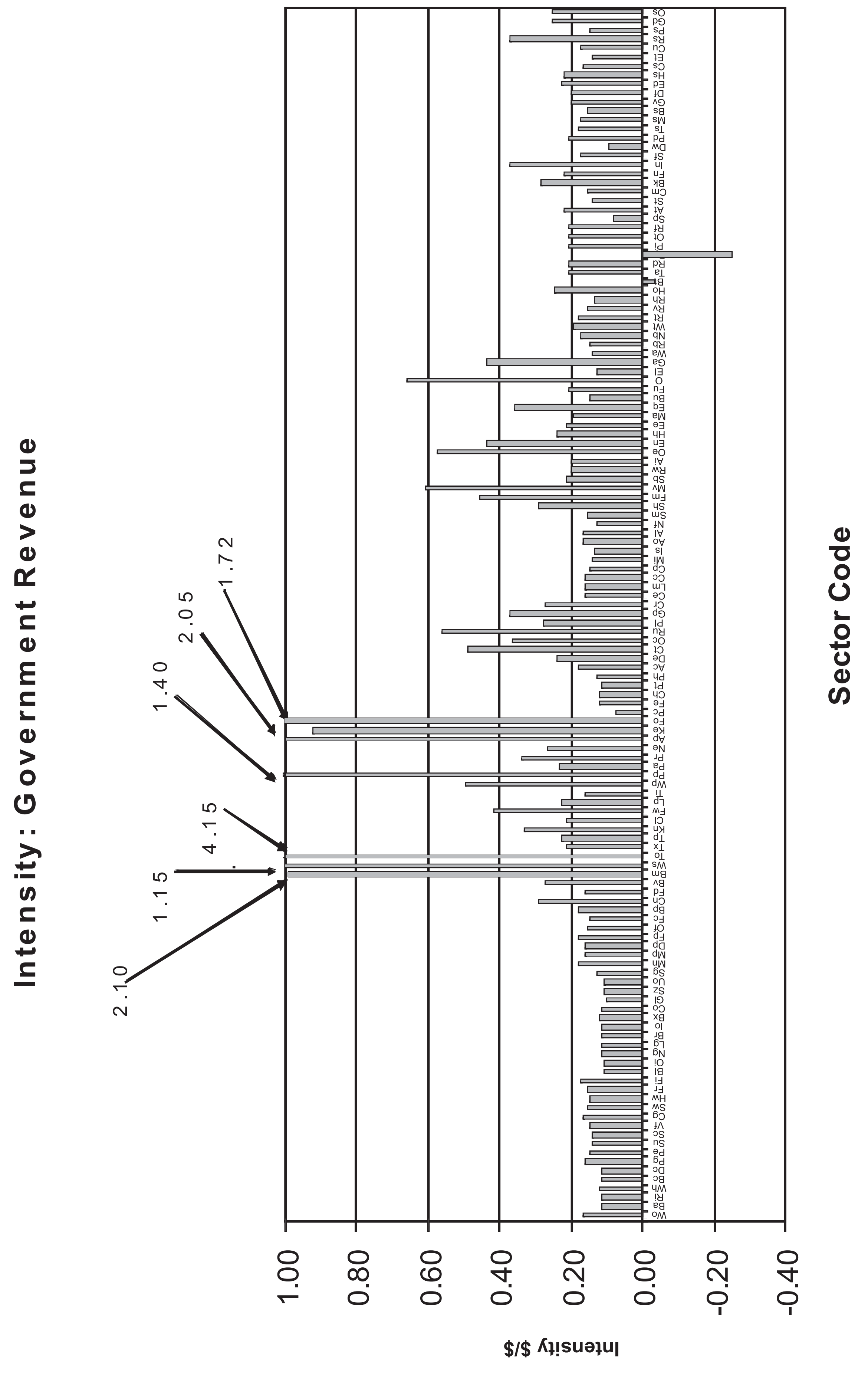
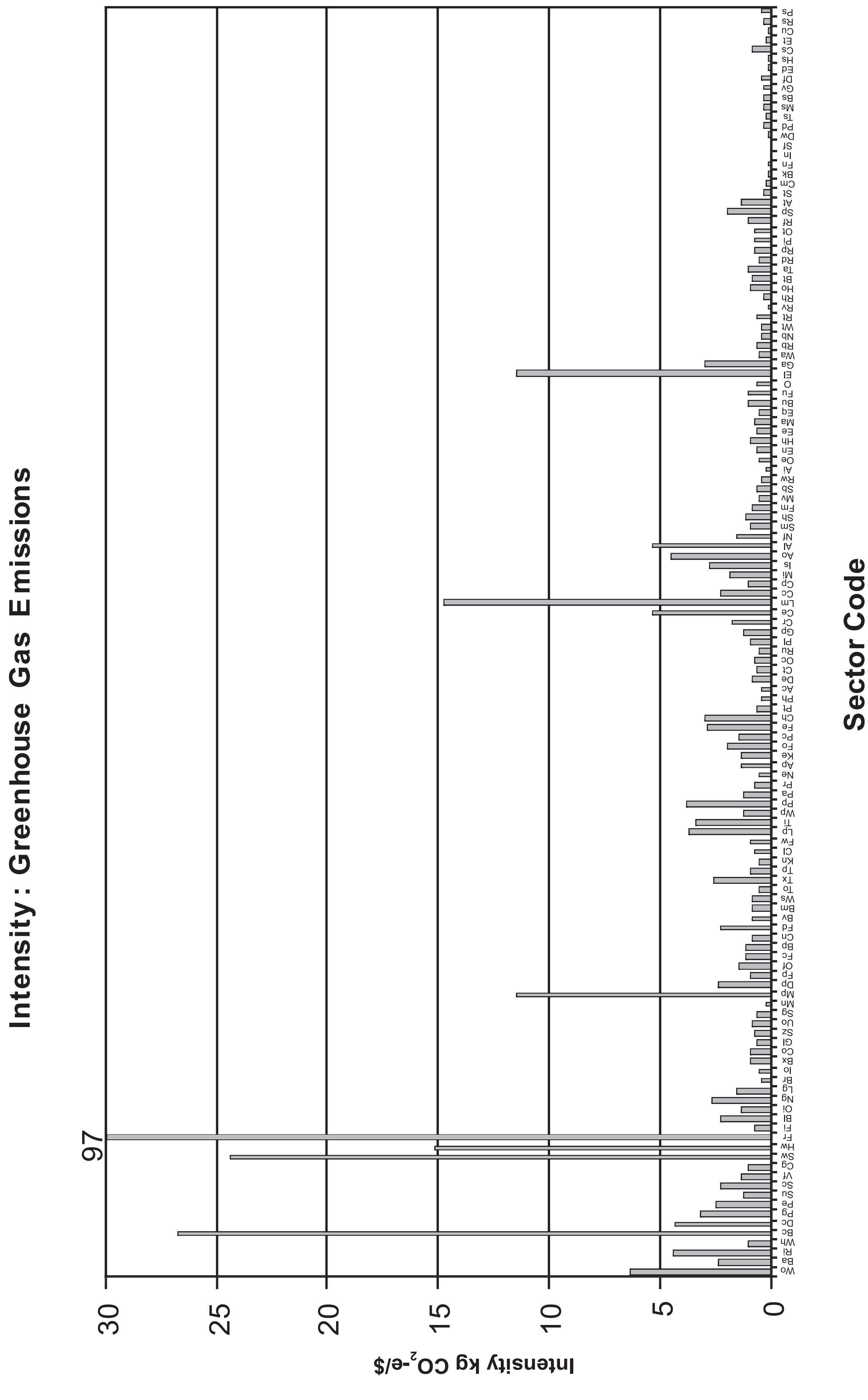
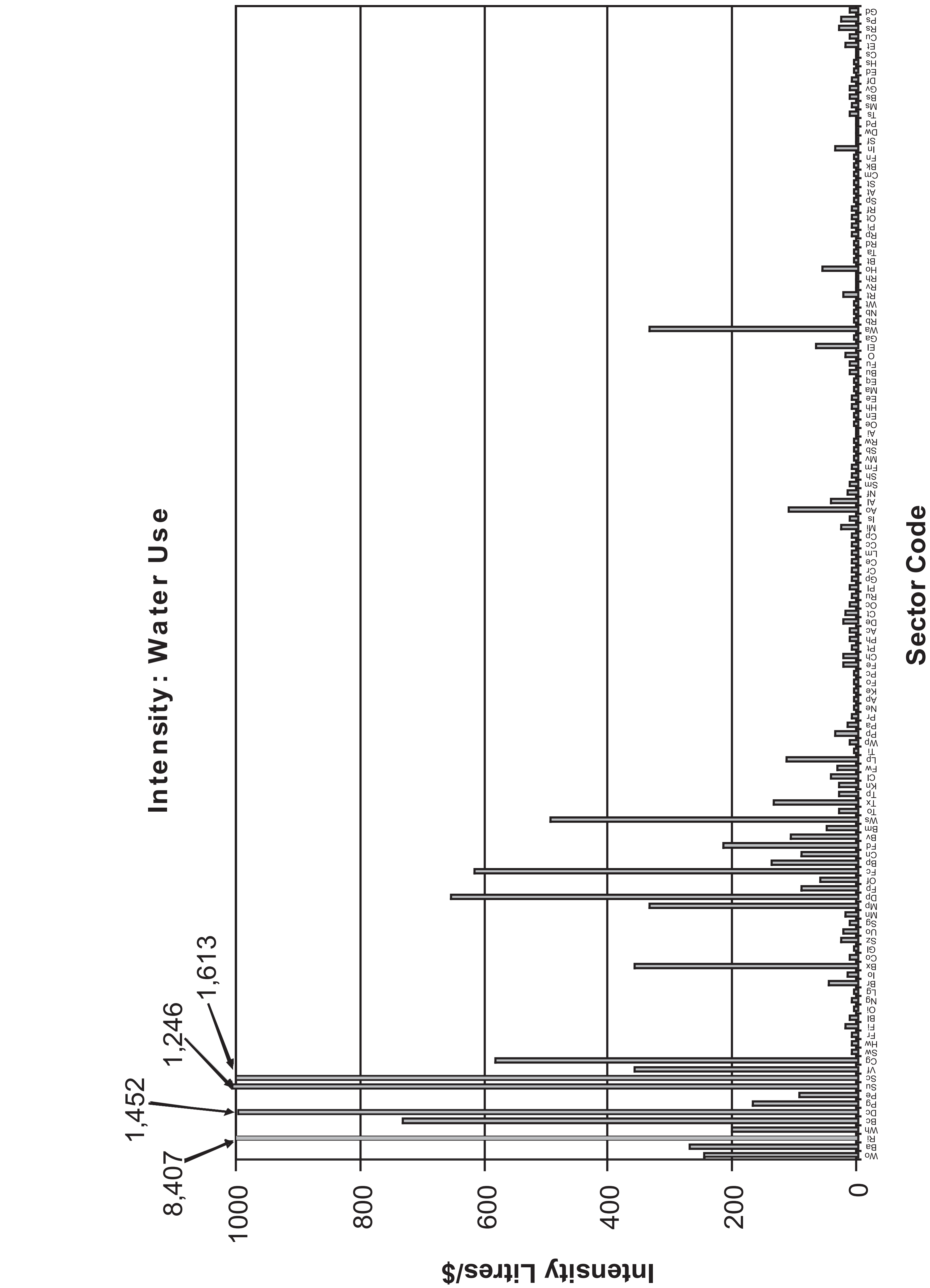
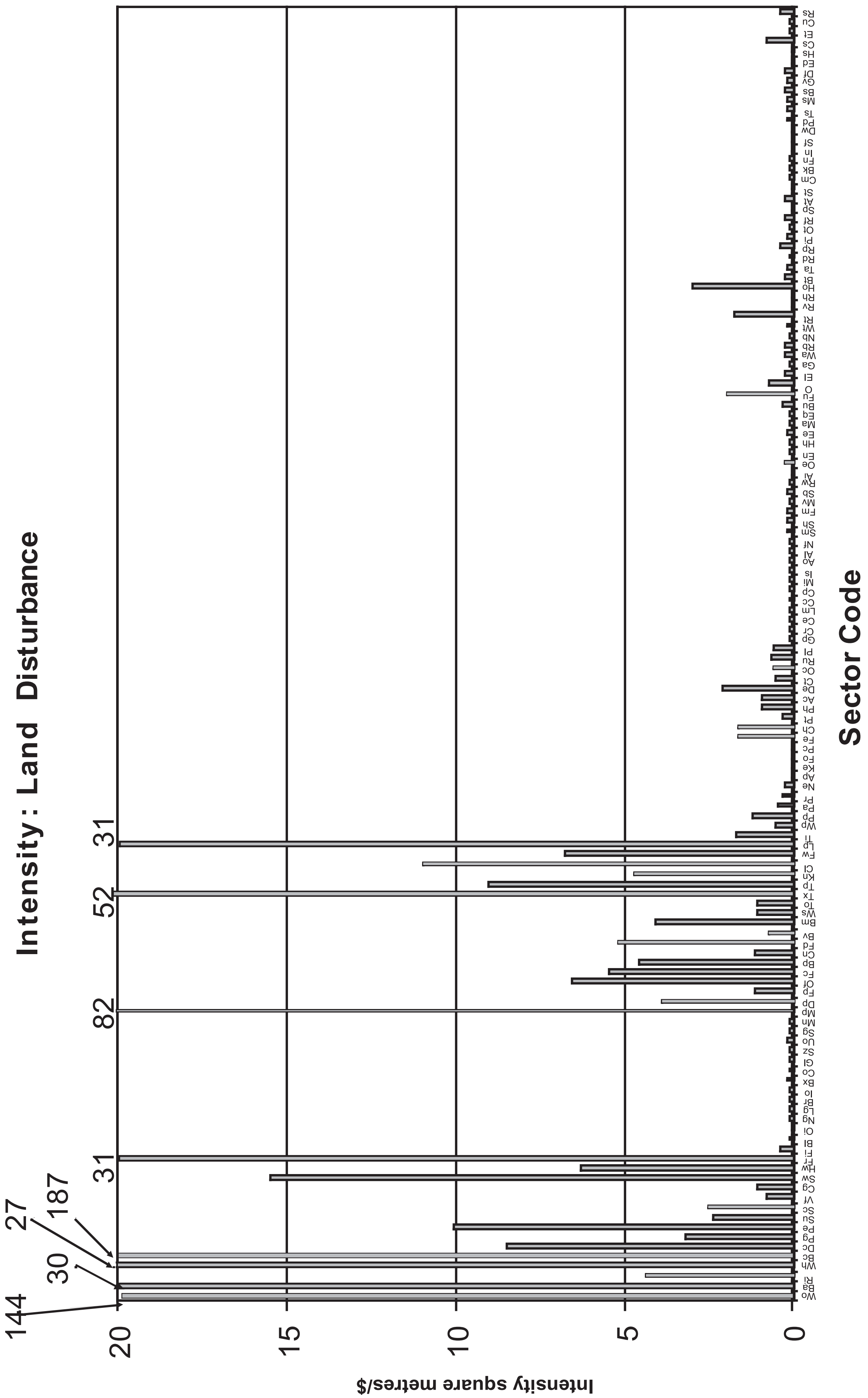
3.00
2.00
1.00
0.00
Sector Code

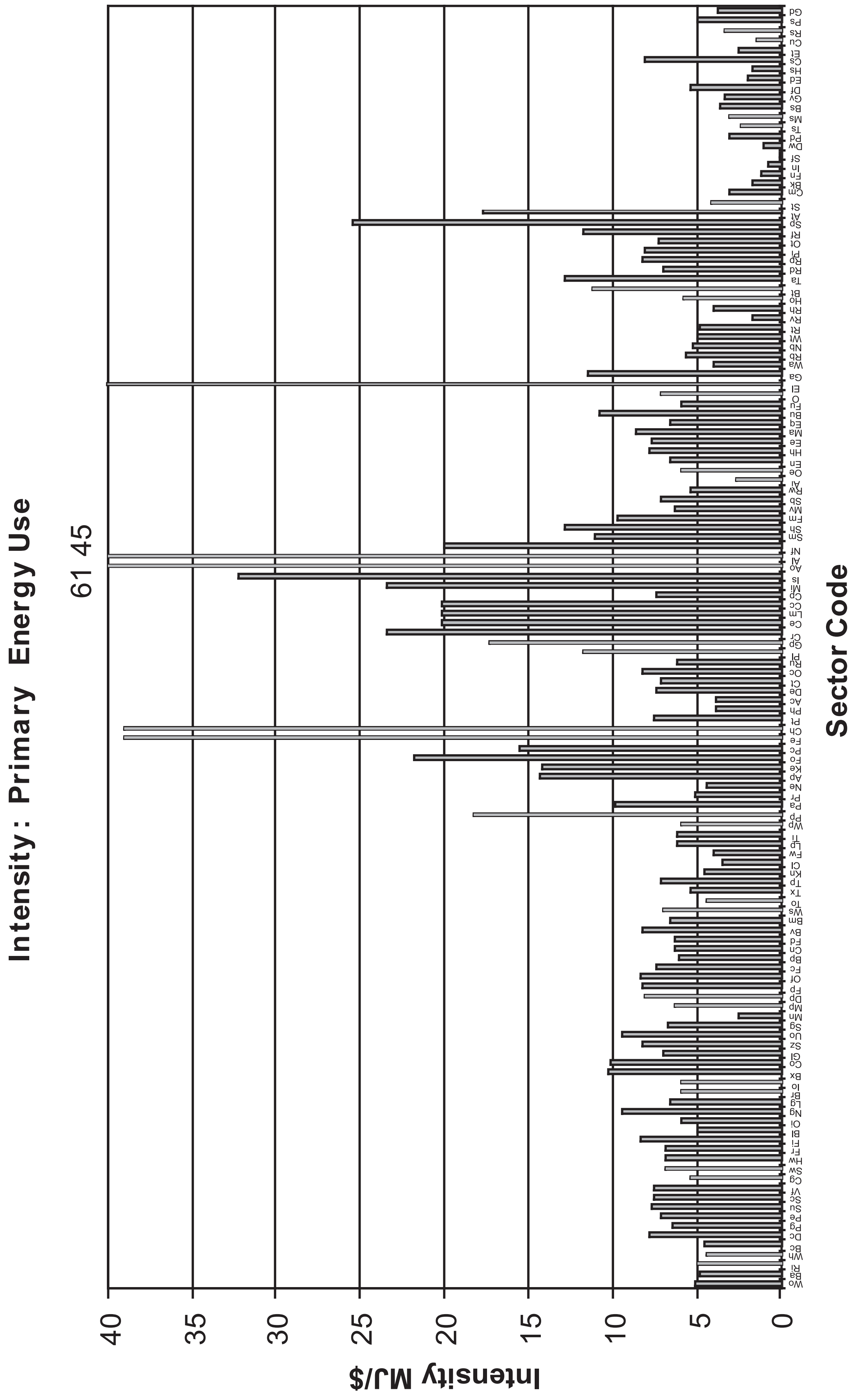

Intensity : Income
Intensity $/$
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
Sector Code


Intensity: Government Revenue
2.10
1.15
4.15
1.40
2.05
1.72
1.00
0.80
0.60
0.40
0.20
0.00
-0.20
-0.40
Intensity $/$
Sector Code


Intensity: Greenhouse Gas Emissions
Intensity kg CO_2-e/$
Sector Code
97
0
5
10
15
20
25
30


Intensity: Water Use
Intensity Litres/$
Sector Code
8,407
1,452
1,246
1,613
1000
800
600
400
200
0

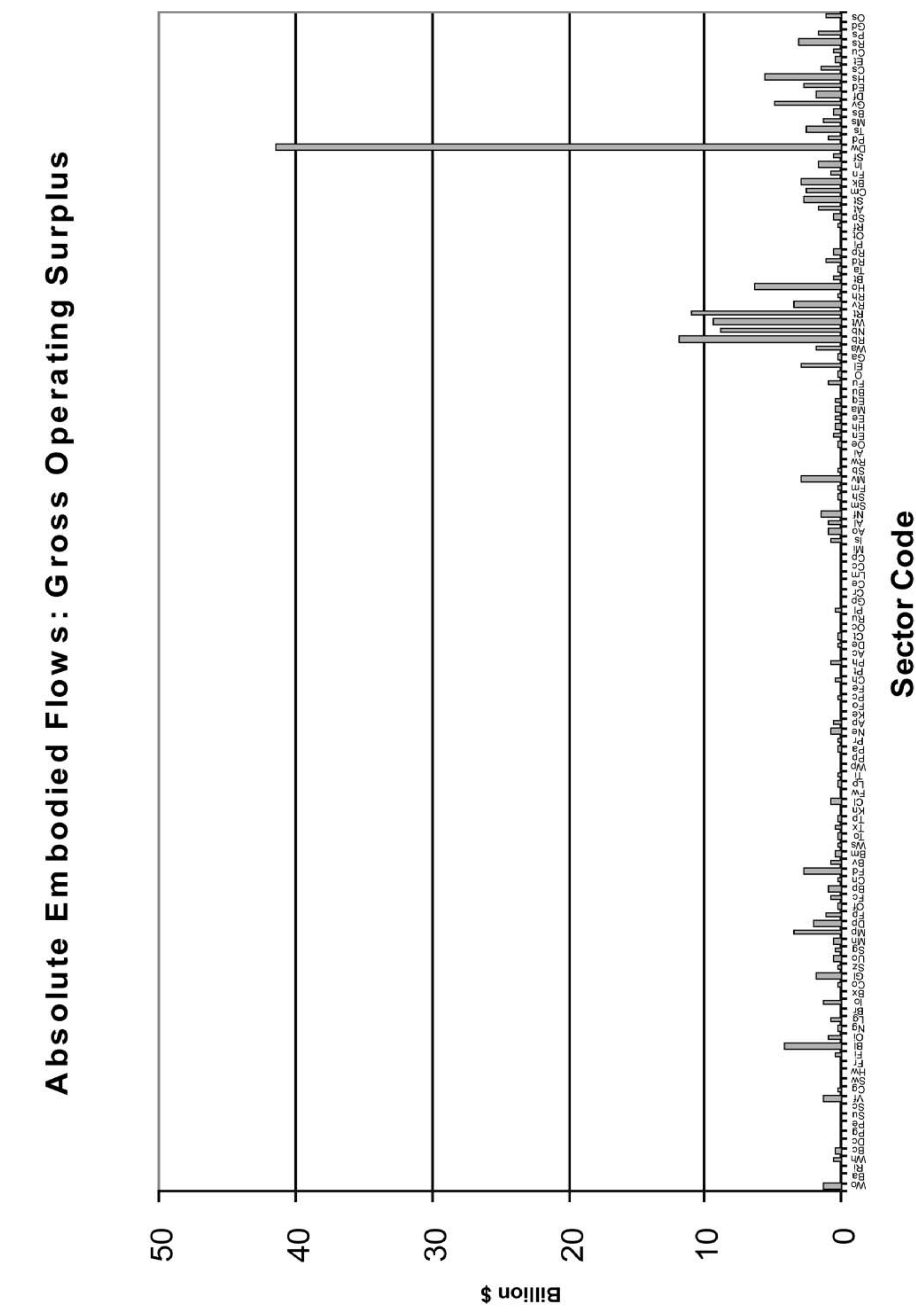

Intensity: Land Disturbance
Sector Code
Intensity square metres/$
0
5
10
15
20
144
30
27
187
31
82
52
31

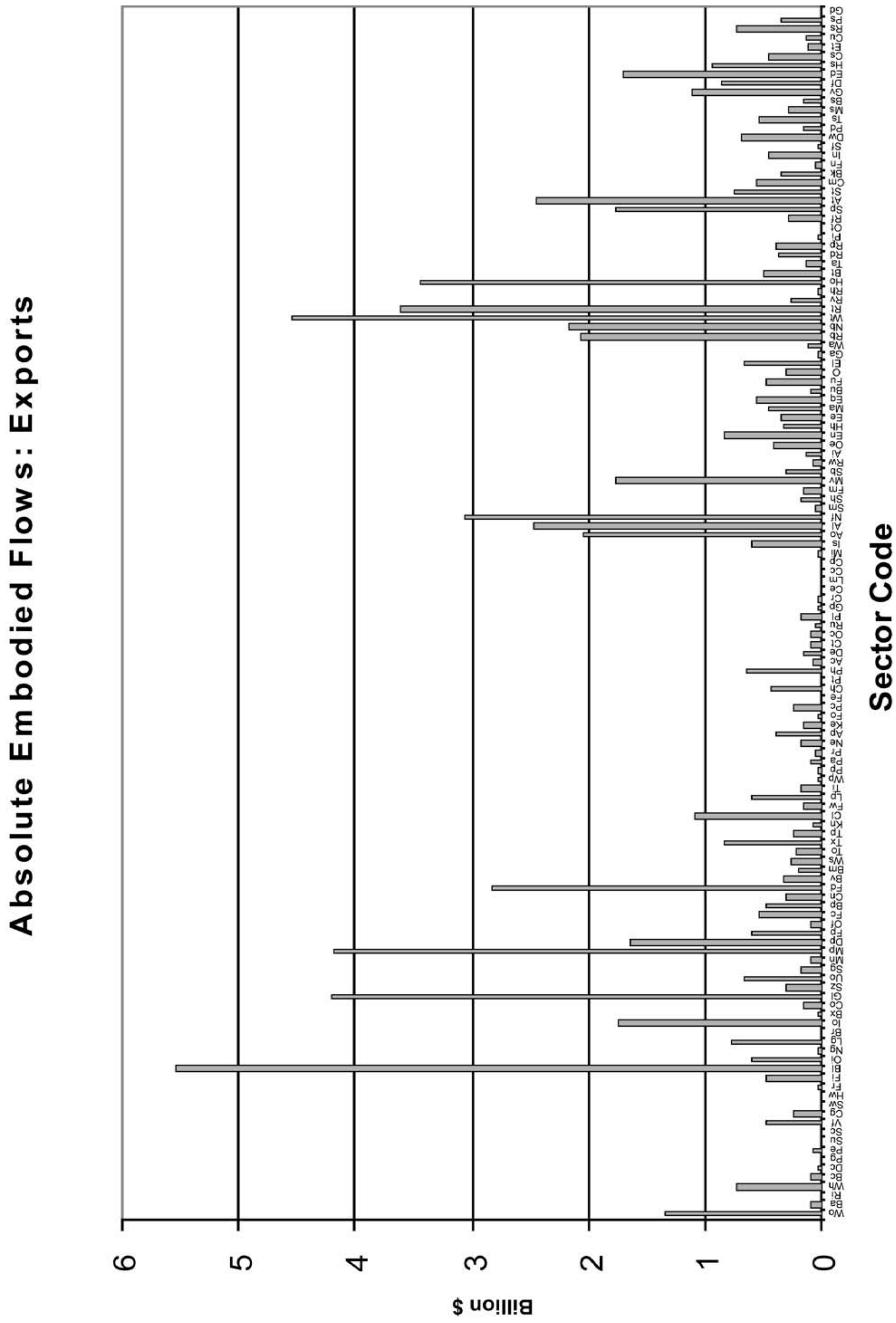

Intensity: Primary Energy Use
61 45
Intensity MJ/$
Sector Code
0
5
10
15
20
25
30
35
40

Appendix 3:

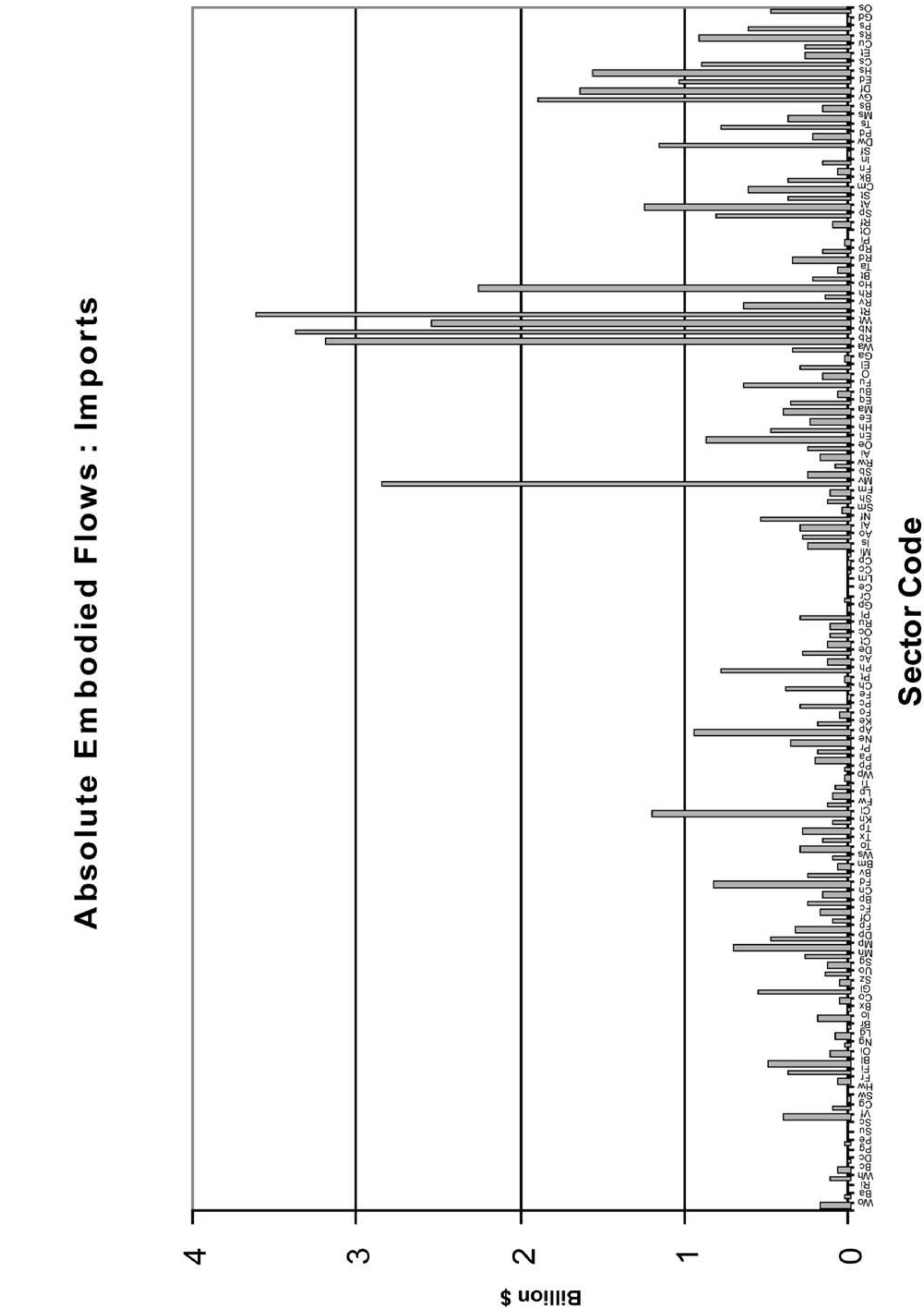
Charts of Absolute Embodied Flows

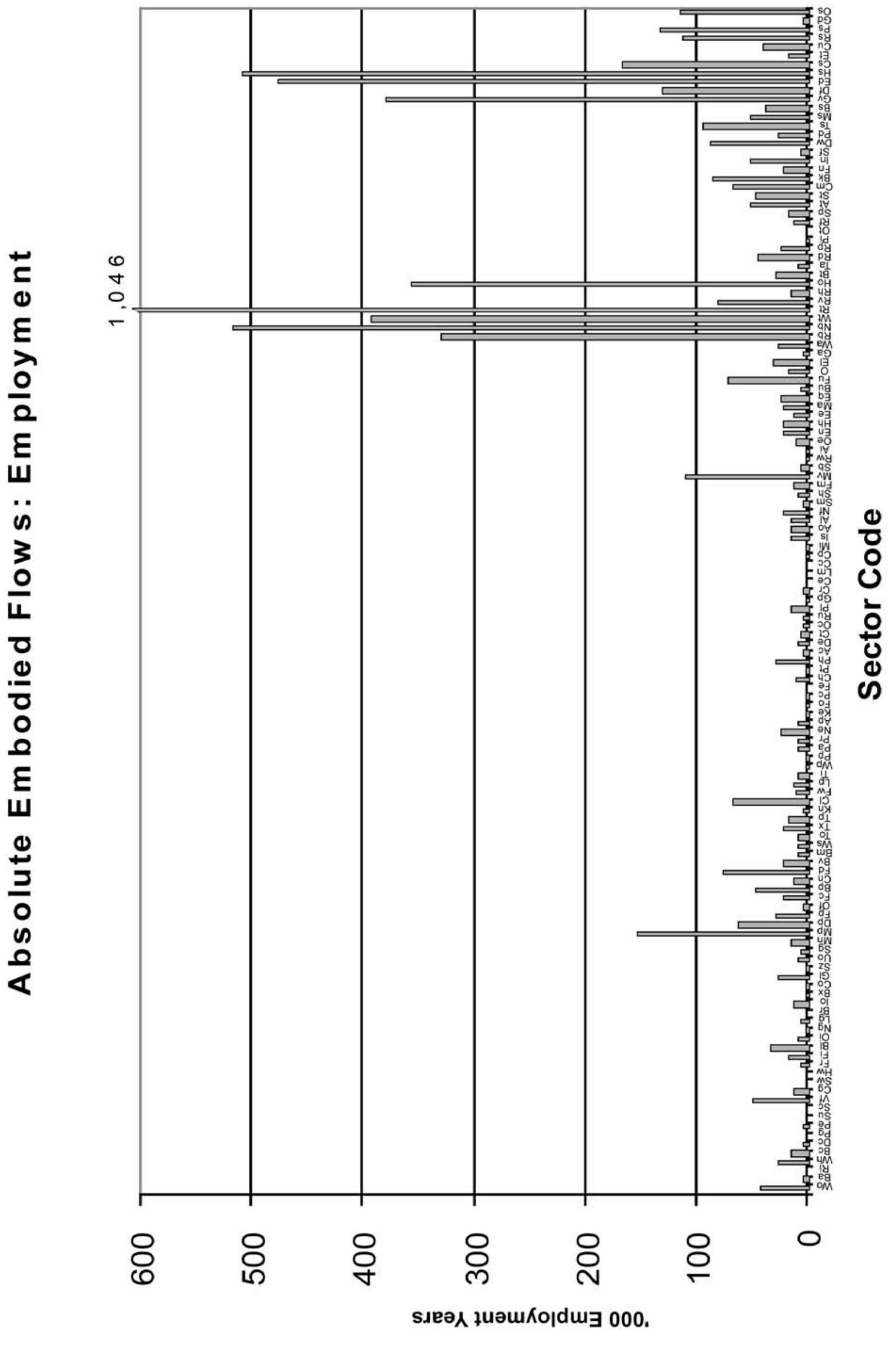
Chart 1	**Absolute Flows: Operating Surplus billion $**
Chart 2	**Absolute Flows: Exports billion $**
Chart 3	**Absolute Flows: Imports billion $**
Chart 4	**Absolute Flows: Employment thousand employment years**
Chart 5	**Absolute Flows: Income billion $**
Chart 6	**Absolute Flows: Government Revenue billion $**
Chart 7	**Absolute Flows: Greenhouse Gas Emissions million tonnes CO_2-e**
Chart 8	**Absolute Flows: Managed Water Use gigalitres**
Chart 9	**Absolute Flows: Land Disturbance million hectares**
Chart 10	**Absolute Flows: Primary Energy Use petajoules**

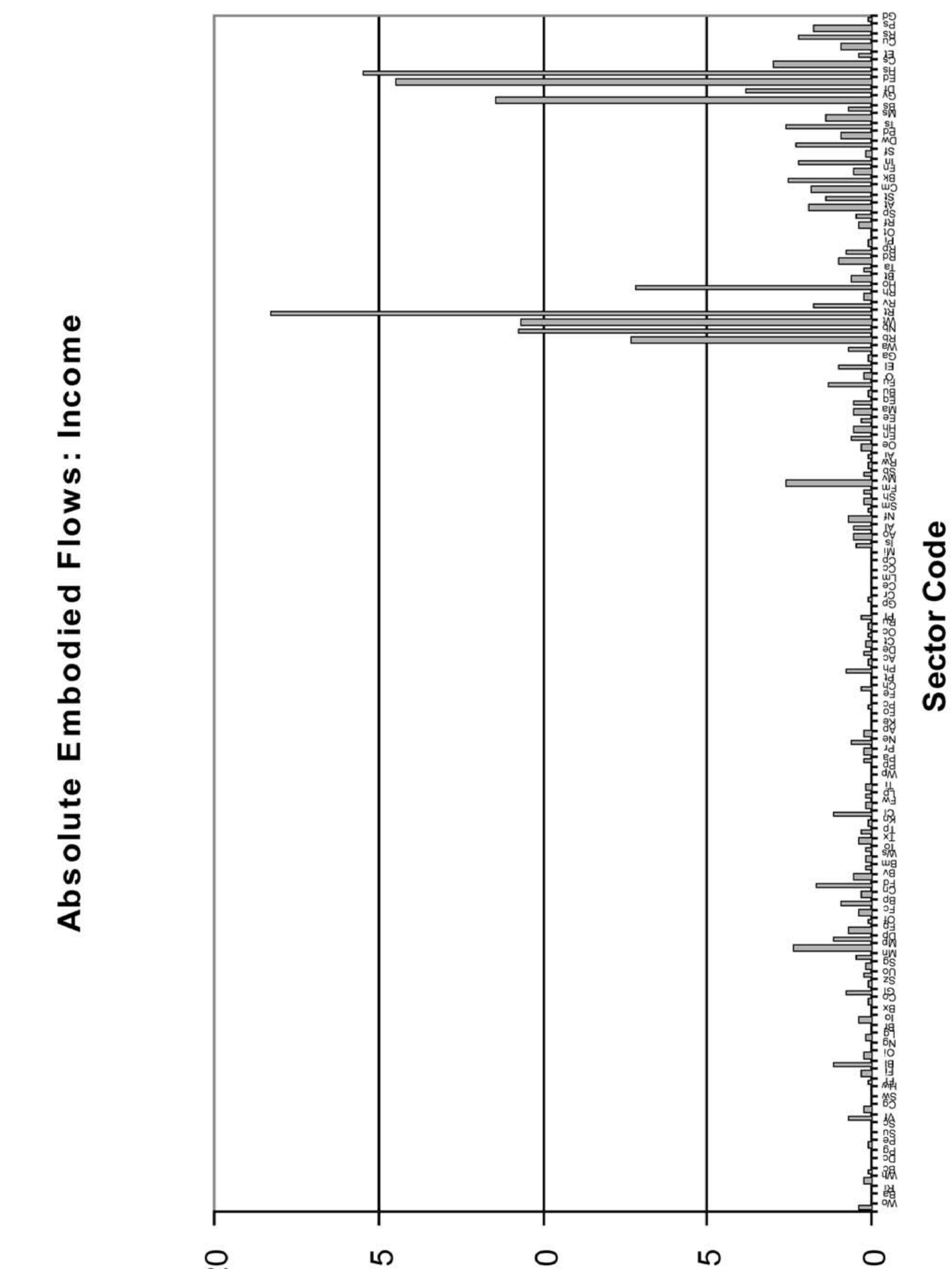

Absolute Embodied Flows: Gross Operating Surplus
Billion $
0
10
20
30
40
50
Sector Code

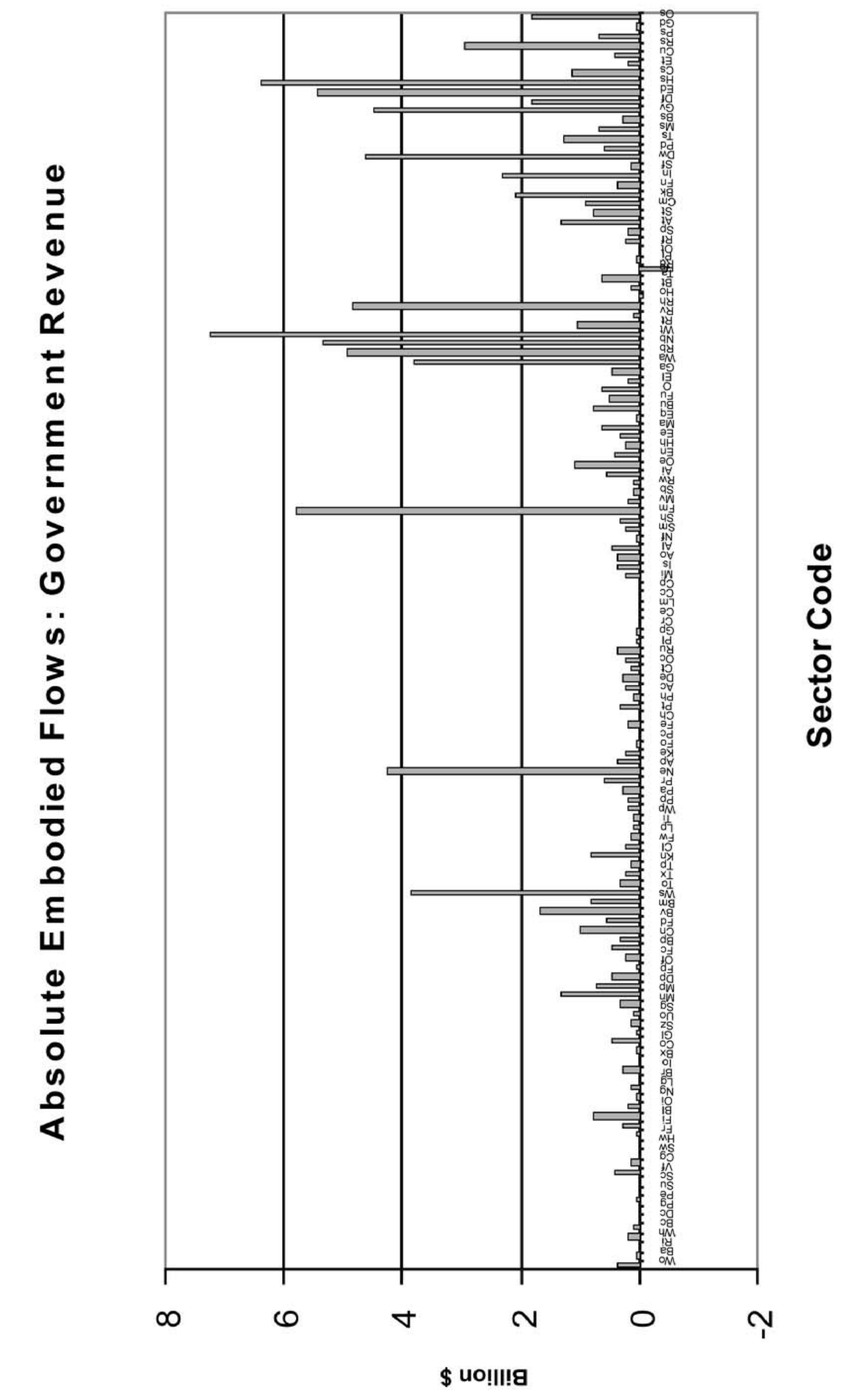


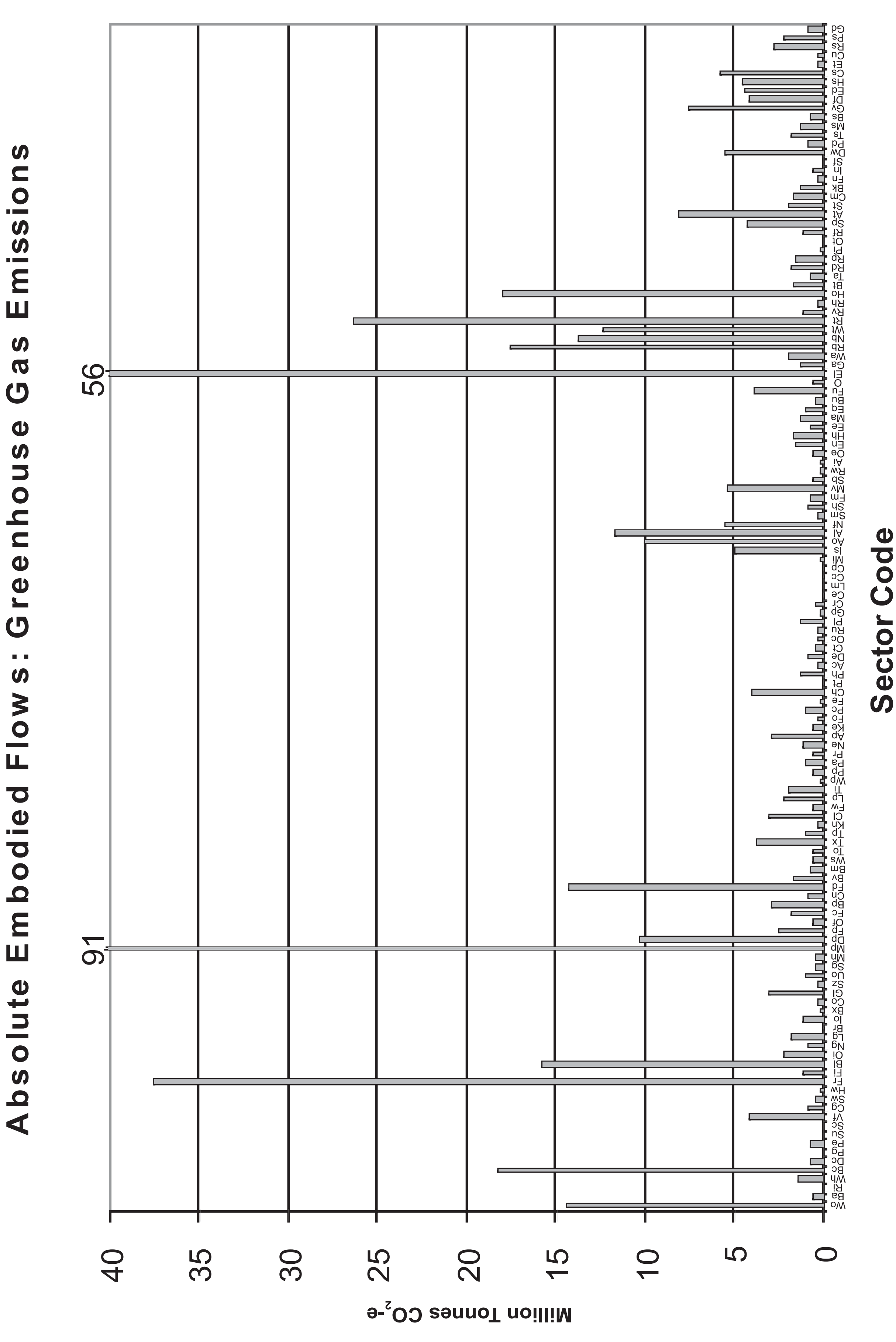
Absolute Embodied Flows: Exports
Billion $
0
1
2
3
4
5
6
Sector Code

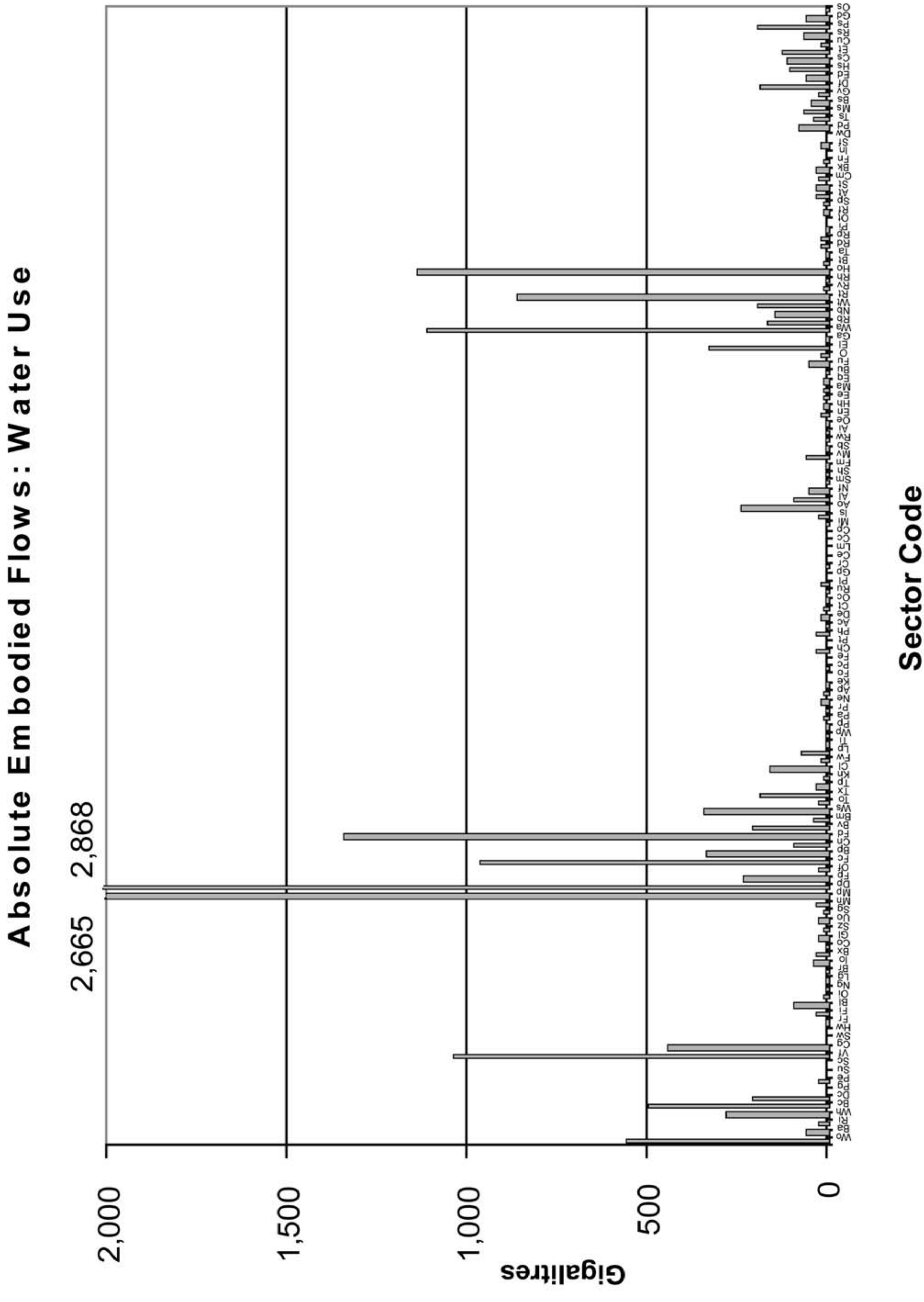

Absolute Embodied Flows : Imports
Billion $
0
1
2
3
4
Sector Code

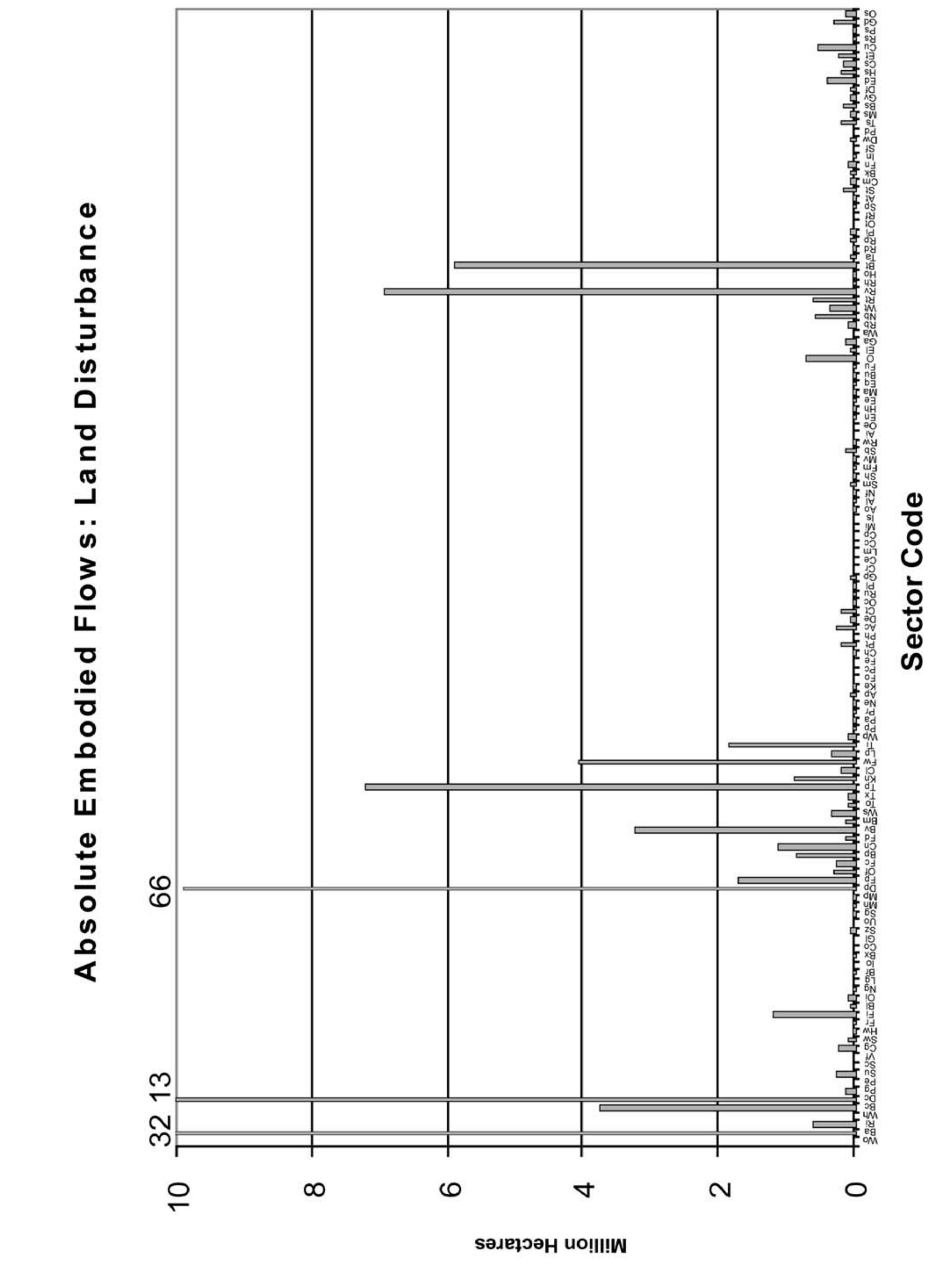

Absolute Embodied Flows: Employment
1,046
600
500
400
300
200
100
0
'000 Employment Years
Sector Code

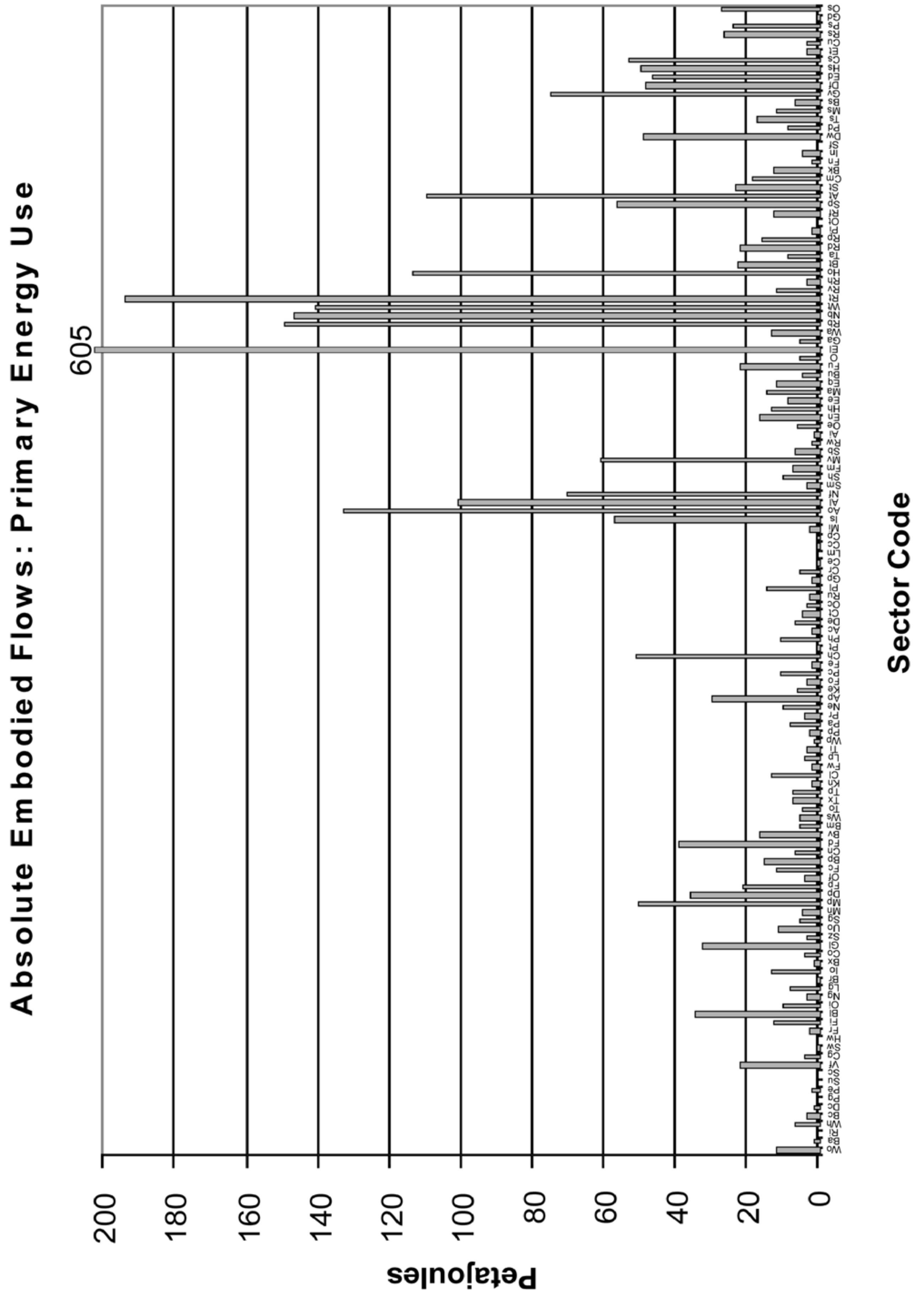

Absolute Embodied Flows: Income
Billion $
20
15
10
5
0
Sector Code


Absolute Embodied Flows: Government Revenue
Billion $
8
6
4
2
0
-2
Sector Code


Absolute Embodied Flows: Greenhouse Gas Emissions
Million Tonnes CO2-e
Sector Code
0
5
10
15
20
25
30
35
40
91
56


Absolute Embodied Flows: Water Use
2,665
2,868
Gigalitres
2,000
1,500
1,000
500
0
Sector Code


Absolute Embodied Flows: Land Disturbance
Million Hectares
Sector Code
0
2
4
6
8
10
32
13
66


Absolute Embodied Flows: Primary Energy Use
605
Petajoules
200
180
160
140
120
100
80
60
40
20
0
Sector Code