ADDIS ABABA UNIVERSITY
SCHOOL OF ECONOMICS

"AN EMPIRICAL STUDY OF CHINA'S TRADE POTENTIAL WITH AFRICA."

BY
MATIAS ASSEFA

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ABBREVIATIONS AND ACRONYMS

CEPII	Centre for Research and Studies on the World Economy
CIA	Central Intelligence Agency
COS	Cosine
DRC	Democratic Republic of the Congo
EIS	Export-Import Similarity
ESI	Export Similarity Index
FDI	Foreign Direct Investment
FOCAC	Forum on China-Africa Cooperation
GDP	Gross Domestic Product
HS	Harmonized System
IITI	Intra-Industry Trade Index
IMF	International Monetary Fund
ITC	International Trade Centre
ITI	Index of Trade Intensity
MII	Import Intensity Index
MLE	Maximum Likelihood Estimation
OLS	Ordinary Least Squares
PSI	Production Similarity Index
RCAI	Revealed Comparative Advantage Index
SFGM	Stochastic Frontier Gravity Model of Trade
SITC	Standard International Trade Classification
TCI	Trade Complementarity Index
TradeSim	Trade Simulation
US	United States of America
XII	Export Intensity Index

ABSTRACT

In recent years, China has intensified its economic engagement with Africa. Growth of the bilateral trade has, in particular, been dramatic. This trade link is expected to have implications for the development of both economies. How much is the room to further expand China's trade with Africa? This thesis work is a quantified evaluation of the trade potential between China and Africa. Trade complementarity index (TCI) and stochastic frontier gravity model of trade (SFGM) are the methods used for the empirical analysis. Calculations of TCI show that on average, the degree of correspondence between the export pattern of African countries and the import pattern of China is about 63 percent. In addition, estimation results of SFGM suggest that China has realised, on average, only 13 percent of its export potential with African countries. Therefore, the scope to expand the China-Africa trade over the near-to-medium term appears to be large. This study recommends that apart from reforming trade policies, both China and Africa should remove other behind-the-border and trade-facilitation constraints in order to actualise their full trade potential.

Keywords: China and Africa, bilateral trade, trade potential, trade complementarity index (TCI), stochastic frontier gravity model of trade (SFGM).

CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND

China's significant and mainly economic engagement in Africa is currently a topic of considerable global interest. This engagement relies on more than half-century-old, mutually supportive relations.[1] From the establishment of the People's Republic of China to its economic opening (1949-1978), China's policy towards Africa was heavily influenced by ideology and politics. China sought Africa as an ally in its struggles against imperialism and hegemony while it fully supported independence movements in Africa (Anshan, 2007). China's contemporary approach to the African continent, however, is shaped by four factors: China's drive for resource security, new markets and investment opportunities, symbolic diplomacy and development cooperation, and forging strategic partnerships (Alden, 2005b).[2]

Since the founding in 2000 of the Forum on China-Africa Cooperation (FOCAC) in Beijing, China has committed itself with various initiatives to cooperating with Africa in areas of trade, investment, infrastructure, finance, health, human resource development, agriculture, science and technology, culture and climate change. In combining economic assistance, debt relief, and expanding market access for African states, China's African engagement strategy is similar to that of the West. China is unique, however, because it relies heavily on the active

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[1] Three separate periods can be distinguished within this timeframe. Initially, relationships were established between China and African nation states as they gained independence. Then came the period when China was given a permanent seat on the United Nations Security Council in 1971. The final phase covers the post-Maoist period and is characterised by the liberalisation and subsequent growth of the Chinese economy (van de Looy, 2006).

[2] Of these four factors, the drive for resource security is usually singled out as the main motive for China's active involvement in Africa. This view is influenced by the continued expansion of the Chinese economy as well as the prominence in the bilateral engagement of resource-rich African countries such as Angola, South Africa, Sudan and Nigeria. In the diplomatic front, China wants African countries to support its One-China policy by denying diplomatic recognition to Taiwan. China also needs African support in multilateral forums (Alden, 2005b).

involvement and cooperation of its corporations in the continent (Gill & Reilly, 2007). Zafar (2007) argues that China's distinctive approach also involves a combination of aggressive diplomacy and the cultivation of friendly ties with a "no-strings attached" financial and technical assistance package. Moreover, China's pledge of non-interference in countries' internal affairs and lack of lending conditions on governance or fiscal management,[3] as noted by Shelton and Paruk (2008), is different from the restrictive, patronising and unrealistic conditional engagement of the West.

Over the last twenty years, China has grown at the rate of nearly 10 percent per annum, driven primarily by the expansion of modern, industrial export-oriented sector (Alemayehu & Atnafu, 2007).[4] The impact[5] of China's economic rise on the world in general, and low income economies and African countries in particular can be channelled through trade, FDI, finance, global governance, migration and environment (Kaplinsky, 2007). In each of these channels, it is possible for the impact to be positive or negative, complementary or competitive, and direct or indirect, creating winners and losers in the process.[6] Focusing on the trade channel, direct impact includes: growth of African exports to china (complementary effect), increased competition from China in third-country markets (competitive effect), and increased competition from China in African markets (competitive effect). China can also exert an indirect impact by pushing up prices of primary commodities (Jenkins & Edwards, 2005) and through global division of labour and specialization (Alemayehu, 2006).

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[3] There is, however, concern that this stand of China could undermine efforts to ensure international standards, good governance, democracy, and respect to human rights in the continent (see Tull, 2006).

[4] Whether in terms of export shares, foreign direct investment (FDI), overall weight in the world economy or impact on world inequality, Chinese growth is indisputably dramatic (Glyn, 2004).

[5] We live in a research vacuum in addressing the impact of China on Africa. This is partly because of the absence of adequate research effort, and partly because the picture is changing so rapidly (Kaplinsky, 2007).

[6] For a detailed discussion of such impacts, see Alden (2005a), Alemayehu (2006), Alemayehu and Atnafu (2007), Broadman (2007), Foster, Butterfield, Chen and Pushak (2008), Jenkins and Edwards (2005), Kaplinsky, McCormick and Morris (2007), Stevens and Kennan (2005), and Zafar (2007).

The general focus of this thesis is on the trade link between China and Africa. International trade flows are a key element in all manner of economic relationships (Baldwin & Taglioni, 2006). During the establishment of FOCAC, expansion of China-African trade was also given a lot of emphasis with an initiative to establish China-Africa Joint Business Council. In addition, China has agreed most-favoured-nation clauses in foreign trade with 41 African countries and held talks on a free-trade agreement with South Africa (Asche & Schuller, 2008). This study is specifically intended to analyse China's potential for trade with African countries. In what follows, this chapter outlines the research problem, objectives and methodology, as well as significance and organisation of the study.

1.2 STATEMENT OF THE PROBLEM

International trade plays a major role in developing economies such as China and those in Africa. Heavy debt necessitates more export earnings; poverty reduction requires more per capita income; private-sector-led growth needs revenue opportunity; small domestic market requires access to external market; and FDI is more driven by trade (Yoshino, 2004). This implies the need to understand trade potential. Trade can impact on poverty through its effect on production and factor markets, government revenues and expenditure, or prices of consumer goods (Jenkins & Edwards, 2005). Be that as it may, Africa's overall international trade performance has been one of marginalisation from global trade flows. In fact, Africa's overall market share has continuously fallen over the last six decades (Broadman, 2007). Unless reversed, this pattern does not bode well for sustained growth on the continent.

Both China and Africa can gain from their bilateral trade. China may provide Africa with appropriate capital goods and cheaper consumer goods, and Africa may provide China with the commodities it requires to fuel its continued economic expansion (Kaplinsky et al., 2007).

Thus, China and Africa can provide markets for each other's products. By providing new export opportunities and widening import possibilities, China can help Africa to diversify its trade destination and source. Africa could also benefit in product diversification (World Bank, 2004), business efficiency, advances in technology, modern labour skills and greater international integration (Broadman, 2007). China-Africa trade also has implications on poverty (Jenkins & Edwards, 2005). All this, however, depends on whether the trade link is significant or not.

China's trade with Africa has recently grown at a dramatic rate. After the establishment of FOCAC in 2000, the bilateral trade flows have soared. The two-way trade (imports and exports summed) burgeoned from 8.3 billion United States of America (US) dollars ($) in 2000 (International Monetary Fund [IMF], 2005) to US$ 107.1 billion in 2008 (International Trade Centre [ITC], n.d.). China has become Africa's third largest trade partner after the US and France (Zafar, 2007). However, the bilateral trade remains small in relative terms□– especially from the perspective of China. Referring to the 2008 data of ITC (n.d.), China accounts for 10.6 percent of Africa's total value of trade while Africa accounts for just 4.2 percent of China's total value of trade. Indeed, China and Africa have set a goal to further expand the two-way trade.

The research questions are: How much is the scope to further expand China's trade with Africa? Or, what is China's trade potential with African countries? Have China and Africa already achieved their full trade potential? If not, what are the implications? There are few rigorous studies that provide answers to these questions. The dominant view in the existing literature, however, is one that suggests untapped trade potential between China and Africa. These suggestions are mainly based on the recently observed pattern of the two-way trade rather than on empirical analysis of the potential itself. Some observe the rapid rise in the bilateral trade and various initiatives intended to sustain it. Others look to the relatively low overall volume of bilateral trade and the existence of many African countries still having limited trade links with China. Still others take the growing demand in Africa for China's manufactured goods and machinery, and the growing demand in China for Africa's natural resources as a sign for economic complementarity and significant bilateral trade potential.

This justifies the need to have a better understanding of China's trade potential with Africa. As argued by Miankhel, Thangavelu and Kalirajan (2009), knowing the trade potential helps the countries to engage in bilateral and multilateral processes to make efforts to minimize or at least mitigate the effect of existing restrictive measures to trade growth.

1.3 OBJECTIVES OF THE STUDY

The general objective of this thesis is to empirically analyse the potential for trade expansion between China and Africa using standard techniques and thereby contribute to the existing literature which is largely speculative on the issue. The specific objectives are:

(a) to assess African countries' trade potential with China based on trade complementarity;

(b) to estimate the magnitude of China's trade potential with African countries; and

(c) to draw policy implications for China and African countries concerning their bilateral trade.

1.4 METHODOLOGY

In order to achieve the specific objectives of this study, we adopt both descriptive and econometric approaches with established theoretical framework. The descriptive approach involves calculating a trade complementarity index (TCI) for 53 African countries and China with a view to achieve specific objective (a). Of various trade indices, TCI is chosen for trade correspondence is one of the necessary conditions for existence of any bilateral trade potential. Assuming that strong match exists between China's exports and African countries' imports (which are mainly manufactures), we examine whether exports of African countries also match the imports of China. To that end, we consider the leading exports of African countries in the imports of China in 2008. The data are disaggregated commodities at two-digit Harmonized System (HS) level and extracted from ITC's TradeMap database. High trade complementarity (TCI close to one) would suggest large potential for Africa to increase its trade with China.

The econometric approach, on the other hand, applies a stochastic frontier analysis to a gravity model of trade between China and 52 African countries with a view to achieve specific objective (b). Estimation is done with maximum likelihood method and STATA 10 computer software. The stochastic frontier gravity model (SFGM) framework is chosen for its ability to produce, specification bias-free, potential trade estimates that are closer to frictionless trade estimates. For this purpose, we use aggregate panel data for the period 2001-2008.[7] The dependent variable is China's merchandise exports to African countries and extracted from ITC's TradeMap database. The explanatory variables are: gross domestic products (GDPs), which are taken from World Development Indicators of the World Bank,

[7] The author considers that the information content of this period suffices for the study. The period is the time when China's trade link with Africa has become more pronounced. China has also joined the World Trade Organisation in 2001 to become more open to the world including Africa. Also statistics-wise, the sample period enables us to have a balanced panel data with no missing observation.

except for Zimbabwe during 2006-2008 which are filled from World Economic Outlook Database of IMF; relative distance, which is obtained from the French Centre for Research and Studies on the World Economy (CEPII); and landlockedness, which is extracted from World Factbook of the Central Intelligence Agency (CIA). Based on the estimated SFGM, China's trade efficiency with African countries is calculated on a zero-to-one scale. An efficiency value of one suggests full realisation of potential trade. Low trade efficiency value would indicate high untapped potential for China's trade with Africa, given the determinants of trade.

Specific objective (c) is to be achieved using a combination of the above two approaches. It is important to recognise the limitations of our methodology from the outset. The first approach, for instance, is subject to aggregation bias and makes a static analysis. On the other hand, the second approach notably produces model-specific results that may not hold in another model setup or with disaggregated data. However, as shown in other researches of this kind, such methodological limitations will not invalidate the solution to the research problem stated in the present study.

1.5 SCOPE AND LIMITATIONS

The present study is limited to empirical examination of trade potential between China and African countries. China here refers to mainland China. Trade potential is a very wide subject and can be approached from different angles. This research, however, approaches the China-Africa trade potential from complementarity of trade and gravity model of trade. Specific focus is on obtaining some quantified indicators as to the scope to further integrate China with Africa by trade. For reliability, consistency and practicality, only merchandise trade after 2000 is considered for empirical analyses. Due to time and data constraints, this thesis does not intend to deeply investigate each bilateral trade flow. Likewise, identification of products with large bilateral potential and assessment of their competitiveness are not the objects of this paper. Moreover, detailed investigation of factors explaining realisations of the bilateral trade potential is out of the reach of this study. Future research can, thus, extend this thesis in several directions.

1.6 SIGNIFICANCE OF THE RESEARCH

This thesis provides important contributions. First of all, it provides a quantified assessment of China's trade potential with Africa, which is scant in the existing literature. The results from this analysis can give valuable insights into the prospects of significantly expanding China's trade with Africa. In addition, the study indicates the African countries with the largest and the smallest potential for trade with China. Further, our analysis highlights some of the factors determining the realisation of China's trade potential with Africa and causing variations in bilateral trade performance. The empirical analyses conducted in this paper, therefore, bear policy implications to expand the Sino-African trade. Last but not least, this thesis can be a useful reference material for academic researchers who would like to do a more in-depth analysis of the China-Africa trade.

1.7 ORGANISATION OF THE THESIS

The structure of this thesis is laid in five chapters. Chapter One has already introduced the study's area of investigation. In Chapter Two, a brief descriptive analysis of the recent pattern of trade between China and Africa is given. Chapter Three provides the theoretical literature on trade potential in connection with trade indices and gravity model of trade, and the empirical literature on trade potential between China and Africa. In Chapter Four, the empirical analyses and results of this study are presented and discussed. Finally, Chapter Five provides the conclusion from the study together with some policy recommendations.

CHAPTER TWO

PATTERNS OF TRADE BETWEEN CHINA AND AFRICA

2.1 TRADE BETWEEN CHINA AND CONTINENTAL AFRICA

In recent years, trade between China and Africa has surged dramatically. Merchandise trade between China and Africa as a whole rose from 4.5 billion US dollars ($) in 1998 to US$ 107.2 billion in 2008, growing at an average rate of 39.2 percent (%) per annum (see Table 2.1). Based on data from IMF (2005) and ITC (n.d.), this growth rate is much higher compared to the average growth rates of total merchandise trades of both Africa (which was 16.5%) and China (which was 23.3%) over the same period. Between 1998 and 2008, Africa's exports to China shot up from US$ 814.3 million to US$ 56.1 billion, averaging a 61.9% annual growth rate which is far greater than the growth rates of Africa's total exports

Table 2.1: Africa's Merchandise Trade with China, 1998-2008

Year	Value in Millions of US $			Annual Growth (%)		
	Export	Import	Total Trade	Export	Import	Total Trade
1998	814.30	3705.51	4519.81	–	–	–
1999	1597.81	3868.06	5465.87	96.2	4.4	20.9
2000	3948.70	4370.82	8319.52	147.1	13.0	52.2
2001	3220.57	4528.72	7749.29	-18.4	3.6	-6.9
2002	3799.07	6018.04	9817.11	18.0	32.9	26.7
2003	7302.82	8941.38	16244.20	92.2	48.6	65.5
2004	11640.38	13405.73	25046.11	59.4	49.9	54.2
2005	17958.50	19641.71	37600.21	54.3	46.5	50.1
2006	26986.89	29773.36	56760.25	50.3	51.6	51.0
2007	24497.94	42119.27	66617.21	-9.2	41.5	17.4
2008	56086.29	51090.50	107176.79	128.9	21.3	60.9
Average				61.9	31.3	39.2

Source: IMF (2005, 2008) and ITC (n.d.), retrieved February 22, 2010.

(19.3%) and China's total imports (23.6%). Over the period considered, Africa's imports from China grew from US$ 3.7 billion in 1998 to US$ 51.1 billion in 2008, registering a 31.3% average rate of growth per annum which eclipses the corresponding growth rates of total imports of Africa (14.3%) as well as total exports of China (23.2%).

As can be seen from Table 2.2, the merchandise trade between Africa and China has also become increasingly important in each other's trade profiles. However, the importance of the bilateral trade remains relatively small especially for China. From 1998 to 2008, the share of exports to China in Africa's overall export profile increased from 0.8% to 10.3% while the share of imports from China in Africa's total imports rose from 2.9% to 10.9%. Likewise, the share of exports to Africa in China's overall export profile grew from 2% to 3.6%, while the share of imports from Africa in China's world imports rose from 0.6% to 5% over the same period. Similarly, the share of the total two-way trade (that is, exports plus imports) in Africa's world trade increased from 2% to 10.6% while the same in China's world trade rose from 1.4% to 4.2% between 1998 and 2008. Note in passing that trade share statistics and

Table 2.2: China and Africa's Mutual Importance in Merchandise Trade Profile, 1998-2008

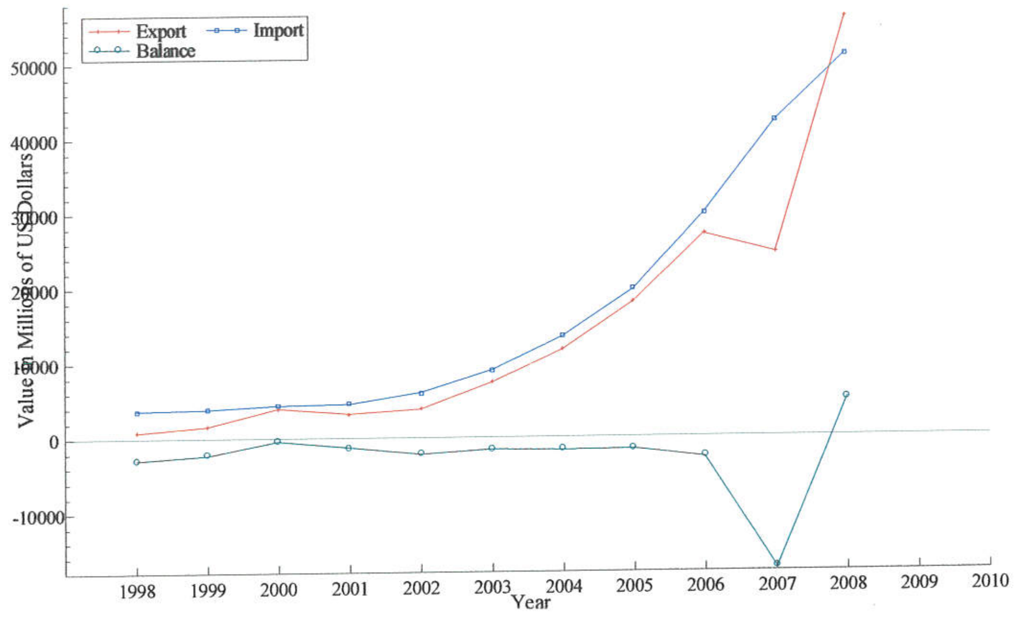
Indicators	1998	2000	2002	2004	2006	2008
Africa's exports to China as % of Africa's world exports	0.8	2.6	2.7	5.2	7.7	10.3
Africa's imports from China as % of Africa's world imports	2.9	3.3	4.2	5.8	9.0	10.9
China's exports to Africa as % of China's world exports	2.0	1.8	1.8	2.3	3.1	3.6
China's imports from Africa as % of China's world imports	0.6	1.8	1.3	2.1	3.4	5.0
China-Africa trade as % of Africa's total trade	2.0	2.9	3.4	5.5	8.4	10.6
China-Africa trade as % of China's total trade	1.4	1.8	1.6	2.2	3.2	4.2

Source: Computed from IMF (2005, 2008) and ITC (n.d.), retrieved February 22, 2010.

their changes over time may reflect not only trade policy but also such numerous factors as physical distance, economic size (Mikic & Gilbert, 2007) and comparative advantage structures (Yamazawa, 1970).

As far as the balance of trade between China and Africa is concerned, it largely favours China. Figure 2.1 mainly tells a story of continuous bilateral trade deficits for Africa. From about US$ 2.9 billion in 1998, the trade deficit for Africa, after ups and downs, widened to US$ 17.6 billion in 2007. The year 2008 is an exception in the sample by recording a surplus of about US$ 5 billion for Africa. The trade deficits for Africa have occurred in spite of the much faster growth rate of Africa's exports to China than Africa's imports from China. That is because the value of imports started from a higher base compared with the value of exports. The observed trade imbalance may be explained by, among other things, the structure of the

Figure 2.1: Balance of Africa's Merchandise Trade with China (million US$), 1998-2008



Note: Trade balance is obtained as Africa's export to China minus its import from China.
Source: IMF (2005, 2008) and ITC (n.d.), retrieved February 22, 2010.

two-way trade with Africa exporting primary products but importing manufactured goods from China. Shelton and Paruk (2008) argue that to balance the bilateral trade over the longer term, African exporters will have to diversify and more aggressively target the Chinese market.

Turning to the composition of trade between China and Africa, it can be observed that African exports to China lack diversification and are mainly driven by primary products (see Table 2.3). In particular, the exports of Africa to China are highly concentrated in crude petroleum oils. Referring to data in 2008, these products account for about 70% of the total value of African exports to China. Iron ores and concentrates are the next important products accounting for 4% of the total value of African exports to China, followed by manganese ores and concentrates with a share of 3%.

Table 2.3: Africa's Top Ten Merchandise Exports to China, 2008

Product	Share in the Total Value of Merchandise Exports to China (%)
Crude petroleum oils	69.6
Iron ores and concentrates	4.0
Manganese ores and concentrates, etc	3.0
Chromium ores and concentrates	1.8
Cobalt ores and concentrates	1.8
Platinum, unwrought or semi-manufactured	1.6
Wood in the rough	1.6
Copper ores and concentrates	1.6
Diamonds, not mounted or set	1.5
Unrefined copper, copper anodes	1.2

Source: Calculated from ITC (n.d.), retrieved January 13, 2010.

Imports of Africa from China, on the other hand, mainly constitute manufactured products such as electrical and electronic equipment, machinery and vehicles. Table 2.4 shows that, based on 2008 data, electric appliance for line telephony account for 6.7% of the total value of African imports from China, followed by woven cotton fabrics (3.7%), motor cycles and side cars (2.3%), and trucks and motor vehicles for the transport of goods (2.2%). In comparison to exports, we observe that African imports from China are more diversified but industrial goods dominate. Combining the information in tables 2.3 and 2.4 supports the argument (Broadman, 2007; Zafar, 2007) that trade flows between Africa and China follow the predictions of comparative advantage and factor endowment theories, with China exporting manufactures and high-technology products and Africa exporting raw materials, oils and resource-based products. There are concerns (for example, Alemayehu, 2006) that this pattern may lock

Table 2.4: Africa's Top Ten Merchandise Imports from China, 2008

Product	Share in the Total Value of Merchandise Imports from China (%)
Electrical appliance for line telephony	6.7
Woven cotton fabrics, 85% or more cotton	3.7
Motor cycles, side cars	2.3
Trucks, motor vehicles for transport of goods	2.2
Bulldozer, angle dozer, grader, excavator, etc	1.8
Footwear, outer soles and uppers of rubber	1.7
Electric generating sets and rotary converters	1.5
New pneumatic tires, of rubber	1.5
Structures (rods, angle, plates) of iron and steel	1.5
Woven fabrics of synthetic filam yarn	1.5

Source: Computed from ITC (n.d.), retrieved January 13, 2010.

Africa in primary goods[8] production and adversely impact on efforts in the continent geared towards economic development through industrialisation.

2.2 TRADE BETWEEN CHINA AND SPECIFIC AFRICAN COUNTRIES

Having analysed the trade pattern between China and Africa as a continent, we next do the analysis by considering specific African countries. As indicated in Table A1 of Appendix A, Angola is the most important African trade partner of China accounting for about 23.6% of Africa's total trade with China in 2008, followed by South Africa (16.7%), Sudan (7.6%), Nigeria (6.8%) and Egypt (5.9%). Algeria, Congo (Brazzaville), Libya, Morocco and Equatorial Guinea complete the top ten ranking by sharing 4.3% to 2.4% of China's total trade with Africa. It is shown that out of 53 African nations, 20 countries account for 1% or more of the Africa-China trade while 33 countries have a share of less than 1%. Thus, China's trade with Africa shows moderate geographic concentration with 60.6% of the two-way trade involving only the top five countries of the continent.

While merchandise trade with China might have increased in recent years, its importance in the trade profiles of many African countries remains limited (see Table A2 of Appendix A). In 2008, for instance, the share of exports to China in total country exports is the highest for Burundi (85.4%), relatively high for Sudan (66.6%), Congo DRC (42.5%), Mauritania (42.5%) and Angola (33.5%), but low (less than 10%) for many others. Likewise, the share of imports from China in total imports is the highest for Gambia (53.3%), high for Benin (36.8%) and Togo (34.7%), but low for several countries in Africa. Concerning the total trade with China, Gambia leads by having 52.1% of its total trade as trade with China, followed by Benin (35%), Sudan (31.6%) and Burundi (30.4%). However, trade with China is not that

[8] These goods are traditionally characterised by strong price volatility, low responsiveness to income, secular deterioration of terms of trade and limited scope for technological development (Alemayehu, 2010).

significant for several African countries such as Sao Tome and Principe, Seychelles, Cape Verde, Tunisia and Guinea-Bissau.

The balance of trade between China and individual African countries mirrors the image depicted in the previous section for Africa as a whole with deficits dominating the scene (see Table A3 of Appendix A). The majority of African countries exhibit deficits in their merchandise trade with China. It has been argued by Shelton and Paruk (2008) that this situation is particularly evident in the case of African countries which have no resources to trade. In 1998, only Angola, Cameroon, Equatorial Guinea and Gabon show trade surpluses while Comoros appear with an almost balanced trade. After ten years in 2008, Comoros exhibits trade deficits with China while Angola, Cameroon, Equatorial Guinea and Gabon improve their bilateral trade balances. Meanwhile, Botswana, Burkina Faso, Burundi, Cameroon, Central African Republic, Congo (Brazzaville), Congo DRC, Libya, Mauritania, Namibia, South Africa, Sudan, Zambia and Zimbabwe join the small group of countries having a trade surplus with China. Otherwise, from 1998 to 2008, about 35 African countries have seen their trade balances with China deteriorate further. It is important to note that in order to draw meaningful inference from a trade deficit of a country, one has to identify the causes and consider it in relation to the overall balance-of-payments position of the country (Mannur, 1983). In any case, a continuous trade deficit is undesirable for any economy.

The product distribution of trade with China for individual African countries also resembles that for the continent as a whole, dominated by primary products on the export side and manufactures on the import front (see tables A4 and A5 in Appendix A). Let us consider the case for the top ten African trade partners of China and the top three products of the bilateral trade in 2008. African countries depend on export of natural resources, particularly mineral fuels and oils. For instance, the share of the value of mineral fuels, oils and distillation products in the total value of merchandise exports to China is almost 100% for Angola, Algeria, Sudan and Libya, 84.8% for Nigeria, 82.8% for Congo (Brazzaville) and 41.5% for Egypt. South Africa's exports to China, on the other hand, are mainly minerals such as ores, precious stones, metals, iron and steel whose total value make up about 72% of the total value of the country's merchandise exports to China. The primary export of Benin to China is cotton (with 75% share). Morocco is an interesting exception in that its main exports to China are electrical and electronic equipment (with 61.1% share).

Imports of African countries from China, on the contrary, are concentrated in manufactures such as nuclear reactors, boilers, machinery, electrical and electronic equipment, and vehicles. The share of nuclear reactors, boilers and machinery in the total value of merchandise imports from China is as high as 30.1% for Libya, 21.1% for Sudan, 17.5% for Algeria, 16.9% for Egypt, 16.8% for Morocco, 16.4% for Angola, 15.5% for Congo (Brazzaville), 14.4% for South Africa and 13.7% for Nigeria. Similarly, in the total imports from China, electrical and electronic equipment share as much as 27.1% in Nigeria, 19.6% in South Africa, 17.5% in Sudan, 17.3% in Morocco, 14.7% in Egypt, 14.6% in Congo (Brazzaville), 14.1% in Angola, 13% in Libya and 11.1% in Benin. Here, Benin is an exception by having cotton (a primary product) as its main import from China (with 42.9% share). The share of vehicles other than railway and tramway in the total value of merchandise imports from China, on the other hand, reaches 19.5% in Angola, 19.2% in Algeria, 12.9% in Nigeria, 10.7% in Congo (Brazzaville) and 9.4% in Egypt.

To conclude this chapter, let us put the main points in a nut shell. First, trade between China and African countries has grown very rapidly over the past decade or so. However, the importance of the two-way trade is still small in relative terms. Second, the balance of trade is mainly favouring China. Third, China's trade in Africa exhibits moderate geographic concentration. Finally, Africa mainly exports primary products to China whereas it imports mostly manufactures from the same country. A recent study by Broadman (2007) shows that apart from formal trade policies as well as traditional economic and geographic factors, domestic business environment, competiveness of market structures, quality of market institutions, supply constraints like poor infrastructure and trade facilitation significantly influence the pattern of trade between Africa and Asia.

CHAPTER THREE

REVIEW OF THE LITERATURE

3.1 THEORIES ON TRADE POTENTIAL

When analysing international trade between countries, the central theme is the examination of whether or not there are any significant differences between the actual trade and potential trade, given the determinants of trade flows (Kalirajan, 1999). In theory, trade potential is defined as the maximum level of trade with the least[9] level of restrictions possible given the current level of determinants of trade (Miankhel et al., 2009). It is important for countries negotiating on a bilateral basis to start the process by establishing the bilateral trade potential and, based on this, identify gains to be made from removing trade barriers (Baker, Kirchbach, Mimouni, & Pasteels, 2002). Trade potential estimates can provide guidance as to (a) what the prospects are of significantly increasing trade over the near-to-medium term; and (b) which countries present the greatest untapped potential for increasing trade (Soderling, 2005). In what follows, we discuss in turn nonparametric indices and econometric models used to establish bilateral trade potentials.

3.1.1 Trade Potential and Trade Indices

Different trade indicators are used to analyse international trade and its potential at national, regional or global level. A trade indicator can be defined as an index or a ratio that can be used to describe and assess the state of trade flows and trade patterns of a particular economy or economies and can be used to monitor these flows and patterns over time or across economies (Mikic & Gilbert, 2007). Trade indicators may be used as leading indicators (when

[9] In reality, it is very difficult to assume that there will not be any restrictions to trade between a group of countries (Kalirajan, 1999).

they have predictive power) or as lagging indicators (when they describe what has happened in the past). Trade indices also differ in the information they best provide and data requirement. In any case, it is argued that trade indicators need to observe the criteria of being simple, measureable, consistent and comparable.

Whether there is any trade potential between any two countries can primarily be examined by measuring the intensity of trade between them (Kalirajan & Bhattacharya, 2007). Mikic and Gilbert (2007) define index of trade intensity (ITI) as a ratio of the share of the destination of interest in the exports of the region under study to the share of the destination of interest in the exports of the world as a whole.[10] The ITI tells us whether or not the observed share of trade is greater than the world average, or intense relative to what we might expect. As argued by Kalirajan and Bhattacharya (2007), if the intensity between two countries is low, it is obvious that the two countries have much trade potential to reap between them. High trade intensity reflects factors such as strong complementarity in comparative advantage structures, smaller geographical and psychic distances, and mutually favourable trade agreements, and low intensity the contrary situations (Yamazawa, 1970). The advantage of using ITI, according to Mikic and Gilbert (2007), is that it is free from any size (economic or bloc) bias, allowing comparison of the statistic across regions and over time. However, ITI is limited in that it is inadequate to reflect trade policy.

Overlap indices are other indicators of potential trade, which measure the degree to which categories match, or overlap (Mikic & Gilbert, 2007). These indices share a common mathematical foundation. One such index is the trade complementarity index (TCI), which is an overall measure of the degree to which the export pattern of one country matches the

[10] See Appendix B.1 for mathematical expressions of trade intensity indices.

import pattern of another. Mikic and Gilbert (2007) define TCI as the sum of the absolute value of the difference between the import category shares and the export shares of the countries under study, divided by two.[11] As shown by van Beers and Linnemann (1988), one alternative to measure complementarity is to measure the cosine (COS) of the angle between the vector of one country's export and the vector of another country's imports in a multi-dimensional commodity space. Another alternative is to measure export-import similarity (EIS) by summing over all commodity classes of the share of a given commodity class in one country's export or in the other country's import — whichever of these two shares is lower, so that only the overlap counts. COS and EIS measures indicate a trade probability, or an expected intensity of trade, between a pair of countries.[12]

High TCI value is assumed to indicate a large room to expand bilateral trade while low TCI value is taken to show smaller bilateral trade potential (Mikic & Gilbert, 2007). Changes over time may tell us whether the trade profiles are becoming more or less compatible. High TCI value may result from high trade diversification or high trade concentration in similar products while low TCI value could be explained in terms of moderate diversification of export supply and import demand in the countries under consideration (Das, Ratanakomut, & Mallikamas, 2002). One limitation of TCI (as well as COS and EIS) as highlighted in the literature is its sensitivity to the level of aggregation. Another drawback is that high values of the index may be misleading if the countries are geographically distant, or if the size difference in the economies is large (that is, a match in percentage terms does not imply a match in levels). Also, van Beers and Linnemann (1988) note that the degree of trade

[11] Chapter Four contains the mathematical definition of TCI.
[12] Appendix B.2 has formal definitions of COS and EIS measures.

complementarity is only one determinant of the intensity of trade between countries.[13] But these authors also argue that without any commodity correspondence no trade will take place, and with perfect correspondence trade possibilities abound.

Mikic and Gilbert (2007) present an alternative overlap index, known as the export similarity index (ESI). Unlike complementarity indices, ESI provides an overall measure of the degree to which the exports of two countries match, and thus it is an indicator of the degree to which the countries are rivals (as opposed to complementary) on international markets. The ESI is defined as the sum over export categories of the smaller of the sectoral export share (as a percentage) of each country under study.[14] High ESI values may indicate limited potential for inter-industry trade with a regional trading arrangement. However, like complementarity indices, this index is also subject to aggregation bias. In addition, ESI does not consider the level of exports, only the structure, so may be misleading when the size of the economies considered is very different. Furthermore, it is argued by Oramah and Abou-Lehaf (1998) that a much better measure of trade potential is one that looks at the export structure of one country and the import structure of the partner since dissimilarity in export may not be a sufficient condition for trade potential to exist.

In fact, apart from trade structure, production structures of countries can also be examined in order to assess bilateral trade potentials. For instance, there is a hypothesis that countries with similar production patterns, stemming from similar factor endowments and climatic conditions, have limited potential for trade between them (Koester, 1986). This hypothesis can be tested by calculating a production similarity index (PSI). This index measures the

[13] Other determinants are the geographic distance between the trade partners, the level of import tariffs and other barriers to trade, the existence or not of preferential trading or payment arrangements, political factors favouring or obstructing trade, etc (van Beers & Linnemann, 1988).

[14] Refer to Appendix B.3 for a mathematical expression of ESI.

similarity of the production patterns of countries by making use of the shares of a particular commodity in the commodity groups of the countries under study.[15] Higher values of PSI indicate similarity in production, and hence limited bilateral trade potential. However, as indicated by Koester (1986), the cause for similarity (or dissimilarity) could be traced not only to resources and climate but also to trade policy. The actual cause may be revealed when the export patterns of the countries are investigated. Differences in production pattern will most likely be reflected in differences in export patterns of the individual countries, implying the analogy between PSI and ESI.

However, like export dissimilarity, production dissimilarity is not a sufficient condition for trade potential to exist (Oramah & Abou-Lehaf, 1998). Indeed, the higher the similarity is in production structure, the higher would be the potential for intra-industry trade (Das et al., 2002). The Grubel-Lloyd index or the intra-industry trade index (IITI) is commonly calculated to aid the analysis.[16] Das et al. (2002) argue that calculating the index for two countries for products that are being exported by one country to the rest of the world but not being imported by the other country (being imported, instead, from the rest of the world) captures the potentials for intra-industry trade between the two economies. Mikic and Gilbert (2007) add the point that higher value of IITI suggests current exploitation of economies of scale and variety sources of gains in trade; it may also indicate that adjustment costs would be lower with trade expansion.

IITI, however, is sensitive to the definition of industry (Mikic & Gilbert, 2007). It is also subject to aggregation bias (toward unity), both in terms of sectors and regions. Furthermore, the index is not appropriate for measuring changes in intra-industry trade because the index

[15] Formal definition of PSI is given in Appendix B.4.
[16] Appendix B.5 contains the mathematical expression of IITI.

can remain constant even as the volume of intra-industry trade expands. According to Mikic and Gilbert (2007), intra-industry trade indices such as IITI are also overlap indices in the sense that they measure overlap in the import/export profile of a single economy. In specific comparison to complementarity indices, on the other hand, Das et al. (2002) point to IITI's implication that low trade complementarities do not act as a constraint on future trade flows; that is, there may be scope for intensifying intra-industry trade.

Another index that deserves mention here is known as the revealed comparative advantage index (RCAI). RCAI is used to identify the sectors in which an economy has a comparative advantage by comparing the country of interest's trade profile with the world average (Mikic & Gilbert, 2007).[17] High RCAI value implies that the country has a revealed comparative advantage in a given product. De Benedictis and Tamberi (2001) discuss three interpretations to the RCAI. The first and most common one is that each index provides a demarcation between countries that reveal a comparative advantage in a particular sector and those countries that do not. Second, the index quantifies the sector-specific degree of comparative advantage enjoyed by one country with respect to any other country or set of countries. Third, the index generates possible cross-country (with respect to a sector) rankings, ordered according to the specific value of the index. RCAI's major limitation is that it is affected by anything that distorts the trade pattern (Mikic & Gilbert, 2007; Oramah & Abou-Lehaf, 1998). The index's high dependence on country-specific information throws doubt on its suitability to measure cross-country specialisation and trade potential. RCAI, however, helps to calculate other indices such as those of complementarity (see World Bank, 2004).

[17] Refer to Appendix B.6 for mathematical definition of RCAI.

Finally, Helmers and Pasteels (2006) propose an overall qualitative approach in order to assess export potential at the product level using a combination of various quantitative and qualitative indicators of trade costs. The indicators are grouped into 4 categories: (a) trade potential at the sector level, based on ITC's TradeSim gravity model,[18] (b) trade flow analysis at the commodity level, (c) trade costs at the commodity level, and (d) supply and demand conditions at the commodity level. They do not arrive at a precise magnitude of export potentials, but at broad qualitative conclusions in order to identify products that bear potential. Taking the standard gravity approach as a point of departure, the approach builds stepwise a more detailed picture of the trading environment at the commodity level, moving from broad and easily accessible quantitative data to more specific pieces of quantitative and above all qualitative information. Hence, it attempts to overcome the difficulties of standard numerical techniques to analyse trade potential at product level owing to data limitations.

For the purposes of this study, we choose the TCI measure that was discussed above mainly because trade complementarity is considered as an important necessary condition for existence of bilateral trade potential. That is, what is supplied by one country needs to be demanded by the partner country (Alemayehu, 2009). Thus, it is also necessary to examine the degree to which the export pattern of African countries matches the import pattern of China, and vice versa.

3.1.2 Trade Potential and Conventional Gravity Model of Trade

While trade potential is the result of matched export capacities and import demands at the microeconomic level, on a more aggregated level of analysis, proximity in demand, in per capita income, in space, and in culture, are key macroeconomic determinants of trade

[18] This model is discussed in the next section of this chapter.

potential (ITC, 2003). Consequently, various combinations of macroeconomic variables are powerful predictors of trade potential, making the gravity model of trade a suitable tool for the analysis.[19] The model acquires its name from its similarity to the Newtonian theory of gravitation. Newton's law states that the force of gravity between two bodies is positively related to the mass of the attracting bodies and inversely related to the square of their distance (Piermartini & Teh, 2005). The trade version of the law of gravity, as explained by De Benedictis and Vicarelli (2004), represents a reduced form which comprises supply and demand factors (GDP and population), as well as trade resistance (geographical distance, as a proxy of transport costs and home bias) and trade preference factors (preferential trade agreements, common language, common border).[20] One can also include an effect for landlockedness, which is an important resistance to trade (Frankel, 1997).[21]

As indicated by Kalbasi (2004), the conventional gravity equation has the following general specification:

$$X_{ij} = \alpha_0 Y_i^{\alpha_1} Y_j^{\alpha_2} N_i^{\alpha_3} N_j^{\alpha_4} D_{ij}^{\alpha_5} A_{ij}^{\alpha_6} P_{ij}^{\alpha_7} e^{\varepsilon_{ij}}$$

where X_{ij} is the value of the trade flow from country i to country j, Y_i and Y_j are the values of nominal GDP in i and j, N_i and N_j are the sizes of population in both countries, D_{ij} is the physical distance from the economic centre of country i to that of country j, A_{ij} is any other factor either aiding or hindering trade between i and j, P_{ij} is trade preferences among the countries, and ε_{ij} is a log-normally distributed error term (capturing the influence of omitted

19 A computable general equilibrium model can also be used to analyse bilateral trade. However, due to its inherent complexity (Piermartini & Teh, 2005) and data constraints (Greenaway & Milner, 2002), a computable general equilibrium model is difficult to implement and remains to a considerable extent theoretical. In fact, as noted by Mikic and Gilbert (2007), extrapolation from a gravity model may be preferred if trade flows are the only variable of interest (as is the case in this study).

20 Appendix C provides a simple diagram of the standard gravity model of international trade.

21 Baldwin (1994) argues that one needs only population, GDP and geographical distances between countries to project potential trade flows.

variables and statistical errors) with $E(\ln \varepsilon_{ij}) = 0$. The terms: $\alpha_0, \alpha_1, \alpha_2, \alpha_3, \alpha_4, \alpha_5, \alpha_6$ and α_7 are parameters to be estimated, usually by ordinary least squares (OLS) in a log-linear form.

Different factors affect bilateral trade in different directions. The GDP of the exporting country measures productive capacity, while that of the importing country measures absorptive capacity (Kalbasi, 2004). These two variables are expected to be positively related to trade. Population is a measure of country size, but its effect can be positive or negative, depending on whether economies with a larger population trade more (economies of scale) or trade less (absorption effect) (Oguledo & Macphee, 1994). Distance[22] dampens trade since it increases transportation and other transaction costs, and is one determinant of relative prices (Baldwin, 1994). Trade is inversely related to landlockedness for which transport costs are higher (Piermartini & Teh, 2005) and by which trade costs within the source and destination countries are captured (Shepotylo, 2009). Preferential trade agreements are expected to stimulate trade among the constituent countries (Bussiere & Schnatz, 2009). Language and border, as noted by Piermartini and Teh (2005), capture information costs. Search costs are probably lower in trade between countries with common language and border due to better knowledge of each other's business practices, competitiveness and delivery reliability. Thus, countries with common language and border trade more.

The main criticism of the gravity model in the past was that it lacked strong theoretical foundations,[23] but recent work has gone against this. Linnemann (1966) attempted to give a

[22] It is now recognised in the literature that the use of relative distance is preferred to absolute distance in explaining gross trade volumes (Armstrong, 2007). This is because controlling for country size and bilateral distance, trade will be higher between country pairs that are far from the rest of the world than between country pairs that are close to the rest of the world (Harrigan, 2001). As argued by Polak (1996), a relative measure of distance helps to capture the role of countries' location or geography in bilateral trade.

[23] The implications of the lack of theoretical foundations for empirical gravity model include: (1) estimation results are biased due to omitted variables; (2) conducting comparative statics exercises is unfounded (Anderson & van Wincoop, 2003); and (3) the predictive potential of gravity model is inhibited (Bergstrand, 1985).

theoretical basis using a Walrasian general equilibrium system. But it is Anderson (1979) who is considered as the first to give the gravity model a firm theoretical backing by deriving it from constant-elasticity-of-substitution preferences and goods that are differentiated by region of origin. Bergstrand (1985) retains the assumption of constant-elasticity-of-substitution preferences and obtains the model from a partial equilibrium subsystem of a general equilibrium model with nationally differentiated products. Helpman (1987), on the other hand, derives the gravity model from an imperfect competition model, while Deardorff (1995) draws it from the Heckscher–Ohlin model. Moreover, as argued by Haveman and Hummels (2001), the gravity equation as a statistical relationship (and not as a specific prediction about bilateral trade) can also be generated from a model with incomplete specialization. Note that alternative theories predict subtle differences in the coefficient estimates (Feenstra, Markusen, & Rose, 2001), and the challenge, as posed by Evenett and Keller (2002), is to empirically determine which theory accounted for the success of the gravity equation.

There are also other issues that have been widely discussed and debated in the literature on gravity models apart from theoretical foundation, They include: assumption of symmetric[24] trade flows, how trade frictions (barriers) are accounted for, assumption of iceberg[25] transport costs, choice of explanatory variables and proxies (such as distance, population and border), nominal versus real values,[26] omission of multilateral resistance[27] and economic distance[28]

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24 It implies that the volume of imports from A to B equals imports from B to A (Piermartini & Teh, 2005).

25 Iceberg transport costs assume that the further a good travels, the more it loses value (Armstrong, 2007).

26 Since the gravity equation is an expenditure equation, the natural specification is to relate the value of bilateral exports to the value of the importing nation's expenditure (Baldwin & Taglioni, 2006). However, it is common to use real GDP instead of GDP, as if the gravity equation were based on a demand equation instead of an expenditure equation. Trade figures are also wrongly deflated by the US aggregate price index with the probability of creating biases via spurious correlations. Shepherd (2008) argues that theory-consistent gravity data is in nominal value terms.

27 Multilateral resistance refers to average trade barriers that a country faces with respect to all its trade partners (Anderson & van Wincoop, 2003). Trade between two regions is decreasing in their bilateral trade barrier relative to the average barrier of the two regions to trade with all their partners.

28 Economic distance refers to a difference in the partners' per capita incomes (McPherson & Trumbull, 2008). The closer the countries are in their economic development and income (all else equal) the more they will trade. 'Economic distance' factors include country-specific socio-political-institutional factors, historical and cultural ties between countries, the tying up of aid and the lines of communication between countries (Kalirajan, 2007).

terms, how to capture unobservable or difficult-to-quantify resistances to trade, arbitrary addition of variables into the model, interpretation of coefficients, whether gravity model can be used for ex post or ex ante policy analysis, lack of necessary data, functional form[29] of the model and econometric problems (Anderson & van Wincoop, 2003; Armstrong, 2007; Baldwin & Taglioni, 2006; Broadman, 2007; Cassim, 2001; Deardorff, 1995; Evenett & Hutchinson, 2002; Matyas, 1997; McPherson & Trumbull, 2008; Miankhel et al., 2009; Piermartini, 2006; Piermartini & Teh, 2005; Porojan, 2000).

Notwithstanding such varied viewpoints on its use, the gravity model, thanks to its parsimony and empirical robustness (Porojan, 2000), has enjoyed wide applications since its first introduction by Tinbergen (1962), Poyhonen (1963) and Linnemann (1966) to study trade flows between countries. According to ITC (2000), four categories of applications can be mentioned: estimating the cost of the border, explaining trade patterns, identifying effects related to regionalism and finally tabulating trade potentials. The gravity model is particularly suited to estimate trade potential as it provides a natural benchmark taking into account both trade enhancing and trade resistance factors (Ferragina, Giovannetti, & Pastore, 2005). As noted by Mikic and Gilbert (2007), the gravity model estimates a normal trade flow, from which deviations can be investigated; hence, the model achieves econometrically what trade indices attempt to do using simple computation. A well-specified gravity model can, in fact, be thought of as a kind of 'super' trade intensity index.

The International Trade Centre (ITC) has recently developed a gravity model called TradeSim whose objective is to estimate bilateral trade potential of developing countries with any of

[29] Although alternative functional forms could prove to be more efficient (Kalirajan, 2007), the log-linear form is a fair and ready approximation to the optimal form (Sanso, Cuairan, & Sanz, 1993).

their partner countries.[30] The basic idea behind the model is the structure of international trade along natural trading regions and natural bilateral trade patterns. The model estimates an equation on a sample of countries and then uses this equation for simulation purposes in order to derive theoretical (or natural) levels of trade. The tabulation of trade potentials is a two-step procedure. In the fist step, simulated trade values are corrected for overall deviation.[31] In the second step, trade potentials are calculated as the average of the adjusted and unadjusted simulated trade values (ITC, 2000). The first version of TradeSim was developed in 1999. The second version came in 2003. Finally, the third version was developed in 2005 (Helmers & Pasteels, 2005). These versions of TradeSim differ in methodological strength and focus on level of analysis (that is, sectoral versus aggregated level).

In the literature, however, there are mainly two approaches to quantify bilateral trade potential using the conventional gravity model of trade: out-of-sample and in-sample approaches. The out-of-sample method refers to excluding data on trade flows of the countries of interest from the sample while calculating the parameters of the gravity equation (Shepotylo, 2009). At this first stage, the gravity equation is estimated for a group of countries that are most integrated into the world trade system and, therefore, operate at the frontier of trade efficiency. The estimated coefficients are then applied to the data of the countries of interest in order to obtain their natural level of trade. The results indicate what would be the level of trade of the studied countries if the determinants of their trade flows were the same as those of the reference sample (Damijan, De Sousa, & Lamotte, 2006). On the other hand, the in-sample approach

[30] Note that TradeSim is not really "conventional" gravity model of trade. It is discussed in the current section only for convenience and to distinguish it from the gravity model of trade discussed in the next section.

[31] The difference between observed and simulated trade values is associated with residuals in the estimated equation and this deviation from the observed trade value has to be taken into account when tabulating potentials. However, since residuals are not distributed uniformly in the sample, we systematically exclude deviations for large markets from the deviation accounted for when tabulating the correction. That is, we exclude the residual associated with the destination market from the total residual, when tabulating the correction factor for this destination market (ITC, 2000).

involves estimating the gravity equation on a sample including the studied countries. Trade potential is then defined by the residuals of the gravity equation (that is, by the difference between the predicted and the actual trade flows). As implied by Chionis and Liargovas (2002), the choice between in-sample and out-of-sample methods may depend, among other things, on the economic and political characteristics of the countries under investigation.

Both out-of-sample and in-sample approaches have advantages as well as disadvantages. Looking at the out-of-sample methodology, one of its advantages is that it allows estimating trade potentials according to different scenarios of formal integration (Fidrmuc, 1999). It may also avoid a misleading interpretation of residuals (Peridy, 2005). However, the limitation of the out-of-sample approach is that it is based on a strong assumption that the determinants of trade of the countries of interest will converge toward those of the target countries (Damijan et al., 2006). Another shortcoming of the out-of-sample approach, according to Brenton and Di Mauro (1998), is that the residuals of the estimation are not taken into account, which leads, when the obtained coefficients are applied to other data, to a potentially high margin of error. Damijan et al. (2006) also note the possibility of very high margin of error when the countries of interest are specialized in a limited range of products.

The in-sample approach, on the other hand, has an advantage as it allows to estimate ex post the effects of preferential trade agreements in which the countries of interest are included and to calculate ex ante the trade potentials (Damijan et al., 2006). However, the in-sample methodology does not allow disentangling to what extent the results depend on the amount of trade not yet exploited between the two partners under investigation rather than on the fact that the model adopted is unable to explain trade (Ferragina et al., 2005). Egger (2002) further argues that systematic variation of residuals cannot be interpreted as reflecting trade potential, but rather a misspecification of the model due, for example, to serial correlation. Moreover, as noted by Damijan et al. (2006), if the methodology is adopted when the target country group represents a large part of the sample, the results may be biased.

In spite of the caveats associated with the in-sample and out-of-sample approaches, various policy implications have been derived from the estimates of trade potential. The policy advises from the finding of a negative sign in the difference between effective and potential trade (that is, untapped trade potential) go from the necessity of country-specific export promotion and of broader bilateral integration, to the need to anticipate relevant distribution changes due to the effect of expansion in bilateral trade flows in the near future. A positive sign in the difference between effective and potential trade (that is, successful partnership) also generates different policy advises such as trade has reached its potential level and no social cost has to be expected from future integration (De Benedictis & Vicarelli, 2004). The appropriateness of these inferences, however, depends on whether the gravity model is properly estimated or not.[32] According to Piermartini and Teh (2005), the results of trade potential based on gravity model depend on a number of estimation choices: whether the dependent variable is imports, exports or total trade, whether data are aggregated or disaggregated, how zero and missing trade observations are treated, the sample of countries, whether the analysis is run on cross-country, time-series or pooled data, the choice and the length of the time period, and whether fixed effects are country specific, exporter and importer specific or country-pair specific. Let us elaborate on some of these factors in turn.

First of all, whether one uses bilateral exports, imports, total trade, or average trade as the dependent variable makes a difference. Since countries are usually much more concerned

[32] Helmers and Pasteels (2005) underscore the point that potentials should be understood as potentials within the specified model set-up. It is important to get the econometrics right especially if the purpose is policy analysis (Matyas, 1998).

about their imports than exports, bilateral import data are believed to be more reliable than their corresponding export data measured by the trade partner country for the same trade flows (Nam, 2004).[33] Pradhan (2006) argues that as the majority of trade-related welfare gain accrues from improved ability to import better and diversify traded commodity basket, the estimation of trade potential including both merchandise exports and imports from both sides would even be logical. Many gravity models are also estimated on the average of the two-way trade. However, as explained by Baldwin and Taglioni (2006), the basic theory tells us that the gravity equation is a modified expenditure function. The equation explains the value of spending by one nation on the goods produced by another nation, and thereby unidirectional (country-specific) bilateral trade.

It also matters for results obtained from gravity models whether data are aggregated or disaggregated. For trade promotion policies, it is important to tackle the issue of natural bilateral trade patterns at a rather aggregated level (ITC, 2000). Owing to factors such as data availability, estimation ease and empirical robustness, gravity models are predominantly estimated using aggregated trade data. Such models assume symmetric trade costs and ignore zero trade flows. A gravity model of trade developed at disaggregated (industry) level, however, would take into account selection and asymmetry biases related to the existence of zero-trade flows and countries' heterogeneity. It would also allow looking at trade adjustments along both extensive and intensive margins and predicting changes in the composition of trade at the level of sectors of the economy. But in order to obtain consistent results, one needs to address several problems which occur during estimation of the gravity

[33] Piermartini and Teh (2005) argue that the choice between using export or import data is a choice between estimation efficiency and consistency. Export data are evaluated at free-on-board prices and may suffer from measurement errors and result in inefficient estimators. On the other hand, imports are recorded using cost-insurance-freight prices, that is, including transport and insurance costs. This means that variables measuring transport costs, such as distance, are correlated with the error term, thus yielding inconsistent estimates of the distance coefficient.

equation using disaggregated[34] data (Shepotylo, 2009). As suggested by ITC (2000), it may be better to consider structure rather than absolute values of results. Moreover, simulated sectoral trade flows require adjustment, since residuals also refer to comparative advantages.

The way zero and missing trade observations are treated in an estimated gravity model is another important issue. Disregarding zero trade observations, as noted by authors such as Piermartini (2006), introduces a sample selection bias in the estimations. It can also lead to unrealistically high distance elasticity in gravity models (Grossman, 1998). Zero observations are undefined in the log specification of the gravity equation, leading to a truncated data set and warranting a Tobit estimation technique (Brulhart & Kelly, 1999). Coe, Subramanian and Tamirisa (2002) suggest specification of the gravity model in its original nonlinear form with an additive error term, which allows trade to go to zero as the size of either of the economies goes to zero and avoids a non-random screening of the data to remove the zero bilateral trade observations. However, it has been shown in most studies that estimates are not substantially affected by the choice of approach to deal with zero trade values (Baldwin, 1994). Also, as shown by Brulhart and Kelly (1999), omission of zero trade flows may not be a cause for major concern if the number of zero observations in the sample is small.

Another determinant of results of trade potential obtained from gravity model is the nature of data and estimation techniques. For example, using cross-section data and OLS methodology is inappropriate for the calculation of trade potentials, notably because countries' heterogeneity and time dimension are ignored (Damijan et al., 2006). It is also argued by Miankhel et al. (2009) that estimation of potential trade requires a procedure that represents the upper limits of the dataset and not the centred values of the dataset as estimated by OLS

[34] Miankhel et al. (2009) further argue that the only valid form of the gravity equation is the aggregate form. Gravity equations derived for individual commodity class, say K goods are invalid.

(Kalirajan, 1999).[35] Furthermore, when spatial effects[36] are present in the data, spatial econometrics could be superior to standard econometric techniques such as OLS (Anselin, 1999).

Fixed-effects estimation based on a panel of cross-sectional observations over time is usually used to deal with unobserved heterogeneity[37] (McPherson & Trumbull, 2008). The fixed-effects method relegates all time-invariant effects into a bilateral constant term that is composed of one part that is common to all cross-sectional units and one part that is specific to each cross-sectional unit. The disadvantage of this method is that it eliminates the individual effects of observed (such as distance and borders) as well as unobserved fixed effects. In that case, the estimated individual effects will include the effects of all variables that are fixed within the sample at the individual level (Schmidt & Sickles, 1984). Further, as noted by McPherson and Trumbull (2008), for out-of-sample forecasting, one would have to decompose the constant term into a component that is common across the cross-sectional units of observation (trading partners in the gravity model) and one that is specific to the unit of observation. But that would require ad hoc assumptions to be made.

Random-effects model is another panel-data method in which both time-varying and time-invariant variables are included (McPherson & Trumbull, 2008). Unobserved individual effects are included in the error term, but it is assumed that the error term is uncorrelated with the variables incorporated in the model. If correlation exists between included explanatory variables and unobserved (time-invariant) effects, random-effects model does not overcome

[35] See the next section of this chapter for a more detailed discussion of this point.
[36] In regression context, spatial effects refer to spatial interaction (spatial autocorrelation) and spatial structure (spatial heterogeneity). Spatial econometrics deals with methodological concerns that follow from the explicit consideration of spatial effects or "geography" of the data (Anselin, 1999).
[37] Unobserved heterogeneity is the information on differences across observations that are not reflected in the data (Alvarez & del Corral, 2006).

the unobserved heterogeneity problem. Econometrics-wise, a Hausman test is usually carried out to choose between random- and fixed-effects models. And random-effects estimates may be more efficient than the fixed-effects estimates, but they are inconsistent (Ferragina et al., 2005). Moreover, if the variables entering the gravity model contain a unit root, cointegration analysis would be more appropriate than random-effects (or fixed-effects) estimation (Faruqee, 2004).

An alternative to either the fixed-effects or the ordinary random-effects models is what is known as the Hausman-Taylor method (McPherson & Trumbull, 2008). This method is a random-effects, instrumental variable technique that uses only information contained in the model to eliminate the correlation between the error term and included variables. Consequently, time-invariant variables can be estimated without compromising the estimates for time-varying variables. This means that the most appealing characteristics of the fixed-effects technique (consistent estimates of time-varying variables) and the random-effects model (inclusion of time-invariant variables and feasibility of out-of-sample prediction) are retained.

Finally, there is an argument in the literature that a trade potential index derived from a dynamic panel data specification gives more accurate indications on the spread between actual and potential trade (De Benedictis & Vicarelli, 2004). This means that more confidence can be put in interpreting a difference between observed and in-sample predicted trade flows beyond pure indication of misspecification of the econometric model. Peridy (2004) adds the point that a dynamic model captures persistence habits in trade flows in addition to the other determinants of trade. Since it accounts for past inertia, the model tends to decrease the gap between actual and fitted flows, and trade potential is generally smaller (albeit to a limited extent). One drawback of the dynamic equation is that it tends to even out both levels and variations of trade potential for a particular country, as well as differences in trade potential between countries (Peridy, 2005). Furthermore, Baltagi (2001) notes that serious econometric problems are introduced with dynamics in a panel data model owing to inconsistency of the estimators. The next section discusses a relatively new approach to estimate a gravity model-based trade potential.

3.1.3 Trade Potential and Stochastic Frontier Gravity Model of Trade

The recent literature suggests stochastic frontier analysis of the gravity model to deal with some of the outstanding conceptual, theoretical and econometric issues in the conventional model and estimate bilateral trade potential. A stochastic frontier gravity model (SFGM) enables estimation free from specification bias (Kalirajan, 2008). In conventional gravity models, only some resistances to trade can be controlled for but the majority, such as behind-the-border constraints,[38] are difficult to quantify and so they are merged with the statistical random error term with normal properties by implying that they are randomly distributed across observations (Kalirajan & Bhattacharya, 2007). Resistances such as asymmetric and imperfect information and internal constraints are not controlled for at all. Often, the reliance is on a number of variables to proxy total trade resistances, such as physical distance (Armstrong, 2007). Modelling of a multilateral resistance term as a function only of distance and tariffs also ignores the presence and impact of variations in behind-the-border constraints (Kalirajan & Bhattacharya, 2007). As argued by Armstrong (2007), assumptions of frictionless trade or iceberg transport costs to capture all the frictions are also strong but a poor proxy for trade friction. These have implications for estimation.

[38] The effect of economic distance on the intensity of bilateral trade emanates from behind-the-border constraints (Miankhel et al., 2009). Such constraints are socio-political-institutional factors that are specific to home and partner countries (Kalirajan, 2007). The combined effect of these trade constraining factors may be interpreted as 'economic distance' factor (Kalirajan, 2008).

The econometric problems deserve further elaboration. The omission of unobservable trade resistance variables such as economic distance in standard gravity equation leads to incorrect estimates (Kalirajan, 2007). This inherent problem or bias causes heteroskedasticity with unknown source.[39] The log-linearization of the empirical model in the presence of heteroskedasticity leads to inconsistent estimates because the expected value of the logarithm of a random variable depends on higher-order moments of its distribution (Silva & Tenreyro, 2003). The log-normal distribution of the error term is affected and the expected value of the error term is no longer zero (Miankhel et al., 2009). Kalirajan (2007) argues that, in this situation, OLS estimation leads to biased results. As noted by Miankhel et al. (2009), using non-linear-least-squares estimation procedure also results in a loss of efficiency. With heteroskedasticity of unknown form, non-linear least squares might be highly inefficient due to the fact that it gives more weight within the sample to observations with larger variance (Helmers & Pasteels, 2005).

Furthermore, the arbitrary choice of resistance terms included in gravity model leads to different degrees of omitted variable bias that is often only controlled for by using fixed-effects estimation that assumes constant country-pair resistances (Armstrong, 2007). However, the main problem with the fixed-effects approach is that some of the more interesting factors (institutional, cultural and historical) that determine trade volumes are differenced out. The other problem is that this approach discards the overwhelming majority of the variation in the data, which is in the cross-section of country pairs (Harrigan, 2001). Khan (2007) notes that the use of fixed-effects model is also not feasible in the case of long panels, while Miankhel et al. (2009) criticise fixed-effects models' lack of foundation on economic theory. According to Khan (2007), the random-effects or generalised-least-squares

[39] This kind of heteroskedasticity with unknown structure appears to be mainly due to characteristics specific to observations that are not easily quantifiable–such as behind-the-border and implicit beyond-the-border constraints (Kalirajan & Bhattacharya, 2007).

estimation also results in biased estimates due to log-linearization of a gravity model. Tsionas (2002) further argues that the random-effects model is fundamentally the same as the fixed-effects model with heteroskedasticity.

Stochastic frontier analysis of the gravity model of trade, however, is a better way to deal not only with unobservable resistances to trade, but also to estimate them (Armstrong, 2007). The basic idea in production economics of trying to perform on the frontier can be applied to defining a trade frontier. The stochastic frontier gravity model (SFGM) aims to capture trade resistances beyond the explicit resistances that are usually measured in gravity models of trade (Armstrong, Drysdale & Kalirajan, 2008). It is particularly able to measure the combined effect of all factors influencing the economic-distance variable[40] (Kalirajan, 2007). According to Armstrong (2007), instead of finding the average effects of impediments (borders, tariffs and other quantifiable barriers) and whether a country is performing better or worse than the mean sample as in traditional gravity models, SFGM enables estimation of a measure of how much trade resistance exists in a bilateral trade relationship. Unobservable trade resistances are captured in an unobservable term in the conventional gravity model, but captured as a cause for reducing trade in SFGM.

Developed by Meeusen and van Den Broeck (1977) and Aigner, Lovell and Schmidt (1977), stochastic frontier analysis is conventionally used to measure production efficiency. The underlying economic logic is that the production process is subject to two economically distinguishable disturbances, with different characteristics. The statistical error term is

[40] The specific source of inherent imprecision in specifying a gravity model is not including economic distance explicitly and properly between countries. Unless the influence of economic distance is measured; its sources are identified and corrected by appropriate policies, there will always be variances between actual and potential trade (Kalirajan, 2008). Unfortunately, most of the empirical models do not consider this deficiency. Researchers usually do not have information on all factors influencing the economic-distance variable (Kalirajan, 2007).

composed of a nonnegative term which captures production inefficiencies and a more conventional symmetric error term which captures random disturbances. This means that any lower performance than the frontier can be traced back to random noise–beyond the producer's control–as well as inefficiency (Behr & Tente, 2008). Likewise, the random disturbance term in SFGM captures and distinguishes disturbances that are not reflected in the bilateral trading-country characteristics from disturbances which are specific to that bilateral relationship[41] (Armstrong, 2007). The nonnegative disturbance term measures the distance from the frontier and can be thought of as the trade inefficiency term that captures trade resistances that are not specified in the gravity model. Instead of differencing them out, or assuming (strongly) their average effect is zero, unobservable trade resistances are captured and measured in SFGM as the distance between actual trade and potential trade that lies on the frontier.

Trade potential is defined as the trade that could be achieved at an optimum trade frontier with open and frictionless trade possible given the current level of trade, transport and institutional technologies (Kalirajan, 2007). Armstrong (2007) argues that the only trade determinants that need to be included in the gravity model to estimate the frontier are the core, or natural determinants as theoretical derivations would suggest and determinants that can not be changed in the short to medium term. These are economic size, relative distance, border effects, languages and landlockedness.[42] Policy variables and other short-to-medium term trade determinants–man-made determinants–are left to explain deviation from the frontier. The nonnegative disturbance that reduces trade means no one can achieve trade on the frontier–there will always be asymmetric decision making, port inefficiencies, uncertainty, risk and scope for trade facilitation, in addition to lack of proper infrastructure or managerial

[41] Armstrong (2007) emphasises the point that the literature on conventional gravity models has still not been able to deal with this distinction satisfactorily.
[42] See Chapter Four for statistical expression of SFGM

expertise (Kang & Fratianni, 2006). It is argued by Armstrong (2007) that this approach enables proper estimation of determinants of trade in gravity model and a further measure of how much of the trade resistance is explained by quantifiable factors and how much is due to other reasons.

Concerning estimation techniques, most of the earlier studies have estimated bilateral trade potential through OLS. The OLS estimation procedure produces estimates that represent the centred values of the data set (Miankhel et al., 2009). But, for policy purposes, it is rational to define potential trade as the maximum possible trade that can occur between any two countries, which have liberalized trade restrictions the most, given the determinants of trade. According to Kalirajan (2007), this means that potential trade is determined by the upper limits of the dataset and not by the centred values of the data set. SFGM shifts the benchmark, or a reference point, from the mean predicted value to a frontier[43] (Armstrong et al., 2008). With composed error term in SFGM, OLS estimation also leads to biased results (Kalirajan & Singh, 2007). Corrected OLS, fixed-effects and random-effects methods are better alternatives. However, the corrected OLS would not always yield nonnegative values for all residuals, thus failing to satisfy the frontier hypothesis of efficiency (Kalirajan & Shand, 1999). Fixed-effects and random-effects methods are also limited in that regardless of how they are formulated, the effects carry both the inefficiency and, in addition, any time-invariant observation-specific heterogeneity–which must be disentangled (Greene, 2002).

It is, however, possible to apply maximum likelihood estimation (MLE) methods on either cross-section or panel data to estimate the SFGM (Kalirajan, 2007). MLE principle says that,

[43] The estimate of the frontier function lies above the traditional average function (Baten, Kamil, & Fatama, 2009).

out of all the possible values for parameters, the value that makes the likelihood of the observed data largest should be chosen (Wooldridge, 2000). Kalirajan (2007) summarises the advantages of the suggested method of estimation of the gravity model as follows. First, it does not suffer from a loss of estimation efficiency. Second, it estimates the influence of the economic distance term, which is creating heteroskedasticity and non-normality, isolating it from the statistical error term. Third, the suggested approach provides potential trade estimates that are closer to frictionless trade estimates. That is, potential trade can be determined by the upper limit of the dataset, or by those economies that have liberalised restrictions to trade the most. Finally, the suggested method bears strong theoretical and trade policy implications towards finding ways to improving the performance of the socio-political-institutional factors to achieve frictionless trade.

The widespread appeal of MLE is that it is generally the most asymptotically efficient estimator when the population model is correctly specified (Wooldridge, 2000). In a panel data framework, the estimator is consistent and asymptotically efficient as the number of cross-sectional units gets large, regardless of the time-series dimension of the panel (Schmidt & Sickles, 1984). The MLE method is chosen not least because it is warranted by assumption of a certain inefficiency distribution as well as a normal noise distribution (Behr & Tente, 2008). A distributional assumption on the inefficiency term implies that the composed error is negatively skewed, and statistical efficiency requires that the model be estimated by maximum likelihood (Kumbhakar & Lovell, 2000; Pitt & Lee, 1981). The inefficiency term can be assumed to be time-varying or time invariant. Time invariance of efficiency is a very strong assumption, and probably would be unrealistic in many potential applications, particularly for large time dimension in panel data setting (Kalirajan & Shand, 1999). In relation to SFGM, assumption of time-varying efficiency would mean that behind-the-border constraints to bilateral trade have been varying over time (Kalirajan & Singh, 2007).

In this study, therefore, we apply MLE method to SFGM, with what is known as the Battese-Coelli[44] time-varying efficiency estimator, in order to estimate China's trade potential with Africa. As argued by Armstrong (2007), although there has been a limited use of SFGM, its wider use in measuring trade potential is justified, especially because it allows account to be taken of all trade resistances.

3.2 EMPIRICAL STUDIES ON CHINA-AFRICA TRADE POTENTIAL

Although there are theories that give guidance as to how to examine trade potential between countries, there are few systematic, empirical studies of the trade potential between China and Africa. There is mainly speculation on the matter based on observed pattern of trade. Few studies make use of measurement indices to analyse the trade potential. Attempt to quantify the bilateral trade potential using gravity equations, though common in studies for other countries like those in Central and Eastern Europe (Baldwin, 1994; Brulhart & Kelly, 1999; Chionis & Liargovas, 2002; Egger, 2002; Nilsson, 2000), is particularly rare for China and Africa. Be that as it may, there seems to be a general consensus in the literature that there is unexploited trade potential between Africa and China.

For instance, Jenkins and Edwards (2005) take the view that the existence of several countries in Africa with very limited trade link with China is a sign for possibility of unexploited export opportunities. Wang (2007) concurs with the idea by observing China's goal of increasing trade with Africa. Subramaniam and Matthijs (2007) also look to the recent rapid growth of

[44] See Chapter Four and Appendix I for further details on the Battese-Coelli MLE method including time-varying specification of inefficiencies.

the bilateral trade, the relatively high openness to trade of China and the growing middle class with increasing purchasing power in China, and argue for high bilateral trade potential. In addition to openness to trade, Broadman (2007) points to the economic complementarities between Africa and Asia in general (that is, Africa's growing demand for Asia's manufactured goods and machinery and Asia's growing demand for Africa's natural resources), and argues for the sustainability of African-Asian(including China) trade boom supported by factor endowments.

Likewise, Zafar (2007) raises the issues of dramatic surge of the Africa-China trade and complementarity expected from comparative advantage, and predicts exponential growth of the two-way trade even with an economic slowdown in China. On the other hand, Shelton and Paruk (2008) mention economic compatibility, comparative advantage, low overall volume of bilateral trade, supporting initiatives as well as economic growth, increasing domestic demand and emergence of middle class in China, and finally argue that the momentum of two-way trade is certain to accelerate in the years ahead. However, the drawback of this study as well as studies discussed before it is that the predictions are based on observation of trends and pattern without applying systematic methods to measure and establish China's trade potential with Africa.

A study that has attempted to analyse the bilateral trade potential using measurement index (albeit with a wider focus) and produced results contrary to the dominant view in the literature is that of the World Bank (2004). The study assesses the Africa-Asia trade potential by identifying such high-potential products in the exchange as oil, gold and diamonds, seafood, and cotton and textile. It also calculates complementarity scores that represent goodness of fit of a particular Asian country's import profile to a particular African country's export profile relative to the world as a whole, applying revealed comparative advantage to African countries as exporters and its import analogy to Asian countries as importers. The study uses Standard International Trade Classification (SITC)-four product category and data up to 2001. The complementarity score is higher if there are particular products for which both countries are, respectively, a significant exporter and importer and have high shares in their respective trade profiles. The average complementarity score for 12 Asian countries under the study is found to be 2.0, indicating a significant potential for expanding trade relations between Africa and Asia.

However, World Bank's (2004) study finds that China does not show high complementarity (and trade potential) with Africa, registering a low average score of -0.3. Examining China's score with individual countries in Africa, it shows stronger complementarity with Mauritania (3.2), Zambia (1.4), Guinea (0.7) and Cape Verde (0.7). The weakest complementarity is with Angola (-1.4), Nigeria (-1.3) and Libya (-1.1). China's weak complementarity with Africa seems counterintuitive given the growing volume of African exports to China. One possible reason, as suggested in the study, for China's unexpectedly low score is the fact that the country has been obtaining raw materials mostly from domestic sources until recently. Also in interpreting the score figures, one is advised to note that countries with undiversified export profile that have a high reliance on countries with undiversified import profile tend to have significantly high average scores.

Referring to Shelton and Paruk (2008), the Chinese Academy of International Trade and Cooperation also completed a study in 2003 on the question of expansion of Chinese trade with Africa over the longer term. Unlike the World Bank's (2004) result, this study suggested a significant potential for new Chinese exports to Africa in the areas of light industry, machinery, construction, agriculture, tourism and telecommunications. In relation to this, the Chinese academy predicted that a number of African countries would enter a strong growth period within the next few years which would create a healthy demand for Chinese manufactured products. It is also hoped that China's announcement to grant zero-tariff status to some commodities from the least developed African countries would promote trade into the Chinese market.

Finally, when we consider gravity-model-based studies of China's trade potential with Africa, the empirical literature is found wanting. We could only infer results from the studies of ITC which make use of different versions of TradeSim gravity model discussed in the previous section. One study of ITC (2000) uses the 1995-1996 average data of aggregated trade (for all products excluding fuels and minerals) and cross-sectional estimates as a basis for simulation. The basic equation has been estimated in the sample of 53 exporting and 75 importing countries, which includes China, Cameroon, Egypt, Cote d'Ivoire, Kenya, Madagascar, Mauritius, Morocco, South Africa, Sudan, Tunisia and Zimbabwe. China's trade towards each of its 74 destination markets have been simulated. The results agree with those of the World Bank as none of the African countries show unexploited trade potential with China as their simulated trade values overwhelm the observed ones. However, the limitation of the ITC study is the lack of focus on the trade potential between Africa and China. Different versions of TradeSim select different African countries and use them (and China) in different ways, making it difficult to report consistent and focused findings regarding China-Africa potential trade.

To sum up, the upshot of this chapter is the following. First of all, it is important to measure trade potential when analysing trade flows between countries. Appropriate methods to do that include the use of trade indices and econometric gravity models while recognising the different theoretical and empirical limitations present in their applications. In that respect, the empirical literature on China's trade potential with Africa is indicated to be deficient. The next chapter attempts to fill this gap in the literature. In research areas where conclusive empirical evidences are nonexistent, employing different methodologies may result in a reliable conclusion (Alemayehu & Atnafu, 2007). So we will analyse China's trade potential with Africa using a combination of trade complementarity index (TCI) and stochastic frontier gravity model of trade (SFGM). As argued by Helmers and Pasteels (2005), this approach helps to capture trade complementarities between countries in gravity model where trade correspondence is not sufficiently taken into account.

CHAPTER FOUR

EMPIRICAL ANALYSIS AND RESULTS

4.1 TRADE COMPLEMENTARITY INDEX APPROACH

This section examines Africa's potential for trade with China by calculating an index of trade complementarity. After a brief discussion of the computational framework, the empirical results are presented and interpreted.

4.1.1 Computational Framework

One of the ways of ascertaining potentials of trade cooperation between a pair of countries is by comparing their exports and imports vectors at a point of time and bring out the matching between the two (Das et al., 2002). So we want to analyse the degree to which Africa and China complement each other in their trade profiles. The analysis will be carried out using the trade complementarity index (TCI) as presented by Mikic and Gilbert (2007). These authors provide a precise formula for the index and demonstrate its calculation and interpretation in a way that is applicable to developing countries (such as China and Africa). The index is also considered as simple, measureable, consistent and comparable. The TCI is formally expressed as

$$\mathrm{TCI} = 1 - \left[\left(\sum_i \left| \frac{\sum_w m_{iwd}}{\sum_w M_{wd}} - \frac{\sum_w x_{isw}}{\sum_w X_{sw}} \right|\right) \div 2\right]$$

where d is the importing country of interest, s is the exporting country of interest, w is the set of all countries in the world, i is the set of industries, x is the commodity export flow, X is the total export flow, m is the commodity import flow, and M is the total import flow. In words, we take the sum of the absolute value of the difference between the sectoral import shares of one country and the sectoral export shares of the other. Halving and subtracting from one then yields the required numerical results. TCI has a scale of zero to one, with values closer to zero indicating low complementarity and one indicating high complementarity. The TCI is higher if one country has more commodities whose share in its total exports is similar to their share in the total imports of the other country.

4.1.2 Empirical Application and Results

In this study, we examine the degree to which the export pattern of African countries matches the import pattern of China.[45] TCI is calculated based on the top five[46] export commodities of each African country and China's imports of those commodities, taking 2008 as a reference year. The commodities are classified at Harmonized System (HS) two-digit level[47] and retrieved from ITC's (n.d.) TradeMap online database. In computing the complementarity index for Africa and China, we first sum the absolute value of the difference between the sectoral import shares of China and the sectoral export shares of each African country, and divide by two. Subtracting the result from one then produces the required TCI value. A finding of high TCI between Africa and China would be interpreted as indicating a large room to expand trade between them.

Table 4.1 presents the results for selected African countries and China while Table G1 in Appendix G reports the results for 53 African countries and China. With a complementarity coefficient of more than 0.5 (or 50%) out of a maximum of 1 (or 100%), the export pattern of almost all African countries strongly matches the import pattern of China. This implies large

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[45] We assume that the export pattern of China matches the import pattern of African countries. It is well known that the imports of almost all African countries mainly constitute manufactures which can be reasonably matched by the exports of China. We, therefore, find the exercise to analyse the degree to which the export pattern of China matches the import pattern of Africa less interesting.

[46] Although this number is not preferred based on theory, it has been used in similar empirical studies–for example, Alemayehu (2009).

[47] Refer to Appendix D for details of the commodities as classified by HS two-digit code and Appendix E for details of the top five commodities exported by each African country.

Table 4.1: TCI Values between China and Selected African Countries and the Contribution of Selected Commodities, 2008

Destination / Origin	China	Strong Matches in Selected Goods by HS Code					
		27	26	72	71	52	Other
Zimbabwe	0.819		√			√	√
Tunisia	0.816	√					√
Tanzania	0.810		√				√
South Africa	0.792	√	√				√
Senegal	0.760			√			√
Djibouti	0.755	√			√		√
Eritrea	0.735						√
Kenya	0.733						√
Swaziland	0.730						√
Morocco	0.724						√
Cape Verde	0.544						√
Sao Tome and Principe	0.538						√
Ghana	0.538						√
Burkina Faso	0.527						√
Lesotho	0.514					√	√
Angola	0.513				√		√
Zambia	0.506		√				√
Comoros	0.494						√
Guinea-Bissau	0.465			√			√
Mali	0.428						√
Africa on Average	0.625						
Standard Deviation	0.091						

Note: A value in the second column refers to TCI between the export pattern of a country in Africa (origin) and the import pattern of China (destination). √ indicates relatively strong match between China and the concerned African country in the commodity group heading the column or in the commodity group under the 'Other' column. The match is with regard to the commodities covered in the TCI analysis only.
Source: Calculated from ITC (n.d.), retrieved February 28, 2010.

potential to increase African exports to China. African countries having relatively the highest complementarity with China are Zimbabwe (0.819), Tunisia (0.816) and Tanzania (0.810), followed by South Africa (0.792), Senegal (0.760), Djibouti (0.755), Eritrea (0.735), Kenya (0.733), Swaziland (0.730) and Morocco (0.724). These countries and others, twenty in total, have a TCI value more than the average (0.625). On the other hand, African countries showing relatively the weakest compatibility with China are Mali (0.428), Guinea-Bissau

(0.465) and Comoros (0.494). Given the practice in the literature (Alemayehu, 2009; Oramah & Abou-Lehaf, 1998) of taking index values equal to or greater than 0.4 as an evidence of reasonable match between import and export vectors, the export structure of all African countries can be said to fit the import structure of China very well. This result is also intuitive given the rapid rise of African exports to China over the past decade or so.

Out of the commodities used in calculating the complementarity index between China and African countries, some are more responsible than others in explaining the observed TCI values. Zimbabwe's high TCI with China, for instance, is due to HS 26 (ores, slag and ash), 24 (tobacco and manufactured tobacco substitutes), 52 (cotton) and 75 (nickel and articles thereof). Tunisia's high complementarity with China is because of HS 27 (mineral fuels, oils, distillation products, etc), 28 (inorganic chemicals, precious metal compound, isotopes), 31 (fertilizers) and 85 (electrical, electronic equipment). Tanzania's TCI is large due mainly to HS 26 and 24 (like Zimbabwe) but also owing to HS 09 (coffee, tea, mate and spices). Meanwhile, the relatively lower TCI value of Mali is related to low compatibility with China in HS 71 (pearls, precious stones, metals, coins, etc) while that of Guinea-Bissau lies in HS 08 (edible fruits, nuts, peel of citrus fruit, melons) and of Comoros is due to HS 09 (coffee, tea, mate and spices), 89 (ships, boats and other floating structures) and 33 (essential oils, perfumes, cosmetics, toiletries). Overall, the commodities that figure more frequently in strong matches between African countries' exports and China's imports are HS 27 (mineral fuels, oils, distillation products, etc), 26 (ores, slag and ash), 72 (iron and steel), 71 (pearls, precious stones, metals, coins, etc) and 52 (cotton). This is generally in line with World Bank's (2004) finding of strong matches and trade potential between Africa and Asia as a whole in oil, gold and diamond, seafood, and cotton and textile.

As suggested in the literature, TCI values can be explained by the extent of trade diversification. Appendices E and G reveal that African countries with relatively more diversified exports (in terms of the HS codes) are found with higher TCI scores. The countries ranked first to third in their TCI scores- that is, Zimbabwe, Tunisia and Tanzania- support this argument. South Africa, Swaziland, Morocco, Benin, Gambia, Namibia, Mauritius and Sierra Leone are other countries with a higher-than-average TCI score and a relatively diversified export pattern in Africa. There are, however, exceptions such as Niger and Cameroon that have scored TCI values more than the average with less diversified export structure. On the other hand, African countries with a single dominant export commodity face considerably lower match in the imports of China, impacting negatively on the TCIs of these countries.[48] Cases in point include Angola, Chad, Algeria, Equatorial Guinea, Libya, Nigeria and Congo Brazzaville (mineral fuels, oils, distillation products, etc), Mauritania (ores, slag and ash), Cape Verde (fish, crustaceans, molluscs, aquatic invertebrates not elsewhere specified), Malawi (tobacco and manufactured tobacco substitutes), Mozambique (aluminium and articles thereof), and Zambia (copper and articles thereof).[49]

Another interesting observation is that trade complementarity with China in Africa is diversified in terms of geography and economic size. For example, as can be seen from Table G1 of Appendix G, African countries scoring a higher TCI relative to the average include those from the north (Tunisia, Morocco and Egypt), south (Zimbabwe, South Africa, Swaziland and Mauritius), east (Tanzania, Djibouti, Eritrea, Kenya and Uganda) and west (Senegal, Benin, Cameroon, Cote d'Ivoire, Gambia, Namibia, Niger and Sierra Leone) of

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[48] Comparison between the shares of commodities in the total merchandise exports of African countries (Appendix E) and in the total merchandise imports of China (Appendix F) substantiates the point. While the TCIs of these countries are not low per se, they would have been even higher had it not been for the poor match with China in their dominant export commodities.

[49] There seems to be an irony here as Angola, Nigeria, Algeria, Congo Brazzaville, Libya and Equatorial Guinea are among the top ten African trade partners of China. But the reason is that the dominant export commodities of these countries, that is, mineral fuels, oils and distillation products, are high-value primary commodities, pushing the countries' ranking in terms of value to the top.

Africa. The economic size of these countries also ranges from some of the largest in the continent (such as South Africa) to some of the smallest in the continent (such as Eritrea).

To be sure, our approach has limitations (as indicated in Chapter Three) that warrant care in drawing inference from the analysis. First, trade complementarity is just one determinant of the intensity of trade between China and Africa. Factors such as geographic distance, economic size and trade policies are also important. Second, the analysis is static, relying on the trade structure in 2008. But the commodity composition of trade may change over time. Third, the TCI measure is subject to aggregation bias. In our case, the top five commodities at two-digit HS level of disaggregation were used. Finally, matching between exports and imports is in terms of percentage, and not in levels.

However, we can tentatively infer from the above TCI analysis that, given the existing commodity composition of trade, there is large potential to increase African trade with China. China exhibits high probability of being a trade partner to almost all African countries which have shown potential to supply exports that fit the demand of China. Our inference based on the TCI analysis lends support to expectations in the literature (Broadman, 2007; Shelton & Paruk, 2008; Zafar, 2007) of large trade potential between China and Africa based on trade complementarity inferred from observed trade pattern and comparative advantage. It is, however, not in line with World Bank's (2004) finding that China, on average, has low complementarity with Africa. This may be because the World Bank used a different complementarity index (one based on revealed comparative advantage), product classification (SITC 4 category) and reference period (up to 2001).

In the next section, we complement the index analysis with a regression analysis using a gravity model of trade. After accounting for other variables (other than complementarity) that could exert a significant influence on the bilateral trade, an attempt will be made to estimate the trade potential between China and Africa and find out how much of the potential is being realised.

4.2 GRAVITY TRADE MODEL APPROACH

This section makes use of the stochastic frontier gravity model of trade (SFGM) to estimate the magnitude of China's potential trade with Africa. In what follows, the statistical framework and estimation strategy are first outlined, and the empirical results are presented and discussed thereafter.

4.2.1 Statistical Framework

We draw heavily on the statistical framework of Armstrong (2007), who proposes specifications for two stages of SFGM estimation–one for the trade frontier and the other for measuring the trade resistances. The suggestion is that estimation of the frontier or potential trade be made using only natural, or fundamental, determinants of trade: economic size (GDPs), relative distance, border, language and landlockedness. Many other variables that are usually included in gravity models are left for explaining the gap between actual and potential trade, as opposed to estimating it.[50]

Armstrong (2007) demonstrates the idea in a gravity model framework by taking the trade resistance term between countries i and j, t_{ij}, which Baldwin and Taglioni (2006) define as

$$t_{ij} = f(dist_{ij}, \text{other stuff})$$

[50] Armstrong's suggestion is important given the literature's ambiguity and, sometimes, arbitrariness in selection of variables in the two stages of estimation. In the case of stochastic frontier production, the received models provide relatively little in the way of effective ways to incorporate important firm-specific effects (that is, to explain inefficiency) in the first-stage estimation (Greene, 2002).

where $dist_{ij}$ is the distance between i and j, and splitting this into man-made and natural resistances as

$$t_{ij} = f(resist_{ij}) = f(natural_{ij}, manmade_{ij}) = h(natural_{ij})g(manmade_{ij})$$

The natural resistances can be further decomposed to

$$h(natural_{ij}) = rDist_{ij}^{\alpha_1} \exp\left(border_{ij}^{\alpha_2} + landlocked_i^{\alpha_3} + landlocked_j^{\alpha_4} + lang_{ij}^{\alpha_5}\right)$$

where $rDist_{ij}$ is relative distance between i and j; $border_{ij}$ is a dummy variable that takes a value one if i and j share a border, and zero otherwise; $landlocked$ is a dummy variable with value one if a country is landlocked, and zero otherwise; and $lang_{ij}$ is an index of language similarity. Man-made resistances are mainly policy variables and can be further decomposed to

$$g(manmade_{ij}) = g(tradeagreement_{ij}, politicaldist_{ij}, regionalblocs, tariffs \ldots)$$

where $tradeagreement_{ij}$ is a dummy variable indicating a trade agreement between i and j; $politicaldist_{ij}$ is a measure of political closeness between i and j; and there is scope for inclusion of membership to regional blocs, tariff measures, institutional settings and other man-made resistances.

Therefore, as shown by Armstrong (2007), trade resistances would all be captured in

$$\ln t_{ij} = \ln h(natural) + \ln g(manmade)$$

which is equivalent to

$$\ln t_{ij} = \alpha_1 \ln rDist_{ij} + \alpha_2\, border_{ij} + \alpha_3 landlocked_i + \alpha_4 landlocked_j + \alpha_5 lang_{ij} + \ln g(manmade)$$

Now there is a two-step regression to be made. First, by restricting the function for man-made resistances to be nonnegative, a trade frontier or potential can be estimated using the natural resistances. Then, man-made resistances can be explained in a second-stage regression. A gravity model will look like

$$\ln x_{ijt} = \ln \beta_0 + \beta_1 \ln y_{it} + \beta_2 \ln y_{jt} + \beta_3 \ln h(natural) + \sum_m \beta_m \ln Z_m + v_{ijt} - u_{ij}$$

where $u_{ij} = \lambda(manmade_{ij}) \geq 0$; ln is a natural logarithm operator; x_{ijt} is trade from i to j at time t; y_{it} is country i's size (GDP) at time t; y_{jt} is country j's size (GDP) at time t; and Z's are other trade determinants with the potential of including multilateral resistance terms. Here v_{ijt} is a conventional mean-zero random disturbance term and u_{ij} is nonnegative and commonly has a truncated normal, exponential or folded normal distribution.[51]

An important assumption in SFGM is that all trade restrictions (just as all production inefficiencies) are captured in the inefficiency term, u_{ij} (Armstrong, 2007). Miankhel et al. (2009) argue that u_{ij} represents the economic-distance bias, which is specific to the exporting and importing countries, that is a function of behind-the-border measures. Behind-the-border measures include trade policy, infrastructural and institutional reforms (Armstrong et al.,

[51] One advantage of estimating the frontier function with the assumption of distribution functions is that it is possible to find out whether deviation of actual trade from its potential trade is because of inefficiency or external random factors (Kalirajan & Shand, 1999). Otherwise, relative efficiency measures across trade partners are shown not to be critically dependent on the particular distribution (Kang & Fratianni, 2006).

2008). The term u_{ij} takes values between 0 and 1. Values close to 0 indicate that country-specific behind-the-border measures (or, related bias) are not important and the actual and potential trade flows are the same, assuming there are no statistical errors. Values other than 0 (but less than or equal to 1) indicate that country-specific behind-the-border measures (or, related bias) are important and they constrain the actual trade from reaching potential trade. Thus, the term $-u_{ij}$ is bilateral observation-specific and represents the difference between potential and actual trade in logarithmic values that is a function of the inefficiencies that are within the exporting and importing countries' control (Kalirajan, 2008).

In this study, we estimate SFGM using MLE technique in a panel data framework. Among the many advantages of panel data over cross-section data, panel-data models allow consistent estimation of the efficiency of individual cross-sectional units (Kumbhakar & Lovell, 2000). Besides, they can identify more accurately that component of the disturbance which is inefficiency (Kalirajan & Shand, 1999) and permit us to investigate whether the inefficiency is time variant or time invariant (Pitt & Lee, 1981). Unlike Armstrong's (2007) time-invariant inefficiency (u_{ij}), drawing on Armstrong et al. (2008), we assume time-varying nonnegative disturbance term or trade inefficiency (u_{ijt}). In particular, we follow the Battese-Coelli parameterisation of time effects where the inefficiency term is modelled as a truncated normal random variable multiplied by a specific function of time.[52] As noted by Hallam and Machado (1996), in the Battese-Coelli maximum likelihood estimation, it is also assumed that u_{ijt} is distributed independently of v_{ijt} and regressors.[53]

[52] Appendix G contains the formal specification of time-varying inefficiency as well as other statistical details related to the Battese-Coelli MLE method.

[53] Note that with satisfactory panel data, where the number of cross-sectional units is large and the length of the panel tends towards infinity, the distributional and independence assumptions could be avoided (Henderson, 2003).

After we have estimated the SFGM, we turn to computing trade efficiency measures for each observation or bilateral trade flow. In the Battese-Coelli method, the conditional distribution of u_{ijt} is first determined and then either the mean (more commonly) or the mode of the efficiency distribution can be used to produce observation-specific efficiency estimates (Henderson, 2003).[54] Trade efficiency here means actual trade relative to potential trade or the realisation of potential trade (Armstrong et al., 2008). In our case, it is defined as the trade efficiency of China with its African trade partners. Efficiency measures from the frontier method fall in the range from 0 to 1: a value of one indicates 100% efficiency or 0% inefficiency (that is, full realisation of potential trade) and a value of zero suggests 0% efficiency or 100% inefficiency (that is, completely untapped trade potential) (Kang & Fratianni, 2006).

4.2.2 Empirical Implementation and Results

Following Armstrong (2007) and Armstrong et al. (2008), we run a first-stage regression of SFGM to estimate China's trade potential with Africa. One difference in our specification of the model is that we do not include common language and border dummies in China-African country pairs. The reason is that China does not share a border with any African country and that we could not find a language that is spoken by a significant proportion of the population in both China and a given African country.[55] Hence, the estimated SFGM in this study is

$$\ln EXP_{ijt} = \beta_0 + \beta_1 \ln GDP_{it} + \beta_2 \ln GDP_{jt} + \beta_3 \ln rDist_{ij} + \beta_4 Landl_{ij} + (v_{ijt} - u_{ijt})$$

where ln denotes natural logarithm; i refers to China; j refers to a country in Africa; and t is time in year running from 2001 to 2008. The other variables, including the dependent and the

[54] Refer to Appendix G for the derivation procedures.

[55] As far as adjacency or common border is concerned, it may not matter anyway if one is already controlling for distance (Head, 2003).

explanatory variables, are defined as follows.

EXP_{ijt} is the value of China's total merchandise exports to African country j in year t and in thousands of current US dollars.[56] The data are extracted from ITC's TradeMap online database.

GDP_{it} and GDP_{jt} are the gross domestic products of China and African country j, respectively, in year t. They are measured in current US dollars and taken from World Development Indicators of the World Bank (n.d.), except the GDP figures of Zimbabwe for 2006-2008 which are obtained from World Economic Outlook database of IMF (n.d.).

$rDist_{ij}$ is relative distance between China and African country j. It is defined, following Kalirajan (2007), as the physical distance in kilometres between capital cities (economic centres) of China and African country j relative to the average physical distance in kilometres between capital cities of China and all African countries. The distance is measured as the great-circle distance, which is calculated based on the longitude and latitude of the economic centre or capital city of each country under the study (Head, 2003). The data are obtained from CEPII (n.d.).

$Landl_{ij}$ is a variable that measures landlockedness in the bilateral trade between China and African country j. The data are collected from the World Factbook of CIA (n.d.). Drawing on Soderling (2005), the variable is defined as the number of landlocked countries in the country

[56] The standard gravity equation considers every possible bilateral trade flow between all possible pairings (Sohn, 2001). In order to analyse China's trade potential with African countries, however, we limit the dependent variable to the bilateral trade flow between China and African countries. A similar approach has been previously used, for example, by Kalirajan (2007) and Paas (2000). Besides, while it was possible to use African countries' merchandise exports to China as a dependent variable, too many missing observations would make estimation of our SFGM more complicated and less reliable; thus, we dropped that option.

pair. So, the number can be 0, 1, or 2. It is 0 if both countries i and j are not landlocked; it is 1 if either i or j–not both–is landlocked; and it is 2 if both i and j are landlocked. In our case, since China is not landlocked, we have a dummy variable having a value of either 0 or 1, depending on the status of the African country j pairing China.

The term v_{ijt} is the effect of random factors and statistical errors, and is assumed to follow a normal distribution, $N(0, \sigma_v^2)$, with mean 0 and variance σ_v^2, in year t; u_{ijt} is the combined effect of behind-the-border constraints that prevent China from reaching its potential with an African trade partner, and is assumed to follow a nonnegative truncated normal distribution, $N^+(\mu, \sigma_u^2)$ with mean $\mu \geq 0$ and variance σ_u^2, in year t. It is also assumed that v_{ijt} and u_{ijt} are distributed independently of each other and of the explanatory variables.

Finally, β_0, β_1, β_2, β_3, and β_4 are parameters to be estimated by MLE method. Since we have a log-linear model, the slope parameters are interpreted as elasticities.[57] In line with the theoretical literature discussed in Chapter Three (section 3.1.2) as regards the nature of the impact of different variables on bilateral trade, the expected signs of the slope parameters are: $\beta_1, \beta_2, > 0$; and $\beta_3, \beta_4 < 0$.

Table 4.2 shows MLE results of the model using STATA version 10 computer package. Our estimation consists of China and its 52 African trade partners,[58] and the time span covers the period from 2001 to 2008. There is, therefore, a cross section of 52 bilateral trade flows or country-pairs (1×52), with annual data covering eight years (2001-2008) for each trade flow, generating a balanced panel of 416 observations (52×8). Descriptive statistics and correlation

[57] By elasticity, we mean the responsiveness of bilateral trade to a change in an explanatory variable.
[58] See Appendix F for the full list of countries included in the estimation of the SFGM. Due to missing GDP data for the whole sample period, Somalia is excluded from the analysis.

matrix for the variables in our SFGM are presented under Appendix H. The overall significance of the estimated model is good as indicated by Wald chi2 in Table 4.2. Specification tests (see Appendix K) also indicate the appropriateness of the model for our data. The estimated coefficients of all variables confirm the theoretical predictions in terms of signs. Apart from relative distance, the estimated coefficients are also statistically significant at least at the 5% level. The coefficients are also of plausible magnitudes.

Table 4.2: Frontier Maximum Estimation Results for Chinese Exports to African Countries (2001-2008), Dependent Variable: $\ln EXP_{ijt}$

Independent Variables	Coefficient	Standard Error	t-Statistic	Probability
Constant	-27.3581	3.99762	-6.84	0.000***
ln GDP_{it}	0.8674364	0.1477605	5.87	0.000***
ln GDP_{jt}	0.7530035	0.0612129	12.30	0.000***
ln $rDist_{ij}$	-0.7147411	0.9255815	-0.77	0.440
$Landl_{ij}$	-0.7647223	0.3001177	-2.55	0.011**
sigma2	1.170818			
sigma_u2	1.020118			
sigma_v2	0.1506996			
gamma	0.8712869***			
mu	2.332783***			
eta	0.0367426***			
Log likelihood =	-305.76798			
Wald chi2(4) =	336.56			
Prob > chi2 =	0.0000			
No. of observations =	412			

Notes: STATA version 10 computer package is used for estimation. Asterisks *** and ** denote levels of statistical significance at 1% and 5%, respectively. Time period is 2001-2008. Estimation is done assuming normal error term v and truncated normal efficiency term u, where u has the Battese-Coelli time-varying parameterisation (see Appendix G). Formal expressions and statistical meanings of sigma2, gamma, sigma_u2, sigma_v2, mu, eta, log likelihood and Wald chi2 are also found in Appendix G. Likelihood ratio test results for gamma, mu and eta are given in Appendix K.

Source: Own estimation.

Other things being equal, the larger China and African countries are in terms of economic size, the more they trade. A 1 percent (%) increase in the GDP of African countries raises their demand for imports, and thereby China's exports to Africa by 0.87%, whereas for a 1% increase in the GDP of China, the bilateral trade improves by 0.75%. On the other hand, controlling for other factors, landlockedness has a significant negative impact on China's exports to Africa with an elasticity coefficient of 0.76. Indeed, about 30% of African countries are landlocked, making foreign trade costly for these countries. The cost arises from determining how best to utilize logistical, transport and communications systems (Broadman, 2007). Relative distance has an expected negative impact, but it is not statistically meaningful. Overall reductions in transportation costs worldwide (Armstrong et al., 2008) may provide one potential explanation for the insignificant result of relative distance.

Another important set of results is found in the second part of Table 4.2. Sigma2 is a measure of the mean (over the time period) total variation in the model (Kalirajan, 2007). That is, it measures the total variance of China's exports to Africa. This variation can be due to omitted variables and random disturbances (captured by sigma_v2) or due to the influence of behind-the-border, socio-political-institutional factors specific to China and African countries (captured by sigma_u2). Gamma is a ratio of sigma_u2 to sigma2 (an average over the time period); that is, gamma is the proportion of the total variation in the model that is due to the combined effect of behind-the-border constraints (Kalirajan & Bhattacharya, 2007). The results indicate a large and statistically significant estimate of gamma (about 0.87). This implies that the variation in the gap between China's potential and actual exports to Africa is in large part (87%) due to socio-political-institutional factors specific to China and African countries, and in small part (13%) due to other omitted variables and random disturbances.

In the next step, we use our estimated SFGM to calculate China's trade efficiency and potential with each of the 52 African countries included in the study. Table 4.3 reports the results for China and selected African countries while Table L1 in Appendix L presents the results for China and 52 countries in Africa. The efficiency estimates are calculated as the averages for each of the 52 bilateral trade flows, over its number of years in the dataset which is eight. Country pairs are also ranked in terms of their efficiency scores and trade potential. The results show that given the natural determinants of trade in the estimated SFGM, China's exports to Africa are yet to realise a lot of their potential. On average, China's realisation of its exports potential with African partners is only 0.128 or 13%. Such small trade efficiency implies very distant trade frontier given the current trade, transport and institutional technologies (Kang & Fratianni, 2006). It can be inferred with the result in Table 4.2 that China, in spite of the recent escalation of trade with Africa, could still increase its exports to the continent by about 87 percentage points on average, mainly by eliminating behind-the-border constraints in China and Africa. This is not surprising given the relatively low significance of the current two-way trade in China's trade profile and the habit of African countries to import mainly from the West.

There is, however, variation in the result as regards individual African countries. China's export efficiency is the highest with Benin (0.788), followed by Liberia (0.719), Togo (0.642) and Gambia (0.602)–well above the African average. These countries represent the lowest potential for China to increase its trade in Africa. China's trade has also performed higher than the average with Djibouti (0.256), Ghana (0.251), Lesotho (0.217), Nigeria (0.185), Ethiopia (0.182), South Africa (0.175), Sudan (0.151), Mauritania (0.140) and Guinea (0.132). On the other hand, China's export performance with several African countries (39 in number) is lower than the average. The lowest trade efficiency involves Seychelles (0.009),

Table 4.3: Mean Realisation of China's Potential Exports to Selected African Countries, 2001-2008

African Countries to which China Exports	Bilateral Trade Efficiency Score	Bilateral Trade Efficiency Rank	Bilateral Trade Potential Rank
Seychelles	0.009	52	1
Sao Tome and Principe	0.010	51	2
Comoros	0.012	50	3
Central African Republic	0.013	49	4
Chad	0.013	48	5
Equatorial Guinea	0.014	47	6
Gabon	0.015	46	7
Cape Verde	0.016	45	8
Eritrea	0.024	44	9
Rwanda	0.027	43	10
South Africa	0.175	10	43
Ethiopia	0.182	9	44
Nigeria	0.185	8	45
Lesotho	0.217	7	46
Ghana	0.251	6	47
Djibouti	0.256	5	48
Gambia	0.602	4	49
Togo	0.642	3	50
Liberia	0.719	2	51
Benin	0.788	1	52
Africa on Average	0.128		
Standard Deviation	0.174		

Source: Own calculation from results in Table 4.2.

Sao Tome and Principe (0.010), Comoros (0.012), Central African Republic (0.013), Chad (0.013), Equatorial Guinea (0.014), Gabon (0.015) and Cape Verde (0.016). In other words, these countries provide the most potential for trade in Africa for China. High variation (as measured by standard deviation of 0.174 in Table 4.3) in trade efficiency suggests that for relative low-efficiency countries, there is ample room to raise the bilateral trade flows by converging to relative high-efficiency countries (Kang & Fratianni, 2006).

Some other interesting observations can be made from the above results. One of them is that China's trade performance with the dominant economies in Africa–South Africa and Nigeria–

is ranked in the top ten while China has lowest trade efficiencies with relatively smaller economies such as Seychelles, Sao Tome and Principe and Comoros. This is also predicted by the result in Table 4.2 that the GDP of African countries has a positive effect on their imports from China. On the other hand, it is striking that China's trade with its most important African trade partners–Angola, South Africa, Sudan, Nigeria and Egypt–remains well below the potential level, achieving less than 20% for Chinese exports to these countries. One can also observe that, out of thirteen African countries found in higher-than-average trade efficiency score, eight of them, including the top four, are from West Africa and only two of them are landlocked.

Variations in bilateral trade efficiency measures could be explained by different factors. In general, lower bilateral trade efficiencies imply larger bilateral trade frictions while higher bilateral trade efficiencies indicate smaller bilateral trade frictions (Kang & Fratianni, 2006). Our analysis suggests a considerable impact of socio-political-institutional resistances on China's trade with Africa. For example, frictions due to political distance can help to explain China's lower-than-average trade performance with Sao Tome and Principe, Chad, Burkina Faso, Swaziland and Malawi due to the latter's diplomatic ties with Taiwan. China's only precondition on African states is to adhere to a one-China policy which precludes diplomatic relation with Taiwan (Shelton & Paruk, 2008). Other factors such as trade policies including tariffs and non-tariff barriers and trade facilitating measures could also explain the variation in trade efficiency. However, while we recognise the importance of such factors underlying the observed variation in trade efficiency or potential, we do not intend to pursue them here. That requires further investigation in its own right, but it is beyond the scope of the present study.

Finally, we emphasize the point that the interpretation of our results is subject to some caveats. In particular, we should emphasise that the measures are model specific. But as long as the SFGM is considered to be the best model, the efficiency measures that it generates can also be regarded as the best ones (Kang & Fratianni, 2006). It is also important to notice that judgments indicating trade potential are independent of the absolute value of trade (Helmers & Pasteels, 2005). Hence, for example, 'high untapped trade potential' does not imply that this potential is high in absolute terms but that it is high compared to the current trade. Be these caveats as they may, we can still make a valid inference that given the core determinants of trade (that is economic size, relative distance and landlockedness), the magnitude of China's trade potential with Africa is very high with a room to grow further by about 87 percentage points on average for exports if, among other things, behind-the-border constraints are eliminated. This finding is running counter with that of ITC (2000) where no African country has shown unexploited trade potential with China. The likely explanation is that ITC used a different model (TradeSim), sample (11 African countries), data (aggregated but average) and estimation approach (cross section). Our results, however, support those who predict large potential for expansion of China-Africa trade.

In conclusion to this chapter, our empirical analyses of the trade potential between China and African countries reveal two results. The first result is that with a complementarity coefficient of more than 50 percent (out of a maximum of 100 percent), the export pattern of almost all African countries strongly matches the import pattern of China. This suggests considerable potential for African countries' trade with China given the existing composition of trade. The second result is that given economic size, relative distance and landlockedness, China has potential to increase its exports to African countries by as much as 87 percent on average if behind-the-border constraints are eliminated. This indicates a large magnitude of China's unexploited trade potential with Africa.

CHAPTER FIVE

CONCLUSION AND POLICY IMPLICATIONS

5.1 CONCLUSION

The purpose of this study has been to analyse China's trade potential with Africa in light of the recent acceleration of the bilateral trade. The research questions were: How much is the scope to further expand China's trade with Africa? Or, what is the China-Africa trade potential? Have China and Africa already achieved their full trade potential? If not, what are the implications? In providing answers to these questions, the existing empirical literature showed gaps, particularly in making quantitative analysis. This study hoped to fill this gap by making analyses using a combination of trade complementarity index (TCI) and stochastic frontier gravity model of trade (SFGM).

First, TCI measures were obtained by examining the degree to which the export pattern of 53 African countries matches the import pattern of China. We used disaggregated commodities at the Harmonized System (HS) two-digit level by taking 2008 as a reference year. Upon the analysis, strong complementarity is found with an average TCI value of about 63 percent (%) and 50 African countries having a TCI of more than 50%. African countries recording the relatively highest TCI values with China are Zimbabwe, Tunisia and Tanzania, whereas the lowest TCI values involve Mali, Guinea-Bissau and Comoros. The commodities that figured more frequently in strong matches between African countries' exports and China's imports are mineral fuels, oils and distillation products (HS 27), ores, slag and ash (HS 26), iron and steel (HS 72), pearls, precious stones, metals and coins (HS 71) and cotton (HS 52).

Second, the magnitude of China's trade potential with Africa was estimated using SFGM, where China's merchandise exports to Africa were explained by economic size of the trade partners, bilateral relative distance and landlockedness. Maximum likelihood estimation (MLE) technique was applied to panel data covering China and 52 African countries (excluding Somalia) from 2001 to 2008. It was found that economic size and landlockedness are significant determinants of China's trade with Africa. In addition, China has realised, on average, only 13% of its export potential with Africa. The results indicated that behind-the-border measures specific to China and African countries are significant determinants of the gap between potential and actual trade. In relative terms, China's trade integration deficit was the lowest with Benin, Liberia, Togo and Gambia–considered as outliers, and was the highest with Seychelles, Sao Tome and Principe, Comoros, Central African Republic, Chad, Equatorial Guinea, Gabon and Cape Verde.

Given the above empirical results, the conclusion is that China and African countries have considerable scope to further expand their bilateral trade by increasingly exploiting their trade complementarity, by eliminating/minimising behind-the-border constraints to trade and by enhancing trade facilitation. This conclusion supports the majority of predictions in the literature (Broadman, 2007; Jenkins & Edwards, 2005; Shelton & Paruk, 2008; Subramaniam & Matthijs, 2007; Wang, 2007; Zafar, 2007), whereas it runs counter with a peripheral study of ITC (2000).

5.2 POLICY IMPLICATIONS

The general implication of the above conclusion is that measures to promote further trade integration between China and Africa are justified. Specifically, the following implications seem relevant to the findings of this study.

First, China and Africa can make efforts to intensify the two-way trade based on the complementarities in their trade structure. Exports of China are assumed to match the import needs of almost all African countries, which are primarily manufactures. This study has found that the export structure of virtually all African countries can also reasonably match the import structure of China, mainly in natural resources and raw materials. This implies high potential to benefit in the immediate future from greater China-Africa trade. Any endeavour to take advantage of such complementarities, however, should take into account the longer term benefits of African economies from economic development through industrialisation.

Second, behind-the-border constraints should be dealt with to increase China's trade with Africa. Reforms in trade policy alone are not adequate but efforts should also be directed against country-specific constraints such as those mentioned by Broadman (2007): domestic business environment, competiveness of market structures, quality of market institutions, and supply constraints like poor infrastructure, and underdeveloped human capital and skills. Bilateral cooperation may be required in order to determine the relative importance of each of these factors and take appropriate remedial action.

Third, it is also useful to improve trade facilitation. Broadman (2007) elaborates trade facilitation factors to mean physical movement of consignment, customs regulations, information and communications technology, financial and insurance requirements, and international trade standards. In this regard, China's establishment of industrial zones across Africa in the future might help trade facilitation by reducing trade costs due, for instance, to landlockedness.

Fourth, continued economic growth of China and Africa is likely to strengthen the level of the bilateral trade integration. That is, as much as trade is expected to contribute to economic growth, positive impact in the reverse direction is also predicted to be the case for China-Africa relation. Therefore, policies which promote higher economic growth in China as well as Africa are also likely to promote trade integration between China and Africa.

Fifth, it appears that China has unexploited potential for trade with relatively small as well as large economies of Africa in all corners of the continent. This implies the need for China to focus on trade with not only its current most important African partners (Angola, South Africa, Sudan, Nigeria and Egypt) but also others including Sao Tome and Principe, Chad, Burkina Faso, Swaziland and Malawi–countries currently maintaining diplomatic ties with Taiwan and thus failing to meet China's one-China policy.

Last but not least, the findings of unexploited trade potential between China and African countries in this study imply the need to anticipate relevant distribution changes due to the effect of trade expansion in the near future. In other words, social cost has to be expected from future trade integration between China and Africa.

To conclude this thesis, China's recent and significant economic engagement in Africa is drawing world attention. The surge of China-Africa trade, in particular, is dramatic. This trade link is expected to have important implications for China as well as African countries and requires more research. This thesis has made an empirical investigation of the two-way trade potential. The results suggest that there is a considerable potential for China and Africa to increase their bilateral trade further. Full realisation of this potential requires dealing with important resistances to trade such as country-specific socio-political-institutional constraints and improving trade facilitation. However, further in-depth analyses such as case studies are required in order to take bilateral-specific measures to promote trade integration between China and African countries.

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APPENDICES

APPENDIX A: CHINA'S TRADE WITH INDIVIDUAL AFRICAN COUNTRIES

This appendix has the geographic distribution of China's trade in Africa (Table A1), the share of merchandise trade with China in the African country totals (Table A2), the balance of trade between China and its trade partners in Africa (Table A3), and the top three export products to China (Table A4) and the top three import products from China (Table A5) for China's top ten trade partners in Africa.

Table A1: Geographic Distribution of China's Trade in Africa, 2008

Country	Exports to China (million US$)	Imports from China (million US$)	Total Trade with China (million US$)	Share in Africa's Total Trade with China (%)	Rank
Angola	22382.0	2942.5	25324.5	23.63	1
South Africa	9235.0	8618.0	17853.0	16.66	2
Sudan	6325.9	1874.3	8200.2	7.65	3
Nigeria	508.0	6767.0	7275.0	6.79	4
Egypt	428.9	5874.0	6302.9	5.88	5
Algeria	849.2	3752.0	4601.2	4.29	6
Congo (Brazzaville)	3731.7	614.3	4346.0	4.05	7
Libya	2589.0	1640.0	4229.0	3.95	8
Morocco	461.0	2349.0	2810.0	2.62	9
Equatorial Guinea	2267.9	277.4	2545.3	2.37	10
Benin	110.2	2314.1	2424.3	2.26	11
Gabon	1792.6	139.6	1932.2	1.80	12
Ghana	93.4	1747.9	1841.3	1.72	13
Congo DRC	1583.7	234.6	1818.3	1.70	14
Ethiopia	81.6	1230.7	1312.3	1.22	15
Kenya	34.7	1249.3	1284.0	1.20	16
Togo	30.9	1218.2	1249.1	1.17	17
Mauritania	1044.1	189.1	1233.2	1.15	18
Liberia	5.9	1137.0	1142.9	1.07	19
Tanzania	131.6	950.4	1082.0	1.01	20
Cameroon	479.2	379.3	858.5	0.80	21
Tunisia	90.3	696.9	787.2	0.73	22
Zambia	522.5	264.3	786.8	0.73	23
Madagascar	65.2	602.6	667.8	0.62	24
Cote d'Ivoire	70.6	531.5	602.1	0.56	25

Namibia	282.0	243.2	525.2	0.49	26
Mozambique	125.9	296.0	421.9	0.39	27
Senegal	5.0	401.5	406.5	0.38	28
Guinea	25.3	334.4	359.7	0.34	29
Botswana	183.9	169.0	352.9	0.33	30
Mauritius	5.7	320.1	325.8	0.30	31
Zimbabwe	148.2	133.1	281.3	0.26	32
Djibouti	1.8	252.3	254.1	0.24	33
Uganda	17.1	230.1	247.2	0.23	34
Mali	62.9	167.7	230.6	0.22	35
Gambia	3.2	175.7	178.9	0.17	36
Niger	0.1	166.8	166.9	0.16	37
Burundi	121.0	17.7	138.7	0.13	38
Chad	41.6	79.9	121.5	0.11	39
Burkina Faso	62.5	46.2	108.7	0.10	40
Malawi	8.1	81.0	89.1	0.08	41
Rwanda	29.6	59.4	89.0	0.08	42
Sierra Leone	5.3	78.8	84.1	0.08	43
Lesotho	1.7	79.6	81.3	0.08	44
Somalia	0.2	40.3	40.5	0.04	45
Central African Republic	21.4	11.3	32.7	0.03	46
Swaziland	11.3	21.0	32.3	0.03	47
Eritrea	2.5	29.0	31.5	0.03	48
Comoros	0.0	25.4	25.4	0.02	49
Seychelles	3.7	14.1	17.8	0.02	50
Cape Verde	0.0	14.9	14.9	0.01	51
Guinea-Bissau	1.2	6.1	7.3	0.01	52
Sao Tome and Principe	0.0	1.9	1.9	0.00	53

Source: ITC (n.d.), retrieved February 22, 2010.

Table A2: Share of Merchandise Trade with China in African Country Totals (%), 2008

Country	Exports	Imports	Total Trade
Algeria	1.2	9.5	4.1
Angola	33.5	14.4	29.0
Benin	17.4	36.8	35.0
Botswana	7.8	18.8	10.8
Burkina Faso	14.2	3.5	6.1
Burundi	85.4	5.6	30.4
Cameroon	8.9	9.9	9.3
Cape Verde	0.0	1.7	1.6
Central African Republic	12.8	3.8	7.1
Chad	1.1	11.2	2.6
Comoros	0.0	12.9	11.0
Congo (Brazzaville)	29.4	18.0	27.0
Congo DRC	42.5	6.2	24.3
Cote d'Ivoire	0.7	6.7	3.4
Djibouti	1.4	12.4	11.7
Egypt	1.6	11.1	8.0
Equatorial Guinea	14.2	17.0	14.5
Eritrea	10.2	11.3	11.2
Ethiopia	5.1	14.2	12.8
Gabon	22.5	5.6	18.5
Gambia	23.0	53.3	52.1
Ghana	2.3	19.3	14.1
Guinea	1.7	17.5	10.6
Guinea-Bissau	0.9	2.5	2.0
Kenya	0.7	11.2	8.0
Lesotho	0.3	25.9	8.3
Liberia	0.5	9.7	8.9
Libya	4.1	9.1	5.3
Madagascar	3.9	15.7	12.1
Malawi	0.9	3.7	2.9
Mali	3.3	5.0	4.4
Mauritania	42.5	9.9	28.2
Mauritius	0.2	6.9	4.6
Morocco	2.3	5.6	4.5
Mozambique	4.7	7.4	6.3
Namibia	6.0	5.2	5.6
Niger	0.0	13.4	9.5
Nigeria	0.6	24.0	6.6
Rwanda	7.4	5.2	5.8
Sao Tome and Principe	0.2	1.7	1.5
Senegal	0.2	6.2	4.7
Seychelles	1.5	1.5	1.5
Sierra Leone	1.5	10.6	7.7
Somalia	0.1	4.4	3.7

South Africa	12.5	9.8	11.1
Sudan	66.6	11.4	31.6
Swaziland	1.3	7.6	2.8
Tanzania	6.5	15.5	13.2
Togo	1.8	34.7	23.8
Tunisia	0.5	2.8	1.8
Uganda	1.0	5.1	4.0
Zambia	10.2	5.2	7.7
Zimbabwe	8.7	4.7	6.2

Source: Computed from ITC (n.d.), retrieved February 22, 2010.

Table A3: Balance of Trade between China and its Trade Partners in Africa (million US$), 1998-2008

Country	1998			2008		
	Exports to China	Imports from China	Trade Balance	Exports to China	Imports from China	Trade Balance
Algeria	0.00	212.00	-212.00	849.20	3752.00	-2902.80
Angola	139.73	40.20	99.53	22382.00	2942.50	19439.50
Benin	2.86	37.96	-35.10	110.20	2314.10	-2203.90
Botswana	0.00	11.00	-11.00	183.90	169.00	14.90
Burkina Faso	3.87	5.65	-1.78	62.50	46.20	16.30
Burundi	0.10	6.40	-6.30	121.00	17.70	103.30
Cameroon	31.53	30.58	0.95	479.20	379.30	99.90
Cape Verde	0.00	1.97	-1.97	0.00	14.90	-14.90
Central African Republic	0.01	1.16	-1.15	21.40	11.30	10.10
Chad	0.00	0.17	-0.17	41.60	79.90	-38.30
Comoros	0.00	0.00	0.00	0.00	25.40	-25.40
Congo (Brazzaville)	38.00	62.95	-24.95	3731.70	614.30	3117.40
Congo DRC	1.60	55.53	-53.93	1583.70	234.60	1349.10
Cote d'Ivoire	19.94	64.80	-44.86	70.60	531.50	-460.90
Djibouti	0.00	34.00	-34.00	1.80	252.30	-250.50
Egypt	9.00	419.00	-410.00	428.90	5874.00	-5445.10
Equatorial Guinea	62.64	3.23	59.41	2267.90	277.40	1990.50
Eritrea	0.00	3.00	-3.00	2.50	29.00	-26.50
Ethiopia	0.78	67.52	-66.74	81.60	1230.70	-1149.10
Gabon	135.76	11.17	124.59	1792.60	139.60	1653.00
Gambia	0.65	55.75	-55.10	3.20	175.70	-172.50
Ghana	7.75	122.54	-114.79	93.40	1747.90	-1654.50
Guinea	0.00	45.89	-45.89	25.30	334.40	-309.10
Guinea-Bissau	0.00	1.59	-1.59	1.20	6.10	-4.90
Kenya	1.30	68.30	-67.00	34.70	1249.30	-1214.60
Lesotho	0.00	9.00	-9.00	1.70	79.60	-77.90
Liberia	0.00	30.55	-30.55	5.90	1137.00	-1131.10
Libya	0.00	78.00	-78.00	2589.00	1640.00	949.00
Madagascar	4.43	24.17	-19.74	65.20	602.60	-537.40
Malawi	0.00	2.76	-2.76	8.10	81.00	-72.90
Mali	4.42	26.81	-22.39	62.90	167.70	-104.80
Mauritania	1.10	10.50	-9.40	1044.10	189.10	855.00
Mauritius	0.88	114.04	-113.16	5.70	320.10	-314.40
Morocco	54.00	217.00	-163.00	461.00	2349.00	-1888.00
Mozambique	0.00	12.70	-12.70	125.90	296.00	-170.10
Namibia	8.00	9.00	-1.00	282.00	243.20	38.80
Niger	0.00	14.71	-14.71	0.07	166.80	-166.73
Nigeria	25.00	393.00	-368.00	508.00	6767.00	-6259.00
Rwanda	1.74	2.33	-0.59	29.60	59.40	-29.80
Sao Tome and Principe	0.00	0.06	-0.06	0.02	1.90	-1.88

Senegal	3.25	28.67	-25.42	5.00	401.50	-396.50
Seychelles	0.00	3.14	-3.14	3.70	14.10	-10.40
Sierra Leone	0.00	4.89	-4.89	5.30	78.80	-73.50
Somalia	0.04	0.20	-0.16	0.20	40.30	-40.10
South Africa	168.00	777.00	-609.00	9235.00	8618.00	617.00
Sudan	1.34	384.56	-383.22	6325.90	1874.30	4451.60
Swaziland	0.00	2.00	-2.00	11.30	21.00	-9.70
Tanzania	1.92	48.33	-46.41	131.60	950.40	-818.80
Togo	2.50	6.20	-3.70	30.90	1218.20	-1187.30
Tunisia	64.45	78.83	-14.38	90.30	696.90	-606.60
Uganda	0.12	11.87	-11.75	17.10	230.10	-213.00
Zambia	0.93	6.70	-5.77	522.50	264.30	258.20
Zimbabwe	16.66	46.13	-29.47	148.20	133.10	15.10

Note: Trade balance is obtained as exports to China minus imports from China.
Source: IMF (2005) and ITC (n.d.), retrieved February 22, 2010.

Table A4: China's Top Ten Trade Partners in Africa and their Top Three Export Products to China, 2008

Countries	Products and the Share (%) of their Value in the Total Value of Merchandise Exports to China		
South Africa	Ores, slag and ash: 43.6%	Pearls, precious stones, metals, coins, etc: 18.5%	Iron and steel: 9.8%
Sudan	Mineral fuels, oils, distillation products, etc: 99.5%		
Egypt	Mineral fuels, oils, distillation products, etc: 41.5%	Salt, sulphur, earth, stone, plaster, lime and cement: 30.8%	Plastics and articles thereof: 10.6%
Nigeria	Mineral fuels, oils, distillation products, etc: 84.8%	Ores, slag and ash: 5.9%	Raw hides and skins (other than fur skins) and leather: 3.3%
Algeria	Mineral fuels, oils, distillation products, etc: 99.6%		
Angola	Mineral fuels, oils, distillation products, etc: 99.9%		
Congo (Brazzaville)	Mineral fuels, oils, distillation products, etc: 82.8%	Ores, slag and ash: 7.7%	Wood and articles of wood, wood charcoal: 4.3%
Morocco	Electrical, electronic equipment: 61.1%	Fertilizers: 17.9%	Ores, slag and ash: 10.4%
Libya	Mineral fuels, oils, distillation products, etc: 98.6%	Ores, slag and ash: 1.4%	
Benin	Cotton: 74.7%	Wood and articles of wood, wood charcoal: 11.4%	Aluminium and articles thereof: 9.6%

Notes: Only shares of 1% or above are indicated in the table. The product cluster "mineral fuels, oils, distillation products, etc" can be disaggregated further into phenols, petroleum distillates, aviation spirit, heavy furnace oil and petroleum oils and products.
Source: Calculated from ITC (n.d.), retrieved January 13, 2010.

Table A5: China's Top Ten Trade Partners in Africa and their Top Three Import Products from China, 2008

Countries	Products and the Share (%) of Their Value in the Total Value of Merchandise Imports from China		
South Africa	Electrical, electronic equipment: 19.6%	Nuclear reactors, boilers, machinery, etc: 14.7%	Articles of apparel, accessories, knit or crochet: 5.6%
Sudan	Nuclear reactors, boilers, machinery, etc: 21.1%	Electrical, electronic equipment: 17.5%	Articles of iron or steel: 11.8%
Egypt	Nuclear reactors, boilers, machinery, etc: 16.9%	Electrical, electronic equipment: 14.7 %	Vehicles other than railway, tramway: 9.4%
Nigeria	Electrical, electronic equipment: 27.1%	Nuclear reactors, boilers, machinery, etc: 13.7%	Vehicles other than railway, tramway: 12.9%
Algeria	Vehicles other than railway, tramway: 19.2%	Nuclear reactors, boilers, machinery, etc: 17.5%	Articles of iron or steel: 17.1%
Angola	Vehicles other than railway, tramway: 19.5%	Nuclear reactors, boilers, machinery, etc: 16.4%	Electrical, electronic equipment: 14.1%
Congo (Brazzaville)	Nuclear reactors, boilers, machinery, etc: 15.5%	Electrical, electronic equipment: 14.6%	Vehicles other than railway, tramway: 10.7%
Morocco	Electrical, electronic equipment: 17.3%	Nuclear reactors, boilers, machinery, etc: 16.8%	Articles of apparel, accessories, knit or crochet: 6.7%
Libya	Nuclear reactors, boilers, machinery, etc: 30.1%	Electrical, electronic equipment: 13.0%	Articles of iron or steel: 7.4%
Benin	Cotton: 42.9%	Electrical, electronic equipment: 11.1%	Special woven or tufted fabric, lace, tapestry etc: 8.6%

Note: The product category "nuclear reactors, boilers, machinery, etc" is meant to constitute air or gas compressors, hoods, parts of vacuum pumps, compressors, fans, blowers and hoods, air conditioning machines, refrigerators, nondomestic and nonelectric dryers, and machinery and plant/laboratory equipment.
Source: Computed from ITC (n.d.), retrieved January 13, 2010.

APPENDIX B: INTERNATIONAL TRADE INDICES

This appendix contains formal expressions of trade indices discussed in Chapter Three with more details of relevance.

B.1: Index of Trade Intensity (ITI)

ITI tells us whether or not a region exports more (as a percentage) to a given destination than the world does on average (Mikic & Gilbert, 2007). ITI can be formally computed as:

$$ITI = \frac{\sum_{sd} X_{sd} / \sum_{sw} X_{sw}}{\sum_{wd} X_{wd} / \sum_{wy} X_{wy}}$$

where s is the set of countries in the source, d is the destination, w and y represent the countries in the world, and X is the bilateral flow of total exports. In words, the numerator is the export share of the source region to the destination and the denominator is export share of the world to the destination. ITI takes a value between 0 and $+\infty$. Values greater than 1 indicate an intense trade relationship.

Kalirajan & Bhattacharya (2007), on the other hand, express trade intensity by differentiating between import intensity and export intensity. Accordingly, the import intensity index (MII) is mathematically expressed as

$$MII_{IJt} = [M_{IJ} / M_I] / [X_J / (X_W - X_I)]$$

where MII_{IJ} is import intensity index of country I with country J, M_{IJ} is import of country I from country J, M_I is total import of country I, X_J is total export of country J, X_W is total world export, X_I is total export of country I, and t is time.

If the value of MII_{IJt} is 0 or nearer to 0, it implies import link between country I and country J is negligible and if the value is more (or less) than 100, country I is importing more (or less) from country J than might be expected from that country's share in total world trade.

Similarly, export intensity index (XII) is measured as

$$XII_{IJt} = [X_{IJ} / X_I] / [M_J / (M_W - M_I)]$$

where XII_{IJ} is export intensity index of country I with country J, X_{IJ} is export of country I to country J, X_I is total export of country I, M_J is total import of country J, M_W is total world imports, M_I is total imports of country I, and t is time.

Again, if the value of XII_{IJt} is 0 or nearer to 0, it implies that export link between countries I and J is negligible. On the other hand, if the value is nearer to 100, it indicates that performance is significant; if it exceeds 100, it indicates that country I is exporting more to country J than might be expected from that country's share in world trade.

B.2: Alternative Measures of Trade Complementarity: COS and EIS

As discussed by van Beers and Linnemann (1988), there are two alternative measures for the degree of commodity correspondence between the exports of a country and the imports of another country. One of these measures is labeled COS and the other one is called EIS. If the subscripts i, j and k refer to exporting country, importing country and commodity class, respectively, the two measures are defined as

$$COS_{ij} = \frac{\sum_k E_{ik} M_{jk}}{\sqrt{\sum_k E_{ik}^2 \sum_k M_{jk}^2}}$$

and

$$EIS_{ij} = \sum_{k} \min\left(\frac{E_{ik}}{\sum_k E_{ik}}, \frac{M_{jk}}{\sum_k M_{jk}}\right)$$

The measure COS is the cosine of the angle between the vector of country i exports (E_{ik}) and the vector of country j imports (M_{jk}) in an n-dimensional commodity space. The measure EIS is the sum over all commodity classes of the share of commodity class k in country i exports or in country j imports - whichever of these two shares is the lower, so that only the overlap counts.

Both measures vary between 0 (no similarity at all) and 1 (perfect similarity), and produce close numerical values (except when there is a high commodity concentration in trade, in which case COS gives higher numerical values than EIS due to non-linear properties of the former). Increasing the number of commodity classes, on the other hand, will tend to lower the numerical value of the measures.

B.3: Export Similarity Index (ESI)

ESI is designed to measure the degree of similarity between the export profiles of two economies (Mikic & Gilbert, 2007). Mathematically, it can be defined as

$$ESI = \sum_{i} \min\left(\frac{\sum_w x_{isw}}{\sum_w X_{sw}}, \frac{\sum_w x_{idw}}{\sum_w X_{dw}}\right) \times 100$$

where d and s are the countries of interest, w is the set of all countries in the world, i is the set of industries, x is the commodity export flow, and X is the total export flow. In words, we take the smaller of the sectoral export share (as a percentage) in each product category, and add them together.

ESI takes a value between 0 and 100 per cent. A value of 0 indicates no overlap in the export profiles (the countries are not competitors), whereas a value of 100 indicates perfect overlap (the countries are competitors).

B.4: Production Similarity Index (PSI)

Suppose agricultural production is the concern of analysis. Then, as shown by Koester (1986), a production similarity index (PSI), which measures the similarity of the production patterns of two countries, a and b, is defined by the formula:

$$PSI = S^{Q}(ab,c) = \left\{\sum_{i} \text{Minimum}\left[X_i(ac), X_i(bc)\right]\right\} 100$$

where X_i (ac) is the share of commodity i in a's agricultural production and X_i (bc) is the share of commodity i in b's agricultural production.

The index varies between 0 and 1. It will be 0 if the production patterns of the two countries are completely dissimilar while it will be 1 if the production patterns are completely similar.

B.5: Intra-Industry Trade Index (IITI) or Grubel-Lloyd Index

Intra-industry trade (as opposed to inter-industry trade) denotes two-way trade, both imports and exports, of relatively similar products with high substitutability between two countries, and accounts for a large share of global trade (Nam, 2004). As explained by Oramah and Abou-Lehaf (1998), for countries that follow import substitution policy, differences in production structures may in fact reflect differences in consumer preferences since import replacement is by definition intended to lead to local production of those goods the country used to import. In this kind of situation, production similarity may be an evidence for trade potential to exist. This is more so in cases where, despite import replacement policies, domestic production levels still lag behind domestic demand.

Intra-industry trade can be analysed by what is known as the Grubel-Lloyd index or IITI (Das et al., 2002). This index is formally given as

$$IITI = 1 - [\,|X_{iA} - M_{iB}|\,] / [X_{iA} + M_{iB}]$$

where X is exports, i is a product, A is exporting country, B is importing country and M is imports. The index ranges from 0 to 1. According to Mikic and Gilbert (2007), 0 indicates pure inter-industry trade while 1 indicates pure intra-industry trade. Das et al. (2002), on the other hand, take a value of 0 as an indication of no potential for intra-industry trade and a value of 1 as a significant potential. Product categories that display high or medium levels of IIIT (between 0.25 and 1) are thought to imply rich potential for such trade flows.

Das et al. (2002) point out that the higher is the level of aggregation while defining industry the higher would be IITI, and vice versa. The suggestion is that 4-digit level of standard international trade classification (SITC) is close to optimum level on which thc industry bias of the index is minimum.

B.6: Revealed Comparative Advantage Index (RCAI)

In theoretical models, comparative advantage is expressed in terms of relative prices evaluated in the absence of trade. Since these are not observed, in practice we measure comparative advantage indirectly through RCAI (also known as the Balassa index) that only makes use of trade pattern (Mikic & Gilbert, 2007). The basic logic behind RCA is to evaluate comparative advantage on the basis of a country's specialization in exports relative to some reference group of countries (Serin & Civan, 2008). On the assumption that the commodity pattern of trade reflects the inter-country differences in relative costs as well as in non-price factors, this is assumed to "reveal" the comparative advantage of the trading countries (Batra & Khan, 2005).

Mikic and Gilbert (2007) give the mathematical definition of RCAI as

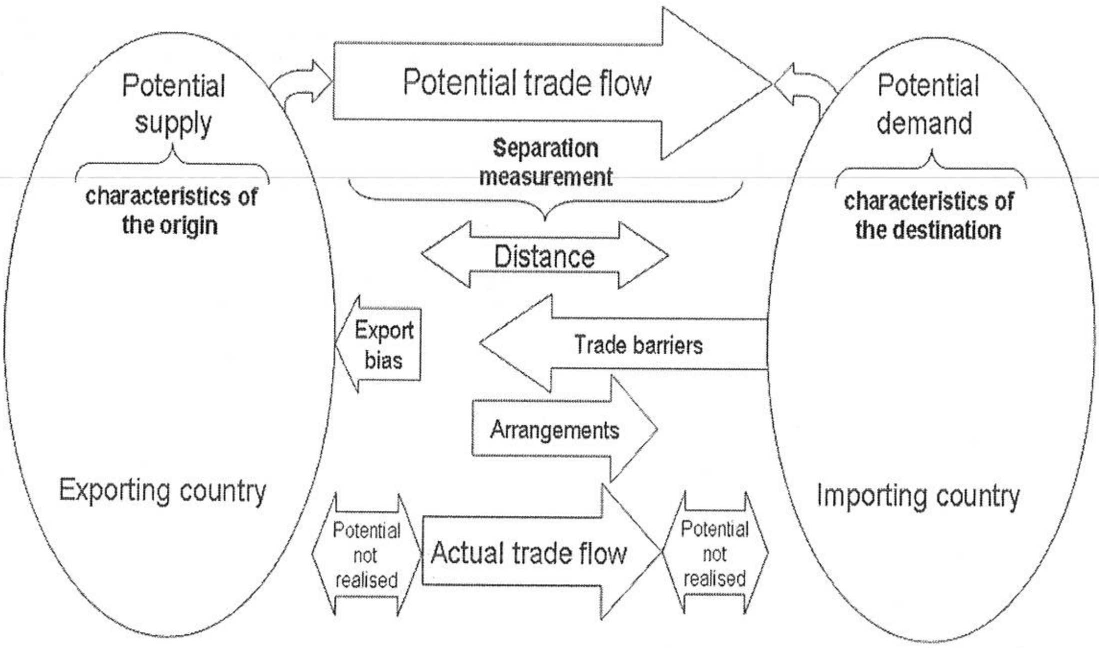
$$\mathrm{RCAI} = \frac{\sum_d x_{isd} / \sum_d X_{sd}}{\sum_{wd} x_{iwd} / \sum_{wd} X_{wd}}$$

where s is the country of interest, d and w are the set of all countries in the world, i is the sector of interest, x is the commodity export flow and X is the total export flow. The numerator is the share of good i in the exports of country s, while the denominator is the share of good i in the exports of the world. RCAI takes a value between 0 and $+\infty$. RCAI value exceeding 1 indicates the presence of revealed comparative advantage in sector (or good) i.

APPENDIX C: DIAGRAMMATIC VIEW OF GRAVITY MODEL OF TRADE

This appendix presents the design of the standard gravity model of trade in a simple diagram in order to demonstrate the general essence of the model (see Figure C1).

Figure C1: Graphical Representation of Gravity Model of Trade



Source: Department of Trade and Industry (n.d.), South Africa.

Figure C1 shows that potential supply and demand, determined by the sizes of the economies, predict the potential trade flow between countries of the trade partners. This flow is subject to certain trade resistance factors that are improved by trade arrangements. Finally, the actual trade flow results (Department of Trade and Industry, n.d.).

APPENDIX D: CLASSIFICATION OF COMMODITIES BY TWO-DIGIT HS CODE

This appendix contains two-digit Harmonized System (HS) codes and the commodities they refer to (see Table D1). Only the commodities used to analyze the complementarity of Sino-African trade are considered.

Table D1: Product Labels of Two-Digit HS Codes

HS Code	Product Label
01-05	Live animals; animal products
01	Live animals
02	Meet and edible meat offal
03	Fish, crustaceans, molluscs, aquatic invertebrates nes
06-14	Vegetable products
06	Live trees, plants, bulbs, roots, cut flowers etc
07	Edible vegetables and certain roots and tubers
08	Edible fruit, nuts, peel of citrus fruit, melons
09	Coffee, tea, mate and spices
12	Oil seed, oleagic fruits, grain, seed, fruit, etc, nes
13	Lac, gums, resins, vegetable saps and extracts nes
16-24	Prepared foodstuffs; beverages, spirits and vinegar; tobacco and manufactured tobacco substitutes
16	Meat, fish and seafood food preparations nes
17	Sugars and sugar confectionery
18	Cocoa and cocoa preparations
21	Miscellaneous edible preparations
22	Beverages, spirits and vinegar
23	Residues, wastes of food industry, animal fodder
24	Tobacco and manufactured tobacco substitutes
25-27	Mineral products
25	Salt, sulphur, earth, stone, plaster, lime and cement
26	Ores, slag and ash
27	Mineral fuels, oils, distillation products, etc
28-38	Products of the chemicals or allied industries
28	Inorganic chemicals, precious metal compound, isotopes
29	Organic chemicals
31	Fertilizers
33	Essential oils, perfumes, cosmetics, toiletries
38	Miscellaneous chemical products
39-40	Plastics and articles thereof; rubber and articles thereof
39	Plastics and articles thereof
40	Rubber and articles thereof
41-43	Raw hides and skins, leather, furskins and articles thereof; saddle and harness; travel goods, handbags and similar containers; articles of animal gut (other than

	silk-worn gut)
41	Raw hides and skins (other than furskins) and leather
44-46	Wood and articles of wood; wood charcoal; cork and articles of cork; manufactures of straw, of esparto or of other plaiting materials; basket ware and wickerwork
44	Wood and articles of wood, wood charcoal
47-49	Pulp or wood or of other fibrous cellulosic material; recovered (waste or scrap) paper or paperboard; paper and paperboard and articles thereof
49	Printed books, newspapers, pictures etc
50-63	Textile and textile articles
52	Cotton
61	Articles of apparel, accessories, knit or crochet
62	Articles of apparel, accessories, not knit or crochet
63	Other made textile articles, sets, worn clothing etc
64-67	Footwear, headgear, umbrellas, sun umbrellas, walking-sticks, seat-sticks, whips, riding-crops and parts thereof; prepared feathers and articles made therewith; artificial flowers; articles of human hair
64	Footwear, gaiters and the like, parts thereof
71	Pearls, precious stones, metals, coins, etc
72-83	Base metals and articles of base metal
72	Iron and steel
73	Articles of iron or steel
74	Copper and articles thereof
75	Nickel and articles thereof
76	Aluminium and articles thereof
79	Zinc and articles thereof
81	Other base metals, cermets, articles thereof
84-85	Machinery and mechanical appliances; electrical equipment; parts thereof; sound recorders and reproducers, television image and sound recorders and reproducers, and parts and accessories of such article
84	Nuclear reactors, boilers, machinery, etc
85	Electrical, electronic equipment
86-89	Vehicles, aircraft, vessels, and associated transport equipment
87	Vehicles other than railway, tramway
88	Aircraft, spacecraft, and parts thereof
89	Ships, boats and other floating structures
90-92	Optical, photographic, cinematographic, measuring, checking, precision, medical or surgical instruments and apparatus; clocks and watches; musical instruments; part and accessories thereof
90	Optical, photo, technical, medical, etc apparatus
93	Arms and ammunition, parts and accessories thereof

99	Commodities not elsewhere specified

Notes: The acronym 'nes' stands for 'not elsewhere specified'. HS code 84 (nuclear reactors, boilers, machinery, etc) is disaggregated further into are air or gas compressors, hoods; parts of vacuum pumps, compressors, fans, blowers, hoods; air conditioning machines window or wall types, self-contained; air conditioning machines nes, including a refrigerating unit; refrigerators, household type, absorption type, electrical; refrigerators, household type, nes; non-domestic, non-electric dryers nes; machinery, plant/laboratory equipment for treat of mat by change of temperature nes.

Source: ITC (n.d.) and Infodrive India (n.d.).

APPENDIX E: LEADING EXPORT COMMODITIES OF AFRICAN COUNTRIES

This appendix outlines the top five export products of African countries and details their relative importance in the total merchandise exports of those countries (see Table E1).

Table E1: Top Five Export Products of African Countries by Two-Digit HS Code and Order of Importance in Total Merchandise Exports, 2008

Country	Products by HS Code and the Share (%) of Their Value in the Total Value of Merchandise Exports
Algeria	27 (96.9%) , 72 (0.7%) , 28 (0.6%) , 25 (0.4%) , 29 (0.2%)
Angola	27 (98.2%) , 71 (1.3%) , 88 (0.1%) , 25(0.05%) , 84 (0.04%)
Benin	52 (27.2%) , 27 (21.3%) , 08 (13.6%) , 72 (9.8%) , 74 (7.5%)
Botswana	71 (46.7%) , 75 (30.2%) , 26 (6.2%) , 25 (2.2%) , 02 (2.1%)
Burkina Faso	52 (54.6%) , 71 (15.8%) , 12 (15.1%) , 08 (2.5%) , 84 (2.2%)
Burundi	71 (43%) , 09 (32.6%) , 87 (5.7%) , 26 (3.7%) , 41 (2.3%)
Cameroon	27 (57.7%) , 44 (15.2%) , 18 (7.8%) , 08 (7.1%) , 76 (3%)
Cape Verde	03 (51.4%) , 64 (9.1%) , 62 (7.5%) , 61 (5.6%) , 85 (5.4%)
Central African Republic	44 (50.6%) , 71 (20.7%) , 52 (9.4%) , 27 (6.2%) , 09 (2.2%)
Chad	27 (97.1%) , 52 (0.9%) , 13 (0.8%) , 99 (0.3%) , 76 (0.2%)
Comoros	09 (29.3%) , 89 (27.6%) , 33 (26.3%) , 71 (15%) , 39 (0.4%)
Congo (Brazzaville)	27 (87.1%) , 26 (5.2%) , 44 (3%) , 74 (1.9%) , 71 (1.2%)
Congo DRC	26 (41.7%) , 81 (15%) , 74 (14.1%) , 71 (13.4%) , 7 (5.8%)
Cote d'Ivoire	27 (37.1%) , 18 (28.7%) , 40 (5.1%) , 44 (3.9%) , 08 (3.4%)
Djibouti	01 (27.4%) , 27 (19.9%) , 41 (6.7%) , 71 (6%) , 99 (5.3%)
Egypt	27 (44.2%) , 72 (4.7%) , 39 (3.4%) , 38 (3%) , 85 (3%)
Equatorial Guinea	27 (96.8%) , 29 (2.1%) , 44 (0.7%) , 71 (0.1%) , 99 (0.1%)
Eritrea	87 (26.8%) , 41 (10.7%) , 12 (7.7%) , 62 (7.2%) , 93 (5.5%)
Ethiopia	09 (35.8%) , 12 (16.1%) , 07 (14%) , 06 (7.7%) , 41 (5.7%)
Gabon	27 (67.9%) , 26 (17.6%) , 44 (12.6%) , 40 (0.7%) , 99 (0.2%)
Gambia	03 (24.6%) , 08 (17%) , 72 (14.8%) , 12 (7.8%) , 24 (3.1%)
Ghana	71 (45.5%) , 18 (27.3%) , 44 (7.5%) , 08 (3.2%) , 84 (1.9%)
Guinea	26 (40%) , 71 (32.6%) , 28 (11.7%) , 49 (7.9%) , 44 (1.9%)
Guinea-Bissau	08 (93.7%) , 72 (1.5%) , 44 (1.2%) , 03 (0.9%) , 84 (0.5%)
Kenya	09 (21.9%) , 06 (11.6%) , 07 (5.5%) , 28 (4.4%) , 27 (4%)
Lesotho	71 (41.4%) , 61 (34.3%) , 62 (21.1%) , 52 (1.7%) , 99 (0.5%)
Liberia	89 (40.1%) , 27 (28.5%) , 40 (23.9%) , 71 (1.9%) , 72 (1.8%)
Libya	27 (96.6%) , 29 (1.1%) , 72 (0.7%) , 71 (0.4%) , 31 (0.3%)
Madagascar	62 (37.1%) , 61 (15.9%) , 03 (7.5%) , 09 (6%) , 27 (5.4%)
Malawi	24 (67.1%) , 17 (6%) , 09 (4.8%) , 52 (2.7%) , 12 (2.4%)
Mali	71 (74.9%) , 52 (10.7%) , 01 (6%) , 84 (1.5%) , 27 (1.5%)
Mauritania	26 (60.6%) , 03 (18.4%) , 27 (17.7%) , 72 (1%) , 23 (0.9%)
Mauritius	61 (23.3%) , 99 (13.1%) , 17 (12.3%) , 62 (11.5%) , 16 (9.1%)
Morocco	28 (14.8%) , 85 (12.5%) , 62 (12.3%) , 25 (11.8%) , 31 (7%)
Mozambique	76 (54.7%) , 27 (10.8%) , 99 (7.5%) , 24 (7.3%) , 03 (2.8%)

Namibia	70 (20.3%) , 26 (17.5%) , 49 (17.1%) , 03 (10.8%) , 79 (6%)
Niger	26 (57.5%) , 01 (9.2%) , 63 (6.1%) , 52 (4.5%) , 71 (4.4%)
Nigeria	27 (92%) , 89 (2.3%) , 41 (0.8%) , 18 (0.7%) , 39 (0.7%)
Rwanda	09 (45.4%) , 26 (33.9%) , 22 (7.9%) , 07 (3.2%) , 87 (1.2%)
Sao Tome and Principe	18 (48.4%) , 27 (46.5%) , 87 (1.5%) , 84 (1%) , 73 (0.5%)
Senegal	27 (34%) , 28 (10.2%) , 03 (9.8%) , 25 (7.6%) , 72 (5.3%)
Seychelles	16 (37.2%) , 27 (36.3%) , 03 (18.7%) , 90 (1.6%) , 88 (1.4%)
Sierra Leone	71 (27.1%) , 26 (20%) , 27 (14.3%) , 18 (9.9%) , 85 (3.4%)
Somalia	01 (33.5%) , 71 (19.3%) , 41 (9.6%) , 44 (7.6%) , 02 (7.2%)
South Africa	71 (17%) , 72 (12.2%) , 87 (10%) , 26 (9.8%) , 27 (9.6%)
Sudan	27 (94%) , 12 (2.1%) , 01 (0.7%) , 13 (0.7%) , 52 (0.6%)
Swaziland	17 (20.9%) , 33 (11.2%) , 21 (9.4%) , 61 (8.3%) , 84 (7.9%)
Tanzania	71 (11.9%) , 03 (10.7%) , 09 (8.2%) , 24 (7.2%) , 26 (6.7%)
Togo	52 (44.3%) , 25 (17.9%) , 18 (14.5%) , 27 (4%) , 72 (3.7%)
Tunisia	27 (17.3%) , 85 (15.8%) , 62 (14.4%) , 31 (7.9%) , 28 (5.7%)
Uganda	09 (26.4%) , 03 (6.9%) , 85 (5.2%) , 25 (4.6%) , 24 (4%)
Zambia	74 (64.3%) , 26 (15.1%) , 81 (5.8%) , 24 (1.4%) , 85 (1.3%)
Zimbabwe	06 (11%) , 75 (9.8%) , 52 (8.6%) , 26 (8.1%) , 24 (7.5%)

Note: The first two-digit number in the table refers to the HS code of a commodity as defined in Appendix D while the percentage share of the commodity in the total value of merchandise exports of the country of interest is given in parenthesis.
Source: Calculated from ITC (n.d.).

APPENDIX F: CHINA'S IMPORTS OF SELECTED COMMODITIES

This appendix elaborates the significance of the top five export products of African countries (as given in Appendix E) in the total merchandise imports of China (see Table F1).

Table F1: Relative Importance of Selected Products in the Total Merchandise Imports of China by HS Two-Digit Classification, 2008

Country	Products by HS Code and the Share (%) of Their Value in the Total Value of Merchandise Imports
China	85 (23.5%) , 27 (14.9%) , 84 (12.2%) , 26 (7.6%) , 90 (6.9%) 3 9 (4.3%) , 29 (3.5%) , 87 (2.4%) , 74 (2.3%) , 72 (2.2%) 12 (2%) , 40 (1%) , 73 (0.9%) , 88 (0.9%) , 38 (0.8%) 28 (0.8%) , 44 (0.7%) , 71 (0.7%) , 52 (0.6%) , 76 (0.6%) 25 (0.5%) , 41 (0.5%) , 75 (0.4%) , 99 (0.4%) , 03 (0.3%) 31 (0.3%) , 02 (0.2%) , 23 (0.2%) , 81 (0.1%) , 89 (0.1%) 08 (0.1%) , 62 (0.1%) , 22 (0.1%) , 33 (0.1%) , 64 (0.09%) 79 (0.08%) , 61 (0.07%) , 49 (0.07%) , 2 4 (0.07%) , 07 (0.05%) 21 (0.04%) , 17 (0.04%) , 18 (0.03%) , 63 (0.02%) , 13 (0.01%) 01 (0.009%) , 09 (0.009%) , 06 (0.008%) , 16 (0.007%) , 93 (0.0003%)

Note: The first two-digit number in the table refers to the HS code of a commodity as defined in Appendix D while the percentage share of the commodity in the total value of merchandise imports of China is given in parenthesis.
Source: Computed from ITC (n.d.).

APPENDIX G: VALUES OF TCI BETWEEN AFRICAN COUNTRIES AND CHINA

In this appendix, the results of the TCI analysis conducted to measure the degree of correspondence between the export pattern of 53 African countries and the import pattern of China is presented (refer to Table G1).

Table G1: TCI Values between China and 53 African Countries Ranked in Order of Magnitude and the Contribution of Selected Commodities, 2008

Destination / Origin	China	Strong Matches in Selected Goods by HS Code					
		27	26	72	71	52	Other
Zimbabwe	0.819		√			√	√
Tunisia	0.816	√					√
Tanzania	0.810		√				√
South Africa	0.792	√	√				√
Senegal	0.760			√			√
Djibouti	0.755	√			√		√
Eritrea	0.735						√
Kenya	0.733						√
Swaziland	0.730						√
Morocco	0.724						√
Egypt	0.723			√			√
Benin	0.704	√		√			√
Uganda	0.704						√
Cote d'Ivoire	0.693						√
Gambia	0.687						√
Namibia	0.685		√				√
Mauritius	0.656						√
Sierra Leone	0.653	√					√
Niger	0.636				√	√	√
Cameroon	0.627						√
Mozambique	0.624	√					√
Somalia	0.624						√
Gabon	0.623		√				√
Madagascar	0.622	√					√
Mauritania	0.622	√		√			√
Ethiopia	0.616						√
Congo (Brazzaville)	0.611		√		√		√
Liberia	0.610			√	√		
Malawi	0.599					√	√
Sudan	0.597					√	√
Botswana	0.596		√				√
Congo DRC	0.586	√					
Seychelles	0.586						√
Chad	0.582					√	√

Nigeria	0.581						√
Burundi	0.580		√				√
Equatorial Guinea	0.580				√		√
Rwanda	0.580						√
Guinea	0.579						√
Libya	0.572			√	√		√
Algeria	0.564			√			√
Togo	0.560	√		√			
Central African Republic	0.552	√				√	√
Cape Verde	0.544						√
Sao Tome and Principe	0.538						√
Ghana	0.538						√
Burkina Faso	0.527						√
Lesotho	0.514					√	√
Angola	0.513				√		√
Zambia	0.506		√				√
Comoros	0.494						√
Guinea-Bissau	0.465			√			√
Mali	0.428						√
Average	0.625						
Standard Deviation	0.091						
Skewness	0.011						
Kurtosis	-0.340						

Notes: A value in the second column refers to TCI between the export pattern of a country in Africa (origin) and the import pattern of China (destination). √ indicates relatively strong match between China and the concerned African country in the commodity group heading the column or in the commodity group under the 'Other' column. The match refers only to the commodities covered in the TCI analysis.

Source: Calculated from ITC (n.d.), retrieved February 28, 2010.

APPENDIX H: LIST OF COUNTRIES USED IN THE SFGM ANALYSIS

This appendix contains the list of countries included in the maximum likelihood estimation of the stochastic frontier gravity model (SFGM) in this study (see Table H1).

Table H1: List of Countries in Maximum Likelihood Estimation of SFGM

Exporting Country	Importing Country
China	Algeria, Angola, Benin, Botswana, Burkina Faso, Burundi, Cameroon, Cape Verde, Central African Republic, Chad, Comoros, Congo Brazzaville, Congo DRC, Cote d'Ivoire, Djibouti, Egypt, Equatorial Guinea, Eritrea, Ethiopia, Gabon, Gambia, Ghana, Guinea, Guinea-Bissau, Kenya, Lesotho, Liberia, Libya, Madagascar, Malawi, Mali, Mauritania, Mauritius, Morocco, Mozambique, Namibia, Niger, Nigeria, Rwanda, Sao Tome and Principe, Senegal, Seychelles, Sierra Leone, South Africa, Sudan, Swaziland, Tanzania, Togo, Tunisia, Uganda, Zambia, Zimbabwe

Source: Own elaboration.

APPENDIX I: THE BATTESE-COELLI MLE METHOD

In general, in maximum likelihood estimation (MLE) technique, using a given combination of variables, we maximize a likelihood function. However, since a logarithmic function is monotonically increasing and easier to work with, we usually maximize or differentiate the log-likelihood function with respect to the parameters of interest (Greene, 2003). In the literature on stochastic frontier production models, as shown by Henderson (2003), the log-likelihood function of the Battese-Coelli MLE method is

$$\ln L = c - \frac{N(T-1)}{2}\ln \sigma_v^2 - \frac{N}{2}(\sigma_v^2 + T\sigma_u^2) - N\ln\left[1 - \Phi\left(-\frac{\tilde{\mu}}{\sigma_u}\right)\right] + \sum_i \ln\left[1 - \Phi\left(-\frac{\tilde{\mu}}{\sigma_*}\right)\right]$$
$$- \frac{\sum \varepsilon_i' \varepsilon_i}{2\sigma_v^2} - \frac{N}{2}\left(\frac{\mu}{\sigma_u}\right)^2 + \frac{1}{2}\sum_i \left(-\frac{\tilde{\mu}_i}{\sigma_*}\right)^2$$

where ln denotes natural logarithm, c is a constant, i indexes firms, N (i = 1, 2, ..., N) is the maximum number of firms, T (t = 1, 2, ..., T) is the maximum number of time periods, v is a normally distributed random error term, u is a nonnegative disturbance or inefficiency term having a truncated normal distribution, σ_v^2 is variance of v, σ_u^2 is variance of u, and ε = v-u. In addition, Φ denotes the distribution function of the standard normal random variable, and

$$\tilde{\mu}_i = \frac{\mu\sigma_v^2 - T\bar{\varepsilon}_i\sigma_u^2}{(\sigma_v^2 + T\sigma_u^2)}$$

$$\sigma_*^2 = \frac{\sigma_u^2\sigma_v^2}{(\sigma_v^2 + T\sigma_u^2)}$$

$$\bar{\varepsilon}_i = (T)^{-1}\sum_t \varepsilon_{it}$$

where $\tilde{\mu}_i$ is a weighted mean for each i, σ_*^2 is a weighted variance term and $\bar{\varepsilon}_i$ is the average of ε_{it}. The conditional distribution of u given ε is

$$f(u|\varepsilon) = \frac{f(u,\varepsilon)}{f(\varepsilon)} = \frac{\exp\left(-\frac{(u-\tilde{\mu})^2}{2\sigma_*^2}\right)}{(2\pi)^{\frac{1}{2}}\sigma_*\left[1-\Phi\left(-\frac{\tilde{\mu}}{\sigma_*}\right)\right]}$$

After these have been derived, then either the mean or the mode of the distribution can be used to help define producer-specific estimates of technical efficiency. In the case of time-invariant efficiency, the mean and mode are listed as

$$E(u_i|\varepsilon_i) = \tilde{\mu}_i + \sigma_*\left(\frac{\phi\left(-\frac{\tilde{\mu}}{\sigma_*}\right)}{1-\Phi\left(-\frac{\tilde{\mu}}{\sigma_*}\right)}\right)$$

where ϕ represents the density function for the standard normal random variable, and

$$M(u_i|\varepsilon_i) = \begin{cases} \tilde{\mu}_i, & \tilde{\mu}_i \geq 0 \\ 0, & \text{otherwise} \end{cases}$$

respectively. These values are used to determine producer specific time-invariant technical efficiency. In the case time-variant efficiency, the steps are similar to those of the time invariant case. Log-likelihood functions are derived, the conditional distributions are determined and the mean and the mode for efficiency distribution are

$$E(u_i|\varepsilon_i) = \mu_{*i} + \sigma_{**}\left(\frac{\phi\left(-\frac{\tilde{\mu}_{*i}}{\sigma_{**}}\right)}{1-\Phi\left(-\frac{\tilde{\mu}_{*i}}{\sigma_{**}}\right)}\right)$$

and

$$M(u_i|\varepsilon_i) = \begin{cases} u_i^*, & \sum_t \alpha(t)\varepsilon_{it} \geq 0 \\ 0, & \text{otherwise} \end{cases}$$

where

$$\mu_{*i} = \frac{\mu\sigma_v^2 - \alpha'\bar{\varepsilon}_i\sigma_u^2}{(\sigma_v^2 + \alpha'\alpha\sigma_u^2)}$$

$$\sigma_{**}^2 = \frac{\sigma_u^2\sigma_v^2}{(\sigma_v^2 + \alpha'\alpha\sigma_u^2)}$$

$$\alpha(t) = \exp[-\eta(t - T)]$$

$$\alpha' = (\alpha(1), \alpha(2), \ldots, \alpha(T))$$

where the variables μ_{*i} and σ_{**}^2 have similar interpretations as before. The function $\alpha(t)$ is nonnegative and used to for parameterisation of the time varying efficiency, $u_{it} = \alpha(t)u_i$. According to Baten et al. (2009), eta (η) is an unknown scalar parameter to be estimated, which determines whether inefficiencies are time-varying or time invariant. If η is positive, then $-\eta(t - T) = \eta(t - T)$ is positive for $t < T$ and so $\exp[-\eta(t - T)] > 1$, which implies that the technical inefficiencies of firms remains constant. However, if η is negative, then $-\eta(t - T) < 0$ and thus the technical inefficiencies of firms increase over time. Henderson (2003) notes that any of the previously defined α's can be used.

As shown by Behr and Tente (2008), using the mean of the efficiency distribution, the Battese-Coelli firm-specific time-varying technical efficiencies, TE_{it} are then calculated as

$$TE_{it} = E\{\exp(-u_{it} \mid \varepsilon_{it})\}$$

where $\varepsilon_{it} = v_{it} - u_{it}$.

Upon estimation of stochastic frontier models by MLE, we also have estimates of sigma2 (σ^2), sigma_u2 (σ_u^2), sigma_v2 (σ_v^2), gamma (γ) and phi (φ), where

$$\sigma^2 = \sigma_v^2 + \sigma_u^2$$

$$\gamma = \frac{\sigma_u^2}{\sigma^2}$$

$$\varphi = \frac{\sigma_u}{\sigma_v}$$

So sigma2 is the composed error term, phi is the ratio of the standard deviation of u to the standard deviation of v (Kang & Fratianni, 2006) and gamma is defined as the total variation in output from the frontier level of output attributed to technical efficiency (Baten et al., 2009). Gamma lies on the interval [0, 1]. If γ is positive and significant, it implies that firm specific technical efficiency is important in explaining the total variability of output produced. Phi can be interpreted to be an indicator of the relative variability of the two sources of random error that distinguish firms from one another (Aigner et al., 1977).

In addition, econometrics packages such as STATA version 10 also compute what is known as the Wald test statistic. In a linear model, the Wald statistic can be recognised as simply the F-statistic (Engle, 1984; Wooldridge, 2000). In general, a Wald test only requires computation the unrestricted model and is based on measuring the extent to which the unrestricted estimates fail to satisfy the hypothesized restrictions (Greene, 2003). Let θ be a vector of parameters to be estimated, and let H_0 specify some sort of restriction on these parameters. Let $\hat{\theta}$ be the vector of parameter estimates obtained without restrictions. We hypothesize a set of restrictions $H_0: c(\theta) = q$. The Wald test statistic is

$$W = [c(\hat{\theta}) - q]' \left(\text{Asy.Var}[c(\hat{\theta}) - q]\right)^{-1} [c(\hat{\theta}) - q]$$

Under H_0, in large samples, W has a chi-squared distribution with degrees of freedom equal to the number of restrictions [that is, the number of equations in $c(\hat{\theta}) - q = 0$]. For example, if H_0: $\beta_1 = \beta_2 = \beta_3 = \beta_4 = 0$, there are four restrictions and therefore four degrees of freedom. A large value of W leads to rejection of the hypothesis.

Now, a series of formal hypothesis tests can be conducted to determine the distribution of the random variables associated with the existence of technical inefficiency and the residual error term (Baten et al., 2009). These are tested through imposing restrictions on the model and using the generalized likelihood-ratio statistic (λ) to determine the significance of the restriction. The generalized likelihood ratio statistic is defined by

$$\hat{\lambda} = -2\{\ln[L(H_0)] - \ln[L(H_1)]\}$$

where $\ln[L(H_0)]$ and $\ln[L(H_1)]$ are the values of the log-likelihood function for the frontier model under the null and alternative hypotheses. If H_0: $\gamma = 0$, we are testing that technical inefficiency effects are not present in the model. If the null hypothesis states that mu is zero, or H_0: $\mu = 0$, specifying that the inefficiency distribution is half-normal (which is a special case of the truncated normal distribution), the log-likelihood ratio of the half-normal model is that of the null hypothesis, while the log-likelihood ratio of truncated normal model is that of the alternative hypothesis. If H_0: $\eta = 0$, we are testing the hypothesis that efficiency is invariant over time.

Finally, note that we have thus far made the discussion mainly in terms of production (output) and firms. However, for the purposes of this study, we use trade instead of production and country pairs (ij) instead of firms (i). For example, in deriving country-pair specific efficiency, we would have TE_{ijt} which is interpreted as trade efficiency of country i (China in our case) with its trade partner j (an African country in our case) (Kalirajan & Bhattacharya, 2007). Otherwise, the statistical results remain the same.

APPENDIX J: SUMMARY STATISTICS AND CORRELATION MATRIX OF THE EMPIRICAL SFGM

In this appendix, the descriptive statistics and correlation matrix of the empirical stochastic frontier gravity model used in this study are presented. Thus, the variables concerned are $\ln EXP_{ijt}$, $\ln GDP_{it}$, $\ln GDP_{jt}$, $\ln rDist_{ij}$ and $Landl_{ij}$. The descriptive statistics of these variables are computed in Table J1 as follows.

Table J1: Summary Statistics for Variables in the Empirical SFGM

Variables	Observation	Mean	Standard Deviation	Minimum	Maximum
ln EXP_{ijt}	416	11.19	2.11	5.04	15.97
ln GDP_{it}	416	28.42	0.39	27.91	29.10
ln GDP_{jt}	416	22.32	1.64	18.15	26.37
ln $rDist_{ij}$	416	-0.01	0.15	-0.35	0.20
$Landl_{ij}$	416	0.29	0.45	0.00	1.00

Source: Own calculation.

The next table, Table J2 presents the correlation matrix for variables in the model. The signs of the correlation coefficients between the dependent variable ($\ln EXP_{ijt}$) and the explanatory variables ($\ln GDP_{it}$, $\ln GDP_{jt}$, $\ln rDist_{ij}$ and $Landl_{ij}$) are in conformity with the theoretical predictions.

Table J2: Correlation Matrix for Variables in the Empirical SFGM

	ln EXP_{ijt}	ln GDP_{it}	ln GDP_{jt}	ln $rDist_{ij}$	$Landl_{ij}$
ln EXP_{ijt}	1.0000				
ln GDP_{it}	0.376	1.0000			
ln GDP_{jt}	0.7726	0.1869	1.0000		
ln $rDist_{ij}$	-0.0699	-0.0000	-0.1748	1.0000	
$Landl_{ij}$	-0.3239	0.0000	-0.1247	0.0032	1.0000

Source: Own computation.

APPENDIX K: SPECIFICATION TEST RESULTS FOR THE EMPIRICAL SFGM

Following Armstrong et al. (2008), this appendix contains results of likelihood ratio tests conducted to determine whether the assumptions of the empirical SFGM are appropriate (see Table K1).

Table K1: Specification Test Results for the Empirical SFGM

Null Hypothesis	LR Chi2 Statistic	Prob>chi2	Decision	Conclusion
H_0: gamma=0	83.04	0.0000	Reject H_0	The composite error specification is appropriate
H_0: mu=0	17.35	0.0000	Reject H_0	The truncated normal distribution fits the data better than the special half-normal distribution
H_0: eta=0	23.72	0.0000	Reject H_0	Time-varying efficiency term is appropriate

Source: Own calculation.

APPENDIX L: REALISATION OF CHINA'S TRADE POTENTIAL WITH AFRICA FROM SFGM

This appendix presents estimation results of the mean percentage achievements of China's potential exports to 52 African countries (see Table L1).

Table L1: Mean Realization of China's Potential Exports to 52 African Countries, 2001-2008

African Countries to which China Exports	Bilateral Trade Efficiency Score	Bilateral Trade Efficiency Rank	Bilateral Trade Potential Rank
Algeria	0.080	25	28
Angola	0.074	28	25
Benin	0.788	1	52
Botswana	0.053	33	20
Burkina Faso	0.027	42	11
Burundi	0.037	39	14
Cameroon	0.038	38	15
Cape Verde	0.016	45	8
Central African Republic	0.013	49	4
Chad	0.013	48	5
Comoros	0.012	50	3
Congo (Brazzaville)	0.099	20	33
Congo DRC	0.029	41	12
Cote d'Ivoire	0.090	24	29
Djibouti	0.256	5	48
Egypt	0.114	14	39
Equatorial Guinea	0.014	47	6
Eritrea	0.024	44	9
Ethiopia	0.182	9	44
Gabon	0.015	46	7
Gambia	0.602	4	49
Ghana	0.251	6	47
Guinea	0.132	13	40
Guinea-Bissau	0.054	31	22
Kenya	0.104	18	35
Lesotho	0.217	7	46
Liberia	0.719	2	51
Libya	0.042	37	16
Madagascar	0.104	17	36
Malawi	0.045	36	17
Mali	0.102	19	34
Mauritania	0.140	12	41
Mauritius	0.094	22	31
Morocco	0.114	15	38
Mozambique	0.054	32	21

Namibia	0.050	34	19
Niger	0.071	30	23
Nigeria	0.185	8	45
Rwanda	0.027	43	10
Sao Tome and Principe	0.010	51	2
Senegal	0.078	26	27
Seychelles	0.009	52	1
Sierra Leone	0.073	29	24
South Africa	0.175	10	43
Sudan	0.151	11	42
Swaziland	0.030	40	13
Tanzania	0.094	23	30
Togo	0.642	3	50
Tunisia	0.050	35	18
Uganda	0.074	27	26
Zambia	0.098	21	32
Zimbabwe	0.109	16	37
Average	0.128		
Standard Deviation	0.174		
Skewness	2.615		
Kurtosis	9.127		

Source: Own calculation from results in Table 4.2 of Chapter Four.

DEDICATION

In praise of God, this thesis is dedicated to the memory of my mother, Aster and to my father, Assefa, to my brothers, Mehari, Fikre and Yonas, and to my sister, Esete.

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DECLARATION

I declare that this thesis is my original work and has not been presented for a degree in any other university, and that all sources of materials used for the thesis have been duly acknowledged.

The examiners' comments have been duly incorporated.

Declared by:

Name: Matias Assefa

Signature: ______________________

Date: 24 June, 2010

Confirmed by advisor:

Name: Alemayehu Geda

Signature: ______________________

Date: 24 June, 2010

Place and date of submission:

Addis Ababa University, July 2, 2010