Australian Government

Department of Industry, Innovation and Science

Senate Economics References Committee

# Submission to the inquiry into the future of Australia's Steel Industry

February 2016

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# INTRODUCTION

## Submission and Inquiry Terms of Reference

This submission addresses the following Terms of Reference (ToR) of the inquiry:

a. the future sustainability of Australia's strategically vital steel industry and its supply chain; and

b. any other related matters.

It provides information and data relevant to understanding the comparative international performance of the steel industry and, in that context, Australia's steel sector, production and an overview of Australia's steel supply chain. Cost data are presented, as well as information about the characteristics of the domestic industry, to inform commentary about emerging pressures. Information on the Australian Government's existing policy measures related to the steel industry is also presented.

The use of different sources of data in the analyses, i.e. commissioned plant level data and economic data from the Australian Bureau of Statistics (ABS) provides a means of checking the internal consistency of the commentary.

The structure and content of the submission reflect an understanding that the objective question of the ToR relates to the capacity of the industry to continue in its current form and analyses relevant matters to enable an objective assessment of the current state of the industry. It also addresses matters relevant to providing an accurate context of the operating environment facing the industry and implications going forward.

## Role of the Department of Industry, Innovation and Science

The Australian Government's primary industry and innovation policy agenda is to ensure a business environment that enables Australian firms, whether large or small, and across the breadth of sectors of the economy to be globally competitive through sustainable growth and productivity.

To help realise this vision, the Department of Industry, Innovation and Science (the department) delivers a range of Government policies and programmes under four key objectives: supporting science and commercialisation, growing business investment and improving business capability, streamlining regulation and building a high performance organisation.

The department brings together a range of functions that are critical to improving the competitiveness of Australian industry. These include industry policy, innovation, science, research and development, energy and resources, and anti-dumping. In particular, the department is taking forward key elements of the Government's National Innovation and Science Agenda. It is doing so by:

- supporting businesses to collaborate with scientists and researchers in universities and other institutions to maximise commercial returns from public investment in science, research and development;
- promoting the growth of internationally competitive industries by facilitating nationwide action on deregulation, skills, collaboration, commercialisation and international engagement;
- facilitating competitive marketplaces and business investment by assisting adjustment to inevitable industrial transformation;
- providing regulatory frameworks to sustainably expand Australia's resource base and provide adequate, reliable and affordable energy to underpin international competitiveness and economic growth; and
- reducing business costs, including energy costs through effective regulation.

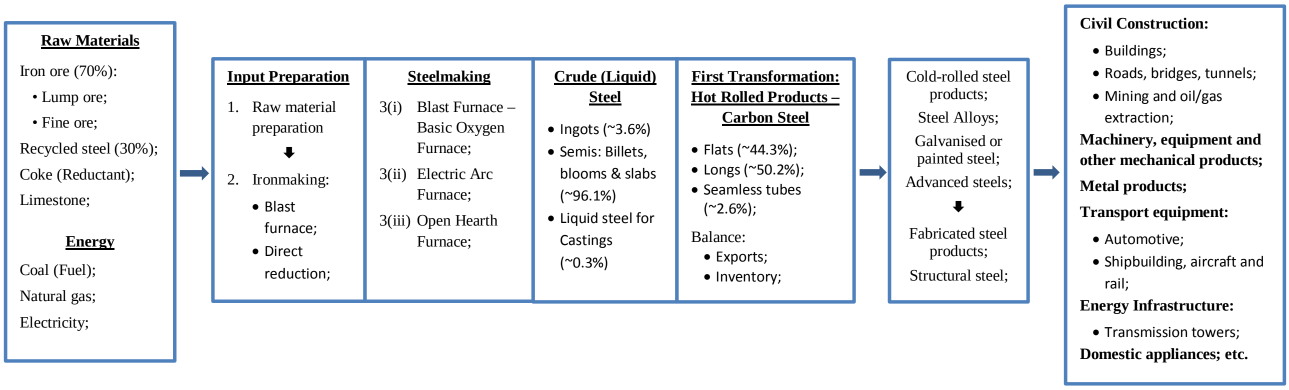
The department supports the delivery of the 2015–16 Budget measures and more recently the Government's $1.1 billion National Innovation and Science Agenda (NISA) announced on 7 December 2015.

# BACKGROUND ON STEEL PRODUCTION

## Summary of Global Steel Production and Supply Chain

The steel supply-chain takes into account raw material inputs, crude steel and steel products manufacturing and end-use demand for steel products. The firms' cost structure, which is a function of the production technology, regulatory environment and location[1], and the demand for steel products for a given market structure are factors affecting profitability. The main stages of steel production and consumption are shown in **Figure 1** to assist with understanding the main sources of production costs for steel manufacturing plants.

**Figure 1.** Steel production and use




The World Steel Association reports that in 2015, total global steel output was about 1,622.8 million metric tonnes (Mt). Asia accounted for 1,113.8 Mt and the EU28 was 166.2 Mt. By country, China's steel output was 803.8 Mt followed by Japan at 105.2Mt. Australia's steel output was 4.9 Mt in 2015.

The world steelmaking capacity was estimated to have more than doubled from 1,060 Mt observed in 2000 to 2,241 Mt in 2014[2]. But it masks an underlying fall in the capacity utilisation rate, which was 64.6%[3] in December 2015, exacerbated by continuing investments in production capacity and softening steel demand.

The time-series data published by the World Steel Association on global capacity utilisation rates[4] since 2008 indicate fluctuating monthly capacity utilisation ranging from 90.8% in June 2008 to 58.3% in December 2008. However, the monthly global steel capacity utilisation over the four financial years from 2009-10 to 2013-14 has been between a narrower band of about 82% down to 72%. The available monthly capacity utilisation data since 2008 suggest some cyclical patterns with declining capacity utilisation usually starting around September, reaching a minimum around December before lifting again early in the following year.

## Steel Production Technologies

The Blast Furnace/Oxygen Blast Furnace (BOF) and the Electric Arc Furnace (EAF) technologies are the main methods of crude steel production globally, accounting respectively for approximately 74% and 26% of global crude steel output[5]. As will be discussed later the operating costs of the two methods are significantly different[6] but the EAF method can also be used for steel recycling from scrap steel. The choice of raw material input (i.e. iron ore versus scrap steel) and economies of scale will affect the relative competitiveness of the different producers.

The relative use of the two production methods globally differs substantially by region (**Table 1**):

[1] As iron ore prices are denominated in US dollars, the exchange rate can also have an impact.
[2] Source: OECD (2015) *OECD Science, Technology and Industry Policy Papers, No. 18*. OECD Publishing, Paris.
[3] World Steel Association, 2016.
[4] The capacity utilisation rate or ratio is expressed as actual steel production as a ratio of the maximum available production capacity. Source: *Ibid*.
[5] A small number of plants use the Open Hearth Furnace method, which is being phased out (*Ibid*.).
[6] ArcelorMittal indicates that a growing number of integrated mills use the direct reduction process to produce sponge iron without coke ovens and blast furnaces (www.corporate.arcelormittal.com). This will of course affect cost structures.

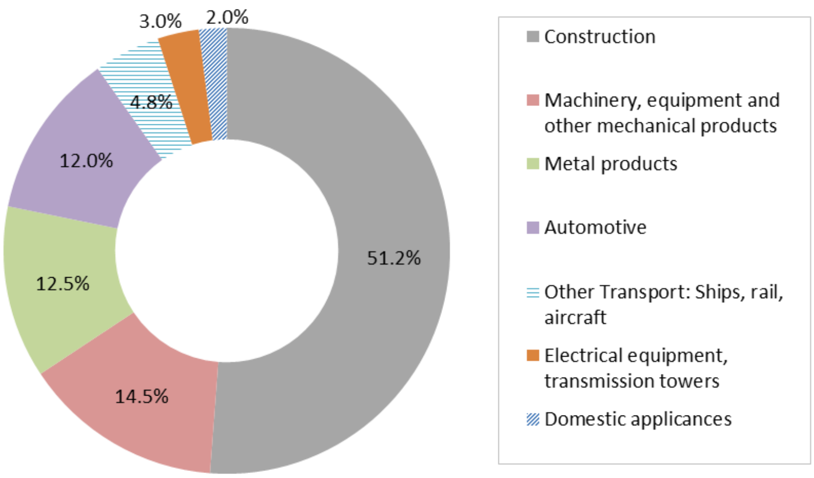
**Table 1.** Global distribution of the major steel production methods

| Region | Crude Steel Production Method | |
|---|---|---|
| | Blast Furnace/Blast Oxygen Furnace (%) | Electric Furnace (%) |
| Africa | 31 | 69 |
| Asia | 84 | 16 |
| CIS | 67 | 26 |
| Europe | 55 | 45 |
| Middle East | 9 | 91 |
| North America | 38 | 62 |
| Oceania (Australia and New Zealand) | 72 | 24 |
| South America | 65 | 34 |
| World Crude Steel Share by Method | 74 | 26 |

**Source:** OECD (2015) *OECD Science, Technology and Industry Policy Papers, No. 18*. OECD Publishing, Paris.

The OECD estimates that just over half (51.2%) of the global final demand for steel output is accounted for by product demand for civil construction activities, while machinery and equipment and transport equipment manufacturing account for a further 31%. The demand by broad classes of end-use is shown in **Figure 2**.

**Figure 2.** Overview of global final demand for steel by broad class of activities




**Source:** OECD (2010) 68TH Steel Committee Meeting, Paris. DSTI/SU/SC(2010)4.

# AUSTRALIAN STEEL INDUSTRY, PRODUCTION AND SUPPLY CHAIN

## Industry Definition

For the purposes of this submission, unless otherwise indicated, the Australian steel manufacturing industry comprises units classified according to the following Australian and New Zealand Standard Industrial Classification (ANZSIC) Groups and Classes:

| | | | |
|---|---|---|---|
| **211** | Basic Ferrous Metal Manufacturing | **2110** | Iron Smelting and Steel Manufacturing |
| **212** | Basic Ferrous Metal Product Manufacturing | **2121** | Iron and Steel Casting |
| | | **2122** | Steel Pipe and Tube Manufacturing |

**Source:** ABS (2006) Australian and New Zealand Standard Industrial Classification 2006 – ANZSIC. Catalogue No. 1292.0

The reason for this definition is that crude steel and the closely related first-transformation products, such as steel alloys, galvanised steel, rolled steel and seamless steel tubes, are the main outputs of these units using unprocessed raw materials as the primary input (refer also to **Figure 1**). The next stages of the steel supply chain, on the other hand, use first-transformation steel products as their primary input to production.

## Brief History of Steel Manufacturing in Australia

Australia's two current integrated steel producers, Arrium Limited (Arrium) and BlueScope Steel (BlueScope), were both formerly part of the BHP Limited (Ltd), now BHP Billiton Plc. Arrium Ltd developed from the demerged long products segment of BHP Steel, a wholly owned subsidiary of BHP Ltd, in 2000 and listed on the Australian Stock Exchange (ASX) originally as OneSteel.

Currently, OneSteel and OneSteel Recycling are wholly owned subsidiaries of Arrium Ltd's steel segment. The former BHP Steel Limited, a wholly owned subsidiary of BHP Billiton Plc, was demerged from the parent company in 2002 and is listed on the ASX as BlueScope Steel.

Integrated[7] steel manufacturing in Australia can be traced back to iron ore resources discovered in South Australia in the late 19th century. Significant steel making operations first began with the opening of the BHP Newcastle steelworks in 1915 (subsequently closed in 1999), followed by the steelworks at Port Kembla in 1928 (noting smaller operations prior to these, including near Lithgow, NSW).[8]

Arrium and BlueScope operate the two remaining integrated steelworks in Australia. BlueScope's Port Kembla steelworks opened in 1928, using coal from the region's coal fields and iron ore from South Australia. Arrium's Whyalla steelworks opened in 1941[9], using iron ore from South Australia and coal from NSW.

Both of these steelworks are connected to downstream steel fabrication and distribution networks Australia-wide. In 2015, total Australian crude steel output of 4.9 Mt represented about 0.3 percent of world output. **Table 2** provides an overview of the current production capacity of the two Australian producers.

**Table 2.** Summary of Australia Producers

| | Major Product Type | Product Description | Production |
|---|---|---|---|
| Arrium Limited | Steel long products | Hot-rolled structural bars, rail and sleepers | 2.5 Mt |
| BlueScope Steel Limited | Steel flat products | Hot-rolled coils | 2.6 Mt |

**Source:** Arrium Mining and Materials Annual Report 2014; BlueScope Annual Report 2014/15

The volume of Australian crude steel production has fallen in recent years. World Steel Association time series data10 starting from 1980 indicates that Australian crude steel output was 7.6 Mt in 1980 reaching a peak of 8.9 Mt in 1998; Australian steelworks were still producing 7.3 Mt in 2010.

**Table 3** provides a summary of some performance indicators which are discussed further in the sections on the characteristics of the Australian steel industry.

**Table 3.** Summary performance indicators for Australian steel production

| Summary Steel Manufacturing Indicators | 2006-07 | 2010-11 | 2013-14 |
|---|---|---|---|
| Crude Steel Production (million tonnes, Mt)* | 7.9 | 6.9 | 4.6 |
| Steel Industry Value-Added - IVA (AU$ million, at basic prices#) | 4,752 | 3,869 | 2,995 |
| Steel IVA share of Manufacturing IVA (%) | 4.8 | 3.8 | 3.1 |
| Steel Employment 4-Quarter Average (no.) | 43,925 | 44,175 | 38,500 |

**Notes:** * In this table, the crude steel financial year output was estimated as the mean output of two calendar years. # Basic prices are expressed as producers' price minus taxes plus subsidies; to arrive at the GDP equivalent measure, taxes are added back minus subsidies. Value-added is output at basic prices minus intermediate consumption at purchasers' prices.
**Source:** ABS (2015) Australian Industry, 2013-14, Catalogue No. 8155.0; ABS (2015) Labour Force, Australia, Detailed, Quarterly, Nov 2015, Catalogue No. 6291.0.55.003; World Steel Association (2015) Crude steel production, 1980-2014.

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[7] An integrated steelmaker is a producer that converts iron ore into semi-finished or finished steel products, which traditionally requires coke ovens, blast furnaces, steelmaking furnaces and rolling mills. Sources: www.corporate.arcelormittal.com; and www.istc.illinois.edu/info/library_docs/manuals/primmetals/chapter2.htm.
[8] https://s3-ap-southeast-2.amazonaws.com/bluescope-corporate-umbraco-media/media/1007/founding-of-a-steel-industry.pdf
[9] http://www.whyalla.sa.gov.au/page.aspx?u=944
[10] http://www.worldsteel.org/dms/internetDocumentList/statistics-archive/production-archive/steel-archive/steel-annually/steel-annually-1980-2014/document/steel%20annually%201980-2014.pdf

## Changes for the Australian Steel Industry

Significant Government policy reforms over previous decades included a phased reduction in tariffs on imported steel and implementing a flexible exchange rate system which have increased the exposure of steel manufacturers to direct competition from overseas markets.

Free Trade Agreements (FTAs) with China, Japan, Korea and Trans-Pacific Partnership countries has opened up the market further. The FTAs are aimed to provide better Australian access to important markets, increase two-way investment, and reduce import costs for Australian businesses and consumers.[11]

## Crude-Steel Producers, Output and Capacity

### Arrium Limited[12]

Arrium Ltd is an Australian public company with its head office in Sydney, New South Wales. Its Australian steel operations include both the Steel and Recycling businesses. Its steel manufacturing businesses, *OneSteel Whyalla Steelworks* and *OneSteel Rod Bar Wire*, specialise in steel long (hot-rolled structural sections[13], tubes and pipes, bars, rail and sleeper) products with production capacity of approximately 2.5 million tonnes per annum.

It reported steel and steel recycling operations' sales revenues of about $4 billion in the 2015 financial year. Its Australian steel operations employed around 5,500 persons in 2015, with about 1,100 employees at its Whyalla steelworks in South Australia.

The Arrium Recycling business operates out of 24 locations on the east coast of Australia and in South Australia and supplies steelmaking raw materials to domestic and international foundries, smelters and steel mills, as well as non-ferrous metals for recycling. It also operates collection sites and trading offices in nine countries.

Arrium acquired the Smorgon Steel Group in 2007. Included in the acquisition were some mining consumables businesses, including a grinding media business in Australia. It acquired the Moly-Cop Group mining consumables business from Anglo American plc. at the end of 2010, and the subsidiaries owning the iron ore assets of WPG Resources Limited in South Australia in 2011.

Arrium's Moly-Cop business manufactures forged steel grinding balls and grinding rods. Moly-Cop has manufacturing facilities located close to mining sites in Australia, Canada, Chile, Indonesia, Mexico, Peru, and the United States of America (USA).

Its Newcastle mill has a nominal capacity of 250,000 tonnes of grinding media per annum and the grinding media produced at the Newcastle plant are used in mining operations in Asia and parts of Africa. The Moly-Cop Railway Wheels & Forge (Comsteel) business manufactures rail wheels, axles and wheel sets, and supplies the products domestically and for export.

AltaSteel is a scrap-based mini-mill operation located in Canada and a wholly-owned subsidiary of Arrium. The plant has both melting and casting facilities and a production capability of 350,000 tonnes of steel billets annually. The business manufactures heat-treated grinding rod, which is sold to the Moly-Cop businesses direct to mining operations.

It also manufactures feedstock for the manufacture grinding balls for the Moly-Cop businesses and various round, flat, and square bar shapes for use by downstream manufacturers in the mining, oil and gas exploration, automotive, construction and agricultural industries.

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[11] http://dfat.gov.au/trade/agreements/Pages/trade-agreements.aspx
[12] www.arrium.com
[13] The local production of steel products are governed by Australian/New Zealand Standards, for example: AS/NZS 3679.1; columns: AS/NZS 3679.1 – 300; deformed bar: AS/NZS 4671:200; angles: AS/NZS 4791

**BlueScope Steel Limited**[14]

BlueScope Steel Ltd is an Australian public company with its head office in Melbourne, Victoria, and produces flat steel products, including slab, hot rolled coil, cold rolled coil, plate and metallic coated and painted steel. Through its BlueScope Australia and New Zealand business segment, it manufactures slab, hot rolled coil and plate products[15] at the Port Kembla Steelworks, which has a production capacity of 2.6 million tonnes of steel per annum.

BlueScope reported $2 billion in sales of locally produced steel each year. Its steel products include COLORBOND®. Other products include: Clean COLORBOND®, ZINCALUME® steels, XLERPLATE® steel, LYSAGHT® steel building products, and Butler® and Varco Pruden® engineered buildings.

BlueScope currently employs around 3,500 people at its Port Kembla Steelworks in the Illawarra region of New South Wales.

New Zealand Steel is a fully owned subsidiary of BlueScope Steel Ltd and operates an integrated flat products steelworks in New Zealand. It uses locally-sourced iron sand and coal to produce about 600 000 tonnes of steel slabs a year.

In FY2014, BlueScope acquired the Fielders building products business, pipe and tube manufacturer and distributor Orrcon Steel, and the sheet and coil processing and distribution assets of OneSteel. BlueScope acquired the downstream long-products rolling and marketing operations of Fletcher Building's Pacific Steel Group, based in Auckland, New Zealand in FY2015.

North Star BlueScope Steel is BlueScope's steel plant in the United States of America, which BlueScope Steel now fully owns North Star following the purchase of remaining shares not currently held by it. Around 2 million tonnes of hot rolled coil are produced annually from North Star's dual electric arc furnaces, using scrap metal, pig iron and alloys.

Other global operations are BlueScope Buildings North America, which includes Butler Buildings and Varco Pruden Buildings; ASC Profiles; Steelscape with a total annual capacity of approximately 446,000 tonnes of metal-coated steel products and Castrip LLC – BlueScope Steel, which has a 47.5% shareholding of Castrip LLC, is a joint-venture partner with Nucor and Ishikawajima-Harima Heavy Industries.

The Castrip® technology involves casting a continuous thin strip of steel directly from the furnace. BlueScope Coated Products is a joint venture between BlueScope, Tata, and Nippon Steel. It operates 100 facilities in 17 countries, employing around 16,000 people.

## Liquid (Crude) Steel Cost by Method of Production

The main methods of liquid (crude) steel production around the world and in Australia are the Blast Oxygen Furnace (BOF) and the Electric Arc Furnace (EAF), with the majority of production using the BOF. The cost and available global capacity for the respective production methods differ and are discussed separately.

Australian steel production uses mainly the BOF. Australia's weighted capacity utilisation of the BOF in 2015 is lower relative to the weighted world average at 74.4%, while the reported plant-level EAF capacity utilisation is very high at 97% (**Table 4**). The capacity utilisation at the plant level is calculated as the ratio of actual output to the reported total (maximum) available productive capacity at each plant. The Australian plants using either of the steel production technologies are not further identified in the analyses that follow to maintain confidentiality.

[14] www.bluescope.com/about-us/

[15] Examples of Australian/New Zealand Standards governing the production of these products include: AS/NZS 1365:1996; AS/NZS 1594:2002; coils: AS/NZS 1595:1998; coatings: AS/NZS 1397:2001 and AS/NZS 2728:2007. The following links also provide more specific examples of standards applied to products: http://www.bluescopesteel.com.au/go/news/what-those-grade-names-really-mean; http://www.onesteel.com/images/db_images/productspecs/Relevant%20Australian%20Standards%20List.pdf;

It should be noted that the comparative country cost data discussed in the following sections represent estimates derived from different sources and should not be assumed to be official company data.

**Table 4.** Available capacity and capacity utilisation for crude steel production, by method in 2015

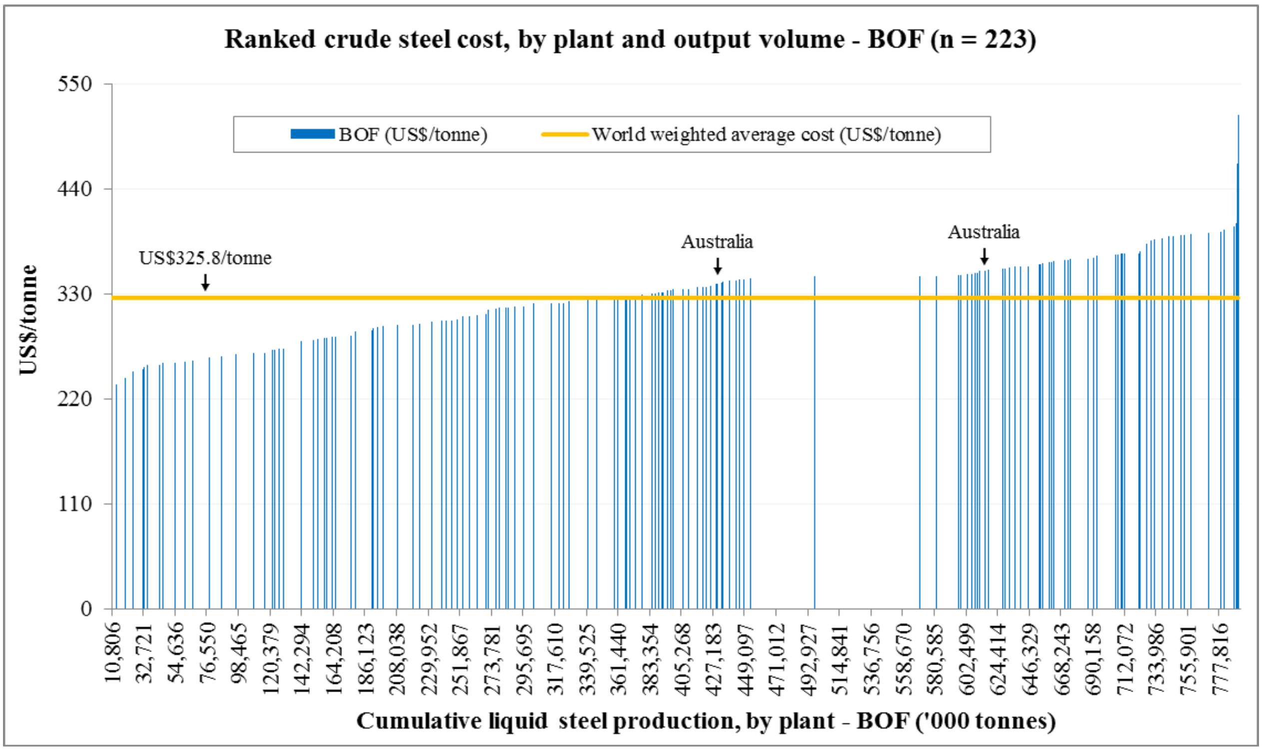
| | Blast Oxygen Furnace (BOF) | | Electric Arc Furnace (EAF) | | Notes |
|---|---|---|---|---|---|
| | Available Capacity ('000 tonnes) | Capacity Utilisation (%) | Available Capacity ('000 tonnes) | Capacity Utilisation (%) | Available capacity includes inactive or mothballed lines. |
| **Australia** | 6,556 | 74 | 1,558 | 97 | |
| **World (n=677)** | 970,816 | 81 | 354,595 | 89 | |

**Source:** MCI Steel Consultants and Department calculations; capacity utilisation is output divided by total available plant capacity.

## Blast Oxygen Furnace (BOF)

The estimated costs per tonne of steel produced at Australian plants relative to other plants around the world using the BOF method are shown in **Figure 3**. The relative positions for Australia are indicated by the arrows. The distances between the bars are indicative of a plant's relative contribution to global steel production (in '000 tonnes) and also their relative capacity to impact world steel prices.

**Figure 3.** Australian crude steel production cost relative to the rest of the world (BOF), 2nd quarter, 2015




**Note:** See Explanatory Note B for calculating the weighted average cost per tonne.
**Source:** MCI Steel Consultants and Department calculations; Capacity utilisation is the output divided by the total plant capacity.

Disaggregating the total cost per tonne of steel produced according to major inputs indicates that Australian plants have a material cost advantage relative to other plants in terms of raw materials, being about 10 % lower than other plants on average.However, this advantage appears to be offset by a significantly higher average labour & overhead cost and capital charges of 54% and 40% respectively. When the cost differences are weighted by their relative contributions to total cost, the cost per tonne output for Australia is about 14 % higher on average (**Table 5**).

A caveat is that the costs are not adjusted for the degree of transformation and quality of the output. Direct labour weighted across all plants on average accounts for about 44% of the combined labour & overhead costs. Capital charges comprise both depreciation and interest charges.

**Table 5:** Contribution of input costs to total product costs – total plant (BOF), 2015

| | Raw Materials | Energy & Reductants | Labour & Overheads | Capital Charges | Total Cost |
|---|---|---|---|---|---|
| Australian input cost relative to weighted world average input cost | -10% | +6% | +54% | +40% | +14% |
| Component share of Australian total cost | 31% | 25% | 28% | 15% | 100% |
| Weighted world average component share of total cost | 40% | 27% | 21% | 12% | 100% |

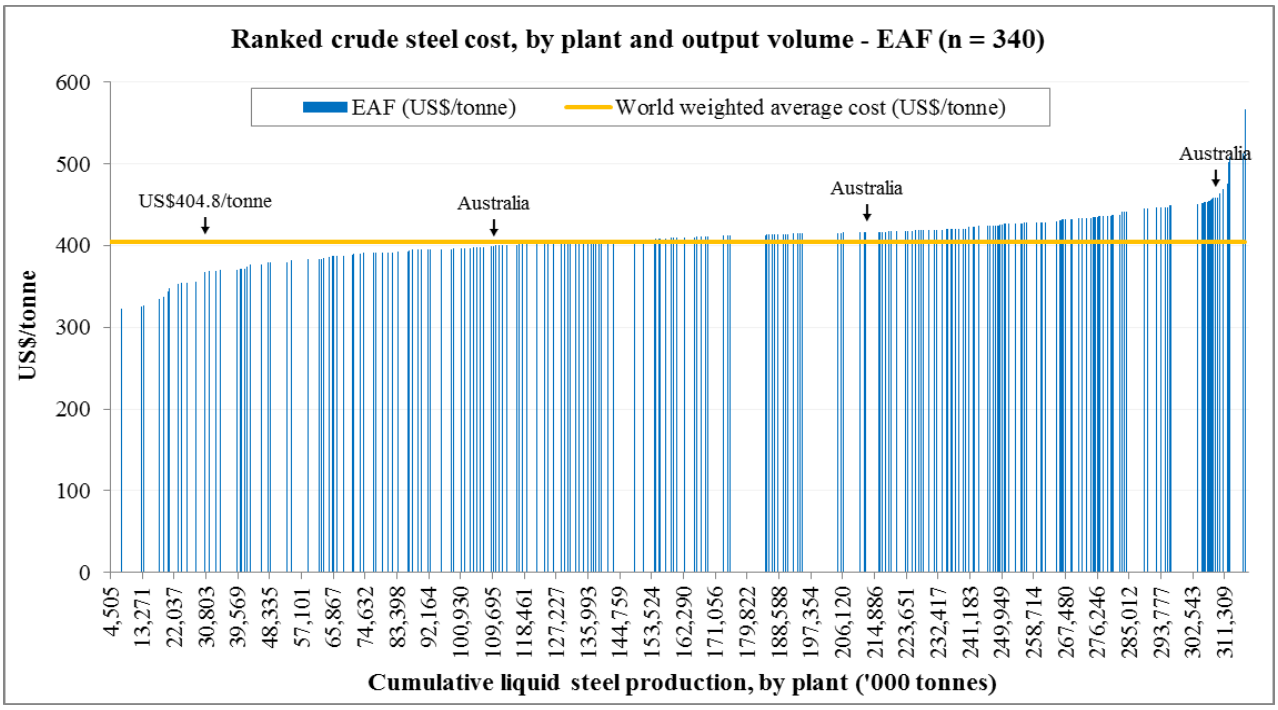
**Source:** MCI Steel Consultants and Department calculations

## Electric Arc Furnace (EAF)

The estimated weighted average capacity utilisation of Australian plants employing the EAF method for crude steel production in 2015 appears high relative to other global plants at 97% (refer to **Table 4**). However, the EAF method of production is also on average more expensive than the BOF method as indicated by the weighted global average cost per tonne of crude steel produced at US404.8/tonne and US325.8/tonne, respectively (**Figure 4** cf. **Figure 3**).

Crude steel is recovered from recycled steel by the EAF method. The positions for Australia relative to other producers using the EAF method are indicated by the arrows in **Figure 4**. As before, a caveat is that the relative costs are not adjusted for the degree of transformation and quality of the crude steel output.

**Figure 4.** Australian crude steel production cost relative to the rest of the world (EAF), 2nd quarter, 2015




**Note:** See Explanatory Note B for calculating the weighted average world cost per tonne.
**Source:** MCI Steel Consultants and Department calculations

The weighted average (total) cost per tonne of the Australian plants for this stage of production is near the world weighted average, being some 4% lower (**Table 6**).

The relative contributions to cost by key inputs appear to be similar between Australia and other plants in terms of raw materials and energy & reductants. The Australian plants appear to have less of an advantage in terms of raw material inputs possibly because recycled steel is also used as an input in this process.

As with the BOF, labour & overheads are again significantly higher than other plants around the world. While the reported capital charges are much lower for this reference period, it has a small relative weight.

**Table 6:** Contribution of input costs to total costs for steel production, total plant: EAF. 2015

| | Raw Materials | Energy & Reductants | Labour & Overheads | Capital Charges | Total Cost per tonne |
|---|---|---|---|---|---|
| Australian input costs relative to weighted world average cost | -4% | -7% | +18% | -34% | -4% |
| Weighted input cost share of Australian total cost | 66% | 13% | 16% | 5% | 100% |
| Weighted world average input cost share of total cost | 65% | 14% | 13% | 8% | 100% |

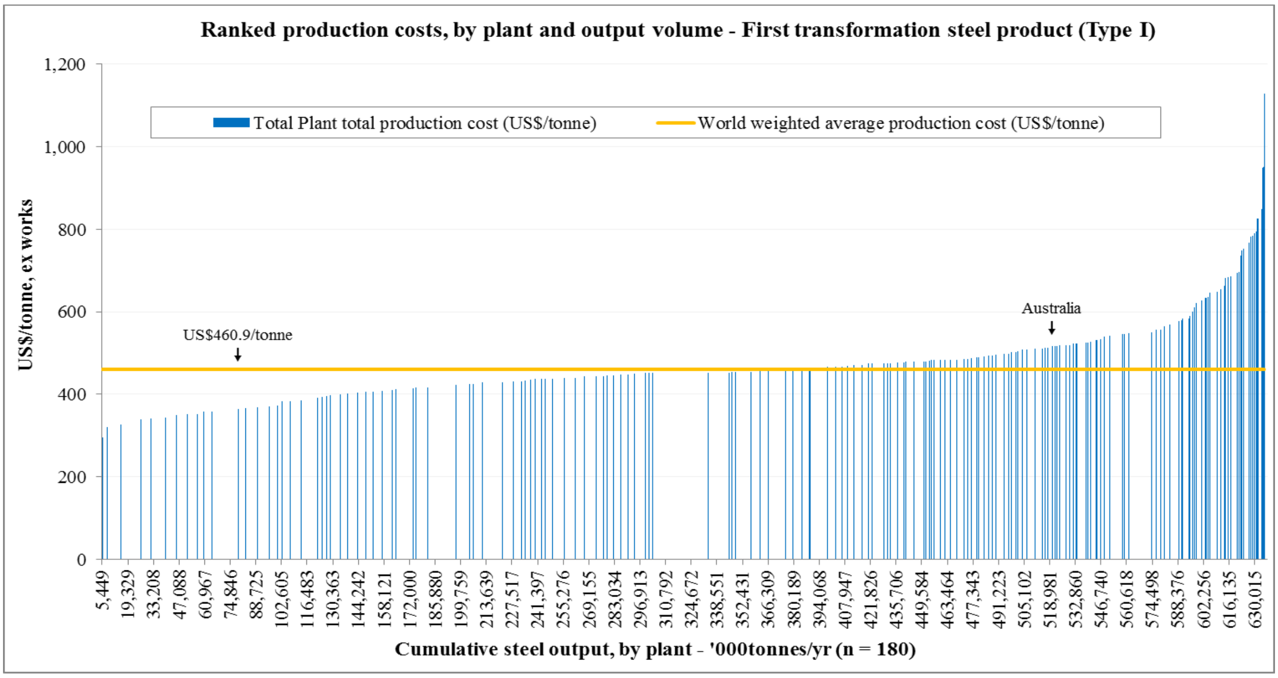
**Source:** MCI Steel Consultants and Department calculations

There are three major types of steel products from the first transformation of crude steel: flat products (hot rolled coiled), long products (billets, blooms, rebars, wire rod, sections and rails) and seamless tubes. Because Australian plants tend to specialise in either flat or long products, the products for price comparison purposes are not further identified to maintain the confidentiality of the plant. Therefore, the products are categorised only as either ***Type I*** or ***Type II***.

## Production Costs for Steel Product (Type I)

**Figure 5** shows the position of Australian product cost ex works i.e. manufacturing costs only excluding transport costs, indicated by an arrow, relative to a selection of countries and the world average weighted by volume of output.

**Figure 5.** Cost of Australian steel (Type I) production relative to the rest of world, 2nd quarter, 2015




**Note:** See Explanatory Note B for calculating the weighted average world cost.
**Source:** MCI Steel Consultants and Department calculations

The cost of producing one tonne of Australian steel product *Type I* is on average about 12% higher than the world average price. This is again not adjusted for quality or variety. The distance between the bars is indicative of the plant's relative contribution to world output. As the major Australian plants are structured as integrated plants, the higher average total cost per tonne of this first transformation of crude steel is likely a reflection of the cumulative stage costs, starting from the crude steel as input to the next stage of transformation.

**Table 7** indicates that Australia has an advantage over many larger global producers in terms of raw material costs, which are 17% below the weighted world average to produce this type of steel product. This advantage appears to be eroded by significantly higher labour & overhead costs and capital charges, which together represent 41% of Australian output costs. Their relative weights in this product contribute overall to a 12% higher total cost on average.

**Table 7.** Contributions to total costs, by component – first transformation steel product Type I, 2015

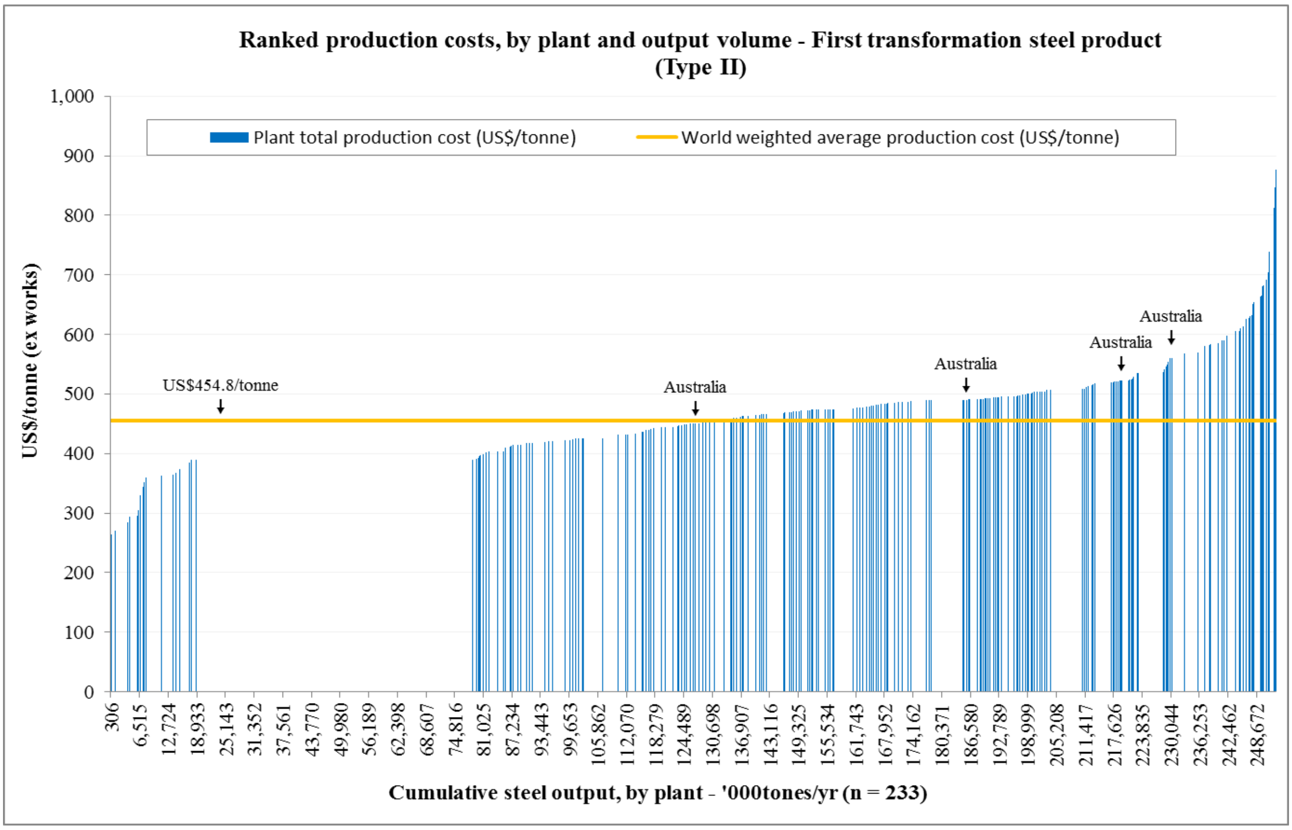
| | Raw Materials | Energy & Reductants | Labour & Overheads | Capital Charges | Total Cost |
|---|---|---|---|---|---|
| Australian input cost relative to weighted world average cost | -17% | +20% | +59% | +37% | +12% |
| Input cost share of Australian total cost | 35% | 24% | 27% | 14% | 100% |
| Weighted world average input cost share of total cost | 47% | 22% | 19% | 11% | 100% |

**Source:** MCI Steel Consultants and Department calculations

## Production Costs for Steel Product (Type II)

The estimated total cost for *Type II* steel products ranked by plant/country and by output volume is shown in **Figure 6**, with the Australia's relative production costs being indicated by the arrows. The distance between the bars are indicative of the plant's relative contribution to world output.

**Figure 6.** Cost of Australian steel (*Type II*) production relative to the rest of the world, 2nd quarter, 2015




**Note:** See Explanatory Note B for calculating the weighted average world cost. The large gap between 18.9 Mt and 78 Mt comprises a group of plants not further identified i.e. it is not the output of a single plant.
**Source:** MCI Steel Consultants and Department calculations

For *Type II* product (*cf. Type I*), the Australian plants' raw material costs are significantly higher, about 37% higher than the global average (**Table 8**; see also **Table 7**), suggesting the effect of cumulative stage costs due to the integrated production arrangement or the cost of scrap metal input. Notwithstanding the relatively lower input costs due to energy & reductants and capital charges, the relative high weight of raw materials has contributed to the higher average total product cost.

**Table 8:** Contributions to total costs, by major input – first transformation steel product Type II**,** 2015

| | Raw Materials | Energy & Reductants | Labour & Overheads | Capital Charges | Total Cost |
|---|---|---|---|---|---|
| Australian cost relative to weighted world average cost, by component | +37% | -39% | +3% | -48% | +10% |
| Component share of Australian total cost | 72% | 11% | 13% | 4% | 100% |
| Weighted world average component share of total cost | 59% | 20% | 14% | 8% | 100% |

**Note:** The world average is a weighted average by plant output volumes. See Explanatory Notes B for details of the calculation.
**Source:** MCI Steel Consultants and Department calculations

## Direct Labour Costs and Overhead Costs

The contributions to total cost of direct labour and labour & overheads appear to vary with the type of furnace technology used. The direct labour costs are significantly higher for both the Australian BOF and EAF plants while overhead costs are significantly higher for the Australian BOF plant relative to the respective weighted world average costs (**Table 9**).

As before, a caution is that the product costs are not quality adjusted and the variation also includes exchange rate effects. Nonetheless, the differences suggest that a deeper understanding of the drivers of Australian labour and overhead costs would be helpful.

However, it should be noted that the variation from world weighted average price may also be affected by the capacity utilisation rate. The difference between the weighted combined direct labour and overhead costs per tonne steel of the Australian EAF plants and the world average is lower than the comparable unit cost differences of the BOF plants (**Table 9**, column 2). If there is any economies-of-scale effect, it would be due to fixed-costs accounting for a smaller share of total unit costs [see Explanatory Notes B(II)] as the quantity of output rises for the given plant capacity.

**Table 9.** Weighted Australian plant labour and overhead costs, by type of furnace, relative to the weighted respective plant cost for the rest of the world

| 2015 Q2 | | | Percentage difference AU:RoW (%) | Difference in combined labour & overhead costs AU:RoW (%) | Difference in capacity utilisation (percentage points) |
|---|---|---|---|---|---|
| BOF | Direct Labour Cost per tonne | Weighted Australian plant costs relative to weighted rest of world plant costs | +79 | +55 | -7 pp |
| | Overhead Cost per tonne | Weighted Australian plant costs relative to weighted rest of world plant costs | +37 | | |
| EAF | Direct Labour Cost per tonne | Weighted Australian plant costs relative to the weighted rest of world plant costs | +39 | +19 | +8 pp |
| | Overhead Cost per tonne | Weighted Australian plant costs relative to the weighted rest of world plant costs | +3 | | |

**Note:** Abbreviations: Blast oxygen furnace (BOF); electric arc furnace (EAF); Australia (AU); Rest of World (RoW). The cost comparisons applies the US$/tonne component costs. pp is the abbreviation for ‘percentage points’.
**Source:** MCI Steel Consultants and Department calculations

# CHARACTERISTICS OF THE AUSTRALIAN STEEL MANUFACTURING INDUSTRY

## Trade in Primary Steel Products

Australian steel exports have been negatively affected by the Global Financial Crisis and, until recently, the high exchange rate, with the export index falling almost two thirds since 2005-06. Imports of steel into Australia have been less affected, which may be due to some combination of price effects, the import of varieties not produced in Australia and the continuing investments in the mining and gas sectors (**Table 10**).

**Table 10.** Indices of Australian steel exports and imports – 2006-07 to 2015-16 (2005-06 = 100.0)

| Iron and Steel Exports | 2006/07 | 2008/09 | 2010/11 | 2012/13 | 2014/15 |
|---|---|---|---|---|---|
| Export Value (AU$ million) | 1,742.8 | 1,363.0 | 1,303.0 | 820.4 | 692.5 |
| Export Quantity Index (2005/06 = 100 or 2.4 Mt) | 109.1 | 71.7 | 73.5 | 40.9 | 35.0 |
| Iron and Steel Imports | 2006/07 | 2008/09 | 20010/11 | 2012/13 | 2014/15 |
| Import Value (AU$ million) | 2,479.3 | 3,191.0 | 2,121.5 | 1,755.0 | 1,731.3 |
| Import Quantity Index (2005/06 = 100 or 2.2 Mt) | 105.8 | 95.0 | 85.2 | 76.5 | 71.8 |

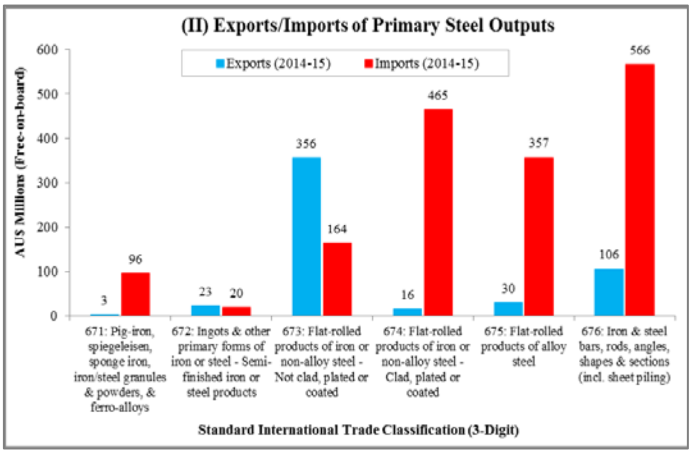
**Source:** Economic and Analytical Services, Department of Industry, Innovation and Science – Resources and Energy Statistics

The World Steel Association estimates that there are currently more than 3,500 different grades of steel with different physical, chemical, and environmental properties. Approximately 75% of modern steels have been developed in the past 20 years[16], indicating significant scope for specialisation and niche production.

The low levels of Australia's imports iron ore and ferrous scraps (raw material inputs) shown in **Figure 7(I)** suggests the materials are primarily sourced locally and appears to be consistent with the raw material cost advantage indicated in **Tables 4-6**.

**Figure 7(II)** indicates that Australia is a net exporter of flat-rolled not clad, coated or plated non-alloy steel products but a net importer of the remaining varieties of first transformation steel products (clad, plated/coated and steel alloys).

**Figures 7(I) and (II).** Australian imports and exports of steel in 2014-15: (I) raw materials and (II) primary steel outputs

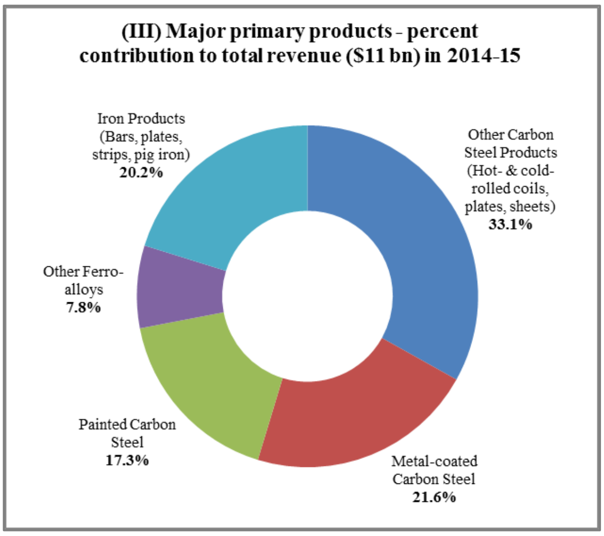




**Source:** ABS (2016) International Trade in Goods and Services, Australia. Catalogue No. 5368.0

As both Arrium and BlueScope have overseas subsidiaries and/or joint-ventures, it should be noted that data aggregated at this level cannot distinguish the internal transfers between domestic and overseas subsidiaries from the complementary or competing imports[17].

[16] www.worldsteel.org/faq/about-steel.html; World Steel Association members have plants located in 66 countries and account for approximately 85% of total global steel output.
[17] See Anti-dumping Commission (2015) Summary of measures applied against iron and steel imports into Australia. www.adcommission.gov.au/measures/Documents/Summary%20of%20Measures%20Applied%20Against%20Iron%20and%20Steel%20Imports%2022Oct15.pdf

**Figure 8.** Australian imports and exports of steel in 2014-15: Relative contribution of key products to sales revenue




**Source:** IBISWorld (2015) Industry Report C2110 – *Iron Smelting and Steel Manufacturing in Australia*

Australian steel producers recorded net exports for the flat rolled products of iron/non-alloyed carbon steel (not clad, plated or coated) product in 2014-15 [**Figure 8],** which also accounted for the largest share (33.1%) of total sales revenue out of the major iron/steel products in 2014-15 **[Figure 8].**

It can be noted that of the five classes of flat products belonging to this group, antidumping measures are in force for four[13]. The exception is cold-rolled steel (width >600mm) with no measures currently in force or ongoing investigations. Confirmed or interim antidumping measures are also in force for three of the five classes of bars/rods and wires of non-alloy steel.

Regarding steel product imports, there are subsidiaries, agents or representatives of overseas steel suppliers established in Australia, for example, Atlas Steels Australia, a subsidiary of Atlas Steels Canada, supplies specialty steels and alloys to Australia and New Zealand and JSteel Australia, which represents ArcelorMittal in Australia, New Zealand and in the South Pacific.

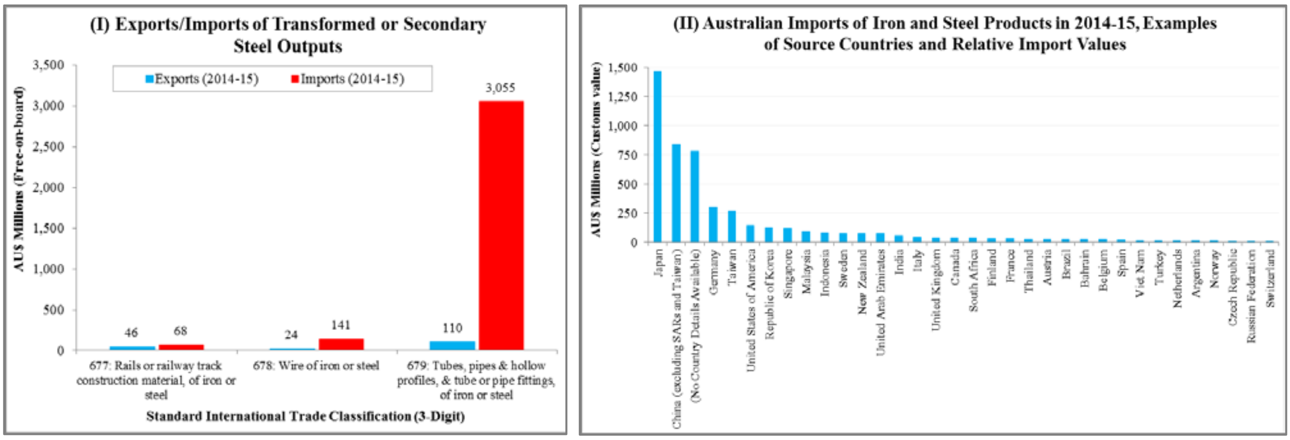
As indicated above, the overseas sourced steel stocks including through intra-firm transfers between local and overseas subsidiaries will be reflected in the import data. No antidumping measures are currently in force, nor are there ongoing investigations, for any of the 5 classes of flat and long stainless steel products.

Group 679 [see **Figure 9(I)**], comprising two important subgroups hollow steel products: (i) seamless tubes and (ii) tube and pipes for oil/gas drilling as well as oil/gas pipelines, is the largest contributor to Australia's imports of transformed steel products. Australia does not currently manufacture seamless hot-extruded steel tubes locally and there are neither antidumping measures in force nor investigations underway for this product.

Australia sources steel from a wide variety of countries. **Figure 9(II)**, while not exhaustive, is illustrative of the wide variety of countries from which Australia sources it steel products, ranked by total value of the imports in 2014-15. Japan was the most important supplier by value, about $1.5 bn. China, Germany and Taiwan were also important sources of steel by value.

Australia also sourced steel products from countries not usually associated with having large steel industries, such as: Sweden, Italy, New Zealand, United Arab Emirates, Finland, France and Austria. The sub-group of European Union countries in this select list of countries accounted for $601 million of steel product imports in 2014-15. This aspect must be considered when discussing the issue of costs, prices and competitiveness of the Australian operations.

**Figure 9.** Australian imports and exports of secondary steel products in 2014-15 and sources of steel imports




**Source:** ABS (2016) International Trade in Goods and Services, Australia. Catalogue No. 5368.0; ABS (2016) International Merchandise Imports, Australia, December 2015. Catalogue No. 5439.0; Department calculations

## Standards Governing Steel Products

Australian steel production is governed by a set of standards administered by the Standards Australia. The Australian Government recognises Standards Australia as its peak standards development body. Standards Australia is a non-government, membership based, not-for-profit organisation. Standards Australia works closely with all interests in the steel sector in Australia including those representing the interests of domestic steel producers and importers.

In alignment with Australian Government objectives, Standards Australia looks to adopt international standards to the maximum extent possible. Only in the absence of an appropriate existing international standard, and after verification that the proposed standard will not be anti-competitive, will a new standard be drafted.

Australian standards, including steel standards, are developed on a consensus basis by volunteer committee members who represent a balance of consumer, business, government and academic interests. Standards Australia has actively supported the steel sector in Australia, through numerous work programs, and the development of a roadmap to assist the steel sector in establishing its technical priorities.

Australia is a signatory and has commitments to observe the World Trade Organisation (WTO) Technical Barriers to Trade Agreement. The WTO is vital to the Australian Government's international efforts to push for substantial reductions in trade distorting subsidies, tariffs and tariff quotas and export subsidies and protection used by other countries.

The department understands that Standards Australia recently concluded a work program on structural steel standards. Standards Australia has confirmed its commitment to continue working with stakeholders in the steel sector to develop and adopt Australian Standards and other technical specifications to serve the needs of all stakeholders and in compliance with Australia's international trade obligations.

## Other Characteristics

Of the employing businesses, the majority of the firms in the Iron Smelting and Steel Manufacturing, Iron and Steel Casting, and Steel Pipe and Tube Manufacturing industries are small businesses employing 1-19 employees. It is only in the upstream industries i.e. the Iron Smelting and Steel Manufacturing and the Iron and Steel Casting industries where there are any large firms employing 200 employees or more (**Table 11**). The largest reduction in the number of firms was observed in the *Steel Pipe and Tube Manufacturing* class.

**Table 11.** Australian Steel Industry Firm Counts

| ANZSIC Industry class | | Count of firms operating at the end of June 2014 | | | | | % Change |
|---|---|---|---|---|---|---|---|
| | | Non Employing | 1-19 Employees | 20-199 Employees | 200+ Employees | Total | |
| Code | Label | no. | no. | no. | no. | no. | |
| 2110 | Iron Smelting and Steel Manufacturing | 497 | 651 | 122 | 9 | 1279 | -24 |
| 2121 | Iron and Steel Casting | 90 | 94 | 22 | 6 | 212 | 77 |
| 2122 | Steel Pipe and Tube Manufacturing | 87 | 112 | 20 | 0 | 219 | -118 |
| Iron Smelting and Steel Manufacturing | | 674 | 857 | 164 | 15 | 1710 | -65 |

**Source:** Economic and Analytical Services, Department of Industry, Innovation and Science; ABS, Catalogue No. 81650 Counts of Australian Businesses, including Entries and Exits, Jun 2010 to Jun 2014

Employment in the wider steel industry has been declining since 2006. **Table 12** shows that total steel production employment (i.e. full- and part-time) had been above 40,000 between 2006 and 2011, but has since 2012 remained below 40,000. The fall in employment between 2011 and 2015 was about 26% compared with about 12% for manufacturing over the decade. Steel production employment as a share of total manufacturing employment has also decreased to a lower level since 2012.

**Table 12.** Changes in the Employment for the steel industry, manufacturing and all industries between 2006 and 2015 (total employment)

| Employment, levels and share | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 |
|---|---|---|---|---|---|---|---|---|---|---|
| Steel Production ('000) | 45.5 | 42.3 | 48.8 | 40.9 | 43.1 | 45.4 | 36.2 | 35.7 | 39.7 | 33.8 |
| Manufacturing ('000) | 1,009.5 | 1,027.7 | 1,044.8 | 998.2 | 978.7 | 947.3 | 947.8 | 920.1 | 921.7 | 888.6 |
| All industries ('000) | 10,088 | 10,408 | 10,695 | 10,775 | 10,991 | 11,178 | 11,315 | 11,425 | 11,536 | 11,770 |
| Steel as a percentage of manufacturing (%) | 4.5 | 4.1 | 4.7 | 4.1 | 4.4 | 4.8 | 3.8 | 3.9 | 4.3 | 3.8 |

**Source:** Economic and Analytical Services, Department of Industry, Innovation and Science; ABS, Labour Force, Australia, Detailed, Quarterly, Nov 2015, cat.no. 6291.0.55.003

Employment counts for steel production in New South Wales (NSW) and in South Australia (SA) stayed at or above the 2006 levels from 2007 to 2010 in NSW and up to 2012 in SA (**Table 13**). However, employment in the sector in 2015 recorded their lowest levels for both states.

**Table 13.** Steel employment in New South Wales and South Australia

| Employment, by state | 2006 ('000) | 2007 ('000) | 2008 ('000) | 2009 ('000) | 2010 ('000) | 2011 ('000) | 2012 ('000) | 2013 ('000) | 2014 ('000) | 2015 ('000) |
|---|---|---|---|---|---|---|---|---|---|---|
| New South Wales | 16.9 | 17.0 | 19.4 | 17.4 | 16.8 | 15.7 | 13.6 | 14.5 | 15.0 | 12.5 |
| South Australia | 3.5 | 4.8 | 3.5 | 3.3 | 4.0 | 4.8 | 3.9 | 2.5 | 3.3 | 1.9 |

**Source:** Economic and Analytical Services, Department of Industry, Innovation and Science; ABS, Labour Force, Australia, Detailed, Quarterly, Nov 2015, cat.no. 6291.0.55.003

A note of caution when interpreting the data is that for large and complex businesses, the industry employment counts reflect only that of the business divisions classified to the particular ANZSIC industry class and not the entire corporate group, which will have business divisions classified to other ANZSIC industry classes. Therefore, the changing shares at the divisional level do not necessarily reflect the performance of the corporate group.

Employees in the three steel industry classes tend to have a lower level of Bachelor or Post graduate qualifications than manufacturing and all industries in aggregate but a higher level of VET qualified employees (**Table 14**).

**Table 14.** Qualifications of employees in the steel related industries

| Qualifications | Steel (%) | Manufacturing (%) | All industries (%) |
|---|---|---|---|
| No post-school qualifications | 41.2 | 45.4 | 39.0 |
| VET | 47.4 | 40.2 | 34.0 |
| Bachelors | 8.6 | 10.8 | 19.2 |
| Post-graduate | 2.9 | 3.5 | 7.8 |

**Source:** Economic and Analytical Services, Department of Industry, Innovation and Science; ABS, 2011 Census of Population and Housing (TableBuilder)

The wage and salaries of employees in the primary steel class is on average lower than those of the wider manufacturing sector and all industries in aggregate (**Table 15**). It should be noted that wages and salaries are a partial measure of the total cost of employment. The National Accounts *Compensation of Employees* measure is a more accurate measure of employment costs because it includes all other legislated entitlements, bonuses, training and other employee benefits, but data at the industry class level is not publicly available.

**Table 15.** Wages and salaries per employee

| Financial Year | Wages and salaries per Employee (AU$) | | | |
|---|---|---|---|---|
| | Steel | Primary Metal and Metal Product Manufacturing | Manufacturing | All Industries* |
| 2006-2007 | 46,892 | 53,336 | 48,686 | 45,564 |
| 2007-2008 | 43,263 | 58,777 | 49,432 | 48,226 |
| 2008-2009 | 49,725 | 55,806 | 52,495 | 49,246 |
| 2009-2010 | 45,946 | 55,328 | 53,200 | 50,761 |
| 2010-2011 | 44,361 | 51,327 | 56,458 | 53,870 |
| 2011-2012 | 61,253 | 56,678 | 59,184 | 57,132 |
| 2012-2013 | 57,327 | 60,889 | 60,306 | 58,357 |
| 2013-2014 | 52,612 | 62,410 | 60,083 | 59,848 |

**Source:** Economic and Analytical Services, Department of Industry, Innovation and Science; ABS, Australian Industry, 2013-14, Catalogue No. 8155.0 table 3; ABS, Labour Force, Australia, Detailed, Quarterly, Nov 2015, Catalogue No. 6291.0.55.003; *ABS, Australian System of National Accounts, 2014-15, Catalogue No. 5204.0, table 48 (includes all industry divisions)

The primary *Metal and Metal Product Manufacturing* subdivision has a higher R&D intensity (expressed as a percentage of Gross Value Added), notwithstanding a fall in 2013-14 (**Table 16**). It is likely due to the increasingly technology intensive production of transformed steel products, as well as the continued improvements in production technology.

**Table 16.** Business R&D intensity (R&D expenditure as a share of value-added), 2008-09 to 2013-14

| | 2008-09 (%) | 2009-10 (%) | 2010-11 (%) | 2011-12 (%) | 2013-14 (%) |
|---|---|---|---|---|---|
| Primary Metal and Metal Product Manufacturing | 7.4 | 6.8 | 6.5 | 7.0 | 5.9 |
| Manufacturing | 4.2 | 4.0 | 4.5 | 4.2 | 4.8 |
| All Industries | 1.5 | 1.4 | 1.5 | 1.4 | 1.4 |

**Source:** Economic and Analytical Services, Department of Industry, Innovation and Science, Department's calculations; Australian Bureau of Statistics (ABS) (2015) Catalogue No. 8104.0, Research and Experimental Development, Businesses, Australia, 2013-14; ABS (2015) Catalogue No. 5204.0; Australian System of National Accounts, 2014-15, Table 5; ABS (2015) Catalogue No. 8155.0, Australian Industry, 2013-14

# INDUSTRY LINKAGES

## Supply of Intermediate Inputs to Iron and Steel Manufacturing

The relative shares of key input flows by supplying industry to iron and steel manufacturing at basic prices (i.e. the value after subtracting taxes and adding subsidies) are summarised in **Table 17**. The magnitudes are indicative of the relative contributions to the cumulative production costs of crude steel production.

**Table 17.** Top suppliers of intermediate inputs to Iron and Steel Manufacturing by value share of total inputs

| Australian Industry Inputs into Steel (2012-13) | | | |
|---|---|---|---|
| **Input-Output Industry Groups** | | **Value ($Million)** | **Input Share (%)** |
| 0801 | Iron Ore Mining | 6,741 | 66 |
| 0601 | Coal mining | 650 | 6 |
| 2101 | Iron and Steel Manufacturing | 606 | 6 |
| 0802 | Non Ferrous Metal Ore Mining | 557 | 5 |
| 4701 | Rail Transport | 320 | 3 |
| 4601 | Road Transport | 243 | 2 |
| 5201 | Transport Support services and storage | 155 | 2 |
| 3301 | Wholesale Trade | 138 | 1 |
| 2605 | Electricity Transmission, Distribution, On Selling and Electricity Market Operation | 97 | 1 |
| 2202 | Structural Metal Product Manufacturing | 97 | 1 |
| 2601 | Electricity Generation | 94 | 1 |

**Source:** Economic and Analytical Services, Department of Industry, Innovation and Science, Department's calculations; ABS National Accounts Input-Output Tables 2012-13. Catalogue No: 5209.0.55.003

The National Accounts Input-Output tables also provide valuable information about how a nation's industrial outputs are used for production and consumption. **Table 18** indicates that of the total supply from Australian Iron Ore Mining in 2012-13, about 81% by value was exported, leaving 19%[18] for distribution between domestic industry (intermediate) uses and final uses (*final consumption, gross fixed capital formation, changes in inventory* and *exports*).

Iron and steel manufacturing and private sector production of non-current, fixed assets (Private Gross Fixed Capital Formation) were the major domestic uses of iron ore mining supplies, together accounting for around 77% of the residual domestic use[19]. Iron and Steel Manufacturing alone accounted for the majority of the total *industry intermediate use* of iron ore mining output in 2012-13 of about 78%, highlighting the importance of the local iron and steel manufacturing industry to the domestic use for iron ore (**Table 18**).

**Table 18.** Use of *Iron Ore Mining* Outputs in 2012-13 (Industry by Industry Flow at Basic Prices)[i]

| | **Total Supply ($million)** | **Exports ($million)** | **Industry Uses (ii) ($million)** | **Other Domestic Uses (ii) ($million)** | **Steel Industry Use** | | **Private Gross Fixed Capital Formation ($million)** |
|---|---|---|---|---|---|---|---|
| | | | | | **Value ($million)** | **Share of Industry Uses (%)** | |
| *Iron Ore Mining* | 63,958 | 51,719 | 8,672 | 3,567 | 6,741 | 77.7 (iii) | 2,659 |

**Notes:** *(i)* Basic prices are defined as: *Output price minus Taxes plus Subsidies*.
*(ii) Industry Uses* represent intermediate uses for production; *Other Domestic Uses*: *63,958 - 51,719 = 12,239 - 8,672 = 3,567.*
*(iii) (6,741/8,672) x 100 = 77.7% - see columns 3 and 5.*
**Source:** National Accounts Input-Output Tables Catalogue No. 5209.0.55.001 – Table 5 Industry by Industry Flow Table (Direct Allocation of Imports); and Department calculations

[18] (Table 17) exports share of total supply: *51,719/63,958 X 100 = 80.9%;* domestic use: *(63,958-51,719)/63,958 x 100 = 19.1%;*
[19] (Table 17) Iron & Steel Mfg. and Gross Fixed Capital Formation shares: *(6,741+2,659)/(63,958 – 51,719) x 100 = 76.8%;*

### Demand for Steel Outputs

The demand for domestic steel outputs is still substantial. The major users of steel industry outputs as intermediate inputs are in the construction and metal product manufacturing industries and for private sector investment in fixed assets (Private Gross Fixed Capital Formation)[20] (**Table 19**). The top 3 listed account for about 53% of total output by value, with the remaining sectors accounting for a further 30%.

**Table 19.** Examples of major uses of Australian steel industry output

| Use of outputs from Australian Iron and Steel Manufacturing (2012-13) | | | |
|---|---|---|---|
| **Iron and Steel Manufacturing – Total Supply: $13,045 m.** | | **Value ($Million)** | **Use as a Share of Total Supply (%)** |
| Intermediate Use | Construction Services | 3,383 | 25.9 |
| | Structural Metal Product Manufacturing | 2,262 | 17.3 |
| | Heavy and Civil Engineering Construction | 1,066 | 8.2 |
| | Residential Building Construction | 790 | 6.1 |
| | Iron and Steel Manufacturing | 606 | 4.6 |
| | Specialised and Other Machinery and Equipment Manufacturing | 599 | 4.6 |
| | Other Fabricated Metal Product Manufacturing | 507 | 3.9 |
| | Motor Vehicles and Parts; Other Transport Equipment Manufacturing | 460 | 3.5 |
| | Metal Containers and Other Sheet Metal Product Manufacturing | 318 | 2.4 |
| | Coal Mining | 263 | 2.0 |
| | Non-Residential Building Construction | 238 | 1.8 |
| | Non Ferrous Metal Ore Mining | 170 | 1.3 |
| | All Other Manufacturing (balance of Manufacturing Classes not listed) | 1,123.6 | 8.9 |
| Final Use | Private Gross Fixed Capital Formation | 162.1 | 1.2 |

**Note:** This is not an exhaustive list but serves to highlight some of the key uses.
**Source:** Economic and Analytical Services, Department of Industry, Innovation and Science, Department's calculations; ABS National Accounts Input-Output Tables 2012-13. Catalogue No: 5209.0.55.003.

## Collaboration and Specialised Steel Products

The local development of specialised high strength steel products is a product of collaboration between iron and steel manufacturing and downstream steel product manufacturers. The Unanderra firm Bisalloy Steels Pty Ltd[21] collaborated with BHP Steel (now BlueScope Steel) at Port Kembla and Defence Science and Technology Organisation (DSTO) to produce high strength steel hull plates to a US MIL specification for the construction of 2 guided missile frigates.

The collaboration with BlueScope Steel has also led to the development of a family of Bisplate® steel products for the fabrication of various military products including steel plates for submarines and quenched and tempered high hardness steel armour plates using customised BlueScope steel for the Bushmaster Protected Mobility Vehicle. While the quantities demanded of these specialist products are not large, the production of these products is technology and research and development (R&D) intensive.

Examples of the variety of high strength and hardness steel products that are produced[22] include structural grades (e.g. for high-rise construction, dump truck bodies, storage bins etc.), wear grades (e.g. for earthmoving buckets, cement rotating mixer, compactors etc.), armour/defence grades, and other specialised grades (e.g. for tanker vessels, refinery and petrochemical equipment etc).

[20] Gross fixed capital formation refers to expenditures on new fixed assets plus net expenditure on second-hand fixed assets, including both additions and or replacements net of disposals. Fixed assets are produced assets that are used repeatedly, or continuously, in processes of production for more than one year and consist of dwellings, non-dwelling construction, machinery and equipment, weapons systems, cultivated biological resources, ownership transfer costs and intellectual property products including R&D. (**Source:** ABS, 2015, Australian System of National Accounts 2014-15 – Glossary). Private means the private sector.
[21] http://investor.bisalloy.com.au/application/assets/uploads/announcement/Bisalloy_TKMSA_Media_Release_November_20151.pdf
[22] www.bisalloy.com.au/products

# EMERGING PRESSURES

## Excess Capacity

Due to new investment projects in several countries[23], the total worldwide steelmaking capacity is projected to reach 2,361 Mt (million metric tonnes) by 2017, up from 2,160 Mt in 2013, by which time the non-OECD economies' share of world capacity is expected to increase to 71.4%. As a result, the global steel sector is expected to continue to experience significant levels of excess capacity in the future.

The outlook for the global steel sector remains weak with global steel demand stagnating. The sharp slowdown in steel demand growth partly reflects structural shifts occurring in some major economies, and falling commodity prices (coal, metals and oil) which are expected to depress steel-intensive infrastructure construction activity.

Ministers at the OECD Ministerial Council Meeting in May 2014 and the OECD Steel Committee[24] considered the persistently high levels of excess capacity to be one of the main challenges facing the global steel sector which is consequently suffering from low profitability (see also below under *Industry Profits*).

## Potential Sources of Demand shocks

One feature of the demand for primary steel output is that in Australia, consistent with the patterns observed for aggregate global steel demand (**Figure 2**), civil construction activity including for mining and gas/oil exploration and extraction account for approximately half of total steel use. Therefore, price shocks for the outputs of key users of steel will affect the demand for steel.

The three largest Australian sectoral users of iron and steel manufacturing output, *Construction Services*, *Structural Metal Product Manufacturing*, and *Heavy & Civil Engineering Construction* industries are interlinked through the significant use of their outputs for private sector investment in fixed assets – *final demand* (**Table 20**). This makes the demand sensitive to private sector profits and investments. The recent large falls in crude oil and iron ore prices, for example, may flow on to steel demand through falling investment in mining and extraction infrastructure.

**Table 20.** Characteristics of the top three industry users of Australian iron and steel manufacturing outputs as indicators of the potential sources of economic shocks

| Supplying industry | Major user | Value ($Million) | Use as a Share of total supply (%) |
|---|---|---|---|
| Construction Services (Total Supply: $182,650 m) | Private Gross Fixed Capital Formation | 47,302 | 26 |
| | Heavy and Civil Engineering Construction | 18,576 | 10 |
| | Residential Building Construction | 17,817 | 10 |
| | Non-Residential Building Construction | 11,192 | 6 |
| | General Government | 7,049 | 4 |
| | Iron Ore (54%) and Non-Ferrous Metal Ore (46%) Mining | 4,168 | 2 |
| Structural Metal Product Manufacturing (Total Supply: $15,700m) | Construction Services | 2,537 | 16 |
| | Heavy and Civil Engineering Construction | 2,398 | 15 |
| | Residential Building Construction | 2,160 | 14 |
| | Coal (49.7%) and Non-Ferrous Metal Ore (50.3%) Mining | 1,285 | 8 |
| | Private Gross Fixed Capital Formation | 1,122 | 7 |
| Heavy and Civil Engineering Construction (Total Supply: $104,050m) | Private Gross Fixed Capital Formation | 64,703 | 62 |

**Source:** ABS National Accounts Input-Output Tables 2012-13. Catalogue No: 5209.0.55.003; Department calculations

[23] www.oecd.org/sti/ind/steelcapacity.htm
[24] OECD (2015) Excess Capacity in the Global Steel Industry and the implications of New Investment Projects. *OECD Science, Technology and Industry Policy Papers*, No. 18, OECD Publishing, Paris.

## Industry Profits

**Table 21** shows that in global terms, 286 out of the 670 plants (43%) with valid data entries recorded positive (i.e. > 0%) profit margins on revenue or excess of breakeven. These plants accounted for 53% and 55% of global steel output shipped and total global sales revenue, respectively.

The weighted average profit margin across all 670 plants was 0.36% (roughly break-even). Despite the largest reported profit margin being at 44%, the weighted average profit margins for firms with positive margins was only 8%.

**Table 21.** Weighted average world plant profit margins (n = 670)

| No. of plants recording strictly positive profit margins | Total product shipped – all plants (000 tonnes) | Total product shipped by profitable plants (000 tonnes) | Cumulative sales revenue – all plants (US$000) | Cumulative sales revenue by profitable plants (US$000) | Weighted global profit margin (%) | Minimum recorded profit margin (%) | Maximum recorded profit margin (%) |
|---|---|---|---|---|---|---|---|
| 286/670 | 1,202,500 | 640,062 | 546,024,404 | 299,654,873 | 0.36 | -148 | +44 |

**Note:** The profit margin here is calculated as: (US$ Profit – Earnings before Tax /US$ Sales Revenue) x 100%.
**Source:** MCI Steel Consultants and Department calculations

The returns to capital or *Gross Operating Surplus and Mixed Income* are a better indicator of payments or returns to capital. **Table 22** indicates the significant fall in the returns to capital (i.e. income accruing to capital inputs) for the *Iron and Steel Manufacturing* sector. Although the level of the returns to labour or *Compensation of Employees* fell in nominal terms in 2012-13 relative to 2009-10, its share had increased dramatically to 95% of value-added. This suggests that in the short- and possibly medium-run, labour costs are relatively inflexible and payments to labour come at the expense of payments to capital.

This substantial decline in the payments to capital in *Iron and Steel Manufacturing* relative to manufacturing in general is of concern as it affects future capital investment decision and capacity. Other taxes on production have increased in share to a lesser extent. This aggregate industry-level effect appears to reflect effects observed at the plant level discussed earlier. Explanatory Notes B(III) outlines the economic reasoning indicating the importance of returns to capital, usually captured in accounting profits.

**Table 22.** Distribution of output (value-added) between the primary factors of production – labour and capital

| | | 2006-07 (%) | 2007-08 (%) | 2008-09 (%) | 2009-10 (%) | 2012-13 (%) |
|---|---|---|---|---|---|---|
| 1. Returns to Labour (Compensation of Employees) | Iron and Steel Manufacturing | 53.4 | 54.2 | 57.0 | 57.7 | 95.2 |
| | All Manufacturing | 55.4 | 54.6 | 55.5 | 55.0 | 61.7 |
| 2. Returns to Capital (Gross Operating Surplus and Mixed Income) | Iron and Steel Manufacturing | 43.6 | 42.5 | 41.0 | 40.3 | 1.1 |
| | All Manufacturing | 41.4 | 42.1 | 42.2 | 42.9 | 36.6 |
| 3. Other Taxes Less Subsidies on Production | Iron and Steel Manufacturing | 3.0 | 3.2 | 2.0 | 2.0 | 3.8 |
| | All Manufacturing | 3.2 | 3.3 | 2.2 | 2.2 | 1.6 |

**Notes:**
(i) Value-added is the total value of output minus the value of the intermediate inputs i.e. it is the value of the work done on intermediate inputs by the firms' primary factors of production, namely, labour and capital. In macroeconomic accounts, the intermediate input are attributed to the value-added of preceding industries and are, therefore, excluded to avoid double counting upon aggregating. Value-Added is the sum of Items 1-3 and always sums to 100%, by definition.
(ii) 2008-09 was the period when the Global Financial Crisis was at its most acute.
**Source:** ABS National Accounts Input-Output Tables 2012-13. Catalogue No: 5209.0.55.003; Department calculations

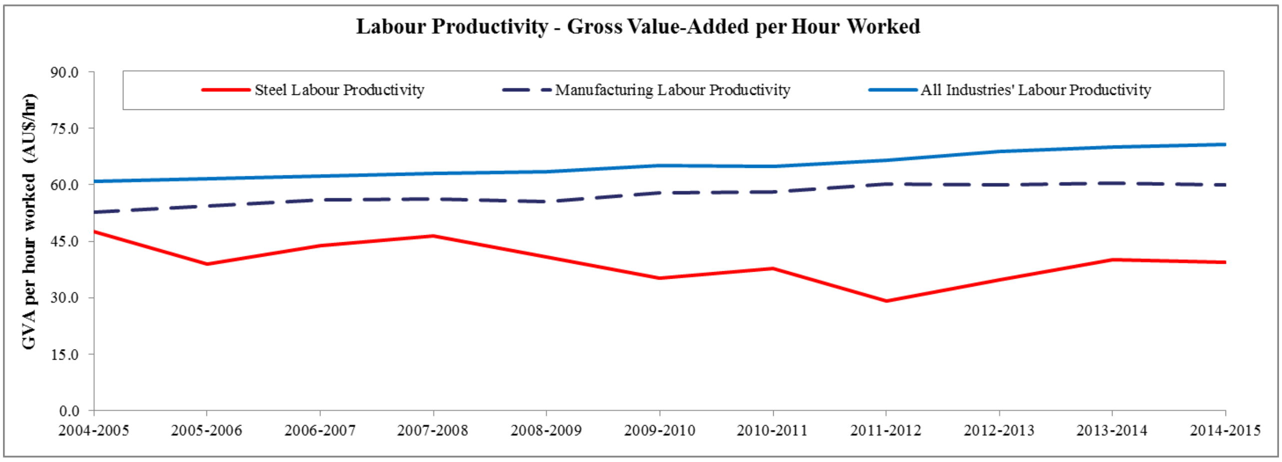
## Productivity

In the Australian context, at the plant level, the relatively high contribution of labour & overhead costs to total production costs would be expected to flow through stage costs and erode any advantage that early stage domestic steel production has in terms of the lower raw material costs relative to other producers in the world.

The importance of some labour and overhead cost flexibility is indicated by comparing of the steel industry's labour productivity (i.e. the value of output for each worker-hour worked on average expressed as gross value-added per hour worked) with manufacturing and the aggregate for all industries (**Figure 10**).

Labour productivity for manufacturing and all industries has been rising modestly on average from 2004-05 to 2014-15 while the output per hour worked for the steel industry had progressively declined since 2005-06. Despite recovering from the low level reached in 2011-12 due to the ongoing effects of the Global Financial Crisis, the labour productivity for steel in 2014-15 is still about 34% and 44% lower than manufacturing and all industries, respectively.

**Figure 10.** Steel manufacturing labour productivity from 2004-05 to 2014-15 (Gross Value-Added per Hour Worked)




**Source:** Economic and Analytical Services, Department of Industry, Innovation and Science, Department's calculations; ABS (2015) Catalogue No. 5204.0; Australian System of National Accounts; ABS (2015) National Accounts Input-Output Tables 2012-13, Catalogue No: 5209.0.55.003; ABS (2015) Labour Force, Australia, Detailed, Quarterly, Nov 2015, Catalogue No. 6291.0.55.003

An improvement in productivity would require a stronger focus on these cumulative stage costs (i.e. their components and drivers for why they are higher in Australia), which appear to be putting pressure on Australian steel producers' competitiveness, taking into consideration scale effects.

Another potential pressure on costs is the falling exchange rate of the Australian dollar relative to the US currency. As indicated in **Table 5**, Australia's raw material costs account for about 31% of total cost per tonne of steel produced. Since the iron ore price is denominated in US dollars, significant changes in the relative exchange rates will add pressure to the cost of production.

## POLICY MEASURES

The Australian Government believes that competition in the market can promote efficiency and foster technological progress. Its primary focus is to enable a business environment for firms to grow and be competitive, as well as to capitalise on incentives provided for innovation.

In that context, firms need to make the necessary decisions and investments to ensure their long term viability. However, there may be existing market or regulatory impediments beyond the firms' control that require action.

The Government has implemented significant policy reforms to strengthen the competitiveness of Australia's steel industry through measures to alleviate the costs of regulatory burden, which include the repeal of the carbon tax, the provision of a 100 per cent exemption from the Renewable Energy Target for emissions intensive, trade exposed industries and major reforms to Australia's anti-dumping regime.

## Deregulation

The Government repealed the carbon-tax related suite of legislation, which received Royal Assent on 17 July 2014 with effect from 1 July 2014. This included discontinuing the *Steel Transformation Plan Act 2011* (STP Act).

The Government is committed to fostering an environment that supports competitive Australian industries. Besides the repeal of the carbon tax, it has introduced regulation reform with the aim of reducing the cost of red tape by $1 billion per year.

In order to protect Australian jobs and help industries remain competitive during the operation of the Carbon Tax, a 100 per cent exemption from the Renewable Energy Target (RET) for emissions intensive, trade exposed industries was established on 23 June 2015. This was extended to the steel industry.

## Anti-Dumping Reforms

Australia's anti-dumping system addresses imported goods that are dumped or subsidised and causing material injury to Australian producers and manufactures.

Dumping occurs when an exporter sells goods to Australia at a price that is below the 'normal value' of the goods. The normal value will usually be the domestic price of the goods in the country of export.

Subsidisation occurs when imported goods benefit from government assistance in the country of export. Certain countervailable subsidies can be also be addressed through the anti-dumping system.

Dumping and countervailable subsidies are not illegal; however the World Trade Organization rules allow Australia to take action against such goods that injure Australian businesses. Such action is in the form of an anti-dumping measure such as a dumping duty or countervailing duty that is applied on the relevant imported goods to prevent any injury that is being caused.

The Government's anti-dumping reforms, which were fully implemented in November 2015, make significant improvements to strengthen Australia's anti-dumping system. The reforms address many of the concerns raised by Australian industry with the Government.

The reforms ensure the system will be more responsive in dealing with unfairly dumped imports and cracking down on entities which seek to undermine the system by exploiting previous loopholes in the legislation.

The Government introduced new anti-circumvention regulations in April 2015 to address situations where dumped goods are slightly modified in order to avoid payment of duties. A number of cases regarding possible circumvention of duties imposed on steel products are currently underway.

The Government will be closely monitoring and evaluating the effect of its reforms and keeping a close watch on developments in international jurisdictions in determining whether further reforms to the anti-dumping system are warranted.

In the meantime, the Government has provided additional funds to the Anti-Dumping Commission to enable it to employ additional investigators and strengthen its market intelligence unit. The Commission is also implementing measures to improve the efficiency of its internal operations.

In 2015, the Commission experienced the highest level of demand for trade remedy relief in the past decade. This has been driven in part by the relatively high Australian dollar and an oversupply in commodities.

In response to this significant increase demand for trade remedies, particularly by Australian steel producers, the Commission has undertaken both a record number of investigations into and applied a record number of measures against steel imports in recent years.

Investigations and resulting measures have primarily involved goods produced in China, and to a lesser extent Korea and Taiwan. The products involved include flat steel products, long steel products, coated steel products, stainless steel products, and fabricated steel products.

As a result of these investigations there are currently 41 anti-dumping measures (in the form of dumping duty, countervailing duty, and provisional measures) in place on 11 steel products from 11 countries (as of 19 February 2016). In this context, a World Trade Organisation count is used in which one ‘measure’ is one type of duty applied to one country although one ‘application’ may cover multiple duties and measures.

Of the measures, again on a World Trade Organisation count, 18 of 41 apply to products produced by the Arrium Group and 16 out of 41 measures apply to products produced by BlueScope.

The Commission’s activities are increasingly focused on identifying and remedying anti-circumvention activities. Activities being undertaken to support the Commission’s work on anti-circumvention of steel trade measures are: investigating likely claims of circumvention by Australian Industry; liaising with domestic steel producers regarding high risk areas for circumvention; and working with the Department of Immigration and Border Protection in relation to monitoring trade flows.

**Anti-Dumping Measures Related to Steel Products[25]**

Since 2012, the Commission has investigated eight requests for trade remedies from BlueScope.[26] Six are completed and two more recent requests are ongoing. The ongoing investigations are anti-circumvention inquiries in relation to zinc coated (galvanised) steel exported from China, Taiwan and Korea.

Product lines produced by BlueScope currently subject to anti-dumping or countervailing measures include hot rolled plate steel, zinc coated galvanised steel, aluminium zinc coated steel, and hot rolled coil steel. Countries covered by these measures include: China, Korea, Taiwan, Japan, Malaysia, and Indonesia.

Since 2011, the Commission has undertaken 12 investigation regarding requests for trade remedy from companies within the Arrium Group. Five are completed and seven are ongoing.[27] Products covered by these investigations include steel reinforcing bar, hollow structural sections, grinding balls, hot rolled structural steel sections and rod in coils.

Product lines produced by Arrium currently subject to anti-dumping or countervailing measures include hollow structural sections, rod in coils, steel reinforcing bar and hot rolled structural steel sections. Countries covered by these measures include China, Korea, Taiwan, Japan, Thailand, Indonesia, Singapore, Spain and Malaysia.

**Economic Analysis of the Steel and Aluminium Markets**

On the 18th February 2016, the Minister for Industry, Innovation and Science, the Hon Christopher Pyne MP requested the Anti-Dumping Commission to undertake an economic analysis of the Asian steel markets. The request was made in response to the Minister’s ongoing concern that distortions in Asian steel and aluminium markets are unfairly damaging the viability and growth of the Australian steel and aluminium sector.

The Minister requested that the analysis:

- identify trends in dumping and circumvention behaviour in steel and aluminium markets;
- improve the efficiency of investigations of potential dumping and circumvention; and
- inform any recommendations on the most effective form of measures where there is evidence of dumping and circumvention activities.

[25] Product coverage is current as at 25 January 2016.
[26] The eight investigations include six investigations into dumping or countervailing and two anti-circumvention inquiries. Resumed investigations and reinvestigations are not included in this total.
[27] The 11 investigations include 10 investigations into dumping or countervailing and one anti-circumvention inquiry. Resumed investigations and reinvestigations are not included in this total.

The Minister has requested that the findings of the analysis be provided to him by Monday 4 April 2016.

## Australian Industry Participation (AIP)

Australian Industry Participation (AIP) policy is underpinned by the AIP National Framework (the Framework), endorsed by Commonwealth, state and territory ministers in 2001. The key objective of AIP policy is that Australian industry should have full, fair and reasonable opportunity to supply goods and services to major projects. This is achieved through the development and implementation of AIP plans. States and territories have developed their own local industry participation policies and place requirements on their procurement and projects they fund, to develop local industry participation plans.

The Framework does not mandate a minimum level of Australian content and Australian suppliers must be competitive in terms of price, schedule and capability to be considered for contract award. Activities under the Framework are consistent with Australia's international obligations, including those under the World Trade Organisation (WTO) and Free Trade Agreements (FTAs).

The *Australian Jobs Act 2013* (the Jobs Act) commenced on 27 December 2013 and requires proponents of major private and public projects ($500 million and above) in Australia to develop and implement an AIP plan that ensures full, fair and reasonable opportunity for Australian entities to supply key goods and services to the project. Prior to the Jobs Act, AIP plans were only required for applications for the Enhanced Project By-law Scheme (EPBS). A regulatory reform was achieved in June 2015 when the former Industry Minister agreed to allow proponents to use their approved Jobs Act AIP plan in their EPBS applications. This eliminated the need for separate plans.

The Jobs Act created the statutory position of the AIP Authority to monitor compliance with the legislation and provide guidance to proponents. Since the Jobs Act commenced the AIP Authority has approved 14 AIP plans for major projects around Australia, mainly in the resources sector. Summaries of each approved AIP plan are published on the department's website (www.industry.gov.au/aip). Each AIP plan includes steps the proponent will take to publicise opportunities to supply goods and services to the project, the design standards used in the project and any supplier pre-qualification requirements. Proponents report at six monthly intervals to the AIP Authority on implementation of their AIP plans.

The Australian Government has requirements in place for its own procurement. Since 2010, companies bidding for major Government procurements of $20 million or more have been required to prepare and implement an AIP plan as part of the tender process. These AIP plans outline the actions a tenderer will take to provide Australian suppliers, especially small and medium enterprises (SMEs), with full, fair and reasonable opportunities to supply goods and services on a project.

On 1 July 2012 the AIP plan requirement was extended to Government grants and Commonwealth funded infrastructure projects of $20 million or more. To avoid duplication, an AIP plan is not required if the state or territory government applies its own industry participation plan to the project. Since 1 July 2013, AIP plans have also been required of selected Clean Energy Finance Corporation investments of $20 million or more.

Since 2013 there has been a reduction in major project activity particularly in the resources sector and an increase in government funded infrastructure projects. Many of these new projects fall below the $500 million threshold but still present opportunities for local industry involvement. Increasingly, communities are looking to such projects to provide economic growth, particularly in regional areas. Proponents in the resources sector have long recognised the need for a social licence to operate from local communities and a large part of this is achieved through the provision of jobs and opportunities to supply goods and services for a project.

The Australian Government supports an open market economy as the best way to generate investment and employment, and is committed to fostering an environment where Australian businesses have equal opportunities to bid for work on major Australian public and private projects and be evaluated on the merits of their offerings, consistent with Australia's international trade obligations.

### Other Policy Measures

The Australian Government has a number of broad industry support initiatives, centred on the Government's National Innovation and Science Agenda, which is a blueprint for a more skilled, innovative and entrepreneurial Australia that will transform our country. Measures include the Industry Growth Centres initiative to foster smart, high value and export focused industries; the Entrepreneurs' Programme for business competitiveness and productivity at the firm level; and the Industry Skills Fund, which provides training places and support services across Australia.

The Government is supporting the deepening of collaboration between Australia's steel industry and the research sector. The Government, through the Australian Research Council, has provided $5 million to the Steel Research Hub, launched on 4 September 2014. The Steel Research Hub, based at the University of Wollongong, brings together the Commonwealth, universities and industry partners to develop cutting-edge processes and product innovations. This will enable steel industry partners to improve their global competitiveness.

The Government is also providing support to employees made redundant from BlueScope's Port Kembla operations and Arrium's Whyalla steelworks. Retrenched workers will have access to intensive employment assistance from the Government's Jobactive Employment Service which connects job seekers with employers to help find employment, as well as offering other support services including training in skills that local employers need and assistance preparing for interviews.

The New South Wales Government recently agreed to defer $60 million in payroll taxes over three years for BlueScope, which, along with concessions from unions and employees, contributed to BlueScope announcing its intention to continue steelmaking at Port Kembla.

The South Australian Government has also provided mining royalty concessions to Arrium, signed a Memorandum of Understanding with Arrium to create a multi-user port at Arrium's wholly-owned Port of Whyalla, along with announcing a $4.3 million Steel Taskforce that will work with Arrium and local fabricators to create a highly competitive and sustainable steel industry in South Australia and implement a third party audit that will monitor the South Australian Government's commitment to use steel which meets Australian standards and certification in all future State Government projects.

## CONCLUDING REMARKS

Australia is a relatively small steel producer compared with other countries but it is still an important supplier of steel products for domestic use, driven mainly by demand for construction, heavy engineering, and manufacturing. A significant final use of output from these steel-using sectors is private sector fixed capital investment. Analysis of the industry-to-industry flows from iron ore mining, through the steel using industries, to final use presents a clearer context for the industry linkages in Australia. It also provides an indication of potential sources of demand pressures.

Australia's steel industry continues to experience challenging trading conditions, particularly since the Global Financial Crisis. Notwithstanding this, Australia's steel industry is continuing to be adaptive and innovative, for example through the collaborations to develop specialised high-strength steel products and the continuous steel casting method direct from the furnace. Australian plants appear to have some advantage in terms of raw materials cost for crude steel production. However, the drivers of labour and overhead costs, and their impacts on cumulative stage costs, are areas that require further investigation.

# EXPLANATORY NOTES

A. Hot rolled products are the products of first transformation of crude steel:

- Flat products include slabs, hot-rolled coil, cold-rolled coil, coated steel products, tinplate and heavy plate. They are used in automotive, heavy machinery, pipes and tubes, construction, packaging and appliances.
- Long products include billets, blooms, rebars, wire rod, sections, rails, sheet piles and drawn wire. The main markets for these products are construction, mechanical engineering, energy and automotive.
- Steel production technology: Input requirement to produce 1,000 kg of crude steel by the Blast Oxygen Furnace and Electric Arc Furnace methods.

| **Raw material Input** | **Steel Production Method** | |
|---|---|---|
| | **Blast Oxygen Furnace** | **Electric Arc Furnace** |
| Iron Ore Input | 1,400 kg | - |
| Coal Input | 800 kg | 16 kg |
| Limestone Input | 300 kg | 64 kg |
| Recycled Steel Input | 120 kg | 800 kg |
| **Crude Steel Produced** | **1,000 kg** | **1,000 kg** |
| Share of world steel production | **70%** | **30%** |

**Source:** World Steel Association (2015) Fact Sheet – Steel and raw materials

B. The approach to addressing the inquiry's reference sustainability is to consider the general factors associated with the assumption of an entity continuing as a going concern (generally meaning that firms/entities are able to repay debts as they fall due).

It is not the objective to look at the performance of any particular firm in the industry, information on industry cost structure, profits and market structure can provide an objective means of addressing the issues related to the question of sustainability.

The economic framework for considering these matters is outlined in parts (II) and (III). The framework also helps to guide the internal consistency and relevance of the submission's contents, analyses and interpretation of findings.

(I) The weighted average cost, using output quantities as weights, is calculated according to the following method:

$\sum_{i=1}^{n} \frac{v_i}{V_T} \times p_i; Total\ output \equiv V_T = \sum_{i=1}^{n} v_i$; where
$i \in \{1, \cdots, n\}; Plant\ level\ output \equiv v_i; Plant\ level\ price\ or\ cost \equiv p_i$

(II) Total Cost ($C_{(q)}$) = Total Fixed Cost + Total Variable Cost. For some total cost function, $C_{(q)}$, the average cost is defined as[28]: $AC_{(q)} = \frac{C_{(q)}}{q}$ and the marginal cost is defined as: $MC_{(q)} = \frac{dC_{(q)}}{dq} \equiv C'_{(q)}$

The change in the average cost with respect to output is given by[20]:

$AC'_{(q)} \equiv \frac{dAC_{(q)}}{dq} = \frac{C'_{(q)} \cdot q - 1 \cdot C_{(q)}}{q^2} = \frac{1}{q}\left[C'_{(q)} - \frac{C_{(q)}}{q}\right]$; Therefore, $AC'_{(q)} = \frac{1}{q}\left[MC_{(q)} - AC_{(q)}\right]$.

[28] **Sources:** (i) For the description of crude steel types, see World Steel Association; (ii) For the cost and production functions, see for example: Hoy, M., J. Livernois, C. McKenna, R. Reed, T. Stengos (2011) Mathematics for Economics. Third Ed. MIT Press, Massuchussetts.

This implies that whenever $MC_{(q)} < AC_{(q)}$, then $AC'_{(q)} < 0$; and whenever $MC_{(q)} > AC_{(q)}$, then $AC'_{(q)} > 0$.

For a given interval of output quantities, while total and variable costs are functions of output quantities, the fixed cost component of total cost does not vary over the given interval and is distributed over the quantity of output. This means that the contribution of fixed cost per unit of output, or $\frac{(Total\ Fixed\ Cost)}{q}$, falls as $q$ rises – within some specified interval. This is an implication of economies-of-scale on output costs.

(III) Competitive market outcomes is modelled by imposing the assumption that the production function is homogeneous of degree one and concave. This strict assumption excludes economies of scale in the base case. The important conclusion through Euler's Theorem is that in the special case of constant returns to scale the factor payments exhaust total output.

Thus, for a limited case of a competitive firm as a price taker with three inputs (which can be extended to more inputs), we impose the assumptions of a homogeneous, concave production function. By Euler's Theorem[29], we have:

$f(\lambda L, \lambda K, \lambda x) = \lambda^n f(L, K, x)$ . Differentiating both sides with respect to some $\lambda > 0$:

$$\frac{\partial f(\cdot)}{\partial \lambda L} \cdot L + \frac{\partial f(\cdot)}{\partial \lambda K} \cdot K + \frac{\partial f(\cdot)}{\partial \lambda x} \cdot x = n\lambda^{n-1} f(L, K, x)$$

For $\lambda = 1$:

$$\frac{\partial f(\cdot)}{\partial L} \cdot L + \frac{\partial f(\cdot)}{\partial K} \cdot K + \frac{\partial f(\cdot)}{\partial x} \cdot x = nf(L, K, x)$$

In particular, for n=1:

$$\frac{\partial f(\cdot)}{\partial L} \cdot L + \frac{\partial f(\cdot)}{\partial K} \cdot K + \frac{\partial f(\cdot)}{\partial x} \cdot x = f(L, K, x) = y$$

Therefore, for this market structure with no economies-of-scale, the firm pays its factors their marginal product implying that total factor payments will exhaust total output or income. This result applies more generally to a function with n-inputs $f: \mathbb{R}^n_{++} \to \mathbb{R}$.

The constant-returns-to-scale production function in this example satisfies the following properties:
$y = L^\alpha K^\beta x^\gamma; s.t. 0 \leq \alpha, \beta, \gamma \leq 1 \ and \ \alpha + \beta + \gamma = 1$

This outcome indicates the importance of profits at least in terms of the rough equivalent idea of cost of capital. However, for innovations which are costly and uncertain together with information asymmetry, a relaxation of the assumptions to include imperfect competition.

[29] **Source:** Hoy, M., J. Livernois, C. McKenna, R. Reed, T. Stengos (2011) Mathematics for Economics. Third Ed. MIT Press, Massachussetts.