Emission Intensity in New Zealand Manufacturing and the Short-run Impacts of Emissions Pricing[1, 2]

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Abstract:

This paper reports the emission intensity of New Zealand (NZ) manufacturing at a combination of industry group and class levels (sub-sectors). The short-run impacts of emissions pricing is investigated with a focus on exporting activities. Emission intensive sub-sectors accounted for slightly over 9 percent of national GDP. It is found that there is much variability of emission intensity within manufacturing and even within sub-sectors. Several emission intensive activities are found to be export exposed. These activities are at most risk of losing competitiveness if emissions are priced in NZ ahead of other countries and they are not shielded.

JEL Classifications: O56, Q43, Q48
Keywords: emissions; emission intensity; trade intensity; New Zealand; manufacturing;

[1] This study was one input into the New Zealand Government's deliberations on changes to the Emissions Trading Scheme in 2009.

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1. Introduction

This paper reports the emissions intensity profile of New Zealand (NZ) manufacturing and illustrates the potential short-run impacts of emissions pricing on NZ manufacturing industries. This analysis assists in striking the right policy balance in:

1. Domestic industry coverage and allocation policies - between the risks of exposure for particular businesses/industries and the fiscal and economic cost of shielding those industries; and
2. Future national emissions commitments - between making a meaningful contribution to global efforts, and minimising the economic impact on trade exposed industries (and associated fiscal risks).

Earlier analyses of emissions price effects on the NZ economy have used General Equilibrium (GE) models, which are useful in predicting the economy-wide effects of an emissions price once responses have been taken into account (e.g., Infometrics 2008). However, transitional effects (short-run impacts) are the more immediate challenges faced by businesses and industry, and a disaggregated analysis of short run impacts - needed to support policy - has been missing.[3] The present paper seeks to bridge this knowledge gap. Specifically, the results of this paper provide a basis for exploring the potential short-run implications of alternative emission reduction and free allocation policies for emission intensive industries.[4]

The rest of this paper is organised as follows. The next section describes the main indicators applied in the analysis and the data underlying their construction. In section 3, the level and variation of the emissions intensity of sub-sectors within NZ manufacturing are presented and discussed. Section 4 juxtaposes emission intensity measures with trade intensity estimates to identify activities that may be relatively at risk of international competitiveness effects. The last section offers concluding remarks.

2. Indicators and Data

There are three broad approaches that can be taken to create an indicator of emissions intensity: emissions as a proportion of a) gross output, b) intermediate consumption and c) value added. While each has their relative merits (see Bartleet et al. (2010)), this paper defines emission intensity as the ratio of emissions to value added, where the latter is defined as gross output minus the value of intermediate goods and services used in production. At the national level, this aggregates to GDP.

The advantage of using value added as the denominator is that it makes more sense from a macro-economic perspective, by indicating the contribution of each sub-sector to the value of total output. It is also the measure that is used most commonly in comparable studies (e.g. Hourcade et al. 2008, de Bruyn et al. 2008, Carbon Trust 2008). As far as the measurement of emissions is concerned, direct emissions caused by onsite combustion and indirect emissions from electricity use are both included. Industrial process emissions cannot be included at the sub-sector level owing to data confidentiality issues (see Brown-Santirso and Fu 2008).

Firm level emissions were determined by combining energy consumption data with emission factors. The data for this study comes from the prototype Longitudinal Business Database (LBD), administered by Statistics NZ.[5] Among other data, the LBD contains information compiled from Manufacturing Energy Use Survey (2006) (MEUS) and the Annual Enterprise Survey (AES). Energy data were extracted from the Manufacturing Energy Use Survey (MEUS) administered by Statistics New Zealand. This survey compiled energy use data, by type, for 1026 manufacturing firms for the year ended March 2006.[6] The bulk of the energy consumption in NZ is accounted for by a relatively small number of high energy use firms. All of these firms are included in the MEUS sample, thus its coverage of sector-wide energy consumption is comprehensive. Emission factors by energy type

[3] The most disaggregated New Zealand GE models contain only 126 industry sectors. Given there are 19 industry divisions and divisions such as manufacturing have 15 subdivisions (2-digit) alone, GE models at this time are unable to assist in getting a disaggregated sub-sectoral level picture of impacts.

[4] The results from this study should be interpreted as 'day after effects'. Over a longer duration, the results are less likely to be meaningful for a variety of reasons. It is conceivable that the production technology of firms may change in response to an emissions price, consumer behaviour may be modified, newer trade patterns may evolve and there may be movement of resources across industries and sectors. Indeed, one would expect these changes to take place as a consequence of effective emissions price legislation.

[5] The LBD is discussed in more detail in Fabling et al. (2008) and Statistics NZ (2007).

[6] For details of the survey and findings, see Brown-Santirso and Fu (2008).

(presented in Appendix 1) are drawn from Ministry of Economic Development (2008), and are discussed in detail in Brown-Santirso and Fu (2008).[7] The financial data needed to compute value added were taken from the Annual Enterprise Survey (AES) administered by Statistics New Zealand.

Energy consumption data from the MEUS and financial data from the AES were jointly available only for 668 firms, which comprise the sample for this study. Significantly, the reduced sample does not constrain a pertinent analysis of emissions pricing on the NZ manufacturing sector. The reduced sample of 668 firms accounts for 86 percent of manufacturing sector emissions, 94 percent of sector energy use, and 57 percent of sector value added. These numbers imply that the firms excluded from the sample are, on average, significantly less intensive with respect to greenhouse gas emissions. This provides some comfort that the analysis is not likely to systematically omit emissions intensive firms from the analysis.[8]

Trade exposure can be defined in terms of export intensity, or import intensity. For the NZ manufacturing sector, it has been found that the transitional effects of import induced competition are not significant (see Bartleet et al. 2010). Therefore, the paper focuses on exports. Export intensity is constructed as the ratio of exports over domestic production. The treatment of trade partners matters in the discussion of emissions price effects on exports, since emissions reduction policy settings differ from country to country. Therefore, separate trade intensity variables are used in this study, that are specific to Australia, Kyoto 'Annex B' countries and Kyoto 'non-Annex B' countries, respectively.[9]

Exports data are derived as zero rated sales from the Business Activity Indicator (BAI) survey administered by Statistics New Zealand.[10] Most NZ exports, over 80 percent, come from the manufacturing sector, dominated by primary products (Iyer 2010). This leads us to believe that the coverage of trade related risks in this paper is comprehensive.

3. Emissions Intensity: Profile and Discussion

This section estimates the level and variation of greenhouse gases emitted per unit value added - the emissions intensity - of different activities within the manufacturing sector.[11] An overall

[7] The emission factors applied in this study is for direct emissions are the same as in Brown-Santirso and Fu (2008). However, the emissions factor for electricity emissions used here is the marginal factor rather than the average factor. It is conceded that use of an average electricity emissions factor provides a more actuate estimate of physical emissions. However, because electricity prices are determined at the margin (during peak periods being a mix of gas and coal generation), the emissions costs passed through to consumers will correlate more closely to the application of a marginal emissions factor. As a result the estimate of indirect emissions in this report differs from Brown-Santirso and Fu.

[8] The data imply that the firms omitted from the sample contributed 43% to sector output, but consumed only 6% of manufacturing sector energy use and 14% to sector emissions. They are, thus, least likely amongst manufacturing firms to be materially affected in the short run by the imposition of a given emissions reduction policy.

[9] The Annex B list includes industrialised countries which committed themselves as a group to reducing their emissions of the six greenhouses gases by at least 5% below 1990 levels over the period between 2008 and 2012. These are: Australia, Austria, Belgium, Bulgaria, Canada, Croatia, Czech Republic, Denmark, Estonia, Finland, France (including Monaco), Germany, Greece, Hungary, Iceland, Ireland, Italy (including San Marino), Japan, Latvia, Lithuania, Luxembourg, Netherlands, New Zealand, Norway, Poland, Portugal, Romania, Russian Federation, Slovakia, Slovenia, Spain, Sweden, Switzerland (including Liechtenstein), Ukraine, United Kingdom, United States of America

[10] Zero rated sales is only a crude proxy for exports (see, Fabling et. al. 2008). The correlation between actual exports and zero rated sales is remarkably high at 97 percent, lending some comfort to the analysis. The actual exports data could not be used since they are not consistent (in sample coverage) with the other variables used in this paper.

[11] This study treats the manufacturing sector in isolation from other industries, such that impacts of emissions pricing on, for example, the primary sector are not taken into account in estimating the flow-on impacts on manufacturing. Given the importance of these inter-linkages, it is reasonable to conclude that a careful consideration of adjustment mechanisms across the value chain is required for a comprehensive analysis. But at the time of writing this paper, data on agricultural farm level energy emissions were not available. As a result, the indirect emission effects on primary goods processing activities that may emanate from

picture of emissions in NZ manufacturing helps establish a perspective to consider the economic impacts associated with a given emissions reduction policy. To this end, Table 1 below presents the key emissions related statistics for NZ manufacturing.

Insert Table 1 about here

According to the ANZSIC industry classification system, NZ manufacturing is classified under nine 2 digit chapters. These chapters can each be further disaggregated into different 3 digit industry groups, which can be further broken down into 4 digit industry classes.[12] Industry groups are made up of reasonably homogeneous industries, while industry classes are made up of firms that are homogenous in terms of industrial activity.

At the lowest level of disaggregation, NZ manufacturing is made up of 150 industry classes. It is reasonably obvious that policy intervention is likely to be most relevant when directed at the class level, rather than the aggregate manufacturing level. This motivates the study's estimation of emission and export intensities at a combination of industry group and class levels – herein referred to as sub-sectors. The analysis could not be performed entirely at the industry class level, i.e., the highest level of disaggregation due to data constraints. Indeed, even at the self-designed sub-sector level, not all firms within the sample lend themselves to further investigation.[13] As a result, industrial activities with too few firms need to be excluded, or aggregated with similar classes of activity. Likewise, industrial activities dominated by a major firm also have to be excluded. As a result of these constraints, our sample of 668 firms drops to 600.

These 600 firms are classified into 51 sub-sectors, which are either industry classes (4-digits) or groups (3-digits).[14] These 600 firms account for less than half of the emissions of the 668 firm sample which in turn, it is recalled, accounts for 86 percent of the total manufacturing emissions. This means that the 68 omitted firms, on average, are large emitters. Analysis of the omitted firms reveals that 21 of them account for most of the remaining emissions.[15] This reflects the fact that NZ manufacturing consists of a handful of 'large to mega emitters' who operate in industry classes with few firms and/or dominate their industrial activity.

Excluding the large to mega emitters will clearly dilute the analysis. Therefore, these 21 firms are re-grouped into two additional categories for analysis. These two categories and the 51 sub-sectors are mutually exclusive. Mega emitters are defined as firms that had emissions in excess of 20,000 tonnes for the year ended 31 March 2006, and large emitters are defined as those firms that emitted more than 5,000 but less than 20,000 tonnes over the same period. The nature of activities of these large and mega emitters are not disclosed so that the individual firm data cannot be inferred. At a generalised level, it is possible to pinpoint which 2 digit industry chapters are concentrated in these two categories (See Table 2).

Insert Table 2 about here

Metal Product Manufacturing (ANZSIC chapter C27), does not feature in the large and mega emitters group. This is perhaps counterintuitive, given the nature of the industry, but can be explained by the mega and large emitters' categories containing only those huge emitters that could not be otherwise presented at the sub-sector (3/4 digit) level. This was not the case for firms in metal product manufacturing. On the other hand, smelting is a huge source of emissions in NZ. This activity was not included within the 51 sub-sectors, or within the mega and large emitter's category, however, because the nature of industry concentration precludes publication of smelting emissions data.

Firms that fell within the 51 sub-sector activities and the 'mega' and 'large' emitter categories were assessed for their emission intensity, defined specifically as $KgCO_2$-e per NZ$1000 of value added. Emissions intensities are readily translated into cost increases relative to value added at alternative emissions prices.[16] The conversion table

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energy emission price effects on farms has not been accounted for.

[12] For example, within manufacturing (C2): sector C21 comprises of food, beverage and tobacco production. This sector includes industry group C211: meat and meat product manufacturing which in turn includes industry class C2112: poultry processing.

[13] In principle, it is not possible to present data that has the potential to reveal statistics associated with an identifiable firm. This confidentiality requirement is contained within the Statistics Act 1974.

[14] The MEUS is weighted to ensure adequate coverage at the ANZSIC 2-digit level. Thus, the formation of groups at the 3-4 digit level cannot be guaranteed to be representative of the broader make-up of the manufacturing sector.

[15] This number is random rounded to base 3.

[16] The translation at alternative carbon prices is quite straightforward as shown below:

- Emissions Cost @ NZ$100 as a % of VA = Emission Intensity /100

is included as Appendix 2. The firm level emissions intensities were then aggregated to create un-weighted average emissions intensities by sub-sector.[17]

For the purposes of this paper, the analysis focuses on materially impacted industries. Generally, a material impact is felt when, at reasonable and foreseeable emissions prices, the effects faced by industry are noticeable to the extent that they are likely to elicit a behavioural response. One determining criterion for whether an impact should be deemed 'material' is the level of emission intensity. As there is no universal view on the level at which an impact becomes material, this paper has drawn on cut-offs used in pioneering works from the international literature, such as Hourcade et al. (2008) and Carbon Trust (2008). Specifically, the threshold used is average emission intensity in excess of 400 $KgCO_2$-e per NZ$1000 of value added (VA). The established threshold translates to a cost impost of 2 percent of value added at an assumed carbon price of NZ$50 per tonne. It has been noted that cost increases below these levels are likely to be dwarfed by volatility and variability in other factors like exchange rates, taxation, labour costs, or infrastructure provision (Hourcade et al., 2008).[18]

It is found that not all manufacturing activities in NZ are sufficiently emissions intensive, as determined by the chosen threshold, to warrant exploration of the impacts of emissions pricing. Interestingly, the 400 $KgCO_2$-e per NZ$1000 VA threshold also presents a natural breakpoint in the data. Focusing exclusively on activities with emission intensity less than 1000 $KgCO_2$-e per NZ$1000 VA, the break point is easily represented visually (see Figure 1).[19]

- Emissions Cost @ NZ$50 as a % of VA = Emission Intensity /200
- Emissions Cost @ NZ$25 as a % of VA = Emission Intensity /400
- Emissions Cost @ NZ$12.5 as a % of VA = Emission Intensity /800

[17] Firm level data cannot be released, as discussed.

[18] For the avoidance of doubt, the choice of this threshold is not an assertion of the authors' on what the threshold should be for free-allocation policy. Indeed, 400 $KgCO_2$-e per NZ$1000 of value added is likely to be a generous interpretation of "materiality" especially with emissions prices below $50 per tonne CO_2-e.

[19] It is noted that there are 9 sub-sectors including the mega and large emitter category which have emissions above 1000 $KgCO_2$-e per NZ$1000 VA; these sub-sectors are not shown in Figure 1.

The application of the 400 $KgCO_2$-e threshold results in 26 sub-sectors and the mega and large emitter categories being identified for inclusion in the study. These 28 groups are listed in rank order in Appendix 3.

Insert Figure 1 about here

Figure 2 presents the average emission intensity for each of the 28 groups. The height of the bars in Figure 2 depicts the emission intensity in Kg's CO_2-e per $1000 VA and the width represents the contribution of the activity to national GDP. The emission intensity of the groups is decomposed into direct emission intensity (non-electricity) and indirect emissions intensity (electricity purchased from the grid). The underlying data are set out in Appendix 4. Indirect emissions (electricity purchased from the grid) have been calculated using marginal emissions factors. When considering the effect of emissions pricing on electricity prices, it is the marginal generation source that sets the price of electricity. In NZ, the marginal generation source is often a mix of coal and gas.

It is known that the manufacturing economy as a whole accounts for 14.5 percent of NZ's national GDP. Activities contributing nearly two thirds (9.11 percent) to that output have emissions intensities above 400 KgCO2-e per $1000 of VA. A relatively greater proportion of manufacturing is emissions intensive in NZ compared to other developed countries. For Australia, UK and Germany the comparable numbers are 6.18, 1.1 and 2.05 percent respectively. For the USA, 2.75 percent of manufacturing gross output (as opposed to value added) is generated by emission intensive industries (for details, see Bartleet et al., 2010).

Insert Figure 2 about here

In general, the same industries are identified across all country studies as being emissions intensive. A notable exception, however, is the case of food processing, which is found to be emission intensive in NZ and Australia only.

For NZ, most manufacturing activities related to primary produce are emission intensive. These include food, seafood, fruit and vegetables and meat processing activities as well as leather, textiles, wood and paper production related activities. Together, these activities make up almost 3.5 percent of national GDP. Significantly, the contribution to GDP is grossly understated, given that a number of primary producers are dominant players in their activity and appear within the 'mega' and 'large' emitting categories rather than in primary sub-sectors. The mega and large emitters group account for 2.18 and 0.39 percent of GDP respectively. Furthermore, emission intensities for activities pertaining to agricultural output are

understated since emission pricing effects at the farm level have not been accounted for (refer footnote 10).

In most activities, the share of indirect emissions is higher than that of direct emissions. On average, the share of indirect emissions in total emissions is about 65 percent. Manufacture of ink and chemicals, industrial machinery and equipment, textile fibre, leather, and the mega emitters group are the only categories for which direct emissions exceed indirect emissions. While most primary goods processing activities have greater indirect emissions, it is not possible to determine whether primary produce processors in the mega emitters group share this characteristic.

Arguably, the finding that indirect emissions are dominant will not hold if average emission factors are used to compute emissions from electricity. Indeed, the calculation of emissions intensities using average electricity emissions factors was considered and resulted in lower overall emissions intensities, by up to one-third for some industry groups. This is because the contribution of hydro generation is proportionately very large in NZ, which pulls down the average emissions factor. As the emissions liability relates to actual emissions (to which average emissions factors relate), the nature of the electricity market is likely to result in an emissions cost pass through that exceeds the actual level of emissions. There will thus be a transfer of wealth from electricity purchasers to electricity suppliers, and within the electricity industry itself. Specifically, total emissions estimated using the marginal factor is 11,640 kilo tonnes as opposed to the estimate of 8,190 kilo tonnes arrived at when using the average factor. The difference of 3,450 kilo tonnes, at an assumed carbon price of $25, amounts to a dollar value of $86.25 million.[20] In the first instance, this can be viewed as an upper bound estimate of the annual net transfer of wealth from industrial users of electricity to electricity suppliers.

The data reveal that there is significant within sub-sector variability in emission intensity profiles. Using unweighted coefficients of variation (CV) to measure variability, firms in sub-sectors with CVs in excess of 100 percent can be considered dissimilar in terms of their emission intensities.[21,22] Table 3 lists emission intensities of the 28 groups and the corresponding CVs.

Insert Table 3 about here

Of the 26 sub-sectors listed above, 20 are observed to have high variance with respect to their emission intensities. Expectedly, the 'mega' and 'large' emitter groups that contain dissimilar firms by construction have CVs in excess of 100 percent. Compared to this, slightly more than half the activities that are not found to be emission intensive (that is, have an estimated emission intensity less than 400 KgCO2-e per $1000 of VA) had CVs less than 100 percent. Based on this observation, it was investigated if higher emission intensity also implies greater variability of emission intensity. Simple regression results suggest that this not the case, see Bartleet et al. 2010.

The high CVs within most of the emission intensive activities could mean either of the two things:

(a) even within the disaggregated sub-sector level, there exists a range of dissimilar activities; or

(b) the firms within each sub-sector are relatively homogeneous in their outputs, but vary considerably in the technology used to produce the particular outputs.

Where activities have been aggregated within sub-sectors due to data confidentiality issues, it is not possible to explore them further. Where this is the case, then policy interventions designed at the activity level may not be able to address the unique circumstances of individual firms. If, on the other hand, the disaggregated sub-sectors produce relative homogenous outputs using different energy technologies, two useful implications can be drawn. First, there exists considerable scope for adjustment within the industry to move to lower carbon emissions without greatly constraining production. Second, where the marginal costs of emission reduction are increasing in the level of emissions, a high variance implies that the short run costs are greater than would be the case where the emissions profile is more homogeneous. Judgment will be required to determine which of these cases holds. The data required for further insights in the matter are not available.

4. Emissions Intensity and Trade Intensity

Figures 3-6 show the relationship between export intensity on the vertical axis and emission intensity on the horizontal axis for a range of destination market groups. The size of the bubble representing each sub-sector reflects the share of the activity in national GDP. Figure 3 has an overall 'Rest of World' focus, Figures 4 and 5 measure export intensity specific to Annex B (including Australia) and non Annex B countries, respectively, and Figure 6 is specific to Australia. As discussed earlier, export intensities with respect to different

[20] In 2006, this would have amounted to 0.11 percent of national GDP.

[21] CV=(standard deviation/mean)*100

[22] In this report we use unweighted CVs since the averages are unweighted.

groups of destination markets are analysed separately to control for the fact that emissions reduction policies are not uniform across different markets. Note that the four figures use varying scales to enable individual activities to be distinguished visually. Sub-sector wise export intensity data are set out in Appendix 5.

Insert Figures 3-6 about here

Figure 3 suggests that the mega emitters group stands out not only for its high emission intensity (6,663 $KgCO_2$-e per $1000 VA), but also its high export intensity (40 percent). In terms of its contribution to GDP, the group makes up 2.18 percent of national output, which translates to roughly 14.5 percent of manufacturing output. The group also provides employment to approximately 14,000 workers. The large emitters group is not as export exposed by comparison, though its exports-to-domestic-production ratio is still notable at roughly 25 percent. The emission intensity of the large emitters group is also high at 4,075 $KgCO_2$-e per $1000 VA. It is not possible to disclose the identity of the 21 firms in the mega and large emitter groups, but it is recalled from table 2 that the food, beverage and tobacco sector, the petroleum, coal and chemicals sector, and machinery and equipment sector each contribute 6 firms to these groups. The 3 other firms are from the non-metallic mineral product sector. It can be concluded that the mega and large emitters from these 4 sectors that export are at significant risk of losing competitiveness if emissions prices are imposed in NZ unilaterally.

It is known that roughly two thirds of NZ exports pertain to primary production. In the previous section, it was reported that most manufacturing sub-sectors related to the processing of primary produce are emissions intensive. Of particular note are meat processing, seafood processing, leather product manufacturing and paper manufacturing activities. All of these sub-sectors have export intensities in excess of 60 percent, and emission intensities in excess of 500 $KgCO_2$-e per $1000 VA. Furthermore, these sub-sectors jointly contribute 1.8 percent to national GDP.

The competitiveness effects of emissions pricing legislation on primary sub-sectors has not been discussed as widely in the media as, say, the potential effects on some of the big players (who presumably fall in the mega and large emitters group). But, in fact, while the primary production processing sub-sectors have lower emissions intensities and match the GDP contribution of the mega group, these activities are more export intensive than the mega and large emitters. These activities also provide employment to 1.3 percent of the country's workers. This is about 1.6 times the employment in the mega and large emitters group. Exporting firms in these sub-sectors might also be at risk of losing competitiveness if the price of emissions is high. It is recalled that the analysis here in fact understates the impacts on these sub-sectors given that the direct effects of the proposed emissions pricing in the primary sector has not been accounted for.

Other emitting activities that are export intensive to a larger extent include the manufacture of synthetic resin and organic chemicals and textile fibre, basic iron and steel and electrical equipment manufacturing, log sawmilling and ship building.

It is possible, indeed likely, that trade patterns may change significantly over time. For example, 'third country effects' - where Annex B country exporters may lose market share to non-Annex B exporters in international markets – may become increasingly relevant. These changes cannot be predicted with any certainty, and are less likely, in the short run timeframe adopted for this study.[23]

5. Concluding Remarks

The existing body of knowledge on the economic impacts of an emissions price on NZ manufacturing draws largely from the results of economy wide GE modelling. The potential short-run, or so called 'day-after', effects of emissions pricing on the manufacturing sector at large have not been explored. The results from this paper provide some evidence of the expected short-run effects. These estimates should support policy design and evaluation.

Based on energy consumption data taken from the manufacturing energy use survey and input-specific emission factors, the total emissions from the manufacturing sector for the year ending 31 March 2006 were estimated to be 11,640 Kilo tonnes, 65 percent of which were indirect (from electricity). In the case of most sub-sectors, the share of indirect emissions is higher than that of direct emissions, though the nature of the electricity market is likely to result in emissions costs in excess of the 'value' of actual attributable emissions. This implies a transfer of wealth from electricity purchasers to electricity suppliers, and within the electricity industry itself, in the short term.

[23] The authors considered incorporating into the analysis demand elasticities export products in target markets. However, as there were no estimated demand elasticities to draw from in the literature, this analysis was not feasible within the confines of this paper. It does, however, provide a potentially fruitful area of further enquiry.

The average emission intensity for the manufacturing sector as a whole was estimated at 506 $KgCO_2$-e per NZ$1000 value added (VA), although there was much variability within manufacturing and even within each sub-sector. The manufacturing industry was grouped into 26 sub-sectors. Big emitters which could not be grouped into the sub-sectors, owing to data confidentiality issues, were grouped into two categories: mega emitters and large emitters. Average emission intensity for each of these 28 groups was then estimated. Drawing from international studies, a threshold level of 400 $KgCO_2$-e per NZ$1000 VA was established as a basis to identify those sub-sectors that might incur material short run competitiveness impacts from imposing a price on emissions. Groups with emission intensity over the threshold were classified as being emission intensive and subjected to further enquiry.

The groups classified as emission intensive accounted for nearly two-thirds of manufacturing value added, taking the share of emission intensive manufacturing sub-sectors to slightly over 9 percent of national GDP. This is high in comparison with several other developed countries, including Australia. The list of industries identified as emission intensive in NZ is similar to other comparable countries; excepting that food processing is emission intensive only in NZ and Australia. Indeed, even without accounting for on farm emissions, most primary produce processing activities in NZ are emission intensive. Several emission intensive groups were also export exposed especially the big emitter categories and primary produce processors. These sub-sectors and groups are at most risk of losing competitiveness if they are not shielded and emissions prices are imposed in NZ ahead of other countries. In the longer term, consideration of factors driving differences in value added per unit emissions for NZ, relative to developed country comparators, should be investigated.

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Table 1: Key Statistics for the New Zealand Manufacturing Industry

Energy Use	152 PJ
Energy related Emissions KtCO2-e	11,640[24] Kilo tonnes
- Electricity Emissions KtCO2-e	7,572 Kilo tonnes
- Non-Electricity Emissions KtCO2-e	4,068 Kilo tonnes
Industrial Processing Emissions	3,319 Kilo tonnes
Value Added	23,009 NZ$ million
Total Employment	230,250 FTE
Emissions Intensity (KgCO2-e per $1000 Value Added)	506
Emissions Cost at NZ$12.5 per tonne	145.5 NZ$ million
Emissions Cost at NZ$25 per tonne	291 NZ$ million

Source: Manufacturing Energy Use Survey (2006), Annual Enterprise Survey (2006)

[24] Total emissions differ from the 8,190 kilo tonnes presented in Brown-Santirso and Fu (2008) because the method used for calculating indirect emissions differs. Brown-Santirso and Fu use the average emissions factor for electricity while this report applies the marginal emissions factor. From the point of view of assessing the cost impact on firms, we believe marginal emissions factors are more appropriate since firms will be charged by the electricity companies accordingly. But where the motive is to estimate the actual physical emissions using average emission factors might be a better option since marginal emission factors tend to inflate total emissions.

Table 2: Mega and Large Emitters by manufacturing 2 digit chapters[25]

Manufacturing Chapters	Number of firms
C21: Food, Beverages & Tobacco	6
C25: Petroleum, Coal & Chemicals	6
C26: Non-metallic Mineral Products	3
C28: Machinery & Equipment	6

[25] Data from some chapters have been suppressed (confidentialised) and the number of firms has been random rounded.

Table 3: Emission Intensity Average and CV of Emission Intensive groups

Group	Average Emission Intensity_VA	CV Emission Intensity_VA
Mega Emitters	6663	156
Aluminium Drawing, Rolling & Extruding	5016	160
Large Emitters	4075	142
Iron & Steel	3217	135
Pulp, Paper & Paperboard	2062	123
Sheet Metal Products	1907	169
Plastic Blow-moulded	1420	85
Fruit & Vegetable	1214	102
Other Wood Products	1093	115
Seafood	955	109
Architectural Aluminium	947	87
Plastic Injection Moulded Product	882	162
Textile Fibre	827	84
Log Sawmilling	817	76
Structural Metal Products nec	812	152
Food excl. Seafood	774	137
Fertiliser	748	176
Concrete Slurry	714	169
Ink & Chemical Products nec	694	155
Leather & Leather Products	668	80
Electrical Equipment & Appliance	625	156
Ship & Boat building	623	177
Fabricated Metal Products	616	142
Industrial Machinery & Equipment nec	544	146
Textile Product	532	114
Meat Product	518	28
Bag, Film & Other Plastic Products	514	118
Synthetic Resin & Organic Industrial Chemical	473	109

Figure 1: Emissions Intensity for all Manufacturing Industry Activities and Groups below 1000 $KgCO_2$-e

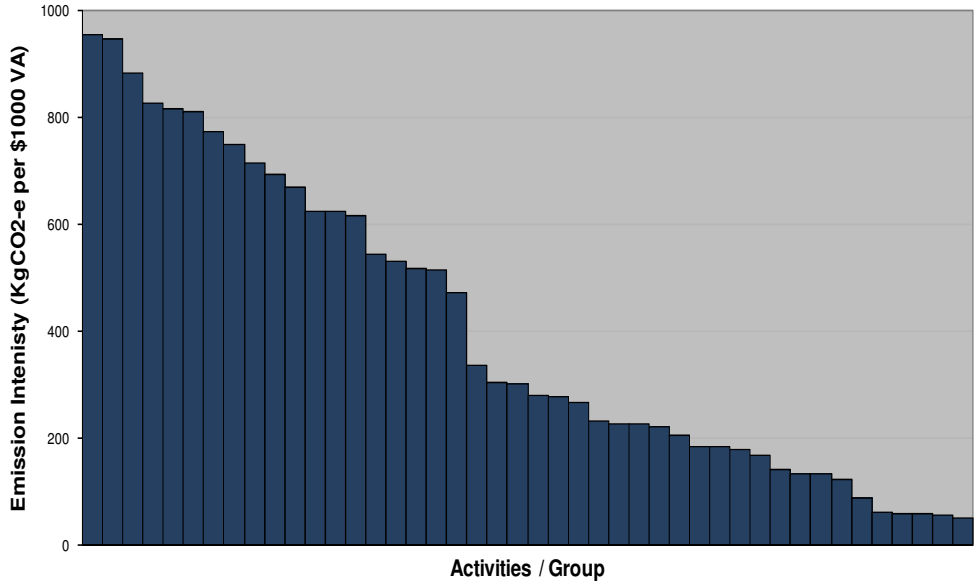


Figure 2: Emission Intensity of Industry Groups: Decomposed into Direct and Indirect Sources

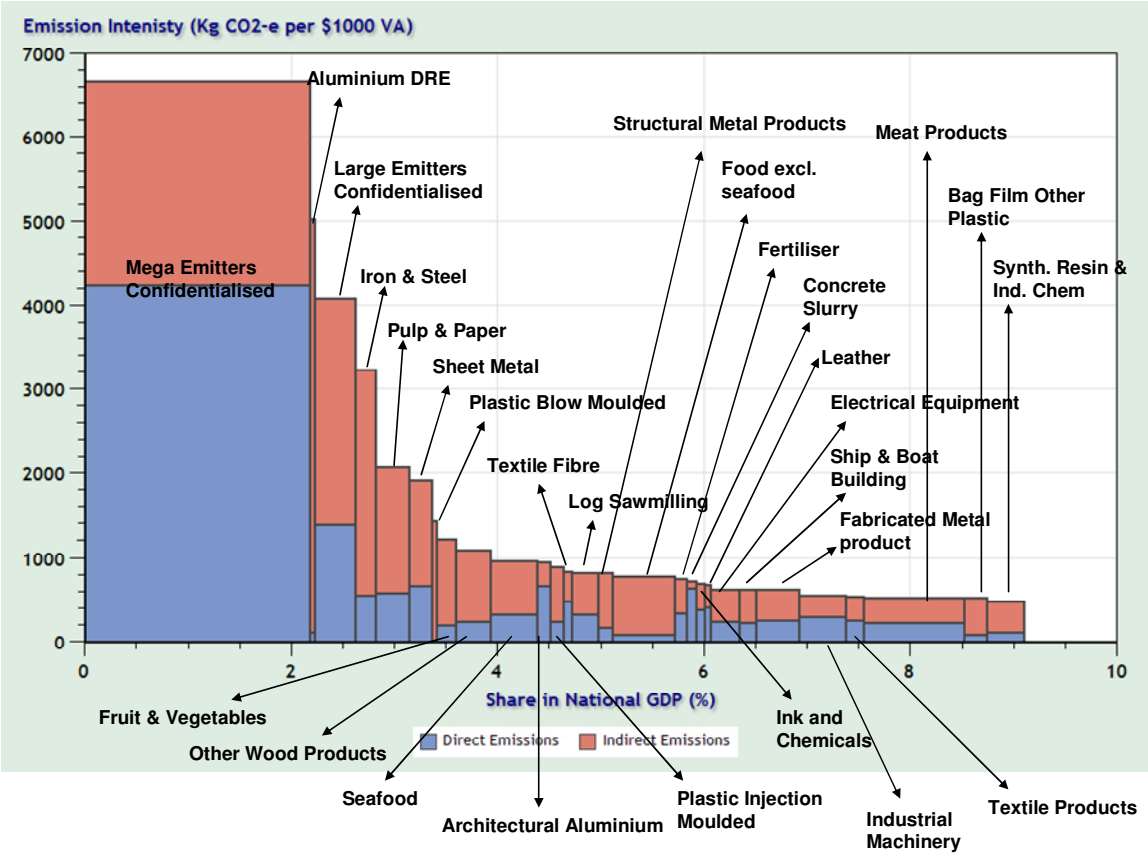


Figure 3: Bubble-plot of Emission Intensity and World Export Intensity

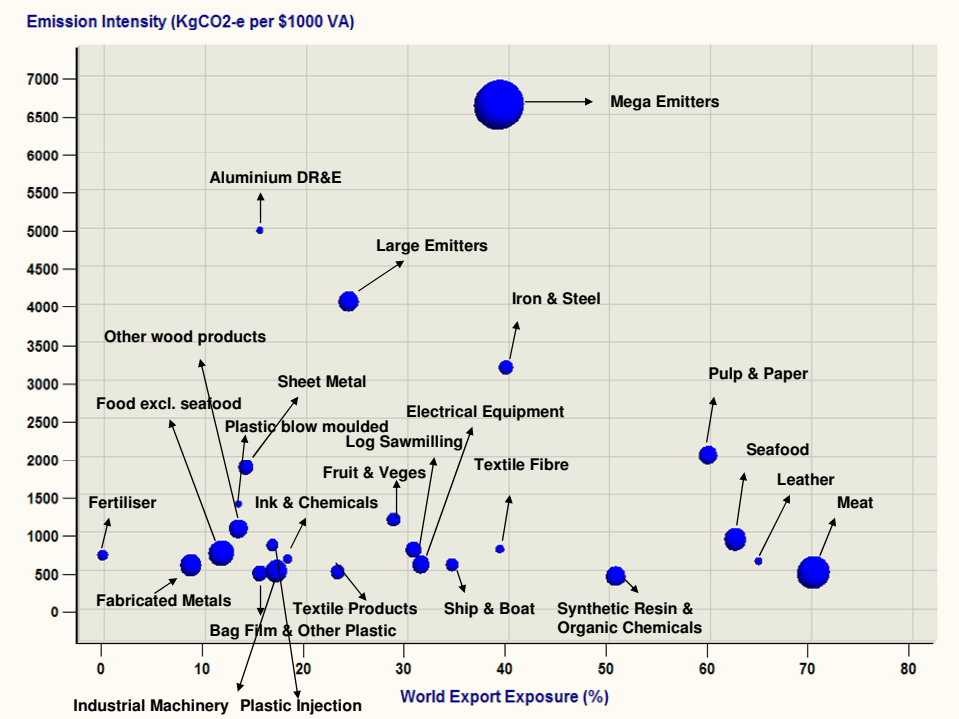


Figure 4: Bubble-plot of Emission Intensity and Annex B Export Intensity

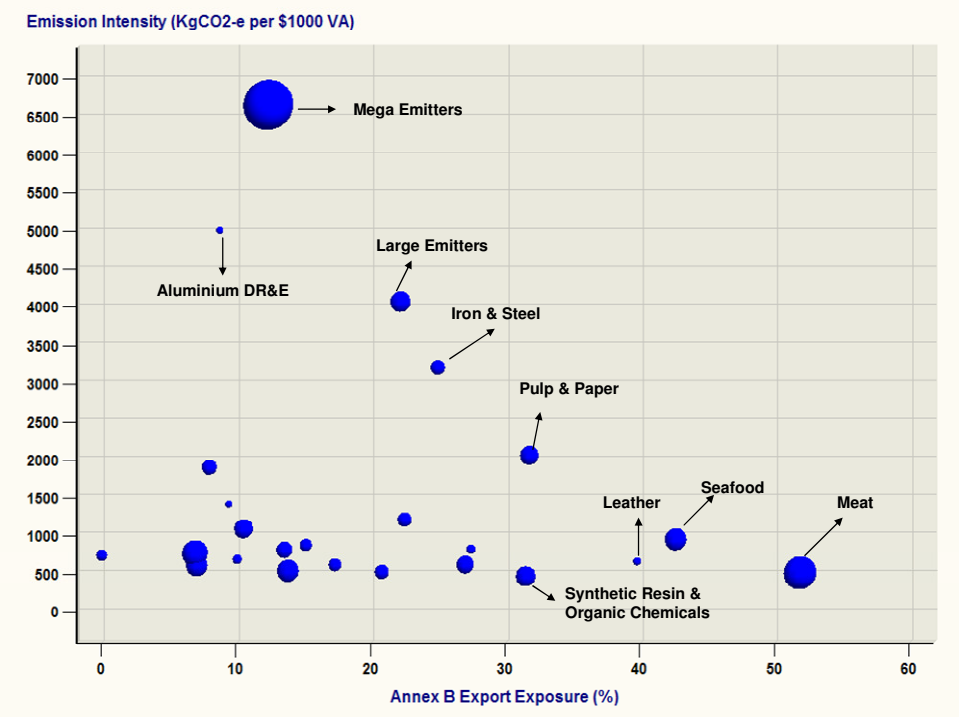


Figure 5: Bubble-plot of Emission Intensity and Non Annex B Export Intensity

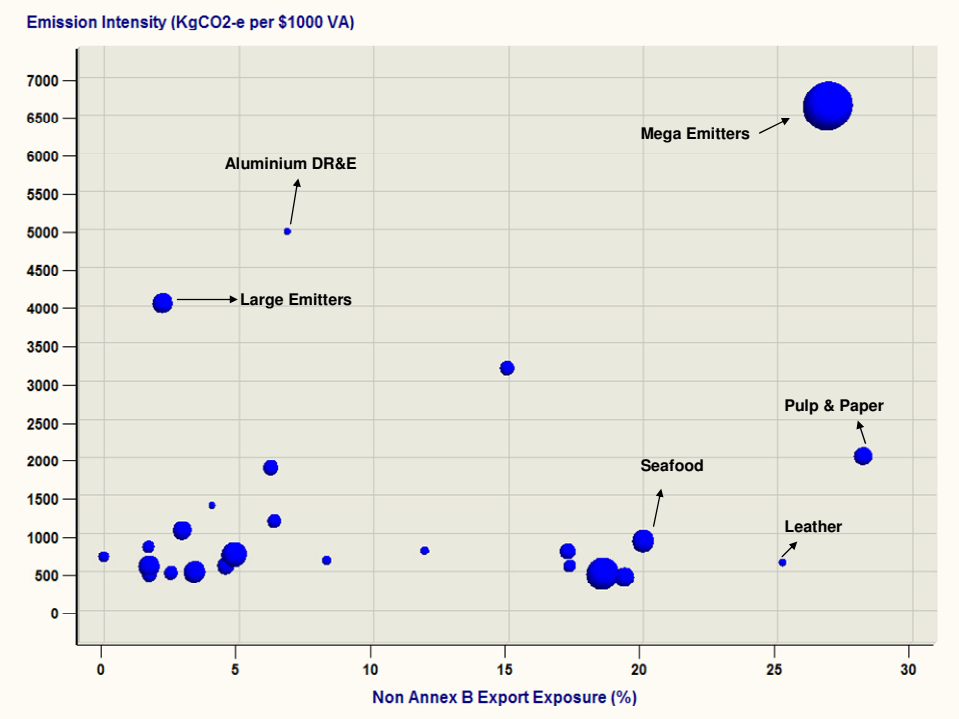
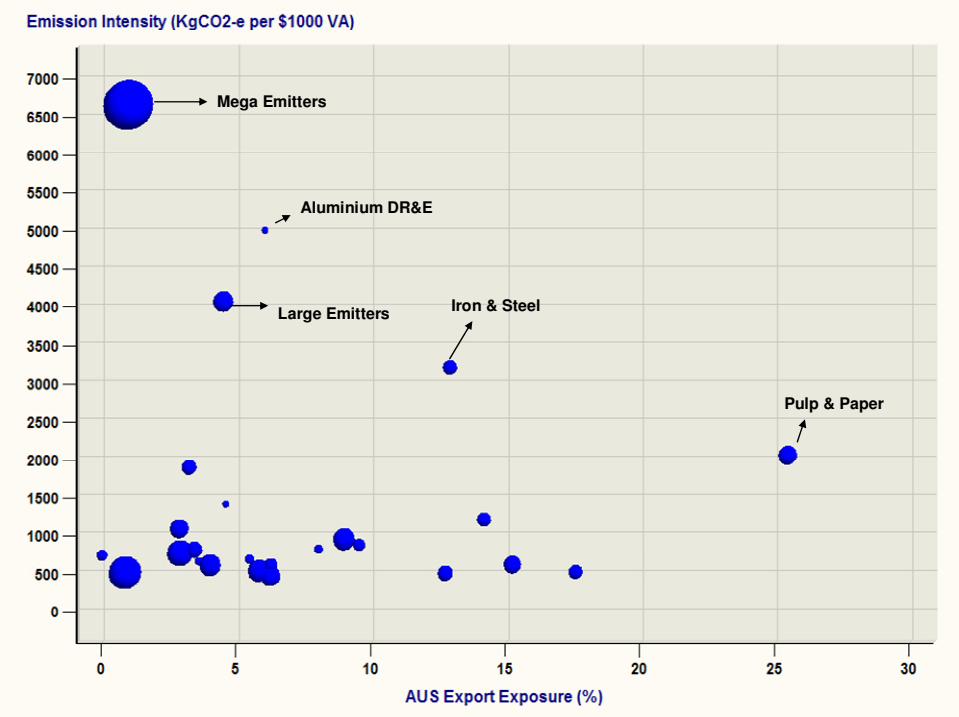


Figure 6: Bubble-plot of Emission Intensity and Australia Export Intensity



Appendix 1: Emissions factors for energy inputs

Fuels	**CO_2 Emissions (grams/MJ)**	**N_2O Emissions (grams/MJ)**	**CH_4 Emissions (grams/MJ)**	**Total CO_2-e emissions (grams/MJ)**
Electricity	144.44			144.44
Petrol	66.2	0.443	0.389	67.032
Diesel – road	69.5	1.150	0.080	70.730
Diesel – other	69.5	0.118	0.004	69.622
LPG – road	60.4	0.177	0.599	61.175
LPG – other	60.4	0.177	0.022	60.599
Fuel oil	72.75	0.140	0.068	72.958
Nat. Gas	52.3	0.028	0.026	52.354
Coal	91.2	0.472	0.014	91.685

Appendix 2: Conversion of Emissions Intensities into Emissions Costs

Emissions Intensity -KgCO2-e per $1000 VA	**Emissions Cost/Value Added at $12.5 tCO_2 (%)**	**Emissions Cost/Value Added at $25 tCO_2 (%)**	**Emissions Cost/Value Added at $50 tCO_2 (%)**	**Emissions Cost/Value Added at $100 tCO_2 (%)**
400	0.5	1	2	4
600	0.75	1.5	3	6
800	1	2	4	8
1000	1.25	2.5	5	10
1200	1.5	3	6	12
1400	1.75	3.5	7	14
1600	2	4	8	16
1800	2.25	4.5	9	18
2000	2.5	5	10	20
2600	3.25	6.5	13	26
2800	3.5	7	14	28
3000	3.75	7.5	15	30
3200	4	8	16	32
4000	5	10	20	40
5000	6.25	12.5	25	50
6600	8.25	16.5	33	66

For example, Aluminium, Drawing Rolling and Extruding has an emissions intensity of 5016 $KgCO_2$-e per $1000 value added which amounts to a emissions cost of 25.08 percent of value added at an emissions price of $50 per tCO_2-e.

Appendix 3: Industry groups that cross the 400 $KgCO_2$-e threshold (In descending order of emissions intensity)

- Mega Emitters – industry activity: heterogeneous and confidentialised
- Aluminium drawing, rolling and extruding
- Large Emitters – industry activity: heterogeneous and confidentialised
- Iron and steel manufacturing
- Pulp, paper & paperboard manufacturing
- Sheet metal products manufacturing
- Plastic blow-moulded manufacturing
- Fruit and vegetable processing
- Other wood product manufacturing
- Seafood processing
- Architectural aluminium manufacturing
- Plastic injection moulded product manufacturing
- Textile fibre manufacturing
- Log sawmilling
- Structural metal products nec manufacturing
- Food processing excluding seafood processing
- Fertilisers manufacturing
- Concrete slurry manufacturing
- Ink and chemical products nec manufacturing
- Leather and leather products manufacturing
- Electrical equipment and appliance manufacturing
- Ship and Boat building
- Fabricated metal products manufacturing
- Industrial machinery and equipment nec manufacturing
- Textile products manufacturing
- Meat products manufacturing
- Bag, film and other plastic products manufacturing
- Synthetic resin and organic industrial chemicals manufacturing

Appendix 4: Share in GDP and Emission Intensity of activities/groups

Activity / Group	Share in GDP (%)	Direct Emissions Intensity_VA	Indirect Emissions Intensity_VA	Total Emissions Intensity_VA
Mega Emitters	2.18	4230	2433	6663
Aluminium Drawing, Rolling & Extruding	0.05	114	4902	5016
Large Emitters	0.39	1388	2687	4075
Iron & Steel	0.20	547	2671	3217
Pulp, Paper & Paperboard	0.32	573	1489	2062
Sheet Metal Products	0.21	663	1244	1907
Plastic Blow-moulded	0.05	11	1410	1420
Fruit & Vegetable	0.19	189	1025	1214
Other Wood Products	0.34	240	852	1093
Seafood	0.45	318	636	955
Architectural Aluminium	0.13	655	292	947
Plastic Injection Moulded Product	0.14	241	641	882
Textile Fibre	0.08	483	343	827
Log Sawmilling	0.25	322	495	817
Structural Metal Products nec	0.14	170	641	812
Food excl. Seafood	0.60	82	692	774
Fertiliser	0.12	329	419	748
Concrete Slurry	0.09	636	78	714
Ink & Chemical Products nec	0.08	372	322	694
Leather & Leather Products	0.06	411	257	668
Electrical Equipment & Appliance	0.28	233	392	625
Ship & Boat building	0.15	224	399	623
Fabricated Metal Products	0.43	255	361	616
Industrial Machinery & Equipment nec	0.44	297	247	544
Textile Product	0.18	256	276	532
Meat Product	0.97	219	299	518
Bag, Film & Other Plastic Products	0.22	87	427	514
Synthetic Resin & Organic Industrial Chemical	0.37	104	370	473

Appendix 5: Export Intensity (Exports/Value added)

Group	Overall Export Exposure	AUS Export Exposure	Annex B Export Exposure	Non-Annex B Export Exposure
Meat Product	0.71	0.01	0.52	0.19
Fruit & Vegetable	0.29	0.14	0.23	0.06
Food excl. Seafood	0.12	0.03	0.07	0.05
Seafood	0.63	0.09	0.43	0.20
Beverage & Malt	0.21	0.07	0.20	0.01
Textile Fibre	0.39	0.08	0.27	0.12
Textile Product	0.23	0.18	0.21	0.03
Clothing & Footwear	0.14	0.10	0.13	0.01
Leather & Leather Products	0.65	0.04	0.40	0.25
Log Sawmilling	0.31	0.03	0.14	0.17
Timber Re-sawwing & Dressing	0.30	0.09	0.24	0.06
Other Wood Products	0.14	0.03	0.11	0.03
Pulp, Paper & Paperboard	0.60	0.25	0.32	0.28
Printing & Services to Printing	0.05	0.03	0.04	0.01
Publishing	0.07	0.05	0.07	0.00
Fertiliser	0.00	0.00	0.00	0.00
Synthetic Resin & Organic Industrial Chemicals	0.51	0.06	0.32	0.19
Paint	0.01	0.01	0.01	0.00
Medicinal & Pharmaceutical Product	0.42	0.12	0.32	0.11
Soap & Other Detergent	0.17	0.16	0.16	0.01
Cosmetic & Toiletry	0.30	0.18	0.26	0.04
Ink & Chemical Products nec	0.18	0.06	0.10	0.08
Plastic Blow-moulded	0.14	0.05	0.09	0.04
Plastic Extruded Product	0.12	0.08	0.09	0.03
Bag, Film & Other Plastic Products	0.16	0.13	0.14	0.02
Plastic Injection Moulded Product	0.17	0.10	0.15	0.02
Glass & Glass Product	0.04	0.02	0.03	0.01
Ceramic	0.03	0.01	0.02	0.01
Concrete Slurry	0.00	0.00	0.00	0.00
Other Concrete Products	0.01	0.00	0.00	0.01
Iron & Steel	0.40	0.13	0.25	0.15
Aluminium Drawing, Rolling & Extruding	0.16	0.06	0.09	0.07
Structural Steel Fabricating	0.05	0.02	0.03	0.03
Architectural Aluminium	0.03	0.01	0.01	0.02
Structural Metal Products nec	0.10	0.07	0.07	0.03
Sheet Metal Products	0.14	0.03	0.08	0.06
Fabricated Metal Products	0.09	0.04	0.07	0.02
Motor Vehicle & Parts	0.24	0.13	0.22	0.03
Ship & Boat building	0.35	0.06	0.17	0.17
Electronic Equipment	0.53	0.12	0.34	0.19
Electrical Equipment & Appliance	0.32	0.15	0.27	0.05
Agricultural Equipment	0.22	0.06	0.20	0.02
Lifting & Material Handling Equipment	0.16	0.08	0.12	0.04
Industrial Machinery & Equipment nec	0.17	0.06	0.14	0.03
Prefabricated Building	0.06	0.02	0.02	0.04

Wooden Furniture & Upholstered Seat	0.06	0.04	0.05	0.01
Sheet Metal Furniture	0.13	0.09	0.12	0.02
Furniture nec	0.01	0.01	0.01	0.00
Jewellery & Silverware	0.26	0.21	0.24	0.02
Toy and Sporting Goods	0.25	0.10	0.20	0.05
Manufacturing nec	0.09	0.05	0.08	0.02
Large Emitters Confidentialised	0.24	0.05	0.22	0.02
Mega Emitters Confidentialised	0.39	0.01	0.12	0.27