The use of Environmentally Extended Input and Output Analysis to measure and evaluate the carbon and employment footprint of an equity investment

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Abstract

There is little doubt that carbon emissions from human activities are universally considered to be the primary cause of anthropogenic global warming. Equity investment is a major stimulant of economic activity and therefore carbon emissions, but it is also a potential enabler in transitioning to a sustainable economy. The purpose of this study is to quantitatively determine the carbon footprint of selected Australian equity investments using Environmentally Extended Input-Output Analysis(EEIOA) and evaluate the potential impacts of Socially Responsible Investment (SRI) and divestment.

We examine three superannuation funds managed by Australian Super and obtained the equity holdings and representative facilitated industry output of these investments. We then attributed a carbon footprint proportional to the carbon emissions of that industry over the 2014-15 Australian financial year. The analysis similarly calculates the representative employment footprint of these investments to observe the wider impacts of a transition to a low-carbon economy.

The results of this study indicate that SRI criteria can significantly reduce the carbon footprint of an equity portfolio. Specifically, this study finds a 29% difference in carbon footprint per dollar invested between SRI and non-SRI funds. It was also found that employment generated per dollar invested was not affected by the SRI criteria. Divestment scenarios revealed that the carbon or employment footprint of a portfolio can be significantly reduced or increased by shifting funds between shareholdings.

The techniques developed in this study is useful to investors to better control the carbon emissions facilitated by their equity investment. Furthermore, this form of analysis would be a valuable tool for the development of investment and regulatory policy by governments using financial inputs to mitigate climate change and/or maximise overall employment.

1 INTRODUCTION

Since the industrial revolution in the 1800s, an unprecedented amount of greenhouse gas (GHG) has been released into the atmosphere due to fossil fuel consumption and industrial processes. There is a consensus from the scientific community that an average increase of global temperature to as little as 2°C could have a drastic impact on global weather patterns, causing major damage to natural ecosystems and the built environment. The Paris Agreement aims to keep temperature increases well below the 2 ° C limit (Council of the European Union, 2017). This will require a substantial restructuring of the global economy which could significantly impact overall employment distribution, particularly in Australia due to its dependence on large fossil fuel industry. Equity investment is a major stimulant of economic activity and a potential enabler in transitioning to a sustainable economy. Most large companies are dependent on significant amounts of equity investment to establish and continue their operations. By this logic, selective investment (or divestment) could have the potential to allow certain companies to be successful whilst disadvantaging others. Socially Responsible Investors (SRIs) have started to screen their equity investments based on environmental, social and governance (ESG) criteria with the view to reduce their investment's environmental and social impact but there is uncertainty over their true impact. There is over $1.7 (AUD) trillion invested in equity in Australia, highlighting the enormous potential for large-scale SRI or divestment to lead the transition to a low-carbon economy. A small number of studies have used input-output analysis to attribute a carbon footprint to equity investment portfolios but no study (to our knowledge) has used input-output analysis to determine the employment footprint of an equity investment.

This study aims to calculate the upstream carbon and employment footprint of equity investments within the Australian economy over the 2014-15 financial year using Environmentally Extended Input-Output Analysis (EEIOA). The goal of this research is to determine the role of Australian equity investment in mitigating global warming by reducing the overall carbon emissions of its investment. Furthermore, this research determines the impacts of changes in equity investment behaviour on employment facilitated by this investment, given the negative publicity in Australia suggesting transitioning to low-carbon economy leads to reduction in employment. This study is motivated by the global need to reduce carbon emissions and the recent movements in SRI and call for divestment from fossil fuel industry. There is also a call for accounting scholars to rethink their conceptions of "accounts" and "nature" (Russell, Milne and Dey, 2017) and this study aims to start a conversation on how accounting data could facilitate the analysis and quantification of natural capital.

This study examines three equity portfolios held by Australian Super, totalling over $20 (AUD) billion in shareholdings. These portfolios encompass two traditionally managed portfolios ("high growth" and "balanced") and one "socially aware" portfolio for comparison between different fund management approaches. The results aim to provide a basis for portfolio managers to determine the carbon and employment impact of their own portfolios and adjust their management approach to align with the social responsibility interests of their customers.

An input-output table and relevant carbon emissions and employment data is obtained from the Australian Bureau of Statistics (ABS), Australian Greenhouse Emissions Information System (AGEIS) and Industrial Ecology Laboratory (IELab) to calculate the carbon and employment footprint of three equity portfolios. Divestment scenarios for the largest of these portfolios will also be modelled to investigate the optimisation of equity portfolios for low carbon footprint and high employment footprint. These results will then be compared to previous studies and used to provide recommendations for investors, portfolio managers and policymakers. The approach used in this study could also be developed into software for real-time carbon footprint management of equity portfolios and may extend to employment footprint as well.

The remainder of the paper discusses the literature, data and methods, results and conclude with suggestions for further research.

2 LITERATURE REVIEW

2.1 Climate Change

Previous research concludes that for global temperature increases to stay below the 2°C limit the world has to stick to a carbon budget of 1,100 Gt (Giga tonnes) CO_2-e (carbon dioxide equivalent) to use from 2013 to 2050 (Australian Government Climate Change Authority, 2013). The Australian Government has calculated that Australia's share of this carbon budget is 10.1 Gt CO_2-e (Australian Government Climate Change Authority, 2013). However, despite Australia making up an insignificant proportion of global GDP and population it is currently one of the highest emitters of carbon per capita, emitting almost 4 times the global average on an annual basis (World Bank, 2017). This is mostly a result of Australia's dependence on coal power and an indirect result of its fossil fuel production and exports (Department of the Environment and Energy, 2014). Reducing consumption of fossil fuels (encompassing coal, oil and gas) is crucial to keeping within the global carbon budget.

Although Australia has made progress in curbing its carbon emissions between 2003 to 2012, wherein there was no growth in carbon emissions despite strong economic growth (ClimateWorks, 2013) there is evidence to suggest that the transitioning to renewable energy of Australia's energy sector may not be enough to stay within its carbon budget. Howard et al. (2017) modelled the carbon emissions impact of various transition scenarios of the Australian energy sector from fossil fuels to renewable energy and found that in most cases this transition will fail to achieve the emissions reductions needed to stay within the 1.5 ° C increase in global temperature. Nevertheless, the transitioning of Australia's energy sector is an important step in reducing overall carbon emissions even though further actions may need to be taken in the long term.

2.1.1 Employment in a Low-Carbon Economy

It has been widely predicted that the shift to a low-carbon economy will require drastic changes to the economic structure of the world. As expected, this change could also radically affect the distribution of employment opportunities as carbon-intensive industries decline and carbon-efficient industries grow. Research in the late 1990s indicated that stricter environmental policy is unlikely to affect employment as national job growth is ultimately controlled by the monetary policy of central banks (Goodstein, 1996). Furthermore, it was suggested that a shift towards a low-carbon economy could possibly stimulate more employment opportunities by acting as a catalyst for innovation (McEvoy et al., 2000).

A recent report by the Organisation for Economic Cooperation and Development (OECD) concluded that the shift to a low-carbon economy will only have minor impacts on job demand. This was because the industries most affected by environmental policy (energy generation and fossil fuel resources) make up a very small proportion of the overall workforce (OECD, 2012). The study predicted that the fossil fuel industry would face the greatest reduction in workforce whilst the renewable energy industry would see the most growth (OECD, 2012). This impact could be particularly profound in Australia due to its large fossil fuel industry and relatively small renewable energy sector.

2.1.2 Investment and Climate Change

Many studies have highlighted the changes that a transition to a low-carbon economy will have on investment. Firstly, it is widely suggested that efforts to mitigate climate change will reduce the financial attractiveness of carbon-intensive investments (Griffin et al., 2015). This is because it will be impossible for the valuable fossil fuel reserves owned by mining and oil and gas companies to be burned whilst also staying below the carbon budget, turning them into "stranded" assets (Carbon Tracker, 2013 and Climate Council, 2015). Furthermore, it is also predicted that lower-carbon investments will start to display better financial returns as they become more important in reducing overall carbon output (Mercer, 2015).

Despite the substantial research outlining the reactionary impacts climate change will have on investment, little quantitative research exists on the potential impact that changed investment patterns could have on the global fight against climate change. Given that investment patterns are partly responsible for causing climate change (the fossil fuel industry is dependent on significant amounts of investment) and that literature widely suggests that investment needs to change to be aligned with carbon budgets, there is a strong implication that investment has the potential to dramatically influence economy-wide carbon emissions. To determine the magnitude of this impact it would be necessary to quantify the change in total carbon emissions resulting from a shift in investment behaviour.

2.2 Investment

2.2.1 Socially Responsible Investment (SRI) and Divestment

SRI can be defined as *"Investment which considers environmental, social and governance (ESG) issues as selection criteria."* (Richardson, 2008). Whilst early SRI was focused on solving local social issues, current approaches aim to tackle environmental issues on a global scale, primarily global warming. This shift in focus occurred during the late 1990s as anthropogenic climate change started to become a widely accepted phenomenon (Richardson, 2008). SRI has become increasingly popular over the past two decades. Over $8.72USD trillion is invested under SRI criteria in the USA as of 2015, accounting for 1 out of every 5 dollars under professional management (US SIF, 2016). Divestment (Richardson, 2016) on the other hand is defined as: *"Avoiding ownership of shares or bonds in certain industries or companies because of the characteristics of their products or operations."*

2.2.2 Performance of SRI Funds

There has been much debate over the financial implications of SRI and whether returns on investment differ from investment without screening. Some studies have found no relationship between SRI and financial performance (Ito et al., 2013) whereas others have concluded that SRI funds have slightly worse financial performance than non-screened funds (Capelle-Blancard & Monjon, 2014). Overall, there appears to be consensus that there is negligible correlation between the social responsibility of a fund and its financial performance.

However, SRI initiatives can lead to a lack of demand and subsequent under-valuing of “sin” stocks, such as those of alcohol, tobacco and firearms companies. These stocks can be purchased for below-value and typically outperform other non-sin stocks of a similar value. A study by Hong & Kacperczyk (2009) found that on average sin stocks outperform comparable stocks by approximately 2.5% per year.

Siew et al. (2015) investigates the impact of ESG disclosures and institutional ownership on market information asymmetry for 683 firms listed on the New York Stock Exchange for years 2007–2011. The results suggest that there is a statistically significant negative relationship between ESG disclosures and bid-ask spread and that the presence of institutional investors reduces market information asymmetry.

2.2.3 Australian Superannuation Funds and SRI

Most large Australian superannuation funds offer socially responsible investment options for its members. These options promise to invest in organisations and projects screened against a set ESG criteria, with the exact screening criteria varying between funds. However, there appears to be a great deal of ambiguity over where exactly the money is invested. A recent study by Super Switch found that 83% of all assets owned by Australia’s top 50 super funds are undisclosed (Super Switch, 2016).

Furthermore, the study found that many of the SRI options offered by major superannuation funds disclosed less than 20% of their assets (Super Switch, 2017). This leads to uncertainty over the actual nature of these socially responsible investment options.

2.3 Carbon Footprint

2.3.1 Definition of Carbon Footprint

Measuring the "carbon footprint" of an activity, product or entity has become the predominant method of determining contribution towards the carbon budget. According to Wiedmann and Minx (2008), a carbon footprint is defined as:

"A measure of the exclusive total amount of carbon dioxide emissions that is directly and indirectly caused by an activity or is accumulated over the life of a product."

When applying this definition to individual company the Greenhouse Gas Protocol (2017) is the most widely-used emissions accounting framework. This protocol groups emissions into three scopes:

- ***Scope 1:*** *All direct GHG emissions.*
- ***Scope 2:*** *Indirect GHG emissions from the consumption of purchased electricity, heat or steam.*
- ***Scope 3:*** *Other indirect emissions, such as the extraction and production of purchased materials and fuels, transport-related activities in vehicles not owned or controlled by the reporting entity, electricity-related activities (e.g. transmission & distribution losses) not covered in Scope 2, outsourced activities, waste disposal, etc.*

Scope 1 & 2 emissions are the easiest to measure and report for companies. Scope 3 emissions are harder to calculate as it extends beyond the corporate boundaries and are not mandatory in most emissions reporting standards unless the organization is applying for carbon neutrality. However, reporting all three emissions scopes gives the best overall picture of an organisation's emissions performance. In fact, a recent study found that scope 3 emissions can often make up a larger proportion (when compared to scope 1 and 2 emissions combined) of the total emissions produced by a company or industry (Huang et al., 2009). The study found that this was particularly apparent for industries which are heavily reliant on the products of other industries, such as services, publishing and pharmaceuticals.

The emissions resulting from a company's activities can also be viewed from two "directions", defined as "upstream" and "downstream". Upstream emissions result from the actions taken in the production of assets, goods or services by a company (Lenzen & Murray, 2010). In contrast, downstream emissions encompass those caused by the usage of this output and its eventual disposal (Lenzen & Murray, 2010). Downstream emissions also include "enabled" impacts, which are subsequent emissions resulting from economic activity enabled by the company's outputs (such as the use of wages paid to employees or taxes paid to governments).

Linking equity investment to these emissions is best explained with an example. If an investor purchases shares in the Australian mining company BHP Billiton, this equity investment gives them a partial ownership over that company. BHP Billiton then creates upstream emissions (through the use of heavy machinery in mining and transporting coal) and downstream emissions (from the eventual combustion of that coal and the economic activity simulated by its employee's wages). As an equity investor and partial owner, this individual then has a percentage ownership and responsibility over these environmental impacts.

2.3.2 The Carbon Footprint of Australia

Whilst carbon footprint reporting is often done on an organisational or product level, techniques exist to determine carbon footprints on a national or global scale. Of these, Environmentally Extended Input-Output Analysis (EEIOA) is the most widely accepted method in research (Gao et al., 2014). This form of analysis has been used in numerous studies to calculate the carbon footprint of Australia.

An early study by Wood and Dey (2009) used EEIOA to determine the carbon footprint of the Australian economy. This was achieved by utilising an input-output table developed by the Australian Bureau of Statistics (ABS) which mapped the financial transactions between industry sectors in the Australian economy over the 2004-5 financial year. Sector-level carbon emissions data were sourced from the Australian National Greenhouse Gas Inventory and converted to an emissions intensity relative to the total output of each industry. These emissions intensity factors were then used to calculate a carbon footprint for each industry based on the levels of final demand for goods and services in that industry using the basic input-output relationship (see section 3.1.1 for an explanation of this method). These industry carbon footprints could then be aggregated to determine the total carbon footprint for Australia.

A more recent study by Levitt et al. (2017) used EEIOA to calculate the carbon footprint of Australia for the years 1995 to 2009. It was discovered that Australia's upstream carbon footprint continually increased over this time period, from 405 Mt CO_2-e in 1995 to 558 Mt CO_2-e in 2009, a 38% increase (Levitt et al., 2017). This study similarly attributed the electricity, agriculture and construction industries as the major contributors towards Australia's carbon footprint. This rapidly increasing trend reinforces concerns about the carbon-intensity of Australia's economy and the need to reduce overall carbon emissions.

2.3.3 The Carbon Footprint of Equity Investment

Koellner et al. (2007) was one of the earliest investigations in using input-output analysis in calculating the environmental impacts of equity investment. This research assessed the environmental impact of the equity holdings of 26 European investment funds (comprised of 13 sustainable investment funds and 13 conventional funds) using an input-output life-cycle assessment.

An important step in determining this impact was linking the amount invested in a company to a representative output for use with environmental factors associated with input-output analysis. The assumption made by this study was that by owning shares in a company, the shareholder has a percentage ownership of that company and hence has the same percentage ownership over its production (Koellner et al., 2007). By extension, this assumption also implies that the shareholder has the same percentage ownership over the environmental damage caused by that company. This relationship is displayed graphically in 2.1 below:

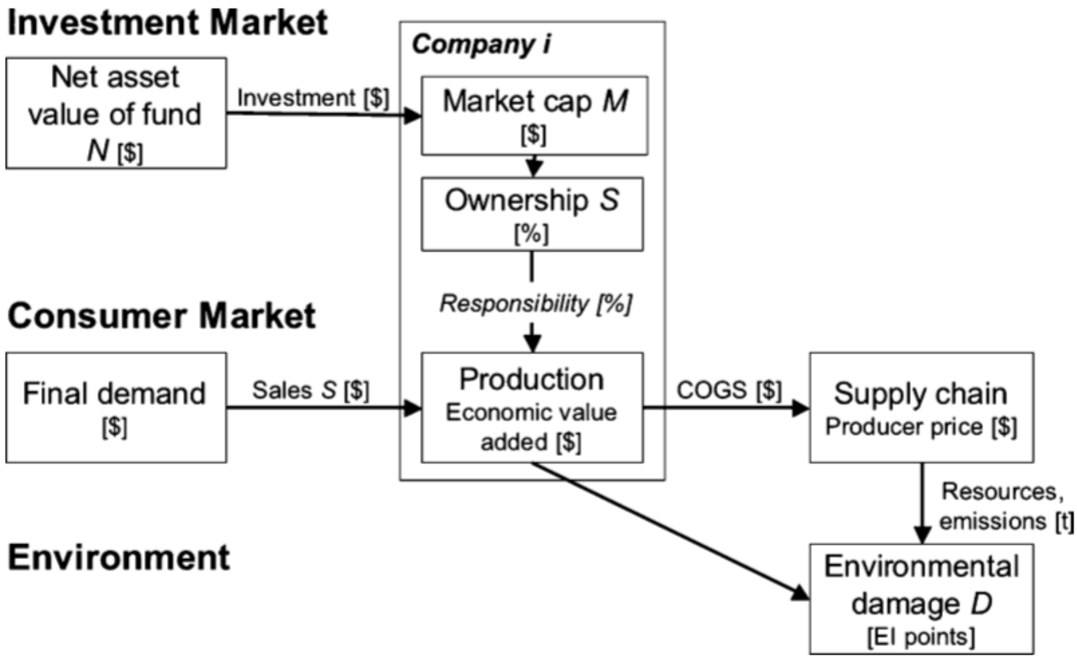

Figure 2.1: Relationship between share ownership and environmental damage (taken from Koellner et al. (2007))

To calculate the environmental impact of equity investment in a company, the percentage ownership of the company *i* was first calculated:

$$ownership\ share_i = \frac{value\ of\ shareholdings_i}{market\ capitilisation_{\ i}}$$

Then the total environmental damage of that company was calculated, using a factor representing the environmental damage caused by a dollar of goods purchased in that company's industry *j* (obtained from input-output data) multiplied by the annual sales of that company:

$$total\ environmental\ damage_i = damage\ per\ dollar\ of\ goods\ purchased_j * annual\ sales_i$$

The environmental damage of this equity investment could then be determined by combining these two values:

$$environmental\ damage\ of\ shareholdings_i = ownership\ share_i * total\ environmental\ damage_i$$

Koellner et al., 2007 find that the differences in environmental impact between the conventional and sustainable investment funds was trivial and they attribute this to the fact that all 26 funds were managed to the same investment benchmark (Morgan Stanley Capital International World) to minimise their financial risk. It was also noted that the portfolio structure of the conventional and sustainable investment funds analysed were similar which would minimise potential differences in environmental impact.

Trucost (2007) provides an alternative way to calculate the carbon footprint of 185 UK-based equity investment funds, totalling £73.65bn in assets. This study was undertaken by utilising published greenhouse gas (GHG) disclosures (both direct and indirect) from companies which these funds held shares in. For companies that hadn't disclosed GHG emissions a proprietary input-output model was used to calculate a representative emissions figure based of that company's industry sector. The carbon footprint for each shareholding was calculated as follows:

$$Carbon\ footprint_i\ (CO_2e) = GHG\ emissions_i * \frac{value\ of\ shareholdings\ _i}{market\ capitalisation_i}$$

The total carbon emissions were summed across each portfolio to derive the carbon footprint of the investment fund. To allow for comparison between funds the footprint of each portfolio was normalised against the portfolio value to find a "carbon intensity" for each pound invested.

$$carbon\ intensity\ \left(\frac{CO_2e}{£}\right) = \frac{carbon\ footprint\ of\ portfolio\ (CO_2e)}{portfolio\ value\ (£)}$$

The study found that carbon intensities varied significantly between investment funds, with the highest fund intensity being almost 10x the amount of the lowest fund intensity (Trucost, 2007). To quantify this difference, the study predicted that moving £7,000 from the least-carbon efficient to most carbon efficient fund would equate to a saving of over 10 tonnes of CO_2-e per annum (Trucost, 2007). SRI funds and high growth funds were found to generally have lower carbon intensities but again varied dramatically. It was also discovered that there was no correlation between financial performance or fund size and carbon footprint (Trucost, 2007).

A more recent study by Ritchie and Dowlatabadi (2014) focused on determining the carbon footprint impacts of equity investment and divestment. The research used publicly available economic input-output life cycle assessment (EIO-LCA) models to develop a Shadow Impact Calculator (SIC) which could calculate a representative carbon footprint for an investment scenario based off the carbon footprint of the companies or industry sectors invested in (Ritchie & Dowlatabadi, 2014). This study used a similar method to Koellner et al. (2007) of comparing annual revenue and market capitalisation to find the proportion of final demand facilitated by each dollar invested.

Using a SIC allowed for carbon footprints per dollar to be mapped to various industry sectors the study revealed that the most carbon-intensive industries were those related to power generation, metals production and fossil fuels (Ritchie & Dowlatabadi, 2014). The study modelled the investment portfolio of a major Canadian university and calculated the change in carbon shadow following a shift of funds from carbon-intensive to low-carbon alternative investments. Two divestment scenarios were investigated for this portfolio, (1) shifting all holdings in oil, gas and mining (approx. $8.7 million) towards alternative energy and (2) redirecting the entire portfolio in an effort to reduce overall carbon footprint. Divestment scenario 1 resulted in a 18.5% reduction in carbon shadow when compared to the fossil fuel investment holdings (Ritchie & Dowlatabadi, 2014).

Divestment scenario 2 was split into two further scenarios (2a) where money was shifted from funds with the highest carbon shadow to those with the lowest carbon shadow and (2b) where the entire fund was shifted to the least carbon intensive option (an unrealistic scenario but used to test the upper limit of extreme divestment). Divestment scenario 2a resulted in a total carbon footprint reduction of 4.2%, whereas scenario 2b caused a reduction of 11% (Ritchie & Dowlatabadi, 2014). Overall, the study concluded that divestment has less of an impact on carbon footprint than typically expected, with the most radical shift only causing a reduction of 11%. Furthermore, it was also noted that a reduction in carbon footprint for a particular investment portfolio doesn't necessarily lead to a reduction of greenhouse gases across the economy as these investments are simply sold to another investor who will then own that carbon footprint (Ritchie & Dowlatabadi, 2014).

2.4 Conclusions from Literature Review

Equity investment is a major stimulant of economic activity and therefore carbon emissions, but it is also a potential enabler in transitioning to a sustainable economy. This has been highlighted by the recent SRI and divestment movements appearing across the world. However, there has been little quantitative research on the carbon emissions and employment impacts of equity investment. Assets in Australian superannuation funds are almost twice the value of annual GDP, making them a prime candidate for analysis on the emissions and employment impacts of SRI and divestment.

Environmentally expanded input-output analysis has been used extensively in determining carbon and employment footprints. Previous studies by Koellner et al. (2007) and Ritchie and Dowlatabadi (2014) have linked equity investment to final demand for use with IOA and this method can be readily adapted to find the carbon or employment impacts of equity investment by Australian superannuation funds.

3 METHOD & DATA

3.1 Input-Output Analysis

Input-output analysis (IOA) was developed by economist Wassily Leontief in the 1940s to understand the interrelation between economic sectors (Bjerkholt, 2006) or changes in resource and labour requirements given a change in economic output (Hendrickson et al., 2006) or the environmental impacts of economic activity (Leontief, 1970). The use of IOA for determining environmental impact is commonly referred to as Environmentally Extended Input-Output Analysis (EEIOA).

EEIOA is undertaken using an input-output table which tracks the financial transactions between the inputs and outputs of industry sectors within an economy (Wiedmann, 2010). The method for calculating an employment or carbon footprint using EEIOA is identical, although different extension multipliers are used for different footprint types. An input-output table takes the form below, where all values are in units of currency ($AUD for this study):

Table 3.1: Sample of an input-output table.

	Output 1	**Output 2**	**Final Demand (C+G+I+E-M)**	**Total Output**
Input 1	X_{11}	X_{12}	Y_1	X_1
Input 2	X_{21}	X_{22}	Y_2	X_2
Primary Inputs (D+W+TP)	V_1	V_2		
Total Production	X_1	X_2		

Variables are defined as:

$X_{ij} = intermediate\ flow\ of\ money\ from\ sector\ i\ to\ sector\ j$

$X_i = final\ production\ of\ sector\ i$

$Y_i = final\ demand\ for\ sector\ i$

$C = household\ consumption$

$G = government\ expenditure$

$I = investment$

$E = exports$

$M = imports$

$V = primary\ inputs$

$D = depreciation$

$W = wages$

$TP = taxes \,\&\, profits$

$\sum_{i=1}^{n} X_i = total\ production\ for\ the\ economy$

3.1.1 Leontief Demand-Pull Model

The Leontief demand-pull model is used to determine the upstream impacts of economic activity, based on the final demand for goods and services (Wood, 2011). The rows of the input-output table represent the delivery (sales) from each sector to intermediate and final users, expressed as:

$$X_i = \sum_{j=1}^{n} X_{ij} + Y_i$$

The input-output model relies upon the assumption that output can be expressed as a linear combination of its inputs. A constant a_{ij} can be defined that represents the intermediate requirement from sector i per unit of input of sector j (Leontief, 1970):

$$a_{ij} = \frac{X_{ij}}{X_j}$$

This allows the above supply and demand equation to be re-written as:

$$X_i = \sum_{j=1}^{n} a_{ij} X_j + Y_i$$

These a_{ij} factors can be combined into a $i * j$ matrix, indicated by $\boldsymbol{A}$, called the (technological) coefficient matrix (Miller & Blair, 2009). Therefore, the overall supply and demand equation for the economy becomes:

$$\boldsymbol{x} = \boldsymbol{A}\boldsymbol{x} + \boldsymbol{y}$$

Where $\boldsymbol{x}$ represents the column vector of outputs and $\boldsymbol{y}$ represents the column vector of final demands (Rodrigues & Domingos, 2008). This relationship can then be solved for $\boldsymbol{x}$:

$$\boldsymbol{x} - \boldsymbol{A}\boldsymbol{x} = \boldsymbol{y}$$

$$(\boldsymbol{I} - \boldsymbol{A})\boldsymbol{x} = \boldsymbol{y}$$

$$\boldsymbol{x} = (\boldsymbol{I} - \boldsymbol{A})^{-1}\boldsymbol{y} = \boldsymbol{L}\boldsymbol{y}$$

Where $\boldsymbol{L}$ is called the **Leontief inverse matrix** (Miller & Blair, 2009). This matrix is then used to generate upstream Total Impact Multipliers (TIMs) for each industry which relate the environmental footprint of that industry to final demand (Chen et al., 2016). An upstream carbon footprint TIM is referred to as a "carbon backward multiplier" (denoted as CBM_i) and an upstream employment footprint TIM is referred to as an "employment backward multiplier" (denoted as EBM_i).

$$TIM_i = e_j \boldsymbol{L}$$

Where e_j is a row vector of carbon emission coefficients for each industry j for a CBM (in the units kg CO_2-e/$) and alternatively a row vector of the employment coefficients for each industry j for an EBM (in the units FTE/$mil) (Chen et al., 2016). A matrix where upstream TIM values have been placed on the diagonal can then be used to calculate the representative upstream carbon or employment footprint (denoted as $F(upstream)_i$) for each industry *i* by multiplying it by the vector of final demand (an alternative is an element-wise multiplication (symbol $\times$) with a transposed vector of TIMs):

$$F(upstream)_i = \; diag(TIM_i) \cdot \boldsymbol{y} = (TIM_i)^T \; \times \; \boldsymbol{y}$$

Similarly, the upstream carbon or employment footprint of an individual industry can be calculated by multiplying the CBM or EBM of that industry by its final demand:

$$F(upstream)_i = \; TIM_i * Y_i$$

3.2 Using Equity Investment Data in Environmentally Extended Input-Output Analysis

EEIOA uses data related to output (namely final demand or primary inputs for an industry sector) to calculate the environmental impacts of an economic activity. In this study it is assumed that an equity investment creates a proportional responsibility over the respective carbon and employment footprint of that company (consistent with the assumptions of aforementioned Koellner et al. (2007) and Ritchie and Dowlatabadi (2014)).

The investment data used in this research takes the form of equity portfolios of ASX (Australian Securities Exchange) listed shares. These data need to be converted into a representative final demand within an industry to determine the upstream carbon and employment footprints (by applying the relevant TIMs as described in section

3.1.1). Whilst many large organisations operate across several industries, for simplicity each equity holding is mapped to the industry in which that company produces the most output (mostly due to lack of available data on the output distribution of corporations).

3.2.1 Converting Equity Investment to Final Demand

This research utilises the same method for converting equity investment to final demand (for use with a CBM or EBM) as Koellner et al. (2007). This conversion can be done on an individual company or industry sector level depending on data availability. It relies upon data on the total annual final demand (i.e. revenue) and market capitalisation (value of all equity at a point in time) of a company or industry. The assumption of this conversion is that for each dollar invested in a company or industry this facilitates an amount of revenue (demand) proportional to the total annual revenues divided by total market capitalisation (Ritchie & Dowlatabadi, 2014). Using this relationship, the amount of demand facilitated by a dollar of investment is:

$$facilitated\ demand_i = \$\ invested_i \frac{annual\ revenue_i}{market\ capitalisation_i}$$

However, the annual revenues reported by companies are in terms of "purchaser's prices" which include net taxes and profit margins. This EEIOA method relies upon "basic prices" (which exclude net taxes and profit margins) so this facilitated demand must be augmented to account for this by applying a ratio of basic prices relative to purchaser's prices for that industry:

$$faciliated\ demand_i =$$

$$\$\ invested_i * \frac{annual\ revenue_i}{market\ capitalisation_i} * \frac{basic\ prices_i}{purchaser's\ prices_i}$$

This facilitated demand is then converted into an upstream carbon or employment footprint using the relevant CBM or EBM for that industry:

$$F(upstream)_i =$$

$$TIM_i * \$\ invested_i * \frac{annual\ revenue_i}{market\ capitalisation_i} * \frac{basic\ prices_i}{purchaser's\ prices_i}$$

3.2.2 Converting Backward Multipliers to Equity Investment Footprint Multipliers

As equity investment can be converted into a representative final demand within an industry, a CBM or EBM can similarly be converted to a factor which relates carbon or employment footprint to dollars of equity investment in an industry. This study will introduce the following terms:

- **Equity Investment Footprint Multiplier (EIFM)**: The general term for a factor relating equity investment in a company within a specific industry to an environmental footprint.
- **Equity Carbon Footprint Multiplier (ECFM)**: A factor which relates equity investment in a company within a specific industry to carbon footprint.
- **Equity Employment Footprint Multiplier (EEFM)**: A factor which relates equity investment in a company within a specific industry to employment footprint.

CBMs are converted into an industry ECFM using the following relationship:

$$ECFM_i = CBM_i * \frac{annual\ revenue_i}{market\ capitalisation_i} * \frac{basic\ prices_i}{purchaser's\ prices_i}$$

Hence the upstream carbon footprint of equity investment in an industry can be calculated by:

$$Carbon\ Footprint\ (upstream)_i = ECFM_i * \$\ invested_i$$

EBMs are converted into an industry EEFM using the following relationship:

$$EEFM_i = EBM_i * \frac{annual\ revenue_i}{market\ capitalisation_i} * \frac{basi\ \ prices_i}{purchaser's\ prices_i}$$

Hence the upstream employment footprint of equity investment in an industry can be calculated by:

$$Employment\ Footprint(upstream)_i = EEFM_i * \$\ invested_i$$

These multipliers can give an indication of the actual impacts of investing in companies in different industries. These factors are more useful than CBMs or EBMs for equity investment analysis as industry relationships between revenue and market capitalisation can drastically alter the actual footprint of equity investment.

3.3 Data

3.3.1 Input-Output Data and Model

The input-output table used for analysis of the Australian economy was sourced from the Australian National Accounts developed by the ABS (Australian Bureau of Statistics, 2017b). This table maps total input and output over the course of the 2014-15 Australian financial year (i.e. 1st July 2014 to 30th June 2015) categorised into 114 industries. A separate multi-region input-output table was obtained from the Eora database (see Lenzen et al. (2013) and Lenzen et al. (2011)) to find values of Australian imports and exports over the same time period, categorised into 26 industry categories. These two tables were combined to form a complete input-output table representing the Australian economy (including imports and exports) for the 2014-15 financial year.

Direct emissions for each industry for the 2015 year were obtained from the Australian Greenhouse Emissions Information System (AGEIS, 2017). These data were more aggregated than the input-output table used and hence needed to be disaggregated to match the industry sector breakdown. This was achieved by using proxy information on the structure of the Australian economy sourced from the Industrial Ecology Virtual Laboratory see Lenzen et al. (2014) and Lenzen (2011). Carbon emission coefficients e_j were then calculated by dividing the carbon emissions of an industry sector by its respective total inputs.

$$e_j = \frac{Direct\ carbon\ emissions_j}{Total\ inputs_j}$$

The CBM_i for each industry were then calculated following the steps detailed in section 3.1.1.

The direct employment of each industry sector for the 2014-15 financial year was sourced from the IELab (see Lenzen and Fry (2016)). Employment generation coefficients e_j were then calculated by dividing the total direct employment within an industry sector by its respective total inputs.

$$e_j = \frac{Direct\ employment_j}{Total\ inputs_j}$$

The EBM_i for each industry were then calculated following the steps detailed in section 3.1.1.

3.3.2 Equity Portfolio Data

We limit our analysis to Australian Super as this is the only superannuation fund which publicly discloses the entirety of its equity investment portfolios. Australian Super offers a range of investment options for its superannuation costumers, based on their attitudes towards risk and social responsibility. Precise breakdowns of each of these options are publicly available on Australian Super's website and the portfolio breakdowns as at 31st December 2016 were used for this study.

This study looked at data from the "High Growth" and "Balanced" options (being the two largest portfolios held by Australian Super) and the "Socially Aware" option (a portfolio selected using ESG screening (Australian Super, 2016b). This study focuses on the "Australian Shares" component of each option, excluding shareholdings with a value less than $500,000. Any investments in cash or equity futures were also excluded. As the timeframe of the equity portfolio valuation and the input output table differed, these values were adjusted for inflation using the ABS industry-categorised consumer price index ratio between the 2014-15 financial year and December 2016 (see Australian Bureau of Statistics (2016)). Table 3.1 summarises the market capitalisation of the portfolios.

Table 3.1: Value of Australian Super investment options as at 31st December 2016 (sourced from Australian Super (2016b))

Investment Option	Total Value	Value of Australian Shares Component	Value of Australian Shares >$500,000
High Growth	$5,611,408,000	$1,679,974,970	$1,651,156,399
Balanced	$77,303,640,000	$18,512,525,619	$18,469,547,003
Socially Aware	$1,513,095,000	$385,258,206	$384,755,275

3.3.3 Price-Sales Ratios

Information on annual revenues and market capitalisation was needed to convert equity investment into final demand. Obtaining this information for every equity held by Australian Super would require substantial amounts of manual data analysis, so instead standard values for the price-sales ratios (price meaning market capitalisation and sales meaning annual demand) for each industry were used. These price-sales ratios were then inverted to provide a ratio of annual revenue to market capitalisation:

$$\frac{annual\ revenue}{market\ capitalisation} = \frac{1}{price: sales\ ratio}$$

Price-sales ratios for each industry sector as at January 2015 were sourced from public data produced by the New York University (NYU) Stern School of Business (for more information, see Damodaran (2015)). Sector averages for the USA economy were used as no dataset existed for Australia. Price-sales ratios from the same database were used for the same purpose in the aforementioned Shadow Impact Calculator study by Ritchie and Dowlatabadi (2014). These ratios were grouped into 102 industry sectors with a slightly different categorisation compared to the ABS Input Output tables. To overcome these differences, ratios were matched to the most relevant sector in the input-output table. Due to this, some sectors had identical price-sales ratios when a NYU Stern category spanned across two or more ABS industry sectors. For the brevity, the Price-sales ratios for each industry are not reported.

3.3.4 Conversion of Purchaser's Prices to Basic Prices

Total flows in terms of basic and purchaser's prices for each industry in the Australian economy for the 2014-15 year were obtained from the ABS (see Australian Bureau of Statistics (2017a)). To find the ratio for conversion of demand facilitated by an equity investment into purchaser's prices the following calculation was made (where *i* is each industry sector in the ABS Australian National Accounts):

$$\frac{basic\ prices_i}{purchaser's\ prices_i} = \frac{Sum\ of\ final\ demand\ in\ basic\ prices_i}{Sum\ of\ final\ demand\ in\ purchaser's\ prices_i}$$

Any ratios above 2 were normalised to the economy average (excluding any outliers).

3.4 Limitations and Assumptions

3.4.1 Aggregation of Industry Sectors

The primary weakness of IOA is the high level of aggregation of industry data (Wiedmann, 2010). Data are modelled on an industry sector level rather than a product or company level which makes it difficult to assess the actions of individual entities within an industry. Aggregation into industry sectors also means that entities and products within an industry sector are assumed to be homogenous and a change in spending by one company will be assumed to have the same impact as a change in spending by another within that industry. This issue could be resolved by building an input-output table split into discrete organisations or products but this would take considerably longer and be much more difficult to produce (Wiedmann, 2010).

Similarly, data on direct carbon emissions and employment were sourced using the Industrial Ecology Virtual Laboratory (https://ielab.info). This meant that these data were available with less industry aggregation but needed to be aggregated into 114 sectors due to the structure of the ABS input-output table used.

3.4.2 Assumption of Price Uniformity

Another major assumption of EEIOA is that the prices of goods or services are uniform within a given industry sector (Rowley et al., 2009). This assumption has important implications for this study as the footprint of an equity investment is calculated using the price-sales ratio for its respective industry. Therefore identical, more expensive goods or services are perceived to have a higher footprint than their cheaper substitutes. In this study, it is assumed that because the equity portfolios analysed hold shares in numerous companies in each industry this spreads the investment across a range of price points, negating the skewed results caused by assumed price uniformity.

3.4.3 Assumption of Constant Returns to Scale

Input-output analysis assumes that there are constant returns to scale, meaning an increase in inputs has a constant proportional change in outputs (Murray & Wood, 2010). This assumption would then lead to a constant proportional increase in footprints for an increase in purchases between industry sectors. As economies generally become more cost efficient and less resource intensive as they expand this would inflate the actual footprint change resulting from this growth.

3.4.4 Limitation on the Footprint of Imported Products

The input-output table used in this study includes both domestically produced and imported goods and services. The carbon or employment footprints of production outside of Australia could vary drastically from domestically produced goods or services depending on the work practices in the overseas industry. In an attempt to account for these differences, a two-region IO table is used for this study where the world outside of Australia (ROW) is represented as one economy with a resolution of 26 sectors. This allows for a distinction to be made between the carbon intensity or employment generated by Australian and overseas industries. However, this model provides no differentiation between individual foreign countries.

3.4.5 Assumption of Proportionality of Investment to Output

This study follows the assumption of Koellner et al. (2007) and Ritchie and Dowlatabadi (2014) that equity investment creates a percentage ownership over a company and the same percentage ownership over that company's output and carbon/employment footprint. This assumption is a reasonable interpretation but the actual link between investment and output is much more complicated and dependent on the individual company's financial strategy and operations.

3.4.6 Assigning Conglomerate Equities to Primary Output Sector

Most large ASX-listed companies operate across a range of industry categories. However, for this analysis equities held in a company were mapped to the industry for which that company produces most of its output. This was mostly due to the lack of data available regarding the distribution of output between a company's operating industries. Whilst this does simplify calculations it causes the carbon and employment footprints of smaller industries to be underrepresented and the footprints of larger industries to be overstated.

3.4.7 Differences in Industry Categorisation and Geography for Price-Sales Ratios

The input-output table used in this analysis was grouped into 114 domestic industry sectors. An industry-aggregated dataset for price-sales ratios which matched the ABS categorisation couldn't be found so a NYU Stern dataset (see Damodaran (2015)) with 102 industry sectors was used and assigned to the closest matching industry category. This meant that some sectors had identical price-sales ratios where a NYU Stern category matched more than one category in the input-output table. These ratios may differ from the actual price-sales ratios for Australia.

3.4.8 Difference in Data Timeframes

Due to issues in data availability there were slight differences in the time ranges of the data used in this study. The ABS input-output table modelled transactions over the 2014-15 financial year so this period was used as a base when sourcing other relevant data. Data on CO_2 emissions for each industry was for the year 2015 rather than the 2014-15 financial year, price-sales ratios were dated January 2015 and equity portfolio data was dated December 2016.

This difference in time is particularly important for the equity portfolio data given the significant fluctuations in share value over time. However, equity values were corrected for inflation to minimise any differences caused by changes in currency value over this time frame. The variability in share value would also impact the price-sales ratios as they are a function of market capitalisation. Whilst the Australian economy has remained relatively stable over this period these differences could lead to inaccuracies in results obtained.

4 Results & Discussion

4.1 Industry Carbon Emissions and Employment

4.1.1 Direct Carbon Emissions

The data sourced from the AGEIS detailed the total direct carbon emissions of each industry sector, which is a useful reference when interpreting the carbon investment intensity results (see Section 4.2.1). Based on AGEIS (2017) the Australian industries with the most direct carbon emissions for the 2015 year were:

1. Electricity Generation (156,797 kt CO_2-e)
2. Coal Mining (62,089 kt CO_2-e)
3. Sheep, Grains, Beef and Dairy Cattle (58,990 kt CO_2-e)

Electricity Generation in particular had a significant contribution towards Australia's emissions, making up almost 30% of total direct emissions in the national economy. For brevity, we report the top 5 industry sectors only. Details are available from the authors upon request.

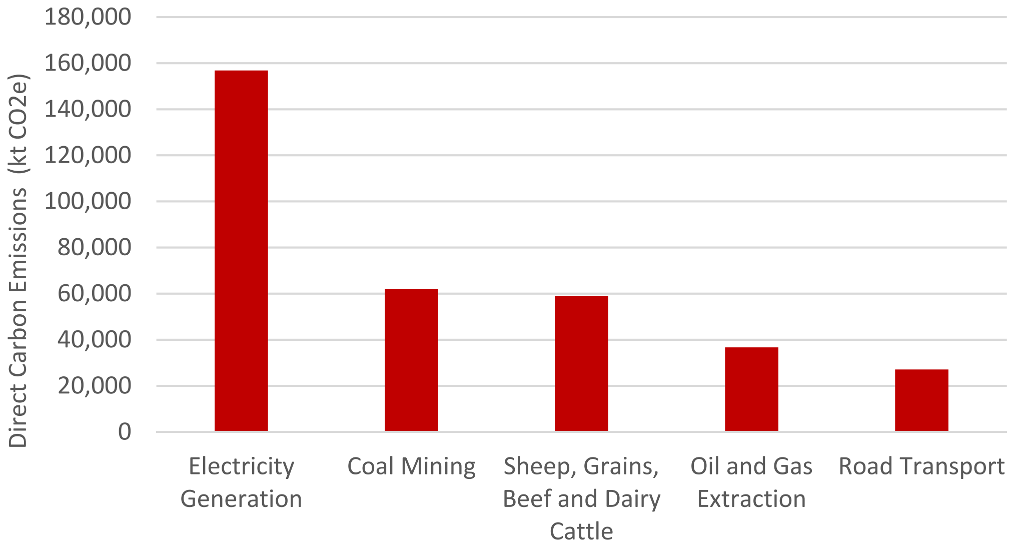

Figure 4.1: Highest-emitting Australian industries for the 2015 year (AGEIS, 2017)

4.1.2 Direct Employment

Employment data sourced from the IELab detailed the total direct employment of each industry sector, which is a useful reference when interpreting the employment investment intensity results (Section 4.2.2). Based on Lenzen and Fry (2016) the Australian industries with the most direct employment for the 2014-15 year were:

1. Retail (914,200 FTE)
2. Health Care Services (651,818 FTE)
3. Professional, Scientific and Technical Services (639,761 FTE)

It was found that Australia's direct employment was heavily concentrated within a small number of key industry sectors, with the total employment from the 10 largest employment industries making up over half of Australia's direct employment. Similarly details of direct employment for each industry is available upon request.

Overall, results show that levels of carbon emissions and employment vary dramatically between industries and there was no apparent correlation between industry carbon emissions and levels of employment.

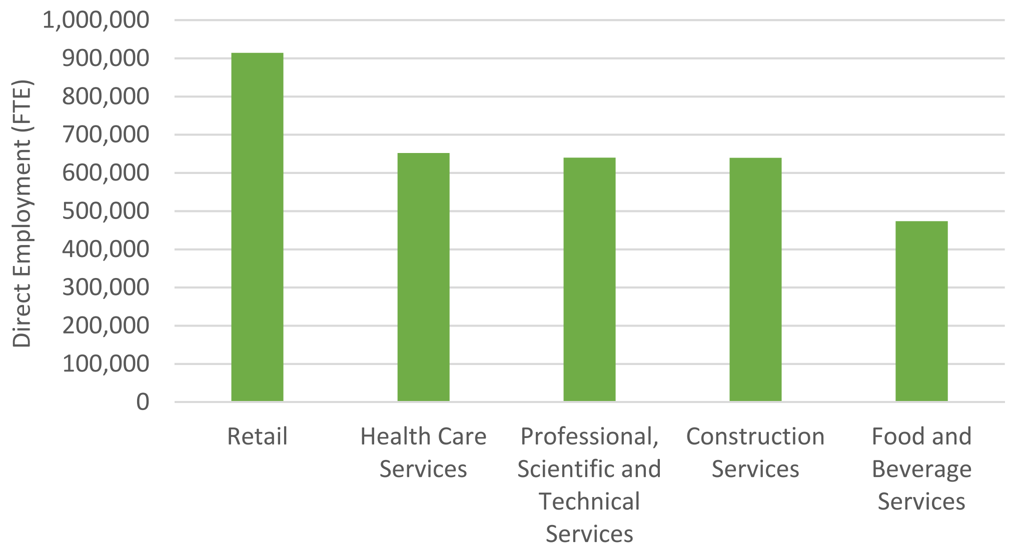

Figure 4.2: Largest employment industries for the 2014-15 financial year (Lenzen & Fry, 2016)

4.2 Equity Carbon and Employment Footprint Multipliers by Industry

Equity Carbon and Employment Footprint Multipliers were calculated for each industry using the method detailed in 3.2.2. These multipliers provide a basis for which industries should be avoided in order to reduce the carbon footprint of an equity portfolio. Similarly, these factors can be used to determine the amount of employment facilitated by an equity portfolio (assuming high employment is ideal and should be maintained or increased where possible). Any industries not invested in by Australian Super were excluded, as these would not be a viable option for potential SRI or divestment.

4.2.1 Equity Carbon Footprint Multipliers by Industry

The industries with the highest ECFMs were found to be:

1. Electricity Generation (2.20 kg CO_2-e/$)
2. Poultry and Other Livestock (1.35 kg CO_2-e/$)
3. Waste Collection, Treatment and Disposal Services (1.33 kg CO_2-e/$)
4. Coal Mining (1.29 kg CO_2-e/$)

Interestingly, Electricity Generation not only had the highest direct emissions for the 2015 year but was also one of the most carbon-intensive industries in terms of total, economy-wide emissions generated per $ of equity investment.

The industries with the lowest ECFMs were:

1. Finance (0.017 kg CO_2-e/$)
2. Computer Systems Design and Related Services (0.035 kg CO_2-e/$)
3. Non-Residential Property Operators and Real Estate Services (0.044 kg CO_2-e/$)

Therefore, a portfolio manager looking to minimise the carbon footprint of their equity portfolio would look to not invest in companies within the more carbon-intensive industries (such as Electricity Generation or Coal Mining) and instead invest in companies within more carbon-efficient industries (such as Finance).

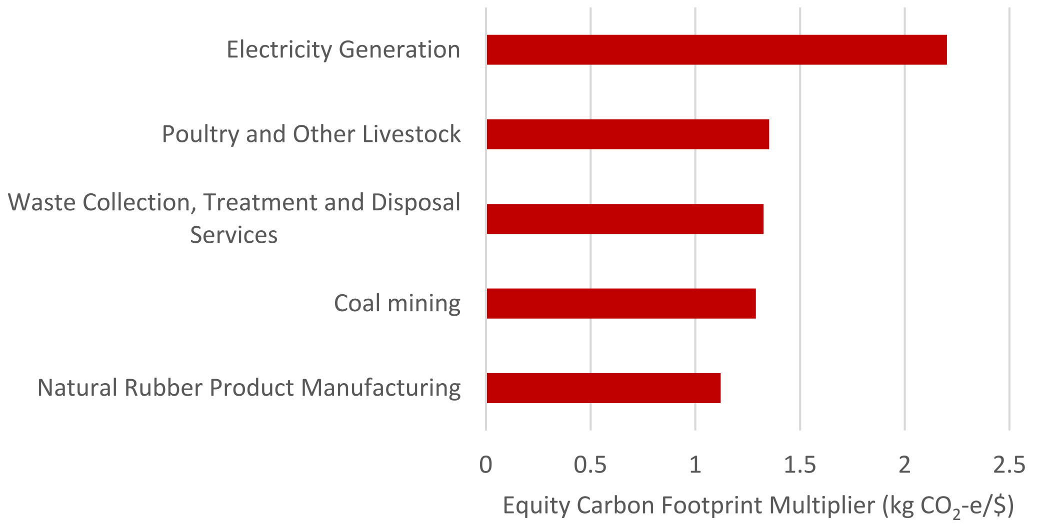

Figure 4.3: Highest Equity Carbon Footprint Multipliers by industry.

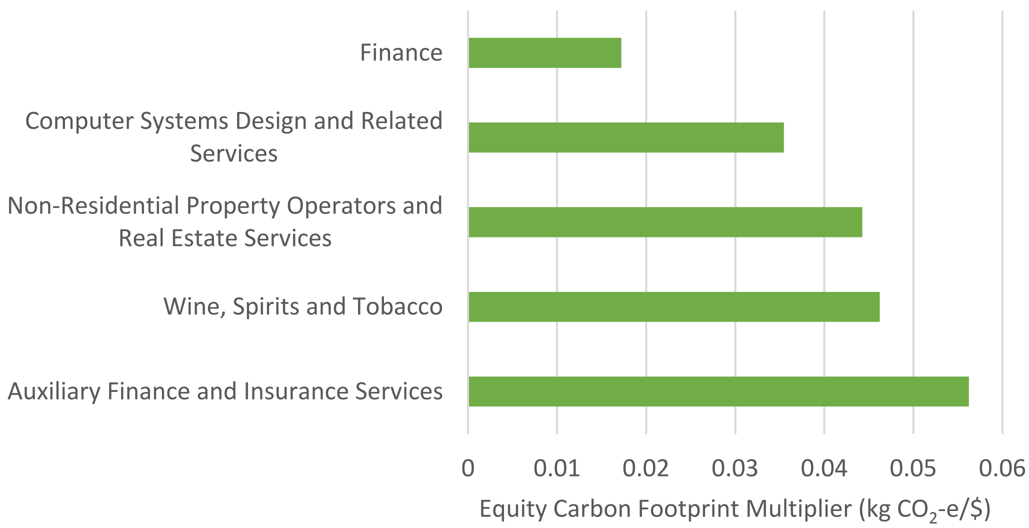

Figure 4.4: Lowest Equity Carbon Footprint Multipliers by industry.

4.2.2 Equity Employment Footprint Multipliers by Industry

The industries with the highest EEFMs were found to be:

1. Health Care Services (19.96 FTE/$mil)
2. Non-Residential Building Construction (19.40 FTE/$mil)
3. Retail Trade (19.27 FTE/$mil)

Interestingly, the Retail Trade industry had the highest direct employment for the 2014-15 year and one of the highest EEFMs, making it an ideal investment industry for portfolio managers or policymakers looking to maximise facilitated employment. The industries with the least employment generated per dollar invested in equity were:

1. Wine, Spirits and Tobacco (0.68 FTE/$mil)
2. Finance (0.91 FTE/$mil)
3. Non-Residential Property Operators and Real Estate Services (1.33 FTE/$mil)

These EIFM results show that there is not an obvious correlation between equity carbon and employment footprint multipliers within an industry. Whilst in some cases these multipliers are highly correlated (for example in the Finance industry which had not only the lowest ECFM but also one of the lowest EEFMs) in other cases they can be significantly negatively correlated (such as the Electricity Generation industry which had the highest ECFM and one of the lowest EEFMs). ECFMs and EEFMs for each industry invested in by Australian Super are detailed in Appendix A.

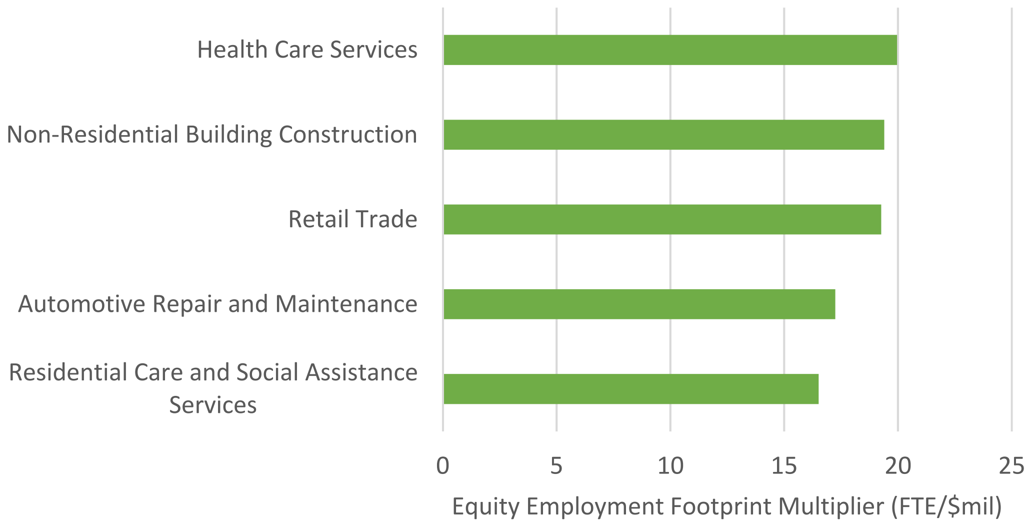

Figure 4.5: Highest Equity Employment Footprint Multipliers by industry.

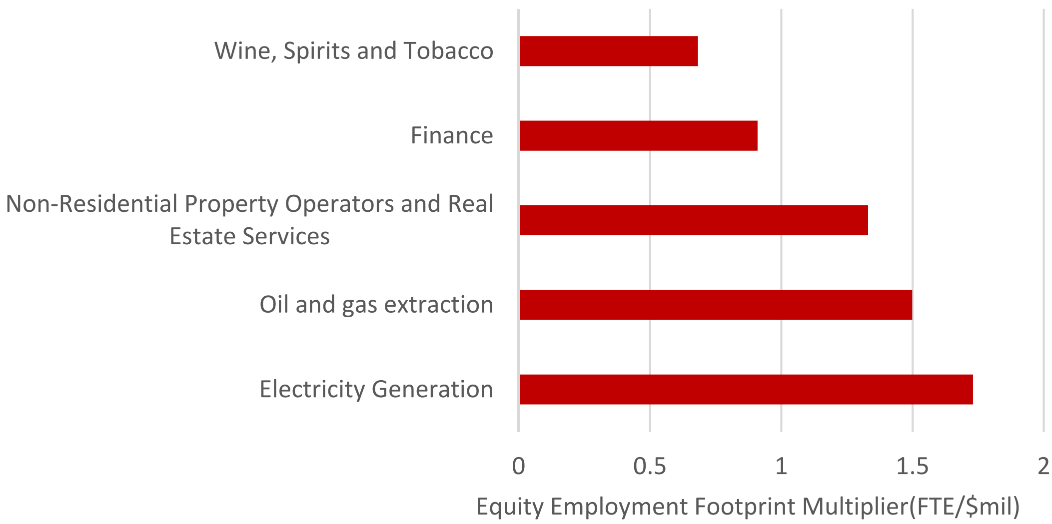

Figure 4.6: Lowest Equity Employment Footprint Multipliers by industry.

4.3 Equity Portfolio Carbon and Employment Footprints

Carbon and employment footprints were generated for the three Australian Super investment portfolios (High Growth, Balanced and Socially Aware options) following the method outlined in section 3.2.1. These footprints were subsequently divided by the total value of the portfolio in order to allow for comparison between the three portfolios based on a normalised footprint per dollar basis.

4.3.1 Equity Portfolio Carbon Footprints

The total carbon footprint of each portfolio was calculated to be:

- High Growth: 0.557 Mt CO_2-e (for a portfolio value of $1.651 billion)
- Balanced: 6.209 Mt CO_2-e (for a portfolio value of $18.470 billion)
- Socially Aware: 0.092 Mt CO_2-e (for a portfolio value of $0.385 billion)

When converted to a carbon footprint per dollar invested, it was found that the High Growth and Balanced portfolio had identical footprints of 0.34 kg CO_2-e/$. However, the Socially Aware portfolio had a significantly lower footprint of 0.24 CO_2-e/$, 29% lower than the other two portfolios. These results suggest that the SRI criteria implemented by Australian Super for its Socially Aware portfolio noticeably reduced the carbon footprint of the portfolio.

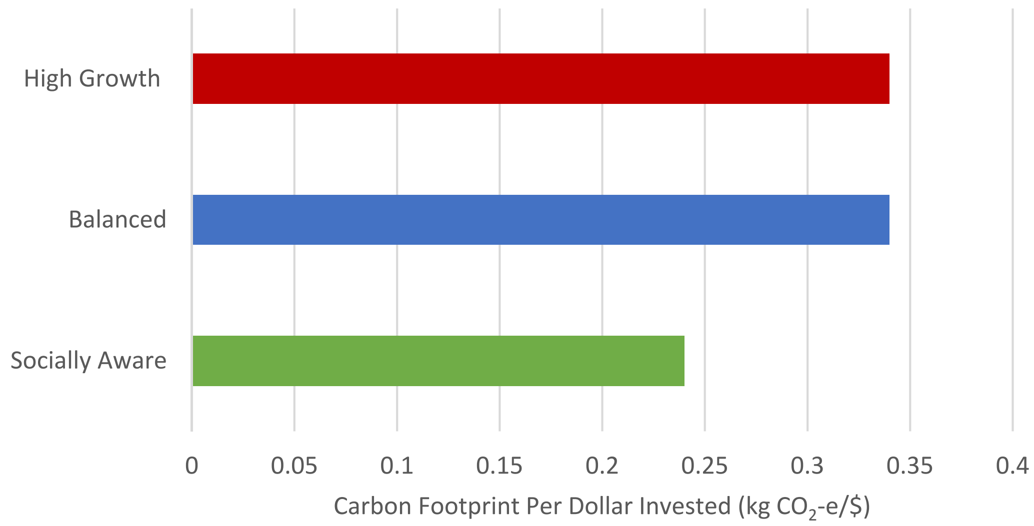

Figure 4.7: Comparison of carbon footprint per dollar invested.

4.3.2 Equity Portfolio Employment Footprints

The total employment footprint of each portfolio was calculated to be:

- High Growth: 8,203 FTE (for a portfolio value of \$1.651 billion)
- Balanced: 93,610 FTE (for a portfolio value of \$18.470 billion)
- Socially Aware: 1,918 FTE (for a portfolio value of \$0.385 billion)

The employment footprints per dollar invested were found to be very similar between the three portfolios, all sitting close to 5 FTE/\$mil. This implies that whilst the SRI and non-SRI portfolios invested in different companies (and hence facilitate employment in different industries) the overall facilitated employment was not affected by SRI criteria.

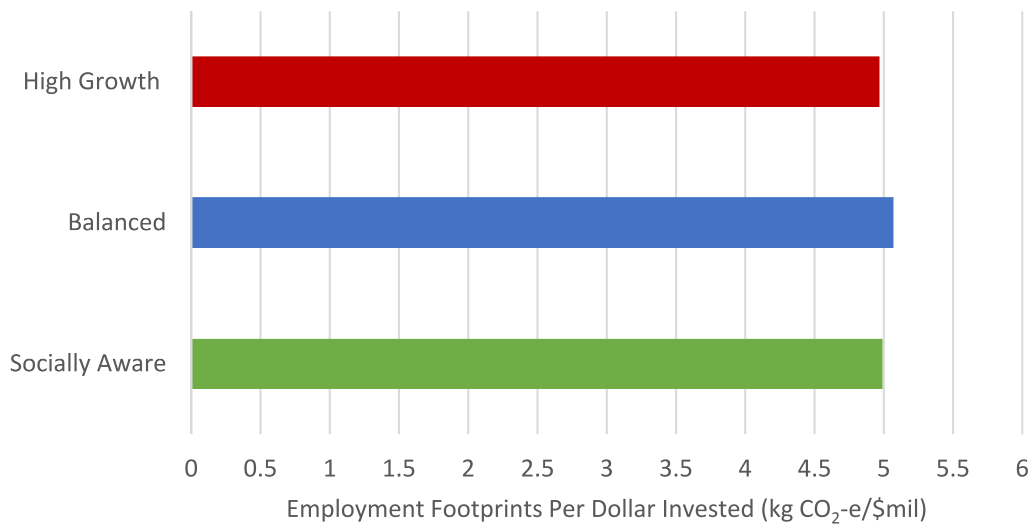

Figure 4.8: Comparison of employment footprint per dollar invested.

4.3.3 Comparison of Portfolio Structure

The differences in the carbon footprint of the three investment portfolios analysed is ultimately a result of variances in portfolio structure. The three portfolios invested in different companies in varying amounts which influenced their overall footprint.

All three portfolios invested heavily in companies from the Finance sector (through buying shares in banks or other financial services organisations), making up over 30% of the total portfolio value in each case. The Finance industry was found to have a very low carbon and employment intensity (see Section 4.2.1 and 4.2.2) so it was assumed that these shareholdings contributed very little to the overall carbon and employment footprint of each portfolio.

The key factor which led to the significant reduction in the carbon footprint of the Socially Aware portfolio is the lack of investment (or minimal investment) in mining and power companies. The High Growth and Balanced portfolios invested significantly in companies in the Coal Mining industry (8% of total fund value for each portfolio) and moderately in companies in the Electricity Generation industry (3% of total fund value for each portfolio) which were both shown to have very high carbon intensities (see section 4.2.1). In comparison, the Socially Aware portfolio didn’t invest in any Coal Mining companies and had less than 1% of its total value invested in Electricity Generation companies. The shareholdings and footprints of each portfolio are further detailed by industry in the Appendix.

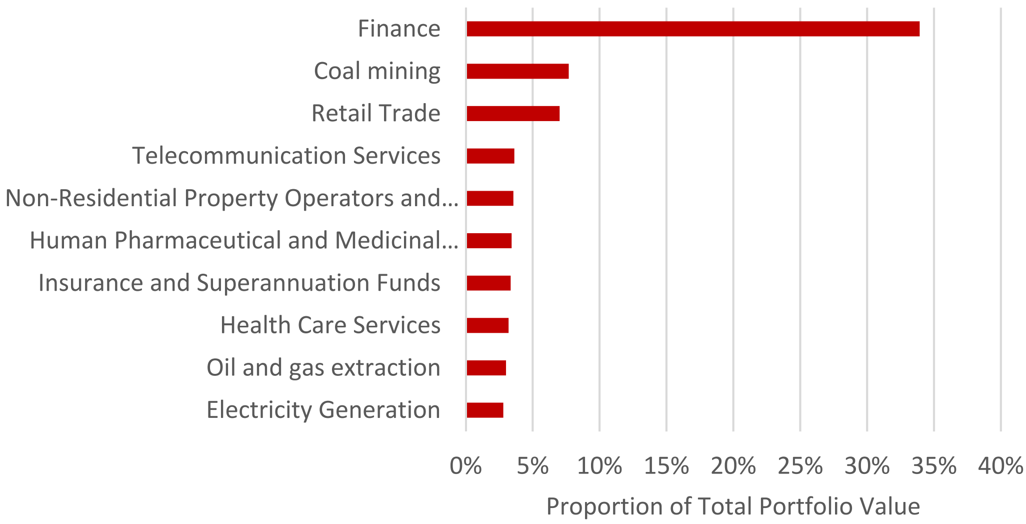

Figure 4.9: Primary industries invested in by the High Growth portfolio.

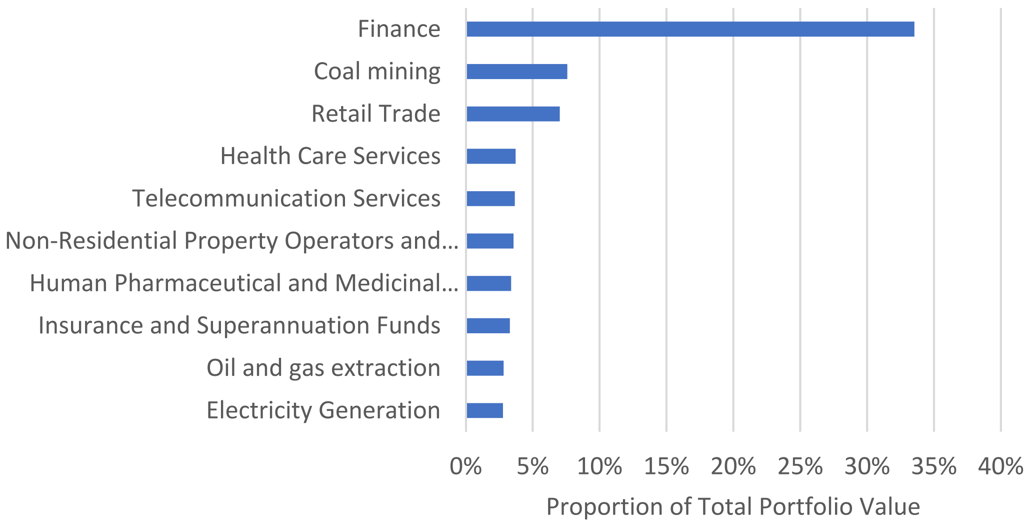

Figure 4.10: Primary industries invested in by the Balanced portfolio.

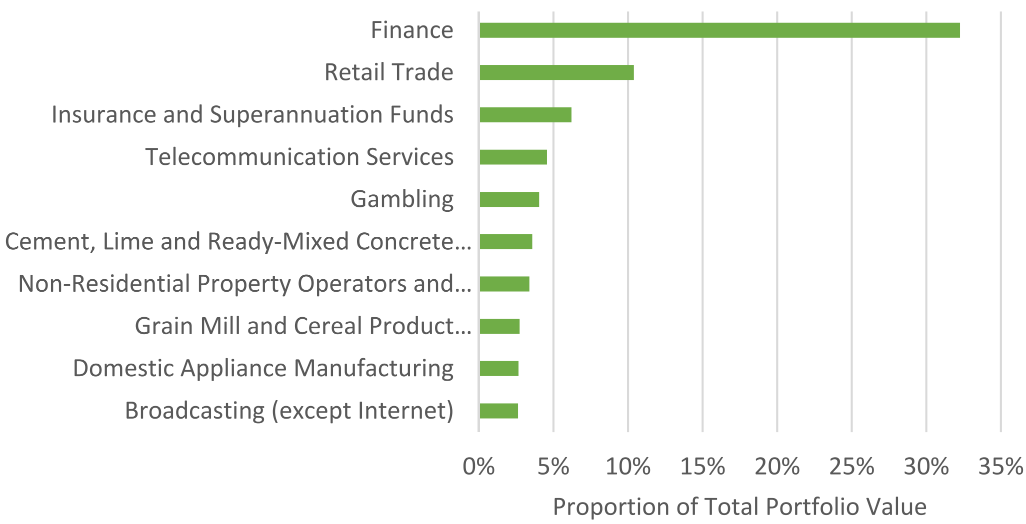

Figure 4.11: Primary industries invested in by the Socially Aware portfolio.

4.3.4 Comparison to the Carbon Footprint of Australia

Supporters of SRI and divestment argue that it has the potential to influence the carbon emissions of entire economies. Therefore, it is useful to compare the carbon footprints of these portfolios to the carbon emissions of Australia to determine their relative level of influence. As the largest equity portfolio held by Australian Super, the Balanced portfolio totals over $18 billion worth of shareholdings. This makes up just over 1% of the Australian All Ordinaries, which is the index of the 500 largest ASX-listed companies by market capitalisation (Market Index, 2017).

Using the ABS 2014-15 input-output table and relevant carbon emissions data, the upstream carbon emissions of Australia for the 2014-15 year were calculated to be 590 Mt CO_2-e. In comparison, the carbon footprint of the Balanced portfolio was 6.2 Mt CO_2-e, making up just over 1% of Australia's total upstream emissions. This indicates that if SRI and divestment can be shown to be effective in reducing the emissions facilitated by an equity portfolio, large-scale SRI and divestment could be able to impact economy wide carbon emissions by supporting carbon-efficient industries and not supporting carbon-intensive industries.

4.4 Optimising Portfolios for Carbon Footprints and Employment

Using the equity investment carbon and employment intensities derived in section 4.2, the investment structure of the Balanced portfolio was shifted to observe the impacts of divestment on overall carbon and employment footprint.

Firstly, scenario (1) aiming to minimise the carbon footprint of the portfolio was modelled. To achieve this 10% of the portfolio value was shifted from shareholdings in the most carbon-intensive industries to invest in (being Electricity Generation, Poultry and Other Livestock, Waste Collection Treatment and Disposal Services, Coal Mining and Natural Rubber Product Manufacturing) to shareholdings in the least carbon intensive industry to invest in (being Finance). This relatively small shift of overall fund value reduced the normalised carbon footprint of the portfolio to 0.14 kg CO_2-e/$, a 57% reduction. The normalised employment footprint of this portfolio was slightly reduced to 4.13 FTE/$mil, a 19% reduction. This result highlighted the significant potential for SRI and divestment to reduce the overall carbon footprint of an equity portfolio whilst maintaining overall facilitated employment.

Secondly, scenario (2) aiming to maximise the employment footprint of the portfolio was modelled. The methodology was similar, with 10% of the portfolio value being shifted from shareholdings in the least-employment intensive industry (being Wine, Spirits and Tobacco and Finance) towards shareholdings in the most employment intensive industry (being Health Care Services). This divestment scenario increased the normalised employment footprint of the portfolio to 6.38 FTE/$mil, a 26% increase. This divestment scenario had very little impact on the carbon footprint of the portfolio, reducing the normalised carbon intensity by less than 3%. Whilst to a lesser extent, these results implied that SRI and divestment have the potential to noticeably increase the employment footprint of an equity portfolio.

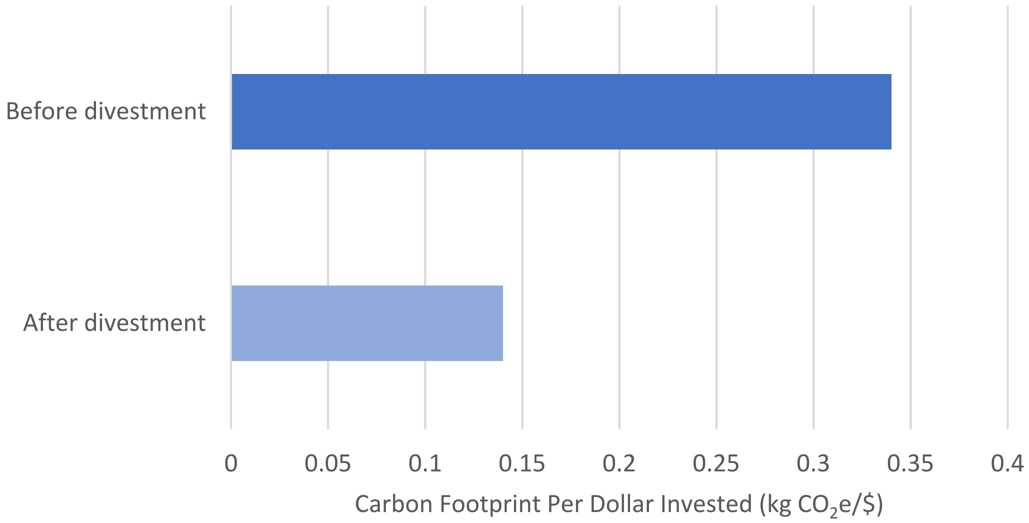

Figure 4.12: Change in carbon footprint of Balanced portfolio after scenario (1).

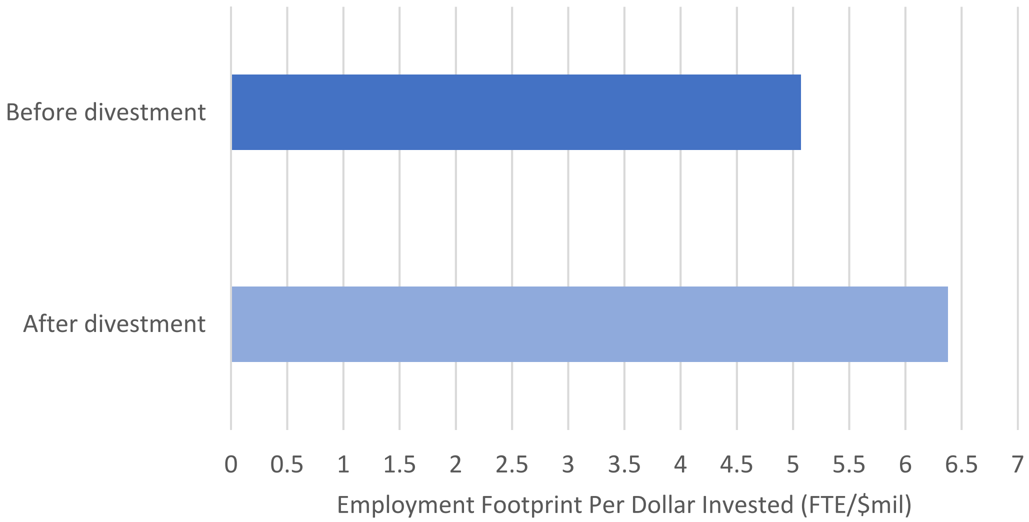

Figure 4.13: Change in employment footprint of Balanced portfolio after scenario (2).

4.5 SRI & Divestment vs Shareholder Engagement

SRI and divestment have become remarkably popular in recent years as a way for companies and consumers remove their support for fossil fuel companies and other "sin" industries. Many large Australian companies and financial institutions have publicly announced their divestment from fossil fuel investments in a stand against the industry. Whilst SRI and divestment are expected (and somewhat proven in this study) to be major influences in the transition to a low-carbon economy, they may not be the best approach to achieve this.

Whilst the long-term avoidance of carbon-intensive investments has the potential to facilitate the reduction of carbon emissions across an economy, divestment and SRI often involve the selling-off of carbon-intensive shareholdings. Selling shares to another investor will do a great deal to reduce the carbon footprint of an individual equity portfolio but in reality, this is just "selling the problem" to another investor. Companies whose shareholdings have been sold are still operating and demand for their goods/services is unwatered by this divestment, raising questions over the true impacts of SRI and divestment.

Whilst mass SRI or divestment may be able to disrupt these industries by bankrupting companies or changing social and consumer attitudes, they are doing little to solve the underlying problem of dependence on fossil fuels. There is a case to be argued for shareholder engagement over SRI or divestment. If investors instead leverage the carbon-intensive companies which they have partial ownership over to reduce their carbon emissions this may in fact be more effective than divesting and "selling the problem". Investigation on the effectiveness of shareholder engagement is a worthwhile focus of future research to determine the best way to leverage equity investment in the transition to a low-carbon economy.

4.6 Comparison with Other Studies

This study had noticeably different results in comparison to most previous research on the carbon footprints of equity investment. Koellner et al. (2007) found minor differences in the carbon footprint of SRI and non-SRI funds. However, this study analysed portfolios which were managed to the same investment benchmark

(Morgan Stanley Capital International World) and had little variation in portfolio structure. As shown in section 4.3.3, the portfolios analysed in this study had significant differences in structure, with the Socially Aware portfolio containing almost no fossil fuel investment.

Ritchie and Dowlatabadi (2014) found that divestment had minimal impacts on the carbon footprint of an equity portfolio, with an 11% reduction in the most extreme divestment scenario modelled. This is likely due to the low amounts of equity investment in fossil fuel and mining companies in the portfolio analysed. The portfolio had 0.87% of its total value invested in these industries, compared to 14% for the Australian Super Balanced portfolio modelled for divestment in this study.

The results of this study are more aligned with those of the Trucost Carbon Counts reports. These reports found large variations in the carbon footprints of different equity portfolios, particularly for Australian superannuation funds. These reports attributed high carbon footprints with equity investment in the Metals & Mining, Oil & Gas and Construction Materials industries which also aligns with the results of this study.

Overall, the Australian economy is more dependent on fossil fuels than the European (studied in Koellner et al. (2007)) and Canadian (studied in Ritchie and Dowlatabadi (2014)) economies, which provides more potential for carbon emissions reductions from SRI and divestment. The comparison of these results appears to show that the carbon footprint of equity investments depends greatly on the economy being invested in. Equity investment in carbon-intensive economies is likely to facilitate a higher carbon footprint than similar investment in carbon-efficient economies, which explains why equity investment in Australia has such a high relative carbon footprint and divestment in Australian equity portfolios has such significant impacts on this footprint.

5 CONCLUSION & RECOMMENDATIONS

5.1 Conclusion

This study aims to quantitatively determine the carbon and employment footprint of Australian equity investment using EEIOA and examine the impacts of SRI and divestment. The lack of research on the carbon and employment footprints of equity investments coupled with the enormous amounts invested in equity across the globe highlights the importance of this area of research. This study also provides insights to measuring impacts on nature using financial inputs.

We calculate the carbon and employment footprints for three equity portfolios (defined as High Growth, Balanced and Socially Aware) held by Australian Super. An input-output table categorised into 114 industry sectors was extended using sector-level carbon and employment data to develop footprints for these portfolios and examine the main industries contributing towards this footprint. Divestment scenarios designed to minimise carbon footprint and maximise employment footprint were also modelled by moving the funds within these portfolios between shareholdings.

The results indicate that SRI criteria can significantly reduce the carbon footprint of an equity portfolio. For example, the Socially Aware portfolio analysed in this study had a carbon footprint per dollar 29 percent lower than the other two “traditionally managed” portfolios. Furthermore, it was found SRI criteria did not affect the overall employment footprint of a portfolio, with all portfolios facilitating approximately 5 Full Time Equivalents (FTEs) of employment per dollar invested. This implies that the carbon footprint of an equity portfolio can be reduced significantly without affecting its overall facilitated employment.

The differences in the footprints of the SRI and non-SRI portfolios were solely attributed to investment in different industries. This analysis enabled observation of the carbon and employment intensities of different industries from an equity investment perspective. It was found that Australian Super’s most carbon intensive investments were within the Electricity Generation, Poultry and Coal Mining industries. Portfolio managers looking to minimise the carbon footprint of their portfolios should therefore aim to avoid or minimise investment in these industries. In comparison, Finance and Computer Systems Design were found to be the least carbon intensive industries to invest in and would be an appropriate investment choice for low-carbon footprint portfolios.

When observing the employment intensities of industries from an equity investment perspective, it was found that Health Care Services, Non-Residential Building Construction and Retail Trade facilitated high levels of employment per dollar of equity investment. Governments or investors looking to facilitate high levels of employment through equity investment could therefore look to invest in these industries. In contrast, it was discovered that investing in Finance or Real Estate Services facilitated very low levels of employment per dollar invested.

Furthermore, the Balanced portfolio was modelled for two divestment scenarios, each shifting approximately 10 per cent of the portfolio value between shareholdings. The first scenario aimed to optimise the portfolio for a low carbon footprint and led to a reduction in carbon footprint by 57 per cent . A similar scenario aiming to maximising the employment footprint of the portfolio led to a 26 per cent increase in overall employment footprint.

In conclusion, this study suggests that SRI and divestment have the potential to significantly change the carbon emissions or employment facilitated by an equity portfolio. If so, large-scale SRI or divestment could have the influence to radically change the carbon or employment footprint of national and international economies. The techniques developed in this study could be used by portfolio managers to better control the carbon emissions and employment facilitated by their equity portfolios. Furthermore, this form of analysis would be a valuable tool for the development of investment and regulatory policy by governments looking to mitigate climate change or maximise overall employment.

Future research should consider:

- **Data Quality and Resolution:** Replicate the analysis of this study using more current data with less industry aggregation. The IELab could facilitate this due to its efficiency in generating input-output models.
- **Global Impacts and International Shareholdings:** This study focused on Australian shares and investment in Australian industries. Expanding this study to assess international share portfolios using MRIO analysis could determine the global economic footprint impacts of SRI and divestment.
- **Company-Specific Price-Sales Ratios:** This study used average price sales ratios for a given industry to convert equity investment into final demand. Provided that data is available for for specific companies, dividing annual revenues by market capitalisation could provide more granular accurate results and allow for definition between different companies in the same industry.
- **Distributing Conglomerate Companies Between Separate Output Sectors:** This study assigned equity investment in a company to the primary output sector of that company. This meant that carbon emissions or employment generated by companies who operate across a range of industries was assumed to result only from their primary industry, skewing the footprint of that investment. Future research could look to split these companies based on revenue from different industry sectors for greater accuracy.
- **Downstream Impacts of Equity Investment:** This research focused purely on the upstream impacts of equity investment. Currently no studies have attempted to determine downstream impacts from this investment, mostly due to the difficulty in linking equity investment to value added. Future research could assess the average cost structure of companies and industries to determine this link.

References

AGEIS. (2017). National Inventory by Economic Sector. Retrieved from http://ageis.climatechange.gov.au/ANZSIC.aspx#

Alsamawi, A., Murray, J., & Lenzen, M. (2014). The Employment Footprints of Nations. *Journal of Industrial Ecology, 18*(1), 59-70. doi:10.1111/jiec.12104

Association of Superannuation Funds of Australia. (2017). Superannuation Statistics. Retrieved from https://www.superannuation.asn.au/resources/superannuation-statistics

Australian Bureau of Statistics. (2016). *6401.0 Consumer Price Index, Australia TABLE 7. CPI: Group, Sub-group and Expenditure Class, Weighted Average of Eight Capital Cities* Retrieved from: http://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/6401.0Dec%202016?OpenDocument

Australian Bureau of Statistics. (2017a). *5209.0.55.001 Australian National Accounts: Input-Output Tables - 2014-15: Table 4 Reconciliation of Flows at Basic Prices and at Purchasers' Prices by Product Group*. Retrieved from: http://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/5209.0.55.0012014-15?OpenDocument

Australian Bureau of Statistics. (2017b). *Table 5. Australian National Accounts: Input-Output Tables, 2014-15. ABS Catalogue Number 5209.0.55.001*. Retrieved from: http://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/5209.0.55.0012014-15?OpenDocument

Australian Government Climate Change Authority. (2013). Chapter 8 Australia's emissions budget to 2050.

Australian Super. (2016a). About Us. Retrieved from https://www.australiansuper.com/about-us.aspx

Australian Super. (2016b). What We Invest In. Retrieved from https://www.australiansuper.com/investments-and-performance/what-we-invest-in.aspx

Bjerkholt, O. (2006). Introduction: the History of Input–Output Analysis, Leontief's Path and Alternative Tracks. *Economic Systems Research, 18*(4), 331-333. doi:10.1080/09535310601020850

Business Dictionary. (2017). Equity Investment. Retrieved from http://www.businessdictionary.com/definition/equity-investment.html

Capelle-Blancard, G., & Monjon, S. (2014). The Performance of Socially Responsible Funds: Does the Screening Process Matter? *European Financial Management, 20*(3), 494-520. doi:10.1111/j.1468-036X.2012.00643.x

Carbon Tracker Initiative and Grantham Research Institute on Climate Change. (2013). *Unburnable Carbon 2013: Wasted capital and stranded assets*. Retrieved from http://www.carbontracker.org/wp-content/uploads/2014/09/Unburnable-Carbon-2-Web-Version.pdf.

Chen, G., Hadjikakou, M., & Wiedmann, T. (2016). Urban carbon transformations: unravelling spatial and inter-sectoral linkages for key city industries based on multi-region input–output analysis. *Journal of Cleaner Production*.

Climate Council. (2015). *Unburnable Coal - Why we need to leave fossil fuels in the ground.* . Retrieved from https://www.climatecouncil.org.au/unburnable-carbon-why-we-need-to-leave-fossil-fuels-in-the-ground

ClimateWorks. (2013). *Tracking Progress Towards a Low Carbon Economy - 1. National Progress Report*. In. Retrieved from http://www.climateworksaustralia.org/tracking-progress

Council of the European Union. (2017). International agreements on climate action.

Crawford, R. H., Bontinck, P.-A., Stephan, A., & Wiedmann, T. (2017). Towards an Automated Approach for Compiling Hybrid Life Cycle Inventories. *Procedia Engineering, 180*, 157-166. doi:http://dx.doi.org/10.1016/j.proeng.2017.04.175

Damodaran, A. (2015). *Price and Value to Sales Ratios and Margins by Industry Sector - January 2015*. Retrieved from: http://www.stern.nyu.edu/~adamodar/New_Home_Page/data.html

Department of the Environment and Energy. (2014). *Emissions Reduction Fund White Paper*. Retrieved from http://www.environment.gov.au/system/files/resources/1f98a924-5946-404c-9510-d440304280f1/files/emissions-reduction-fund-white-paper_0.pdf

Gao, T., Liu, Q., & Wang, J. (2014). A comparative study of carbon footprint and assessment standards. *International Journal of Low-Carbon Technologies, 9*(3), 237-243. doi:10.1093/ijlct/ctt041

Goodstein, E. (1996). Jobs and the environment: An overview. *Environmental Management, 20*(3), 313-321. doi:10.1007/bf01203840

Greenhouse Gas Protocol. (2011). *Corporate Value Chain (Scope 3) Accounting and Reporting Standard*. In.

Greenhouse Gas Protocol. (2017). Frequently Asked Questions. Retrieved from http://www.ghgprotocol.org/calculationg-tools-faq

Griffin, P. A., Jaffe, A. M., Lont, D. H., & Dominguez-Faus, R. (2015). Science and the stock market: Investors' recognition of unburnable carbon. *Energy Economics, 52*, 1-12. doi:http://dx.doi.org/10.1016/j.eneco.2015.08.028

Hansen, J., Sato, M., Ruedy, R., Schmidt, G. A., Lo, K., & Persin, A. (2017). Global temperature in 2016. *Energy and Environmental Science, 8*(7), 2093-2117.

Hendrickson, C. T., Lave, L. B., & Matthews, H. S. (2006). *Environmental life cycle assessment of goods and services: an input-output approach*: Resources for the Future.

Howard, B., Hamilton, N. E., Diesendorf, M., & Wiedmann, T. (2017). *Modelling the Carbon Budget of the Australian Electricity Sector's Transition to Renewable Energy* University of New South Wales, Sydney.

Huang, Y. A., Lenzen, M., Weber, C. L., Murray, J., & Matthews, H. S. (2009). The role of input–output analysis for the screening of corporate carbon footprints. *Economic Systems Research, 21*(3), 217-242.

Industry Super. (2017). Super-Basics. Retrieved from http://www.industrysuper.com/understand-super/super-basics/

IPCC. (2013). *Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change.* In.

Ito, Y., Managi, S., & Matsuda, A. (2013). Performances of socially responsible investment and environmentally friendly funds. *Journal of the Operational Research Society, 64*(11), 1583-1594.

Koellner, T., Suh, S., Weber, O., Moser, C., & Scholz, R. W. (2007). Environmental Impacts of Conventional and Sustainable Investment Funds Compared Using Input-Output Life-Cycle Assessment. *Journal of Industrial Ecology, 11*(3), 41-60. doi:10.1162/jiec.2007.1147

Lenzen, M. (2011). AGGREGATION VERSUS DISAGGREGATION IN INPUT–OUTPUT ANALYSIS OF THE ENVIRONMENT. *Economic Systems Research, 23*(1), 73-89. doi:10.1080/09535314.2010.548793

Lenzen, M., & Fry, J. (2016). Employment datafeed. In: Industrial Ecology Virtual Laboratory.

Lenzen, M., Geschke, A., Kanemoto, K., & Moran, D. (2011). Eora: A Global Multi-Region Input Output database. In.

Lenzen, M., Geschke, A., Malik, A., Fry, J., Lane, J., Wiedmann, T., . . . Cadogan-Cowper, A. (2017). New multi-regional input–output databases for Australia – enabling timely and flexible regional analysis. *Economic Systems Research, 29*(2), 275-295. doi:10.1080/09535314.2017.1315331

Lenzen, M., Geschke, A., Wiedmann, T., Lane, J., Anderson, N., Baynes, T., . . . West, J. (2014). Compiling and using input–output frameworks through collaborative virtual laboratories. *Science of The Total Environment, 485–486*, 241-251. doi:https://doi.org/10.1016/j.scitotenv.2014.03.062

Lenzen, M., Moran, D., Kanemoto, K., & Geschke, A. (2013). Building Eora: a global multi-region input–output database at high country and sector resolution. *Economic Systems Research, 25*(1), 20-49.

Lenzen, M., & Murray, J. (2010). Conceptualising environmental responsibility. *Ecological Economics, 70*(2), 261-270. doi:http://dx.doi.org/10.1016/j.ecolecon.2010.04.005

Leontief, W. (1970). Environmental Repercussions and the Economic Structure: An Input-Output Approach. *The review of economics and statistics, 52*(3), 262-271. doi:10.2307/1926294

Levitt, C. J., Saaby, M., & Sørensen, A. (2017). Australia's consumption-based greenhouse gas emissions. *Australian Journal of Agricultural and Resource Economics, 61*(2), 211-231. doi:10.1111/1467-8489.12198

Markandya, A., Arto, I., González-Eguino, M., & Román, M. V. (2016). Towards a green energy economy? Tracking the employment effects of low-carbon technologies in the European Union. *Applied Energy, 179*, 1342-1350. doi:https://doi.org/10.1016/j.apenergy.2016.02.122

Market Index. (2017). All Ordinaries. Retrieved from http://www.marketindex.com.au/all-ordinaries

McEvoy, D., Gibbs, D. C., & Longhurst, J. W. S. (2000). The employment implications of a low-carbon economy. *Sustainable Development, 8*(1), 27-38. doi:10.1002/(SICI)1099-1719(200002)8:1<27::AID-SD120>3.0.CO;2-O

Mercer. (2015). Investing in a Time of Climate Change. Retrieved from Mercer website: https://www.mercer.com.au/our-thinking/investing-in-climate-change.html

Miller, R. E., & Blair, P. D. (2009). *Input-output analysis: foundations and extensions*: Cambridge University Press.

Murray, J., & Wood, R. (2010). *The sustainability practitioner's guide to input-output analysis*: Common Ground Pub.

NASA. (2017). Global Climate Change: Vital Signs of the Planet. Retrieved from https://climate.nasa.gov/vital-signs/global-temperature/

OECD. (2012). *The jobs potential of a shift towards a low carbon economy*. Retrieved from http://www.oecd.org/els/emp/thejobspotentialofashifttowardsalow-carboneconomy.htm

Rebitzer, G., Ekvall, T., Frischknecht, R., Hunkeler, D., Norris, G., Rydberg, T., . . . Pennington, D. W. (2004). Life cycle assessment: Part 1: Framework, goal and scope definition, inventory analysis, and applications. *Environment International, 30*(5), 701-720. doi:https://doi.org/10.1016/j.envint.2003.11.005

Richardson, B. J. (2008). *Socially responsible investment law: Regulating the unseen polluters*: Oxford University Press.

Richardson, B. J. (2016). Fossil fuels divestment: Is it lawful? *Browser Download This Paper*.

Ritchie, J., & Dowlatabadi, H. (2014). Understanding the shadow impacts of investment and divestment decisions: Adapting economic input–output models to calculate biophysical factors of financial returns. *Ecological Economics, 106*, 132-140. doi:http://dx.doi.org/10.1016/j.ecolecon.2014.07.005

Rodrigues, J., & Domingos, T. (2008). Consumer and producer environmental responsibility: Comparing two approaches. *Ecological Economics, 66*(2–3), 533-546. doi:http://dx.doi.org/10.1016/j.ecolecon.2007.12.010

Rowley, H. V., Lundie, S., & Peters, G. M. (2009). A hybrid life cycle assessment model for comparison with conventional methodologies in Australia. *The International Journal of Life Cycle Assessment, 14*(6), 508-516.

Russell, S., Milne, M. & Dey, C. (2017). Accounts of nature and the nature of accounts: Critical reflections on environmental accounting and propositions for ecologically informed accounting. *Accounting, Auditing and Auditing Journal, 30 (7)*, 1426-1458.

Sakai, M., Owen, A., & Barrett, J. (2017). The UK's Emissions and Employment Footprints: Exploring the Trade-Offs. *Sustainability, 9*(7). doi:10.3390/su9071242

Siew, R., Balatbat, M.C., & Carmichael, D. (2016). The impact of ESG disclosures and institutional ownership on market informaiton asymmetry. *Asia-Pacific Journal of Accounting & Economics 23(4).* 432-448.

Södersten, C.-J., Wood, R., & Hertwich, E. G. (2017). Environmental Impacts of Capital Formation. *Journal of Industrial Ecology*, n/a-n/a. doi:10.1111/jiec.12532

Super Switch. (2016). $1 trillion in super fund assets hidden from the public. Retrieved from http://superswitch.org.au/analysis/1-trillion-in-super-fund-assets-hidden-from-the-public/

Super Switch. (2017). Funds. Retrieved from http://superswitch.org.au/funds/

Trucost. (2007). *Carbon Counts 2007: The Trucost Carbon Footprint Ranking of UK Investment Funds*. In.

Trucost. (2008). *Carbon Counts 2008: The Carbon Footprints of Australian Superannuation Investment Managers*. In. Retrieved from https://www.trucost.com/publication/carbon-counts-2008-carbon-footprints-australian-superannuation-investment-managers/

Trucost. (2011). *Carbon Counts: The Carbon Footprints of Australian Superannuation Investment Managers*. In.

US SIF. (2016). Report on Sustainable and Responsible Investing Trends in the United States.

Vendries Algarin, J., Hawkins, T. R., Marriott, J., & Khanna, V. (2016). Effects of Using Heterogeneous Prices on the Allocation of Impacts from Electricity Use: A

Mixed-Unit Input-Output Approach. *Journal of Industrial Ecology*, n/a-n/a. doi:10.1111/jiec.12502

VicSuper. (2007). *The VicSuper Carbon Count*. In. Retrieved from https://www.trucost.com/publication/vicsuper-carbon-count-2007/

VicSuper. (2009). *VicSuper Carbon Count 2009*. In. Retrieved from https://www.trucost.com/publication/vicsuper-carbon-counts-2009/

Wiedmann, T. (2010). Frequently Asked Questions about Input-Output Analysis. *Centre for Sustainability Accounting*.

Wiedmann, T. (2017). An input–output virtual laboratory in practice – survey of uptake, usage and applications of the first operational IELab. *Economic Systems Research, 29*(2), 296-312. doi:10.1080/09535314.2017.1283295

Wood, R. (2011). Construction, stability and predictability of an input–output time-series for Australia. *Economic Systems Research, 23*(2), 175-211.

Wood, R., & Dey, C. J. (2009). AUSTRALIA'S CARBON FOOTPRINT. *Economic Systems Research, 21*(3), 243-266. doi:10.1080/09535310903541397

World Bank. (2017). World Bank Open Data. Retrieved from http://data.worldbank.org/

World Resources Institute. (2017). What is an INDC? Retrieved from http://www.wri.org/indc-definition

6 APPENDIX

Industry Sector	High Growth Portfolio			Balanced Portfolio			Socially Aware Portfolio		
	Shareholdings in Industry* ($)	Upstream Carbon Footprint* (kg CO2e)	Upstream Employment Footprint* (FTE)	Shareholdings in Industry* ($)	Upstream Carbon Footprint* (kg CO2e)	Upstream Employment Footprint* (FTE)	Shareholdings in Industry* ($)	Upstream Carbon Footprint* (kg CO2e)	Upstream Employment Footprint* (FTE)
Sheep, Grains, Beef and Dairy Cattle	-	-	-	-	-	-	-	-	-
Poultry and Other Livestock	9,115,066	12,333,397	108	102,486,363	138,672,061	1,213	1,773,472	2,399,646	21
Other Agriculture	-	-	-	662,471	335,675	5	-	-	-
Aquaculture	-	-	-	2,718,199	2,032,408	36	-	-	-
Forestry and Logging	-	-	-	-	-	-	-	-	-
Fishing, Hunting and Trapping	-	-	-	-	-	-	-	-	-
Agriculture, Forestry and Fishing Support Services	-	-	-	1,286,126	1,234,632	23	-	-	-
Coal Mining	127,010,196	163,760,534	691	1,402,388,935	1,808,169,487	7,629	-	-	-
Oil and Gas Extraction	49,666,108	24,914,717	74	522,561,851	262,140,144	783	5,575,165	2,796,749	8
Iron Ore Mining	5,474,857	992,669	15	59,423,023	10,774,238	160	-	-	-
Non Ferrous Metal Ore Mining	32,245,120	13,258,167	215	364,980,114	150,068,209	2,438	8,130,310	3,342,925	54
Non Metallic Mineral Mining	12,336,798	5,000,567	60	136,037,467	55,141,085	662	4,671,870	1,893,684	23
Exploration and Mining Support Services	1,510,433	1,169,677	10	20,750,534	16,069,184	139	-	-	-
Meat and Meat product Manufacturing	-	-	-	-	-	-	-	-	-
Processed Seafood Manufacturing	1,891,827	761,720	7	20,861,108	8,399,462	79	1,992,165	802,120	8
Dairy Product Manufacturing	624,236	383,867	3	11,202,087	6,888,590	54	7,760,058	4,771,956	37
Fruit and Vegetable Product Manufacturing	3,020,953	665,648	11	33,311,949	7,340,081	124	2,186,242	481,725	8
Oils and Fats Manufacturing	-	-	-	-	-	-	-	-	-
Grain Mill and Cereal Product Manufacturing	3,250,866	1,810,997	14	35,847,184	19,969,804	157	10,516,720	5,858,671	46
Bakery Product Manufacturing	-	-	-	-	-	-	-	-	-
Sugar and Confectionery Manufacturing	1,295,109	420,948	5	14,281,125	4,641,781	54	-	-	-
Other Food Product Manufacturing	1,225,500	342,362	4	21,601,727	6,034,762	75	-	-	-
Soft Drinks, Cordials and Syrup Manufacturing	11,730,017	1,203,735	22	129,346,499	13,273,549	241	4,553,016	467,231	8
Beer Manufacturing	-	-	-	-	-	-	-	-	-

Wine, Spirits and Tobacco	14,675,404	678,271	10	161,825,186	7,479,270	110	10,040,062	464,034	7
Textile Manufacturing	-	-	-	-	-	-	-	-	-
Tanned Leather, Dressed Fur and Leather Manufacturing	-	-	-	-	-	-	-	-	-
Textile Product Manufacturing	1,095,717	312,674	2	12,082,434	3,447,845	25	-	-	-
Knitted Product Manufacturing	-	-	-	-	-	-	-	-	-
Clothing Manufacturing	-	-	-	-	-	-	-	-	-
Footwear Manufacturing	571,135	163,293	1	6,297,889	1,800,630	15	-	-	-
Sawmill Product Manufacturing	-	-	-	-	-	-	-	-	-
Other Wood Product Manufacturing	-	-	-	587,984	726,232	9	-	-	-
Pulp, Paper and Paperboard Manufacturing	-	-	-	-	-	-	-	-	-
Paper Stationery and Other Converted Paper Manufacturing	-	-	-	-	-	-	-	-	-
Printing (including the reproduction of recorded media)	2,864,565	1,224,860	29	32,115,124	13,732,111	330	-	-	-
Petroleum and Coal Product Manufacturing	-	-	-	-	-	-	-	-	-
Human Pharmaceutical and Medicinal Product Manufacturing	56,535,189	5,358,530	109	626,232,044	59,355,659	1,211	9,626,642	912,434	19
Veterinary Pharmaceutical and Medicinal Product Manufacturing	-	-	-	2,821,264	1,259,678	8	-	-	-
Basic Chemical Manufacturing	11,796,829	7,994,764	88	129,191,607	87,553,734	963	8,892,222	6,026,299	66
Cleaning Compounds and Toiletry Preparation Manufacturing	2,272,105	757,930	9	25,054,430	8,357,666	95	2,312,135	771,283	9
Polymer Product Manufacturing	7,987,139	8,292,729	119	84,713,736	87,954,900	1,260	-	-	-
Natural Rubber Product Manufacturing	3,104,610	3,481,315	23	34,234,428	38,388,339	252	-	-	-
Glass and Glass Product Manufacturing	1,524,155	380,692	6	16,806,806	4,197,874	63	-	-	-
Ceramic Product Manufacturing	641,641	297,759	1	7,075,356	3,283,383	14	-	-	-
Cement, Lime and Ready-Mixed Concrete Manufacturing	24,075,775	21,183,358	155	265,482,760	233,588,175	1,713	13,773,108	12,118,433	89
Plaster and Concrete Product Manufacturing	-	-	-	-	-	-	-	-	-
Other Non-Metallic Mineral Product Manufacturing	-	-	-	-	-	-	-	-	-
Iron and Steel Manufacturing	-	-	-	3,650,721	2,442,504	29	-	-	-
Basic Non-Ferrous Metal Manufacturing	-	-	-	-	-	-	-	-	-

Forged Iron and Steel Product Manufacturing	-	-	-	-	-	-	-	-	-
Structural Metal Product Manufacturing	-	-	-	-	-	-	-	-	-
Metal Containers and Other Sheet Metal Product Manufacturing	2,212,974	1,067,457	13	27,522,464	13,275,824	156	-	-	-
Other Fabricated Metal Product manufacturing	-	-	-	1,431,109	503,956	9	-	-	-
Motor Vehicles and Parts; Other Transport Equipment	4,888,303	3,223,517	80	53,903,156	35,545,615	887	3,604,441	2,376,894	59
Ships and Boat Manufacturing	-	-	-	2,981,675	945,859	22	-	-	-
Railway Rolling Stock Manufacturing	-	-	-	-	-	-	-	-	-
Aircraft Manufacturing	-	-	-	-	-	-	-	-	-
Professional, Scientific, Computer and Electronic Equipment	12,796,549	2,919,309	66	150,102,807	34,243,332	771	7,065,869	1,611,955	36
Electrical Equipment Manufacturing	-	-	-	-	-	-	-	-	-
Domestic Appliance Manufacturing	16,849,359	5,032,208	61	184,280,107	55,036,863	668	10,240,347	3,058,369	37
Specialised and other Machinery and Equipment Manufacturing	-	-	-	-	-	-	-	-	-
Furniture Manufacturing	2,785,137	1,088,942	26	30,711,618	12,007,729	287	-	-	-
Other Manufactured Products	-	-	-	-	-	-	-	-	-
Electricity Generation	46,395,028	102,163,765	80	512,887,856	1,129,400,215	888	3,602,614	7,933,105	6
Electricity Transmission, Distribution and Market Operation	2,122,076	404,674	5	26,069,274	4,971,337	65	-	-	-
Gas Supply	-	-	-	-	-	-	-	-	-
Water Supply, Sewerage and Drainage Services	-	-	-	-	-	-	-	-	-
Waste Collection, Treatment and Disposal Services	9,585,594	12,714,038	36	109,639,776	145,422,838	417	2,798,092	3,711,303	11
Residential Building Construction	6,610,721	2,024,890	50	70,871,232	21,708,143	540	-	-	-
Non-Residential Building Construction	5,371,548	4,115,970	104	58,148,404	44,556,449	1,128	-	-	-
Heavy and Civil Engineering Construction	4,799,744	3,099,796	76	54,462,772	35,173,435	857	-	-	-
Construction Services	-	-	-	-	-	-	-	-	-
Wholesale Trade	-	-	-	-	-	-	-	-	-
Retail Trade	115,912,792	44,780,787	2,233	1,297,585,830	501,298,550	25,000	39,996,798	15,452,031	771
Accommodation	3,630,016	492,275	14	40,028,063	5,428,305	154	1,090,769	147,922	4
Food and Beverage Services	12,725,676	1,723,064	58	141,489,219	19,157,725	645	-	-	-
Road Transport	8,158,504	4,945,373	71	89,963,549	54,532,458	781	-	-	-

Rail Transport	9,224,480	2,231,800	23	100,511,531	24,318,081	247	2,957,238	715,484	7
Water, Pipeline and Other Transport	-	-	-	-	-	-	-	-	-
Air and Space Transport	25,121,416	16,794,338	255	277,013,013	185,190,608	2,807	-	-	-
Postal and Courier Pick-up and Delivery Service	-	-	-	-	-	-	-	-	-
Transport Support services and storage	33,392,271	5,640,946	167	368,005,508	62,167,061	1,841	3,149,270	532,005	16
Publishing (except Internet and Music Publishing)	1,632,151	272,011	8	17,997,670	2,999,460	83	-	-	-
Motion Picture and Sound Recording	625,352	86,424	2	11,855,522	1,638,441	44	-	-	-
Broadcasting (except Internet)	8,064,816	631,337	23	98,965,897	7,747,332	280	10,109,836	791,427	29
Internet Service Providers, Websearch Portals and Data Processing	23,225,581	6,684,627	173	261,143,412	75,160,496	1,943	-	-	-
Telecommunication Services	59,947,664	10,323,868	303	677,021,034	116,592,960	3,418	17,606,881	3,032,163	89
Library and Other Information Services	-	-	-	-	-	-	-	-	-
Finance	560,311,291	9,640,955	510	6,194,123,407	106,578,725	5,636	124,132,635	2,135,879	113
Insurance and Superannuation Funds	55,375,163	4,961,651	231	609,479,663	54,609,774	2,547	23,891,678	2,140,710	100
Auxiliary Finance and Insurance Services	20,435,833	1,149,095	48	236,562,505	13,301,768	557	4,870,981	273,892	11
Rental and Hiring Services (except Real Estate)	-	-	-	-	-	-	-	-	-
Ownership of Dwellings	-	-	-	-	-	-	-	-	-
Non-Residential Property Operators and Real Estate Services	58,789,624	2,602,724	78	658,990,801	29,174,726	877	13,059,898	578,186	17
Professional, Scientific and Technical Services	12,874,285	1,859,576	84	162,080,060	23,411,017	1,056	-	-	-
Computer Systems Design and Related Services	6,087,613	215,952	11	75,653,014	2,683,719	131	-	-	-
Employment, Travel Agency and Other Administrative Services	14,076,297	1,709,047	80	161,520,473	19,610,700	918	-	-	-
Building Cleaning, Pest Control and Other Support Services	-	-	-	-	-	-	-	-	-
Public Administration and Regulatory Services	-	-	-	-	-	-	-	-	-
Defence	-	-	-	-	-	-	-	-	-
Public Order and Safety	-	-	-	-	-	-	-	-	-
Primary and Secondary Education Services	1,944,054	190,348	15	21,437,014	2,098,955	164	-	-	-
Technical, Vocational and Tertiary Education Services	3,658,511	432,629	31	40,342,281	4,770,588	336	1,441,534	170,465	12
Arts, Sports, Adult and Other Education Services	2,109,158	322,811	18	26,161,981	4,004,146	218	-	-	-
Health Care Services	52,781,233	16,421,850	1,054	687,473,397	213,893,930	13,722	6,785,528	2,111,185	135

Residential Care and Social Assistance Services	6,642,821	1,218,330	110	73,799,995	13,535,330	1,219	-	-	-
Heritage, Creative and Performing Arts	-	-	-	-	-	-	-	-	-
Sports and Recreation	2,036,482	255,990	9	22,456,215	2,822,789	100	-	-	-
Gambling	45,715,888	4,693,153	141	497,150,833	51,037,073	1,533	15,581,076	1,599,540	48
Automotive Repair and Maintenance	517,131	205,757	9	5,702,382	2,268,877	98	-	-	-
Other Repair and Maintenance	-	-	-	-	-	-	-	-	-
Personal Services	4,181,913	1,045,068	56	44,101,953	11,021,158	590	966,603	241,556	13
Other Services	-	-	-	-	-	-	-	-	-
Total	**1,651,156,399**	**556,531,534**	**8,203**	**18,469,547,003**	**6,208,599,499**	**93,610**	**384,755,275**	**91,721,260**	**1,918**