6 Where does the money go?

And who is involved?

Most of us have never directly purchased engineered materials—because we buy them when they have been formed into components and assembled into finished goods. So, when we buy cars or buildings, how much of the money flows back to the material producers, and who else is involved?

"Good morning, I'd like an office block please."

"Certainly Sir—would that be the 4-storey or the 7-storey?"

"Mmmm… I think I'll take the 7-storey, with all the trimmings."

"An excellent choice Sir—so that would be one 7-storey steel-framed office block, with advanced treble glazing, aluminium curtain walls, white flat roof, natural circulation, your name projected by laser on all surrounding buildings, and the three large pot plants at reception?"

"Just the job yes—and I think I'll take a small backup power supply and air conditioning unit on the side."

"No problem at all, and that comes to … about 14 million pounds all round."

"Good Heavens, you chaps certainly know how to add on a margin or two! I thought these office blocks used about 100 kg of steel per square metre of floor space, and with steel around £400/tonne I was thinking more in the line of £400,000?"

"I see sir—well, we do have a couple of abandoned wooden huts we could offer you in that range. Would that be more your sort of thing?"

So what's in an office block? Let's assume that our 7 storey office block has a footprint of about 10,000 square metres. When bidding for the job of constructing an office block, building contractors have various rules of thumb for estimating quantities of materials. 100 kg steel/square metre is a typical rule for the steel framed type of building that we saw in our catalogue in chapter 3. Typically the floor slabs in the building will be poured concrete at a rate of about 1,900 kg per square metre. Add on 4,600 square metres of triple glazed 4 mm thick glass, and 46 tonnes of aluminium for the frames which support the glass and we're nearly there. We don't really know what else will be in the building—the metal for heating, air conditioning and ventilation equipment, furniture, carpets and so on, but based on our catalogue of metal use in construction, let's assume that our rules of thumb have covered 85 % of the material by volume so we'll add a further 15 %.

Now we can make the estimate of material costs for the building shown in Table 6.1. The prices are approximate but typical for 2009 in the UK, and we've reached an estimate that the materials required to build our 7 storey office block cost about £0.9 million? But the price we were offered was £14 million—why?

Table 6.1—**Cost estimates for a 7 storey office block**

	Material Requirement (t)	**Unit Cost (£/t)**	**Material cost (£000's)**	**Material cost as share of building costs (%)**
Steel	1,000	410	410	3
Aluminium	50	1,100	55	<1
Concrete	4,500	32	140	1
Glass	140	2,000	280	2
+15 %	810	-	130	1
Total	**6,200**	-	**880**	**6**

The answer is of course obvious. Most of the difference between £14 million and £0.9 million is the cost of people involved in every stage of the process: block masons, carpenters, electricians, plumbers, plasterers, concrete workers, construction and building inspectors, equipment operators, glazers, painters, roofers, fabricators, steel fixers, construction managers, project managers, surveyors, civil/structural engineers, services engineers, specialist engineers and subcontractors, architects, interior designers, all of whom need to be managed, paid, supported and trained. The construction project probably requires some financing, to allow the contractor to purchase materials before the client pays the final price, so the bankers want their (large) share of the pie, and if there is any surplus it will be paid as profit to be distributed among the owners of the many companies involved.

With so many people involved, costing so much money, negotiations over the building process to create the office block will include a trade-off between material price and labour: if labour is expensive relative to materials, then most decisions will be slanted towards saving labour even if material purchasing increases. So that's why we need to know about the flow of money, to find out how much anyone cares to save material.

In fact, apart from the people being paid for the construction of the office block, several other groups have an interest in it: local planners will be concerned about the effect of the new office on neighbours; protest groups and other NGOs (Non-Governmental Organisations) may be concerned about the influence of the new office on natural species; community groups may be concerned about its social impact.

To understand options for changing the materials supply chain, we must understand the full directory of who's involved and why. Our ambition in this chapter is therefore to generalise from the office-block example and ask two questions: for products which contain steel and aluminium, where does the money involved in final purchase eventually flow? and who is involved in the whole business of delivering products containing the two metals?

Where does the money flow?

We're going to answer this question in two stages. Firstly we'll ask, "who, by their purchasing, causes steel and aluminium to be made?" Then, for these final purchasers who drive use, we can ask "where does the money they spend on goods that include steel and aluminium eventually end up?"

In both cases, we'll develop our answer by using a technique called "Input-Output" analysis, invented in 1936 by Wassily Leontieff, a Nobel Prize winning Russian, born in Munich, who emigrated to the US aged 25 to spend the rest of his career at Harvard University. Leontieff modelled money flow through an economy with a table that shows how the money flowing into one sector is the result of purchasing from another. The columns of this table show the production recipe for each sector in the economy: they show, for example, that a furniture supplier needs to make some purchases from other industries (for things like wood, metal and financial services), buy imports, pay a return on any capital invested, and pay for labour and taxes in order to make furniture. Collectively all of the spending from any one sector (the sum of all the costs in the column, which are called inputs, because the money is spent in order to buy inputs to the sector's activity) should add up to the total sales (or output) of that sector. This is what is shown in the rows of the table: they show purchases that are made by other sectors and also final purchases by households, government, exporters and businesses that are adding to their stock of equipment or other goods in order to produce more of their own outputs in the future. Input-Output tables for whole countries are adjusted so that if you add up either the sum of the row totals (all sales) or the sum of the column totals (all spending) you reach an identical single measure of the country's economic activity, the GDP (Gross Domestic Product). The tables are an interesting way to see the exchanges in the economy but Leontieff's particular innovation was to use these tables repeatedly in order to explore the origin of final demand: if some furniture is bought by equipment makers for their offices, then really that part of demand is driven by the volume of equipment being purchased. So, who causes equipment to be purchased, that in turn causes furniture to be bought? And so on. Eventually, using Wassily Leontief's maths, we can show how each different type of final demand (purchasing by households, government etc.) causes activity in each producing sector, or inversely, for each producing sector, we can find the primary causes of demand.

Input-Output analysis depends on a table of numbers that show the flow of money through a country's sectors. The original purpose of these tables was to reconcile different measures of GDP, so many countries produce them as part of their National Accounts. They can be published in various forms from raw data to 'balanced' Input-Output tables adjusted so that supply is equal to demand for each product and input equals output in each sector. Both the raw data collection and the balancing process are time consuming which limits the frequency of publication and level of detail in each country's reports[1].

Recent developments in Input-Output analysis have allowed exploration of environmental effects: if we attribute some environmental damage to a particular sector, and then assume that responsibility for that damage 'flows' with the money that flows into the sector through purchasing, then we can eventually find out which types of final consumption spending drive the damage. This is the approach taken by John Barrett, whom we mentioned in chapter 4, to understand the UK's responsibility for CO_2 emissions related to consumption.

For our needs in this chapter, we've used a global input-output table with 57 sectors[2]. The importance of using global data is that, as we already know from John Barrett's work, if we looked just at the UK we would find that a lot of steel is imported and we would be unable to trace the money flow once it leaves our borders. But with the global table we can trace all money from spending back to its source.

We're now armed to address our two questions: where does the money flow and who is involved? The answers are presented in five diagrams: the first two show which sectors purchase aluminium and steel; for the three largest sectors identified

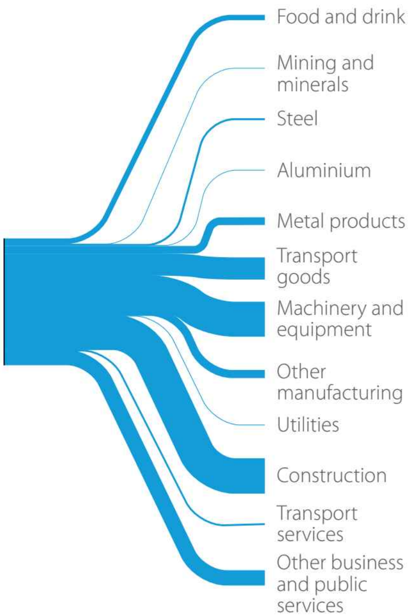

Figure 6.1—**Which sectors purchase steel?**

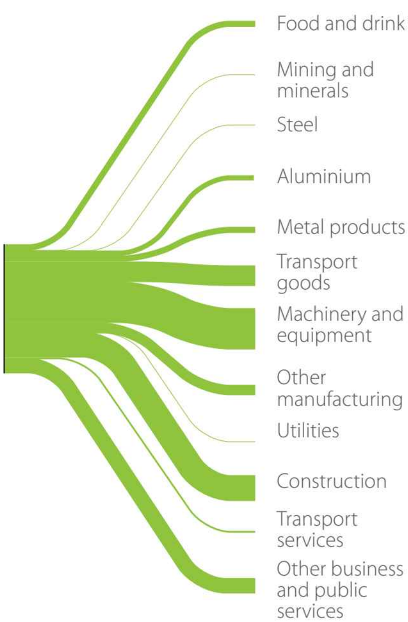

Figure 6.2—**Which sectors purchase aluminium?**

in the first diagrams, the other three diagrams show the final destinations of all their purchasing.

The first pair of diagrams show us a story related to our earlier Sankey diagrams of metal flow: the main sectors of final demand for steel are construction, vehicles, equipment and consumer goods. However, the weighting of the different sectors is not the same in money units as it was in material units. This is because of the variety in processing required when completing different types of finished goods and because of different profit margins that can be charged on more bespoke products.

The other three diagrams show us how the money spent on final goods containing steel and aluminium flows back to other sectors. In all three cases, most spending is within the sector, which seems surprising but is a consequence of describing the entire economy with just 57 sectors. For example, in building the 7-storey office block that our hopeful client wanted at the opening of the chapter, his money might flow first to an agent, then to a design consultant, then to an architect, then a contractor and so on—but all of the businesses mentioned so far would be in the same one of our 57 sectors.

The key message of the diagrams is that for most goods containing these two metals, the value of the metal is of the order of 4% to 6% of the final purchase price. In the example with which we started the chapter, the total cost of all materials was about 6% of the final purchase price, so a similar ratio. These diagrams show us where all the rest of the money has gone.

We've learnt something very important from this analysis: the ultimate costs of our two metals are small compared to the final prices of almost all final goods containing them. As a result, decisions about metal use may often have less priority than decisions about other costs, particularly labour. In turn, this suggests that we may well be purchasing more metal than we physically need to provide a given service, if doing so allows us to avoid other costs.

Who is involved in delivering products containing steel and aluminium?

Let's go back to our new office building. We've already started a list of all the different people we need to pay to understand why the price for the office block is

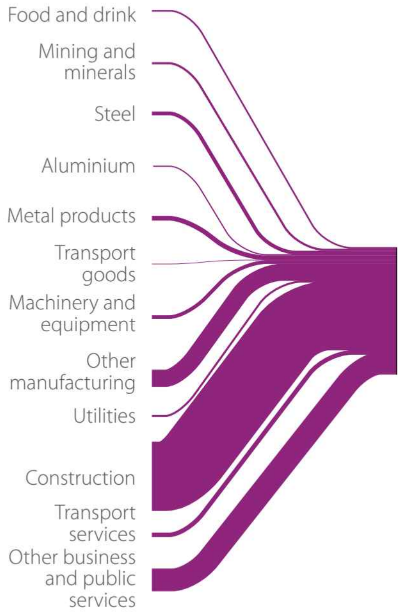

Figure 6.3—**Where does spending by the construction sector end up**

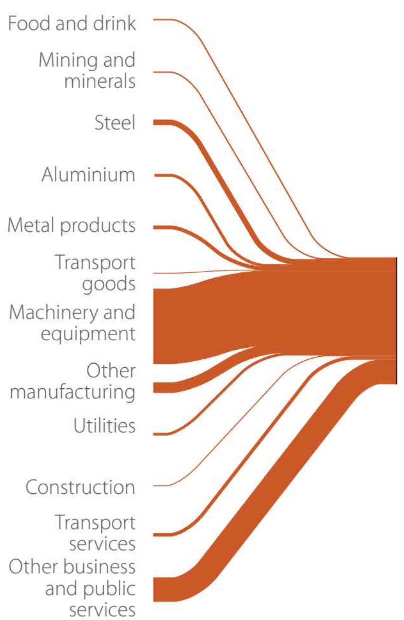

Figure 6.4—**Where does spending by the machinery and equipment sector end up**

so much higher than the cost of materials within it. Who do they all work for? Our opening conversation was between a client and an agent of some type. To build his building he'd certainly need a contracting firm (who do the actual construction), an architect, an engineering consultancy and, in many cases, a property company who might own the land on which the building is to be erected, or who might own and build the building, with the client as the first tenant. The engineering consultants must comply with building regulations, construction standards and certification, insurance industry needs and planning regulations. The contractor will mainly pour and assemble materials on the construction site, but use a fabricator to make any non-standard steel shapes, including the reinforcement bar cages used in foundations, and the steel sections of a steel framed building. In turn the fabricator buys steel either from the steel mill directly, or more likely through a stockist or importer. The stockist purchases steel from the steel mill, which often has the same ownership as the rest of the production chain back to ore or scrap. The ore is bought from a mining company, possibly via a commodities market, and the scrap from a scrap metal merchant. Those are the direct players, but all the processes need an energy supply, there are plenty of specialised component or equipment suppliers involved too, along with the consultants, trade associations and other organisations that provide information. This whole network of companies is regulated, for the health and safety of its employees, and for environmental and safety concerns, and to ensure product quality, and is likely to be influenced by various levels of governmental support. NGOs, lobby groups, and charities may have local concerns about different aspects of the production process, whether about the noise of construction in a city, or the environmental impact of emissions, or the conditions of employment of the labourers.

We've illustrated this vast range of business types on the picture that follows (overleaf). As we explore how the services provided by steel and aluminium might evolve in future, we need to remain aware of this picture, to remember which groups would support or oppose possible changes.

We can estimate the total number of people employed in the world of steel and aluminium from the online data set at the website of the International Labour Organisation. This gives a detailed breakdown of employment by sector from countries which represent about one third of the world's workforce. We have to assume that these countries are representative of the whole, although given that China and India do not have detailed figures, our scaling won't be precise. However, the numbers suggest that around 120 million people worldwide are employed in transforming ores and scrap into manufactured metal goods. In addition around 250 million people worldwide are involved in construction, much

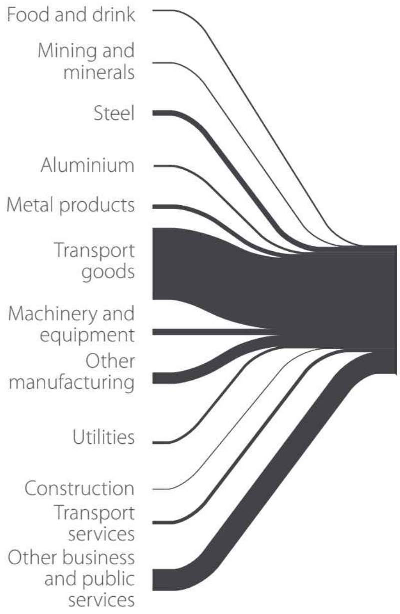

Figure 6.5—**Where does spending by the transport goods sector end up**

of which involves steel, whether for reinforcing bars in concrete, or as sections. That makes a direct target audience of 370 million people who should be buying our book, and if they each enjoy it as much as we think they will, and then buy two more copies to give to family members as a gift…

The development of today's steel industry

The history of steel begins in 1856 with Bessemer's invention which was rapidly adopted by the former iron industry and soon there were over 200 steelmakers in England and Wales[3]. Andrew Carnegie, one of the earliest supporters of steel, took the process with him to Pittsburgh to found the Carnegie Steel Company. Unlike the UK where many small companies were active, US steelmaking was rapidly dominated by few larger companies. The biggest of them began when a group headed by Elbert H. Gary and JP Morgan bought Carnegie's steel company in 1901 to form the largest steel enterprise launched to that date, making two-thirds of US steel production[4]. Soon, companies in the US and elsewhere in Europe had overtaken UK productivity and national differences led to a period of protectionism[5]. Successive rounds of tariff reductions and the formation of free trade areas in Europe and North America later reduced barriers so that world trade in steel doubled between 1975 and 1995. In turn, this allowed individual producers to specialise in production of particular products at high volumes[6]. Global steel production grew 5% each year as Europe recovered from the Second World War until the global energy crisis of 1974[7]. This crisis depressed industrial activity and coupled with the saturation of steel demand per person in developed nations that we discussed in chapter 4, the industry stopped growing in the 1980's and early 1990's. However, the extraordinarily rapid growth of China starting in the 1990's followed by the other BRIC countries (Brazil, Russia and India) led to growth in global production of steel by 7% each year between 2000 and 2005. This growth, which has driven the great expansion of the steel industry in these countries, caused a rapid shift in relative output: the fraction of the world's steel production made in the BRIC countries has grown from 28% in 1999 to 58% in 2010[8].

Steel is a strategic industry, so state aid supported ailing steel works allowing differences in costs between similar countries to develop. For example, the cost per tonne of cold rolled coil was a third higher in Germany than that in Britain for much of the 1990's[9]. The collapse of the Soviet Union and a wave of privatization elsewhere in Europe led to a reduction in state ownership of steel works from 53% in 1986 to 12% in 1995[10]. Regional price differences however continue as shown

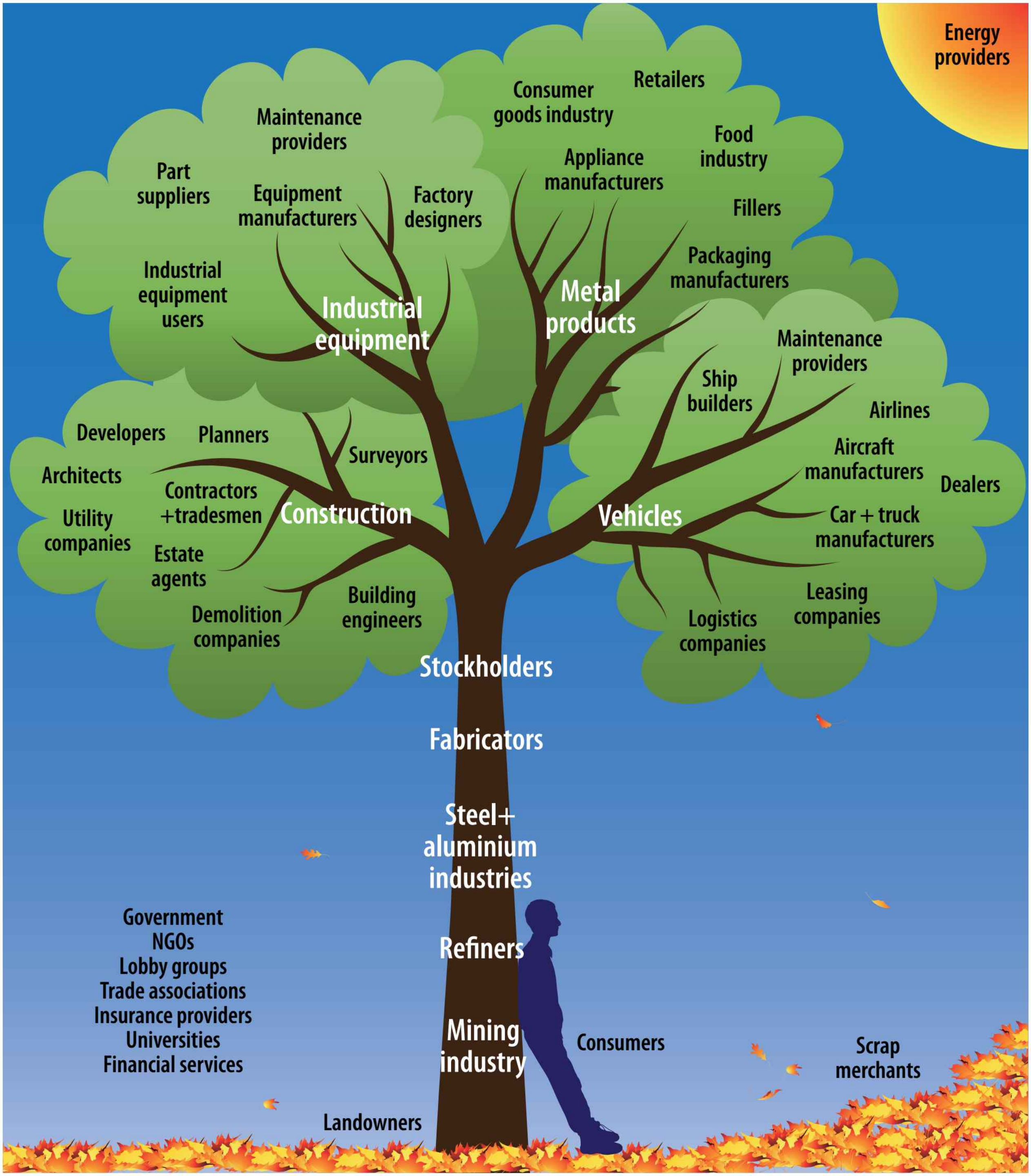

Figure 6.6—**An arboreal depiction of the steel industry**

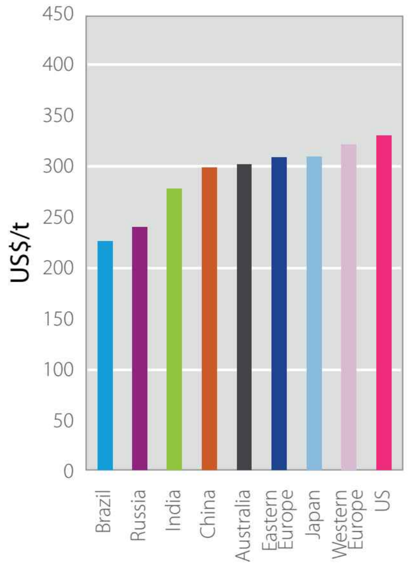

Figure 6.7—**Comparison of international steel slab costs**

in Figure 6.7, with BRIC economies using cheap raw materials and labour and benefiting from their recent expansion through having some of the newest, and most efficient, technologies.

Steelmaking remained mainly a nation-based industry until the mid-1990's when a succession of mergers and acquisitions led first to regional consolidation (the creation of Corus in 1999 and Arcelor in 2001 in Europe and the formation of JFE in Japan in 2002) and then global consolidation (the creation of ArcelorMittal in 2006 and the take over of Corus by Tata Steel)[11]. Greater consolidation allowed steel companies to expand their activity downstream, for instance with Tata also now owning the car maker Jaguar Land Rover, and to increase their bargaining power for inputs.

Despite recent trends towards globalisation and consolidation the industry is still surprisingly fragmented: the top 10 global companies produce less than a quarter of all steel, and the largest producer, ArcelorMittal, makes only 6% of production[12]. Having many smaller steel-makers, rather than just a few dominant ones, increases competition for inputs, mainly for iron ore and coke, so gaining reliable access to raw materials is a key concern in the industry at present.

Table 6.2—**Industry leaders**

	Company*	Market Cap ($bn)	Company†	Output (Mt)	Company†	Output (Mt)
	Mining		Steel		Aluminium	
1	BHP Billiton	210	ArcelorMittal	78	UC Rusal	4.1
2	Vale	170	Baosteel	31	Rio Tinto Alcan	3.8
3	Rio Tinto	140	POSCO	31	Alcoa	3.4
4	Shenhua	84	Nippon Steel	27	Chalco	3.0
5	Anglo American	61	JFE	26	Hydro	1.3
6	Suncor	58	Jiansu Shagang	21	BHP Billiton	1.2
7	Xstrata	57	Tata Steel	21	Dubal	1.2
8	Barrick	41	Ansteel	20	China Power Inv. Corp.	1.0
9	Freeport-McMoRan	38	Severstal	17	Xinfa Group	0.9
10	NMDC	37	Evraz	15	Aluminium Bahrain	0.9

* Listed in descending order of Market Capitalisation, † Listed in descending order of total output (Mt)

Table 6.2 shows that the mining industry is more heavily consolidated than steelmaking: three large companies, BHP Billiton, Vale and Rio Tinto, have a quarter of all the sales of the world's top 100 mining companies. These "super groups" purchase a wide range of resources and sell two thirds of the global seaborne iron ore market[13]. Both iron ore and bauxite are abundant in the earth's crust. The main iron ore deposits are in Brazil, Australia and Russia. There are also high volume but lower quality deposits in China and the Ukraine. Australia and Brazil also have major deposits of bauxite, as do Guinea, Vietnam and India. In 2009, China imported almost two-thirds of the world's total iron ore exports and produced about 60% of the world's pig iron.

The structure of today's aluminium industry

The development of the aluminium industry sector has been driven by the need for access to high quality bauxite and cheap electricity. As a result, a recent trend has been for the major aluminium companies to purchase mining, electricity generation and alumina producing businesses. Ten years ago, the American aluminium company Alcoa had the largest share of bauxite mining. Today it ranks just 26th, with mining companies dominating bauxite extraction and taking a sizeable stake of aluminium production: the super group Rio Tinto acquired the aluminium company Alcan in 2007 to form Rio Tinto Alcan (now the second largest producer of aluminium) and BHP Billiton has expanded its aluminium operations to become the sixth largest aluminium producer globally. We saw in chapter 5, the process of refining bauxite to alumina and the process of smelting alumina to aluminium are both energy intensive with energy purchasing being around a third of all costs. As a result, aluminium makers have set up aluminium smelters in countries such as Brazil which have a rich supply of bauxite and cheap electricity. Aluminium production can be matched effectively with the flexibility but high power of hydro-electricity. In effect the electricity becomes embodied in the aluminium, so can be traded and exported without the expense and cost of electricity distribution.

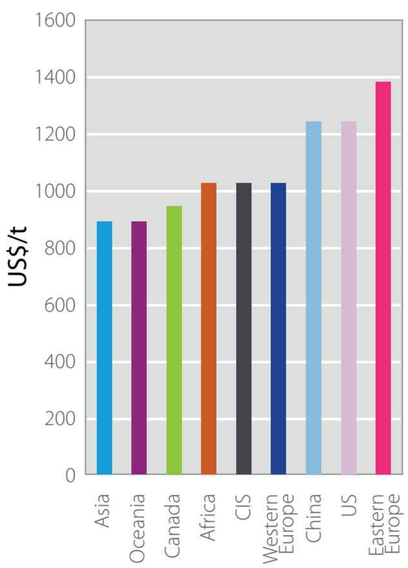

Figure 6.8—**Comparison of international aluminium slab costs**

Even when aluminium companies buy electricity rather than generate their own, they buy so much that they can negotiate low prices with long-term contracts, which may be linked to the primary metal price, and the form of these contracts has a significant influence on total costs. Figure 6.8 compares aluminium production costs by region and shows differences of up to $500/tonne between Asian and Eastern European plants[14].

Most smelting companies have long-term contracts with alumina suppliers that set the price at a fixed proportion (10-15%) of commodity aluminium prices, which helps to reduce the risk of sudden cost variations. High-grade aluminium and aluminium alloy is typically traded on long-term contracts between producers and consumers with prices again set relative to an index supplied by the London Metals Exchange. This practice of relating prices to the underlying metal cost continues further downstream, for example the price of aluminium cans is typically expressed as a mark-up on the metal price. This means that, in the short term at least, the cost of aluminium production and the value of intermediate aluminium products are strongly influenced by the basic metal price so the sector is intensely cost competitive.

The story of regional production shifts for aluminium is similar to that for steel. Aluminium production grew rapidly from the turn of the millennium due to demand from China, with an amazing average yearly growth of 24% from 2000 to 2002[14]. A reduction in production in the US at the same time increased the relative shift of production from west to east. The global aluminium industry is more dominated by big companies than steel, with the top 10 producers making 85% of all output[15].

Global trade in steel and aluminium

Relating our brief history of the two sectors to our earlier picture of the main businesses involved in steel and aluminium, we have seen a significant 'consolidation' (fewer larger companies) in producing primary metals. Nearer to final consumers business is more fragmented with smaller companies serving localised markets. The clear exception to this is the automotive sector in which the top four producers make over half of all new cars[16]. The construction industry tends to be more localised although there are a handful of international companies, chief amongst them the French company Vinci with a turnover of $31bn[17]. The packaging sector remains similarly fragmented despite a couple of large players[18].

So much for company size—what about the flow of metal goods around the world? The map of Figure 6.9 shows the money value of trade in metal at various stages of its journey from ore to metal to final product. The largest two trade flows for each good are shown. The map shows a general flow from Southern to Northern hemispheres, but the value of the trade increases as the ores are processed into more complete goods. China's role as an importer of ores, scrap and machinery

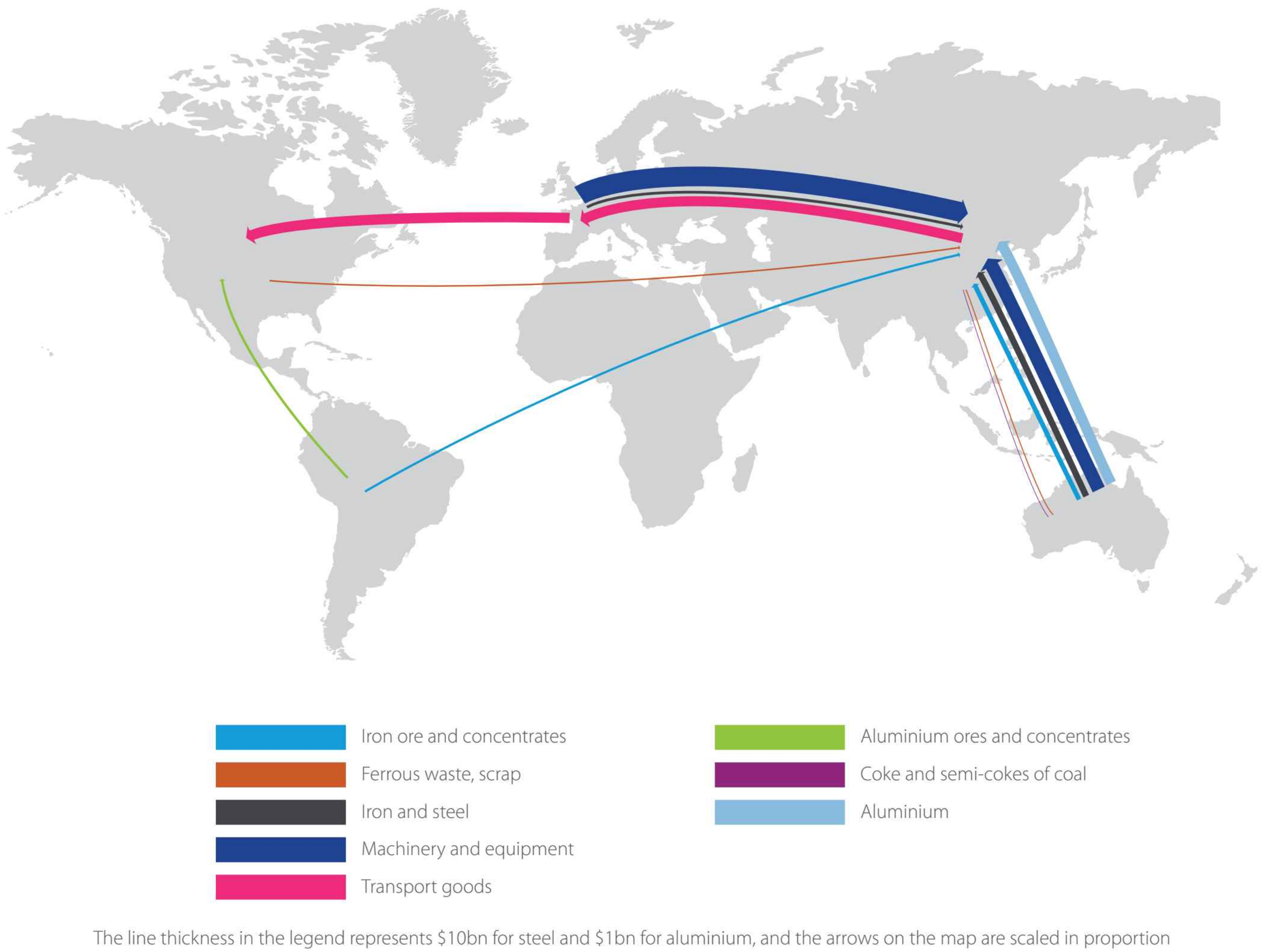

Figure 6.9—**Map of global trade**

and equipment and exporter of vehicles is clear. We can also see that the United States is a major exporter of scrap.

Outlook

We've seen through our tour of industry structure, history and trade, that our friend who opened the chapter by considering the purchase of a new office building would, had he saved up enough to go ahead, have triggered an activity that would ripple round the world. Almost all of the money he would have spent would eventually be paid as wages, across the vast span of businesses required to deliver the completed building. The social needs of everyone employed and affected by the process, would be considered by a range of government regulations and other lobby groups. So, let's end by re-writing our sketch from a completely different angle:

"Good morning, I'm thinking of providing employment for about 4,500 people across the globe for around six months each."

> "Certainly Sir—did you have any particular activities it mind?"

"Mmmm… I'm not too concerned about that, but I would like to be sure that they work in reasonably safe, socially acceptable conditions and receive a fair wage."

> "An excellent idea Sir—we do our best to ensure that all employment we create is well regulated, and we do support several active charities to watch our labour conditions and keep us up to the mark."

"Super—now, any ideas what they might actually do with their time?"

> "Well, I think if we play our cards right we could just about get them organised to make a 7-storey steel-framed office block, with advanced treble glazing, aluminium curtain walls, white flat roof, natural circulation, your name projected by laser on all surrounding buildings, and the three large pot plants at reception?"

"Just the job yes—time I had a new office. Now, any idea how this might all total up?..."

Notes

Where does the money go?

1. As a result, in the UK, the Office of National Statistics last published a full set of input-output tables in 1995, opting instead to publish annual supply and use table (the unbalanced constituent parts of input-output tables) as part of the Blue Book (ONS, 2010a), and allowing academics to bid for funding to construct the full set of balanced tables. For example the UK-MRIO project (Wiedmann et al. 2007) produced a set of input-output tables for the UK 1992-2004 based on the supply and use tables published annually in the blue book (ONS 2011). The UK supply and use tables cover 123 sectors meaning that there are over 15,000 numbers to be collected. Most countries publish some form of input-output tables, however sector groupings differ from country to country and disclosure agreements can limit the amount of data that is made publicly available. The arduous process of data collection, verification and the balancing of tables (referred to in the literature as 'optimising') does not end there; to really understand the chain of purchases that are instigated by a product that is consumed in the UK (or conversely the ultimate source of demand for goods produced in the UK) we need to take into account trade. Queue another round of data difficulties: we need a concordance matrix to match up sectors that are grouped differently in different countries, and we need to make sure that everything adds up i.e. that, at the global level, imports are equal to exports when duly adjusted for tariffs, transport costs and suchlike. There are a handful of initiatives globally that have taken on this task, for example the GTAP database (GTAP, 2011), EXIOPOL (n.d.) and EORA (Kanemoto, 2011).

2. The data set we used was based on the most widely accepted collection of national input-output tables, known as the GTAP database (GTAP, 1997). To create a world input-output data, we added up national input-output tables, taking care to avoid double-counting activities related to trade.

The development of today's steel industry

3. The British national organisation for the steel construction industry produced a history of steel in construction to mark the Centenary of the metal (BCSA, 2006).

4. US Steel still exists and this information was taken from the history section of the company's website (US Steel, 2011)

5. The history of the steel industry produced by the BCSA (2006) states that Austin Chamberlain suggested a 5-10% tariff on imported steel in 1904 in order to guard against other countries (that were themselves beginning to erect trade barriers) dumping surplus output on the UK market. It was many years before this policy was implemented in the UK.

6. Aylen (1998) tracks trends in the international steel market.

7. Ibid 6.

8. Each year, the World Steel Association produce "World Steel in Figures" (World Steel Association, 2010) which includes annual production by region and by method.

9. Tim Bouquet & Byron Ousey (2008) describe the exciting journey that led to the formation of ArcelorMittal.

10. Ranieri & Gibellieri (1998) provide a commentary on the steel industry in the new millennium.

11. In 2006 the UK Parliament commissioned a report on globalisation in the steel industry (Parliamentary business, 2006).

12. The annual statistical publication by the World Steel Association (2010) provides production data for the top 49 steel companies.

13. Data collected by mining industry analyst Barry Sergeant (2010).

The development of today's aluminium industry

14. Zheng Luo & Antonio Soria (2007) produced a comprehensive appraisal of the aluminium industry for the European Commission.

15. Data supplied by industry analysts CRU (2011).

Global trade in steel and aluminium

16. Datamonitor provides regular industry reports for most sectors including Global automobile manufacturers (Datamonitor, 2007).

17. Every year the Financial Times identifies the top 500 companies by market capitalisation. A sector breakdown of these companies is also available (Financial Times, 2010).

18. Datamonitor reports for the containers and packaging industry (2008).