

## Triple–Bottom–Line Accounting of Social, Economic and Environmental Indicators – A New Life–Cycle Software Tool for UK Businesses

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### Conference Subject Areas

- Measuring and monitoring sustainable value
- Corporate social responsibility
- Social enterprise and procurement
- Ecological economics

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## Abstract

Triple-Bottom-Line (TBL) accounting is a wide-spread concept for firms wishing to realise broader societal and environmental objectives in addition to increasing shareholder value. TBL accounts routinely cover social, economic and environmental indicators and enable decision-makers to quantify trade-offs between different facets of sustainability.

Since these indicators are referenced against financial units and are consistent with the System of National Accounts, they can be applied to financial accounts of a firm, a service or a product, and allow a robust triple-bottom-line account to be developed across a range of scales. The critical advantage of the presented approach is that it includes both the direct (on-site, immediate) effects as well as the indirect (off-site, diffuse, upstream) effects associated with a large and distant web of supply paths. The incorporation of all indirect or upstream effects therefore removes boundary problems. Both products and organisations can be assessed and compared properly in sustainable chain management terms.

A new TBL software tool, developed at the University of Sydney, has been adapted to the UK economy ([www.bottomline3.co.uk](http://www.bottomline3.co.uk)). An organisation's financial accounts, together with on-site impact data, act as input. Software outputs include aggregate figures, detailed breakdowns and rankings of economic, social and environmental indicators. Sector benchmarking, structural path analysis (upstream supply chain analysis), production layer decomposition and quantification of 'shared responsibility' are available for all indicators. Example sectors of the UK economy are chosen to demonstrate TBL assessments using the BottomLine<sup>3</sup> tool.

## Keywords

triple-bottom-line accounting, corporate responsibility, reporting, input-output analysis, benchmarking, supply chain analysis

# 1. Corporate Sustainability – an introduction to Triple Bottom Line reporting

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 term originally coined by John Elkington<sup>1</sup> 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.

Triple Bottom Line can be viewed as a reporting device (e.g. information presented in annual reports) and/or an approach to improving decision-making and the fundamental functions of organisations (e.g. the provision of tools and frameworks for considering the economic, environmental and social implications of decisions, products, operations or future plans).

The concepts of Triple Bottom Line and associated systems and reporting frameworks are increasingly being taken up by companies worldwide as the Global Reporting Initiative (GRI)<sup>2</sup> and the work of bodies such as the OECD build momentum. In the wake of this work national and international regulations are changing and companies are more and more required to report their environmental performance.<sup>3</sup>

TBL provides a framework for measuring and reporting corporate performance against economic, social and environmental benchmarks. Reporting on TBL makes transparent the organisation’s decisions that explicitly take into consideration impacts on the environment and people, as well as on financial capital. It can reduce risk, assist in delivering better outcomes for employees, shareholders, customers and clients, and enhance reputation.

The ISA group at the University of Sydney have developed a new TBL software tool, termed BottomLine<sup>3</sup> (“BL-cubed”). The UK version is available from ISA<sup>UK</sup> Research & Consulting.<sup>4</sup> An organisation’s financial accounts, together with on-site impact data, act as input. Software outputs include aggregate figures, detailed breakdowns and rankings of economic, social and environmental indicators. Sector benchmarking, structural path analysis (upstream supply chain analysis) and production layer decomposition are available for all TBL indicators. Quantification of ‘shared responsibility’ is realised by delineating impacts into mutually exclusive and collectively exhaustive portions of responsibility to be shared by all agents along a supply chain).

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<sup>1</sup> His book “Cannibals with Forks: The Triple Bottom Line of 21<sup>st</sup> Century Business” introduced the concept of the Triple Bottom Line to a wider audience in 1997 (Elkington, 1997).

<sup>2</sup> <http://www.globalreporting.org>

<sup>3</sup> The EU Accounts Modernisation Directive (AMD), for example, introduces requirements for (large) companies to include a balanced and comprehensive analysis of the development and performance of the business in their Directors’ Report. The analysis should “include both financial and, where appropriate, non-financial key performance indicators relevant to the particular business, including information relating to environmental and employee matters”. This part of the EU Accounts Modernisation Directive is effective for financial years beginning on or after 1 April 2005.

<sup>4</sup> [www.bottomline3.co.uk](http://www.bottomline3.co.uk)

The need for robust tools and advice on environmental and sustainability reporting is growing rapidly and will persist in the future. A recent report from Trucost, published by Defra (DEFRA, 2006), hints at significant gaps:

- “... there is still a lack of quantification in most reporting. The Environment Agency study of Annual Reports and Accounts of the FTSE All Share companies, noted that the majority of reports lack depth, rigour or quantification. The study concluded that quantified environmental disclosure levels in Annual Reports and Accounts were found to be low...” (page 14)
- “Most business will have supply chain impacts that they should understand and consider reporting. There is no single, quantifiable measure that companies can use as a KPI [Key Performance Indicator] for the effect of their upstream supply chain on the environment.” (page 63).

The methodology and the BL<sup>3</sup> tool described in this paper have been developed to address this lack of quantification and comparability. It is science-based, consistent and robust. It uses regularly published, publicly available National Accounts data. It ensures that the real bottom line is quantified, not a figure determined by an arbitrary cut-off point that could be different in different organisations. Reporting on the real bottom line can deliver the full benefits of TBL reporting, including: the ability to make comparisons within and between organisations; completely transparent communication of an organisation’s impacts to all stakeholders; and detailed information across the whole supply chain as a basis for strategic decision making.

In this contribution

- we describe the analytical approach to measure the indirect impacts of a producing entity in a comprehensive Triple Bottom Line account and
- we describe the new software tool BottomLine<sup>3</sup> that allows a consistent quantification of indirect impacts and their allocation to individual supply chains.

## 2. Measuring all indirect impacts

In this study, the principle of the Triple Bottom Line (TBL) is assessed using input-output analysis (IOA). Input-output analysis is a top-down economic technique, which uses sectoral monetary transactions data to account for the complex interdependencies of industries in modern economies. The result of generalised input-output analyses is a  $f \times n$  matrix of TBL factor multipliers, that is embodiments of  $f$  TBL indicators (such as exports, labour, energy, etc.) per unit of final demand of commodities produced by  $n$  industry sectors. A multiplier matrix  $\mathbf{M}$  can be calculated from a  $f \times n$  matrix  $\mathbf{Q}$  containing the direct, sectoral TBL indicator scores (e.g. from national economic, social and environmental accounts), and from a  $n \times n$  direct requirements matrix  $\mathbf{A}$  according to

$$\mathbf{M} = \mathbf{Q}(\mathbf{I} - \mathbf{A})^{-1} \quad \text{Eq. (1)}$$

where  $\mathbf{I}$  is the  $n \times n$  unity matrix. For many countries, the direct requirements matrix  $\mathbf{A}$  can be compiled from the input-output tables published by the national statistical agencies.

The  $f \times 1$  TBL inventory  $\mathbf{F}$  of a given sectoral final demand represented by a  $n \times 1$  commodity vector  $\mathbf{y}$  is then simply

$$\mathbf{F} = \mathbf{M}\mathbf{y} \quad \text{Eq. (2)}$$

An introduction into the input–output method and its application to environmental problems can be found in Leontief and Ford, 1970; Proops, 1977; Miller and Blair, 1985 and Lenzen, 2001.

There is a well-known precedent for IO analysis techniques improving assessment processes: In life cycle assessment (LCA), which aims to calculate the total environmental burdens associated with a product, IOA has experienced a significant role in overcoming what is known as the boundary problem, or the problem of incompleteness of an LCA inventory due to the arbitrary truncation of the system by a subjectively set boundary (Suh et al., 2004), thus preventing decision-makers from overlooking important hidden upstream impacts.

In an empirical application the IO formalism was applied by the ISA team at the University of Sydney to compile a comprehensive TBL account of the Australian economy. National- and state-level economic sector level data for 344 sectors of the Australian economy were compiled, using input-output tables and additional data. A part of these accounts are published<sup>5</sup> and contain information on the aggregate and average performance of 135 economic sectors for ten TBL indicators together with their main data sources. The synthesis of disparate data sources is a major component of the development of a generalised IOA framework.

The Australian TBL sector accounts also describe in hard numbers economic, social and environmental indicators against a common unit of one dollar of final demand. The latter constitutes a convenient and meaningful numeraire, because it is the destination of GDP, the common measure of national economic performance. Social indicators such as employment, wages and government revenue can be described as "the minutes of employment generated per dollar of final demand". Environmental indicators 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. However, the presentation of such complex analyses is always fraught with the tension between simplicity and complexity.

### 3. Unravelling the supply chain

The boundary within which an organisation accounts for its environmental, social and/or economic effects is usually defined as that over which the company has direct influence and can exercise control. However, such a definition faces a number of challenges. The level of influence and control will vary from organisation to organisation and from year to year,

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<sup>5</sup> [www.isa.usyd.edu.au/publications/balance.shtml](http://www.isa.usyd.edu.au/publications/balance.shtml), see also Foran et al. (2005a, b)

invalidating comparisons within and between organisations. Moreover, extending the boundary beyond the immediate control of the organisation still begs the question of exactly where to draw the line. Decisions will differ between organisations and over time. Establishing a clear boundary for an analysis that is consistent across all indicators seems at first sight to be almost impossible.

Notwithstanding these challenges, the boundary problem can be solved by taking a full life-cycle perspective and by taking into account the structure of the economic system as described in the national input-output tables. This structure is best depicted as an ever-expanding "tree of interdependence" that starts at a particular economic entity, and stretches across upstream production layers, containing sectors at different production stages linked together by supply chains. Thus a particular impact associated with a good or a service cascades from primary industries producing raw materials, via secondary (manufacturing) industries into the sector or company that delivers the final product to the consumer.

The general decomposition approach described in the following was introduced into economics and regional science in 1984 under the name 'structural path analysis' (Crama et al., 1984; Defourny and Thorbecke, 1984). In order to systematically determine environmentally important production chains, the total factor multipliers derived in Eq. (1) can be decomposed into contributions from all input paths, by 'unravelling' the Leontief inverse using a series expansion. A multiplier  $m_i$  for industry  $i$  can then be derived, representing the sum over a direct factor input  $q_i$ , occurring in industry  $i$  itself, and higher order input paths (see Lenzen, 2002 and 2003 for details).

Such a structural path analysis covers the entire upstream supply chain. It "unravels" a company's impacts into single contributing supply paths. It gives extensive detail of the impact of a sector's or company's activities. It allows investigating the location of impacts within the supply chain. In the case of a company, the control over the input procurement process then provides the possibility of substituting impact-intensive suppliers with more sustainable suppliers.

Detailed outputs of the BottomLine<sup>3</sup> tool derived from the application of structural path analysis include:

- a description of the path
- the path value (e.g. the greenhouse gas impact in grams of CO<sub>2</sub>-equivalent per £ of final output of business management services),
- the path order (that is, from which upstream supply layer the path originates),
- the path coverage, that is, the relative contribution (in %) to the total TBL impact of the company.

## 4. The software tool BottomLine<sup>3</sup>

At the University of Sydney, TBL Accounting has been formulated as a quantitative framework using an input-output-based LCA method. This framework has been applied to dozens of organisations in reporting on their sustainability performance – companies, government departments, NGOs. Experiences were collected in a 3-year pilot project. It became clear that the data collection burden for the organisation has to be as small as

possible. As a result, a software tool was developed in collaboration with the using organisations, enabling users to create a comprehensive sustainability report solely by importing their existing financial accounts.

This software tool is called BottomLine<sup>3</sup>, or short BL<sup>3</sup> (“BL-cubed”). A version for the UK economy has been co-developed by ISA<sup>UK</sup> Research & Consulting, who are also licensing the tool in the United Kingdom.<sup>6</sup>

BL<sup>3</sup> accepts any organisation’s financial accounts as imported input, and uses this financial information to calculate upstream, indirect impacts in terms of physical indicators chosen by the user. On-site physical impacts are entered separately. The TBL indicator set of BL<sup>3</sup> UK features a number of economic, social and environmental indicators, including greenhouse gases; toxic, ozone-creating, acidifying and eutrophication air pollutants; heavy metals; energy and resource use; the Ecological Footprint; and material flows. In total the whole database distinguishes well over 100 indicators.

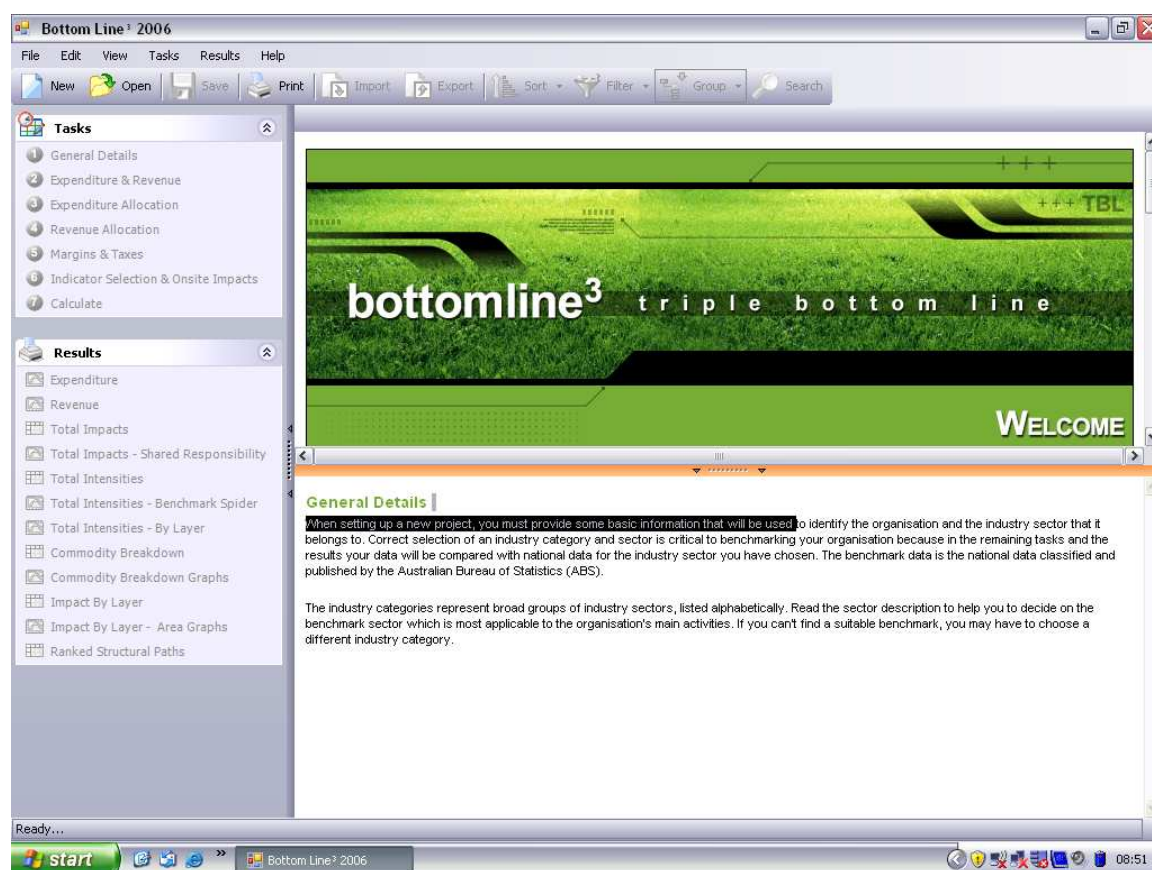


Figure 1: User input page of the BottomLine<sup>3</sup> software

Software outputs include aggregate figures, detailed breakdowns, sector benchmarking and rankings of indicators into supply chain contributions. Several examples are presented in the following.

<sup>6</sup> See [www.bottomline3.co.uk](http://www.bottomline3.co.uk) and [www.isa-research.co.uk](http://www.isa-research.co.uk)

A number of Triple Bottom Line figures for a company can be compared to the average performance of the sector to which the company belongs (see the Figure below). This is called ‘benchmark spider diagram’. The regular polygon in the centre of the diagram (thick black line) shows the average TBL performance of the sector whereas the company’s performance in key financial, social and environmental indicators is shown as a red line. Indicators with above average performance are closer to the centre, while below average indicators are positioned closer to the outside boundary. The smaller the area enclosed by the red line, the smaller is the total TBL impact of the company.

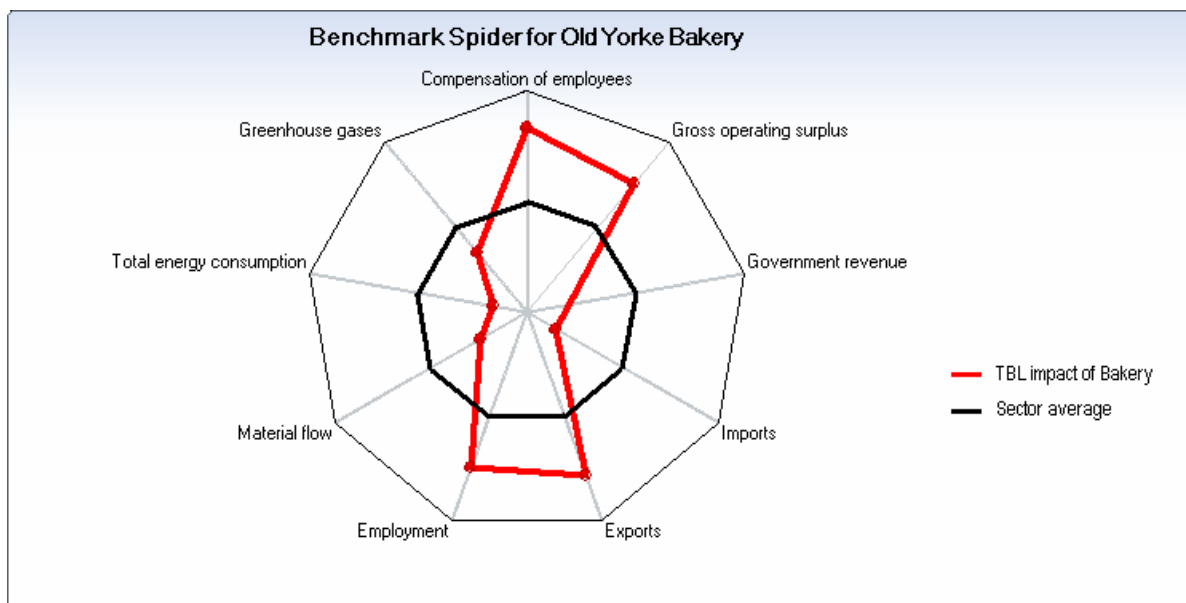


Figure 2: A spider diagram presentation of Triple Bottom Line performance of an example company in key financial, social and environmental indicators (red line). The regular polygon in the centre of the diagram (thick black line) shows the average TBL performance of the food sector, allowing a benchmark comparison between the company and its sector. Indicators with above average performance are closer to the centre, while below average indicators are positioned closer to the outside boundary.

The TBL performance of whole sectors in an economy can also be quantified separately. The Table below represents a comparison between key TBL indicators for the Food sector and the Hotel sector in the UK. The analysis shows that the Hotel sector causes significantly less environmental impacts but employs more people per £ of final demand than the Food sector. The economic performances of both sectors are comparable with the Hotel sector paying higher salaries, facing less taxes and making less profits per £ of final demand than the Food sector.

Table 1: Comparison of 12 TBL indicators of the Food and the Hotel sector in the UK. Performances are expressed as 'Total Intensities' in impacts per £ of final demand.

TBL Indicator	FOOD Sector Total Intensity	HOTEL Sector Total Intensity
Compensation of employees (wages & salaries)	25.4 p/£	29.9 p/£
Gross operating surplus (profits)	13.8 p/£	12.7 p/£
Government revenue (taxes)	17.5 p/£	12.8 p/£
Employment	0.0005 emp-wk/£	0.0009 emp-wk/£
Total energy consumption	0.00022 toe/£	0.00007 toe/£
Net Electricity	0.000023 toe/£	0.00001 toe/£
Total Ecological Footprint	2.82 g-m2/£	0.81 g-m2/£
Total material flow	1.97 kg/£	0.09 kg/£
Acid rain precursors	0.004 kg SO <sub>2</sub> -e/£	0.001 kg SO <sub>2</sub> -e/£
Greenhouse gases	0.68 kg CO <sub>2</sub> -e/£	0.19 kg CO <sub>2</sub> -e/£
Chromium	0.00012 kg/£	0.000023 kg/£
Particulate matter	0.00017 kg/£	0.000032 kg/£

The BL<sup>3</sup> tool quantifies supply chain contributions to TBL impacts according to the principle of 'shared responsibility'. This is realised by delineating impacts into mutually exclusive and collectively exhaustive portions of responsibility to be shared by all agents along a supply chain. A detailed description of this concept is given in Gallego and Lenzen (2005), Lenzen et al. (2006) and Wiedmann and Lenzen (2006). The Figure below shows an example.

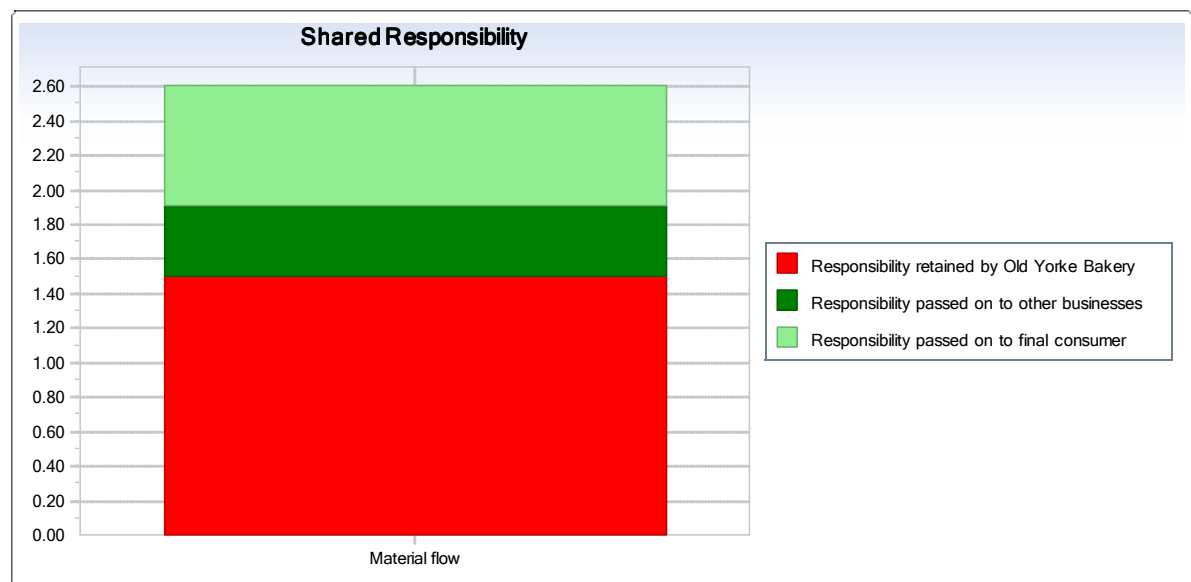


Figure 3: Depiction of responsibility shares of a material flow impact. 1.5 tonnes of the total 2.6 t impact are retained by the example company whereas 1.1 tonnes are passed on further down the supply chain (0.4 t to other businesses and 0.7 t to final consumers).

These outputs enable the user to determine

- which of the operating inputs embody the largest impacts,
- whether these impacts occur at direct suppliers, or at more remote supply chain locations,
- and which single input paths carry the largest impacts (through structural path analysis).

Users perceive especially the latter information as very helpful, because it can be used for organisational planning and priority setting for informed action towards financial, social and environmental sustainability. In particular, it shows organisations alternatives for effective procurement policy changes, which may be applied instead of perhaps costly on-site measures.

Ranked Structural Paths - Total energy consumption				
Rank	Path Description	Path Value	Path Order	Percentage in total impact
1	Food and drink > Old Yorke Bakery	313 kWh	2	24.4 %
2	Agriculture > Old Yorke Bakery	191 kWh	2	14.9 %
3	Fertilisers > Agriculture > Old Yorke Bakery	121 kWh	3	9.45 %
4	Iron and steel > Machinery and equipment > Old Yorke Bakery	69.1 kWh	3	5.40 %
5	Machinery and equipment > Old Yorke Bakery	60.1 kWh	2	4.69 %
6	Gas distribution > Old Yorke Bakery	42.8 kWh	2	3.34 %
7	Electricity production and distribution > Food and drink > Old Yorke Bakery	34.2 kWh	3	2.67 %
8	Electricity production and distribution > Old Yorke Bakery	33.6 kWh	2	2.63 %
9	Coke ovens, refined petroleum & nuclear fuel > Agriculture > Old Yorke Bakery	27.2 kWh	3	2.13 %
10	Electricity production and distribution > Agriculture > Old Yorke Bakery	27.0 kWh	3	2.11 %
11	Agriculture > Food and drink > Old Yorke Bakery	19.4 kWh	3	1.51 %
12	Food and drink > Agriculture > Old Yorke Bakery	18.9 kWh	3	1.47 %
13	Electricity production and distribution > Machinery and equipment > Old Yorke Bakery	18.5 kWh	3	1.44 %
14	Electricity production and distribution > Gas distribution > Old Yorke Bakery	15.9 kWh	3	1.24 %
15	Fertilisers > Agriculture > Food and drink > Old Yorke Bakery	12.3 kWh	4	0.96 %
16	Pulp and paper > Food and drink > Old Yorke Bakery	12.3 kWh	3	0.96 %
17	Non-ferrous metals > Machinery and equipment > Old Yorke Bakery	12.1 kWh	3	0.94 %
18	Other land transport > Food and drink > Old Yorke Bakery	9.41 kWh	3	0.73 %
19	Coke ovens, refined petroleum & nuclear fuel > Food and drink > Old Yorke Bakery	7.54 kWh	3	0.59 %
20	Plastic products > Food and drink > Old Yorke Bakery	7.01 kWh	3	0.55 %

Table 2: Results of a BL<sup>3</sup> structural path analysis of an example company. The total energy consumption embodied in the supplies from upstream producers is broken down into contributions from the supplying sectors. The list shows path values and orders (i.e. how large and how far away the impacts are).

The BL<sup>3</sup> software has been extensively road-tested over three years. Users had no difficulty in understanding and accepting indirect impacts occurring off-site, in addition to on-site direct impacts. Users felt that assessing their organisation's indirect impacts was a valuable feature because it increases abatement options, enables meaningful benchmarking, avoids loopholes in reporting and informs about real risk. Sydney University's TBL software has been designed so it can readily be implemented for any economy for which input-output data complemented with physical data are available. Trial versions include Australia, the UK, Japan, the US, and Germany. In principle it is possible to develop a version based on a multi-national IO framework that covers international trade flows.

## 5. Conclusions

Numerate Triple Bottom Line accounting at the company level highlights a number of key issues important to the sustainable development agenda. Especially if all upstream impacts stemming from a web of supply chains are taken into account, new insights and useful information for corporate decision-making can be gained. With the approach described in this work we are able to allocate TBL loadings amongst the actors of economic chains, including all producers and consumers of commodities, in a mutually exclusive and collectively exhaustive way, that is without double counting of any impacts.

It is important to harmonise this analytical approach, with its strengths of integration and lack of boundaries, with international approaches rapidly gaining headway such as 'The Global Reporting Initiative' and 'The Equator Principles'. These approaches have widespread support through many globalised companies and national governments. However they are currently orientated to a 'within the factory fence' approach, but do acknowledge a number of first order issues such as the origin of water and energy, and some second and third order effects particularly the labour practices used to supply intermediate inputs to production. Part of the harmonisation process will require the development of indicator datasets that match the requirements of these initiatives, as well as collaborating in the development of international software tools that enable the fluent use of whole economy accounting without boundaries.

## 6. Acknowledgement

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