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ORIGINAL PAPER

Trade specialisation patterns in major steelmaking economies: the role of advanced economies and the implications for rapid growth in emerging market and developing economies in the global steel market

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Abstract This study examines the steel-related export structure of the 15 largest steelmaking economies in 2015. The study provides a broad view of linkages between steel-related export structure, steelmaking technologies, and the level of economic development of each economy. To shed light on exporters' patterns of specialisation, indices of revealed symmetric comparative advantage are used, indicating that patterns of steel exports differ widely across economies. In addition, this study focuses on the difference between steel exports in volume and value terms amid growing debate over the issue of value creation caused by excess capacity in the steel industry. This study concludes that the choice of steelmaking technologies and the level of economic development are significant determinants of trade specialisation patterns in major steelmaking economies. Although emerging market and developing economies have played a significant role in volume terms in the global steel market, advanced economies still have a crucial role as key suppliers, especially for high value-added products.

Keywords Steelmaking technologies · Steel trade · Revealed comparative advantage · Trade specialisation

JEL classification F14 · L6 · O14

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Introduction

The global steel industry is experiencing pressures with regard to both demand and supply conditions. Weak economic conditions, global excess capacity, and weak profitability are some of the pressures facing the steel industry. Many steel firms have adopted a number of strategies to cope with these adverse factors, such as moving toward supplying growing markets and adding value to their steel products. Under the circumstances, steel trade has played an increasing economic role among major steelmaking economies over the past few years.[1] Steel trade has important implications for conditions in the world steel market. The current situation of steel trade reflects, for example, the level of technology, productivity, types of steel products, quality of steel products, and convergence of emerging market and developing economies.[2] As a result, developments in steel trade and related trade policies are receiving increasing attention by governments and industry alike.

The economic literature has focused on the convergence of developing economies, suggesting that they should experience faster growth than advanced economies (e.g. Baumol 1986; Barro and Sala-i-Martin 1991; Barro 2012; Rodrik 2013). In the steel industry, less developed steelmaking economies have converged to more developed steelmaking economies by taking advantage of economic backwardness over

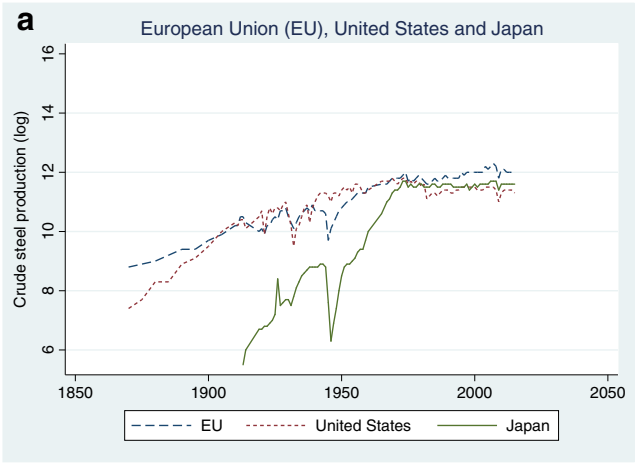
[1] The global export ratio (exports as a percentage of production) increased from 29.4% in 2010 to 30.7% in 2015 (World Steel Association 2016a).
[2] The definitions of advanced economies and emerging market and developing economies in this study are based on the International Monetary Fund's (IMF) World Economic Outlook Databases (IMF 2016).

the past several decades (Fig. 1a, b).[3] For example, China has rapidly converged to more developed steelmaking economies and has surpassed them to become the largest steel producer in the world. In 2015, China's crude steel output reached 803.8 million metric tonnes (mmt), representing 49.6% of global steel production.[4]

The global steel industry has experienced rapid growth in production since the start of the twenty-first century, although excess capacity has become one of the main challenges facing the industry today (OECD 2015a). Global nominal crude steel capacity reached 2384 mmt in 2015, which is more than three times as high as the 697-mmt capacity observed in 1970, according to WV Stahl (2016) (Fig. 2a). The growth in steelmaking capacity has occurred mainly in emerging market and developing economies.[5] Steelmaking capacity data from the OECD (2016a) seem to support this trend—non-OECD economies will continue to lead the capacity expansion in the global steel industry, with their share of world capacity expected to increase from 42% in 2000 to 72.4% by 2017 (Fig. 2b). This trend suggests that advanced economies have been losing market share in the global steel industry over the past decade. However, the question arises: have emerging market and developing economies converged to advanced economies from the viewpoint of value creation?

Turning to steel trade, global steel exports, including intra-trade exports, have been increasing over the last few years.[6] There has been a decoupling between steel exports in volume and value terms amid weak domestic demand conditions, with steel exports in value terms declining while steel exports in volume terms have continued to climb (Fig. 3a). Global steel exports in volume terms reached a record high of 456.7 mmt. On the other hand, global steel exports in value terms declined significantly from USD 391.2 billion in 2014 to USD 342.7 billion in 2015, reaching the second lowest level for several years after the financial crisis in 2009.

Figure 3b shows the shares of steel exports of the world's 15 steelmaking economies in global steel exports in volume and value terms in 2015. There is a huge gap between volume



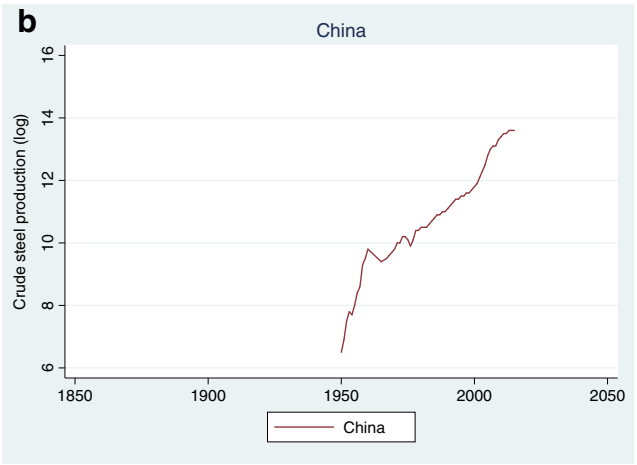


Fig. 1 Convergence for selected economies/region (1870–2015). **a** European Union (EU), USA, and Japan. **b** China. Source: Author's calculation based on data from Wirtschaftsvereinigung Stahl (WV Stahl) (2016) and the World Steel Association (2016b)

and value terms.[7] China exported 111.6 mmt of steel, accounting for 24.4% of global steel exports in volume terms, while its share declined significantly to 18.1% in value terms, suggesting that Chinese exports were concentrated in low value-added items. On the contrary, the shares of steel exports in several advanced economies in value terms were greater than the shares of exports in volume terms, suggesting that these economies have played important roles in supplying higher value-added products.

In recent years, amid recent weak financial performance of steelmakers and continued capacity expansion, there has been a debate that focuses on 'value creation' in the steel industry.[8] For instance, the World Steel Association (2015a, p. 9) has pointed out that 'industry will need to focus on value-added instead of tons'. Moreover, the Organisation for Economic Co-operation and Development's (OECD) Steel Committee

[3] Gerschenkron (1962) introduced the concept of 'advantage of economic backwardness' as a means of identifying the development mechanism in developing economies, suggesting that a late-starting industrial economy might be able to enjoy faster growth than advanced economies by importing existing technology from abroad.

[4] Figures for production and trade in this study are taken or calculated from the World Steel Association (2016b) and the International Steel Statistics Bureau (ISSB 2016), unless otherwise indicated.

[5] China has been the driving force of the global steel industry over the past decade, although some industry analysts have pointed out that Chinese steel production might have already reached its peak and is likely to stabilise in the coming years (OECD 2015b). China's steelmaking capacity, which was less than 200 mmt per year during 1970–2002, began rising sharply in 2003 and reached 1154 mmt in 2015, accounting for 48.4% of global nominal crude steel capacity, according to WV Stahl (2016).

[6] It should be noted that intra-regional trade has been significant in some regions (e.g. European Union or North American Free Trade Agreement), according to the World Steel Association (2016a).

[7] Detailed steel export indicators are presented in Appendix Table 5.

[8] For details of the recent financial performance of the steel industry, see, for example, the OECD (2015b, 2016b).

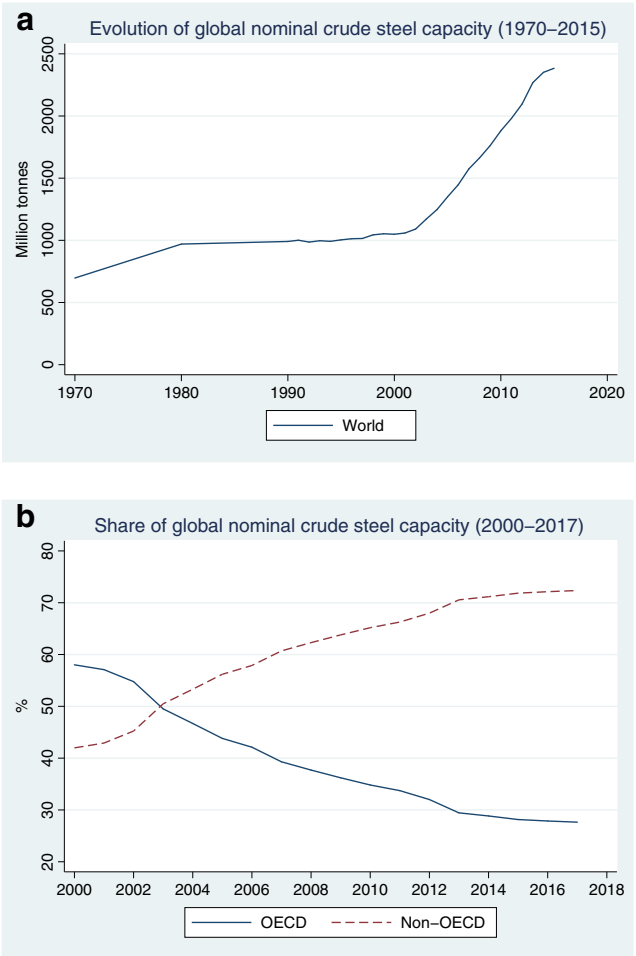


Fig. 2 **a** Evolution of global nominal crude steel capacity (1970–2015). **b** Share of global nominal crude steel capacity (2000–2017). Source: WV Stahl (2016) and author's calculation based on data from the OECD (2016a)

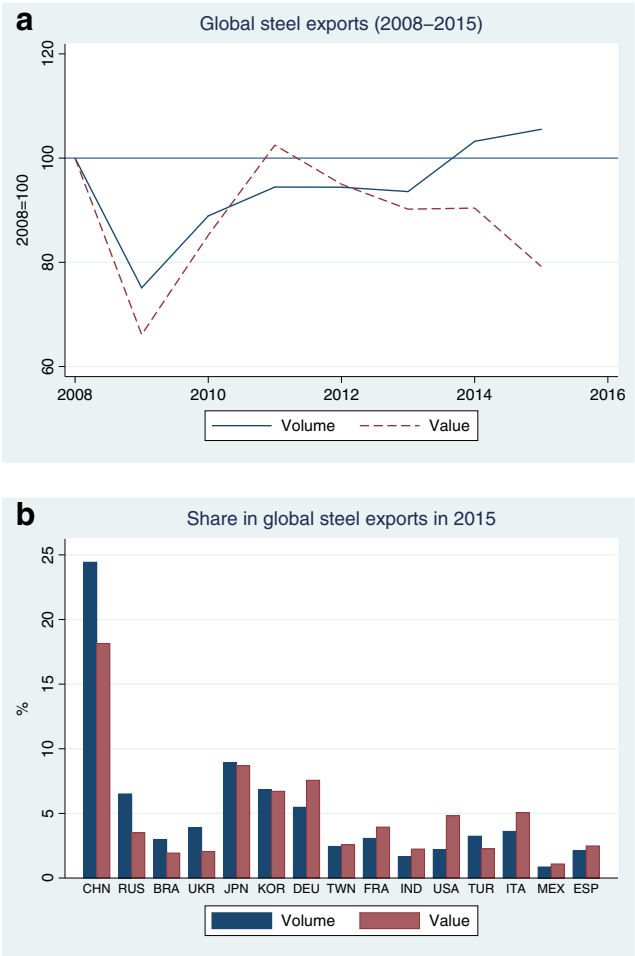


Fig. 3 Evolution of global steel exports and shares of steel exports of the 15 steelmaking economies. **a** Global steel exports (2008–2015). **b** Share in global steel exports in 2015. Notes: *BRA* denotes Brazil, *CHN* denotes China, *DEU* denotes Germany, *ESP* denotes Spain, *FRA* denotes France, *IND* denotes India, *ITA* denotes Italy, *JPN* denotes Japan, *KOR* denotes South Korea, *MEX* denotes Mexico, *RUS* denotes Russia, *TUR* denotes Turkey, *TWN* denotes Taiwan, *UKR* denotes Ukraine, and *USA* denotes the United States. Source: Author's calculation based on data from the ISSB (2016)

argues that 'a focus on creating value instead of volume could help the industry capture opportunities arising from many long-term structural changes' (OECD 2015c, para. 5). This suggests that it is important to consider how different the structure in value terms is from that in volume terms. However, publicly available data on the value of steel products are difficult to come by, and trade data are more readily available and more coherent than production data, enabling comparison between economies. Thus, trade data could be a useful tool to show the difference between them as a first step toward considering the issue of value creation in the steel industry.

With respect to global steel exports by product, hot-rolled sheets/strips, used widely as a basic material for transformation in downstream products, are the largest export item in volume terms, followed by bars, ingots and semi-finished products, and galvanised sheets.[9] Although the share of ingots and semi-finished products was 11.2% in volume terms, it has declined to 6.1% in value terms. On the other hand, the share of pipes and tubes was 8.5% in volume terms, but has risen to 19.2% (the largest export item in value terms), indicating that the product category is the highest value-added product in the industry. Moreover, the share of cold-rolled sheets/strips increased from 8.8% in volume terms to 11.4% in value terms.

The purpose of this study is to examine the export structure of the 15 largest steelmaking economies in 2015 based on production structure and the level of economic development.[10] The structure of the paper is as follows. The next section provides a brief literature review on theories related to the development of the steel industry and steel trade as well

[9] For an explanation of each product, see, for example, De Carvalho and Sekiguchi (2015).

[10] Although Iran was ranked the 14th largest steel producer in the world in 2015, it is excluded from this study because of lack of detailed trade data.

as the analytical perspective used in this study. The section thereafter discusses the structures of exports for the 15 steelmaking economies analysed in this study by dividing them into three groups; in addition, this section presents the empirical results of trade specialisation using the revealed symmetric comparative advantage (RSCA) index. The final section draws conclusions from the arguments in this study and addresses their implications.

Literature review and analytical perspective

Steel is processed through one of two primary production routes, that is, blast furnaces/basic oxygen furnaces (BF/BOF) and electric arc furnaces (EAF).[11] There are a number of significant differences between integrated mills (BF/BOF route) and mini-mills (EAF route). These include raw materials, size, type of products, and investment requirements (Hogan 1987). The BF/BOF route is a process that uses raw materials, including iron ore, coking coal, limestone, and recycled steel, while the EAF route uses primarily recycled steel and direct reduced iron (DRI) or hot metal and electricity (World Steel Association 2016c). While integrated mills produce mainly flat products used in the automotive, machinery, and consumer appliance industries, mini-mills produce low value-added, high-carbon long products, principally used in construction (D'Costa 1999). Table 1 summarises major steel products by process and end use.

Production technologies have played a crucial role in the steel industry, and a number of studies have focussed on the development of iron-making/steelmaking technologies. Okamoto (1984) explains that the structure of the steel industry in an economy is composed of a heterogeneous group of steel companies. Kawabata (2005) develops this framework using firm typology according to steel production technologies: steel firms can be grouped into three main types, namely, (i) integrated firms, (ii) EAF firms or mini-mills, and (iii) rolling firms. Numerous factors affect the structure of steel exports. These include firm types and production technologies that establish the structure of the steel industry in an economy, thereby affecting its trade structure (Kawabata 2005).

Since large amounts of capital are needed to build large-scale steelworks that use the BF/BOF route (Kawabata 2005), most developing economies have adopted the EAF route.[12] Compared to the EAF route, the BF/BOF route uses more capital-intensive technology and enables mass production. Since more capital is accumulated, steel firms in advanced economies tend to adopt the BF/BOF route. However, emerging market and developing economies have become major BF/BOF producers in the world. In addition to production technologies, production items are also important factors that affect trade specialisation patterns. Theoretically, integrated mills (BF/BOF route) are used mainly to produce flat products for the manufacturing sector, while most mini-mills (EAF route) are used to produce long products for the construction industry (D'Costa 1999).[13]

It is difficult to stop the operation of the BF/BOF route: once a BF is started, it will continuously run for 4–10 years with only short stops to perform planned maintenance (American Iron and Steel Institute 2017), and thus, exports play an important role, especially for BF/BOF producers.

This study examined the export structure of the world's 15 largest steelmaking economies in 2015. Table 2 provides production indicators for these economies. Their combined production reached 1.44 billion tonnes in 2015, representing 88.8% of global steel production. The BF/BOF-oriented economies tend to export large quantities of steel, while the export volumes of EAF-oriented economies are limited. The gap between domestic demand and supply might partially explain export volumes in some economies. Ukraine has low steel demand, but its economy has a high self-sufficiency rate (the share of domestic production in steel demand), reflecting a high degree of export orientation of its steel producers.

The issue of product mix will likely have significant implications, since the level of economic development could be a determinant of the mix of steel products exported. Therefore, it is important to examine the steel-related export structure by product of each economy.

Trade specialisation and the role of innovation

According to Laursen (2015), the concept of specialisation implies a strong focus on a narrow area of activity and less intense focus on others. Some empirical studies focus on trade specialisation between economies and industries, indicating that patterns of trade specialisation vary significantly across economies and industries (Dalum et al. 1998; Laursen 2000, 2015). Redding (1999) describes how comparative advantage is endogenously determined by past technological change, while simultaneously shaping current rates of innovation. According to De Carvalho and Sekiguchi (2015), steel trade is determined to a large extent by the comparative advantage

[11] Globally, the BF/BOF route has been the major steelmaking technology, accounting for 74.2% of global crude steel production in 2015, but patterns of steel production by process vary significantly across regions.

[12] However, this does not apply to some economies. For example, the USA has been a major EAF producer, and several DRI-based mini-mill projects have been announced in recent years to take advantage of shale gas developments (OECD 2015a).

[13] However, there are some cases in which this does not apply. For example, some mini-mills, such as Nucor in the USA, have been encroaching increasingly on the flat products market, with EAF/thin slab casting technology for hot-rolled coil production (Hogan 1987; Kawabata 2005).

Table 1 Major steel product markets by type of operation and end use

Product	Integrated process	Mini-mills	End use
Long products			
Reinforcing bars	x	x	Construction
Hot-rolled bars	x	x	Auto/construction
Wire rods	x	x	Wire makers/construction
Small structural shapes	x	x	Construction
Large structural shapes	x	x	Construction
Rails	x	–	Railways
Wheels and axles	x	–	Railways
Seamless tubes	x	x	Construction/auto/oil/gas
Flat products			
Plates	x	x	Construction/machinery
Hot-rolled sheets	x	x	Pipe makers/auto
Cold-rolled sheets	x	–	Auto/appliances
Coated sheets	x	–	Auto/appliances/construction/containers
Welded pipes/tubes	x	x	Oil/gas/construction

Source: Author based on D'Costa (1999)

of steel producers. The authors applied specialisation to the steel-related export structure of the world's 10 largest steel-making economies, and found correlation between innovation activity and export specialisation in higher value-added steel segments.

Trade sophistication, diversification, and economic growth

Estimating the level of technological sophistication embodied in an economy's export portfolio gives an indication of that

Table 2 Overview of the 15 steelmaking economies in 2015 millions of metric tonnes, in percentage

Region	Economy	Crude steel demand/ production		Percentage of production		Production items		Steel exports
		Demand	Supply	BF/ BOF	EAF	Long	Flat	Volume
Asia	**China**	700.4	803.8	93.9	6.1	498.6	322.3	111.6
Asia	**Japan**[a]	67.8	105.1	77.1	22.9	28.8	62.7	40.8
Asia	India	89.4	89.0	42.9	57.1	41.8	48.1	7.6
NAFTA	USA[a]	108.3	78.8	37.3	62.7	21.5	56.3	10.0
CIS	**Russia**	44.6	70.9	66.3	30.5	17.0	27.5	29.7
Asia	**South Korea**[a]	58.1	69.7	69.6	30.4	20.2	47.5	31.2
Europe	**Germany**[a]	42.3	42.7	70.4	29.6	12.7	23.8	25.0
Latin America	**Brazil**	23.7	33.3	78.2	20.2	8.9	13.4	13.6
Other Europe	Turkey	36.6	31.5	35.0	65.0	20.8	na	14.8
CIS	**Ukraine**	3.8	23.0	71.8	5.6	5.6	6.3	17.7
Europe	Italy[a]	26.1	22.0	21.8	78.2	11.2	10.5	16.5
Asia	**Taiwan**[a]	21.1	21.4	62.3	37.7	10.3	14.7	11.2
NAFTA	Mexico	28.8	18.2	29.7	70.3	8.3	8.6	3.9
Europe	**France**[a]	14.5	15.0	65.6	34.4	4.4	10.6	14.0
Europe	Spain[a]	13.7	14.8	31.7	68.3	9.1	4.7	9.6

The definition of advanced economies is based on the IMF (2016). The BF/BOF-oriented economies are marked in bold letters. Long products are major production items in Turkey, according to data from the World Steel Dynamics (2016). Source: Author's calculation based on data from the World Steel Association (2016b) and ISSB (2016)

[a] Advanced economies

economy's economic development (World Bank 2013). The products that developing economies export today affect their future growth, which departs from the standard comparative advantage argument that emphasises the benefits from specialisation (Asian Development Bank 2010). Various recent empirical studies support the existence of a positive relationship between export sophistication and economic growth, suggesting that export sophistication should promote faster and sustainable economic growth (Lall et al. 2005; Hausmann et al. 2007). On the other hand, various studies support the positive relationship between the level of economic development and export diversification (Hesse 2009; Cadot et al. 2011; Agosin et al. 2012). Hesse (2009) argues that export diversification plays an important role in transformation, where economies move from producing 'poor-economy goods' to 'rich-economy goods'.

Link between economic growth and steel demand/production in the steel industry

The development of a country's steel industry is closely linked to its level of economic development (Sato 2008). According to Sato (2013), the structure of the steel industry in an economy shifts with economic growth (i) from import substitution of downstream facilities (e.g. rolling or surface treatment) to import substitution of upstream facilities, (ii) from long products to flat products, and (iii) from low value-added products to high value-added products. Various recent empirical studies support the existence of a positive relationship between economic development and steel demand/production. Among these studies, gross domestic product is used to explain changes in steel demand/production over time, suggesting that the economic growth impacts steel supply/demand across economies (e.g. Ghosh 2006; Huh 2011; Dobrotă and Căruntu 2013; Döhrn and Krätschell 2014; Wårell 2014).

Development of global steel trade and the growing role of emerging market and developing economies in global steel industry

Few studies focus on the steel-related export structure. Most studies on steel trade have centred on steel trade policies.[14] Hogan (1983) highlights the development of global steel trade, suggesting that the landscape of international trade in the steel industry has changed significantly since World War II owing to a number of developments, including rapid growth in global steel production, the development of extensive trade between steelmaking economies, and the installation of steelmaking capacity in developing economies. OECD (2016c) notes that global steel exports have continued to increase over the past few years despite declining global steel demand and growing excess capacity.

Emerging market and developing economies have played a growing role in the global steel industry. OECD (2013) shows that several emerging market and developing economies have enjoyed faster economic growth rates and, consequently, steel demand expansion. In fact, the share of emerging market and developing economies in global steel demand increased from 58.3% in 2000 to 73.4% in 2015 (World Steel Association 2016d). De Carvalho and Sekiguchi (2015) find that export specialisation patterns might change noticeably as some steel producers in emerging market and developing economies move up the value chain and begin exporting more sophisticated steel products.

Analytical perspective

A country's comparative advantage in exports of a product may change as its economy grows. If the choice of technology is successful, specialisation of that product may occur in the country. The country may specialise further in that product once technology is chosen and efforts are made to improve the productivity and quality of that product. Then, the country could begin exporting more sophisticated goods.

Some issues for discussion include the following.

- How can the balance between BF/BOF and EAF affect trade specialisation patterns in emerging market and developing economies and advanced economies?
- What are the characteristics of comparative advantage in emerging market and developing economies?
- Do advanced economies still have different structures of comparative advantage compared to emerging market and developing economies?

The analytical perspective is defined as follows.

Analytical perspective The choice of steelmaking technologies and the level of economic development are significant determinants of trade specialisation patterns in major steelmaking economies.

Results and analysis

Data

The data were provided by the ISSB's 'Trade Enquiry System', an online database of steel trade data (ISSB 2016). The data are based on the ISSB's classification and have been

[14] For example, Lee and Mensbrugghe (2005), Vandenbussche and Zarnic (2008), and Bown (2013) assess the effects of US safeguard measures on steel products.

aggregated to 14 product groups. In addition, the regional aggregation is based on the ISSB's classification.[15] Steel export values based on the British pound were converted to the US dollar using the OECD's exchange rate database (OECD 2016d). The exchange rate for the British pound to the US dollar in 2015 is quoted at 1.5279.

Grouping

In order to group economies and analyse export structure according to their production structure and the level of economic development, the hierarchical cluster analysis approach was used. The analysis was performed using three indicators, namely, (i) the level of economic development (advanced economies or emerging market and developing economies), (ii) steelmaking technologies (BF/BOF or EAF), and (iii) major production items (long products or flat products), with Ward's clustering method and Pearson's similarity measure.[16] A graphical representation of hierarchical clustering is presented by the dendrogram in Fig. 4. Three main clusters can be recognised, and the three separated clusters of economies are labelled as groups A, B, and C (see Table 3). The economies in group A, namely, China, Russia, Brazil, and Ukraine, are labelled as 'emerging market and developing steelmaking economies' which all use BF/BOF production technology. On the other hand, the economies in group B, namely, Japan, South Korea, Germany, Taiwan, and France, are labelled as 'advanced steelmaking economies' which all use BF/BOF technology and mainly produce flat steel products. Finally, the economies in group C are either emerging market and developing economies or advanced economies which all use the EAF route, and they are labelled 'EAF-based steelmaking economies'.

The 15 steelmaking economies have played a key role in global steel trade, but it is important to distinguish whether each economy is a net exporter or a net importer as a proxy to measure its export competitiveness. Lafay (1992) introduced a tool called the trade balance index (TBI) as a measure to analyse whether a country has specialisation in exports (as a net exporter) or in imports (as a net importer) for specific products. The TBI is formulated as follows:

$$\mathrm{TBI}_{ki} = (x_{ki} - m_{ki}) \Big/ (x_{ki} + m_{ki})$$

[15] For details on the product categories and regional aggregation, see ISSB (2010a, b).

[16] The level of economic development is a dummy variable that takes a value of 1 for advanced economies and 0 for emerging market and developing economies. Steelmaking technology is a dummy variable that takes a value of 1 for the BF/BOF route and 0 for the EAF route. Production item is a dummy variable that takes a value of 1 for flat products and 0 for long products.

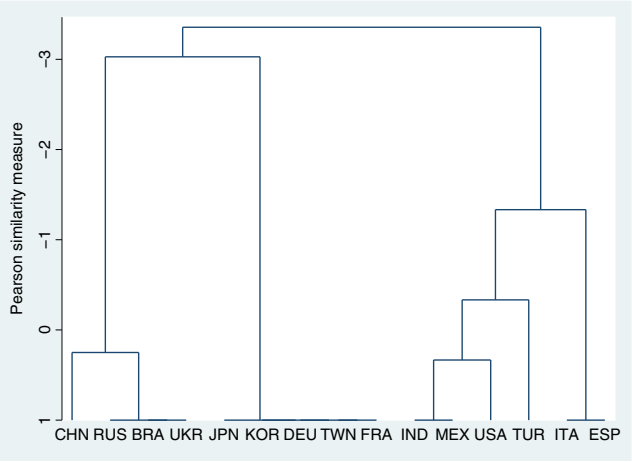


Fig. 4 Dendrogram of the 15 steelmaking economies clustered according to production structure and level of economic development. Notes: *BRA* denotes Brazil, *CHN* denotes China, *DEU* denotes Germany, *ESP* denotes Spain, *FRA* denotes France, *IND* denotes India, *ITA* denotes Italy, *JPN* denotes Japan, *KOR* denotes South Korea, *MEX* denotes Mexico, *RUS* denotes Russia, *TUR* denotes Turkey, *TWN* denotes Taiwan, *UKR* denotes Ukraine, and *USA* denotes the United States. Source: Author's calculation

where TBI_{ki} represents the TBI of country k for steel product group i and x_{ki} and m_{ki} denote exports and imports of i group of steel products by country k, respectively. The value of this index ranges from −1 to +1.

Figure 5a, b. presents the TBI for the 15 steelmaking economies in 2015. BF/BOF-oriented producers (groups A and B) are net exporters of steel. China, Russia, Ukraine, and Japan are huge net exporters of steel, and Ukraine has the highest TBI index, followed by China, Japan, and Russia in volume terms, although China fell from second to third place and Japan was ranked second in value terms. On the other hand, most EAF-oriented producers in group C are net importers of steel, except some European economies, suggesting that the EAF route might be less linked to steel export structure compared to the BF/BOF route.

Results and analysis

Distribution of unit values of steel exports by product

The unit value of steel exports (nominal sales divided by tonnes of steel exported) provides useful information when considering the structure of steel exports. To enable a better comparison of unit values, and to gain insights into possible differences of product quality across exporting economies, Table 4 presents the distribution of unit values of steel exports by product for each economy in 2015.

Table 3 Classification of the 15 economies according to selected indicators

Variable	Means		
	Group A (4 economies)	Group B (5 economies)	Group C (6 economies)
Advanced economy	0.00	1.00	0.50
BF/BOF-oriented structure	1.00	1.00	0.00
Flat product-oriented structure	0.75	1.00	0.50

Source: Author's calculation

Group A has quite low unit values for a number of steel products compared to other exporters. In fact, these economies have relatively lower costs of production for several reasons, including low raw material prices and low labour costs (OECD 2012). China has the lowest unit value for bars, while Russia, Brazil, and Ukraine have the lowest unit value for ingots and semi-finished products. Meanwhile, the structure of Brazilian steel exports might be more sophisticated than that of other economies within the group, as Brazil exports relatively high value-added pipes and tubes (mainly seamless pipes). The structure of exports in group B seems more sophisticated and diverse than other groups, as economies within the group are strong exporters of flat products. Japan has a more diverse export structure within the group, as it exports a wide range of steel products from commonly used steel products (e.g. ingots and semi-finished products or hot-rolled sheets/strips) to very high value-added products (e.g. electrical sheets or seamless pipes). France has a very high unit value for pipes and tubes (both welded pipes and seamless pipes). With regard to group C, Turkey has the lowest unit value for long products, especially bars, and is a large net exporter of this type of steel. On the contrary, the USA has higher unit values for a number of products (e.g. seamless pipes).

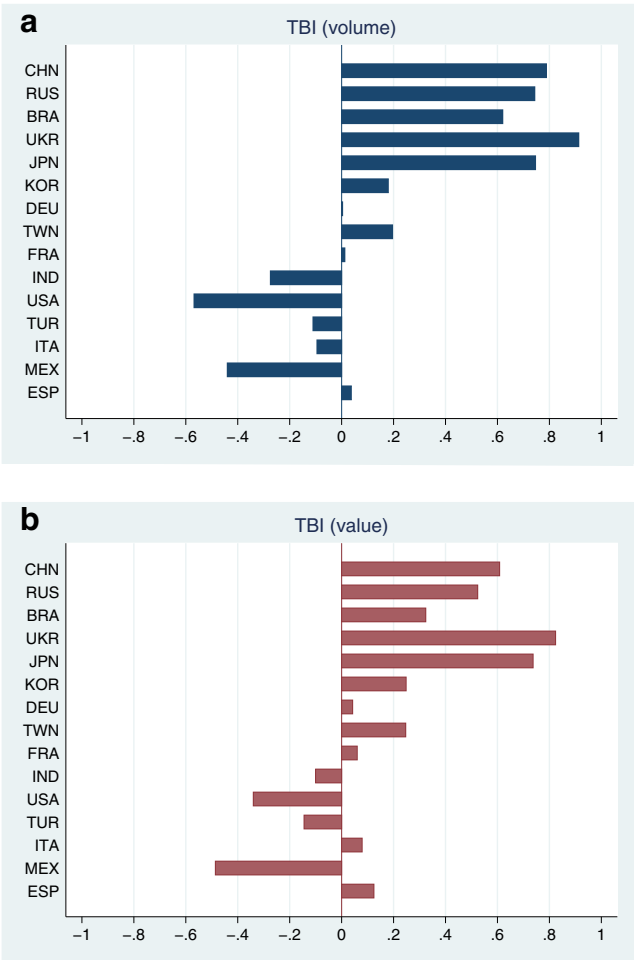


Fig. 5 Trade balance index in 2015. **a** TBI (volume). **b** TBI (value). Notes: *BRA* denotes Brazil, *CHN* denotes China, *DEU* denotes Germany, *ESP* denotes Spain, *FRA* denotes France, *IND* denotes India, *ITA* denotes Italy, *JPN* denotes Japan, *KOR* denotes South Korea, *MEX* denotes Mexico, *RUS* denotes Russia, *TUR* denotes Turkey, *TWN* denotes Taiwan, *UKR* denotes Ukraine, and *USA* denotes the United States. Source: Author's calculation based on data from the ISSB (2016)

Trade specialisation patterns

In 1965, Balassa introduced the concept of 'revealed comparative advantage' (RCA) indices as a measure of a country's specialisation (Balassa 1965). This measure can be applied to steel by calculating the ratio of the share of a given steel product category in an economy's total steel exports to the share of that product group in world steel exports. If x_{ki} were exports of steel product group i from country k, then the revealed comparative advantage index would be

$$\mathrm{RCA}_{ki} = \frac{x_{ki}/\sum_i x_{ki}}{x_{wi}/\sum_i x_{wi}}$$

where subscript w refers to the rest of the world, that is, total world steel exports excluding country k. Although this indicator is one of the most commonly used measurements for trade specialisation, several associated problems have been pointed out by many studies in the literature. For example, the distribution of RCA values ranks from zero to infinity and, therefore, is asymmetric (Laursen 2015). For these issues, Dalum et al. (1998) and Laursen (1998, 2015) transformed the Balassa Index to a

Table 4 Unit value of narrow steel product exports in 2015 USD per tonne of steel

Group	Group A				Group B					Group C					
Economy	CHN	RUS	BRA	UKR	JPN	KOR	DEU	TWN	FRA	IND	USA	TUR	ITA	MEX	ESP
Ingots and semi-finished	769	320	345	323	337	375	528	540	751	407	2655	583	979	509	947
Long products	382	464	672	428	828	643	783	1063	913	1560	1200	449	771	614	603
Wire rods	383	381	514	397	896	593	564	1218	779	864	1124	437	658	511	601
Bars	356	465	794	452	928	914	1081	1194	1039	1813	1389	430	821	611	644
Sections	468	486	662	393	611	577	766	653	659	1851	950	530	697	715	558
Rails	844	658	1601	848	760	924	1233	930	1292	1063	1122	1197	806	819	797
Flat products	565	455	546	404	639	664	863	679	745	739	1184	579	806	814	1046
Plates	443	475	789	427	699	577	955	1111	970	820	1065	531	659	676	1114
Hot-rolled sheets/strips	509	368	418	370	456	522	571	432	489	607	1021	428	673	534	810
Cold-rolled sheets/strips	707	458	896	436	901	708	1315	1057	1316	853	1572	1164	1381	1099	1448
Tin plates and tin-free	815	808	860	1210	887	902	983	884	887	830	761	1058	1082	1592	948
Galvanised sheets	560	646	653	509	779	753	742	738	698	672	990	673	598	824	689
Other coated products	621	864	798	1171	1593	947	1246	826	1134	778	1598	909	951	936	1421
Electrical sheets	1056	1082	1689	1364	1541	1127	963	600	1347	1880	2177	1981	1396	2229	1596
Pipes and tubes	1159	815	2559	986	2550	1426	2586	2154	4245	1451	3530	747	1735	1625	2286
Welded pipes	850	656	1492	639	1567	935	2026	1699	3982	1097	1918	687	1260	1044	1233
Seamless pipes	1094	996	2571	1192	3098	2597	2238	2254	3905	2260	4625	2064	2263	1750	3034
Pipe fittings	2933	3807	37,267	5187	16,514	5762	12,558	5541	10,378	2966	14,684	4379	5717	6918	4449
Other steel products	1188	638	1905	665	2849	1754	2075	1703	2091	2401	3421	1081	1843	1627	1655
Total steel products	557	404	485	395	729	738	1036	789	964	1017	1651	524	1053	957	887

Source: Author's calculation based on data from the ISSB (2016)

BRA Brazil, *CHN* China, *DEU* Germany, *ESP* Spain, *FRA* France, *IND* India, *ITA* Italy, *JPN* Japan, *KOR* South Korea, *MEX* Mexico, *RUS* Russia, *TUR* Turkey, *TWN* Taiwan, *UKR* Ukraine, *USA* denotes the United States

symmetric index, called the RSCA, which ranges from −1 to +1 ($-1 \leq \mathrm{RSCA}_{ki} \leq +1$). A number of studies have examined comparative advantage in various economies with the RSCA indices.[17] The index is defined as

$$\mathrm{RSCA}_{ki} = (\mathrm{RCA}_{ki} - 1) \Big/ (\mathrm{RCA}_{ki} + 1)$$

RSCA_{ki} greater than zero for a given product i indicates that a country has a revealed comparative advantage in the exports of that product. On the contrary, RSCA_{ki} less than zero suggests a comparative disadvantage in exports of a given product. The steel-specific RSCA indices are useful not only for revealing a country's specialisation in a given steel product but also for identifying diversification across steel products within a given country. RSCA indices, in volume and value terms, are calculated for the world's 15 largest steelmaking economies for 14 product groups, namely, (i) ingots and semi-finished products, (ii) wire rods, (iii) bars, (iv) sections, (v) rails, (vi) plates, (vii) hot-rolled sheets/strips, (viii) cold-rolled sheets/strips, (ix) tin plates and tin-free, (x) galvanised sheets, (xi) other coated sheets, (xii) electrical sheets, (xiii) pipes and tubes, and (xiv) other steel products.[18]

Figures 6, 7, and 8 show trade specialisation of the 15 steelmaking economies on a product basis in 2015. The RSCA index in volume terms is on the x-axis, and the RSCA index in value terms is on the y-axis. Each figure is composed of four quadrants at points (0,0). The upper right quadrants show products that are trade specialisation in both volume and value terms. The lower right quadrants reveal products that have trade advantages in volume terms but not in value terms. The upper left quadrants represent steel products that have trade competitiveness only in value terms. Finally, the lower left quadrants represent products that have no trade advantages in either volume or value terms. Each code number represents product categories (Tables 5, 6, and 7).[19]

[17] For example, Widodo (2009a, b) examines changes in comparative advantage in Asian economies with RSCA indices.

[18] Other steel products range from wire to steel castings.

[19] RSCA indices for narrow steel product groups and major exporters in 2010 and 2015 are presented in Appendices Tables 6 and 7.

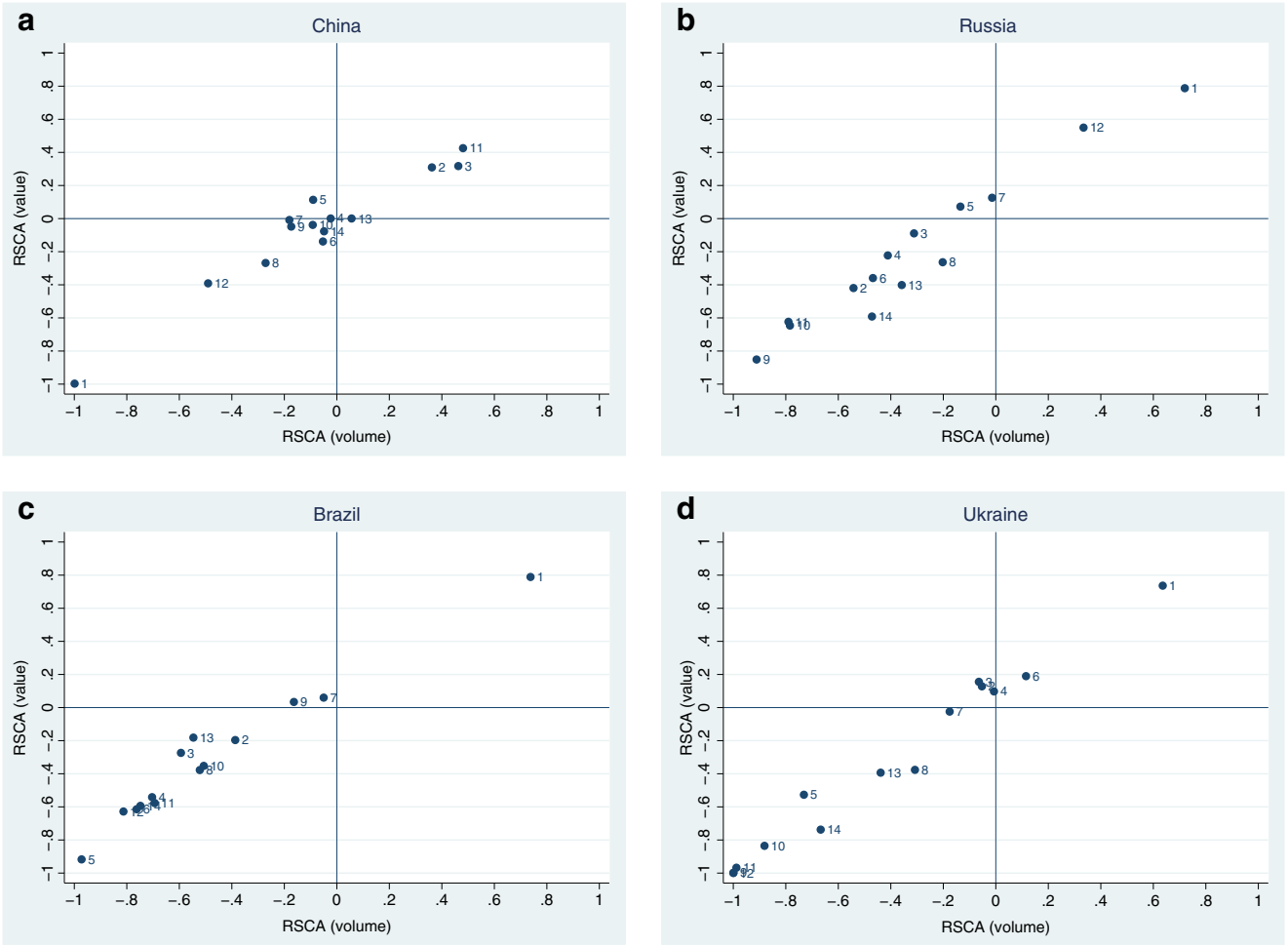


Fig. 6 RSCA index values by product group in 2015 (group A). **a** China. **b** Russia. **c** Brazil. **d** Ukraine. Notes: Each code number (1–14) represents product categories. *1* denotes ingots and semi-finished products, *2* denotes wire rods, *3* denotes bars, *4* denotes sections, *5* denotes rails, *6* denotes plates, *7* denotes hot-rolled sheets/strips, *8* denotes cold-rolled sheets/strips, *9* denotes tin plates and tin-free, *10* denotes galvanised sheets, *11* denotes other coated sheets, *12* denotes electrical sheets, *13* denotes pipes and tubes, and *14* denotes other steel products. Source: Author's calculation based on data from the ISSB (2016)

Group A (emerging market and developing steelmaking economies)

Economies in group A have high RSCA values for a number of low value-added steel products, and are extremely specialised in specific products, such as ingots and semi-finished products (Fig. 6a–d). Since 2010, most economies have tended to be more specialised in specific products. In China, the category of other coated sheets has retained the highest RSCA values since 2010. China's RSCA value for bars in volume terms increased from −0.21 in 2010 to 0.46 in 2015, and thus, the economy is now by far one of the most specialised in this product category as well as in wire rods. On the other hand, China's specialisation in ingots and semi-finished steel products has declined significantly over the past decade; ingots and semi-finished steel products in volume terms accounted for as much as 26% of China's exports in 2005 (ISSB 2005), but by 2015 the share fell to 0%. Market analysts have pointed out that such developments might have occurred in response to changes in the differential VAT rebates that are applied to steel exports, resulting in greater incentives to export, and most Chinese billets are now labelled 'square bars' and shipped as finished products (CRU 2016).[20] The Chinese RSCA values for rails, relatively high value-added products, increased from 0.02 in 2010 to 0.11 in 2015 in value terms. In addition, the economy is slightly specialised in pipes and tubes, although only in volume terms.

Russia, Brazil, and Ukraine all have high RSCA values for ingots and semi-finished products, which are greater than 0.6 in both volume and value terms; these three economies have tended to be more specialised in

[20] It should be noted that China's implied ingots and semi-finished exports, derived from world ingots and semi-finished imports from China, reached 8.1 mmt in 2015, its third largest export item. China is ranked second behind Russia but ahead of Brazil and Ukraine, according to data derived from world ingots and semi-finished imports.

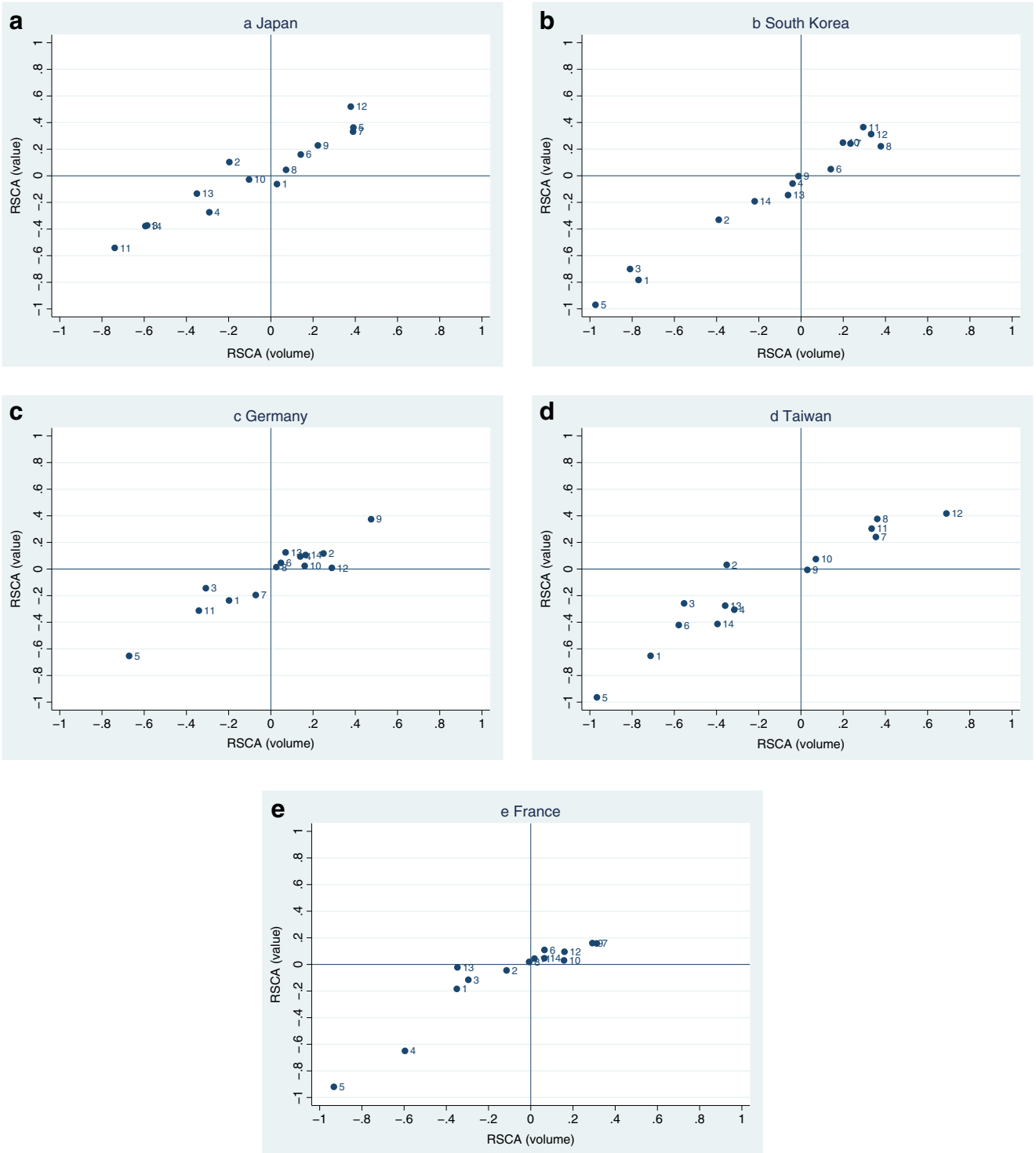


Fig. 7 RSCA index values by product group in 2015 (group B). **a** Japan. **b** South Korea. **c** Germany. **d** Taiwan. **e** France. Notes: Each code number (1–14) represents product categories. *1* denotes ingots and semi-finished products, *2* denotes wire rods, *3* denotes bars, *4* denotes sections, *5* denotes rails, *6* denotes plates, *7* denotes hot-rolled sheets/strips, *8* denotes cold-rolled sheets/strips, *9* denotes tin plates and tin-free, *10* denotes galvanised sheets, *11* denotes other coated sheets, *12* denotes electrical sheets, *13* denotes pipes and tubes, and *14* denotes other steel products. Source: Author's calculation based on data from the ISSB (2016)

this product category since 2010. In Russia, ingots and semi-finished products have become more important export items over the last 5 years. Aside from ingots and semi-finished products, Russia has a high RSCA index value for electrical sheets and tends to be more specialised in this high value-added product. In value

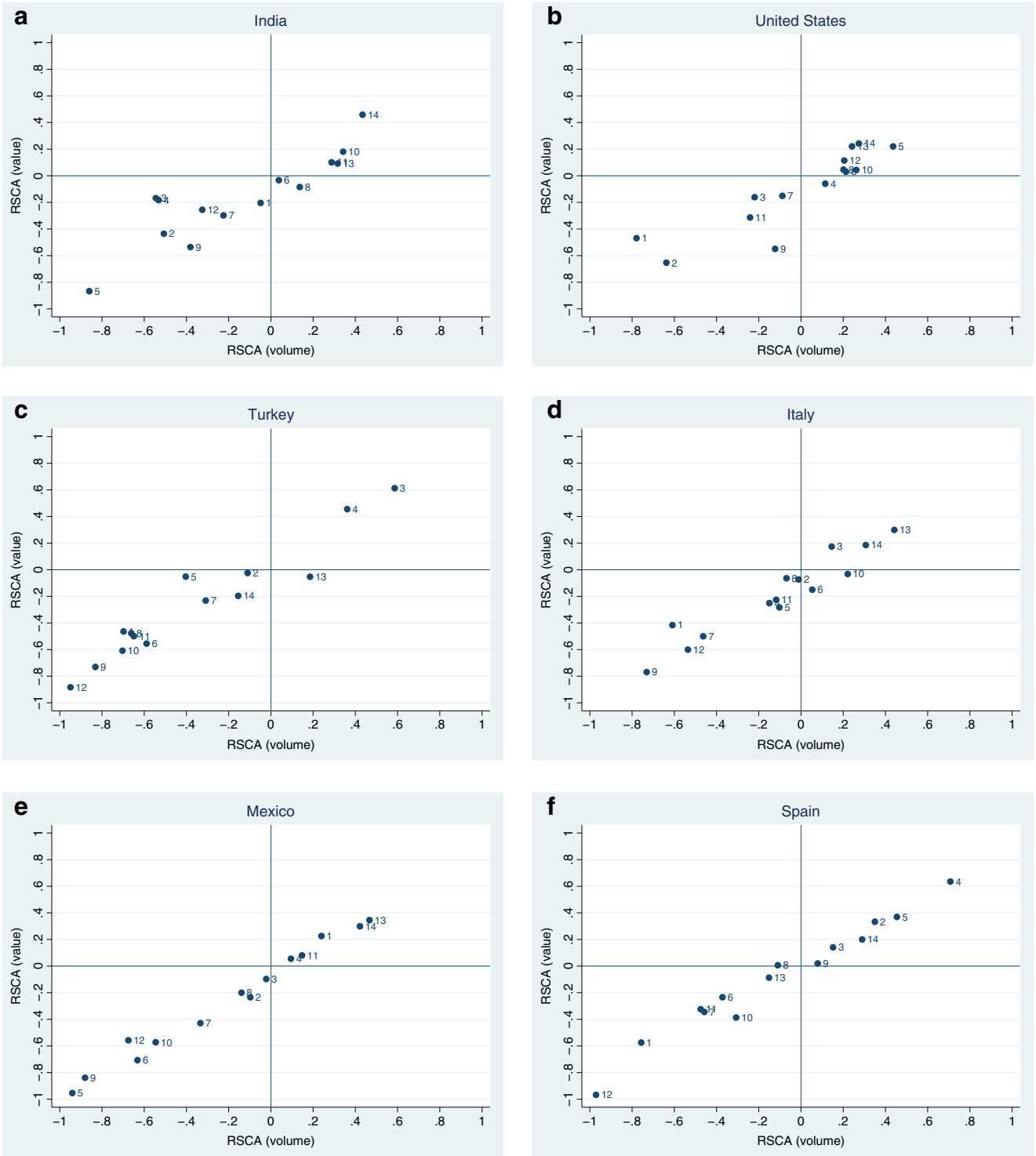


Fig. 8 RSCA index values by product group in 2015 (group C). **a** India. **b** *USA*. **c** Turkey. **d** Italy. **e** Mexico. **f** Spain. Notes: Each code number (1–14) represents product categories. *1* denotes ingots and semi-finished products, *2* denotes wire rods, *3* denotes bars, *4* denotes sections, *5* denotes rails, *6* denotes plates, *7* denotes hot-rolled sheets/strips, *8* denotes cold-rolled sheets/strips, *9* denotes tin plates and tin-free, *10* denotes galvanised sheets, *11* denotes other coated sheets, *12* denotes electrical sheets, *13* denotes pipes and tubes, and *14* denotes other steel products. Source: Author's calculation based on data from the ISSB (2016)

terms, Russia is slightly specialised in rails and hot-rolled sheets/strips. Brazil's RSCA value for ingots and semi-finished products in volume terms increased from 0.60 in 2010 to 0.74 in 2015, and thus, the economy is by far the most specialised in this product category. In addition, Brazil's specialisation in hot-rolled sheets/strips

has increased slightly since 2010, with an RSCA index in value terms greater than 0.06 in 2015, up from −0.20 in 2010. Ukraine is specialised in ingots and semi-finished products and its RSCA value for the product in volume terms increased from 0.54 in 2010 to 0.64 in 2015. The economy is relatively specialised in plates and number of long products, although only in value terms.

Group B (advanced steelmaking economies)

Economies in group B are specialised in a large number of products. This group comprises strong exporters in the flat products category, and is relatively specialised not only in commonly used steel products (e.g. hot-rolled sheets/strips) but also in high value-added products (e.g. electrical sheets) (Fig. 7a–e). Japan has a high RSCA index value for electrical sheets (greater than 0.5 in value terms both in 2010 and 2015), which is higher than that in volume terms.[21] In addition, Japan is quite focussed on exports of rails, with RSCA values greater than 0.3 in both volume and value terms in 2015. In Japan, the trade specialisation pattern has changed slightly over the last few years. Compared to its RSCA value in 2010, there was a marked increase in 2015 in the shares of ingots and semi-finished products as well as hot-rolled sheets/strips, while Japan's share of galvanised sheets declined. This reflects changes in Japanese steelmakers' export behaviour in expanding overseas production and supplying pre-processed original steel materials to local mills owned by Japanese companies (De Carvalho and Sekiguchi 2015).

South Korea's pattern of trade specialisation somewhat resembles that of Taiwan. These economies are not specialised in ingots and semi-finished products and long products, but they are quite specialised in cold-rolled sheets/strips, other coated sheets, and electrical sheets. South Korea is specialised in a number of flat products. For example, the economy has the highest RSCA values for cold-rolled sheets/strips in volume terms, with RSCA values greater than 0.3 in 2010 and 2015. The South Korean RSCA values for ingots and semi-finished products, hot-rolled sheets/strips, and plates have changed significantly over the last few years, as its major steelmakers have invested heavily in both upstream and downstream facilities.[22] For instance, the South Korean RSCA values for plates increased from 0.05 in 2010 to 0.14 in 2015 in volume terms, while its RSCA values for hot-rolled sheets/strips became greater than 0.2 in both volume and value terms in 2015. On the other hand, Taiwan has the highest RSCA value for electrical sheets in the world in volume terms, and its RSCA value for electrical sheets in volume terms increased from 0.61 in 2010 to 0.69 in 2015.[23] In addition, the product category of hot-rolled sheets/strips has become a more important export item for the economy and growth in Taiwan's hot coil-making capacity recently, which might explain part of this development. The economy is slightly specialised in wire rods, although only in value terms.

European economies in this group are specialised in some flat products, such as tin plates and tin-free. Their trade specialisation patterns have not changed much since 2010. Germany is specialised in tin plates and tin-free, with RSCA values greater than 0.3 in volume and value terms in 2015. Although Germany's RSCA values for electrical sheets is quite low in value terms, the economy is quite specialised in the product in volume terms, with RSCA indices higher than 0.2 both in 2010 and in 2015. Germany has a slightly different structure; the economy is relatively specialised in a number of long products, such as wire rods and sections as well as pipes and tubes. France is the most focussed on the export of tin plates and tin-free, with RSCA values greater than 0.2 in volume terms. On the other hand, France's RSCA indices for hot-rolled sheets/strips have increased since 2010, with RSCA values greater than 0.3 in volume terms in 2015.

Group C (EAF-based steelmaking economies)

The trade specialisation patterns in group C vary significantly across economies (Fig. 8a–f). Economies in this group are all EAF-based economies, and therefore, some economies have extremely high RSCA values for a number of long products, although the EAF-oriented production structure might be less linked to the steel export structure compared to the BF/BOF route. India is the most focussed on exports of other steel products, and has tended to be more specialised in the product category since 2010, with RSCA values greater than 0.4 in both volume and value terms in 2015.[24] India's RSCA values for flat products have been increasing slightly in the past 5 years. For example, India's

[21] This is a high-value product; its unit export value was USD 1541 per tonne in 2015.

[22] For example, Hyundai Steel completed its integrated mill project at its Dangjin works by blowing in its three blast furnaces between 2010 and 2013, and thus, South Korea now has two integrated mills. In addition, major South Korean steelmakers have commissioned new plate mills and hot strip mills over the past few years.

[23] Although the economy has the world's highest RSCA value for electrical sheets in volume terms, the export unit value was USD 600 per tonne in 2015.

[24] Steel castings (product code 732599) are the most competitive export product of other steel products in India, with RSCA values greater than 0.8 in both volume and value terms.

specialisation in cold-rolled sheets/strips has increased in the past 5 years, with an RSCA index in volume terms greater than 0.1 in 2015, up from 0.00 in 2010. On the other hand, the USA' RSCA value for rails in volume terms increased from 0.23 in 2010 to 0.44 in 2015, and thus, the economy is by far the most specialised in this product category. In addition, the economy is specialised in pipes and tubes, with RSCA values greater than 0.2 in both volume and value terms in 2015. Mexico is quite focussed on exports of pipes and tubes as well as other steel products, with RSCA values greater than 0.3 in both volume and value terms in 2015.

Turkey, Italy, and Spain are all specialised in a number of long products. Turkey is the most specialised economy in long products within the 15 steelmaking economies, with RSCA values for bars greater than 0.5 both in 2010 and 2015. Moreover, the economy has tended to be more specialised in sections since 2010, with RSCA values greater than 0.3 in both volume and value terms in 2015. On the other hand, Turkey's RSCA values for ingots and semi-finished products in volume terms declined from 0.21 to −0.70 in 2015. Italy's RSCA value for pipes and tubes in volume terms increased from 0.36 in 2010 to 0.44 in 2015, and thus, the economy is by far the most specialised in this product category. Moreover, Italy has comparative advantage in other steel products and bars both in volume and in value terms. On the other hand, Spain has strongly revealed comparative advantages in several long products, from wire rods to rails. In addition, the economy has tended to be more specialised in sections since 2010, with RSCA values greater than 0.7 in volume terms and 0.6 in value terms in 2015.

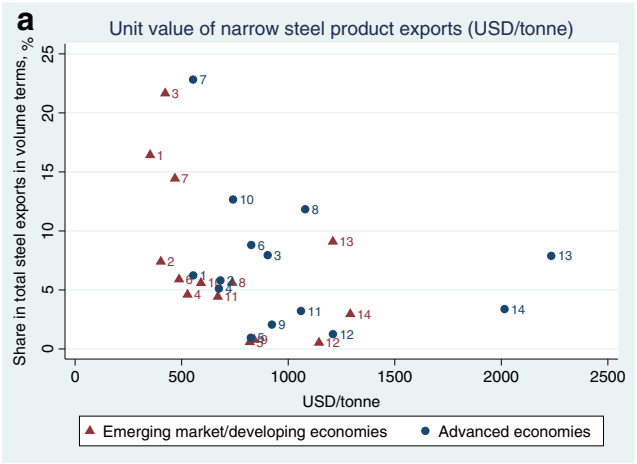


Fig. 9 Unit value and RSCA index values for emerging market/developing economies and advanced economies in 2015. **a** Unit value of narrow steel product exports (USD/tonne). **b** RSCA index values. Notes: The definitions of advanced economies and emerging market and developing economies are based on the IMF (2016). Each code number (1–14) represents product categories. *1* denotes ingots and semi-finished products, *2* denotes wire rods, *3* denotes bars, *4* denotes sections, *5* denotes rails, *6* denotes plates, *7* denotes hot-rolled sheets/strips, *8* denotes cold-rolled sheets/strips, *9* denotes tin plates and tin-free, *10* denotes galvanised sheets, *11* denotes other coated sheets, *12* denotes electrical sheets, *13* denotes pipes and tubes, and *14* denotes other steel products. Source: Author's calculation based on data from the ISSB (2016)

Differences of export structure between emerging market/developing economies and advanced economies

Export structure provides useful information when considering the current level of industry development in emerging market and developing economies as well as advanced economies, and has important implications for productivity level between these economies. Further investigation of export structure could be undertaken through unit value and RSCA index values to examine the differences in export structure in advanced economies versus emerging market and developing economies. Advanced economies have higher unit values for a number of products (e.g. pipes and tubes or other steel products), and the structure of steel exports in advanced economies is more sophisticated than in emerging market and developing economies (Fig. 9a). In fact, the percentage of flat products in the steel exports of advanced economies in volume terms is greater than that of long products, reaching 62.7% in 2015. On the other hand, the flat-to-long product ratio is almost the same at 37:34 in emerging market and developing economies. In other words, low value-added long products have played an important role in the steel exports of emerging market and developing economies.

Turning to RSCA values, advanced economies tend to be specialised in a large number of products, while emerging market and developing economies have comparative advantage in a small number of products Fig. 9a. Advanced economies are specialised in several flat products, such as tin plates and tin-free and electrical sheets. On the other hand, emerging market and developing economies specialise the most in bars within the 14 product groups, followed by ingots and semi-finished products and other coated sheets, although emerging market and developing economies are relatively specialised in pipes and tubes in volume terms.

Implications for rapid growth in emerging market and developing economies in the global steel market

Although some emerging market and developing economies have rapidly converged to advanced economies in terms of steel production/export volume, there is a still huge gap between emerging market and developing economies and advanced economies from the viewpoint of value creation, suggesting that convergence of emerging market and developing economies has been limited.

Another issue to bear in mind when considering steel trade is the link with excess capacity. Some recent studies (Brun 2016; Kawabata 2017) highlight the link between excess capacity and steel exports, suggesting that excess capacity might promote low value-added steel exports in some emerging market and developing economies. Therefore, their rapid growth in steelmaking capacity could lead to large quantities of low value-added steel exports and low level of profitability, thereby accentuating the extent of the excess capacity challenge. In a context of global excess capacity, 'focus on creating and delivering value' (World Steel Association 2015b, p. 18) could be one of the most important strategies for steel firms to help them become more economically viable ultimately.

Conclusion

This study examined patterns of trade specialisation in major steelmaking economies, providing a broad view of linkages between the steel-related export structure, steelmaking technologies, and the level of economic development of each economy. The study showed that the balance between BF/BOF and EAF processes and the stage of an economy's development determine the export structure of major steelmaking economies. Although emerging market and developing economies have played a significant role in the global steel market, advanced economies still have a crucial role to play as key suppliers, especially for high value-added products in global steel trade. Emerging market and developing economies have converged to advanced economies in the sense that they have become major steelmaking economies, but the convergence has been limited in terms of value creation in the steel industry.

This study focused on convergence of emerging market from the viewpoint of a specific industry, and thereby contributing to development of the discussion of convergence in earlier research findings. In addition, the study showed differences in the volume versus value of steel exports, suggesting that focus on steel exports in value terms could be a useful tool to display the difference of steel export structure of each economy.

Although the results of this study provide insight into the relationships between production technologies, the level of economic development, and trade specialisation patterns in major steelmaking economies, the findings raise a number of questions requiring further research.[25] First, are trade patterns affected by the fact that much of steel exports are 'residual' in the sense that exports reflect occasional excess production? Low value-added steel exports might be 'residual' considering the current situation of excess capacity. In addition, it would be useful to link trade specialisation patterns and developments in steelmaking capacity. Second, which factor—production technology or the level of economic development—has been more important in determining trade specialisation patterns? It would be useful to identify factors that explain export patterns and revealed comparative advantage across major steelmaking economies through empirical studies.

A possible area of further study would be to link trade developments and trade specialisation patterns to global value chains (GVCs) alongside developing international division of labour and growing debate over the issue of value creation in the steel industry, whereby steelmakers in some economies import raw materials or inputs (e.g. ingots and semi-finished products or hot-rolled sheets/strips) and transform these into downstream products.[26] These developments could have important implications for raw material markets and global steel markets through the supply chain.

[25] The author thanks an anonymous referee for bringing these issues to attention.

[26] The 82nd Session of the OECD Steel Committee discussed the role of GVCs in the context of the steel industry (OECD 2017). For a discussion on GVCs, see, for example, Gereffi et al. (2001, 2005).

Appendix

Table 5 Steel exports by product and market destination in 2015, % shares of total exports

Group A	China		Russia		Brazil			
	Volume	Value	Volume	Value	Volume	Value	Volume	Value
Ingots and semi-finished	0.0	0.0	51.5	40.9	64.0	45.2	44.1	36.2
Long products	44.4	30.4	12.8	14.6	7.4	10.6	23.7	25.8
Wire rods	11.0	7.6	2.0	1.9	2.9	3.1	6.2	6.0
Bars	28.0	17.9	8.1	9.1	3.7	6.2	13.0	14.7
Sections	4.7	3.9	2.0	2.5	0.7	1.2	5.1	4.8
Rails	0.6	1.0	0.7	1.0	0.0	0.0	0.0	0.3
Flat products	43.5	44.1	30.3	34.3	25.7	29.0	27.7	28.5
Plates	6.8	5.4	2.7	3.3	0.7	1.7	9.0	10.0
Hot-rolled sheets/strips	14.1	12.8	18.2	16.6	16.9	14.6	13.6	12.4
Cold-rolled sheets/strips	5.6	7.1	6.1	6.8	2.9	5.2	4.5	5.2
Electrical sheets	1.1	1.6	0.0	0.1	0.7	1.9	0.0	0.0
Galvanised sheets	8.0	8.0	1.3	1.9	2.9	4.2	0.6	0.8
Tin plates and tin-free	7.4	8.3	0.3	1.0	0.7	1.2	0.0	0.1
Other coated products	0.4	0.7	1.7	4.5	0.0	0.3	0.0	0.0
Pipes and tubes	9.2	19.2	4.0	8.4	2.2	13.4	3.4	8.4
Welded pipes	4.2	6.5	2.7	4.3	0.7	1.4	1.1	2.2
Seamless pipes	4.0	8.0	1.3	3.5	2.2	10.9	2.3	6.1
Pipe fittings	0.9	4.7	0.0	0.5	0.0	1.0	0.0	0.2
Other steel products	3.0	6.3	1.3	1.9	0.7	1.8	0.6	1.1
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
EU28	7.6	8.5	25.6	25.0	14.7	17.4	31.1	30.9
Other Europe	2.9	2.6	19.9	18.1	7.4	4.9	14.7	12.9
CIS	1.4	2.5	17.8	23.8	0.0	0.1	13.6	16.9
NAFTA	3.9	6.9	9.8	9.0	45.6	41.6	1.1	1.8
Latin America	7.5	7.7	1.7	1.8	15.4	20.9	0.6	0.6
Africa	8.2	8.3	8.4	7.3	2.9	2.7	22.6	20.4
Middle East	9.6	9.5	3.7	3.8	1.5	2.9	14.1	14.1
ASEAN	30.9	26.1	1.3	1.4	6.6	4.6	0.0	0.1
Other Asia	27.1	26.7	11.4	9.9	5.9	4.8	2.3	2.2
Oceania	0.7	1.1	0.0	0.0	0.0	0.0	0.0	0.0
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Group B	Japan		South Korea		Germany		Taiwan		France	
	Volume	Value	Volume	Value	Volume	Value	Volume	Value	Volume	Value
Ingots and semi-finished	11.8	5.5	1.6	0.8	7.6	3.9	1.8	1.3	5.7	4.3
Long products	13.0	14.8	9.3	8.0	25.2	18.9	9.8	13.5	14.3	13.8
Wire rods	4.7	5.6	2.9	2.4	10.4	5.8	3.6	4.9	5.0	4.3
Bars	4.2	5.2	1.6	2.0	8.0	8.3	4.5	6.5	7.9	8.7
Sections	2.7	2.3	4.5	3.5	6.4	4.7	2.7	2.1	1.4	0.9
Rails	1.5	1.6	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0
Flat products	70.1	61.4	79.5	71.7	53.2	44.4	82.1	71.1	72.1	55.7
Plates	9.6	9.2	9.6	7.5	8.0	7.5	1.8	2.8	8.6	8.4
Hot-rolled sheets/strips	38.2	23.9	28.8	20.5	16.4	9.0	38.4	21.0	35.0	17.7
Cold-rolled sheets/strips	10.0	12.4	17.9	17.3	9.2	11.7	17.9	24.5	8.6	11.8
Electrical sheets	2.2	2.6	1.3	1.7	3.6	3.5	1.8	1.7	2.9	2.4

Table 5 (continued)

Galvanised sheets	7.6	8.1	13.5	13.6	12.4	8.9	10.7	9.9	12.9	9.1		
Tin plates and tin-free	0.7	1.3	6.7	8.5	2.0	2.3	7.1	7.8	4.3	4.6		
Other coated products	1.7	3.8	1.6	2.6	1.6	1.5	4.5	3.3	1.4	1.7		
Pipes and tubes	4.2	15.0	7.7	14.6	9.6	24.1	4.5	11.0	4.3	18.4		
Welded pipes	2.0	4.2	6.4	8.0	5.6	10.9	3.6	7.4	2.1	7.8		
Seamless pipes	2.2	9.6	0.6	2.3	3.6	7.9	0.0	0.5	2.1	8.4		
Pipe fittings	0.0	1.1	0.6	4.3	0.4	5.3	0.9	3.2	0.0	2.1		
Other steel products	1.0	3.4	1.9	4.9	4.4	8.7	1.8	3.0	3.6	7.8		
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0		
EU28	0.7	3.0	7.7	8.8	77.2	69.7	5.4	7.6	80.7	69.5		
Other Europe	1.0	1.2	3.5	3.7	7.2	7.5	0.9	1.7	7.1	4.8		
CIS	0.2	0.6	0.6	1.2	0.8	1.4	0.0	1.0	1.4	5.0		
NAFTA	10.5	13.4	18.9	19.8	6.8	8.8	14.3	19.1	4.3	7.5		
Latin America	3.4	2.7	2.2	2.6	1.2	1.5	0.9	2.1	0.7	1.2		
Africa	3.2	2.6	0.6	1.0	1.6	1.6	2.7	2.2	2.9	4.4		
Middle East	4.2	4.5	7.4	8.1	0.8	1.5	5.4	6.0	0.7	1.9		
ASEAN	30.4	28.5	20.2	18.9	0.4	1.0	33.9	26.3	0.0	0.6		
Other Asia	45.8	42.5	37.5	34.7	3.6	6.8	33.0	29.6	2.1	4.8		
Oceania	0.5	0.9	1.0	1.1	0.0	0.2	3.6	4.4	0.0	0.3		
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0		
Group C	India		United States		Turkey		Italy		Mexico		Spain	
	Volume	Value	Volume	Value	Volume	Value	Volume	Value	Volume	Value	Volume	Value
Ingots and semi-finished	10.5	4.1	1.0	2.3	2.0	2.3	3.0	2.6	17.9	9.7	2.1	1.7
Long products	7.9	12.4	19.0	13.8	66.9	57.4	30.3	22.0	25.6	16.2	60.4	41.4
Wire rods	2.6	1.8	1.0	1.0	5.4	4.4	6.7	4.0	5.1	2.9	13.5	9.1
Bars	3.9	7.8	9.0	7.9	51.4	42.1	19.4	15.1	12.8	8.9	19.8	14.3
Sections	1.3	2.7	6.0	3.5	10.1	10.1	3.6	2.4	5.1	4.4	26.0	16.2
Rails	0.0	0.1	2.0	1.3	0.0	0.8	0.6	0.5	0.0	0.0	2.1	1.8
Flat products	57.9	42.0	60.0	43.4	16.2	18.2	40.6	31.1	25.6	22.0	26.0	30.2
Plates	7.9	6.4	11.0	7.3	2.0	2.0	7.9	5.1	2.6	1.2	3.1	4.3
Hot-rolled sheets/strips	11.8	7.1	16.0	9.7	10.1	8.2	7.3	4.5	10.3	5.3	7.3	6.4
Cold-rolled sheets/strips	11.8	9.7	13.0	12.5	2.0	4.1	7.9	10.1	7.7	7.6	7.3	11.6
Electrical sheets	0.0	0.5	1.0	0.5	0.0	0.3	0.0	0.2	0.0	0.2	2.1	1.8
Galvanised sheets	18.4	12.2	16.0	9.3	1.4	2.1	13.9	8.0	2.6	2.4	5.2	3.8
Tin plates and tin-free	6.6	5.2	2.0	2.3	0.7	1.4	3.0	2.7	5.1	5.0	1.0	2.2
Other coated products	0.0	0.9	1.0	1.8	0.0	0.1	0.0	0.4	0.0	0.4	0.0	0.0
Pipes and tubes	15.8	22.9	14.0	29.3	12.2	17.3	20.6	34.1	23.1	39.0	6.3	16.2
Welded pipes	11.8	13.3	9.0	10.9	12.2	15.5	16.4	19.6	7.7	8.3	3.1	4.4
Seamless pipes	1.3	3.9	3.0	9.2	0.0	0.5	3.0	6.0	15.4	27.3	2.1	8.4
Pipe fittings	1.3	5.7	1.0	9.2	0.0	1.3	1.8	8.6	0.0	3.5	1.0	3.4
Other steel products	7.9	18.5	5.0	11.3	2.0	4.8	6.1	10.1	7.7	13.1	5.2	10.6
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
EU28	21.1	25.9	3.0	8.2	17.6	22.3	68.5	66.0	2.6	2.7	53.1	59.9
Other Europe	1.3	1.6	0.0	1.0	0.7	0.9	9.1	8.0	0.0	1.0	6.3	5.0
CIS	0.0	0.7	0.0	0.7	2.7	4.0	0.6	2.2	0.0	0.9	0.0	0.7
NAFTA	13.2	19.2	87.0	70.7	16.2	15.7	4.2	6.9	71.8	69.9	6.3	6.7
Latin America	5.3	4.6	4.0	5.6	7.4	6.4	0.6	1.0	23.1	18.3	4.2	4.3
Africa	10.5	8.2	1.0	2.1	20.9	19.7	12.7	7.3	2.6	4.4	24.0	15.0
Middle East	23.7	21.9	1.0	2.1	33.1	29.9	2.4	3.8	0.0	1.6	3.1	3.8
ASEAN	6.6	6.1	1.0	1.9	0.7	0.5	0.6	1.1	0.0	0.4	1.0	2.0
Other Asia	18.4	10.9	3.0	7.1	0.0	0.4	1.2	3.7	0.0	0.8	1.0	2.3
Oceania	1.3	1.0	0.0	0.7	0.0	0.2	0.0	0.2	0.0	0.1	0.0	0.3
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Source: Author's calculation based on data from the ISSB (2016)

Table 6 Revealed symmetric comparative advantage indices for the 15 steelmaking economies in 2010

Code	CHN		RUS		BRA		UKR		JPN		KOR		DEU		TWN	
	Volume	Value	Volume	Value	Volume	Value	Volume	Value	Volume	Value	Volume	Value	Volume	Value	Volume	Value
1	−0.96	−0.95	0.63	0.72	0.60	0.68	0.54	0.67	−0.13	−0.16	−0.54	−0.55	−0.30	−0.33	−0.54	−0.49
2	0.01	−0.01	−0.32	−0.27	−0.03	0.10	0.14	0.21	−0.20	−0.02	−0.45	−0.34	0.30	0.13	−0.20	0.07
3	−0.21	−0.22	−0.24	−0.09	−0.27	−0.08	0.06	0.16	−0.48	−0.34	−0.40	−0.44	−0.11	−0.05	−0.34	−0.26
4	−0.04	−0.07	−0.67	−0.52	−0.64	−0.56	−0.04	0.09	−0.30	−0.32	0.14	0.06	0.06	0.04	−0.23	−0.32
5	0.03	0.02	0.17	0.20	−0.97	−0.90	−0.44	−0.22	0.25	0.30	−0.80	−0.79	0.04	0.03	−0.99	−0.99
6	0.15	0.05	−0.49	−0.42	−0.06	−0.01	0.16	0.23	0.17	0.15	0.05	−0.02	−0.03	0.00	−0.67	−0.57
7	0.11	0.14	0.03	0.17	−0.28	−0.20	−0.22	−0.10	0.23	0.22	0.10	0.15	−0.20	−0.28	0.17	0.12
8	−0.12	−0.17	−0.25	−0.27	−0.30	−0.25	−0.52	−0.56	0.17	0.09	0.32	0.21	0.03	0.02	0.44	0.45
9	0.02	0.05	−0.75	−0.61	−0.04	0.15	−0.99	−0.99	0.05	0.07	0.00	0.02	0.44	0.35	0.01	−0.05
10	−0.03	−0.03	−0.85	−0.74	−0.69	−0.39	−0.95	−0.91	0.20	0.21	0.10	0.11	0.16	0.06	0.21	0.11
11	0.54	0.48	−0.93	−0.86	−0.95	−0.90	−0.95	−0.89	−0.47	−0.34	0.49	0.48	−0.17	−0.18	0.40	0.28
12	−0.50	−0.56	0.21	0.37	−0.76	−0.65	−1.00	−1.00	0.42	0.51	0.36	0.31	0.23	0.04	0.61	0.36
13	0.32	0.17	−0.58	−0.54	−0.64	−0.37	−0.34	−0.31	−0.22	−0.16	−0.08	−0.15	0.14	0.13	−0.36	−0.32
14	0.27	0.05	−0.67	−0.71	−0.45	−0.37	−0.61	−0.70	−0.61	−0.34	−0.14	−0.06	0.18	0.12	−0.31	−0.37
Code	FRA		IND		USA		TUR		ITA		MEX		ESP		Std. dev.	
	Volume	Value	Volume	Value	Volume	Value	Volume	Value	Volume	Value	Volume	Value	Volume	Value	Volume	Value
1	−0.11	−0.04	−0.42	−0.45	−0.51	−0.43	0.21	0.39	−0.46	−0.36	0.38	0.40	−0.64	−0.51	0.51	0.53
2	0.02	0.04	−0.39	−0.24	−0.44	−0.49	0.13	0.18	−0.07	−0.08	0.13	0.07	0.30	0.34	0.25	0.23
3	−0.12	0.01	−0.48	−0.21	0.03	−0.02	0.66	0.64	0.20	0.22	0.04	−0.06	0.43	0.38	0.33	0.28
4	−0.70	−0.67	−0.64	−0.34	0.29	0.14	0.34	0.44	−0.06	−0.18	−0.25	−0.20	0.68	0.62	0.41	0.36
5	−0.97	−0.94	−0.14	−0.16	0.23	0.06	−0.72	−0.42	0.33	0.14	−0.96	−0.96	0.19	0.16	0.53	0.49
6	−0.09	−0.04	−0.63	−0.74	−0.03	−0.14	−0.82	−0.77	0.11	−0.07	−0.86	−0.86	−0.45	−0.28	0.38	0.35
7	0.21	0.13	−0.21	−0.33	0.02	−0.12	−0.59	−0.48	−0.12	−0.23	−0.19	−0.20	−0.20	−0.22	0.23	0.22
8	−0.03	−0.04	0.00	−0.27	0.07	−0.02	−0.76	−0.73	−0.06	−0.11	−0.35	−0.22	−0.28	−0.03	0.31	0.29
9	0.40	0.32	−0.32	−0.41	0.04	−0.29	−0.73	−0.58	−0.68	−0.71	−0.89	−0.84	−0.07	−0.06	0.46	0.43
10	0.12	0.07	0.27	0.19	0.14	−0.02	−0.73	−0.62	0.01	−0.19	−0.26	−0.26	−0.32	−0.35	0.43	0.35
11	0.09	0.07	0.32	0.17	−0.18	−0.22	−0.84	−0.74	−0.32	−0.38	−0.04	−0.04	−0.48	−0.39	0.53	0.47
12	0.04	0.12	−0.58	−0.73	0.30	0.26	−0.96	−0.90	−0.68	−0.68	−0.64	−0.28	−0.94	−0.96	0.58	0.55
13	−0.21	−0.10	0.56	0.40	0.16	0.25	0.01	−0.10	0.36	0.31	0.22	0.24	−0.22	−0.17	0.35	0.28
14	0.03	0.08	0.35	0.28	0.12	0.19	−0.40	−0.35	0.24	0.20	0.17	0.10	0.25	0.16	0.37	0.33

Notes: Each code number (1–14) represents product categories. 1 denotes ingots and semi-finished products, 2 denotes wire rods, 3 denotes bars, 4 denotes sections, 5 denotes rails, 6 denotes plates, 7 denotes hot-rolled sheets/strips, 8 denotes cold-rolled sheets/strips, 9 denotes tin plates and tin-free, 10 denotes galvanised sheets, 11 denotes other coated sheets, 12 denotes electrical sheets, 13 denotes pipes and tubes, and 14 denotes other steel products

Source: Author's calculation based on data from the ISSB (2016)

BRA Brazil, *CHN* China, *DEU* Germany, *ESP* Spain, *FRA* France, *IND* India, *ITA* Italy, *JPN* Japan, *KOR* South Korea, *MEX* Mexico, *RUS* Russia, *TUR* Turkey, *TWN* Taiwan, *UKR* Ukraine, *USA* denotes the United States

Table 7 Revealed symmetric comparative advantage indices for the 15 steelmaking economies in 2015

Code	CHN		RUS		BRA		UKR		JPN		KOR		DEU		TWN	
	Volume	Value	Volume	Value	Volume	Value	Volume	Value	Volume	Value	Volume	Value	Volume	Value	Volume	Value
1	−1.00	−1.00	0.72	0.79	0.74	0.79	0.64	0.74	0.03	−0.06	−0.77	−0.78	−0.20	−0.24	−0.71	−0.65
2	0.36	0.31	−0.54	−0.42	−0.39	−0.20	−0.05	0.13	−0.20	0.10	−0.39	−0.33	0.25	0.12	−0.35	0.03
3	0.46	0.32	−0.31	−0.09	−0.59	−0.27	−0.06	0.16	−0.59	−0.37	−0.81	−0.70	−0.31	−0.14	−0.55	−0.26
4	−0.02	0.00	−0.41	−0.22	−0.70	−0.54	−0.01	0.10	−0.29	−0.27	−0.04	−0.06	0.14	0.09	−0.32	−0.31
5	−0.09	0.11	−0.14	0.07	−0.97	−0.92	−0.73	−0.53	0.39	0.36	−0.97	−0.97	−0.67	−0.65	−0.97	−0.96
6	−0.05	−0.14	−0.47	−0.36	−0.76	−0.61	0.11	0.19	0.14	0.16	0.14	0.05	0.05	0.05	−0.58	−0.42
7	−0.18	−0.01	−0.01	0.13	−0.05	0.06	−0.18	−0.02	0.39	0.33	0.23	0.24	−0.07	−0.19	0.36	0.24
8	−0.27	−0.27	−0.20	−0.26	−0.52	−0.38	−0.31	−0.38	0.07	0.05	0.38	0.22	0.03	0.01	0.36	0.38
9	−0.17	−0.05	−0.91	−0.85	−0.16	0.03	−1.00	−1.00	0.22	0.23	−0.01	0.00	0.47	0.37	0.03	−0.01
10	−0.09	−0.04	−0.78	−0.65	−0.51	−0.35	−0.88	−0.84	−0.10	−0.03	0.20	0.25	0.16	0.02	0.07	0.07
11	0.48	0.43	−0.79	−0.62	−0.69	−0.58	−0.99	−0.97	−0.74	−0.54	0.30	0.36	−0.34	−0.31	0.33	0.30
12	−0.49	−0.39	0.33	0.55	−0.81	−0.63	−1.00	−1.00	0.38	0.52	0.33	0.31	0.29	0.01	0.69	0.42
13	0.06	0.00	−0.36	−0.40	−0.55	−0.18	−0.44	−0.39	−0.35	−0.13	−0.06	−0.14	0.07	0.12	−0.36	−0.27
14	−0.05	−0.08	−0.47	−0.59	−0.75	−0.59	−0.67	−0.74	−0.59	−0.38	−0.22	−0.19	0.16	0.11	−0.40	−0.41
Code	FRA		IND		USA		TUR		ITA		MEX		ESP		Std. dev.	
	Volume	Value	Volume	Value	Volume	Value	Volume	Value	Volume	Value	Volume	Value	Volume	Value	Volume	Value
1	−0.35	−0.18	−0.05	−0.20	−0.78	−0.47	−0.70	−0.46	−0.61	−0.42	0.24	0.23	−0.76	−0.57	0.60	0.57
2	−0.11	−0.05	−0.51	−0.44	−0.64	−0.65	−0.11	−0.02	−0.01	−0.07	−0.10	−0.23	0.35	0.33	0.31	0.28
3	−0.30	−0.12	−0.54	−0.17	−0.22	−0.16	0.59	0.61	0.14	0.17	−0.02	−0.10	0.15	0.14	0.41	0.31
4	−0.60	−0.65	−0.53	−0.18	0.12	−0.06	0.36	0.46	−0.15	−0.25	0.09	0.05	0.71	0.64	0.38	0.34
5	−0.93	−0.92	−0.86	−0.87	0.44	0.22	−0.40	−0.05	−0.10	−0.28	−0.94	−0.95	0.45	0.37	0.55	0.53
6	0.07	0.11	0.04	−0.03	0.21	0.03	−0.59	−0.56	0.05	−0.15	−0.63	−0.71	−0.37	−0.23	0.35	0.29
7	0.31	0.16	−0.22	−0.30	−0.09	−0.15	−0.31	−0.23	−0.46	−0.50	−0.33	−0.43	−0.46	−0.34	0.28	0.26
8	−0.01	0.02	0.14	−0.08	0.20	0.05	−0.66	−0.48	−0.07	−0.06	−0.14	−0.20	−0.11	0.01	0.29	0.24
9	0.29	0.16	−0.38	−0.54	−0.12	−0.55	−0.83	−0.73	−0.73	−0.77	−0.88	−0.84	0.08	0.02	0.48	0.46
10	0.16	0.03	0.34	0.18	0.26	0.04	−0.70	−0.61	0.22	−0.03	−0.55	−0.57	−0.31	−0.39	0.42	0.34
11	0.02	0.04	0.29	0.10	−0.24	−0.31	−0.65	−0.50	−0.12	−0.23	0.15	0.08	−0.48	−0.32	0.48	0.41
12	0.16	0.10	−0.33	−0.26	0.20	0.12	−0.95	−0.88	−0.54	−0.60	−0.68	−0.56	−0.97	−0.97	0.59	0.54
13	−0.35	−0.02	0.32	0.09	0.24	0.22	0.19	−0.05	0.44	0.30	0.47	0.35	−0.15	−0.09	0.34	0.23
14	0.06	0.05	0.43	0.46	0.27	0.24	−0.16	−0.20	0.31	0.19	0.42	0.30	0.29	0.20	0.41	0.37

Notes: Each code number (1–14) represents product categories. 1 denotes ingots and semi-finished products, 2 denotes wire rods, 3 denotes bars, 4 denotes sections, 5 denotes rails, 6 denotes plates, 7 denotes hot-rolled sheets/strips, 8 denotes cold-rolled sheets/strips, 9 denotes tin plates and tin-free, 10 denotes galvanised sheets, 11 denotes other coated sheets, 12 denotes electrical sheets, 13 denotes pipes and tubes, and 14 denotes other steel products

Source: Author's calculation based on data from the ISSB (2016)

BRA Brazil, *CHN* China, *DEU* Germany, *ESP* Spain, *FRA* France, *IND* India, *ITA* Italy, *JPN* Japan, *KOR* South Korea, *MEX* Mexico, *RUS* Russia, *TUR* Turkey, *TWN* Taiwan, *UKR* Ukraine, *USA* the United States

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