Gordon Institute of Business Science
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Factor endowments as predictors of bilateral trade flows between countries

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A research project submitted to the Gordon Institute of Business Science, University of Pretoria, in partial fulfilment of the requirements for the degree of Master of Philosophy (International Business)

28 November 2022

Abstract

Countries enter into bilateral and multilateral trade agreements to exploit the benefits of globalisation, which has enabled the flow and trade of goods and services across multiple markets globally. However, studies focussed on determining the economic factors driving countries to enter into these agreements continue to be limited in literature. Therefore, the aim of this study was to evaluate the influence of factor endowments on bilateral trade patterns between countries. The study applied the Heckscher-Ohlin theorem to explain and understand South Africa's trade flows with its trading partners.

The Heckscher-Ohlin theorem states that differences in countries' factor endowments affect their comparative advantage, particularly their ability to produce and trade goods for specific industries. Using quantitative research strategy and secondary data collected for the period between the first quarter of 2009 and fourth quarter of 2019, this study applied the standard version of the Heckscher-Ohlin model to determine the extent to which Heckscher-Ohlin forces affect South Africa's value-added export flows to China. The study also applied the chain version of the Heckscher-Ohlin model to determine the extent to which the chain version of the Heckscher-Ohlin model can predict South Africa's net trade flows with the rest of the world.

Results from the application of the two models were mixed. Both the standard and chain versions of the model found evidence in support of and against the predictions of the Heckscher-Ohlin theorem. In spite of results contradicting predictions of the Heckscher-Ohlin theorem, the standard version of the model was found to be effective in explaining South Africa's mining and quarrying value-added exports to China, whereas the chain version of the model was effective in predicting South Africa's manufacturing value-added exports to the rest of the world. The study contributed to empirical studies aimed at understanding the sources of comparative advantage between countries. Even this study was limited to South Africa, the principles of the Heckscher-Ohlin theorem can be applied to other countries as well.

Keywords

Comparative advantage, Factors of production, Heckscher-Ohlin, Value-added trade, Relative factor intensities

Declaration

I declare that this research project is my own work. It is submitted in partial fulfilment of the requirements for the degree of Master of Philosophy in International Business at the Gordon Institute of Business Science, University of Pretoria. It has not been submitted before for any degree or examination in any other University. I further declare that I have obtained the necessary authorisation and consent to carry out this research.

Name & Surname

Signature

Contents

List of Figures

List of Tables

1 Chapter 1: Introduction

1.1 Background to the Research Problem

Globalisation has enabled the flow of goods and services across multiple jurisdictions and markets. As a result, countries have entered into several bilateral and multilateral trade agreements to exploit the benefits thereof. In fact, international trade has been identified as one of the drivers of countries' success and prosperity (Juozapavičienė & Eizentas, 2010), and the main driver for economic growth globally (Abendin & Duan, 2021; Mhaka & Jeke, 2018). Whereas literature focussing on the benefits of international trade and globalisation exist, studies aimed at determining the economic factors driving countries to enter into trade agreements have not received a lot of attention (Cole & Guillin, 2015).

Economic relationships between countries, enabled by trade and financial agreements, have resulted in economic successes in some African countries (Mhaka & Jeke, 2018). South Africa is part of the international trade network. Stern and Ramkolowan (2021) describe the South African economy as an open and small economy. The researchers state that, like other smaller economies, South Africa is dependent on international trade. Domestic consumption in the country is satisfied using imports, with exports supporting local production and employment. In 2021, the country accounted for approximately 0.56% and 0.42% of the world's total exports and imports respectively (International Trade Centre [ITC], n.d.-f, n.d.-g).

Stern and Ramkolowan (2021) state that the South African Government has developed and reformed its trading policies over the years. Since 1990, the country has signed several bilateral, multilateral, preferential, and regional trade agreements (Mhaka & Jeke, 2018; Stern & Ramkolowan, 2021), resulting in an increase in the goods and services it trades (Mhaka & Jeke, 2018). Examples of such trade policies and agreements include the introduction of the General Export Incentive Scheme in 1990 and the recent ratification of the African Continental Free Trade Area (Stern & Ramkolowan, 2021) which, according to the South African Revenue Service (2021), is yet to be fully implemented.

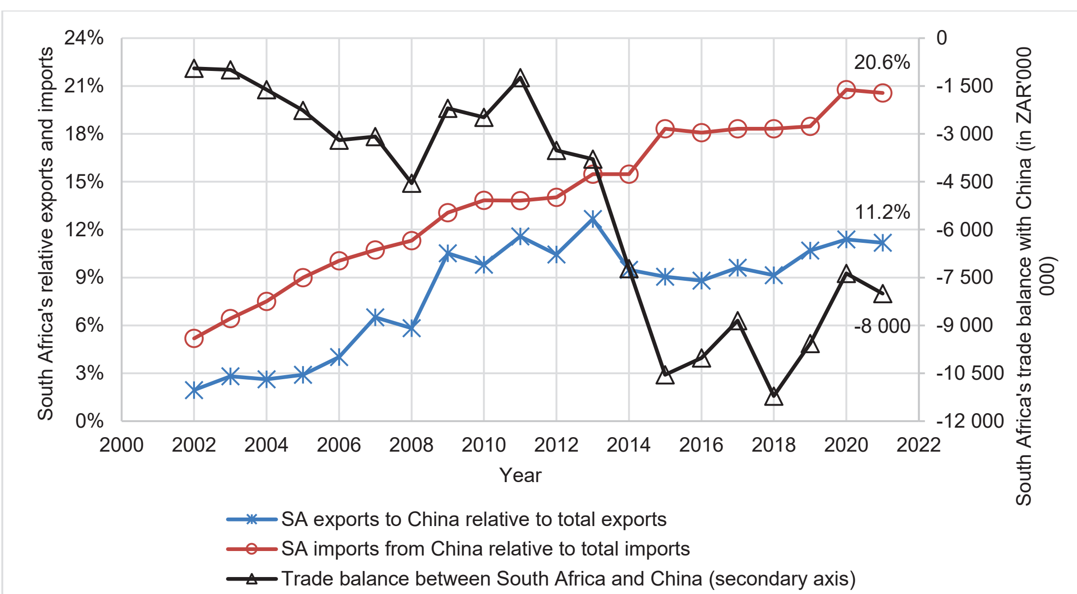
South Africa's economy is classified as small and open (Stern & Ramkolowan, 2021). In 2021, the country contributed about 0.4% to global gross domestic product (GDP) (The World Bank, n.d.). Stern and Ramkolowan mention that for the period between 1990 and 2008, trade openness in South Africa tracked GDP. However, the researchers argue that the country's export growth rate reduced by more than half between 2010 and 2019.

South Africa's main trading partner has been China (Matonana & Phiri, 2020; Mhaka & Jeke, 2018; Stern & Ramkolowan, 2021) since 2009 (Gouvea et al., 2020; Mhaka & Jeke, 2018; Stern & Ramkolowan, 2021). The diplomatic relationship between South Africa and China was established as early as 1998 (Mhaka & Jeke, 2018; Tshedza & Yende, 2021). China is an important partner to South Africa in terms of trade and source of foreign direct investment (FDI) (Gouvea et al., 2020). In 2006, the two countries signed a memorandum of understanding that fostered trade and economic cooperation between them (Stern & Ramkolowan, 2021). However, Mhaka and Jeke (2018) argue that the trade balance between the two countries continues to favour China.

Data from the ITC (n.d.-f, n.d.-g) indicate that, in 2021, China accounted for 11.2% and 20.6% of South Africa's total exports and imports, respectively. In contrast, South Africa accounted for 0.6% and 1.2% of China's total exports and imports respectively in 2021 (ITC, n.d.-a, n.d.-b). Furthermore, the trade balance between the two countries has grown from about ZAR9 billion in 2002 to about ZAR80 billion in 2021, peaking at about ZAR112 billion in 2018 (ZAR represents South African Rands), in favour of China throughout that whole period (ITC, n.d.-c). Figure 1-1-1 presents the full trade statistics between South Africa and China for the period between 2002 and 2021.

Figure 1-1-1

Trade Statistics Between South Africa and China for the Period Between 2002 and 2021



Note. South Africa's relative exports and imports are shown on the primary axis. ZAR represents South African Rands. The trade balance between South Africa and China, shown on the secondary axis, was calculated by subtracting South African imports from China from South African exports to China, i.e., $(\text{South African exports to China})_t - (\text{South African imports from China})_t$, where t denotes year. Data sourced from ITC database.

It is evident from Figure 1-1-1 that, since 2002, there has been a steady growth in South Africa's total imports from China. However, South Africa's exports to China have remained relatively stable since 2009. This has resulted in a significant increase in South Africa's trade balance between China, as shown on the secondary axis of Figure 1-1-1. Coincidentally, the year 2009 is the year in which China became South Africa's largest trade partner in terms of both exports and imports, replacing the United States of America (USA) (Gouvea et al., 2020; Matonana & Phiri, 2020; Mhaka & Jeke, 2018). According to the trade data from ITC, China has since retained and solidified this position up to 2021.

Trade data for South Africa indicate that the country exported mainly raw minerals and metals to China (Mhaka & Jeke, 2018; Stern & Ramkolowan, 2021) and imported mainly China's manufactured products (Mhaka & Jeke, 2018). In 2021, raw minerals and metals constituted about 81% of South Africa's exports to China, whereas machinery, equipment, and vehicles (other than railway or tramway rolling stock), including their associated parts, accounted for about 50% of South Africa's imports from China (ITC, n.d.-d, n.d.-e).

Empirical studies (Hoffmann et al., 2020; Matonana & Phiri, 2020; Mhaka & Jeke, 2018) focussed on understanding the trade patterns and persistent trade skewness between South Africa and China are limited in literature. The study contributed to this knowledge gap and used both the standard version and chain version of the Heckscher-Ohlin theory to explain South Africa's export flows to China, including South Africa's net trade flows.

1.2 Definition of Research Problem and Research Aim

1.2.1 Research Problem

Cole and Guillin (2015) argue that literature on international trade has focussed mainly on determining how trade agreements between countries impact their trade volumes, including how these agreements impact the welfare within each country. The researchers further argue that literature aimed at determining the economic factors driving countries to enter into these trade agreements has not received a lot of attention. Moreover, Ito et al. (2017) contend that the implications of globalisation on trade theory and policy are yet to be fully understood.

One of the international trade theories used to explain trade patterns and sources of comparative advantages between countries is the Heckscher-Ohlin theory. A key insight from the Heckscher-Ohlin theory is that the relative endowments of a country determine the factor intensity of the goods it produces (Schott, 2003). The theory predicts that the scarcity of factor endowments determines a country's trade flows (Bernhofen & Brown, 2016). It evaluates the impact of imperfect factor-mobility on comparative advantages (Takeshima & Kumar, 2021). Chor (2010) and O'Rourke (2006) state that comparative advantages between countries stem from the fact that they differ in their ability to produce for specific industries. Each industry requires certain factor endowments and institutional conditions for production (Chor, 2010). Basically, the Heckscher-Ohlin model is used to explain net trade flows between countries (Cavusoglu, 2019) as it “links relative factor endowments to patterns of international trade” (Koch & Fessler, 2020, p. 2).

The Heckscher-Ohlin model states that a country will export goods that maximise the use of its abundant factor endowments and import goods that require the use its scarce factors (Abendin & Duan, 2021; Akther et al., 2022; Bernhofen & Brown, 2016; Cavusoglu, 2019; Cavusoglu & Elmslie, 2005; Gandolfo & Trionfetti, 2014; Ito et al., 2017; Juozapavičienė & Eizentas, 2010; Koch & Fessler, 2020; Nishioka, 2012; Takeshima & Kumar, 2021). This serves as “the initial reason for both specialisation and foreign trade” (Juozapavičienė & Eizentas, 2010, p. 86).

It therefore becomes evident that a country with an abundance in the required industry-specific factor endowments should have a comparative advantage over other countries producing in that industry. Meaning that, countries should ideally enter into trade agreements that maximise their respective comparative advantages. Several studies (Akther et al., 2022; Blum, 2010, Cavusoglu, 2019; Chor, 2010; Ito et al., 2017; Juozapavičienė & Eizentas, 2010; Koch & Fessler, 2020) have evaluated the predictive ability of the Heckscher-Ohlin theory in explaining trade flows between countries. These studies are largely focussed on understanding the trade relations between the USA and the rest of the world. Koch and Fessler (2020) mention that previous tests on the Heckscher-Ohlin model, mainly conducted using data from the USA, produced results both in support and contradiction of the model.

Despite mixed results, there has also been an emergence of empirical studies (Ito et al., 2017; Koch & Fessler, 2020) that have found evidence that the Heckscher-Ohlin theory is more capable of predicting value-added trade flows between countries instead of gross trade flows. Globalisation has led to the intermediation of goods across multiple borders (Johnson & Noguera, 2017; Koopman et al., 2014). The trading of intermediary products constitutes two-thirds of international trade (Johnson & Noguera, 2012). Producers at different stages of the production process add value to the intermediate products (Koopman et al., 2014). This means that, gross trade statistics often contain value-added trade (Johnson & Noguera, 2012), thus rendering gross trade a less reliable measure of a country’s value added (Koopman et 2014). Ito et al. (2017) argue that, because value-added trade “trace[s] where factors of production are used” (p. 427), it is a better proxy for evaluating Heckscher-Ohlin theory.

The Heckscher-Ohlin model continues to be relevant in modern trade literature, even whilst its criticism remains prevalent. For example, Feenstra (2016) argues that, unless the model relaxes its assumption that countries possess identical technologies, it will remain “an inadequate tool to explain historical or modern trade patterns between countries” (p. 1). The theory has been criticised previously and various modifications to its model have been developed (Takeshima & Kumar, 2021). Meanwhile, Brondino (2021) states that there has been increasing developments in the Heckscher-Ohlin-type models that have either defended or refuted its assumption that trade leads to gains in a country’s abundant endowments and losses in its scarce endowments. In addition, Takeshima and Kumar (2021) argue that the Heckscher-Ohlin theory’s “ideas about the relation[ship] between factor endowments and comparative advantages” (p. 134) are still supported in trade literature. Therefore, there is still value in studies aimed at evaluating trade patterns based on the Heckscher-Ohlin theory.

This study contributes to broader research on trade in four aspects. First, the study adds to research seeking to quantify and understand the impacts of factor endowments on trade patterns and comparative advantages (Akther et al., 2022; Cavusoglu, 2019; Cavusoglu & Elmslie, 2005; Chor, 2010; Ito et al., 2017; Koch & Fessler, 2020; Takeshima & Kumar, 2021), particularly between developing countries. Brondino (2021) states that new models of trade continue to apply the principles of comparative advantage to explain trade patterns. Second, the study builds on empirical studies aimed at evaluating the chain version of the Heckscher-Ohlin theorem. Cavusoglu and Elmslie (2005) note that there is increasing attention in literature on this version of the Heckscher-Ohlin theorem. However, empirical studies (Cavusoglu, 2019; Cavusoglu & Elmslie, 2005) aimed at evaluating this version of the Heckscher-Ohlin theorem were found to be limited in literature.

Third, the study contributes to the continuing debate in literature on the predictive ability of the Heckscher-Ohlin model and its relevance in modern trade (Feenstra, 2016; Guo, 2015a, 2015b; Kiyota, 2021; Paraskevopoulou et al., 2016; Yan & Wang, 2021). Lastly, the study contributes to emerging research using value-added trade as a proxy for trade (Deng et al., 2021; He & Huang, 2021; Ito et al., 2017; Jijun, 2021; Koch & Fessler, 2020). Ito et al. (2017) argue that the implications of fragmented production chains on trade theory and policy are yet to be fully understood. Furthermore, the researchers argue that, because value-added trade identifies the precise location of where the factors of production are used, it is a better proxy for evaluating comparative advantage theories.

This study applied the standard version of the Heckscher-Ohlin model to determine the influence of labour and capital on trade flows between South Africa and China. This was done by regressing value-added exports from South Africa to China with relative country- and industry-level factor intensities. The chain version of the Heckscher-Ohlin model was also applied in this study to determine and rank, from highest to lowest, the factor intensities in each industry sector in South Africa. The ranking was used to determine the order in which the country should produce and export goods more cheaply (Brondino, 2021), thereby maximising its respective comparative advantages.

Empirical studies (Hoffmann et al., 2020; Matonana & Phiri, 2020; Mhaka & Jeke, 2018) evaluating the determinants of the trade flows between South Africa and China were found to be limited. Practically, it is important for policymakers and academics to understand the reasons behind the skewed trade patterns between the two countries, beyond political explanations. Understanding the determinants of trade patterns should be important for policymakers to enable: the development of trade policies that maximise the economic benefits of the current and future trade relationships, renegotiation of current trade agreements, and the design of new bilateral and multilateral trade agreements.

Furthermore, future trade policies need to ensure that South Africa's efforts aimed at growing export volumes are directed at industries that use the country's abundant endowments. This study therefore provides empirical evidence to support such efforts. Studies and modifications to the Heckscher-Ohlin model are more relevant today due to increased trade openness, free flow of capital and labour across countries, and technological differences between countries.

1.2.2 Research Aim

The aim of this study was to evaluate the influence of factor endowments on bilateral trade patterns between countries. This was achieved in two ways. First, by assessing the extent to which Heckscher-Ohlin forces impact South Africa's export flows to China. Second, by assessing the extent to which the chain version of the Heckscher-Ohlin model can predict South Africa's net trade flows with the rest of the world. The Heckscher-Ohlin theory proposes that trade flows between countries should be based on exploiting their respective comparative advantages, i.e., the trade relations should promote the export of goods that require the intensive use of each country's respective abundant resources (Bernhofen & Brown, 2016; Cavusoglu, 2019; Cavusoglu & Elmslie, 2005; Fisher, 2011; Koch & Fessler, 2020; Nishioka, 2012; Takeshima & Kumar, 2021).

1.3 Preface to the Research Study

This study is presented in seven chapters. Chapter 1 provided a brief background to the research problem and the definition of the research problem, aim and questions. The relevance of the study from a business perspective was also discussed in this chapter. Chapter 2 presents a brief description of the literature review and theoretical background to the research and its relevance to the research problem. It serves as a demonstration that the research question and sub-questions for this study are embedded in academic literature. This chapter also presents the conceptual framework for the study.

The research questions, sub-questions, propositions, and hypotheses for this study are described in Chapter 3. Chapter 4 outlines the research methodology and design, including providing a motivation of the suitability of the chosen methodology with the research problem, aim and questions. This chapter also discusses the limitations of the research design and methods, including the ethical consideration for the study. The research results/finding from the study are presented in Chapter 5, whereas Chapter 6 discusses these results in relation to literature. Chapter 7 concludes the report.

2 Chapter 2: Literature Review

Countries enter into bilateral and multilateral trade agreements to enable the flow of goods and services across jurisdictions (Mhaka & Jeke, 2018). Furthermore, globalisation has enabled the flow of resources, both human and non-human, between countries. Globalisation is also responsible for the dispersion of production value chains (Aslam et al., 2017; Brondino, 2021; Ito et al., 2017). Countries are therefore able to participate in the global economy through international trade. However, their ability to participate meaningful and maximise the benefits of international trade is limited by their respective comparative advantages (Abendin & Duan, 2021; Brondino, 2021). A country's comparative advantage is determined by its relative factor endowments (Abendin & Duan, 2021).

This chapter addresses three broad objectives. First, it demonstrates the academic relevance of the identified research problem, and the research question and sub-questions raised in the study. Second, it identifies the knowledge gap in literature based on the assessment and comparison of pertinent literature. Lastly, it develops a conceptual framework outlining the relationship between the research problem, research question, key variables, and interpretive/theoretical framework.

The key themes discussed in this chapter are depicted in Figure 2-2-1. The chapter begins with Section 1 that introduces the comparative advantage concept and its association with international trade and the Heckscher-Ohlin theory. Section 1 discusses the standard version of the Heckscher-Ohlin model and presents literature debates about the applicability of the theory in modern trade. The chain version of the Heckscher-Ohlin model is presented in Section 2.1.2, including literature applications of this version of the theory. Section 2.2 outlines the assumptions of the Heckscher-Ohlin theory. The influence of the type of trade data on the Heckscher-Ohlin predictions is discussed in Section 2.3. Section 2.4 examines the historical context underlying the trade relationship between South Africa and China, and the debates arising in literature around this relationship. Lastly, the chapter is summarised in Section 2.5, which also provides the conceptual framework (see Figure 2-2-3) applied in the study.

Figure 2-2-1

Key Themes for the Literature Review

2.1 Comparative Advantage and the Heckscher-Ohlin Theory

Cole and Guillin (2015) argue that literature aimed at determining the economic factors driving countries to enter into trade agreements has not received a lot of attention. Ito et al. (2017) support this sentiment by arguing that the implications of globalisation on trade theory and policy are yet to be fully understood. Trade agreements have enabled growth in international trade. One of the factors affecting “international trade and the location of economic activit[ies]” (Pflüger & Tabuchi, 2019, p. 2) is comparative advantage (Pflüger & Tabuchi, 2019).

Chor (2010) states that comparative advantage stems from the fact that countries differ in their ability to produce goods and services for specific industries. Furthermore, the researcher notes that each country requires certain factor endowments and institutional conditions for production. Differences in the abundance of factors of production and products’ factor intensity are the underlying determinants for comparative advantage (Abendin & Duan, 2021; Koch & Fessler, 2020). Brondino (2021) argues that the fragmentation of production through global value chains has resulted in deeper degrees of specialisation within countries leading to the maximisation of benefits from international trade and globalisation. Moreover, specialisation has enabled countries to enhance their comparative advantage.

The Heckscher-Ohlin theory has proven to be a useful tool in explaining the sources of comparative advantage between countries. Blum (2010) mentions that, at its core, the Heckscher-Ohlin model posits that the mix of goods produced by a country is determined by changes in the factors of production. In addition, Schott (2003) notes that the Heckscher-Ohlin theory identifies factor endowments as the main determinants for production and trade in a country, meaning that countries specialise in the production of goods "most suited to their relative factor endowments" (p. 688). According to the Heckscher-Ohlin theory, the determinants of trade patterns between countries are relative factor endowments and intensity (Akther et al., 2022). The most well-known outcome of the Heckscher-Ohlin model is that trade promotes growth in the utilisation of a country's abundant factors of production; however, it also results in losses in the utilisation of its scarce factors (Brondino, 2021).

A country that produces and trades commodities that utilise its abundant resources tends to capture a larger share of the global market for those commodities (Romalis, 2004). Jones (1956) points out that the reason for this phenomenon is that, for two countries, where one is capital-abundant and the other is labour-abundant, the opportunity cost of producing a capital-intensive commodity will be lower for the capital-abundant country. Similarly, the opportunity cost of producing a labour-intensive commodity will be lower for the labour-abundant country. This means that, capital-abundant countries will favour the production of capital-intensive commodities, whereas labour-abundant countries will favour the production of labour-intensive commodities (Akther et al., 2022; Fisher, 2011; Fukiharu, 2004; Jones, 1956; Juozapavičienė & Eizentas, 2010; Mhaka & Jeke, 2018).

The Heckscher-Ohlin theory is therefore one of the important theories for explaining international trade, particularly comparative advantage. The theory can be used to explain the role of factor endowments in determining trade flows and specialisation patterns between countries (Bernhofen & Brown, 2016; Brondino, 2021; Cavusoglu, 2019; O'Rourke, 2006). Two versions of the Heckscher-Ohlin trade model are discussed next, namely the standard version and chain version.

2.1.1 The Standard Version of the Heckscher-Ohlin Theory

The Heckscher-Ohlin theory of international trade, also known as the factor proportions or factor abundance theory of trade (Brondino, 2021; Cavusoglu & Elmslie, 2005; O'Rourke, 2006), was first developed by Swedish economists Eli Heckscher and Bertil Ohlin (Jones, 2006, Juozapavičienė & Eizentas, 2010; O'Rourke, 2006). Gandolfo and Trionfetti (2014) state that the standard version of the Heckscher-Ohlin theory is based on a model in which "there are two countries [producing] two final goods [from] two primary factors of production" (p. 63). Jones (1956) refers to this model as "the two-country, two-factor, two-commodity framework" (p. 1), whilst Abendin and Duan (2021) refer to it "as the 2x2x2 model, [i.e.,] two countries, two goods, and two production factors" (p. 4). Similarly, Akther et al. (2022) mention that the theory involves two nations, two factors of production, e.g., labour and capital, and two goods.

For the standard version of the Heckscher-Ohlin model, differences in countries' factor endowments determine their specialisation and international trade patterns (Abendin & Duan, 2021; Gandolfo & Trionfetti, 2014; Koch & Fessler, 2020). Several empirical studies have applied the standard version of the Heckscher-Ohlin model. However, the results from these studies have been mixed and inconclusive, leading to "difficulty in reaching consensus on the empirical validity of [the] factor abundance theory" (Cavusoglu & Elmslie, 2005, p. 404).

One of the applications of the Heckscher-Ohlin theory was conducted by Chor (2010), who applied the theory by extending the model developed by Eaton and Kortum (2002) and used it to explain bilateral patterns of specialisation and industry trade flows across countries. In their model, Eaton and Kortum (2002) represented bilateral trade flows as a function of geographic variables, namely distance between countries, shared border, shared language, and membership to a common trading area and/or treaty. For his study, Chor (2010) extended Eaton and Kortum's (2002) model in several ways. First, he included colony (whether the exporting or importing country was colonised by the trading partner) as one of the geographical variables in the model. Second, he extended the model to include Heckscher-Ohlin variables as independent variables. The Heckscher-Ohlin variables included in the extended model were country- and industry-level skill intensities (skilled labour to total employed labour) and physical intensities (real capital stock to total employed labour).

Lastly, Chor (2010) included institutional variables, namely (a) private credit to gross domestic product; (b) industry dependence on external finance; (c) Herfindahl index of input; (d) strength of a country's legal system; (e) value share of relationship-specific inputs; (f) complexity of job tasks; (g) flexibility of labour institutions; and (h) volatility of sales, as part of the model.

The Herfindahl index of input, formerly known as the Herfindahl–Hirschman Index (HHI), is a proxy for market concentration, it determines the extent to which the market exhibits the characteristics of a monopoly (HHI equal to one) or perfect competition (HHI close to zero) (Naldi & Flamini, 2018).

Using a sample of 83 countries and 20 industries for one analysis year, i.e., 1990, Chor's (2010) results supported the Heckscher-Ohlin predictions. According to the results from the study, skill-abundant countries exported higher volumes in skill-intensive industries. Similarly, capital-abundant countries in the study experienced higher volumes of exports in capital-intensive industries.

Results from other empirical studies also supported the Heckscher-Ohlin predictions. For example, Ito et al. (2017) mimicked the regression model developed by Chor (2010) and used it to evaluate value-added trade flows and gross trade flows in the manufacturing and services sectors. For their study, Ito et al. (2017) specified skill abundance and skill intensity as the only determinants for value-added and gross trade patterns. The researchers defined skilled labour, i.e., non-production workers, as workers with a college degree or higher. Unskilled labour, i.e., production workers, was defined as workers who have below college degree-level qualifications. The skill intensity was then defined as the ratio of hours worked by skilled labour to hours worked by unskilled labour.

Using data from 40 countries and 34 sectors for the period between 1995 and 2009, Ito et al. (2017) found that, for manufacturing sectors, skill-abundant countries have higher volumes of skill-intensive value-added exports. Furthermore, their results also showed that Heckscher-Ohlin forces have a statistically significant impact on value-added exports in manufacturing sectors. However, contrasting results emerged when gross exports were used as the dependant variable in the regression model. For gross exports, Heckscher-Ohlin forces did not have any statistically significant impact on gross exports in manufacturing sectors. These results signify the argument made in literature that the Heckscher-Ohlin theory is more relevant for value-added trade compared to gross trade.

When looking at services trade flows, Ito et al.'s (2017) results were different from the results from manufacturing trade flows. For the services sectors, the researchers did not find any significant difference between value-added export flows and gross export flows. The reason provided for this outcome was that manufacturing sectors have wider global value chains compared to services sectors. Interestingly, the results also showed that capital abundance and capital intensities had no effect on value-added and gross export flows in both manufacturing and services sectors. Furthermore, the researchers also showed that US imports from skill-abundant countries accounted for larger shares of skill-intensive imported commodities. They therefore concluded that the Heckscher-Ohlin theory is being made more relevant by globalisation and the fragmentation of production chains.

A recent empirical study that also evaluated the Heckscher-Ohlin theory using value-added trade flows was conducted by Koch and Fessler (2020). The researchers followed the same approach as Ito et al. (2017). However, Koch and Fessler (2020) provided two different definitions for industry-specific labour-capital endowments and labour-capital intensities. The two definitions provided were factor compensations, i.e., ratio of total labour compensation to capital compensation, and hours worked per capital stock, i.e., ratio of total hours worked to nominal capital stock.

Using a sample of 43 countries and 56 industries for the period between 2000 and 2014, Koch and Fessler's (2020) study produced results that were both in support and contradiction of the predictions of the Heckscher-Ohlin theory. Koch and Fessler's (2020) results supported the Heckscher-Ohlin predictions when the labour-capital endowments and intensities are defined in terms of factor compensations. However, when the labour-capital endowments and intensities are defined in terms of hours worked per capital stock, the results contradicted the Heckscher-Ohlin predictions. The reason provided for this contrasting outcome is that the factor compensations definition implicitly accounts for technological differences between countries.

Furthermore, Koch and Fessler (2020) incorporated skill abundance and skill intensity in their model and their results were comparable to Ito et al.'s (2017) results. Interestingly, their results showed that relative labour endowments and intensities, i.e., labour-to-capital ratios, had a statistically significant impact on value-added trade flows, contrary to the findings from Ito et al. (2017). Additionally, Koch and Fessler (2020) categorised the regression results according to 12 industries and using the factor compensations definition, their results were in support of the Heckscher-Ohlin predictions in nine out of the 12 industries.

Another recent study whose results also supported the Heckscher-Ohlin predictions was conducted by Akther et al. (2022). In their study, the researchers examined the validity of the Heckscher-Ohlin trade model in predicting the relationship between share of Bangladesh imports in US industries and factor intensities. For their model, Akther et al. (2022) selected skill, capital, and raw material intensities as independent variables and share of imports from Bangladesh in US industries as the dependant variable. Using data for the periods 2008 and 2018, their results produced a negative relationship between all three independent variables (factor intensities) and the dependent variable (share of Bangladesh imports in US industries). These results supported the Heckscher-Ohlin predictions in that they showed that Bangladesh, which has an abundance of unskilled labour, has a larger share of US imports in industries requiring low-skilled labour. In contrast, Bangladesh's share of US imports was lower in US industries that are more capital and raw material intensive, which is in line with the Heckscher-Ohlin theory.

Akther et al.'s (2022) study also examined whether Bangladesh's export patterns to the US supported Rybczynski's theory. The theory is similar to the Heckscher-Ohlin theory in that it is also based on a framework underlined by two countries, two goods, and two production factors. Rybczynski's (1955) theory states that an increase in one production factor should result in an increase in the production of goods requiring the intensive use of that factor, whereas the production of other goods that do not require the intensive use of that factor in their production should be reduced. Using the same set of data, Akther et al.'s (2022) results supported Rybczynski's trade predictions. The model results showed that because Bangladesh remained a labour-abundant country between 2008 and 2018, there were minor changes in its trade patterns.

As mentioned before, even though multiple studies have produced results in support of the Heckscher-Ohlin theory, there also exists a substantial number of studies that have produced results that contradict the theory, particularly some of its assumptions as outlined in Section 2. For example, using a sample of 45 countries and 28 manufacturing industries in 1990, Schott (2003) rejected the one-size-fits-all assumption forming the basis of the standard version of the Heckscher-Ohlin theory. Basically, the researcher argues that this version of the model relies on the "single-cone equilibrium in which all countries [of the world] produce all goods using the same technique" (Schott, 2003, p. 704). The cone, formally known as the cone of diversification (Jones, 2011; Schott, 2003), represents the entire range of possible combinations of factor endowments that can be used to produce a mixture of two or more commodities to achieve a trading equilibrium, i.e., maximum utilisation of the available factors of production (Jones, 2011).

Schott (2003) contends that the alternative, far richer, multiple-cone equilibrium provides a better basis for evaluating the Heckscher-Ohlin theory. For the multiple-cone equilibrium, "there are more goods than factors [of production] and countries speciali[s]e in subsets of goods (equal to the number of factors)" (Schott, 2003, p. 688) based on their factor endowments. The researcher concluded that, according to the multiple-cone version of the Heckscher-Ohlin theory, the mix of goods produced by a country is a result of its relative factor endowments.

Similarly, Blum (2010) rejected the Heckscher-Ohlin assumption that states that changes in a country's factor endowments are absorbed by changes in its output-mix. The researcher derived mathematical equations to measure the extent to which changes in a country's outputs absorb the changes in its relative factor supply, including a measurement of the time it takes for the output composition to absorb these changes. Using a sample of 27 countries and 28 manufacturing industries for the period between 1973 and 1990, the researcher proved that changes in factor endowments are predominantly absorbed by changes in production techniques/technologies. Contrary to the expectations of the Heckscher-Ohlin theory, the researcher demonstrated that a country's output mix is unaffected by changes in its factor supply, both in the short-run (over 5 years) and long-run (over 15 years). Blum (2010) therefore concluded that a country's production techniques vary systematically with variations in its factor endowments.

A recent objection to the Heckscher-Ohlin theory was provided by Brondino (2021). The researcher challenged the comparative advantage assumption (within the Heckscher-Ohlin theorem) that states that countries only trade in finished goods that are exclusively produced using domestic factor endowments. Brondino (2021) conducted his study based on the concept of the chain of comparative advantage using mathematical analysis and unit-value isoquants. He argued that the Heckscher-Ohlin is inadequate in explaining recent changes in trade patterns brought about by the intermediation of production chains. Brondino (2021) concluded that factor endowments play a small, if any, role in determining the patterns of specialisation across global supply chains. Basically, he recommended that models that aim to explain the recent changes in trade flows and specialisation patterns should downplay the role played by differences in factor endowments.

Evident from the review of empirical studies evaluating the predictions of the Heckscher-Ohlin theory is the fact that there are mixed and inconclusive results in literature. There are studies in favour (Akther et al., 2022; Chor, 2010; Ito et al., 2017; Koch & Fessler, 2020) and against (Blum, 2010; Brondino, 2021; Koch & Fessler, 2020; Schott, 2003) the theory's predictions. It is for this reason that the study was conducted as it serves as a contribution to the continuing debate in literature on the predictive ability of the Heckscher-Ohlin model and its relevance in modern trade (Feenstra, 2016; Guo, 2015a, 2015b; Kiyota, 2021; Paraskevopoulou et al., 2016; Yan & Wang, 2021).

2.1.2 The Chain Version of the Heckscher-Ohlin Theory

O'Rourke (2006) states that doubts about the Heckscher-Ohlin model have been persistent throughout literature since its initial publication by its developers. The most notable rebuttal of the model came from Wassily Leontief in 1953 (Akther et al., 2022; Jones, 2006).

In his empirical test of the Heckscher-Ohlin model, Leontief’s (1953) results were contrary to the Heckscher-Ohlin theory’s predictions. Leontief (1953) applied the Heckscher-Ohlin model using trade data for the USA and proved that, although the country was capital-abundant in 1947 (Akther et al., 2022; Cavusoglu, 2019, Jones, 2006), its exports embodied higher labour-intensity compared to its imports (Cavusoglu, 2019; Jones, 2006, Koch & Fessler, 2020). Leontief (1953) then concluded that the Heckscher-Ohlin theorem does not hold and this contradictory outcome came to be famously known as the Leontief Paradox (Akther et al., 2022; Cavusoglu, 2019; Jones, 2006, Juozapavičienė & Eizentas, 2010, Koch & Fessler, 2020, Zestos et al., 2021). The Leontief Paradox continues to dominate modern studies (Guo, 2015a, 2015b; Kiyota, 2021; Paraskevopoulou et al., 2016; Yan & Wang, 2021) and textbooks (Feenstra, 2016) on trade.

Post the publication of the Leontief Paradox in 1953, several empirical studies emerged reaffirming its outcomes (Zestos et al., 2021). Unsurprisingly, the Leontief Paradox has also received criticism in literature with the emergence of empirical studies providing support to the Heckscher-Ohlin theorem. One of the earliest critiques of Leontief’s objection to the general Heckscher-Ohlin model was published by an economist Ronald W. Jones. In 1956, Jones proposed the chain version of the Heckscher-Ohlin theory (Cavusoglu, 2019).

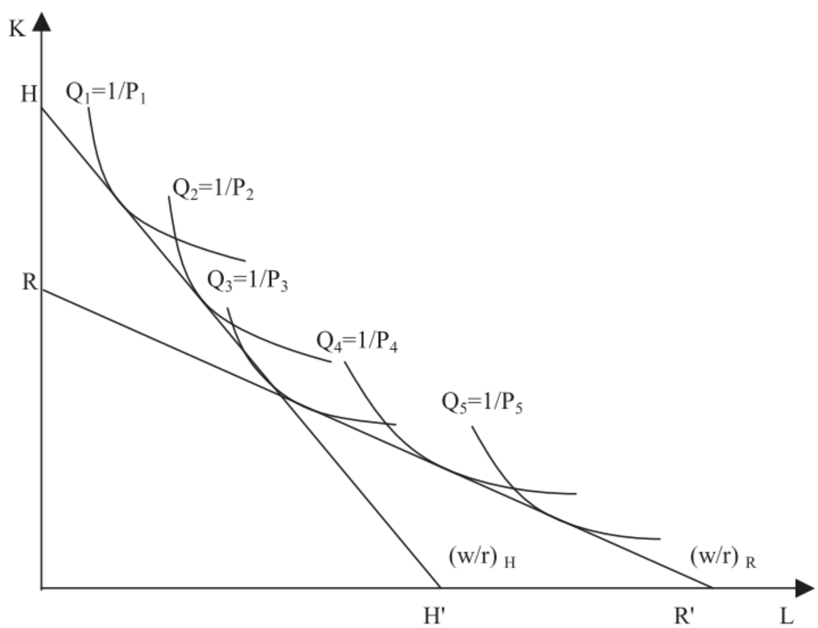
Cavusoglu and Elmslie (2005) explain that the chain version of the Heckscher-Ohlin theory develops a factor intensity ranking list which ranks sector-specific factor intensities, i.e., capital-to-labour ratios, from the highest to the lowest in order to determine trade flows aligned with the comparative advantage theory. The researchers further explain that the chain version of the Heckscher-Ohlin theory is based on an economy with two factors of production, unequal factor prices, and n-goods, where n represents the number of goods produced and traded in a country.

The expectation of the chain version of the Heckscher-Ohlin theory is that capital-abundant countries will have higher capital-to-labour ratios in their export industries compared to their import industries, whereas labour-abundant countries will have lower capital-to-labour ratios in their export industries compared to their import industries (Cavusoglu, 2019; Cavusoglu & Elmslie, 2005; Jones, 1956). Meaning that, capital-abundant countries will be net exporters in capital-intensive industries and labour-abundant countries will be net exporters in labour-intensive industries.

An example of a Lerner diagram illustrating the chain version of the Heckscher-Ohlin theorem for five separate sectors is shown in Figure 2-2.

Figure 2-2

Chain Version of the Heckscher-Ohlin Theorem



Note. The lines H-H' and R-R' represent unit isocost lines between two countries or regions trading with each other. A capital-intensive country will have a steeper unit isocost lines, i.e., H-H' line. Reprinted from "The chain version of Heckscher-Ohlin theory correctly predicts U.S. trade flows!," by N. Cavusoglu, 2019, *International Economics, 157*, p. 172. Copyright 2018 by Centre d'Etudes Prospectives et d'Informations Internationales.

According to the chain version of the Heckscher-Ohlin theory, capital-abundant countries will export goods from sectors with higher factor intensities, meaning those that rank higher on the factor intensity ranking list (Cavusoglu & Elmslie, 2005). This is because exports from capital-abundant countries entail goods with higher capital-to-labour ratios. In contrast, labour-abundant countries will export goods from sectors with lower factor intensities, meaning those that rank lower on the factor intensity ranking list (Cavusoglu

& Elmslie, 2005). This is because exports from labour-abundant countries consist of goods with lower capital-to-labour ratios.

In his rebuttal of Leontief's findings, Jones (1956) applied the chain version of the Heckscher-Ohlin theorem and argued that Leontief's conclusions should not be accepted since they pertained results that were inconsistent with common knowledge about America's factor endowments. Jones (1956) provided a mathematical argument proving that the Heckscher-Ohlin theorem holds for America. He outlined several reasons why Leontief's application of the Heckscher-Ohlin theorem was incorrect. First, he highlighted the fact that Leontief (1953) applied the Heckscher-Ohlin theorem in reverse. Basically, Leontief inferred America's factor endowments from its trade patterns. Jones (1956) pointed out that in doing so, Leontief overlooked the impacts of other factors, such as demand conditions (for example taste), on trade patterns. Jones (1956) argued that the correct way to apply the Heckscher-Ohlin theorem is to use factor endowments to determine trade patterns, not the other way around.

Second, Jones (1956) also pointed out that Leontief compared the factor intensities (capital-to-labour ratios) in America's exports to the factor intensities in its import-competing products. Using the results from comparing the factor intensities of America's exports and import-competing products, Leontief (1953) concluded that the Heckscher-Ohlin theorem does not hold as it portrays America as a labour-abundant country. Subsequently, Jones (1956) then argued that the problem with using this method of determining the validity of the Heckscher-Ohlin theorem is that it does not compare America's factor intensities with the factor intensities of the countries where its exports are destined, and the source of its imports. Based on these reasons, among others, Jones (1956) proved and concluded that Leontief's method of comparing the factor intensities of America's exports and its import-competing products provided no information about the country's relative factor endowments in comparison to the rest of the world.

Since its publication in 1956, the chain version of the Heckscher-Ohlin model has not received sufficient empirical testing. Apart from Jones (1956), there has been limited studies (Cavusoglu, 2019; Cavusoglu & Elmslie, 2005) that have applied this version of the Heckscher-Ohlin theorem. The first empirical test, using data, of the chain version of the Heckscher-Ohlin theorem was conducted by Cavusoglu and Elmslie (2005). In their study, Cavusoglu and Elmslie (2005) applied the chain version of the Heckscher-Ohlin theorem to analyse trade flows between the USA and the rest of the world across nine manufacturing sectors, for the period between 1970 and 2000. The rest of the world was represented by 11 member countries of the Organisation for Economic Co-operation and Development (OECD), namely “Belgium, Canada, Denmark, France, Germany, Italy, Japan, the Netherlands, Norway, Sweden, [and] the United Kingdom” (p. 409).

Cavusoglu and Elmslie (2005) assumed and proved that USA was capital-intensive compared to the rest of the world. However, the findings from Cavusoglu and Elmslie’s (2005) study did not support the predictions of the chain version of the Heckscher-Ohlin theory. The results showed that USA was a net exporter of both capital-intensive and labour-intensive goods, thus contradicting the Heckscher-Ohlin theorem. The researchers argued that one of the reasons for the unexpected outcome from their study was the fact that productive capital stock was used as a proxy for physical capital. Productive capital stock measures gross investments and requires an estimation of “the service lives and age-efficiency patterns of the capital stock for each sector” (Cavusoglu & Elmslie, 2005, p. 417).

Cavusoglu and Elmslie (2005) conclude that average gross investment, i.e., gross fixed capital formation, would be a better proxy for capital stock, instead of productive capital stock, as it does not require the use of estimated or assumed values. Apart from that, when the researchers ranked industries according to their respective investment to labour ratios, America’s net trade flows with the rest of the world could be predicted using relative factor endowments. This was in line with the predictions of the chain version of the Heckscher-Ohlin theory.

Furthermore, Cavusoglu and Elmslie (2005) argue that the other reason their results contradicted the Heckscher-Ohlin theorem was because the period of analysis (time horizon) for the study was too short to cancel the “noise” in net trade flows. The researchers argue that there is a positive relationship between the time horizon of the study and the predictive ability of the chain version of the Heckscher-Ohlin model. Additionally, the researchers argue that the strong international demand for American assets and its currency distorts the country’s net trade balances, resulting in large trade deficits. It is for this reason that the researchers conclude that other countries with more balanced trade should be considered to evaluate the chain version of the Heckscher-Ohlin theory instead of America.

In an effort to explain the findings from Cavusoglu and Elmslie’s study, Cavusoglu (2019) also evaluated the chain version of the Heckscher-Ohlin theorem using data from the USA for the period between 1970 and 2009. In her study, Cavusoglu (2019) used gross capital stock as a proxy for physical capital. The researcher also extended the study to include the services sectors, in addition to the manufacturing sectors, in the analysis.

Cavusoglu and Elmslie's (2005) study only considered manufacturing sectors in their analysis. Cavusoglu's (2019) study supported the predictions of the chain version of the Heckscher-Ohlin theorem, i.e., USA was a net exporter in manufacturing and services sectors where it had the highest capital-to-labour ratios. Similarly, the country was a net importer in manufacturing and services sectors where it had the lowest capital-to-labour ratios. Cavusoglu's (2019) results provided evidence that, during the period between 1970 and 2009, the USA was a net exporter of capital-intensive goods and services, and a net importer of labour-intensive goods and services.

It is evident that empirical studies applying the chain version of the Heckscher-Ohlin theorem are limited in literature. Furthermore, previous studies (Cavusoglu, 2019; Cavusoglu & Elmslie, 2005), that have applied this version of the theorem, produced mixed results with respect to the predictions of the chain version of the Heckscher-Ohlin theorem. With that in mind, this study therefore serves as an important contribution to empirical studies aimed at evaluating the chain version of the Heckscher-Ohlin theorem.

The study evaluated the chain version of the Heckscher-Ohlin theory on other countries, namely South Africa and China, as recommended by Cavusoglu and Elmslie (2005). Both the standard version and chain version of Heckscher-Ohlin model are based on certain assumptions that form the basis of the underlying theory.

2.2 Assumptions for the Heckscher-Ohlin Theory

Like other economic theories, the Heckscher-Ohlin theory is based on certain assumptions. Akther et al. (2022), Bernhofen and Brown (2016), Blum (2010), Cavusoglu (2019), Gandolfo and Trionfetti (2014), Juozapavičienė & Eizentas (2010), Nishioka (2012), Schott (2003), and Tombazos et al. (2005) identify the following assumptions as the basis for the Heckscher-Ohlin theory:

- Consumer preferences are homogenous
- The international market knows the prices of tradeable goods
- The economy gains from trade and factor pricing are equal globally
- All changes in factor endowments are absorbed by changes in output-mix
- Markets exhibit perfect competition, with all countries being small and allowing an open economy
- Countries participating in a similar industry apply the same production techniques/technologies
- Two factors of production, namely capital and labour, are used to produce tradeable goods in an economy

- Technology returns to scale are constant amongst countries, meaning that, all countries have identical technologies
- Production factors can be substituted perfectly across a country's sectors. These factors are limited in supply and are not tradeable across countries
- The factor content of trade, i.e., quantities of factor endowments used to produce tradeable goods, should be calculated based on the factor inputs used at the production facility where the tradeable goods are produced.

These assumptions are applicable to both the standard version and chain version of the Heckscher-Ohlin model. Some of these assumptions have served as the basis for arguments made against the Heckscher-Ohlin theorem (Blum, 2010; Brondino, 2021; Schott, 2003), thus initiating the need for further refinements of the Heckscher-Ohlin model over the years (Fisher, 2011; Fukiharu, 2004; Guo, 2015a; Tombazos et al., 2005). Even though the assumptions of the Heckscher-Ohlin theory have served as the main reason for most of the refinements to the Heckscher-Ohlin model, there is evidence that inputs to the model can also influence the outcomes of the model predictions. One of the inputs influencing the Heckscher-Ohlin model predictions is the type of trade data used, i.e., gross trade versus value-added trade.

2.3 Influence of the Type of Trade Data on the Heckscher-Ohlin Predictions

Cavusoglu (2019) states that, since the release of Leontief's results, many studies have been undertaken which aimed at further evaluating the applicability of the Heckscher-Ohlin model. As mentioned earlier, these tests (Brondino, 2021; Blum, 2010; Chor, 2010; Ito et al., 2017; Koch & Fessler, 2020, Schott, 2003) have produced mixed and inconclusive results. One the reasons provided in literature to explain the diverse empirical results is the fact that previous studies, aimed at evaluating the predictive ability of the Heckscher-Ohlin model, used gross trade data instead of value-added trade data (Koch & Fessler, 2020). The literature denotes that the two sets of data, namely gross trade and value-added trade, measure distinct aspects of a country's international trade flows.

For example, gross exports represent the total output of a country to the rest of the world (Asmal et al., 2017), while value-added exports represent the value-added goods produced in one country and exported to other countries (Asmal et al., 2017; Johnson & Noguera, 2017). Value-added exports account for the use of imported inputs in exports, the presence of exported goods in imported inputs, and the processing of exported inputs in third-world countries (Johnson & Noguera, 2017). Interestingly, globalisation and its associated impact on production and supply chains have been identified as one of the main causes of the discrepancies between gross trade and value-added trade data (Ito et al., 2017; Johnson & Noguera, 2012, 2017; Koopman et al., 2014).

Globalisation has led to the cross-border distribution of production chains (Aslam et al., 2017; Ito et al., 2017) and the establishment of global value chains (Aslam et al., 2017). This integration means that intermediate production inputs cross multiple international borders several times (Johnson & Noguera, 2017; Koopman et al., 2014) before being included in the final product. Johnson and Noguera (2012) state that intermediate inputs trading constitutes nearly two-thirds of international trade. Koopman et al. (2014) note that, at each stage of a production process, a producer adds value to the final product by deploying factors of production. The producer then adds the cost of the value added by the deployed factors of production to the cost of the intermediate good used in the next stage of production.

Traditional trade statistics often use gross trade flows to estimate the performance of the domestic economy (Asmal et al., 2017). The intermediation of goods across global value chains means that a portion of gross trade flows contains value-added trade (Johnson & Noguera, 2012). This leads to gross trade data and statistics to be rendered inaccurate, inadequate, ineffective, and less dependable (Asmal et al., 2017; Johnson & Noguera, 2012, 2017; Koopman et al., 2014). Conventional gross trade data usually measure the value of goods crossing national borders without accounting for the value added at different stages of the production process (Johnson & Noguera, 2017). The use of traditional gross trade data means that domestic content in exports is often overestimated, i.e., double-counted (Ito et al., 2017; Johnson & Noguera, 2012; Koopman et al., 2014).

Koopman et al. (2014) note that, discrepancies between gross trade and value-added trade have been identified by previous case studies on global value chains. Trade balances measured in terms of value-added trade and gross trade have produced differing results (Johnson & Noguera, 2012). In some instances, the trade deficit between two countries was found to be lower when measured on a value-added basis instead of a gross-trade basis, and vice versa.

Ito et al. (2017) argue that because value-added trade identifies the precise location of where the factors of production are used, it is a better proxy for evaluating comparative advantage theories, such as the Heckscher-Ohlin theory, as opposed to using gross trade data. This argument is supported by Johnson and Noguera (2012) who also argue that the appropriate measure of domestic value added should be the one that calculates “the net value added between border crossings” (p. 224). Furthermore, Ito et al. (2017)

argue that the Heckscher-Ohlin predictions are better fitted with value-added trade data compared to gross trade data. Furthermore, Ito et al. (2017) were among the first researchers to evaluate the Heckscher-Ohlin model using value-added trade data instead of gross trade data. This study used value-added export data to evaluate the ability of the standard version of the Heckscher-Ohlin theory to explain trade flows between South Africa and China. In addition, the study used value-added net trade data to predict trade flows between South Africa and the rest of the world.

2.4 Trade Relations between South Africa and China

China is an important partner to South Africa in terms of trade and source of FDI, the relationship between the two countries involves both economic and political dimensions (Gouvea et al., 2020). Diplomatic relations between South Africa and China began in 1998 (Mhaka & Jeke, 2018; Tshedza & Yende, 2021). Both countries have invested in each other's domestic markets (Gouvea et al., 2020). South Africa has been China's largest trading partner in Africa since 2009 (Gouvea et al., 2020; Matonana & Phiri, 2020; Mhaka & Jeke, 2018). Furthermore, the country hosts most of the Chinese projects, funded through FDI, in the continent (Gouvea et al., 2020). China is also the top destination for South Africa's exports and imports (Gouvea et al., 2020; Matonana & Phiri, 2020; Mhaka & Jeke, 2018; Stern & Ramkolowan, 2021).

There exists divergent views regarding South Africa's trade relationship with China. Shoba (2022) states that, on the one hand, there are those who view this relationship as beneficial for promoting economic development, whereas on the other hand there are those who caution that Chinese presence in Africa may threaten the sovereignty of African states.

There has also been concerns that Chinese exports into South Africa are being traded at below market value, representing a trading practice known as dumping, which others argue is harmful to the South African economy (Tshedza & Yende, 2021). Furthermore, Mhaka and Jeke (2018) argue that the trade relationship between South Africa and China is mostly favouring China.

Empirical studies (Mhaka & Jeke, 2018) evaluating the trade relationship between South Africa and China are limited in literature. This is despite the fact that debates about the economic relationship between the two countries continue to be prevalent. Studies aimed at evaluating the extent to which this relationship is informed by economic principles, e.g., Heckscher-Ohlin forces, are therefore necessary. Therefore, the aim with this study is to contribute to this knowledge gap by conducting a quantitative assessment of the trade flows between South Africa and China using the Heckscher-Ohlin model.

This study evaluated the degree to which South Africa's factor endowments influence its bilateral trade flows with China. The study aimed to demonstrate whether economic factors such as factor endowments and exploitation of comparative advantage inform the continued trade relationship between South Africa and China. Furthermore, this study evaluated the extent to which the skewed trade balance between the two countries can be explained by the Heckscher-Ohlin theorem.

2.5 Conclusion

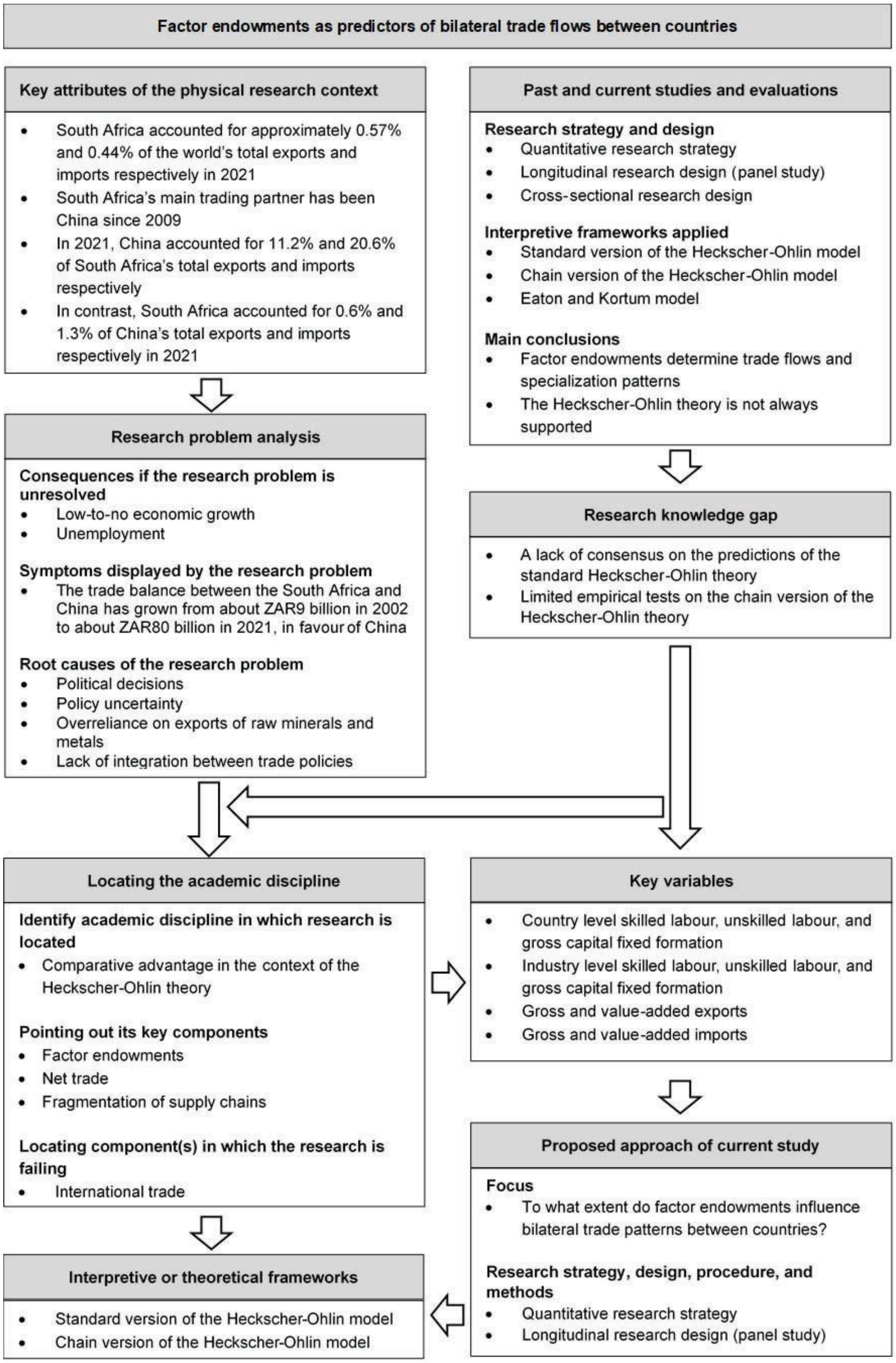
Globalisation has led to growth in international trade and economic prosperity. However, the understanding of the impact of globalisation on trade theory and policy is yet to be fully developed (Ito et al., 2017). Cole and Guillin (2015) state that there exists a need for literature aimed at the determining the basis on which countries enter into trade agreements (Cole & Guillin, 2015). This literature deficit became the basis for conducting this study. Some of the outcomes of globalisation include the fragmentation and intermediation of production through global supply chains (Aslam et al., 2017; Brondino, 2021; Ito et al., 2017). This disintegration has resulted in deeper degrees of specialisation within countries (Brondino, 2021).

One of the international trade theories used to explain trade patterns and sources of comparative advantage between countries is the Heckscher-Ohlin theory. The theory predicts that the scarcity of factor endowments determines a country's trade flows (Bernhofen & Brown, 2016). Like other economic theories, it is based on certain assumptions. Several versions of the Heckscher-Ohlin model have been developed and evaluated in literature over the years, producing mixed and inconclusive results (Cavusoglu & Elmslie, 2005). One of the reasons provided for the inconsistent results is the fact these empirical studies applied the Heckscher-Ohlin model using gross trade data instead of value-added data. Ito et al. (2017) argue that the Heckscher-Ohlin predictions are better fitted with value-added trade data compared to gross trade data.

This study applied both the standard version and chain version of the Heckscher-Ohlin model to evaluate the role of factor endowments in determining trade flows between countries. The study used factor endowments, i.e., labour and capital, to explain the trade flows between South Africa and China for the period between first quarter of 2009 and fourth quarter of 2019. The conceptual framework applied in this study is depicted in Figure 2-2-3.

Figure 2-2-3

A Conceptual Framework for Evaluating the Role of Factor Endowments in Predicting Bilateral Trade Flows Between Countries



Note. Adapted from "Conceptualising Conceptual Frameworks in Public and Business Management Research," by K. Wotela, 2017, p. 378. Copyright 2017 by K. Wotela.

3 Chapter 3: Research Questions and Propositions

The objective of this chapter is to present the main research question and related sub-questions posed to address the research problem outlined in Section 1.2.1 and achieve the research aim presented in Section 1.2.2. The literature background underlying the research questions (main question and two sub-questions) in this chapter was discussed in Chapter 2. Chapter 3 begins with the presentation of a literature argument to justify the main research question raised in the study. Similarly, literature arguments are also presented for each sub-question. Thereafter, research propositions are formulated for each sub-question.

Countries differ in their ability to produce goods and/or services for specific industries and this difference gives rise to an economic concept called comparative advantage. There exist several international trade theories that can explain the sources of comparative advantage between countries, one of which is the Heckscher-Ohlin theory. According to the Heckscher-Ohlin theorem, a country's production patterns and trade flows are determined by scarcity of its factor endowments (Bernhofen & Brown, 2016; Schott, 2003). The main research question for the study is therefore the following:

> **Main research question**: To what extent do factor endowments influence bilateral trade patterns between countries?

This research question seeks to understand and explain the trade relationship between South Africa and China. Diplomatic relations between South Africa and China were developed as early as 1998 (Mhaka & Jeke, 2018; Tshedza & Yende, 2021). This relationship was strengthened by the signing of a memorandum of understanding in 2006, this memorandum fostered trade and economic cooperation between the two countries (Stern & Ramkolowan, 2021). Since then, trade balance between the two countries has grown in favour of China, leading several researchers (Mhaka & Jeke, 2018; Tshedza & Yende, 2021) to conclude that this trade relationship only benefits China whilst being harmful to the South African economy.

The main research question was addressed using the following research sub-questions:

> **Research sub-question 1:** To what extent do Heckscher-Ohlin forces impact South Africa's export flows to China?

> **Research sub-question 2:** To what extent does the chain version of the Heckscher-Ohlin model predict South Africa's net trade flows with the rest of the world?

3.1 Motivation for Research Sub-question 1, and Formulation of Research Hypothesis 1 and Research Proposition 1

The first sub-question aimed to contribute to the continuing literature debate on the predictive ability of the standard version of the Heckscher-Ohlin theory and its relevance in modern trade (Feenstra, 2016; Guo, 2015a, 2015b; Kiyota, 2021; Paraskevopoulou et al., 2016; Yan & Wang, 2021). The standard version of the Heckscher-Ohlin theory states that differences in countries' factor endowments and intensities, i.e., Heckscher-Ohlin forces, determine their production, specialisation, and international trade patterns (Abendin & Duan, 2021; Gandolfo & Trionfetti, 2014; Koch & Fessler, 2020).

Empirical studies that have applied the standard version of the Heckscher-Ohlin model have produced mixed and inconclusive results (Cavusoglu & Elmslie, 2005). Results in favour (Akther et al., 2022; Chor, 2010; Ito et al., 2017; Koch & Fessler, 2020) and against (Blum, 2010; Brondino, 2021; Koch & Fessler, 2020; Schott, 2003) the model's predictions have been presented in literature studies. In addressing the first research sub-question, the standard version of the Heckscher-Ohlin model was applied to determine the extent to which South Africa's value-added export flows to China can be explained by the model. Therefore, the following research hypothesis and proposition were formulated for the first research sub-question:

> **Research hypothesis 1 (H1):** Heckscher-Ohlin forces significantly affect South Africa's value-added export flows to China
>
> **Research proposition 1:** Heckscher-Ohlin forces can be used to predict and explain South Africa's export volumes to China.

3.2 Motivation for Research Sub-question 2 and Formulation of Research Hypothesis 2 and Research Proposition 2

The purpose of the second sub-question was to determine the extent to which South Africa's net trade flows with the rest of the world can be explained by the chain version of the Heckscher-Ohlin model. The chain version of the Heckscher-Ohlin model develops a factor intensity ranking list which ranks sector-specific factor intensities, i.e., capital-to-labour ratios, from the highest to the lowest (Cavusoglu & Elmslie, 2005). This ranking list is used to determine a country's trade flows aligned to the comparative advantage theory.

According to the chain version of the Heckscher-Ohlin model, capital-intensive countries are expected to export goods and services with higher capital-to-labour ratios and import those with lower ratios (Cavusoglu, 2019; Cavusoglu & Elmslie, 2005; Jones, 1956). In contrast, labour-intensive countries are expected to export goods and services with lower capital-to-labour ratios and import those with higher ratios (Cavusoglu, 2019; Cavusoglu & Elmslie, 2005).

To address the second research sub-question, the chain version of the Heckscher-Ohlin model was applied to determine the extent to which South Africa's net trade flows with the rest of the world can be explained by the chain version of the Heckscher-Ohlin model. Therefore, the following research hypothesis and proposition were formulated for the second research sub-question:

> **Research hypothesis 2 (H2)**: The chain version of the Heckscher-Ohlin model can predict South Africa's net trade flows
>
> **Research proposition 2:** The respective net trade flows for South Africa can be explained by the chain version of the Heckscher-Ohlin model.

3.3 Summary

A summary of the research question, sub-questions, hypotheses (both null and alternative), and propositions are shown in Table 3-1.

Table 3-1

Summary of the Research Question, Sub-Questions, Hypotheses, and Propositions

Item	Description
Main research question	To what extent do factor endowments influence bilateral trade patterns between countries?
Research sub-question 1	To what extent do Heckscher-Ohlin forces impact South Africa's export flows to China?
Null hypothesis	*Heckscher-Ohlin forces have no influence on South Africa's export flows to China*
Research hypothesis 1 (H1)	*Heckscher-Ohlin forces significantly affect South Africa's value-added export flows to China*
Research proposition 1	*Heckscher-Ohlin forces can be used to predict and explain South Africa's export volumes to China*
Research sub-question 2	To what extent does the chain version of the Heckscher-Ohlin model predict South Africa's net trade flows with the rest of the world?
Null hypothesis	*The chain version of the Heckscher-Ohlin model cannot predict South Africa's net trade flows with the rest of the world*
Research hypothesis 2 (H2)	*The chain version of the Heckscher-Ohlin model can predict South Africa's net trade flows with the rest of the world*
Research proposition 2	*The respective net trade flows between South Africa and the rest of the world can be explained by the chain version of the Heckscher-Ohlin model*

4 Chapter 4: Research Methodology

This chapter identifies and describes the research philosophy (Section 4.1) and assumptions (Sections 4.1.1, 4.1.2, and 4.1.3) applied in structuring and conducting the study. Furthermore, it describes the research design (Section 4.2), i.e., the general plan of how the research question(s) would be answered. The chapter also outlined the research strategy (Section 4.3) for the study, which entailed the collection of numerical data and application of a deductive method of theory development. Moreover, the chapter describes the research population (Section 4.4) and unit of analysis (Section 4.5). The sampling technique applied in this study and sample size are described in Section 4.6. Details about measurement, data Collection, and data analysis are described in Section 4.7. The chapter also discusses data quality measures (Section 4.8), including the ethical considerations (Section 4.9) for the study. The chapter concludes with a description of the limitations of the study (Section 4.10).

4.1 Research Philosophy

Saunders et al. (2019) mention that a research philosophy is concerned with the beliefs and assumptions informing how knowledge is developed. Furthermore, the authors state that these assumptions and beliefs will influence how researchers structure and conduct their research studies, including how they interpret their research findings. The research philosophy is classified into ontological assumptions, epistemological assumptions (Bell et al., 2019; Saunders et al. 2019), and axiological assumptions (Saunders et al., 2019). Other classifications do exist (Bell et al., 2019) but these are not discussed in this study.

4.1.1 Ontological Assumptions

Ontological assumptions are concerned with the theorisation of the nature of reality (Bell et al., 2019; Easterby-Smith et al., 2015; Quinlan et al., 2019). They determine how researchers view the reality of the world around them (Saunders et al., 2019). Two common ontological positions are objectivism and constructivism (Bell et al., 2019; Bryman, 2012). The study adopted the objectivist ontological approach. The objectivist ontological position is based on the understanding that social actors have no influence on social phenomena (Bell et al., 2019; Saunders et al., 2019), meaning that, the natural world, i.e., social phenomena, exists external to social entities (Bryman, 2012; Saunders et al., 2019). An objectivist "believes that there is only one true social reality experienced by all social actors" (Saunders et al., 2019, p. 135).

The study used existing macroeconomic data and an established international trade model, i.e., the standard and chain versions of the Heckscher-Ohlin model, to explain South Africa's trade flows with China. The macroeconomic data used in this study (as described in Section 4.7) are available for all countries involved in international trade. Furthermore, the Heckscher-Ohlin theory posits that a country's factor endowments determine its production and trade patterns. This means that the influence of factor endowments on production and trade patterns (social phenomena) occurs independent of individual countries (social actors). The Heckscher-Ohlin trade theory is applicable to any country involved in international trade. Therefore, the objectivist ontological approach was thus the most appropriate ontological assumption to apply in the study.

4.1.2 Epistemological Assumptions

Epistemological assumptions are concerned with how knowledge about a theory can be gained (Bell et al., 2019). Quinlan et al. (2019) state that epistemology refers to the understanding and creation of knowledge, whereas Easterby-Smith et al. (2015) define epistemology as the theory of knowledge and how it is generated. Epistemological assumptions focus on the acceptability, validity, and legitimacy of knowledge (Saunders et al., 2019). Several epistemological assumptions exist, examples include positivism, critical theory/realism, and postmodernism (Easterby-Smith et al., 2015; Quinlan et al., 2019; Saunders et al., 2019), interpretivism (Bryman, 2012; Quinlan et al., 2019; Saunders et al., 2019), social constructionism (Easterby-Smith et al., 2015; Quinlan et al., 2019), and pragmatism (Saunders et al., 2019).

A positivist epistemological approach was adopted in this study. Knowledge generation in positivism is based on evidence (observations) and is measured using objective methods (Easterby-Smith et al., 2015). The positivist epistemological position is associated with an objectivist ontological position, and it states that the appropriate method of gathering data about a phenomenon is through observation or measurement (Bell et al., 2019). The study was conducted using only measured macroeconomic data for South Africa and China as described in Section 4.7. Therefore, the positivist position was the most appropriate epistemological assumption to apply in the study.

4.1.3 Axiological Assumptions

Axiological assumptions refer to the role of a researcher's own values and ethics on the research being conducted (Saunders et al., 2019). An objectivist axiological position requires that researchers conduct their studies free and detached from their own values and beliefs, meaning that, they should maintain an objective stance throughout the research process (Saunders et al., 2019). This study used an established economic theory, i.e., Heckscher-Ohlin theory, to interpret the research data and results. No personal beliefs or values were applied when interpreting the social phenomena observed as part of the study. The study also used secondary data available from public databases, meaning that, the author neither engaged with human participants nor had any influence on data sourced.

4.2 Research Design

Bell et al. (2019) define a research design as a framework providing guidance on how evidence will be generated to suit the research question and criteria set for the research. A research design represents the general plan of how the research question(s) will be answered (Saunders et al., 2009). Examples of research designs include experimental design, case study, social survey (Bell et al., 2019; Quinlan et al., 2019; Saunders et al., 2009), longitudinal design, comparative design (Bell et al., 2019; Bryman, 2012), action research, archival research, and grounded theory (Quinlan et al., 2019; Saunders et al., 2009). This study applied the longitudinal research design, defined by Adams et al. (2014), Bell et al. (2019), and Quinlan et al. (2019) as the surveying of respondents or a phenomenon multiple times over a period. The longitudinal research design analyses the continuity and changes of a sample over time (Adams et al., 2014; Quinlan et al., 2019).

There are two types of longitudinal research designs, namely panel study and cohort study (Bell et al., 2019; Bryman, 2012). This study adopted the longitudinal panel study which involves the collection of data, multiple times (usually regular intervals), for the same sample over time (Adams et al., 2014). For this study, quarterly secondary data for the period between the first quarter of 2009 and fourth quarter of 2019 were collected for the respective samples used in Sections 5.1 and 5.2.

Though not explicitly expressed, other studies conducting similar research have also applied the longitudinal panel study research design. For example, in his rejection of the Heckscher-Ohlin assumption stating that changes in a country's factor endowments are absorbed by changes in its output-mix, Blum (2010) collected economic data for 27 countries and 28 manufacturing industries for the period between 1973 and 1990.

Similarly, Ito et al. (2017) collected data for 40 countries and 34 sectors for the period between 1995 and 2009 to conduct their tests that produced results in support of the Heckscher-Ohlin predictions. Moreover, Koch and Fessler (2020) also applied the longitudinal panel study research design by collecting data for 43 countries and 56 sectors for the period between 2000 and 2014, to produce results that were both in support and contradiction of the predictions of the Heckscher-Ohlin theory.

In their application of the chain version of the Heckscher-Ohlin theorem, Cavusoglu and Elmslie (2005) collected data for the USA and 11 OECD member countries for the period between 1970 and 2000. Lastly, Cavusoglu (2019) also applied the chain version of the Heckscher-Ohlin theorem and collected data for the USA for the period between 1970 and 2009. For this study, quarterly macroeconomic data for the period between the first quarter of 2009 and fourth quarter of 2019 were sourced.

4.3 Research Strategy

Common research strategies include qualitative research, quantitative research (Bell et al., 2019; Bryman, 2012), and mixed methods research (Bryman, 2012). This study applied the quantitative research strategy. The quantitative research strategy entails the collection of numerical data and application of a deductive method of theory development (Bell et al., 2019, Bryman, 2012). Some of the features of a quantitative research strategy include causality and generalisation (Bell et al., 2019).

The study focussed on determining the causal relationship between factor endowments and trade flows, with the intention of making generalisation statements about the predictive ability of the Heckscher-Ohlin theory. The quantitative research strategy was therefore identified to be the most appropriate research strategy for the study.

Similar studies also applied the quantitative research strategy. For example, Blum (2010) applied the quantitative strategy to determine the relationship between changes in countries output mix and changes in factor endowments. Similarly, Ito et al. (2017) also applied the quantitative research strategy to determine the impact of skilled and unskilled labour on value-added and gross exports respectively. Lastly, Koch and Fessler (2020) applied the same strategy to determine the relationship between value-added exports and labour-capital endowments and intensities.

4.4 Research Population

A research population represents any complete group (Quinlan et al., 2019) or full set of all possible cases or elements of a research (Saunders et al., 2009). It refers to all entities forming the basis of the data gathering process (Easterby-Smith et al., 2015). The population for this study entails all countries in the world participating in international trade. Since the study was focussed on international trade and national factor endowments, any country characterised as an open economy endowed with capital and labour can form part of the population for the study. Similar studies (Akther et al., 2022; Blum, 2010; Chor, 2010; Ito et al., 2017; Koch & Fessler, 2020; Schott, 2003) used the same population as this study to source country data required to conduct their tests.

4.5 Unit of Analysis

The unit of analysis is defined as "the entity that forms the basis of any sample" (Easterby-Smith et al., 2015, p. 99). In positivist epistemological research, the unit of analysis should be identified in advance (Easterby-Smith et al., 2015). Considering that this study was focussed on evaluating and understanding the trade patterns between South Africa and China, its unit of analysis was export flows from South Africa to China for the first research hypothesis (H1), and net trade flows between South Africa and rest of the world for the second research hypothesis (H2).

4.6 Sampling Techniques and Sample Size

Bell et al. (2019), Easterby-Smith et al. (2015), and Quinlan et al. (2019) define sampling as the selection of a subset of the population that will form part of the research. It is a representation of a population or a smaller number of all cases (Saunders et al., 2009). There are two types of sampling techniques, namely probability sampling and non-probability/judgemental sampling (Bell et al., 2019; Easterby-Smith, 2015; Saunders et al., 2009). This study adopted the non-probability sampling technique.

The non-probability sampling technique encompasses any form of sampling whereby a sample is selected in a non-random manner (Bell et al., 2019; Saunders et al., 2009). Non-probability sampling entails the sampling of units based on the researcher's own subjective judgement (Quinlan et al., 2019; Saunders et al., 2009). Bell et al. (2019) state that, for this technique, "some units in the population" (p. 188) have a higher probability of being selected compared to others. The author further states that even though the samples collected during non-probability sampling represent the population, the statistical outcomes of the research using this sampling method are not representative of the population.

Saunders et al. (2009) note that generalisations made based on non-probability sampling are focussed on the theory being evaluated instead of the population itself. Some of the common types of non-probability sampling techniques are quota sampling, convenience sampling (Bell et al., 2019; Easterby-Smith et al., 2015; Quinlan et al., 2019; Saunders et al., 2009), purposive/judgemental sampling, snowball sampling (Easterby-Smith et al., 2015; Quinlan et al., 2019; Saunders et al., 2009), and self-selection sampling (Saunders et al., 2009). This study applied purposive/judgmental sampling.

Saunders et al. (2009) state that purposive sampling affords researchers the discretion to use their own judgement when choosing the cases that enable them to reach their research objective(s). This study focussed specifically on export flows from South Africa to China, and net trade flows between South Africa and rest of the world. The variables in the study have already been identified by existing Heckscher-Ohlin models.

The period of analysis, first quarter of 2009 and fourth quarter of 2019, was chosen such that the start year coincides with the year in which China became South Africa's largest trade partner, i.e., 2009 (Mhaka and Jeke, 2018). The author of this study applied his judgment in choosing the end year for the period of analysis, i.e., 2019. The author decided to exclude the years 2020, 2021 and 2022 from this study to avoid the global economic disruptions and distortions of international trade brought about by the Covid-19 lockdowns and Russia's invasion of Ukraine. Considering that quarterly macroeconomic data for the period between the first quarter of 2009 and the fourth quarter of 2019 were sourced, the sample size for this study consisted of 44 data points for each variable measured.

Previous studies that evaluated the predictive ability of the Heckscher-Ohlin theory also applied the non-probability purposive sampling technique. For example, Schott (2003) applied this technique when selecting 45 countries and 28 manufacturing industries as part of his sample. Similarly, Cavusoglu and Elmslie (2005) applied the same sampling technique to select a sample that includes the USA and 11 OECD member countries.

Blum (2010) also applied non-probability purposive sampling to select 27 countries and 28 manufacturing industries as part of his sample. In a comparable manner, Chor (2010) selected a sample of 83 countries and 20 industries as part of his study. Non-probability purposive sampling was also applied by Ito et al. (2017) in selecting 40 countries and 34 sectors for their study.

Likewise, Cavusoglu (2019) also applied purposive sampling when selecting the USA as the sample for her study. In additional, Koch & Fessler (2020) also applied non-probability purposive sampling to select 43 countries and 56 industries for their sample. Lastly, Akther et al. (2022) selected the USA and Bangladesh to be part of their study using non-probability purposive sampling.

4.7 Measurement, Data Collection, and Data Analysis

This study used secondary quantitative data sourced from secondary sources i.e., the South African Reserve Bank (SARB), Statistics South Africa (Stats SA), and ITC. Secondary data represents existing raw data and/or published summaries from secondary sources (Quinlan et al., 2019; Saunders et al., 2009), whereas quantitative data represent numerical data or data presented in a numeric format (Quinlan et al., 2019). Saunders et al. (2009) state that there are “three main sub-groups of secondary data: [namely] documentary data, survey-based data, and those compiled from multiples sources” (p. 258). Data for this study fall within the multiple-source data subgroup.

Saunders et al. (2009) define multiple-source data as a dataset that is already amalgamated based on various data from other datasets. Additionally, the authors mention that, within the multiple source subgroup, there is area-based data and time series-based data. This study sourced and used time series-based secondary data since it entailed the observation of data over a period. Data for this study were sourced for the period between the first quarter of 2009 and fourth quarter of 2019. Data collected for the study were stored on the author’s Google OneDrive (cloud storage) which can be access using GIBS student email address. Furthermore, the collected data were also submitted as part of the submission for the study.

Similar studies evaluating the predictive ability of the Heckscher-Ohlin theory also sourced secondary data from multiple sources. For example, these studies sourced their data from the National Bureau of Economic Research (Akther et al., 2022; Chor, 2010), U.S. Census Bureau's Center for Economic Studies (Chor, 2010), World Input-Output Database (Ito et al., 2017; Koch & Fessler, 2020), World Bank (Schott, 2003), United Nations Industrial Development Organization (Blum, 2010; Schott, 2003), United Nations General Industrial Statistics (Blum, 2010), United Nations Comtrade database (Akther et al., 2022), and OECD Statistical Analysis database and Bureau of Labor Statistics (Cavusoglu, 2019; Cavusoglu & Elmslie, 2005), to name a few.

Saunders et al. (2009) state that raw quantitative data need to be processed and analysed first before it can be rendered useful. They explain that the common steps followed when analysing quantitative data include data preparation, data entry and checking, data presentation, statistical tests to describe data and examine trends, and statistical tests to identify relationships and differences between variables. Data for this study were analysed using the statistics software SPSS which provided results for normality tests, descriptive statistics, graphs, correlation tables, multivariate linear regressions and the associated model fit tests, including non-parametric tests conducted to compare means.

4.7.1 Data Preparation and Coding

Before applying the equations presented in Sections 5.1 and 5.2 to evaluate H1 and H2, it was important to first assess availability of data for the respective industries in South Africa. Stats SA publishes macroeconomic data for South Africa both on a total economy level and industry level. The macroeconomic data published by Stats SA cover nine industries, namely (a) mining and quarrying, (b) manufacturing, (c) transport, storage, information, and communication, (d) community, social, and personal services (shortened to personal services), (e) Construction, (f) trade, catering, and, accommodation (shortened to trade), (g) electricity, gas, and water (shortened to utilities), (h) agriculture, forestry, and fishing, and (i) finance, real estate, and business services (shortened to business services). Data published by Stats SA include data for both goods and services; however, this study only focussed on goods. Therefore, services were excluded from the data set being assessed.

Concerning the assessment of availability of quarterly value-added export and import data between South Africa and China, and between South Africa and the rest of the world, the ITC database was found to be the only database that reports value-added export and import data, commonly known as trade data, on a granular basis, i.e., by type of products exported and imported. However, this study also discovered that the ITC database publishes value-added trade data according to the Harmonized Commodity Description and Coding Systems (HS) nomenclature. The HS nomenclature is an internationally recognised nomenclature used to classify products and commodities according to their 2-, 4-, and 6-digit HS codes (Mendoza, 2021).

For this study, quarterly 2-digit HS-coded product data from the ITC database were sourced. However, the models applied (see Sections 5.1 and 5.2) required industry-level trade data, meaning that, trade data from ITC database, presented on a product basis, needed to be transformed to an industry basis. The transformation of product level data to industry level data was performed in two steps.

In the first step of the transformation, quarterly 2-digit HS-coded product data, from the ITC database, were collated by Divisions in accordance with the Standard Industrial Classification of All Economic Activities (ISIC) classification system (see Tables Table 1 to Table 4 in Appendices). The collation was done using the classification tool from ISIC Revision 4, sourced from the OECD (OECD, n.d.).

The ISIC classification system is an international reference classification that aggregates and classifies product-level data (HS coded data) according to type of economic activity (ISIC, n.d.). The tool enables countries to collect and report trade data according to type of economic activity. The original version of ISIC was adopted in 1948 and has been revised several times over the years (ISIC, n.d.).

For the second step of the transformation, the respective Divisions were then aggregated according to the ISIC industries (see Tables Table 5 to Table 8 in Appendices). Table 4-1 shows the results of the transformation of the 2-digit HS codes into ISIC industries.

Table 4-1

Transformation of 2-digit HS-codes into ISIC Industries

ISIC Industry	Applicable 2-Digit HS Codes
Mining and quarrying	25-27, 71
Manufacturing	04-05, 07-24, 28-40, 42-46, 49-70, 73-74, 84-85, 90-96
Agriculture, forestry, and fishing	01-03, 06, 41
Transport, storage, information, and communication	86-89

The results from Table 4-1 show that quarterly HS-coded data could only be aggregated for four out of the nine industries covered by Stats SA's data registry, namely (a) mining and quarrying, (b) manufacturing, (c) agriculture, forestry, and fishing, and (d) transport, storage, information, and communication.

An assessment of availability of quarterly country-level employed labour force, fixed capital formation, and value-added export and import (trade) data, and industry-level employed labour force, fixed capital formation, and quarterly value-added trade data, was conducted to ensure that there is sufficient data for all the variables required to apply the equations presented in Sections 5.1 and 5.2. The results from the assessment of availability of quarterly data for the nine industries covered by the Stats SA registry, including the total economy are shown in Table 4-2.

Table 4-2

Assessment of Availability of Quarterly Country-Level and Industry-Level Macroeconomic Data for South Africa

Industry	Availability of quarterly employment data	Availability of quarterly fixed capital formation data	Availability of quarterly value-added trade data
Total economy	Available	Available	Available
Mining and quarrying	Available	Available	Available
Manufacturing	Available	Available	Available
Transport, storage, information, and communication	Available	Available	Available
Construction	Available	Available	Not Available
Trade	Available	Available	Not Available
Utilities	Available	Available	Not Available
Agriculture, forestry, and fishing	Available	Not Available	Available

Note. The country-level (total economy) fixed capital formation data excludes "agriculture, financial intermediation, insurance, government and educational institutions" (Stats SA, 2022b, p. 7).

Based on the results from Table 4-2, the three industries that had sufficient data to form part of the sample for this study were (a) mining and quarrying, (b) manufacturing, and (c) transport, storage, information, and communication. Therefore, the evaluations for H1 and H2 could only be conducted on these three industries.

4.7.2 Statistical Analysis Techniques Used to Evaluate H1

The statistical analysis techniques used to evaluate the first research hypothesis (H1) were descriptive statistics, correlation analysis and regression analysis. H1 was described in Section 3.1 as follows:

> **Research hypothesis 1 (H1):** Heckscher-Ohlin forces significantly affect South Africa's value-added export flows to China.

4.7.2.1 Descriptive Statistics

Descriptive statistics enable the numerical description and comparison of variables (Saunders et al., 2007). This type of statistical function describes and summarises data collected in some way (Leedy & Ormrod, 2010). Descriptive statistics presented as part of the evaluation of H1 were the minimum, maximum, mean, standard deviation, skewness coefficient, and Kurtosis coefficient.

Panik (2012) defines skewness as the degree to which the distribution of the data set departs from symmetry. The skewness coefficient can be assessed using either the mean and median, and/or mode of the data collected. The interpretation of the skewness coefficient is shown in Table 4-3.

Table 4-3

Interpretation of the Skewness Coefficient

Skewness coefficient	**Interpretation**
Value < 0	Distribution of data set is skewed to the left, i.e., mean < median < mode
Value = 0	Distribution of data set is symmetrical, i.e., mean = median = mode
Value > 0	Distribution of data set is skewed to the right, i.e., mode < median < mean

Note. Adapted from "Statistical Inference: A Short Course," by J. Panik, 2012, p. 35. Copyright 2012 by John Wiley & Sons, Incorporated.

The Kurtosis coefficient measures the degree of flatness/roundness of the peak of the data set against a normal (continuous, bell-shaped, and symmetrical) data distribution (Panik, 2012). Table 4-4 shows the interpretation of the Kurtosis coefficient.

Table 4-4

Interpretation of the Kurtosis Coefficient

Kurtosis coefficient	**Interpretation**
Value < 3	Flatter peak compared to that of a normal distribution
Value = 3	Normal distribution
Value > 3	Sharper peak compared to that of a normal distribution

Note. Adapted from "Statistical Inference: A Short Course," by J. Panik, 2012, p. 38. Copyright 2012 by John Wiley & Sons, Incorporated.

4.7.2.2 Correlation Analysis

Correlation analysis is a statistical test used assess the strength of the linear association between variables (Leedy & Ormrod, 2010; Surez et al., 2017), the relationship is measured using a correlation coefficient (Easterby-Smith et al., 2015; Leedy & Ormrod, 2010; Saunders et al., 2007). The correlation coefficient (represented by the term r in this study) can vary between -1 and +1 (Adams et al., 2014; Ratner, 2009; Saunders et al., 2007; Surez et al., 2017), whereby a value of -1 represents a perfect negative correlation, +1 represents a perfect positive correlation (Adams et al., 2014; Ratner, 2009; Saunders et al., 2007), and 0 represents variables that are perfectly independent (Ratner, 2009; Saunders et al., 2007).

The statistical test used to measure correlation coefficients for the variables in this study was the 2-tailed Pearson product-moment correlation (Adams et al., 2014; Easterby-Smith et al., 2015; Saunders et al., 2007; Surez et al., 2017), whereby the relationship "between variables may be either positive or negative" (Easterby-Smith et al., 2015, p. 332). Table 4-5 shows the interpretation of correlation coefficient values.

Table 4-5

Interpretation of Correlation Coefficient Values

Correlation coefficient	Interpretation of linear relationship
Value = 0	No linear relationship
Positive values	
0 < Value < 0.3	Weak positive
0.3 < Value < 0.7	Moderate positive
0.7 < Value < 1	Strong positive
Value = 1	Perfect positive
Negative values	
-0.3 < Value < 0	Weak negative
-0.7 < Value < -0.3	Moderate negative
-1 < Value < -0.7	Strong negative
Value = -1	Perfect negative

Note. Adapted from "The correlation coefficient: Its values range between +1/−1, or do they?" by B. Ratner, 2009, *Journal of Targeting, Measurement & Analysis for Marketing*, *17*(2), pp. 139-140. Copyright 2009 by Palgrave Macmillan.

4.7.2.3 Regression Analysis

Regression analysis is a statistical analysis that evaluates the relationship between variables (Adams et al., 2014). It assesses the cause-and-effect relationship between a dependent variable and one or more independent/predictor variables (Saunders et al., 2007; Surez et al., 2017). Regression analysis involves regression coefficients, intercept or constant, and an error/residual term represented in a regression model/equation (Adams et al., 2014; Easterby-Smith et al., 2015; Saunders et al., 2007; Surez et al., 2017). The regression coefficients in the regression model measure the contribution of each independent variable (Easterby-Smith et al., 2015).

The raw regression coefficients from the regression model are known as standardised coefficients. The units of measurement for these coefficients are sometimes different and may need to be transformed to a common measuring scale to allow for comparison, this is known as standardisation and the transformed coefficients are known as standardised coefficients (Easterby-Smith et al., 2015).

A regression analysis involving one dependent variable and one independent variable is known as a univariate regression analysis, whereas a multivariate regression analysis entails one dependent variable and more than one independent variable (Saunders et al., 2007). This study conducted multivariate linear regression analyses.

Saunders et al. (2007) state that there are certain assumptions that need to be satisfied in order to perform multivariate linear regression analyses. The assumptions include (a) normal distribution of data for both the dependent and independent variables, (b) existence of a linear relationship between the dependent variable and independent variable(s), (c) homoscedasticity, and (d) absence of multicollinearity. For this study, the normality assumption was tested using the Shapiro-Wilk test as described in Section 4.7.4.2, the linearity relationship assumption was tested as described in Sections 4.8.2 and 4.8.3, homoscedasticity was tested as described in Section 4.8.5, whereas the absence of multicollinearity was tested as described in Section 4.8.6.

Equation (1) shows the regression model used to evaluate the standard version of the Heckscher-Ohlin model in this study. The regression model presented is a modified version of the model proposed by Koch and Fessler (2020). The main difference between the model presented in this study and the one used by Koch and Fessler (2020) is that the dummy variables used in Koch and Fessler's (2020) study were not included as part of Equation (1). The dummy variables used in Koch and Fessler's (2020) study are applicable to studies evaluating export flows between three or more countries. This study focussed on evaluating export flows between two countries, namely South Africa and China, and therefore the dummy variables were not applicable.

$$\log(VX_{it}) = B_1 \log\left(\frac{\ell}{k}\right)_{it} + B_2 \left[\log\left(\frac{\ell}{k}\right)_{it} \times \log\left(\frac{L}{K}\right)_{it}\right] + \varepsilon \quad (1)$$

The term VX_{it} represented value-added exports from the exporting country (South Africa) to the importing country (China). The subscripts *i* and *t* denoted exporting industry and year, respectively. The lowercase letter *ℓ* represented industry-level employed labour force whereas the lowercase letter *k* denoted industry-level fixed capital formation, both for the exporting country.

The country-level total employed labour force and fixed capital formation (both from the exporting country) were represented by the uppercase letters *L* and *K* respectively. The error term was represented by the symbol *ε*. The variable $\left[\log\left(\frac{\ell}{k}\right)_{it} \times \log\left(\frac{L}{K}\right)_{it}\right]$ is referred to as labour-capital intensity and endowment variable in literature (Ito et al., 2017; Koch & Fessler, 2020).

Ito et al. (2017), and Koch and Fessler (2020) state that the regression coefficient B_2 is the coefficient of interest for Equation (1). The Heckscher-Ohlin theory states that a labour-abundant country should export labour-intensive goods (Akther et al., 2022; Fisher, 2011; Fukiharu, 2004; Jones, 1956; Juozapavičienė & Eizentas, 2010; Mhaka & Jeke, 2018), therefore a positive and statistically significant B_2 for a labour-intensive country would demonstrate support for the Heckscher-Ohlin theorem (Ito et al., 2017; Koch & Fessler, 2020).

It is important to note that unlike majority of the common regression models found in literature studies, Equation (1) does not contain a constant/intercept, which is usually featured as part of typical regression models as described in Section 4.7.2.3. The absence of a constant/intercept in Equation (1) is consistent with other empirical studies (Chor, 2010; Ito et al., 2017, Koch & Fessler, 2020) that have previously applied the standard version of the Heckscher-Ohlin model.

The list and descriptions of the variables included in the evaluation of H1, of which data were collected for the three industries forming part of this study, are shown in Table 4-6. It showed be noted that separate regression analyses were conducted for each one of the three industries being evaluated, meaning that, each industry had its own separate regression model and associated regression coefficients.

Table 4-6

Description of Variables Used to Evaluate H1

Variable	Description
Total Economy	
K	Country-level fixed capital formation for South Africa
L	Country-level total employed labour force for South Africa
Mining and Quarrying	
VX_{min}	Value-added exports from South Africa to China in the mining and quarrying industry
k_{min}	Fixed capital formation in South Africa's mining and quarrying industry
ℓ_{min}	Total employed labour force in South Africa's mining and quarrying industry
Manufacturing	
VX_{man}	Value-added exports from South Africa to China in manufacturing industry
k_{man}	Fixed capital formation in South Africa's manufacturing industry
ℓ_{man}	Total employed labour force in South Africa's manufacturing industry
Transport, Storage, Information, and Communication	
VX_{tra}	Value-added exports from South Africa to China in the transport, storage, information, and communication industry
k_{tra}	Fixed capital formation in South Africa's transport, storage, information, and communication industry
ℓ_{tra}	Total employed labour force in South Africa's transport, storage, information, and communication industry

Note. The subscripts *min*, *man*, and *tra* included on the industry-level variables represent the (a) mining and quarrying industry, (b) manufacturing industry, and (c) transport, storage, information, and communication industry, respectively.

4.7.3 Variables Used to Evaluate H1

The dependent variable used to evaluate the first research hypothesis (H1) in this study was industry-level value-added exports. The other variables included in the sample were industry-level fixed capital formation and employed labour force, and country-level total fixed capital formation and total employed labour force, all of which were treated as independent variables.

4.7.3.1 Industry-Level Value-Added Exports

Industry-level value-added export data from South Africa to China (in Rands) were sourced, on a quarterly basis, from the ITC database as described in Section 4.7.1. As stated earlier, value-added exports represented value-added goods produced in one country and exported to other countries (Asmal et al., 2017; Johnson & Noguera, 2017). Similar to other empirical studies (Chor, 2010; Ito et al., 2017, Koch & Fessler, 2020), value-added exports from South Africa to China were used as the dependent variable in the regression models developed.

4.7.3.2 Industry-Level Fixed Capital Formation

Based on the recommendation from Cavusoglu and Elmslie (2005), the study intended to use gross fixed capital formation as a proxy for physical capital. However, it was discovered that, during the data collection phase of the study, while both Stats SA and the SARB do actually publish gross fixed capital formation on a quarterly basis, the data are presented by type of organisation, i.e., general government, public corporations, and private business enterprises (SARB, 2022; Stats SA, 2022a), instead of by type of economic activity (industry-level).

Furthermore, the industry-level gross fixed capital formation data published Stats SA and the SARB are presented on an annual basis instead of a quarterly basis (SARB, 2022; Stats SA, 2022a). Interestingly, until the second quarter of 2017, the SARB used to publish quarterly gross fixed capital formation data for both the total economy and by type of economic activity (industry). However, from the third quarter of 2017 onwards, the SARB only published quarterly gross fixed capital formation data for the total economy and no longer published these data by type of economic activity.

To mitigate the lack of quarterly industry-level gross fixed capital formation data, fixed capital formation was used as a proxy for physical capital in this study, instead of gross fixed capital formation. Fixed capital formation is similar to gross fixed capital formation which was recommended by to be a better proxy for capital stock (Cavusoglu & Elmslie, 2005). According to Chetty (2007), fixed capital formation represents the capital spent to acquire plant, machinery, and equipment. Stats SA publishes data, on a quarterly basis, on capital expenditure on new property, plant, and equipment by type of economic activity, i.e., industry-level (Stats SA, 2022b). These data were sourced (in Rands) and used as industry-level fixed capital formation data in this study.

4.7.3.3 Industry-Level Employed Labour Force

Quarterly industry-level employed labour force data represented number of people employed in a specific industry. These data were sourced from the quarterly labour force survey published by Stats SA (Stats SA, 2022c).

4.7.3.4 Country-Level Total Fixed Capital Formation

Similar to the industry-level fixed capital formation, data representing capital expenditure on new property, plant, and equipment for all industries were used as a proxy for country-level fixed capital formation. To ensure alignment with industry-level fixed capital formation data, quarterly country-level total fixed capital formation data, sourced (in Rands) from Stats SA, were used in this study.

4.7.3.5 Country-Level Total Employed Labour Force

The country-level total employed labour force represented total number of people employed in the economy. Stats SA (2022c) reports total labour force data on a quarterly basis, and the data includes employees in both the formal and informal sectors, including private households.

4.7.4 Statistical Analysis Techniques Used to Evaluate H2

The second research hypothesis (H12) was described in Section 3.2 as follows:

> **Research hypothesis 2 (H2)**: The chain version of the Heckscher-Ohlin model can predict South Africa's net trade flows.

The evaluation of the second research hypothesis (H2) was conducted by applying the methodology employed in empirical studies conducted by both Cavusoglu (2019), and Cavusoglu and Elmslie (2005). Similar to these two studies, this study followed the methodology employed by these researchers to evaluate the ability of the chain version of the Heckscher-Ohlin model to predict South Africa's net trade flows with the rest of the world. The first step in the methodology included the application of Equation (2) to calculate the net trade balances for the combined economy.

$$TB_t = \sum_i X_{it} - \sum_i M_{it} \qquad \text{Equation (2)}$$

The variables X_{it} and M_{it} in Equation (2) represented combined economy total exports and imports, respectively, for industry *i* in year *t*. As mentioned in Section 4.7.5.2 and 4.7.5.3, the combined economy total exports included the sum of industry-level exports from South Africa to the rest of the world for mining and quarrying, manufacturing, and transport, storage, information, and communication industries, whereas combined economy total imports consisted of the sum of industry-level imports from the rest of the world to South Africa for the same three industries. Combined economy trade balances for year t was denoted by the variable TB_t.

Cavusoglu (2019), and Cavusoglu and Elmslie (2005) state that the second step in the evaluation entails the distribution of combined economy net trade balances across the industries of interest, namely mining and quarrying, manufacturing, and transport, storage, information, and communication, using three different weight measures. Equation (3) represented the formula employed to distribute the combined economy net trade balances across the three industries.

$$TB_{it}^{A} = TB_{it} - (\omega_{it} \times TB_t) \quad \text{Equation (3)}$$

The variable TB_{it} in Equation (3) signified trade balances for industry i in year t, and the weight measure was denoted by the variable ω_{it}. The adjusted trade balances by industry were denoted by the variable TB^{A}_{it}. The three weight measures used to distribute combined economy net trade balances were equal weight, volume weight, and balance weight. The equal weight measure was represented by Equation (4).

$$\omega_{it} = \frac{1}{n} \qquad \text{Equation (4)}$$

Equation (4) assumed that trade balances are equally distributed across the three industries forming part of the study. The lowercase letter n represented number of industries being considered. For this study, the value for n would was three since three industries formed part of the study, namely (a) mining and quarrying, (b) manufacturing, and (c) transport, storage, information, and communication. Equations (5) and (6) represented formulas for the volume weight and balance weight, respectively.

$$\omega_{it} = \frac{(X_{it}+M_{it})}{\sum_i (X_{it}+M_{it})} \qquad \text{Equation (5)}$$

$$\omega_{it} = \frac{(X_{it}-M_{it})}{\sum_i (X_{it}-M_{it})} \qquad \text{Equation (6)}$$

The non-balanced net trades, which represented unadjsted net trade balances for each industry, was computed using Equation (7).

$$NB_{it} = X_{it} - M_{it} \qquad \text{Equation (7)}$$

As seen from Equation (7), the computation of non-balanced net trades for each industry does not require any of the weight measures shown in Equations (4) to (6). The individual factor intensities for the three industries evaluated as part of the study were calculated using Equation (8).

$$(Factor\ intensity)_i = \left(\frac{k}{\ell}\right)_i \times \frac{1}{1000} \qquad \text{Equation (8)}$$

Similar to Section 5.1, the lowercase letter ℓ represented industry-level employed labour force whereas the lowercase letter k denoted industry-level fixed capital formation. Based on the equations presented and described above, a list of variables of which data were collected to evaluate H2 are shown in Table 4-7.

Table 4-7

Description of the Variables Used to Evaluate H2

Variable	Description
Combined Economy	
X	Total value-added exports for mining and quarrying, manufacturing, and transport, storage, information, and communication industries in South Africa
M	Total value-added imports for mining and quarrying, manufacturing, and transport, storage, information, and communication industries in South Africa
Mining and Quarrying	
X_{min}	Value-added exports in South Africa's mining and quarrying industry
M_{min}	Value-added imports in South Africa's mining and quarrying industry
k_{min}	Fixed capital formation in South Africa's mining and quarrying industry
ℓ_{min}	Employed labour force in South Africa's mining and quarrying industry
Manufacturing	
X_{man}	Value-added exports in South Africa's manufacturing industry
M_{man}	Value-added imports in South Africa's manufacturing industry
k_{man}	Fixed capital formation in South Africa's manufacturing industry
ℓ_{man}	Employed labour force in South Africa's manufacturing industry
Transport, Storage, Information, and Communication	
X_{tra}	Value-added exports in South Africa's transport, storage, information, and communication industry
M_{tra}	Value-added imports in South Africa's transport, storage, information, and communication industry
k_{tra}	Fixed capital formation in South Africa's transport, storage, information, and communication industry
ℓ_{tra}	Employed labour force in South Africa's transport, storage, information, and communication industry

Note. The variables presented were based on the equations used by Cavusoglu (2019), and Cavusoglu and Elmslie (2005). The subscripts *min*, *man*, and *tra* included on the industry-level variables represent the (a) mining and quarrying industry, (b) manufacturing industry, and (c) transport, storage, information, and communication industry, respectively.

The statistical techniques applied to evaluate H2 were descriptive statistics, Shapiro-Wilk test, and Kruskal-Wallis test.

4.7.4.1 Descriptive Statistics

Similar to Section 4.7.2.1, the descriptive statistics presented as part of the evaluation of H2 were the minimum, maximum, mean, standard deviation, skewness coefficient, and Kurtosis coefficient.

4.7.4.2 Normality Test

The Shapiro-Wilk test is one of the commonly used statistical tests to test for normality of data (Salkind, 2007). The test estimates the W statistic (Grous, 2013; Salkind, 2007) which has a maximum value of one (Salkind, 2007). The null hypothesis for the Shapiro-Wilk test for normality is that data are normally distributed (Grous, 2013; Salkind, 2007), meaning that, the W statistic is close to one and above a specific level of statistical significance, usually 0.05 (Salkind, 2007). The alternative hypothesis for the Shapiro-Wilk test is that data are not normally distributed (Grous, 2013; Salkind, 2007). The interpretation of the W statistic is shown in Table 4-8.

Table 4-8

Interpretation of the W statistic

W statistic	Statistical significance of W statistic	Interpretation
Value close to 1	$p > 0.05$ or $p > 0.1$	Data are normally distributed
Value is small	$p \leq 0.05$ or $p \leq 0.1$	Data distribution is not normal

Note. Adapted from “Encyclopedia of measurement and statistics,” by N. J., Salkind, 2007, p. 885. Copyright 2007 by Sage Publications, Inc.

4.7.4.3 Kruskal-Wallis Test

The Kruskal-Wallis test is one of the commonly used statistical tests for evaluating differences between three or more independent samples or groups consisting of ranked data (Easterby-Smith et al., 2015; Salkind, 2007). The test does not rely on any assumption “about an underlying theoretical parametric distribution [of the] data” (Easterby-Smith et al., 2015; p. 260). It is therefore considered non-parametric, meaning that, it does not rely on data being normally distributed (Salkind, 2007).

4.7.5 Variables Used to Evaluate H2

The variables included in the sample to evaluate the second research hypothesis (H2) were industry-level value-added exports, value-added imports, employed labour force, fixed capital formation, including combined economy value-added exports and imports. Definitions of and sources of data for industry-level value-added exports, employed labour force, and fixed capital formation have already been described in Section 4.7.3.

4.7.5.1 Industry-Level Value-Added Imports

Similar to industry-level value-added exports described in Section 4.7.3.1, industry-level value-added imports represented value-added goods (in Rands) imported from the rest of the world into South Africa for the three industries described in Section 4.7.1.

4.7.5.2 Combined Economy Value-Added Exports

The definition for combined economy value-added exports was similar to the one described in Section 4.7.3.1 for the industry-level definition, with the difference being that combined economy value-added exports were the sum of value-added exports (in Rands) from South Africa to the rest of the world for the three industries described in Section 4.7.1, instead of only China as discussed in Section 4.7.3.1.

4.7.5.3 Combined Economy Value-added Imports

Combined economy value-added imports were the sum of value-added imports (in Rands) from the rest of the world to South Africa for the three industries described in Section 4.7.1.

4.8 Data Quality

Data quality assessment is a key step in data processing. Bicevskis et al. (2018) conclude that data quality issues have been in existence since the emergence of data processing. As part of their study, the researchers proposed a data quality model that included data that need to be subjected to quality assessment, the conditions to be satisfied for data to be of acceptable quality, and the procedure to be followed to evaluate the quality of data. Bell et al. (2019) state that assessments of data quality are usually necessary for secondary data, especially for data generated as an outcome of commercially commissioned research. Adams et al. (2014) and Saunders et al. (2009) mention that there are three criteria for ensuring data quality and credibility, these include reliability, validity, and generalisability.

Reliability is concerned with consistency (Adams et al., 2014), that is the extent to which the research instruments and methodology will yield reproducible and consistent results (Adams et al., 2014; Easterby-Smith et al., 2015; Saunders et al., 2009). Adams et al. (2014) state that reliability can be assessed by measuring the stability and internal consistency of a measurement. The authors define stability as a test of the repeatability of a measurement, whereas internal consistency is a test of whether the measurement is homogenous. For this study, the reliability of the research instrument and methodologies was assessed using p-values (statistical significance) from the statistical tests conducted.

Adams et al. (2014) state that validity is concerned with measurement accuracy. Validity refers to the degree to which the variables in the study have a causal relationship (Saunders et al., 2009). It assesses the extent to which the research findings represent the phenomenon being described (Easterby-Smith et al., 2015). Validity is therefore more important than reliability. There are four types of validity assessments, namely internal validity, external validity (Adams et al., 2014; Easterby-Smith et al., 2015), construct validity, and conclusion validity (Adams et al., 2014).

According to Adams et al. (2014), internal validity refers to the likelihood that the dependent variable changes only because of the manipulation of the independent variables, whereas external validity assesses whether the results from a research study can be generalised to other constructs. Furthermore, the authors mention that construct validity evaluates whether there is a relationship between the research concepts and the causal relationship being studied. Lastly, the authors state that conclusion validity evaluates whether there is a relationship between the cause (independent variable) and effect (dependent variables) of the study.

For this study, only the internal validity and conclusion validity were assessed. The external validity was not assessed because non-probability sampling was applied in the study. As mentioned in Section 4.6, the findings from a study applying non-probability sampling cannot be generalised to the rest of the population (Saunders et al., 2009).

Construct validity was assumed to be inherent in the study since the study was conceptualised based on a pre-determined regression model, i.e., the Heckscher-Ohlin model. Internal validity was assessed by measuring the slope parameters, their associated statistical significance for the independent variables from the standard Heckscher-Ohlin model utilised, and testing for multicollinearity and homoscedasticity.

The conclusion validity was assessed by measuring the coefficient of determination (R^2) and statistical significance of the multivariate linear regression model utilised, including the statistical significance of the Kruskal-Wallis statistical test used to compare the medians of three or more independent samples of ranked data.

Lastly, generalisability refers to the ability to generalise the findings of a particular research study to other phenomena without the need to study them (Adams et al., 2014). It is also known as external validity (Saunders et al., 2009). Adams et al. (2014) mention that, the higher the degree of reliability and validity in a study, the higher the degree of its generalisability. As mentioned earlier, external validity was not assessed as part of the study, therefore generalisability was not applicable.

Studies that conducted similar internal validity tests include Akther et al. (2022). For their study, the researchers examined the internal validity of the models by assessing multicollinearity using the variance inflation factor (VIF) scores and heteroscedasticity using Breusch-Pagan/Cook-Weisberg test. The examinations showed that there was neither multicollinearity nor heteroscedasticity in their models. Similarly, other studies (Akther et al., 2022; Chor, 2010; Ito et al., 2017; Koch & Fessler, 2020) measured the coefficient of determination for their regression models to determine conclusion validity.

The reliability of the research instruments and methodologies used to evaluate both the first and second research hypotheses, i.e., H1 and H2 respectively, was assessed by computing the statistical significance (*p*-value) of the statistical tests conducted. The description and symbols of the statistical significance used in this study are shown in Table 4-9.

Table 4-9

Descriptions and Symbols of the Statistical Significance Used in this Study

Statistical significance	**Symbol**	**Description**
p-value < .1	*	Statistical significance at the 0.1 or 10% level
p-value < .05	**	Statistical significance at the 0.05 or 5% level
p-value < .01	***	Statistical significance at the 0.01 or 1% level

Validity tests for H1 were conducted by computing R^2 statistic, Durbin-Watson statistic, W statistic, VIF, and conducting several statistical tests that included the following: t-test, F-test, analysis of variance (ANOVA), and test for homoscedasticity.

4.8.1 Coefficient of Determination

Easterby-Smith et al. (2015) define the coefficient of determination (R^2), also known as the squared multiple correlation, as a measurement of the quality of the regression model. The values for the standard R^2 statistic can range between zero (0) and one (+1), or alternatively zero per cent to 100 per cent. The R^2 statistic determines the degree to which the regression model developed can account for the spread in the dependent variable (Easterby-Smith et al., 2015; Saunders et al., 2007). Saunders et al. (2007) states that there exists a relationship between the R^2 statistic and error term (represented by the symbol ε) in the regression model, basically any variations in the dependent variable unaccounted for by the R^2 statistic is part of the error term, meaning that, the sum of the R^2 statistic and error term should be one or 100 per cent (Easterby-Smith et al., 2015).

The adjusted R^2 statistic is similar to the standard R^2 statistic and has the same features, with the main difference being that, unlike the standard R^2 statistic, the adjusted R^2 statistic accounts for the number of independent variables in the estimated regression model and reduces their impact thereof (Saunders et al., 2007), meaning that, the standard R^2 is always higher than the adjusted R^2. The interpretation of the R^2 statistic is shown in Table 4-10.

Table 4-10

Interpretation of the R^2 Statistic

R^2 statistic	**Interpretation**
Value = 0	None of the variation in the dependent variable can be explained by the independent variable(s)
0 < Value < 1	Proportion of the variation in the dependent variable explained by the independent variable(s)
Value = 1	All the variation in the dependent variable can be explained by the independent variable(s)

Note. Adapted from "Research Methods for Business Students," by M. Saunders, P. Lewis, and A. Thornhill, 2007, p. 453. Copyright 2007 by Pearson Education Limited.

4.8.2 t-Test

The t-Test is a statistical test in regression analysis that measures the statistical significance of the regression coefficients in the regression model, it evaluates the null hypothesis that the regression coefficients are zero against an alternative hypothesis that the regression coefficients are different from zero. (Easterby-Smith et al., 2015).

4.8.3 F-test and ANOVA

The F-test is a statistical test in regression analysis that evaluates the null hypothesis that the extent to which the predictor variables can explain the variations in the dependent variable is zero, against the alternative hypothesis that the proportion of the variance explained by the independent variables is more than zero (Easterby-Smith et al., 2015). Salkind (2007) defines the ANOVA test as a statistical test used in regression analysis to evaluate the extent to which a linear model fits the observed data.

The ANOVA test in regression analysis uses the F-test (Salkind, 2007; Surez et al., 2017) to determine for the extent to which there is a linear relationship between the dependent variable and independent variable(s) (Surez et al., 2017). Depending on the number of independent variables, the ANOVA test can be one-way ANOVA (one independent variable), two-way ANOVA (two independent variables), or N-way ANOVA with N representing the number of independent variables (Salkind, 2007). The null hypothesis for the ANOVA test in regression analysis is that the relationship between the dependent variable and independent variables is non-linear, whereas the alternative hypothesis states that there is a linear relationship between the dependent variable and independent variables (Surez et al., 2017).

4.8.4 Durbin-Watson Test

Easterby-Smith et al. (2015) state that the Durbin-Watson statistic is used to determine the relationship between the value of a dependent variable at a point in time compared to its value from a previous period. The authors mention that a phenomenon in which there is a relationship between the point in time (t) and previous (t-1) values of the dependent variable is referred to as autocorrelation or serial correlation. The Durbin-Watson statistic has a range between zero and four. An interpretation of the Durbin-Watson statistic is shown in Table 4-11.

Table 4-11

Interpretation of the Durbin-Watson Statistic

Durbin-Watson statistic	**Interpretation**
Value towards 0	Positive autocorrelation
Value of 2	No autocorrelation
Value towards 4	Negative autocorrelation

Note. Adapted from “Research Methods for Business Students,” by M. Saunders, P. Lewis, and A. Thornhill, 2007, p. 458. Copyright 2007 by Pearson Education Limited.

4.8.5 Homoscedasticity

Homoscedasticity in regression analysis is concerned with homogeneity of variance, serving as a requisite to use the t-Test and F-test (Surez et al., 2017). Salkind (2007) mentions that homoscedasticity assumes that the variance in the predictions of the dependent variable remains stable for all values of the independent variable(s). Furthermore, the author states that the assessment for homoscedasticity entails a scatter plot showing the predicted value (x-axis) and residual values (y-axis), and the determination of the spread of the residual values below and above the zero line on the y-axis. Homoscedasticity is achieved when the residual values are equally spread across the zero line on the y-axis of the scatter plot. Other literature studies that conducted homoscedasticity tests include Akther et al. (2022). Results from Akther et al.'s (2022) study indicated that variances in their regressions were constant, meaning that, these variances were homoscedastic.

4.8.6 Variance Inflation Factor

The variance inflation factor (VIF) is a statistical test commonly used to detect the presence of multicollinearity (Salkind, 2007; Surez et al., 2017). Salkind (2007) defines multicollinearity as a phenomenon in which there is a relationship between the independent variables. The author mentions that the problem is common in multivariate regression analysis. One of the statistical methods used to detect multicollinearity is to compute VIFs (Salkind, 2007; Surez et al., 2017), which measure the extent to which the independent variables are related to one another (Salkind, 2007). The rule of thumb is that the value for VIF needs to be above 10 to indicate the presence of multicollinearity (Akther et al., 2022; Salkind, 2007; Surez et al., 2017).

Other studies that assessed the presence of multicollinearity between the independent variables include Akther et al. (2022). For their study, Akther et al. (2022) assessed the presence of multicollinearity in their regressions and their results produced VIF values below 10, indicating that the absence of multicollinearity.

4.9 Ethical Considerations

Research ethics is a principal element of the research process. The principles of ethical research include factors such as avoidance of harm to participants, voluntary informed consent, privacy, prevention of deception (Bell et al., 2019; Saunders et al., 2009), and the need to keep data and information collected from the participants confidential (Saunders et al., 2009). Given that this study sourced non-personal, secondary data from online public platforms without the need to engage any human participants, the risk of breaching ethical boundaries was considered low.

The study was submitted to GIBS' Master's Research Ethics Committee (MREC), prior to collection of any data, for consideration for an ethical clearance. The final report for the study was submitted to the university together with the ethical clearance certificate received from GIBS' MREC.

4.10 Limitations of the Study

The research limitations for the study include the fact that it is focussed only on two trading partners, namely South Africa and China, and South and the rest of the world. However, the principles of the models used in the study, i.e., the standard and chain versions Heckscher-Ohlin model, can be generalised. The period of analysis for the study was also limited to the period between first quarter of 2009 and fourth quarter of 2019.

Given that quarterly data were used, each variable in the model was limited to 44 data points. However, Saunders et al. (2009) state that there are no rules about the sample size when it comes to non-probability sampling. The study also applied multivariate linear regression analysis to examine the relationship between factor intensities (country-level and industry-level labour-to-capital ratios) and value-added exports from South Africa to China. There exists a possibility that this relationship may be non-linear, and therefore this is discussed in the report should the results from the regression analysis produce non-linear relationships.

5 Chapter 5: Results

This chapter presents the results from the statistical analysis conducted using the methods outlined in Chapter 4. These results present responses to the research question and sub-questions posed in Chapter 3 to evaluate the research propositions. The chapter begins with the presentation of the results for the first research sub-question: ‘To what extent do Heckscher-Ohlin forces impact South Africa’s export flows to China?’, followed by the results for the second research sub-question: ‘To what extent does the chain version of the Heckscher-Ohlin model predict South Africa’s net trade flows with the rest of the world?’. Lastly, the chapter ends with a summary of the research results.

The aim of this study was to evaluate the influence of factor endowments on bilateral trade patterns between South Africa and its trading partners. To achieve this aim, the study evaluated the extent to which trade patterns between South Africa and its trading partners, namely China and rest of the world respectively, could be explained using the Heckscher-Ohlin theorem. The applicability of the Heckscher-Ohlin model was evaluated using two versions of the model, namely the standard version and chain version. The standard version of the Heckscher-Ohlin model was used to evaluate the extent to which Heckscher-Ohlin forces impact South Africa’s export flows to China, which addressed the first research sub-question posed in Section 3.1. The chain version of the model was used to evaluate the extent to which the model predicts South Africa’s net trade flows with the rest of the world, thereby addressing the second research sub-question posed in Section 3.2.

5.1 The Role of Heckscher-Ohlin Forces in Determining South Africa’s Value-Added Exports to China

The results in this section are presented in terms of descriptive statistics, correlation analyses, and regression analyses. The first research hypothesis (H1) was described in Section 3.1 as follows:

> **Research hypothesis 1 (H1):** Heckscher-Ohlin forces significantly affect South Africa’s value-added export flows to China.

5.1.1 Descriptive Statistics

As mentioned in Section 4.2, the period of analysis for this study was between the first quarter of 2009 and fourth quarter of 2019. Furthermore, quarterly data were collected for the variables mentioned in Section 4.7.1. Table 5-1 shows a summary of the descriptive statistics for data collected for the period between 2009 and 2019 to test the first research hypothesis (H1).

Table 5-1

Descriptive Statistics for Variables Used to Evaluate H1

Variable	Minimum	Maximum	Mean	Standard deviation (SD)	Skewness	Kurtosis
Mining and quarrying						
VX_{min} (million Rands)	6 321	27 627	17 150	5 435	0.141	-0.553
k_{min} (million Rands)	8 226	22 843	14 022	3 392	0.722	0.240
ℓ_{min}	301 720	483 245	398 056	47 174	-0.415	-0.961
Manufacturing						
Variable	**Minimum**	**Maximum**	**Mean**	**Standard deviation (SD)**	**Skewness**	**Kurtosis**
VX_{man} (million Rands)	875	6 192	2 440	1 148	1.229	1.861
k_{man} (million Rands)	8 376	25 657	15 973	4 404	0.157	-0.815
ℓ_{man} (thousand)	1 645	2 032	1 802	77	1.043	2.140
Transport, storage, information, and communication						
Variable	**Minimum**	**Maximum**	**Mean**	**Standard deviation (SD)**	**Skewness**	**Kurtosis**
VX_{tra} (million Rands)	11	522	104	135	2.018	2.824
k_{tra} (million Rands)	9 094	34 705	17 418	5 459	0.975	1.420
ℓ_{tra} (thousand)	776	1 025	901	73	-0.078	-1.207
Total Economy						
Variable	**Minimum**	**Maximum**	**Mean**	**Standard deviation (SD)**	**Skewness**	**Kurtosis**
K (million Rands)	45 898	106 518	81 480	14 790	-0.515	-0.506
L (thousand)	13 648	16 529	15 175	946	-0.104	-1.486

Note. The count for all the variables was 44. The information presented in parentheses represent the unit of measurement. The terms VX, k, and ℓ represent industry-level value-added exports, fixed capital formation, and employed labour force, respectively. The terms K and L represent country-level fixed capital formation and total employed labour force, respectively. The subscripted terms *min*, *man*, and *tra* represent the (a) mining and quarrying industry, (b) manufacturing industry, and (c) transport, storage, information, and communication industry, respectively. Data used to determine the descriptive statistics shown were sourced from Stats SA and ITC.

It can be seen from Table 5-1 that, from a descriptive statistic perspective, the mining and quarrying industry has the highest mean in terms of value-added exports (VX_{man}) from South Africa to China (mean = 17 150 million Rands, SD = 5 435 million Rands). The transport, storage, information, and communication industry reported the lowest mean in terms of value-added exports (VX_{tra}) from South Africa to China (mean = 104 million Rands, SD = 135 million Rands).

In terms of industry-level fixed capital formation, the transport, storage, information, and communication industry in South Africa has the highest average amount of fixed capital formation (mean = 17 418 million Rands, SD = 5 459 million Rands), whereas mining and quarrying industry shows the lowest average amount of fixed capital formation (mean = 14 022 million rands, SD = 3 392 million Rands). For the employed labour force, the South African manufacturing industry reported the highest average number of employees (mean = 1 802 thousand, SD = 77 069), whereas mining and quarrying reported the lowest average number of employees (mean = 398 thousand, SD = 47 174).

With respect to the distribution of the data set in Table 5-1, it can be seen that the employed labour force data for mining and quarrying industry, and transport, storage, information, and communication industry are all negatively skewed (skewness < 0), meaning that, the data sets have long tails to the left of the distribution curve. The country-level fixed capital formation and total employed labour force data are also negatively skewed. However, the rest of the other data are all positively skewed (skewness > 0), i.e., the data sets have long tails to the right of the distribution curve.

Concerning the flatness/roundness of the data set peak, it can be seen that all the variables in Table 5-1 have Kurtosis coefficients that are less than three (Kurtosis < 3), with the value added exports from transport, storage, information, and communication industry being the closest to three (Kurtosis = 2.824). As described in Table 4-4, this means that the data sets for these variables have flatter peaks compared to that of normally distributed data set.

5.1.2 Correlation Analyses

Correlation analyses were conducted for the three industries identified in Section 4.7.1 to assess the strength of the linear association between the variables included in Equation (1) and presented in Section 5. The results from the correlations analysis based on data collected for the period between the first quarter of 2009 and fourth quarter of 2019 are shown in Table 5-2, Table 5-3, and Table 5-4.

Table 5-2

Correlation Matrix for Mining and Quarrying Industry

	$\log(\mathrm{VX_{min}})$	$\log\left(\frac{\ell}{\mathrm{k}}\right)_{\mathrm{min}}$	$\log\left(\frac{\ell}{\mathrm{k}}\right)_{\mathrm{min}} \times \log\left(\frac{\mathrm{L}}{\mathrm{K}}\right)_{\mathrm{min}}$
$\log(\mathrm{VX_{min}})$	1		
$\log\left(\frac{\ell}{\mathrm{k}}\right)_{\mathrm{min}}$	-.230	1	
$\log\left(\frac{\ell}{\mathrm{k}}\right)_{\mathrm{min}} \times \log\left(\frac{\mathrm{L}}{\mathrm{K}}\right)_{\mathrm{Min}}$	.407***	-.789***	1

Note. The symbol *** represents a statistical significance at the 0.01 level (2-tailed). The terms VX, k, and ℓ represent industry-level value-added exports, fixed capital formation, and employed labour force, respectively. The terms K and L represent country-level fixed capital formation and total employed labour force, respectively. The subscripted term *min* represents mining and quarrying industry.

According to the results shown in Table 5-2, the correlation coefficient (represented by the term *r* in this study) between variables $[\log(\mathrm{VX_{Min}})]$ and $\left[\log\left(\frac{\ell}{\mathrm{k}}\right)_{\mathrm{Min}}\right]$ is negative (r = -.230) and statistically insignificant (p = .132). This suggests that the linear relationship between the two variable is weak negative ($-0.3 < r < 0$) but not statistically significant. More importantly, the correlation coefficient between variables $[\log(\mathrm{VX_{min}})]$ and $\left[\log\left(\frac{\ell}{\mathrm{k}}\right)_{\mathrm{min}} \times \log\left(\frac{\mathrm{L}}{\mathrm{K}}\right)_{\mathrm{min}}\right]$ is positive (r = .407) and statistically significant (p = .006). This indicates a moderate positive ($0.3 < r < 0.7$) linear relationship between these variables. Interestingly, the two variables $\left[\log\left(\frac{\ell}{\mathrm{k}}\right)_{\mathrm{min}} \times \log\left(\frac{\mathrm{L}}{\mathrm{K}}\right)_{\mathrm{min}}\right]$ and $\left[\log\left(\frac{\ell}{\mathrm{k}}\right)_{\mathrm{min}}\right]$ have the highest correlation coefficient compared to the coefficients between the rest of the other variables. The correlation coefficient for the two variables is negative (r = -.789) and statistically significant ($p < .001$).

Table 5-3

Correlation Matrix for Manufacturing Industry

	$\log(\mathrm{VX_{man}})$	$\log\left(\frac{\ell}{\mathrm{k}}\right)_{\mathrm{man}}$	$\log\left(\frac{\ell}{\mathrm{k}}\right)_{\mathrm{man}} \times \log\left(\frac{\mathrm{L}}{\mathrm{K}}\right)_{\mathrm{man}}$
$\log(\mathrm{VX_{man}})$	1		
$\log\left(\frac{\ell}{\mathrm{k}}\right)_{\mathrm{man}}$	-.716***	1	
$\log\left(\frac{\ell}{\mathrm{k}}\right)_{\mathrm{man}} \times \log\left(\frac{\mathrm{L}}{\mathrm{K}}\right)_{\mathrm{man}}$	.681***	-.966***	1

Note. The symbol *** represents a statistical significance at the 0.01 level (2-tailed). The terms VX, k, and ℓ represent industry-level value-added exports, fixed capital formation, and employed labour force, respectively. The terms K and L represent country-level fixed capital formation and total employed labour force, respectively. The subscripted term *man* represents manufacturing industry.

Similar to the results found in Table 5-3, the correlation coefficient between variables $[\log(\mathrm{VX_{man}})]$ and $\left[\log\left(\frac{\ell}{\mathrm{k}}\right)_{\mathrm{man}} \times \log\left(\frac{\mathrm{L}}{\mathrm{K}}\right)_{\mathrm{man}}\right]$ is positive (r = .681) and statistically significant ($p < 0.01$). Therefore, the correlation between these variables is moderate ($0.3 < r < 0.7$). In contrast, variables $\left[\log\left(\frac{\ell}{\mathrm{k}}\right)_{\mathrm{man}} \times \log\left(\frac{\mathrm{L}}{\mathrm{K}}\right)_{\mathrm{man}}\right]$ and $\left[\log\left(\frac{\ell}{\mathrm{k}}\right)_{\mathrm{man}}\right]$ have a negative (r = -0.966) and statistically significant correlation ($p < 0.01$), which is the highest amongst the correlation coefficients between the other variables. It can also be seen that all the other correlation coefficients shown in Table 5-3 are statistically significant ($p < 0.01$).

Table 5-4

Correlation Matrix for Transport, Storage, Information, and Communication Industry

	$\log(\mathrm{VX_{tra}})$	$\log\left(\frac{\ell}{\mathrm{k}}\right)_{\mathrm{tra}}$	$\log\left(\frac{\ell}{\mathrm{k}}\right)_{\mathrm{tra}} \times \log\left(\frac{\mathrm{L}}{\mathrm{K}}\right)_{\mathrm{tra}}$
$\log(\mathrm{VX_{tra}})$	1		
$\log\left(\frac{\ell}{\mathrm{k}}\right)_{\mathrm{tra}}$	.096	1	
$\log\left(\frac{\ell}{\mathrm{k}}\right)_{\mathrm{tra}} \times \log\left(\frac{\mathrm{L}}{\mathrm{K}}\right)_{\mathrm{tra}}$	-.050	-.962***	1

Note. The symbol *** represents a statistical significance at the 1% level (2-tailed). The terms VX, k, and ℓ represent industry-level value-added exports, fixed capital formation, and employed labour force, respectively. The terms K and L represent country-level fixed capital formation and total employed labour force, respectively. The subscripted term *tra* represents transport, storage, information, and communication industry.

Based on the results from Table 5-4 , it can be seen that the correlation coefficient between terms $\left[\log\left(\frac{\ell}{k}\right)_{tra}\right]$ and $\left[\log\left(\frac{\ell}{k}\right)_{tra} \times \log\left(\frac{L}{K}\right)_{tra}\right]$ is the only one that is statistically significant ($p < 0.01$) compared to the correlations between the rest of the other variables. Similar to the results in Table 5-2 and Table 5-3, the correlation coefficient between the two variables is negative ($r = -0.962$), and statistically significant correlation ($p < 0.01$). On the contrary, the correlation coefficient between variables $[\log(VX_{tra})]$ and $\left[\log\left(\frac{\ell}{k}\right)_{tra} \times \log\left(\frac{L}{K}\right)_{tra}\right]$ is negative ($r = -.050$) and statistically insignificant ($p > 0.1$). Because the correlation coefficient between the two variables is statistically insignificant, there is no sufficient evidence to conclude that the two variables are linearly associated.

5.1.2.1 Summary

To summarise, the results from the correlation analyses show that there is statistically significant linear association between the variables $[\log(VX_{min})]$ and $\left[\log\left(\frac{\ell}{k}\right)_{min} \times \log\left(\frac{L}{K}\right)_{min}\right]$, and the variables $[\log(VX_{man})]$ and $\left[\log\left(\frac{\ell}{k}\right)_{man} \times \log\left(\frac{L}{K}\right)_{man}\right]$. These results therefore show that there exists a linear positive relationship between the country- and industry-level factor intensities, and value-added exports for mining and quarrying industry, and manufacturing industry. The results from the correlation efficient between the variables $\log(VX_{tra})$ and $\left[\log\left(\frac{\ell}{k}\right)_{tra} \times \log\left(\frac{L}{K}\right)_{tra}\right]$ show that there is no sufficient evidence to prove the existence of a linear relationship between the two variables.

5.1.3 Regression Analyses

Regression analyses were conducted for the three industries; namely mining and quarrying, manufacturing, and transport, storage, information, and communication, as identified in Section 4.7.1 to assess the relationship between the variables included in Equation (1) and presented in Section 5. The sections that follow present the results from the regression analyses based on data collected for the period between the first quarter of 2009 and fourth quarter of 2019. The results from the regression analyses in this study are presented in the order in which tests for the assumptions of the multivariate linear regression analysis, i.e., normality test, linearity test, homoscedasticity, and multicollinearity, were conducted. As described in Section 5.1, the coefficient of interest for the multivariate linear regression analyses conducted in this section was B_2. A statistically significant positive B_2 for a labour-intensive country would demonstrate support for the Heckscher-Ohlin theorem (Ito et al., 2017; Koch & Fessler, 2020).

5.1.3.1 Results for Mining and Quarrying Industry

The results for the normality test, i.e., W statistic from the Shapiro-Wilk test, conducted using the data sets for the variables shown in Equation (1), for the mining and quarrying industry, are shown in Table 5-5.

Table 5-5

Normality Test Results for Mining and Quarrying Industry

Variable	Shapiro-Wilk		
	W Statistic	**df**	**Sig.**
$\log(\mathrm{VX}_{\mathrm{min}})$	0.961	44	.145
$\log\left(\frac{\ell}{\mathrm{k}}\right)_{\mathrm{min}}$	0.974	44	.408
$\log\left(\frac{\ell}{\mathrm{k}}\right)_{\mathrm{min}} \times \log\left(\frac{\mathrm{L}}{\mathrm{K}}\right)_{\mathrm{min}}$	0.980	44	.644

Note. The term df denoted degrees of freedom. The terms VX, k, and ℓ represent industry-level value-added exports, fixed capital formation, and employed labour force, respectively. The terms K and L represent country-level fixed capital formation and total employed labour force, respectively. The subscripted term *min* represents mining and quarrying industry.

The *p*-values for the variables $[\log(\mathrm{VX}_{\mathrm{min}})]$, $\left[\log\left(\frac{\ell}{\mathrm{k}}\right)_{\mathrm{min}}\right]$, and $\left[\log\left(\frac{\ell}{\mathrm{k}}\right)_{\mathrm{min}} \times \log\left(\frac{\mathrm{L}}{\mathrm{K}}\right)_{\mathrm{min}}\right]$ are .145, .408, and .644, respectively. The results from Table 5-5 indicate that the W statistics for all the variables shown are statistically insignificant (all the *p*-values are above the significance limit of 0.1). These *p*-values mean that the Shapiro-Wilk test failed to reject the null hypothesis that the data sets are normal, thereby proving that the data sets for all the variables in Table 5-5 are normally distributed.

A summary of the results from the assessment of the predictive ability for the regression model developed for the mining and quarrying industry and the autocorrelation assessment of the dependent variable is shown in Table 5-6.

Table 5-6

Model Predictability and Autocorrelation Assessment for Mining and Quarrying Industry

Model	**R**	**R^2**	**Adjusted R^2**	**Standard error of estimate**	**Durbin-Watson**
1	0.433	0.187	0.148	0.139	0.495

Note. The dependent variable was $\log(\mathrm{VX}_{\mathrm{min}})$. The term VX represents industry-level value-added exports. The subscripted term *min* represents mining and quarrying industry.

Based on the results from Table 5-6, it can be seen that the regression model developed is able to explain 18.7% of the variations in the dependent variable, i.e., value-added exports from South Africa to China in mining and quarrying industry (in log terms). Furthermore, it can be seen in Table 5-6 that the Durbin-Watson coefficient is 0.495, which means that the dependent variable displays a positive autocorrelation. A positive autocorrelation indicates that the point-in-time (t) and previous (t-1) values of mining value-added exports from South Africa to China will trend in the same direction.

The results from the F-test and ANOVA test used to estimate the fit of the model developed for the mining and quarrying industry are shown in Table 5-7.

Table 5-7

Results for the F-test and ANOVA Test for Mining and Quarrying Industry

ANOVA						
Model		**Sum of squares**	**df**	**Mean square**	**F**	**Sig.**
1	Regression	.182	2	.091	4.730	.014
	Residual	.788	41	.019		
	Total	.970	43			

Note. The dependent variable was $\log(\mathrm{VX}_{\mathrm{min}})$. The term VX represents industry-level value-added exports. The subscripted term *min* represents mining and quarrying industry.

The results from Table 5-7 indicate that the regression model developed for the mining and quarrying has a F-statistic of 4.730 and is statistically significant ($p < 0.05$). The statistical significance of the regression model means that the null hypotheses for both the F-test and ANOVA test, as described in Section 4.8.3, are rejected, thereby indicating that the predictor variables in the model developed can explain a certain proportion of the variations in the dependent variable based on a linear relationship. The results of the regression coefficients from the multivariate regression model developed for the mining and quarrying industry are shown in Table 5-8 and Table 5-9.

Table 5-8

Regression Results for Mining and Quarrying Industry

Variable	Unstandardised coefficients	Standard error	Standardised coefficients
	B		β
$\log\left(\frac{\ell}{\mathrm{k}}\right)_{\mathrm{min}}$	.333	.318	.240
$\log\left(\frac{\ell}{\mathrm{k}}\right)_{\mathrm{min}} \times \log\left(\frac{\mathrm{L}}{\mathrm{K}}\right)_{\mathrm{min}}$	.185**	.071	.596

Note. The dependent variable was $\log(\mathrm{VX}_{\mathrm{min}})$. The symbol ** denotes statistical significance at the 5% level. The terms VX, k, and ℓ represent industry-level value-added exports, fixed capital formation, and employed labour force, respectively. The terms K and L represent country-level fixed capital formation and total employed labour force, respectively. The subscripted term *min* represents mining and quarrying industry.

Table 5-9

Additional Results on the Regression Analysis for Mining and Quarrying Industry

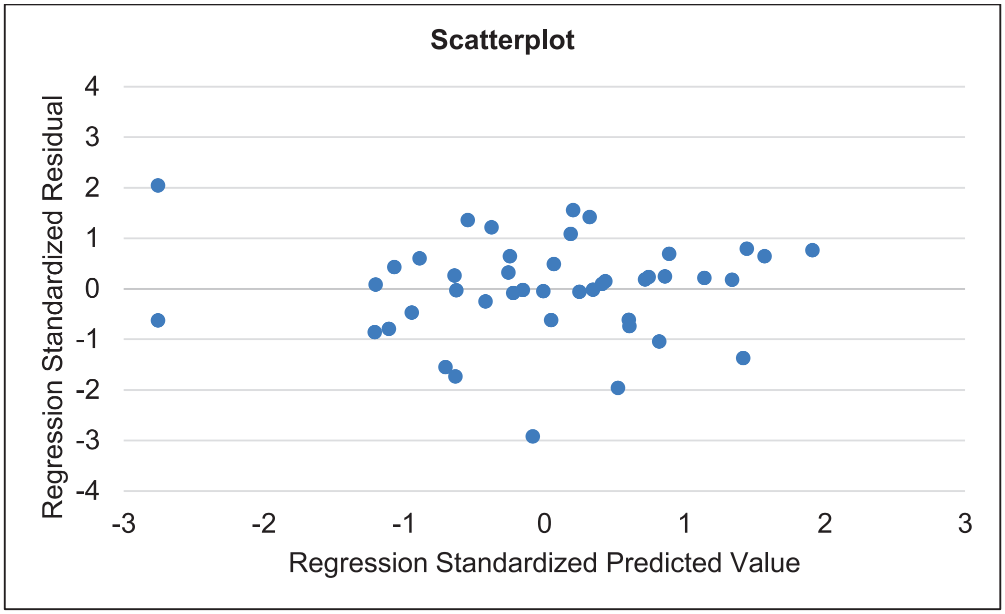
Variable	t-Test	Sig.	95% confidence interval for unstandardised coefficients	
			Lower bound	Upper bound
$\log\left(\frac{\ell}{k}\right)_{min}$	1.047	.301	-.310	.977
$\log\left(\frac{\ell}{k}\right)_{min} \times \log\left(\frac{L}{K}\right)_{min}$	2.604	.013	.041	.328

Note. The dependent variable was $\log(\mathrm{VX}_{\mathrm{min}})$. The terms VX, k, and ℓ represent industry-level value-added exports, fixed capital formation, and employed labour force, respectively. The terms K and L represent country-level fixed capital formation and total employed labour force, respectively. The subscripted term *min* represents mining and quarrying industry.

It can be seen from Table 5-8 and Table 5-9 that the regression coefficient for the labour-capital intensity and endowment variable $\left[\log\left(\frac{\ell}{\mathrm{k}}\right)_{\mathrm{min}} \times \log\left(\frac{\mathrm{L}}{\mathrm{K}}\right)_{\mathrm{min}}\right]$, representing the coefficient of interest B_2 in Equation (1) is positive (B_2 = .185) and statistically significant ($p < 0.05$). The estimated coefficient means that a one unit increase in the variable $\left[\log\left(\frac{\ell}{\mathrm{k}}\right)_{\mathrm{min}} \times \log\left(\frac{\mathrm{L}}{\mathrm{K}}\right)_{\mathrm{min}}\right]$ will increase the value-added exports variable $\log(\mathrm{VX}_{\mathrm{min}})$ by .185. The coefficient is significantly above zero (the 95% confidence interval ranges between .041 and .328). The results from the assessment of homoscedasticity are shown in Figure 5-1.

Figure 5-1

Homoscedasticity Assessment for Mining and Quarrying Industry



Note. The dependent variable was $\log(\mathrm{VX}_{\mathrm{min}})$. The term VX represents industry-level value-added exports. The subscripted term *min* represents mining and quarrying industry.

Based on the results from Figure 5-1, it is evident that the residuals of the model developed for the mining and quarrying industry are equally spread across the zero line on the y-axis of the scatter plot shown. Therefore, the assumption of homoscedasticity is confirmed, meaning that, the variance in the predictions of the dependent variable $\log(\mathrm{VX}_{\mathrm{min}})$ remains stable for all values of the independent variables. The results from the assessment of collinearity between the independent variable for the mining and quarrying industry are shown in Table 5-10.

Table 5-10

Assessment of Collinearity Amongst the Independent Variables for Mining and Quarrying Industry

Variable	Tolerance	VIF
$\log\left(\frac{\ell}{\mathrm{k}}\right)_{\mathrm{min}}$	.378	2.646
$\log\left(\frac{\ell}{\mathrm{k}}\right)_{\mathrm{min}} \times \log\left(\frac{\mathrm{L}}{\mathrm{K}}\right)_{\mathrm{min}}$	.378	2.646

Note. The dependent variable was $\log(\mathrm{VX}_{\mathrm{min}})$. The terms VX, k, and ℓ represent industry-level value-added exports, fixed capital formation, and employed labour force, respectively. The terms K and L represent country-level fixed capital formation and total employed labour force, respectively. The subscripted term *min* represents mining and quarrying industry.

It can be seen from Table 5-10 that the VIF scores for the two independent variables are both lower than 10 (VIF scores = 2.646), signifying the absence of multicollinearity between the independent variables.

Summary

To summarise, the results from the regression analyses conducted show that country- and industry-level factor intensities (Heckscher-Ohlin forces) positively affect South Africa's value-added mining and quarrying exports to China. The results suggest that mining and quarrying industry in South Africa exports more goods that favour the intensive use of labour in their production. The results serve as evidence in support of the Heckscher-Ohlin theorem.

5.1.3.2 Results for Manufacturing Industry

The results for the normality test i.e., W statistic from the Shapiro-Wilk test, conducted using the data sets for the variables shown in Equation (1), for the manufacturing industry, are shown in Table 5-11.

Table 5-11

Normality Test Results for Manufacturing Industry

Variable	**Shapiro-Wilk**		
	W Statistic	**df**	**Sig.**
$\log(\mathrm{VX_{man}})$	.982	44	.732
$\log\left(\frac{\ell}{\mathrm{k}}\right)_{\mathrm{man}}$	.963	44	.166
$\log\left(\frac{\ell}{\mathrm{k}}\right)_{\mathrm{man}} \times \log\left(\frac{\mathrm{L}}{\mathrm{K}}\right)_{\mathrm{man}}$	.956	44	.094

Note. The term df denoted degrees of freedom. The terms VX, k, and ℓ represent industry-level value-added exports, fixed capital formation, and employed labour force, respectively. The terms K and L represent country-level fixed capital formation and total employed labour force, respectively. The subscripted term *man* represents manufacturing industry.

The *p*-values for the variables $[\log(\mathrm{VX_{man}})]$, $\left[\log\left(\frac{\ell}{\mathrm{k}}\right)_{\mathrm{man}}\right]$, and $\left[\log\left(\frac{\ell}{\mathrm{k}}\right)_{\mathrm{man}} \times \log\left(\frac{\mathrm{L}}{\mathrm{K}}\right)_{\mathrm{man}}\right]$ are .732, .166, and .094, respectively. It can be seen from Table 5-11 that the W statistics for the value-added exports variable $[\log(\mathrm{VX_{man}})]$ and labour-capital intensity variable $\left[\log\left(\frac{\ell}{\mathrm{k}}\right)_{\mathrm{man}}\right]$ are both statistically insignificant (their *p*-values are both above the 0.1 significance level). However, the W statistic for the labour-capital intensity and endowment variable $\left[\log\left(\frac{\ell}{\mathrm{k}}\right)_{\mathrm{man}} \times \log\left(\frac{\mathrm{L}}{\mathrm{K}}\right)_{\mathrm{man}}\right]$ is statistically significant ($p < 0.1$).

The W statistic values for the variables $[\log(\mathrm{VX}_{\mathrm{man}})]$ and $\left[\log\left(\frac{\ell}{\mathrm{k}}\right)_{\mathrm{man}}\right]$ mean that the Shapiro-Wilk test fail to reject the null hypothesis that the data sets are normally distributed. However, the W statistic value for the variable $\left[\log\left(\frac{\ell}{\mathrm{k}}\right)_{\mathrm{man}} \times \log\left(\frac{\mathrm{L}}{\mathrm{K}}\right)_{\mathrm{man}}\right]$ rejects the null hypothesis for the Shapiro-Wilk test, meaning that, the data set for this variable is not normally distributed. Table 5-12 shows a summary of the results from the assessment of the predictive ability for the regression model developed for the manufacturing industry and the autocorrelation assessment of the dependent variable.

Table 5-12

Model Predictability and Autocorrelation Assessment for Manufacturing Industry

Model	R	R^2	Adjusted R^2	Standard error of estimate	Durbin-Watson
1	.717	.514	.491	.140	.955

Note. The dependent variable was $\log(\mathrm{VX}_{\mathrm{man}})$. The term VX represents industry-level value-added exports. The subscripted term *man* represents manufacturing industry.

It can be seen from Table 5-12 that the regression model developed is able to explain 51.4% of the variations in the dependent variable, i.e., value-added exports from South Africa to China in the manufacturing industry (in log terms). Furthermore, the Durbin-Watson coefficient of .955, means that the dependent variable exhibits a positive autocorrelation. A positive autocorrelation indicates that the point-in-time (t) and previous (t-1) values of manufacturing valued-added exports from South Africa to China will trend in the same direction. The fit of the model developed for the manufacturing industry was assessed using the F-test and ANOVA. The results from the assessment are shown in Table 5-13.

Table 5-13

Results for the F-test and ANOVA Test for Manufacturing Industry

ANOVA						
Model		Sum of squares	df	Mean square	F	Sig.
1	Regression	.857	2	.428	21.704	<.001
	Residual	.809	41	.020		
	Total	1.666	43			

Note. The dependent variable was $\log(\mathrm{VX}_{\mathrm{man}})$. The term VX represents industry-level value-added exports. The subscripted term *man* represents manufacturing industry.

According to Table 5-13, the F-statistic for the regression model developed for the manufacturing industry is estimated at 21.704 with a statistical significance less than 0.001, thereby signifying a statistical significance at the 1% level, as per Table 4-9. At this statistical significance, the null hypotheses for both the F-test and ANOVA test described in Section 4.8.3 is rejected, thereby indicating that the predictor variables in the model developed can explain a certain proportion of the variations in the dependent variable based on a linear relationship.

The results of the regression coefficients from the multivariate regression model developed for the manufacturing industry are shown in Table 5-14 and Table 5-15.

Table 5-14

Regression Results for Manufacturing Industry

Variable	Unstandardised coefficients	Standard error	Standardised coefficients
	B		β
$\log\left(\frac{\ell}{k}\right)_{man}$	-1.237	.598	-.869
$\log\left(\frac{\ell}{k}\right)_{man} \times \log\left(\frac{L}{K}\right)_{man}$	-.044**	.116	-.158

Note. The dependent variable was $\log(VX_{man})$. The symbol ** denotes statistical significance at the 5% level. The terms VX, k, and ℓ represent industry-level value-added exports, fixed capital formation, and employed labour force, respectively. The terms K and L represent country-level fixed capital formation and total employed labour force, respectively. The subscripted term *man* represents manufacturing industry.

Table 5-15

Additional Results on the Regression Analysis for Manufacturing Industry

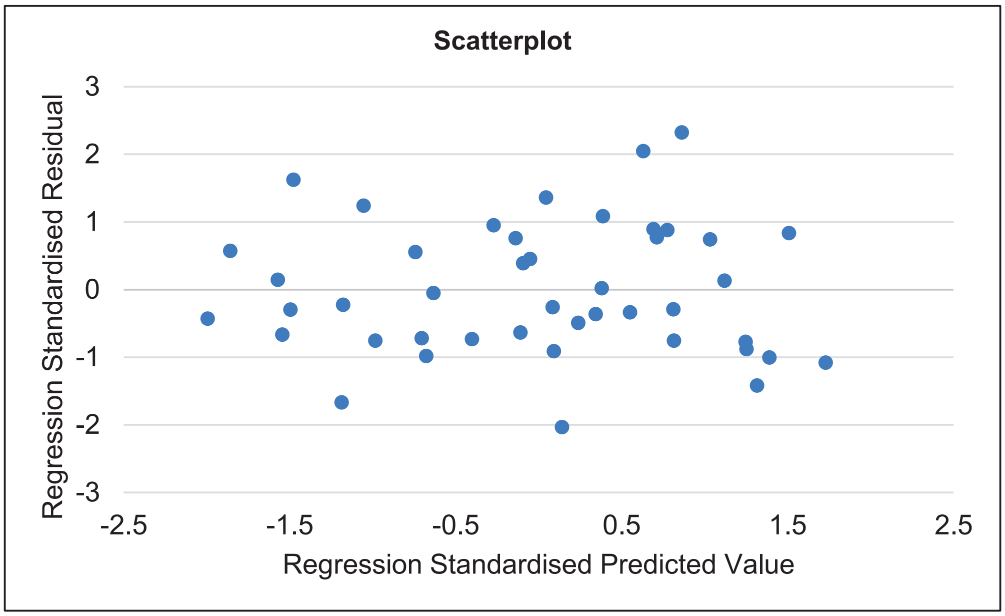
Variable	t-Test	Sig.	95% confidence interval for unstandardised coefficients	
			Lower bound	Upper bound
$\log\left(\frac{\ell}{k}\right)_{man}$	6.122	<.001	3.430	6.808
$\log\left(\frac{\ell}{k}\right)_{man} \times \log\left(\frac{L}{K}\right)_{man}$	-2.070	.045	-2.444	-.030

Note. The dependent variable was $\log(VX_{man})$. The terms VX, k, and ℓ represent industry-level value-added exports, fixed capital formation, and employed labour force, respectively. The terms K and L represent country-level fixed capital formation and total employed labour force, respectively. The subscripted term *man* represents manufacturing industry.

The results from Table 5-14 and Table 5-15 indicate that the regression coefficient for the labour-capital intensity and endowment variable $\left[\log\left(\frac{\ell}{k}\right)_{man} \times \log\left(\frac{L}{K}\right)_{man}\right]$, representing the coefficient of interest B_2 in Equation (1) is negative (B_2 = -.044) and statistically significant (p < 0.05). The estimated coefficient means that a one unit increase in the variable $\left[\log\left(\frac{\ell}{k}\right)_{man} \times \log\left(\frac{L}{K}\right)_{man}\right]$ will decrease the value-added exports variable $\log(VX_{man})$ by .044. The 95% confidence interval for regression coefficient B_2 ranges between -2.444 and -.030, indicating a statistically significant coefficient. The results from the assessment of homoscedasticity are shown Figure 5-2.

Figure 5-2

Homoscedasticity Assessment for Manufacturing Industry



Note. The dependent variable was $\log(VX_{man})$. The term VX represents industry-level value-added exports. The subscripted term *man* represents manufacturing industry.

The results from Figure 5-2 demonstrate that the residuals of the model developed for the manufacturing industry are equally spread across the zero line on the y-axis of the scatter plot shown. These results confirm the assumption of homoscedasticity for the model developed, meaning that, the variance in the predictions of the independent variable $[\log(VX_{man})]$ remains stable for all values of the independent variables. The results from the assessment of collinearity between the independent variables for the manufacturing industry are shown in Table 5-16.

Table 5-16

Assessment of Collinearity Amongst the Independent Variables for Manufacturing Industry

Variable	Tolerance	VIF
$\log\left(\frac{\ell}{k}\right)_{man}$	.067	14.853
$\log\left(\frac{\ell}{k}\right)_{man} \times \log\left(\frac{L}{K}\right)_{man}$	.067	14.853

Note. The dependent variable was $\log(VX_{man})$. The terms VX, k, and ℓ represent industry-level value-added exports, fixed capital formation, and employed labour force, respectively. The terms K and L represent country-level fixed capital formation and total employed labour force, respectively. The subscripted term *man* represents manufacturing industry.

The results from Table 5-16 demonstrate the presence of multicollinearity between the two independent variables. This means that there may be a relationship between the independent variables. This was expected considering that the independent variables $\left[\log\left(\frac{\ell}{k}\right)_{man}\right]$ and $\left[\log\left(\frac{\ell}{k}\right)_{man} \times \log\left(\frac{L}{K}\right)_{man}\right]$ both contain the term $\left[\left(\frac{\ell}{k}\right)_{man}\right]$. The VIF scores for the two independent variables are both larger than 10 (VIF scores = 14.853).

Summary

To summarise, the results from the regression analyses conducted show that country- and industry-level factor intensities (Heckscher-Ohlin forces) negatively affect South Africa's value-added manufacturing exports to China. This would suggest that manufacturing industry in South Africa exports fewer goods which require the intensive of labour in their production. The results therefore serve as evidence against the Heckscher-Ohlin theorem.

5.1.3.3 Results for Transport, Storage, Information, and Communication Industry

The results for the normality test i.e., W statistic from the Shapiro-Wilk test, conducted using data for the variables shown in Equation (1), for the transport, storage, information, and communication industry, are shown in Table 5-17.

Table 5-17

Normality Test Results for Transport, Storage, Information, and Communication Industry

Variable	Shapiro-Wilk		
	W Statistic	df	Sig.
$\log(\mathrm{VX}_{\mathrm{tra}})$	.916	44	.004
$\log\left(\frac{\ell}{\mathrm{k}}\right)_{\mathrm{tra}}$	.967	44	.231
$\log\left(\frac{\ell}{\mathrm{k}}\right)_{\mathrm{tra}} \times \log\left(\frac{\mathrm{L}}{\mathrm{K}}\right)_{\mathrm{tra}}$	.981	44	.655

Note. The term df denoted degrees of freedom. The terms VX, k, and ℓ represent industry-level value-added exports, fixed capital formation, and employed labour force, respectively. The terms K and L represent country-level fixed capital formation and total employed labour force, respectively. The subscripted term *tra* represents transport, storage, information, and communication industry.

The *p*-values for the variables $[\log(\mathrm{VX}_{\mathrm{tra}})]$, $\left[\log\left(\frac{\ell}{\mathrm{k}}\right)_{\mathrm{tra}}\right]$, and $\left[\log\left(\frac{\ell}{\mathrm{k}}\right)_{\mathrm{tra}} \times \log\left(\frac{\mathrm{L}}{\mathrm{K}}\right)_{\mathrm{tra}}\right]$are .004, .231, and .655, respectively. The results from Table 5-17 indicate that the W statistics for the labour-capital intensity variable $\log\left(\frac{\ell}{\mathrm{k}}\right)_{\mathrm{tra}}$ and labour-capital intensity and endowment variable $\left[\log\left(\frac{\ell}{\mathrm{k}}\right)_{\mathrm{tra}} \times \log\left(\frac{\mathrm{L}}{\mathrm{K}}\right)_{\mathrm{tra}}\right]$ are statistically insignificant (their *p*-values are both above 0.1 significance limit). These p-values mean that the Shapiro-Wilk test failed to reject the null hypothesis that the data sets for these variables are normally distributed. However, the W statistic for the value-added exports variable $[\log(\mathrm{VX}_{\mathrm{tra}})]$ is statistically significant ($p < 0.01$), meaning that, the null hypothesis for the Shapiro-Wilk test is rejected. Therefore, the data sets for this variable are not normally distributed.

A summary of the results from the assessment of the predictive ability of the regression model developed for the transport, storage, information, and communication industry and the autocorrelation assessment of the dependent variable is shown in Table 5-18.

Table 5-18

Model Predictability and Autocorrelation Assessment for Transport, Storage, Information, and Communication Industry

Model	R	R^2	Adjusted R^2	Standard error of estimate	Durbin-Watson
1	.181	.033	-.014	.429	.552

Note. The dependent variable was $\log(\mathrm{VX}_{\mathrm{tra}})$. The term VX represents industry-level value-added exports. The subscripted term *tra* represents transport, storage, information, and communication industry.

The results from Table 5-18 demonstrate that the regression model developed is able to explain 3.3% of the variations in the dependent variable, i.e., value-added exports from South Africa to China in the transport, storage, information, and communication industry (in log terms). Moreover, the Durbin-Watson coefficient in Table 5-18 is estimated as 0.552, meaning that, the dependent variable displays a positive autocorrelation. As mentioned earlier, a positive autocorrelation indicates that the point-in-time (t) and previous (t-1) values of transport, storage, information, and communication value-added exports from South Africa to China will trend in the same direction.

The results from the F-test and ANOVA test used to estimate the fit of the model developed for the transport, storage, information, and communication industry are shown in Table 5-19.

Table 5-19

Results for the F-test and ANOVA Test for Transport, Storage, Information, and Communication Industry

ANOVA						
Model		**Sum of squares**	**df**	**Mean square**	**F**	**Sig.**
1	Regression	.257	2	.129	.697	.504
	Residual	7.562	41	.184		
	Total	7.819	43			

Note. The dependent variable was $\log(\mathrm{VX}_{\mathrm{tra}})$. The term VX represents industry-level value-added exports. The subscripted term *tra* represents transport, storage, information, and communication industry.

Based on the results from Table 5-19, the F-statistic for the regression model developed for the transport, storage, information, and communication industry was estimated as .697 with a *p*-value of .504, indicating a statistical insignificance ($p > 0.1$). At this statistical significance, the results fail to reject the null hypotheses for both the F-test and ANOVA test described in Section 4.8.3, thereby indicating that the predictor variables in the model developed are not able to explain the variations in the dependent variable based on a linear relationship.

The results from the regression analysis conducted for the transport, storage, information, and communication industry are shown in Table 5-20 and Table 5-21.

Table 5-20

Regression Results for Transport, Storage, Information, and Communication Industry

Variable	Unstandardised coefficients	Standard error	Standardised coefficients
	B		β
$\log\left(\frac{\ell}{k}\right)_{tra}$	2.324	2.048	.636
$\log\left(\frac{\ell}{k}\right)_{tra} \times \log\left(\frac{L}{K}\right)_{tra}$	.356	.355	.561

Note. The dependent variable was $\log(VX_{tra})$. The terms VX, k, and ℓ represent industry-level value-added exports, fixed capital formation, and employed labour force, respectively. The terms K and L represent country-level fixed capital formation and total employed labour force, respectively. The subscripted term *tra* represents transport, storage, information, and communication industry.

Table 5-21

Additional Results on the Regression Analysis for Transport, Storage, Information, and Communication Industry

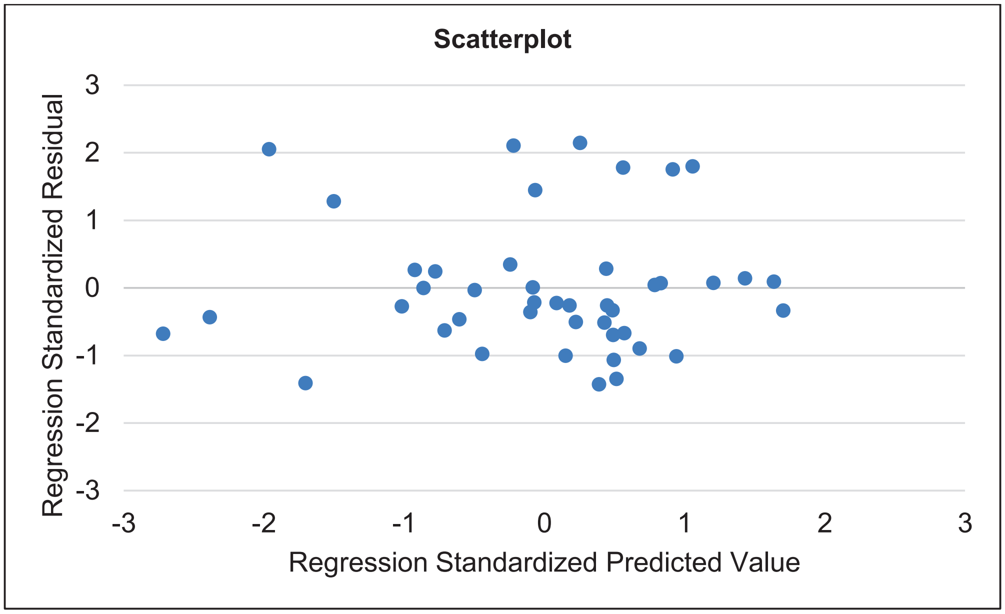
Variable	t-Test	Sig.	95% confidence interval for unstandardised coefficients	
			Lower bound	Upper bound
$\log\left(\frac{\ell}{k}\right)_{tra}$	1.135	.263	-1.812	6.461
$\log\left(\frac{\ell}{k}\right)_{tra} \times \log\left(\frac{L}{K}\right)_{tra}$	1.002	.322	-.362	1.073

Note. The dependent variable was $\log(VX_{tra})$. The terms VX, k, and ℓ represent industry-level value-added exports, fixed capital formation, and employed labour force, respectively. The terms K and L represent country-level fixed capital formation and total employed labour force, respectively. The subscripted term *tra* represents transport, storage, information, and communication industry.

It can be seen from Table 5-20 and Table 5-21 that the regression coefficient for the variable $\left[\log\left(\frac{\ell}{k}\right)_{Log} \times \log\left(\frac{L}{K}\right)_{Log}\right]$, representing the coefficient of interest B_2 in Equation (1) is positive (B_2 = .356) and statistically insignificant ($p > 0.1$). The estimated coefficient means that a one unit increase in the product of the country-level and transport, storage, information, and communication labour intensities (in log terms) will result in transport, storage, information, and communication value-added exports increasing by .356 (in log terms). However, the coefficient of interest B_2 is not significantly above zero, meaning that there exist instances where its value is zero (the 95% confidence interval ranges between -.362 and 1.073). The results from the assessment of homoscedasticity are shown in Figure 5-3.

Figure 5-3

Homoscedasticity Assessment for Transport, Storage, Information, and Communication Industry



Note. The dependent variable was $\log(\mathrm{VX}_{\mathrm{tra}})$. The term VX represents industry-level value-added exports. The subscripted term *tra* represents transport, storage, information, and communication industry.

According to the results from Figure 5-3, the residuals of the model developed for the transport, storage, information, and communication industry are equally distributed across the zero line on the y-axis of the scatter plot shown, thereby confirming the assumption of homoscedasticity that states that the variance in the predictions of the independent variable $[\log(\mathrm{VX}_{\mathrm{tra}})]$ remains stable for all values of the independent variables. The results from the assessment of collinearity between the independent variables for the transport, storage, information, and communication industry are shown in Table 5-22.

Table 5-22

Assessment of Collinearity Amongst the Independent Variables for Transport, Storage, Information, and Communication Industry

Variable	Tolerance	VIF
$\log\left(\frac{\ell}{k}\right)_{tra}$	.075	13.312
$\log\left(\frac{\ell}{k}\right)_{tra} \times \log\left(\frac{L}{K}\right)_{tra}$	.075	13.312

Note. The dependent variable was $\log(VX_{tra})$. The terms VX, k, and ℓ represent industry-level value-added exports, fixed capital formation, and employed labour force, respectively. The terms K and L represent country-level fixed capital formation and total employed labour force, respectively. The subscripted term *tra* represents transport, storage, information, and communication industry.

Table 5-22 shows that the VIF scores for the two independent variables are both larger than 10 (VIF scores = 13.012), signifying the presence of multicollinearity (relationship) between the independent variables. As mentioned earlier, this was expected considering that the independent variables $\left[\log\left(\frac{\ell}{k}\right)_{tra}\right]$ and $\left[\log\left(\frac{\ell}{k}\right)_{tra} \times \log\left(\frac{L}{K}\right)_{tra}\right]$ both contain the term $\left[\left(\frac{\ell}{k}\right)_{tra}\right]$.

Summary

To summarise, the results from the regression analyses conducted provide no evidence that country- and industry-level factor intensities (Heckscher-Ohlin forces) affect South Africa's value-added transport, storage, information, and communication to China in any way. Therefore, no conclusion can be drawn with respect to whether these results are in support of or against the Heckscher-Ohlin theorem.

5.2 Using the Chain Version of the Heckscher-Ohlin Model to Explain the Respective Net Trade Flows Between South Africa and the Rest of the World

The results in this section are presented in terms of descriptive statistics, application of the chain version of the Heckscher-Ohlin model, and comparison of net trade balance data. The second research hypothesis (H2) was described in Section 3.1 as follows:

> **Research hypothesis 2 (H2)**: The chain version of the Heckscher-Ohlin model can predict South Africa's net trade flows**.**

5.2.1 Descriptive Statistics

Quarterly data for the variables mentioned in Section 4.7.4 were collected for the period between the first quarter of 2009 and fourth quarter of 2019. A summary of the descriptive statistics for data collected during the specified period of analysis is shown in Table 5-23. It should be noted that the descriptive statistics presented are specifically for the "raw" variables measured directly and not the transformed variables derived from the application of the equations described in Section 5.2.

Table 5-23

Descriptive Statistics for Variables Used to Evaluate H2

Variable	Minimum	Maximum	Mean	Standard deviation (SD)	Skewness	Kurtosis
Combined Economy						
X (million Rands)	105 612	307 170	202 940	60 378	-0.082	-1.082
M (million Rands)	108 877	286 419	208 942	51 460	-0.504	-0.890
Mining and Quarrying						
X_{min} (million Rands)	57 166	154 269	100 285	24 654	0.089	-0.386
M_{min} (million Rands)	25 664	72 283	48 291	12 339	0.106	-0.837
k_{min} (million Rands)	8 226	22 843	14 022	3 392	0.722	0.240
ℓ_{min} (thousand)	302	483	398	47	-0.415	-0.961
Manufacturing						
X_{man} (million Rands)	37 133	116 836	76 094	25 781	-0.267	-1.485
M_{man} (million Rands)	73 516	200 874	136 959	37 212	-0.308	-1.208
k_{man} (million Rands)	8 376	25 657	15 973	4 404	0.157	-0.815
ℓ_{man} (thousand)	1 645	2 032	1 802	77	1.043	2.140
Transport, Storage, Information, and Communication						
X_{tra} (million Rands)	9 548	52 444	26 560	11 826	0.239	-1.055
M_{tra} (million Rands)	318	3 524	1 358	688	1.071	2.143
k_{tra} (million Rands)	9 094	34 705	17 418	5 459	0.975	1.420
ℓ_{tra} (thousand)	776	1 025	901	73	-0.078	-1.207

Note. The subscripts *min*, *man*, and *tra* included in the industry-level variables represent the (a) mining and quarrying industry, (b) manufacturing industry, and (c) transport, storage, information, and communication industry, respectively. The information presented in parentheses represent the unit of measurement. The count for all the variables was 44. Data used to determine the descriptive statistics shown were sourced from Stats SA and ITC.

As seen from Table 5-23, the mean for South Africa's value-added imports (mean = 208 942 million Rands, SD = 51 460 million Rands) is slightly higher than the mean for its value-added exports (mean = 202 940 million Rands, SD = 60 378 million Rands). From an industry-level, value-added exports perspective, mining and quarrying industry in South Africa provides the highest value-added exports (mean = 100 285 million Rands, SD = 24 654 million Rands), with transport, storage, information, and communication industry providing the lowest value-added exports (mean = 26 560 million Rands, SD = 11 826 million Rands). Similarly, manufacturing industry in South Africa provides the highest value-added imports (mean = 136 959 million Rands, SD = 37 212 million Rands) and transport, storage, information, and communication industry provides the lowest valued-added imports (mean = 1 358 million Rands, SD = 688 million Rands).

From a fixed capital formation perspective, it can be seen from Table 5-23 that the majority of capital expenditure on new plant, machinery, and equipment is in South Africa's transport, storage, information, and communication industry (mean = 17 418 million Rands, SD = 5 459 million Rands). The lowest capital expenditure on new plant, machinery, and equipment is in South Africa's mining and quarrying industry (mean = 14 022 million Rands, SD = 3 392 million Rands). In terms of labour force, it can be seen from Table 5-23 that the manufacturing industry in South Africa has the highest number of employed people (mean = 1 802 thousand, SD = 77 069), whereas the lowest number of employed people is observed in South Africa's mining and quarrying (mean = 398 056, SD = 47 174).

With respect to the distribution of the data set in Table 5-23, it can be seen that data for combined economy exports and imports, mining and quarrying industry employed labour force, manufacturing industry exports and imports, and transport, storage, information, and communication industry employed labour force are all negatively skewed (skewness < 0), meaning that, the data sets have long tails to the left of the distribution curve. The rest of the data sets for the other variables in Table 5-23 are all positively skewed (skewness > 0), i.e., the data sets have long tails to the right of the distribution curve.

In terms of the flatness/roundness of the data set peak, the results in Table 5-23 show that the Kurtosis coefficients obtained are all less than three, indicating that the data sets for these variables have flatter peaks compared to that of normally distributed data set.

5.2.2 Application of the Chain Version of the Heckscher-Ohlin Model

To assess the extent to which the chain version of the Heckscher-Ohlin model predicts South Africa's net trade flows with the rest of the world, the six equations presented in Section 5.2, .i.e., Equations (2) to (7), were applied in a similar manner as studies undertaken by Cavusoglu (2019), and Cavusoglu and Elmslie (2005). These equations involved the computation and distribution of net trade balance across the industries of interest, namely mining and quarrying, manufacturing, and transport, storage, information, and communication, using three different weight measures. The three weight measures applied to distribute net trade balance were equal weight, volume weight, and balance weight.

The ranking list developed based on the application of the chain version of the Heckscher-Ohlin model, using data collected for the period between the first quarter of 2009 and fourth quarter of 2019, are provided in Table 5-24 and Figure 5-4.

Table 5-24

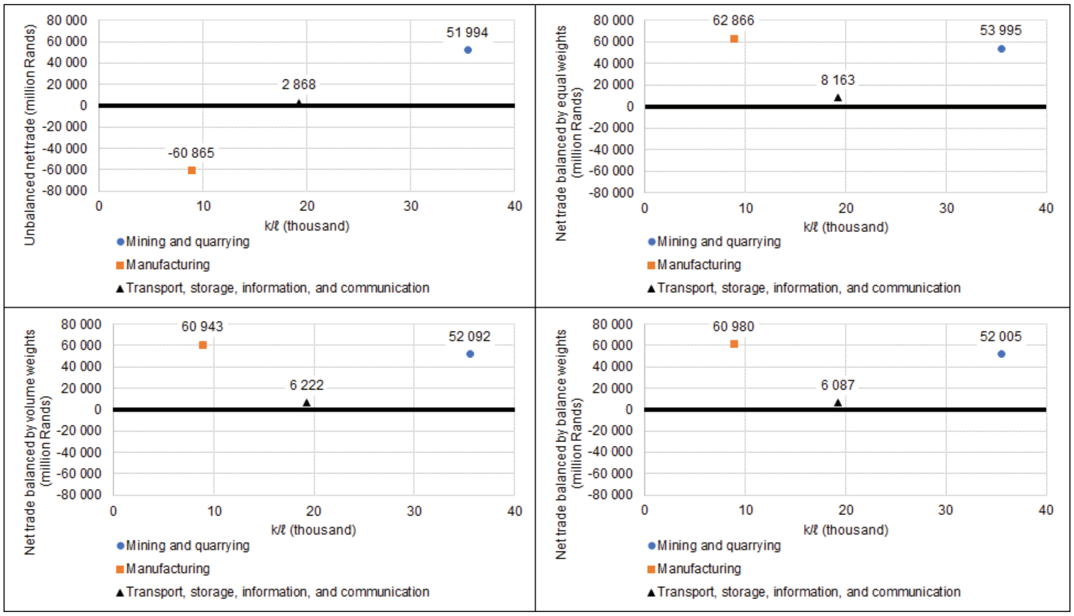
Ranking List According to the Chain Version of the Heckscher-Ohlin Model

Industry	**k/ℓ (thousand)**	**NB_i**	**TB^A_i – equal weights**	**TB^A_i – volume weights**	**TB^A_i – balance weights**
Mining and quarrying	35.53	51 994	53 995	52 092	52 005
Transport, storage, information, and communication	19.24	2 868	8 163	6 222	6 087
Combined economy	***15.26***	***N/A***	***N/A***	***N/A***	***N/A***
Manufacturing	8.95	-60 865	62 866	60 943	60 980

Note. The terms *NB* and *TB* represent non-balanced trade and trade balance, respectively. The uppercase letter *A* denotes adjusted net trade balance. The lowercase *i* represents subscripts *min*, *man*, and *tra* which are abbreviations for the (a) mining and quarrying industry, (b) manufacturing industry, and (c) transport, storage, information, and communication industry, respectively. The terms k and ℓ represent industry-level fixed capital formation and employed labour force, respectively. The abbreviation N/A indicated "not applicable". The values presented represent average values for the period analysed. The k/ℓ ratio for the combined economy was determined by calculating the sum of the individual fixed capital formation values for the three industries evaluated and dividing it by the sum of their respective employed labour force quantities.

Figure 5-4

Net Trade Balances and Capital-Labour (k/ℓ) Ratios



In Table 5-24, the k/ℓ ratios for the three industries evaluated as part of the study were classified as either k-intensive or ℓ-intensive, based on their comparison with the k/ℓ ratio for the total economy. For example, industries with higher k/ℓ ratios compared to the k/ℓ ratio for the total economy were classified as k-intensive, i.e., capital-intensive, whereas those with lower k/ℓ ratios compared to the total economy were classified as ℓ-intensive, i.e., labour-intensive.

Figure 5-4 was developed using average k/ℓ ratios and average values for the non-balanced, equal weighted, volume weighted, and balance weighted net trade balances, for the respective industries evaluated as part of this study. As per the chain version of the Heckscher-Ohlin theory, the industries in Table 5-24 were ranked horizontally. Following that, each industry was then classified as either k-intensive or ℓ-intensive relative to the total economy.

It can be seen from Table 5-24 that South Africa's manufacturing industry is labour-intensive (k/ℓ = 8.95 thousand), whereas mining and quarrying industry (k/ℓ = 35.53 thousand), and transport, storage, information, and communication industry (k/ℓ = 19.24 thousand) are both capital-intensive.

According to net trade balance results from Table 5-24, it can be seen that South Africa, known to be a labour-intensive country (its capital-to-labour intensity for the total economy for the period between the first quarter of 2009 and fourth quarter of 2019 is 5.42 thousand), is consistently a net exporter in the most capital-intensive industry, namely mining and quarrying industry. This is evident across all net trade balance estimations, i.e., non-balanced (net trade balance = 51 994 million Rands), equal weight (net trade balance = 53 995 million Rands), volume weight (net trade balance = 52 091 million Rands), and balance weight (net trade balance = 52 005 million Rands) net trade balances. This is further evidenced by the fact that net trade balance data, from the four net trade balance estimations (non-balanced, equal weight, volume weight, and balance weight), for the mining and quarrying are all above the zero line on the net trade balance axis (Y-axis) in all the scatter plots shown in Figure 5-4.

South Africa is also a net exporter across all four net trade balance estimations for the second most capital-intensive industry, namely transport, storage, information, and communication industry. The country is a net exporter when considering non-balanced (net trade balance = 2 868 million Rands), equal weight (net trade balance = 8 163 million Rands), volume weight (net trade balance = 6 222 million Rands), and balance weight (net trade balance = 6 087 million Rands) net trade balance estimations. The non-balance, equal weight, volume weight, and balance weight net trade balance data for the transport, storage, information, and communication industry are all above the net trade balance zero line (on the Y-axis) on all the scatter plots shown in Figure 5-4.

Lastly, South Africa is a net exporter in three out of the four net trade balance estimations for the manufacturing industry, shown to be labour intensive in Table 5-24. The equal weight (62 866 million Rands), volume weight (60 943 million Rands), and balance weight (60 980 million Rands) are all positive. In contrast, the non-balance net trade balance is negative (-60 865 million Rands). In Figure 5-4, the equal weight, volume weight, and balance weight net trade balances are all indicated as above the zero line on the net trade balance axis (Y-axis) in all the scatter plots presented. As expected, the non-balance net trade balance is depicted as below the zero line in Figure 5-4.

5.2.3 Comparison of Net Trade Balances

The Kruskal-Wallis statistical test, described in Section 4.7.4.3, was conducted to evaluate the extent to which the medians of net trade balance values calculated using Equation (3) to (7) in Section 5.2 and presented in Figure 5-4 were different. Before applying the Kruskal-Wallis statistical test, it was important to first confirm that parametric tests, which assume normality of data, could not have been applied to test for differences between net trade balance values presented in Figure 5-4. This was done by conducting normality tests. The normality test applied was the Shapiro-Wilk test described in Section 4.7.4.2. The results from applying the Shapiro-Wilk test are shown in Table 5-25.

Table 5-25

Normality test results for Net Trade Balance Data for Mining and Quarrying, Manufacturing, And Transport, Storage, Information, and Communication *Industries*

Net trade balance	**Manufacturing**		**Transport, Storage, Information, and Communication**		**Mining and Quarrying**	
	Shapiro-Wilk					
	W-Statistic	**Sig.**	**W-Statistic**	**Sig.**	**W-Statistic**	**Sig.**
NB_i	.968	.265	.928	.009	.947	.042
TB^A_i – equal weights	.953	.070	.962	.155	.970	.314
TB^A_i – volume weights	.966	.222	.889	<.001	.949	.049
TB^A_i – balance weights	.966	.220	.898	<.001	.949	.050

Note. The terms *NB* and *TB* represent non-balanced trade and trade balance, respectively. The uppercase letter *A* denotes adjusted net trade balance. The lowercase *i* represents subscripts *min*, *man*, and *tra* which are abbreviations for the (a) mining and quarrying industry, (b) manufacturing industry, and (c) transport, storage, information, and communication industry, respectively.

As mentioned in Section 4.7.4.2, the null hypothesis for the Shapiro-Wilk statistical test is that the data sets are normally distributed. As can be seen in Table 5-25, net trade balance data for the mining and quarrying industry, across all net trade balance estimations, are all not normally distributed ($p < 0.1$), except for the equal weights net trade balance data (p-value > 0.1) which are normally distributed. Similarly, net trade balance data for the manufacturing industry across all net trade balance estimations, are all normally distributed ($p > 0.1$), except for the equal weights net trade balance data ($p < 0.1$) which are not normally distributed. A similar outcome is also observed for the transport, storage, information, and communication industry. Net trade balance data for this industry are not normally distributed across all four net trade balance estimations (p-values are lower than 0.1 significance level), except for equal weights net trade balance data which are normally distributed (p-value above the 0.1 significance level).

Due to the presence of non-normal data, it is therefore evident from the results in Table 5-25 that only non-parametric tests were applicable for the envisaged comparison, thereby proving the applicability of the Kruskal-Wallis statistical test. Net trade balance data for the three industries evaluated as part of this study needed to be transformed before applying the Kruskal-Wallis statistical test. The transformation was necessary to ensure that the data were arranged in a manner compatible with the application of the Kruskal-Wallis statistical test in the SPSS software. The first step of the transformation involved the categorisation of net trade variables as shown in Table 5-26.

Table 5-26

Categorisation of Net Trade Balance Variables

Net trade balance	**Category**
NB_i	1
TB^A_i – equal weights	2
TB^A_i – volume weights	3
TB^A_i – balance weights	4

Note. The terms *NB* and *TB* represent non-balanced trade and trade balance, respectively. The uppercase letter *A* denotes adjusted net trade balance. The lowercase *i* represents subscripts *min*, *man*, and *tra* which are abbreviations for the (a) mining and quarrying industry, (b) manufacturing industry, and (c) transport, storage, information, and communication industry, respectively.

After categorising net trade balance variables as per Table 5-26, the respective net trade balance data (non-balanced, equal weighted, volume weighted, and balance weighted) for each industry were then stacked vertically while matching the respective net trade balance data with their respective categories, with each industry's data shown in a separate column as shown in Table 5-27.

Table 5-27

Structuring of Net Trade Balance Data in Order to Apply the Kruskal-Wallis Statistical Test

Category	Manufacturing	Transport, Storage, Information, and Communication	Mining and Quarrying
1	Non-balanced net trade balance	Non-balanced net trade balance	Non-balanced net trade balance
2	Equal-weight net trade balance	Equal-weight net trade balance	Equal-weight net trade balance
3	Volume-weight net trade balance	Volume-weight net trade balance	Volume-weight net trade balance
4	Balance-weight net trade balance	Balance-weight net trade balance	Balance-weight net trade balance

Note. Net trade data represents the calculated net trade based on the application of Equations (2) to (7) using data for the period between the first quarter of 2009 and fourth quarter of 2019.

Once the data had been categorised and arranged in a manner compatible with the SPSS software, the Kruskal-Wallis statistical test was conducted to compare the medians of net trade balance data shown in Figure 5-4. The results from the tests conducted are shown in Table 5-28.

Table 5-28

Results from the Kruskal-Wallis Statistical Tests

Item	Manufacturing	Transport, Storage, Information, and Communication	Mining and Quarrying
Kruskal-Wallis Statistic	98.760	18.329	1.015
df	3	3	3
Asymp. Sig.	<.001	<.001	.798

Note. The term df denotes degrees of freedom, whereas Asymp. Sig. represents the p-value for the Kruskal-Wallis Statistic.

The results from Table 5-28 are mixed when it comes to the comparison of the medians of net trade balance data. For the mining and quarrying industry, the results from Table 5-28 show that the Kruskal-Wallis Statistic is 1.015 with a *p*-value of .798. A *p*-value above 0.1 means that the test fails to reject the null hypothesis for the Kruskal-Wallis statistical test, meaning that, there is no sufficient evidence to state that there is statistically significant difference between mining and quarrying net trade balance estimations across the four categories.

In contrast, both manufacturing industry and transport, storage, information, and communication industry produced different results compared to mining and quarrying industry. For the manufacturing industry, the Kruskal-Wallis Statistic is 98.760 with a *p*-value lower than .001, whilst the Kruskal-Wallis Statistic for the transport, storage, information, and communication industry is 18.329 also with a p-value lower than 0.001. Therefore, the tests for manufacturing industry and transport, storage, information, and communication industry reject the null hypothesis for the Kruskal-Wallis statistical test, meaning that, there was enough evidence to indicate that the mean of at least one of the net trade balance estimations across the four categories in each industry is different.

5.3 Conclusions

This chapter presented the results from the statistical analysis conducted to evaluate first and second research hypotheses, i.e., H1 and H2 respectively, as described in the methodology presented in Chapter 3.

5.3.1 Heckscher-Ohlin Forces

The first research hypothesis (H1), outlined in Section 3.1, evaluated the extent to which Heckscher-Ohlin forces can be used to predict and explain South Africa's export volumes to China. This was done by applying the standard version of the Heckscher-Ohlin theorem as described in Section 5.1.3, which entailed the utilisation of multivariate linear regression analyses. As mentioned in Section 5.1, the coefficient of interest in the multivariate linear regression analyses conducted for the standard version of the Heckscher-Ohlin model is B_2. A summary of the B_2 values from the regression analyses conducted to evaluate H1 is shown in Table 5-29.

Table 5-29

Estimated B_2 Values from the Multivariate Linear Regression Analyses for H1

Industry	**Estimated value for B_2**
Mining and quarrying	.185**
Manufacturing	-.044**
Transport, storage, information, and communication	.356

Note. The symbol ** represents statistical significance at the 5% level.

As seen from Table 5-29, the regression coefficient B_2 for the mining and quarrying industry is positive and statistically significant, thereby confirming the predictions of the standard version of the Heckscher-Ohlin theorem, which states that Heckscher-Ohlin forces have a positive effect on South Africa's export flows to China. The coefficient B_2 for the manufacturing industry is negative and statistically significant. These results reject the predictions of the standard version of the Heckscher-Ohlin theorem. The results for the transport, storage, information, and communication industry are statistically insignificant, therefore no conclusions are drawn in relation to the predictions of the Heckscher-Ohlin theorem.

Part of the regression analyses conducted to evaluate H1 was to assess the degree to which the assumptions of the multivariate linear regression equation were adhered to or satisfied. Table 5-30 provides a summary of the results from the assessment conducted.

Table 5-30

Assessment of the Assumptions of the Multivariate Linear Regression Analyses

Assumption	**Assessment of assumption**		
	Mining and Quarrying	**Manufacturing**	**Transport, Storage, Information, and Communication**
Normality	Satisfied	Mixed results	Mixed results
Linearity	Satisfied	Satisfied	Not satisfied
Homoscedasticity	Satisfied	Satisfied	Satisfied
Absence of multicollinearity	Satisfied	Not satisfied	Not satisfied

5.3.2 Chain Version of the Heckscher-Ohlin Theorem

The second research hypothesis (H2), outlined in Section 3.2, evaluated the extent to which the chain version of the Heckscher-Ohlin model can predict South Africa's net trade flows with the rest of the world, followed by a comparison of estimated net trade balance values within each of the three industries evaluated as part of this study. A summary of the results from the application of the chain version of the Heckscher-Ohlin model is shown in Table 5-31.

Table 5-31

Application of the Chain Version of the Heckscher-Ohlin Model Using Various Net Trade Balance Estimations

Industry	k/ℓ (thousand)	NB_i	TB^A_i – equal weights	TB^A_i – volume weights	TB^A_i – balance weights
Mining and quarrying	k-intensive	+	+	+	+
Transport, storage, information, and communication	k-intensive	+	+	+	+
Manufacturing	ℓ-intensive	-	+	+	+

Note. The symbols "+" and "-" represent the sign of the average values from the calculated net trade balance values computed by applying Equations (2) to (7). The terms *NB* and *TB* represent non-balanced trade and trade balance, respectively. The uppercase letter *A* denotes adjusted net trade balance. The lowercase *i* represents subscripts *min*, *man*, and *tra* which are abbreviations for the (a) mining and quarrying industry, (b) manufacturing industry, and (c) transport, storage, information, and communication industry, respectively.

As seen from Table 5-31, the results from the application of the chain version of the Heckscher-Ohlin model, to evaluate H2, produce mixed results. The results show that South Africa, known to be a labour-intensive country, is predominantly a net exporter of goods in the manufacturing industry across the majority of the net trade balance estimations. However, the results also show South Africa as a consistent net exporter of goods in the mining and quarrying industry, and transport, storage, information, and communication industry.

6 Chapter 6: Discussion

This chapter discusses and interprets the research results presented in Chapter 5. The results presented in Chapter 5 are interpreted using the conceptual framework shown in Figure 2-2-3. These results are then compared with results from other literature studies discussed in Section 2. Section 6.1 discusses and interprets the results from the evaluation of the extent to which Heckscher-Ohlin forces impact South Africa's net trade flows to China, whereas Section 6.2 discusses and interprets results from the evaluation of the extent to which the chain version of the Heckscher-Ohlin model can predict South Africa's net trade flows with the rest of the world.

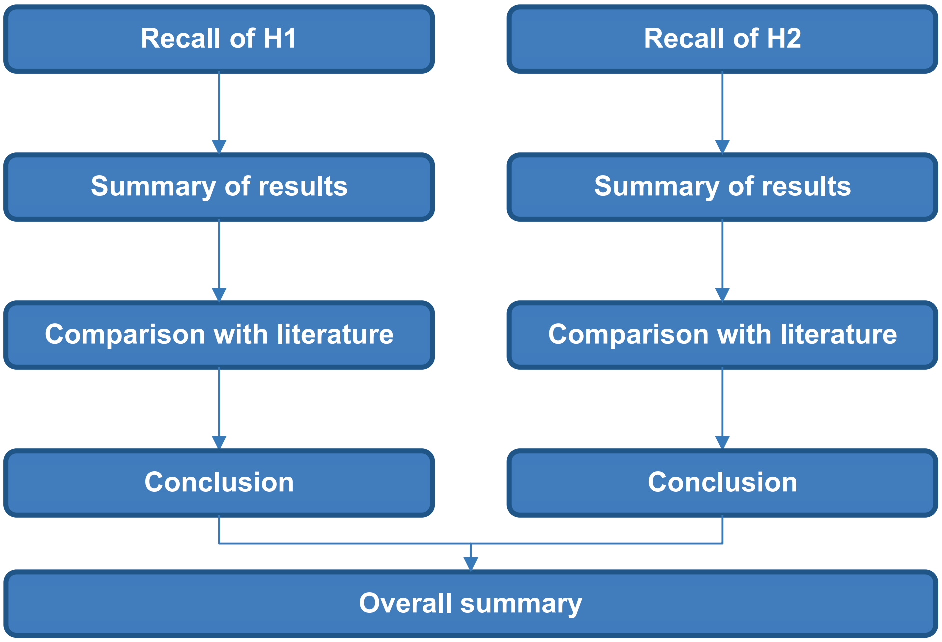
The aim of this study, as discussed in Section 1.2.2, was to evaluate the influence of factor endowments on bilateral trade patterns between countries. Chapter 2 provided the theoretical background to the research problem outlined in Section 1.2.1. The research question formulated in Chapter 3 from the background provided in Chapter 1 and literature review in Chapter 2 focussed on the extent to which factor endowments influence bilateral trade patterns between countries. Subsequently, this research question was segmented into two research sub-questions and propositions, as presented in Sections 3.1 and 3.2.

The fist research sub-question evaluated the extent to which Heckscher-Ohlin forces impact South Africa's net trade flows to China, whereas the second research sub-question evaluated the extent to which the chain version of the Heckscher-Ohlin model predicts South Africa's net trade flows with the rest of the world. For the second research sub-question, the rest of the world was treated as a single country, similar to other literature studies (Cavusoglu and Elmslie, 2005; Leontief, 1953). As shown in Table 4-2, both the standard and chain versions of the Heckscher-Ohlin model were applied only on three out of the nine industries covered by Stats SA due to data availability constraints described in Section 4.7.1.

The procedures and methods used to collect and analyse applicable data were described in Chapter 4. Data collected for evaluating the first research sub-question were analysed using linear multivariate regression analyses, whereas the Kruskal-Wallis statistical test was used to analyse data collected for the second research sub-question. The discussions in this chapter are structured around the two main research hypotheses as shown in Figure 6-1.

Figure 6-1

Structure of the Discussions



6.1 Hypothesis 1 (H1)

As described in Section 3.1, the first research hypothesis (H1) for this study sought to evaluate the extent to which Heckscher-Ohlin forces affect South Africa's value-added export flows to China. H1 was described in Section 3.1 as follows:

> **Research hypothesis 1 (H1):** Heckscher-Ohlin forces significantly affect South Africa's value-added export flows to China.

The evaluation of H1 was performed by applying the standard version of the Heckscher-Ohlin theorem which states that differences in countries' factor endowments determine their specialisation and international trade patterns (Abendin & Duan, 2021; Gandolfo & Trionfetti, 2014; Koch & Fessler, 2020). The evaluation of H1 included an analysis of descriptive statistics, correlation coefficients, and regression coefficients for data collected for the period between the first quarter of 2009 and fourth quarter of 2019 following the methodology described in Section 4.7.2.

6.1.1 Descriptive Statistics

Based on the results from the descriptive statistics in Section 5.1.1, it can be seen that, of all the three industries evaluated as part of this study, mining and quarrying industry in South Africa has the highest value-added exports to China. This was expected since trade data for South Africa shows that the country mainly exported raw minerals and metals to China (Mhaka & Jeke, 2018; Stern & Ramkolowan, 2021).

According to data from the Observatory of Economic Complexity (OEC) (n.d.-a), exports from mining and quarrying industry constituted at least 78% of South Africa's total exports to China in 2020. On the other hand, manufacturing industry had the second largest value-added exports to China. This was also expected considering that manufactured products from China constituted at least 70% of South Africa's total imports from China in 2020 (OEC, n.d.-c). Lastly, the logistic industry in South Africa had the lowest value-exports to China.

The results for industry-level capital expenditure on new property, plant, and equipment, known as fixed capital formation, in South Africa provided different insights compared to the results for South Africa's value-added exports to China. Based on the results in Table 5-1, it is evident that the transport, storage, information, and communication industry in South Africa has the highest fixed capital formation, followed by manufacturing industry. The South African mining and quarrying's fixed capital formation is the lowest compared to the other three industries evaluated in this study. The capital expenditure results show that the majority of the capital expenditure in the South African economy was directed to industries with the second and third largest value-added exports to China.

6.1.2 Correlation Statistics

As described in Section 4.7.1, correlation analyses were conducted to assess the strength of the linear associations between the variables included in Equation (1) presented in Section 5. The correlation coefficients of interest for the correlation analyses conducted were between the variables $[\log(\mathrm{VX_i})]$ and $\left[\log\left(\frac{\ell}{\mathrm{k}}\right)_{\mathrm{i}} \times \log\left(\frac{\mathrm{L}}{\mathrm{K}}\right)_{\mathrm{i}}\right]$, where the subscript *i* represented (a) mining and quarrying industry, (b) manufacturing industry, and (c) transport, storage, information, and communication industry. The term VX represented value-added exports from South Africa to China. The lowercase letter ℓ represented industry-level employed labour force, whereas the lowercase letter *k* denoted industry-level fixed capital formation, both for the exporting country, i.e., South Africa. The country-level total employed labour force and fixed capital formation (both for South Africa) were represented by the uppercase letters *L* and *K*, respectively. A summary of the correlation coefficients from the correlation analyses conducted is shown in Table 6-1.

Table 6-1

Main Correlation Coefficients for Mining and Quarrying, Manufacturing, and Transport, Storage, Information, and Communication Industries

Variable 1	Variable 2	Correlation coefficient
$\log(\mathrm{VX}_{\mathrm{min}})$	$\log\left(\frac{\ell}{\mathrm{k}}\right)_{\mathrm{min}} \times \log\left(\frac{\mathrm{L}}{\mathrm{K}}\right)_{\mathrm{min}}$	.407***
$\log(\mathrm{VX}_{\mathrm{man}})$	$\log\left(\frac{\ell}{\mathrm{k}}\right)_{\mathrm{man}} \times \log\left(\frac{\mathrm{L}}{\mathrm{K}}\right)_{\mathrm{man}}$	.681***
$\log(\mathrm{VX}_{\mathrm{tra}})$	$\log\left(\frac{\ell}{\mathrm{k}}\right)_{\mathrm{tra}} \times \log\left(\frac{\mathrm{L}}{\mathrm{K}}\right)_{\mathrm{tra}}$	-.050

Note. The symbol *** represents a statistical significance at the 0.01 level (2-tailed). The terms VX, k, and ℓ represent industry-level value-added exports, fixed capital formation, and employed labour force, respectively. The terms K and L represent country-level fixed capital formation and total employed labour force, respectively. The subscripts *min*, *man*, and *tra* included on the industry-level variables represent the (a) mining and quarrying industry, (b) manufacturing industry, and (c) transport, storage, information, and communication industry, respectively.

The results from Table 6-1 show that the correlation coefficients of interest for the mining and quarrying industry, and manufacturing industry are positive and statistically significant (p < 0.01). Thereby, indicating that there is a positive linear association between the value-added exports variable $[\log(VX_i)]$ and, labour-capital intensity and endowment variable $\left[\log\left(\frac{\ell}{k}\right)_i \times \log\left(\frac{L}{K}\right)_i\right]$ in these industries. The positive linear association serves as evidence that there exists a linear relationship between value-added exports from these industries and factor endowments. This is in line with the Heckscher-Ohlin model which assumes a positive linear relationship between factor endowments and net trade (Abendin & Duan, 2021; Akther et al., 2022; Blum, 2010; Koch & Fessler, 2020, Schott, 2003).

6.1.3 Regression analyses

Regression models were developed for each of the three industries evaluated in this study, namely (a) mining and quarrying, (b) manufacturing, and (c) transport, storage, information, and communication. These regression models looked to evaluate the effect of Heckscher-Ohlin forces on South Africa's value-added export flows to China. As stated by other studies (Ito et al., 2017; Koch & Fessler, 2020), the regression coefficient B_2 is the coefficient of interest for the models developed.

6.1.3.1 Mining and Quarrying Industry

For the mining and quarrying industry, the relationship between country- and industry-level factor intensities, and value-added exports from South Africa to China has a positive and statistically significant regression coefficient (B_2 = .185, p = .013). This provides evidence in support of the Heckscher-Ohlin theorem.

Literature on the Heckscher-Ohlin theorem states that a statistically significant positive B_2 for a labour-intensive country demonstrates support for the Heckscher-Ohlin theorem (Ito et al., 2017; Koch & Fessler, 2020). According to the theorem, labour-abundant countries will favour the production and export of labour-intensive commodities (Akther et al., 2022; Fisher, 2011; Fukiharu, 2004; Jones, 1956; Juozapavičienė & Eizentas, 2010; Mhaka & Jeke, 2018). This suggests that South Africa, which has an abundance of labour, produces and exports more goods in mining and quarrying industry. Goods produced in this industry appear to favour the intensive use of labour in their production.

These findings are in line with other similar studies. For example, in his study, Chor (2010) defined Heckscher-Ohlin forces in terms of skill intensity (ratio of skilled labour to total employment, in log terms) and physical intensity (ratio of real capital stock to total employment, in log terms). Chor (2010) then extended Eaton and Kortum's (2002) model and his results supported the Heckscher-Ohlin predictions. The researcher's results showed that skill-abundant countries export more goods in skill-intensive industries, whereas capital-abundant countries export more goods in capital-intensive industries. Chor (2010) concluded that his results confirmed the usefulness of the Heckscher-Ohlin model in explaining patterns of trade between countries.

Ito et al. (2017) also found results in support of the Heckscher-Ohlin theorem. For their study, Ito et al. (2017) specified skill abundance and skill intensity as the only determinants, i.e., Heckscher-Ohlin forces, of value-added and gross trade exports. Similar to Chor (2010), the results from Ito et al.'s (2017) study demostrated that skill-abundant countries have higher volumes of skill-intensive value-added exports. Following a similar approach, Koch and Fessler (2020) evaluated the regression coefficients for both labour-capital intensity and endowment variable $\left[\log\left(\frac{\ell}{\mathrm{k}}\right)_{\mathrm{it}} \times \log\left(\frac{\mathrm{L}}{\mathrm{K}}\right)_{\mathrm{it}}\right]$, and skill intensity and endowment variable $\left[\log\left(\frac{\ell_{hs}}{\ell_{us}}\right)_{\mathrm{it}} \times \log\left(\frac{\mathrm{L}_{hs}}{\mathrm{L}_{us}}\right)_{\mathrm{it}}\right]$ in their study, where subscripted terms *hs* and *us* were defined as skilled labour and unskilled labour, respectively. Their results also proved that relative labour-capital intensity and endowment, and skill intensity and endowment (both known to be Heckscher-Ohlin forces) have statistically significant impact on value-added exports.

Futhermore, Akther et al.'s (2022) study also presented results in support of the Heckscher-Ohlin theorem. For their study, Akther et al. (2022) examined the validity of the Heckscher-Ohlin model in predicting Bangaldesh's exports to the US. They defined the Heckscher-Ohlin forces as skill intensity, capital intensity, and raw material intensity. The dependent variable for their study was fraction of imports from Bangladesh in US industries. The results from Akther et al.'s (2022) study showed that Bangladesh, a low-skilled labour-intensive country, has a larger share of US imports in industries requiring low-skilled labour, thereby demonstrating evidence in support of the Heckscher-Ohlin theorem.

The coefficient of determination R^2 for the model developed for the mining and quarrying industry is 0.187. Though this coefficient may appear low, it is in line with results from other literature studies. For example, the R^2 values from Koch and Fessler's (2020) study ranged between 0.138 and 0.335 for the nine industries with results supporting the Heckscher-Ohlin theorem, meaning that, models developed for these industries were able to explain between 13.8% to 33.5% of the export variations in these industries. the nine industries identified were (a) mining and quarrying, (b) manufacturing, (c) electricity, gas, steam and air conditioning supply, and water supply; sewerage, waste management and remediation activities, (d) construction, (e) transportation and storage, (f) accommodation and food service activities, (g) financial and insurance activities, (h) real estate activities, and (i) professional, scientific and technical activities (Koch & Fessler, 2020).

Similarly, the R^2 values from a study conducted by Akther et al. (2022) were also low, ranging between 0.045 and 0.176. These findings therefore demonstrate that the R^2 value of 0.187 in this study is within range compared to other literature studies (Akther et al., 2022; Koch & Fessler, 2020). It is however important to note that higher R^2 values are evident in other literature studies. For example, in his study, Chor's (2010) regression models produced R^2 values that ranged between 0.586 and 0.607. Likewise, Ito et al.'s (2017) regression models produced R^2 values that ranged between 0.374 and 0.674. Both studies (Chor, 2010; Ito et al., 2017) generated R^2 values that were higher than this study.

The higher R^2 values obtained in Chor's (2010) and Ito et al.,'s (2017) studies were expected considering that both these studies included additional independent variables, such as distance between countries, common language, strength of legal institutions, employment flexibility, etc., as predictor variables in their regression models. In most instances, these additional variables improved the R^2 values, meaning that, they improved the extent to which regression models developed explained the variations in the independent variable, i.e., export flows. The inclusion of additional variables provides an avenue for future research as recommended in Section 7.5

6.1.3.2 Manufacturing Industry

Before interpreting the regression coefficient determined in this report for South Africa's manufacturing industry, it is important to first discuss the coefficient of determination R^2 value from the model developed for this industry. The R^2 value for South Africa's manufacturing industry is 0.514, suggesting that the model developed is able to explain 51.4% of the variations in the independent variable, i.e., export flows from South Africa to China in the manufacturing industry. This R^2 value is relatively high (compared to the one for the mining and quarrying industry discussed in Section 6.1.3.1) and falls within the range of R^2 values determined by Ito et al. (2017), i.e., 0.374 to 0.674.

Notwithstanding the high R^2 value for the model developed, the regression coefficient for the manufacturing industry produced results in contradiction to the predictions of the Heckscher-Ohlin theorem. The relationship between labour-capital intensity and endowment variable $\left[\log\left(\frac{\ell}{\mathrm{k}}\right)_{\mathrm{man}} \times \log\left(\frac{\mathrm{L}}{\mathrm{K}}\right)_{\mathrm{man}}\right]$ and value-added exports variable $[\log(\mathrm{VX}_{\mathrm{man}})]$ in the manufacturing industry is negative (B_2 = -.044) and statistically significant (p = .045). This provides evidence against the Heckscher-Ohlin theorem. According to these results, South Africa's manufacturing industry exports fewer goods which require the intensive use of labour in their production. Studies with results contradicting predictions of the Heckscher-Ohlin theorem exist in literature.

For example, Ito et al. (2017) reported regression coefficients of -.00931 and -.00686 for capital-labour intensity and endowment variable $\left[\log\left(\frac{\mathrm{k}}{\ell_{us}}\right)_{\mathrm{it}} \times \log\left(\frac{\mathrm{K}}{\mathrm{L}_{us}}\right)_{\mathrm{it}}\right]$ when evaluating value-added exports in cross-section and panel manufacturing trade, respectively. As mentioned earlier, Ito et al. (2017) initially considered labour intensities and endowments as the only Heckscher-Ohlin forces in their model. However, in the same study, the researchers extended their model to include capital-labour intensity and endowment variable $\left[\log\left(\frac{\mathrm{k}}{\ell_{us}}\right)_{\mathrm{it}} \times \log\left(\frac{\mathrm{K}}{\mathrm{L}_{us}}\right)_{\mathrm{it}}\right]$ and capital-labour intensity variable $\left[\log\left(\frac{\mathrm{k}}{\ell_{us}}\right)_{\mathrm{it}}\right]$.

Furthermore, Ito et al.'s (2017) study produced regression coefficients of -.0198, -.0191, and -.0185 for variable $\left[\log\left(\frac{\mathrm{k}}{\ell_{us}}\right)_{\mathrm{it}} \times \log\left(\frac{\mathrm{K}}{\mathrm{L}_{us}}\right)_{\mathrm{it}}\right]$ when evaluating gross exports in cross-section service trade, panel service trade, and total trade, respectively. The cross-section specification in Ito et al.'s (2017) study signifies data at a fixed point in time, whereas the panel specification represents time series data. Nevertheless, unlike the B_2 value for the manufacturing industry in this study, none of the negative regression coefficients from Ito et al.'s (2017) study were statistically significant.

Interestingly, Koch and Fessler's (2020) study provided slightly different results. Unlike the results in Ito et al.'s (2017) study, the negative regression coefficients from Koch and Fessler's (2020) study were all statistically significant. The researchers obtained a negative statistically significant regression coefficient of -.015 for labour-capital intensity and endowment variable $\left[\log\left(\frac{\ell}{\mathrm{k}}\right)_{\mathrm{it}} \times \log\left(\frac{\mathrm{L}}{\mathrm{K}}\right)_{\mathrm{it}}\right]$. In addition, the researchers then extended their model to include labour intensity and endowment variable $\left[\log\left(\frac{\ell_{hs}}{\ell_{us}}\right)_{\mathrm{it}} \times \log\left(\frac{\mathrm{L}_{hs}}{\mathrm{L}_{us}}\right)_{\mathrm{it}}\right]$ and labour intensity variable $\left[\log\left(\frac{\ell_{hs}}{\ell_{us}}\right)_{\mathrm{it}}\right]$ as additional independent variables. This again resulted in a negative statistically significant regression coefficient of -.012 for labour-capital endowment and intensity variable $\left[\log\left(\frac{\ell}{\mathrm{k}}\right)_{\mathrm{it}} \times \log\left(\frac{\mathrm{L}}{\mathrm{K}}\right)_{\mathrm{it}}\right]$.

From an industry level, Koch and Fessler (2020) attained negative statistically significant regression coefficients for agriculture, forestry, and fishing (coefficient = -.319), wholesale and retail trade, repair of motor vehicles and motorcycles (coefficient = -.414), and information and communication (coefficient = -.056). It is therefore evident that the statistically significant negative B_2 value in this study (B_2 = -.044, p = .045) is not a new phenomenon in literature studies evaluating the predictive ability of Heckscher-Ohlin theorem. However, this does not take away from the fact that a negative B_2 value provides evidence against the Heckscher-Ohlin theorem.

Koch and Fessler (2020) explain that one of the reasons for the negative regression coefficients is the assumption that production technologies are identical between countries. When the researchers relaxed this assumption in their study, their results eventually supported the Heckscher-Ohlin theorem, i.e., the B_2 values changed from negative to positive statistically significant values. Koch and Fessler (2020) controlled for differences in production technologies by defining the labour-capital endowment and intensity in terms of labour compensation to capital stock, instead of their initial definition which was ratio of hours worked to capital stock.

6.1.3.3 Transport, Storage, Information, and Communication

The regression results for the transport, storage, information, and communication industry are quite interesting. First, the coefficient of determination R^2 for this industry is relatively low (R^2 = 0.033), especially when compared with those of mining and quarrying industry (R^2 = 0.187), and manufacturing industry (R^2 = 0.514) in this study. An R^2 value of 0.033 indicates that the variables included in the regression model developed for this industry are only able to explain 3.3% of the variations in the independent variable, i.e., transport, storage, information, and communication export flows from South Africa to China. None of the literature studies (Akther et al., 2022; Chor, 2010; Ito et al., 2017; Koch & Fessler, 2020) evaluated in this study produced R^2 values of such low magnitude.

Furthermore, results from ANOVA test indicate that the test failed to reject the null hypothesis that the relationship between the dependent variables and independent variables is non-linear ($p > 0.1$). The results from the ANOVA test in this study ($R^2 = 0.033$ and $p > 0.1$) therefore provide no evidence that the Heckscher-Ohlin forces significantly affect value-added exports from South Africa's transport, storage, information, and communication industry to the Chinese market.

Interestingly, the regression coefficient B_2 obtained for South Africa's transport, storage, information, and communication industry is positive (B_2 = .356), but statistically insignificant ($p > 0.1$). A statistically significant regression coefficient would have provided support for the Heckscher-Ohlin theorem (Ito et al., 2017; Koch & Fessler, 2020). However, this is not the case from the results obtained. Other literature studies have also produced similar results. For example, Ito et al. (2017) reported positive statistically insignificant regression coefficients for the capital-labour intensity and endowment variable $\left[\log\left(\frac{\mathrm{k}}{\ell_{us}}\right)_{\mathrm{it}} \times \log\left(\frac{\mathrm{K}}{\mathrm{L}_{us}}\right)_{\mathrm{it}}\right]$ when evaluating gross exports in cross-section and panel manufacturing trade, and virtual value-added exports in cross-section and panel services trade.

One of the reasons that could have caused such results to be obtained may the aggregated nature of data for this industry. Macroeconomic data for the transport, storage, information, and communication industry are published on an aggregated basis by Stats SA and SARS. However, it is evident that these data actually represent two separate industries, namely transport and storage industry, and information and communication industry. Though at face value reporting macroeconomic data in this manner may be common, it sometimes creates challenges when developing econometric models.

Previous studies have attempted to overcome this challenge. For example, in her study, Cavusoglu (2019) disintegrated the paper sector into two separate subsectors, namely "pulp, paper and paper products, and printing and publishing" (p. 174). However, the disintegration did not improve her results. Nonetheless, such an approach would have still been useful in this study. Unfortunately, the lack of disintegrated data for South Africa's transport, storage, information, and communication industry made it impossible to implement the said approach in this study.

Another example provided in literature on the lack of supporting evidence for the standard version of the Heckscher-Ohlin theorem is the simplistic nature of the model. As mentioned previously, the Heckscher-Ohlin theorem assumes that a country's specialisation and trade patterns are determined by only two factors of production, namely labour and capital (Abendin & Duan, 2021; Akther et al., 2022; Gandolfo & Trionfetti, 2014; Jones, 1956; Tombazos et al., 2005). Disapprovals of this assumption are prevalent in literature (Brondino, 2021; Cavusoglu, 2019; Leontief, 1953; Schott, 2003). Cavusoglu (2019) contends that the assumption of two factors of production is too simplistic.

Researchers such as Akther et al. (2022), Chor (2010), Ito et al., (2017) have since revised the Heckscher-Ohlin model to include more than two factors of production. For their study, Akther et al. (2022) examined the Heckscher-Ohlin trade model in predicting Bangladesh's export flows to the US. The researchers used three factor endowments as independent variables in their model, namely skill intensity, capital intensity, and raw material intensity. Likewise, Schott (2003) contends that the multiple-cone Heckscher-Ohlin, which assumes that a country's economy has more goods than factor endowments, serves as a better alternative to the standard version of the Heckscher-Ohlin model.

Another assumption of the Heckscher-Ohlin theorem that has been opposed in literature is the assumption that production techniques or technologies are uniform across countries (Bernhofen & Brown, 2016; Schott, 2003; Tombazos et al., 2005). Other versions of the Heckscher-Ohlin model have been developed to overcome this challenge. One example of a modified version of the Heckscher-Ohlin model is the Chamberlin-Heckscher-Ohlin-Samuelson model presented in 1985 by Helpman and Krugman for their general equilibrium model (Rodgers, 1988). According to Rodgers (1988), the Chamberlin-Heckscher-Ohlin-Samuelson model segments each sector in a country into two types. The first type conforms to the basic assumptions of the Heckscher-Ohlin theorem, assuming perfect competition, homogenous goods, and constant returns to scale production techniques. For the second type, the model assumes a monopolistic, competitive economy that produces variations of the same good using production techniques with minimal economies of scale.

It is clear from review of literature that debates about the predictive ability of the Heckscher-Ohlin model continue to exist in academia. This means that studies with results both in support of (Akther et al., 2022; Chor, 2010; Ito et al., 2017; Koch & Fessler, 2020) and against (Blum, 2010; Brondino, 2021; Koch & Fessler, 2020; Schott, 2003) the model are expected. It is therefore unsurprising that the model in this study is unable to explain South Africa's transport, storage, information, and communication value-added exports to China.

6.1.4 Conclusion

For the first research hypothesis (H1) which evaluated the extent to which the Heckscher-Ohlin forces explain South Africa's export flows to China, the results obtained show that support for the Heckscher-Ohlin theorem is only evident is South Africa's mining and quarrying industry. The theorem states that labour-abundant countries will favour the production and export of labour-intensive commodities, whereas capital-abundant countries will favour the production and export of capital-intensive commodities (Akther et al., 2022; Fisher, 2011; Fukiharu, 2004; Jones, 1956; Juozapavičienė & Eizentas, 2010; Mhaka & Jeke, 2018). On the other hand, the results for South Africa's manufacturing industry provide evidence against the Heckscher-Ohlin theorem. Lastly, no conclusions could be drawn on how factor endowments (Heckscher-Ohlin forces) affect export flows from South Africa to China in the transport, storage, information, and communication industry, since the results obtained for this industry are inconclusive.

6.2 Hypothesis 2 (H2)

The second research hypothesis (H2) sought to evaluate the extent to which the chain version of the Heckscher-Ohlin model predicts South Africa's net trade flows with the rest of the world. H2 was described in Section 3.2 as follows:

> **Research proposition 2:** The respective net trade flows for South Africa can be explained by the chain version of the Heckscher-Ohlin model.

The evaluation of H2 involved the application of the chain version of the Heckscher Ohlin model to determine the extent to which it can explain South Africa's net trade flows with the rest of the world. Similar to other previous studies (Cavusoglu and Elmslie, 2005; Leontief, 1953), the rest of the world was treated as a single country in this evaluation. As mentioned in Section 2.1.2, the chain version of the Heckscher-Ohlin theory uses a factor intensity ranking list to rank sector-specific factor intensities, i.e., capital-to-labour ratios, from the highest to the lowest in order to determine trade flows aligned with the comparative advantage theorem (Cavusoglu & Elmslie, 2005).

The chain version of the Heckscher-Ohlin theory posits that capital-abundant countries will have higher capital-to-labour ratios in their export industries compared to their import industries, whereas labour-abundant countries will have lower capital-to-labour ratios in their export industries compared to their import industries (Cavusoglu, 2019; Cavusoglu & Elmslie, 2005; Jones, 1956). Therefore, the expectation of the chain version of the Heckscher-Ohlin theorem is that a labour-abundant country will be a net exporter in labour-intensive industries and a capital-abundant country will be a net exporter in capital-intensive industries.

The evaluation of H2 included an analysis of the descriptive statistics and comparison of net trade balance estimations for data collected for the period between the first quarter of 2009 and fourth quarter of 2019 following the methodology described in Section 4.7.4.

6.2.1 Descriptive Statistics

A noteworthy observation, from the descriptive statistics obtained from analysis of data collected for the variables required to evaluate H2, is the fact that South Africa's mining and quarrying industry has the highest value for value-added exports (mean = 100 285 million Rands) compared to the other two industries in this study. This outcome was expected considering that mining and quarrying exports constituted about 42% of South Africa's total exports in 2020 (OEC, n.d.-b). The lowest value-added exports are observed in transport, storage, information, and communication industry (Mean = 26 560 million Rands).

6.2.2 Net Trade Balance

The chain version of the Heckscher-Ohlin model, used to predict South Africa's net trade flows with the rest of the world, was assessed by applying the equations proposed by Cavusoglu (2019), and Cavusoglu and Elmslie (2005). The equations were applied by following a step-by-step process. First, net trade balances for the combined economy were computed. As mentioned earlier, the combined economy represented the combination of mining and quarrying, manufacturing, and transport, storage, information, and communication industries. The second step entailed the distribution of combined economy net trade balances across the three industries of interest using three different weight measures, namely equal weights, volume weights, and balance weights. Third, non-balanced, meaning unweighted, net trade balances for each industries were also computed. Fourth, capital-to-labour ratios for each industry and combined economy were calculated. Lastly, the industries and their associated weighted and unweighted net trade balances were ranked in ascending order relative to the computed capital-to-labour for the combined economy.

The results from the computation of industry-level capital-to-labour ratios and their subsequent ranking relative to the combined economy's capital-labour ratio show that both South Africa's mining and quarrying industry (k/ℓ = 35.53 thousand), and transport, storage, information, and communication industry (k/ℓ = 19.24 thousand) are capital-intensive when compared to the capital-labour intensity ratio for the combined economy (k/ℓ = 15.26 thousand), with mining and quarrying being the most capital-intensive industry amongst the two industries. The manufacturing industry in South Africa is labour-intensive (k/ℓ = 8.95 thousand) relative to the combined economy. The ranking list for the three industries according to the chain version of the Heckscher-Ohlin model shows mining and quarrying industry as the top-ranked industry, followed by transport, storage, information, and communication industry, and lastly manufacturing industry.

In terms of the prediction of the chain version of the Heckscher-Ohlin theory, the ranking list developed provides mixed results. For example, the results indicate that South Africa, known to be a labour-intensive country (average capital-to-labour ratio for the total economy is 5.42 thousand for the period between the first quarter of 2009 and fourth quarter of 2019), is a consistent net exporter in manufacturing industry when looking at net trade balances by equal weights, volume weights, and balance weights. This is consistent with the expectations of the chain version of the Heckscher-Ohlin theory, which states that labour-abundant will favour the production of labour-intensive commodities (Akther et al., 2022; Fisher, 2011; Fukiharu, 2004; Jones, 1956; Juozapavičienė & Eizentas, 2010; Mhaka & Jeke, 2018).

However, when looking at all four trade balance estimations for mining and quarrying industry, and transport, storage, information, and communication industry, both of which are capital-intensive, the results still show South Africa as a consistent net exporter in both these industries. These results contradict predictions of the chain version of the Heckscher-Ohlin theorem, especially because South Africa is regarded as a labour-intensive country (k/ℓ = 15.26 thousand) and therefore the expectation was that it will be a net importer in capital-intensive industries.

Other studies evaluating the predictive ability of the chain version of the Heckscher-Ohlin theorem have also obtained similar outcomes. For example, Cavusoglu and Elmslie (2005) obtained results both in support of and against the chain version of the Heckscher-Ohlin theorem. The researchers argue that one of the reasons for these results could be the fact that many other factors can influence value-added exports in the short-run, these may include government policies or convergence in technological differences between countries.

Furthermore, Cavusoglu and Elmslie (2005) contend that the time horizon for the analysis may also have an influence on the model outcomes. Supporting this suggestion, the researchers argue that the standard and chain versions of the Heckscher-Ohlin models "are long-run general equilibrium models" (Cavusoglu and Elmslie, 2005, p. 415), stating that these models should perform better when considering longer time horizons. However, Blum (2010) contends that a country's output mix is unaffected by changes in its factor supply, both in the short-run (over 5 years) and long-run (over 15 years).

Similarly, Cavusoglu (2019) obtained results consistent with the predicitons of the chain version of the Heckscher-Ohlin model for all the industries evaluated except for the paper industry. The researcher showed that the USA is a consistent net exporter of paper even though this industry is labour-intensive and the USA is a capital-intensive country. To further understand these findings, Cavusoglu (2019) disaggregated the paper industry into two sectors, namely "pulp, paper and paper products, and printing and publishing" (p. 174). However, the disaggregation continued to produce mixed findings, with some of the results showing the USA as a net importer of capital-intensive pulp, paper, paper products and a net exporter of labour-intensive priniting and publishing products.

Reasons for the mixed results on the predictive ability of the chain version of the Hecksher-Ohlin are similar to the ones raised for the standard version of the Heckscher-Ohlin theorem in Sections 6.1.3.2 and 6.1.3.3. Some of the issues raised are related to some of the underlying assumptions of the Heckscher-Ohlin theorem which include constant technology returns to scale, two production factors in an economy, and other unrelated issues such as the aggregated nature of some of the macroeconomic data required for the evaluation.

6.2.3 Conclusion

Results obtained for the second research hypothesis (H2) were mixed. This research hypothesis evaluated the extent to which the chain version of the Heckscher-Ohlin model predicts South Africa's net trade flows with the rest of the world. The results obtained from the evaluations conducted were inconclusive, showing that the chain version of the Heckscher-Ohlin theorem can only predict South Africa's value-added exports in the manufacturing industry. Therefore, it could not be concluded with some level of certainty that the chain version of the Heckscher-Ohlin theorem can explain South Africa's net trade flows.

6.3 Overall summary

The aim of this study was to evaluate the influence of factor endowments on bilateral trade patterns between countries. Based on literature discussed in Chapter 2, the main research question was formulated and expressed in terms of two research questions and hypotheses. The results obtained from the evaluations conducted produced mixed outcomes.

For the first research question, the study found that the mining and quarrying industry was the only industry with evidence to support predictions of the standard version of the Heckscher-Ohlin theorem. The manufacturing industry produced evidence against the theory. Lastly, no conclusions could be drawn for the transport, storage, information, and communication industry. It is therefore evident that this study was only able to validate the research proposition for one industry, meaning that, clear conclusions could not be drawn on whether the Heckscher-Ohlin forces significantly affect South Africa's value-added export flows to China.

The results for the second research question were also mixed. The results found evidence both in support of and against predictions of the chain version of the Heckscher-Ohlin theorem. The chain version of the Heckscher-Ohlin model was only able to predict South Africa's value-added exports for its manufacturing industry, the model was unable to predict value-added exports for the other two industries, namely mining and quarrying industry, and transport, storage, information, and communication industry. Other literature studies (Cavusoglu, 2019; Cavusoglu & Elmslie, 2005) have also obtained similar outcomes as this study. Therefore, this study was not able to provide sufficient evidence to confirm that the chain version of the Heckscher-Ohlin theorem can explain South Africa's net trade flows.

7 Chapter 7: Conclusion

The aim of this study was to evaluate the influence of factor endowments on bilateral trade patterns between countries. Based literature review discussed in Chapter 2, the research question and two research sub-questions were formulated. The main research question for this study was the following:

> **Main research question**: To what extent do factor endowments influence bilateral trade patterns between countries?

The first research sub-question and associated research hypothesis for this study were described as follows:

> **Research sub-question 1**: To what extent do Heckscher-Ohlin forces impact South Africa's export flows to China?
>
> **Research hypothesis 1 (H1)**: Heckscher-Ohlin forces significantly affect South Africa's value-added export flows to China

The second research sub-question and associated research hypothesis for this study were described as follows:

> **Research sub-question 2**: To what extent does the chain version of the Heckscher-Ohlin model predict South Africa's net trade flows with the rest of the world?
>
> **Research hypothesis 2 (H2)**: The chain version of the Heckscher-Ohlin model can predict South Africa's net trade flows with the rest of the world

A research methodology was proposed in Chapter 4, which identified and described the research philosophy and assumptions applied in structuring and conducting the study. Furthermore, the methodology described the research design and research strategy for the study. Moreover, details about data quality measures applied and ethical considerations for the study were also discussed. Chapter 5 presented the results for this study, whereas Chapter 6 discussed the finding from these results in relation to literature.

This chapter therefore provides theoretical conclusions from this study, contribution of the research to research, recommendations for management and/or other stakeholders, and limitations to the study. In addition, suggestions for future research are also provided.

7.1 Principal Theoretical Conclusions

In response to the main question on the extent to which factor endowments influence bilateral trade patterns between countries, this study could not fully provide sufficient evidence to answer the question. Similarly, the study formulated two research sub-questions and hypotheses, both of which could not be answered and confirmed with a certain level of confidence.

For the first research sub-question which evaluated the extent to which the Heckscher-Ohlin forces can impact South Africa's value-added exports to China, this study found mixed results. The study concluded that country- and industry-level factor intensities (Heckscher-Ohlin forces) do positively affect South Africa's value-added mining and quarrying exports to China. The regression coefficient B_2 obtained for the labour-capital intensity and endowment variable for this industry is positive and statistically significant. As mentioned in literature (Ito et al., 2017; Koch & Fessler, 2020), such an outcome serves as evidence in support of the Heckscher-Ohlin theorem. The theory is used to to explain the role of factor endowments in determining trade flows and specialisation patterns between countries (Bernhofen & Brown, 2016; Brondino, 2021; Cavusoglu, 2019; O'Rourke, 2006).

A different conclusion is drawn for South Africa's manufacturing industry in terms of the extent to which the Heckscher-Ohlin forces can impact value-added exports in this industry. This study finds that the regression coefficient B_2 for the labour-capital intensity and endowment variable for this industry is negative and statistically significant. This coefficient leads to the conclusion that Heckscher-Ohlin forces negatively affect South Africa's manufacturing exports to China. This outcome contradicts predictions of the Heckscher-Ohlin theorem, which state that factor endowments have a positive impact on a country's trade patterns (Abendin & Duan, 2021; Gandolfo & Trionfetti, 2014; Koch & Fessler, 2020).

Lastly, this study did not find sufficient evidence to determine the extent to which the Heckscher-Ohlin forces impact South Africa's transport, storage, information, and communication value-added exports to China. The regression coefficient B_2 for the labour-capital intensity and endowment variable for this industry is positive but statistically insignificant. In addition, the coefficient of determination R^2 for the model developed for this industry is low and statistically insignificant. This study therefore concluded that sufficient evidence is not available to confirm that the Heckscher-Ohlin forces do positively affect South Africa's transport, storage, information, and communication value-added exports to China.

Concerning the second research sub-question which evaluated the extent to which the chain version of the Heckscher-Ohlin model can predict South Africa's net trade flows with the rest of the world, this study also found mixed results. This study concluded that the chain version of the Heckscher-Ohlin theorem can predict South Africa's manufacturing value-added exports. The study proved that South Africa, a labour-intensive country, is a consistent net exporter in the manufacturing industry. The chain version of the Heckscher-Ohlin theorem states that labour-abundant will favour the production of labour-intensive commodities (Akther et al., 2022; Fisher, 2011; Fukiharu, 2004; Jones, 1956; Juozapavičienė & Eizentas, 2010; Mhaka & Jeke, 2018). It can therefore be concluded that the chain version of the Heckscher-Ohlin theorem can predict South Africa's manufacturing net trade flows to the rest of the world.

However, the study came to a different conclusion for South Africa's mining and quarrying, and transport, storage, information, and communication industries. This study show South Africa, a labour-intensive country, as a consistent net exporter in both of these capital-intensive industries. These results contradict predictions of the chain version of the Heckscher-Ohlin theorem, thereby leading to the conclusion that the chain version of Heckscher-Ohlin model is unable to predict South Africa's mining and quarrying, and transport, storage, information, and communication net trade flows.

To summarise, this study came to similar conclusions as other studies (Cavusoglu, 2019; Cavusoglu & Elmslie, 2005; Ito et al., 2017; Koch & Fessler, 2020) that evaluated predictive abilities of the different versions of the Heckscher-Ohlin models and obtained mixed results. Studies of this nature should still be pursued in literature.

7.2 Research Contribution

This study contributes to literature on comparative advantage in several ways. First, the study adds to existing literature aimed at quantifying and understanding the impacts of factor endowments on trade patterns and comparative advantage (Akther et al., 2022; Cavusoglu, 2019; Cavusoglu & Elmslie, 2005; Chor, 2010; Ito et al., 2017; Koch & Fessler, 2020; Takeshima & Kumar, 2021). The principles of comparative advantage continue to be used in literature to explain trade patterns (Brondino, 2021). Comparative advantages between countries stem from differences in their ability to produce for specific industries (Brondino, 2021; Chor, 2010), which are driven by their respective factor endowments and institutional conditions for production (Chor, 2010).

This study applied the standard version of the Heckscher-Ohlin model to determine the extent to which Heckscher-Ohlin forces affect South Africa's value-added export flows to China. Studies (Hoffmann et al., 2020; Matonana & Phiri, 2020; Mhaka & Jeke, 2018) aimed at evaluating the determinants of the trade flows between South Africa and China were found to be limited in literature. Similarly, the study applied the chain version of the Heckscher-Ohlin model to determine the extent to which the model can predict South Africa's net trade flows with the rest of the world. Applications of the chain version of the Heckscher-Ohlin model are also limited in literature (Cavusoglu, 2019; Cavusoglu & Elmslie, 2005; Jones, 1956).

This study also contributes to empirical studies (Cavusoglu, 2019; Cavusoglu & Elmslie, 2005; Jones, 1956) aimed at using the chain version of the Heckscher-Ohlin model to predict a country's net trade flows. The chain version of the Heckscher-Ohlin model was used in this study to predict South Africa's net trade flows with the rest of the world. Third, this study adds to debates in literature on the applicability of the Heckscher-Ohlin theorem in modern trade (Feenstra, 2016; Guo, 2015a, 2015b; Kiyota, 2021; Paraskevopoulou et al., 2016; Yan & Wang, 2021). Results from this study indicate that even though the model was not able to predict trade flows in some industries, it did manage to explain trade patterns in certain industries.

Lastly, the study contributes to empirical studies (Deng et al., 2021; He & Huang, 2021; Ito et al., 2017; Jijun, 2021; Koch & Fessler, 2020) using value-added trade as a proxy for trade in comparative advantage models instead of gross trade. It is argued that comparative advantage models are better fitted with value-added trade data compared to gross trade data (Ito et al., 2017; Johnson & Noguera, 2012). This study used value-added exports as a proxy for both exports from South Africa to China and net trade flows between South Africa and the rest of the world.

7.3 Policy Recommendations

Particularly for policymakers, this study provides a tool to understand how factor endowments and comparative advantage can be considered when determining which countries to enter into trade agreements with. The tool could be a useful addition when establishing new trade agreements, policymakers and negotiators can use it to determine which goods should be included in free trade and/or preferential trade agreements. The tool identifies the goods that maximise the utilisation of a country's abundant endowments in their production. Academics could also use the tool to understand and explain the fundamental reasons behind some of South Africa's skewed trade patterns with its trade partners, beyond political explanations.

Second, policymakers looking at opportunities to grow South Africa's export volumes should ensure that investments are directed to industries that are labour-intensive in order to ensure that these investments exploit the country's abundant endowment, i.e., labour. The Heckscher-Ohlin model posits that a country can capture a larger share of the global market in commodities that maximise the use its abundant resources (Romalis, 2004). Therefore, this study serves as a useful contribution to the development of export growth-focussed policies and legislations.

7.4 Limitations of the Research

Similar to other literature studies, this study had certain limitations. First, the period of analysis for the study was limited to the time horizon between 2009 and 2019. The start year for the study was chosen to coincide with the year in which China became South Africa's main trading partner, whereas the final year was chosen to avoid the impacts of Covid-19 restrictions and Russia's invasion of Ukraine on international trade. Second, data availability constraints, i.e., lack of fixed capital formation and trade data for certain industries in South Africa, restricted the analyses in this study to only three industries out of the nine industries reported by Stats SA and SARB.

Another limitation to this study was the frequency of the data collected. As mentioned, both Stats SA and SARB publish macroeconomic data for the variables used in this study on a quarterly basis. Therefore, both the limitation in data frequency and time horizon (period of analysis) limited the number of data points for each variable included in the respective analyses in this study to 44 data points.

This study was also restricted to using fixed capital formation as a proxy for physical capital for the Heckscher-Ohlin models due to unavailability of quarterly gross fixed capital formation (GFCF) data by type of economic activity, i.e., by industry. Until the second quarter of 2017, the SARB published quarterly GFCF data on both a total economy level and by industry. However, from the third quarter of 2017, SARB no longer publishes quarterly GFCF data by industry, but instead do so only on a total economy basis and by type of organisation, namely general government, public corporations, and private business enterprises (Stats SA, 2022a).

The other limitation to the study was the use of linear multivariate regression analyses to explain and predict South Africa's trade flows. The Heckscher-Ohlin model assumes a linear relationship between trade flows (dependent variable) and factor endowments and intensities (independent variables) (Akther et al., 2022; Chor, 2010; Ito et al., 2017; Koch & Fessler, 2020). However, it is possible that non-linear relationships may exist between these variables.

The models used in this study were also limited to two factor endowments or independent variables, namely labour and capital. Other applications of the Heckscher-Ohlin models with more than two factor endowments are available in literature (Akther et al., 2022; Chor, 2010; Ito et al., 2017), and these have provided better fits in certain instances.

This study did not include additional factors in the models developed for several reasons. First, some of the studies (Chor, 2010; Ito et al., 2017) that included additional factor endowments in their Heckscher-Ohlin models were focussed on evaluating trade flows between more than two countries. This study was however focussed on evaluating trade flows between two countries, noting that the rest of the world was treated as a single country when evaluating the second research hypothesis.

The second reason for not including additional factors in the regression models developed in this study was because of the relevance of some these additional factors. For example, one of the additional variables included in these studies was distance between countries, and obviously this variable would be constant for an evaluation looking at only two countries instead of multiple countries.

Notwithstanding the abovementioned limitations, the contribution of this study to literature on comparative advantage, particularly those using the Heckscher-Ohlin theorem to explain trade flows, is still considered valuable. This study was able to explain South Africa's trade flows in certain industries.

7.5 Suggestions for Future Research

Based on the limitations for this study, opportunities for future research are provided. The first opportunity lies in the expansion of the standard version of the Heckscher-Ohlin model to include additional independent variables. Additional variables could include skilled and unskilled labour, labour compensations, differences in technology, trade openness, ease of doing business, and foreign direct investment. Empirical studies (Akther et al., 2022; Chor, 2010; Ito et al., 2017) that have previously applied the standard version of the model, have in some instances achieved better model fits when including additional variables, instead of just the two proposed by the theory, namely, capital and labour.

Future studies could also extend the standard version of the model to other countries and regions that have signed trade agreements with South Africa. Considering that South Africa has signed and entered into several bilateral, multilateral, preferential, and regional trade agreements (Mhaka & Jeke, 2018; Stern & Ramkolowan, 2021), it may be important to establish whether trade flows emanating from these agreements are based on exploiting comparative advantages between the countries involved.

Another area of future research could be the disaggregation of industries into sub-industries to enable the evaluation of the Heckscher-Ohlin theorem as close as possible to the specific product level. Studies (Cavusoglu (2019) that have applied this disaggregation approach already exist in literature, and it is believed that the Heckscher-Ohlin models could benefit, from a model fit perspective, if such an approach were to be adopted.

Lastly, future research could also explore application of the Heckscher-Ohlin models over longer time horizons. Cavusoglu and Elmslie (2005) contend that the time horizon used in the application of the Heckscher-Ohlin models has an influence on its predictability, basically arguing that these models work well in long-run equilibriums. Periods longer than 15 years should be considered to cancel the “noise” in net trade flows. However, care should be taken to ensure that market disruptions such as the recent Covid-19 restrictions are considered and accounted for in the results.

References

Abendin, S., & Duan, P. (2021). International trade and economic growth in Africa: The role of the digital economy. *Cogent Economics & Finance, 9*(1), 1-25. https://doi.org/10.1080/23322039.2021.1911767

Adams, J., Khan, H. T., & Raeside, R. (2014). *Research Methods for Business and Social Science Students* (2nd ed.). SAGE Publications.

Akther, T., Voumik, L. C., & Rahman, M. H. (2022). The pattern of international trade between Bangladesh and USA: Heckscher-Ohlin and Rybczynski analysis. *Modern Supply Chain Research and Applications*. https://doi.org/10.1108/MSCRA-03-2022-0011

Aslam, A., Novta, N., & Rodrigues-Bastos, F. (2017, July 31). *Calculating Trade in Value Added*. International Monetary Fund: https://www.imf.org/en/Publications/WP/Issues/2017/07/31/Calculating-Trade-in-Value-Added-45114

Bell, E., Bryman, A., & Harley, B. (2019). *Business Research Methods* (5th ed.). Oxford University Press.

Bernhofen, D. M., & Brown, J. C. (2016). Testing the General Validity of the Heckscher-Ohlin Theorem. *American Economic Journal: Microeconomics, 8*(4), 54-90. https://doi.org/10.1257/mic.20130126

Bicevskis, J., Bicevska, Z., Nikiforova, A., & Oditis, I. (2018). *An Approach to Data Quality Evaluation.* Institution of Electrical and Electronics Engineers. https://doi.org/10.1109/SNAMS.2018.8554915

Blum, B. S. (2010). Endowments, Output, and the Bias of Directed Innovation. *Review of Economic Studies, 77*(2), 534–559. https://doi-org.uplib.idm.oclc.org/10.1111/j.1467-937X.2009.00579.x

Brondino, G. (2021). Fragmentation of Production, Comparative Advantage, and the Heckscher-Ohlin Theory. *Review of Political Economy*, 1–20. https://doi.org/10.1080/09538259.2021.1977540

Bryman, A. (2012). *Social Research Methods* (4th ed.). Oxford University Press Inc.

Cavusoglu, N. (2019). The chain version of Heckscher-Ohlin theory correctly predicts U.S. trade flows! *International Economics, 157*, 170–178. https://doi.org/10.1016/j.inteco.2018.10.003

Cavusoglu, N., & Elmslie, B. (2005). The Chain Version of Comparative Advantage: An Empirical Investigation. *Review of World Economics, 141*(3), 404–421. https://doi-org/10.1007/s10290-005-0036-6

Chetty, S. (2007). An analysis of fixed capital formation in South Africa since 1994.

Journal of Economic and Financial Sciences, 1(1), 7-20. https://doi.org/10.10520/EJC139152

Chor, D. (2010). Unpacking sources of comparative advantage: A quantitative approach. *Journal of International Economics, 82*(2), 152–167. https://doi.org/10.1016/j.jinteco.2010.07.004

Cole, M. T., & Guillin, A. (2015). The determinants of trade agreements in services vs. goods. *International Economics, 144*, 66–82. https://doi.org/10.1016/j.inteco.2015.06.002

Deng, G., Lu, F., & Yue, X. (2021). Research on China's embodied carbon import and export trade from the perspective of value-added trade. *Plos One, 16*(11), 1-18. https://doi.org/10.1371/journal.pone.0258902

Easterby-Smith, M., Thorpe, R., & Jackson, P. R. (2015). *Management & Business Research* (5th ed.). SAGE Publications Ltd.

Eaton, J., & Kortum, S. (2002). Technology, Geography, and Trade. *Econometrica, 70*(5), 1741-1779.

Feenstra, R. C. (2016). *Advanced International Trade: Theory and Evidence* (2nd ed.). Princeton University Press.

Fisher, E. O. (2011). Heckscher-Ohlin theory when countries have different technologies. *International Review of Economics and Finance, 20*(2), 202-210. https://doi.org/10.1016/j.iref.2010.11.009

Fukiharu, T. (2004). A simulation of the Heckscher-Ohlin theorem. *Mathematics and Computers in Simulation, 64*(1), 161–168. https://doi.org/10.1016/S0378-4754(03)00129-0

Gandolfo, G., & Trionfetti, F. (2014). *International Trade Theory and Policy.* Springer, Berlin, Heidelberg. https://doi.org/10.1007/978-3-642-37314-5_4

Gouvea, R., Kapelianis, D., & Li, S. (2020). Fostering intra-BRICS trade and investment: The increasing role of China in the Brazilian and South African economies. *Thunderbird International Business Review, 62*(1), 17–26. https://doi.org/10.1002/tie.22098

Grous, A. (2013). *Fracture mechanics 1 : Analysis of reliability and quality control.* John Wiley & Sons, Incorporated.

Guo, B. (2015a). Heckscher-Ohlin Trade, Leontief Trade, and Factor Conversion Trade When Countries Have Different Technologies. *Munich Personal RePEc Archive*, 1-36. https://mpra.ub.uni-muenchen.de/95161/1/MPRA_paper_95161.pdf

Guo, B. (2015b). The North-South Trade Featuring the Leontief Trade Improves Poverty and Inequality. *Munich Personal RePEc Archive*, 1-31.

https://mpra.ub.uni-muenchen.de/113003/1/MPRA_paper_113003.pdf
He, L. -Y., & Huang, H. (2021). Economic Benefits and Pollutants Emission Embodied in China–US Merchandise Trade—Comparative Analysis Based on Gross Trade, Value Added Trade and Value Added in Trade. *Sustainability, 13*(20), 11322–11322. https://doi.org/10.3390/su132011322

Hoffmann, J., Naima, S., & Sødal, S. (2020). Liner shipping bilateral connectivity and its impact on South Africa's bilateral trade flows. *Maritime Economics & Logistics, 22*(3), 473-499. http://dx.doi.org/10.1057/s41278-019-00124-8

International Standard Industrial Classification. (n.d.). *Economic statistics*. Retrieved November 18, 2022, from Introduction to ISIC: https://unstats.un.org/unsd/classifications/Econ/ISIC.cshtml

International Trade Centre. (n.d.-a). *Bilateral trade between China and South Africa*. ITC. Retrieved August 14, 2022, from https://www.trademap.org/Bilateral_TS.aspx?nvpm=1%7c156%7c%7c710%7c%7cTOTAL%7c%7c%7c2%7c1%7c1%7c1%7c2%7c1%7c1%7c1%7c1%7c1

International Trade Centre. (n.d.-b). *Bilateral trade between China and South Africa*. ITC. Retrieved August 14, 2022, from https://www.trademap.org/Bilateral_TS.aspx?nvpm=1%7c156%7c%7c710%7c%7cTOTAL%7c%7c%7c2%7c1%7c1%7c2%7c2%7c1%7c1%7c1%7c1%7c1

International Trade Centre. (n.d.-c). *Bilateral trade between South Africa and China*. ITC. Retrieved August 14, 2022, from https://www.trademap.org/Bilateral_TS.aspx?nvpm=1%7c710%7c%7c156%7c%7cTOTAL%7c%7c%7c2%7c1%7c1%7c3%7c2%7c1%7c1%7c1%7c1%7c1

International Trade Centre. (n.d.-d). *Bilateral trade between South Africa and China in 2021*. ITC. Retrieved August 14, 2022, from https://www.trademap.org/Bilateral.aspx?nvpm=1%7c710%7c%7c156%7c%7cTOTAL%7c%7c%7c2%7c1%7c1%7c1%7c1%7c1%7c1%7c1%7c1%7c1

International Trade Centre. (n.d.-e). *Bilateral trade between South Africa and China in 2021*. ITC. Retrieved August 14, 2022, from https://www.trademap.org/Bilateral.aspx?nvpm=1%7c710%7c%7c156%7c%7cTOTAL%7c%7c%7c2%7c1%7c1%7c2%7c1%7c1%7c1%7c1%7c1%7c1

International Trade Centre. (n.d.-f). *List of importing markets for a product exported by South Africa*. ITC. Retrieved August 9, 2022, from https://www.trademap.org/Country_SelProductCountry_TS.aspx?nvpm=1%7c710%7c%7c%7c%7cTOTAL%7c%7c%7c2%7c1%7c1%7c2%7c2%7c1%7c2%7c1%7c1%7c1

International Trade Centre. (n.d.-g). *List of supplying markets for a product imported by South Africa*. Retrieved August 9, 2022, from https://www.trademap.org/Country_SelProductCountry_TS.aspx?nvpm=1%7c710%7c%7c%7c%7cTOTAL%7c%7c%7c2%7c1%7c1%7c1%7c2%7c1%7c2%7c1%7c1%7c1

Ito, T., Rotunno, L., & Vézina, P. -L. (2017). Heckscher-Ohlin: Evidence from Virtual Trade in Value Added. *Review of International Economics, 25*(3), 427–446. https://doi.org/10.1111/roie.12230

Jijun, Y. (2021). The Impact of Value-Added Trade on Global Economic Comovement. *Social Sciences in China, 42*(4), 73–91. https://doi.org/10.1080/02529203.2021.2003597

Johnson, R. C., & Noguera, G. (2017). A Portrait of Trade in Value-Added over Four Decades. *Review of Economics & Statistics, 99*(5), 896–911. https://doi-org.uplib.idm.oclc.org/10.1162/REST_a_00665

Johnson, R. C., & Noguera, G. (2012). Accounting for intermediates: Production sharing and trade in value added. *Journal of International Economics, 86*(2), 224–236. https://doi.org/10.1016/j.jinteco.2011.10.003

Jones, R. W. (1956). Factor Proportions and the Heckscher-Ohlin Theorem. *The Review of Economic Studies, 24*(1), 1-10. https://doi.org/10.2307/2296232

Jones, R. W. (2006). Eli Heckscher and the Holy Trinity. In R. Findlay, R. G. Henriksson, H. Lindgren, & M. Lundahl, *International Trade, and Economic History* (pp. 91-105). The MIT Press.

Jones, R. W. (2011). In Defence of Cones. In R. M. Stern (Ed.), *Comparative Advantage, Growth, And The Gains From Trade And Globalization: A Festschrift In Honor Of Alan V Deardorff : A Festschrift in Honor of Alan V Deardorff* (Vol. 16, pp. 31-41). World Scientific Publishing Company.

Juozapavičienė, A., & Eizentas, V. (2010). Lithuania exports in the framework of Heckscher-Ohlin international trade theory. *Economics and Management, 15*, 86-92. http://etalpykla.lituanistikadb.lt/fedora/objects/LT-LDB-0001:J.04~2010~1367172760367/datastreams/DS.002.1.01.ARTIC/content

Kiyota, K. (2021). The Leontief Paradox Redux. *Review of International Economics, 29*(2), 296–313. https://doi.org/10.1111/roie.12511

Koch, P., & Fessler, C. (2020). *A test for Heckscher-Ohlin using value-added exports.* arXivLabs. https://arxiv.org/pdf/2009.11743.pdf

Koopman, R., Wang, Z., & Wei, S. -J. (2014). Tracing Value-Added and Double Counting in Gross Exports. *The American Economic Review, 104*(2), 459–494.

https://doi-org.uplib.idm.oclc.org/10.1257/aer.104.2.459

Leedy, P. D., & Ormrod, J. E. (2010). *Practical Research: Planning and Design* (9th ed.). Merrill.

Leontief, W. (1953). Domestic Production and Foreign Trade; The American Capital Position Re-Examined. *Proceedings of the American Philosophical Society, 97*(4), 332-349. https://www.jstor.org/stable/3149288

Matonana, N., & Phiri, A. (2020). Convergence Dynamics between South Africa and Her Main Trading Partners. *Managing Global Transitions, 18*(1), 25–44. https://doi-org.uplib.idm.oclc.org/10.26493/1854-6935.18.25-44

Mendoza, A. (2021, May 12). *Harmonized Commodity Description and Coding Systems (HS)*. UN Statistics Wiki: https://unstats.un.org/wiki/pages/viewpage.action?pageId=87426301

Mhaka, S., & Jeke, L. (2018). An evaluation of the trade relationships between South Africa and China: An empirical review 1995–2014. *South African Journal of Economic and Management Sciences, 21*(1), 1-15. https://doi.org/10.4102/sajems.v21i1.2106

Naldi, M., & Flamini, M. (2018). Dynamics of the hirschman-herfindahl index under new market entries. *Economic Papers: A Journal of Applied Economics and Policy, 37*(3), 344–362. https://doi.org/10.1111/1759-3441.12222

Nishioka, S. (2012). International differences in production techniques: Implications for the factor content of trade. *Journal of International Economics, 87*(1), 98–104. https://doi.org/10.1016/j.jinteco.2011.11.010

Organisation for Economic Co-operation and Development. (n.d.). Retrieved November 18, 2022, from OECD: https://www.oecd.org/sti/ind/

O'Rourke, K. H. (2006). Heckscher-Ohlin Theory and Individual Attitudes Toward Globalization. In R. Findlay, R. G. Henriksson, H. Lindgren, & M. Lundahl, *Eli Heckscher, International Trade, and Economic History* (pp. 107-138). The MIT Press.

Panik, M. J. (2012). *Statistical inference: A short course.* John Wiley & Sons, Incorporated.

Paraskevopoulou, C., Tsaliki, P., & Tsoulfidis, L. (2016). Revisiting Leontief’s Paradox. *International Review of Applied Economics, 30*(6), 693–713. https://doi.org/10.1080/02692171.2016.1173655

Pflüger, M., & Tabuchi, T. (2019). Comparative advantage, agglomeration economies and trade costs. *Journal of Urban Economics, 109*, 1-13. https://doi.org/10.1016/j.jue.2018.11.003

Quinlan, C., Babin, B. J., Carr, J. C., Griffin, M., & Zikmund, W. G. (2019). *Business research methods* (2nd ed.). Cengage Learning.

Ratner, B. (2009). The correlation coefficient: Its values range between +1/−1, or do they? *Journal of Targeting, Measurement & Analysis for Marketing, 17*(2), 139-142. https://doi-org.uplib.idm.oclc.org/10.1057/jt.2009.5

Rodgers, J. R. (1988). Intra-industry Trade, Aggregation and the HOS Model. *Journal of Economic Studies, 15*(5), 5-23. https://doi.org/10.1108/eb002677

Romalis, J. (2004). Factor Proportions and the Structure of Commodity Trade. *American Economic Review, 94*(1), 67–97. https://doi-org.uplib.idm.oclc.org/10.1257/000282804322970715

Rybczynski, T. M. (1955). Factor Endowment and Relative Commodity Prices. *Economica, 22*(88), 336–341. https://doi.org/10.2307/2551188

Salkind, N. J. (2007). *Encyclopedia of measurement and statistics* (Vol. 1). Sage Publications, Inc. https://dx.doi.org/10.4135/9781412952644

Saunders, M. N., Lewis, P., & Thornhill, A. (2009). *Research Methods for Business Students* (5th ed.). Pearson Education Limited.

Saunders, M. N., Lewis, P., Thornhill, A., & Bristow, A. (2019). Understanding research philosophies and approaches. In M. N. Saunders, P. Lewis, & A. Thornhill, *Research Methods for Business Students* (8th ed., pp. 128-171). Pearson Education. https://www.researchgate.net/publication/330760964_Research_Methods_for_Business_Students_Chapter_4_Understanding_research_philosophy_and_approaches_to_theory_development

Saunders, M., Lewis, P., & Thornhill, A. (2007). *Research Methods for Business Students* (4th ed.). Pearson Education Limited.

Schott, P. K. (2003). One Size Fits All? Heckscher-Ohlin Specialization in Global Production. *American Economic Review, 93*(3), 686-708. https://doi.org/10.1257/000282803322157043

Shoba, M. (2022). The Phenomenon of China Shops in South Africa: Development, Entrepreneurship and Social Cohesion. *African Renaissance, 19*(1), 245–270. https://doi.org/10.31920/2516-5305/2022/19n1a12

South African Reserve Bank. (2022). *Statistical Tables National Accounts.* SARB. https://www.resbank.co.za/content/dam/sarb/publications/quarterly-bulletins/quarterly-bulletin-publications/2022/september/10Statistical%20tables%20National%20accounts.pdf

South African Revenue Service. (2021, November 11). *AfCFTA*. South African Revenue Service: https://www.sars.gov.za/legal-counsel/international-treaties-agreements/trade-agreements/afcfta/

Statistics South Africa. (2022a). *GDP P0441- 2022Q2.* [Data set]: Stats SA. https://view.officeapps.live.com/op/view.aspx?src=https%3A%2F%2Fwww.statssa.gov.za%2Fpublications%2FP0441%2FGDP%2520P0441-%25202022Q2.xlsx&wdOrigin=BROWSELINK

Statistics South Africa. (2022b). *Quarterly Financial Statistics (QFS).* Stats SA. https://www.statssa.gov.za/publications/P0044/P0044June2022.pdf

Statistics South Africa. (2022c). *Quarterly Labour Force Survey.* Stats SA. https://www.statssa.gov.za/publications/P0211/P02112ndQuarter2022.pdf

Stern, M., & Ramkolowan, Y. (2021). *Understanding South Africa's trade policy and performance*. Economic Research South Africa: https://www.resbank.co.za/content/dam/sarb/publications/working-papers/2021/WP%202117.pdf

Surez, E., Prez, C. M., Rivera, R., & Martnez, M. N. (2017). *Applications of regression models in epidemiology.* John Wiley & Sons, Incorporated.

Takeshima, H., & Kumar, A. (2021). Returns-To-Scale and Factor-Endowments-Induced Specialization: Agricultural Mechanization and Agricultural Transformation in Nepal. *The Journal of Developing Areas, 55*(4), 133–145. https://doi.org/10.1353/jda.2021.0083

The Observatory of Economic Complexity. (n.d.-a). *What does South Africa export to China? (2020)*. OEC. Retrieved November 16, 2022, from https://oec.world/en/visualize/tree_map/hs92/export/zaf/chn/show/2020/

The Observatory of Economic Complexity. (n.d.-b). *What does South Africa export? (2020)*. OEC. Retrieved November 23, 2022, from https://oec.world/en/visualize/tree_map/hs92/export/zaf/all/show/2020/

The Observatory of Economic Complexity. (n.d.-c). *What does South Africa import from China? (2020)*. OEC. Retrieved November 16, 2022, from https://oec.world/en/visualize/tree_map/hs92/import/zaf/chn/show/2020/

The World Bank. (n.d.). The World Bank. Retrieved August 26, 2022, from https://data.worldbank.org/indicator/NY.GDP.MKTP.CD?locations=ZA-1W

Tombazos, C. G., Yang, X., & Zhang, D. (2005). A Neo-Heckscher-Ohlin Model of Trade with Endogenous Production Patterns. *The Economic Record, 81*(255), S71-S81.

Tshedza, S. T., & Yende, N. E. (2021). An Analysis of China's 'Dumping' of Cheap

Products in South Africa in the perspective of Import Substitution Policy. *Journal of African Foreign Affairs, 8*(1), 115–129. https://doi.org/10.31920/20565658/2021/v8n1a6

Wotela, K. (2017). Conceptualising Conceptual Frameworks in Public and Business Management Research. *16th European Conference on Research Methodology for Business and Management Studies* (pp. 370-379). Academic Conferences and Publishing International Limited.

Yan, B., & Wang, Z. (2021). Analysis of Labor Embodied in China's Inter-regional Trade in Value-Added: Re-Examination of Leontief's Paradox from the Perspective of Energy Use. *Chinese Journal of Urban and Environmental Studies, 9*(4), 1-21. https://doi.org/10.1142/S234574812150024X

Zestos, G. K., Jiang, Y., & Painter, C. (2021). Determinants of German and Japanese Exports: A Comparative Study. *Journal of Economic Integration, 36*(3), 339-371. https://doi.org/10.11130/jei.2021.36.3.339

Appendices

Table 1

Transformation of Agriculture, Forestry and Fishing Trade Data from HS 2-digit Codes to ISIC

Agriculture, Forestry and Fishing Industry	
HS 2-Digits Product Code	**ISIC Division**
• 01 • 03 • 41	• Division 01
• 06	• Division 02
• 01-03	• Division 03

Note. Adapted using the OECD conversion tool

Table 2

Transformation of Mining & Quarrying Trade Data from HS 2-digit Codes to ISIC

Mining & Quarrying Industry	
HS 2-Digits Product Code	**ISIC Division**
• 27	• Division 05 • Division 06 • Division 08
• 26	• Division 07
• 25 • 27 • 71	• Division 08

Note. Adapted using the OECD conversion tool

Table 3

Transformation of Manufacturing Trade Data from HS 2-digit Codes to ISIC

Manufacturing Industry	
HS 2-Digits Product Code	**ISIC Division**
• 04-05 • 07-23 • 31 • 35	• Division 10
• 11 • 22-23	• Division 11
• 24	• Division 12
• 50-60 • 63 • 66	• Division 13

Manufacturing Industry	
HS 2-Digits Product Code	**ISIC Division**
• 70 • 88 • 94	
• 41-43 • 61-62 • 65	• Division 14
• 41-43 • 64 • 91 • 96	• Division 15
• 44-46 • 64 • 96	• Division 16
• 47-48 • 56 • 59 • 96	• Division 17
• 49	• Division 18
• 27	• Division 19
• 15 • 22 • 28-29 • 31-40 • 44 • 54-55 • 84	• Division 20
• 29-30	• Division 21
• 30 • 39-40 • 59 • 65 • 85 • 94	• Division 22
• 38 • 68-70 • 85 • 94	• Division 23
• 85 • 90	• Division 26
• 63 • 73-74 • 84-85 • 90 • 94	• Division 27
• 73 • 84-85 • 95	• Division 28

Manufacturing Industry	
HS 2-Digits Product Code	ISIC Division
• 84-87 • 94	• Division 29
• 94 • 96	• Division 31
• 95-96	• Division 32

Note. Adapted using the OECD conversion tool

Table 4

Transformation of Transport, Storage, Information, and Communication Trade Data from HS 2-digit Codes to ISIC

Transport, Storage, Information, and Communication	
HS 2-Digits Product Code	ISIC Division
• 87	• Division 29T30
• 89	• Division 301
• 86 • 87	• Division 302A9
• 88	• Division 303

Note. Adapted using the OECD conversion tool

Table 5

Detailed ISIC Structure for the Agriculture, Forestry, and Fishing Industry

Agriculture, Forestry, and Fishing Industry	
Division	Description
• Division 01	• Crop and animal production, hunting and related service activities
• Division 02	• Forestry and logging
• Division 03	• Fishing and aquaculture

Note. Reprinted from United Nations Statistics Division

Table 6

Detailed ISIC Structure for Mining and Quarrying Industry

Mining and Quarrying Industry	
Division	**Description**
• Division 05	• Mining of coal and lignite
• Division 06	• Extraction of crude petroleum and natural gas
• Division 07	• Mining of metal ores
• Division 08	• Other mining and quarrying
• Division 09	• Mining support service activities

Note. Reprinted from United Nations Statistics Division

Table 7

Detailed ISIC Structure for Manufacturing Industry

Manufacturing Industry	
Division	**Description**
• Division 10	• Manufacture of food products
• Division 11	• Manufacture of beverages
• Division 12	• Manufacture of tobacco products
• Division 13	• Manufacture of textiles
• Division 14	• Manufacture of wearing apparel
• Division 15	• Manufacture of leather and related products
• Division 16	• Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials
• Division 17	• Manufacture of paper and paper products
• Division 18	• Printing and reproduction of recorded media
• Division 19	• Manufacture of coke and refined petroleum products
• Division 20	• Manufacture of chemicals and chemical products
• Division 21	• Manufacture of basic pharmaceutical products and pharmaceutical preparations
• Division 22	• Manufacture of rubber and plastics products
• Division 23	• Manufacture of other non-metallic mineral products
• Division 24	• Manufacture of basic metals
• Division 25	• Manufacture of fabricated metal products, except machinery and equipment

Manufacturing Industry	
Division	**Description**
• Division 26	• Manufacture of computer, electronic and optical products
• Division 27	• Manufacture of electrical equipment
• Division 28	• Manufacture of machinery and equipment
• Division 29	• Manufacture of motor vehicles, trailers, and semi-trailers
• Division 30	• Manufacture of other transport equipment
• Division 31	• Manufacture of furniture
• Division 32	• Other manufacturing

Note. Reprinted from United Nations Statistics Division

Table 8

Detailed ISIC Structure for Transport and Communication Industry

Transport, Storage, Information, and Communication	
Division	**Description**
• Division 49	• Land transport and transport via pipelines
• Division 50	• Water transport
• Division 51	• Air transport
• Division 52	• Warehousing and support activities for transportation
• Division 53	• Postal and courier activities

Note. Reprinted from United Nations Statistics Division