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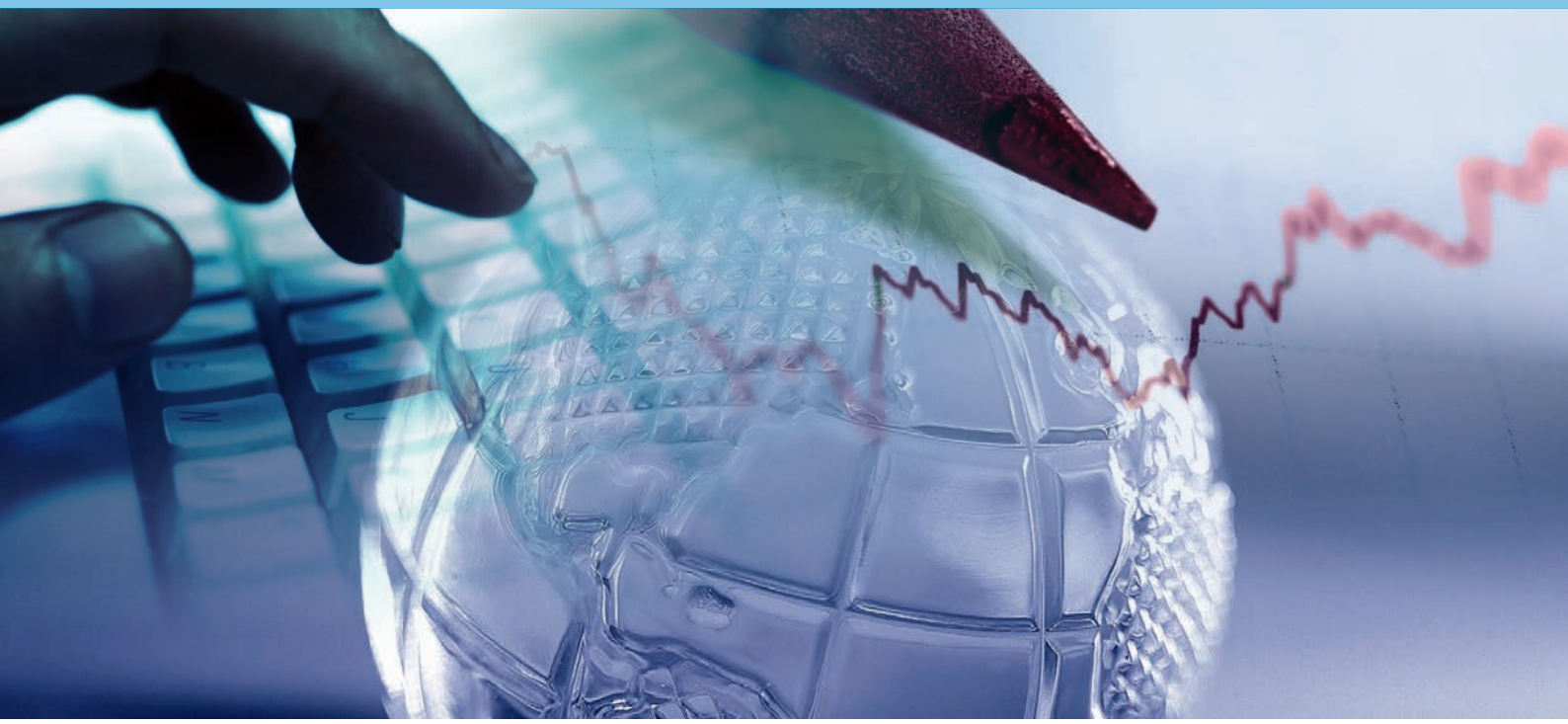

# Comparison of economic linkages between China and Africa: Applying the WIOD database

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION

DEVELOPMENT POLICY, STATISTICS AND RESEARCH BRANCH
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# Comparison of economic linkages between China and Africa: Applying the WIOD database

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## Abstract

The international fragmentation of production evolved in the 1990s due to the consistently decreasing cost of services worldwide (Jones and Kierzkowski, 1990, 2001). This has been the dominant feature of ever-growing globalization and has resulted in more interconnected production processes between countries across the world. Triggered by policy-related issues and following the seminal work of Hummels et al. (2001), input-output tables have been developed to trace the degree of sectoral linkages in production processes between countries, especially in OECD and Asian countries where input-output tables are available and updated regularly.

However, the majority of African countries do not have input-output tables. Building on the recent publication of the world input-output database, this paper focuses on the measurement of Africa's economic linkages with the rest of the world to determine Africa's economic position and to derive policy implications.

The paper is structured as follows. An introductory section presents an overview of Africa's economic development in the last three decades, followed by a brief introduction of input-output tables in Section 2 and their economic implications, especially with regard to tracing economic linkages among sectors and between regions. Databases including the World Input-Output Database and the UNIDO INDSTAT database will be described in Section 3. Section 4 presents the analytical results and future research agenda, and Section 5 concludes.

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## 1. Introduction

The international fragmentation of production evolved in the 1990s. This has been the dominant feature of ever-growing globalization and has resulted in an increase in linked production processes in all countries across the globe. The global financial crisis of 2008/09 clearly demonstrated the extent of the interrelatedness of the world economy. The reason the crisis affected the majority of countries is because an increasing number of countries is involved in the fragmentation of production due to the intensification of globalization. Statistics have shown that trade in intermediate inputs account for as much as two-thirds of international trade, with Barbie dolls to Dell computers and Apple iPods to Boeing airplanes representing good examples (Johnson and Noguera (2009), Tempest (1996) on Barbie; Kraemer and Dedrick (2002) on Dell computers; Linden, Kraemer, and Dedrick (2007) and Varian (2007) on the iPod; and Grossman and Rossi-Hansberg (2009) on Boeing.

The fragmentation of production is theoretically not a new phenomenon; it refers to a series of production components within a production process, which are connected by service linkages either internationally or nationally. One of the key reasons why production processes now include so many countries is the continuously decreasing costs of service linkages among countries, resulting in decreasing total production costs (Jones and Kierzkowski, 1990). The degree of linkages between countries lies at the top of the agenda among policymakers: how interconnected are the countries that are involved in a production process and what is the impact on national economic growth in general?

Building on the seminal work of Hummels et al. (2001), input-output tables have been developed to determine the degree of sectoral linkages in a production process involving several countries, particularly in OECD and in Asian countries where input-output tables are available and regularly updated (WTO-IDE, 2011, among others).

Concerns about the increasing interconnectedness of the world economy and the ensuing structural changes have been raised by policymakers and academia, in addition to the need to monitor the global economy. Hence, the need to establish a proper database for structural analysis has emerged as a top priority. In consideration of the fact that an increasing number of countries are now involved in global production processes, combining statistics on trade and production has been discussed as an option. In May 2009, the EU financed the establishment of the World Input-Output Database (WIOD) which combines statistics on production and trade by including a higher number of international organizations and academic institutes. This shall

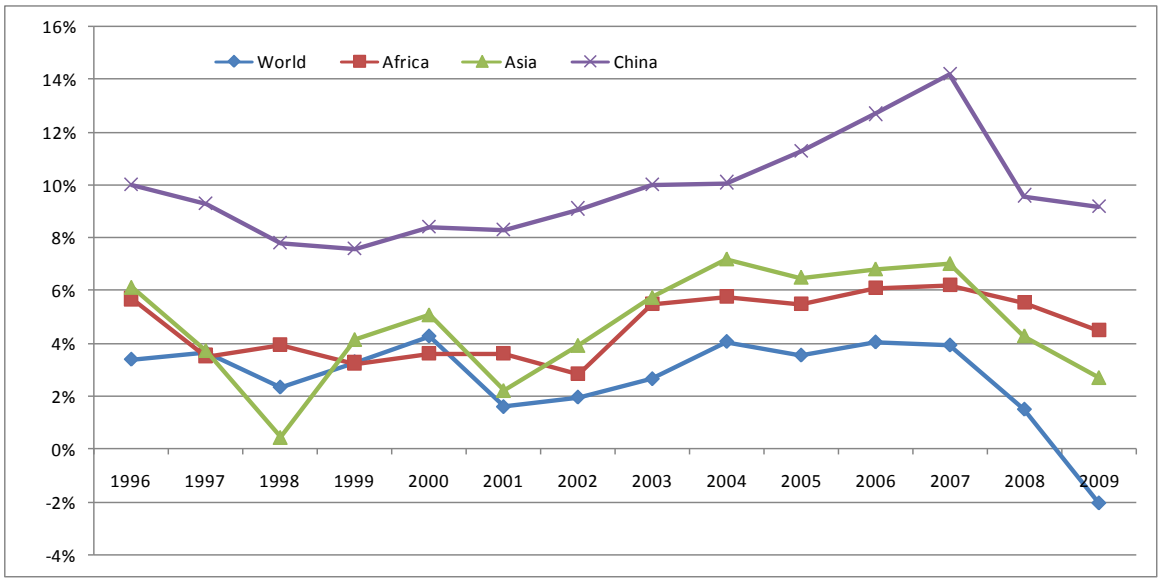
ensure that future policymaking on the monitoring of economic structural change is based on a reliable and current database.

## 2. Research purpose

While Asian countries have benefitted from the global fragmentation of production over the last decades, the impact on Africa has not been properly documented because the majority of African countries do not have input-output tables. Taking advantage of the recent release of the world input-output database (hereafter: WIOD), this paper focuses on the measurement of Africa's economic linkages with the rest of the world to determine Africa's economic position.

Africa has experienced accelerated growth in recent years and according to the World Bank (2007), "Growth has been sustained in Africa over the past decade." Seventeen countries in Africa, home to 36 percent of the continent's population, have been growing at an average rate of 5.5 percent annually over the last 10 years. As illustrated in Figure 1, the growth trend of Africa has been rising continually since the beginning of 2000, with an average growth rate that was higher than Asia's between 2002 and 2007 and has been much higher than the world's average growth rate since 2001. The export of goods and services from African countries has accelerated in recent decades as well. According to figures from the World Bank (2011), the export of goods and services as a share of African GDP increased from 25.4 percent during 1980-1989 to 29.9 percent during 1990-1999 and reached 32.4 percent during 2000-2009.

**Figure 1 GDP growth rate of world, Africa, Asia and China: 1995 to 2009**




*Source*: UNIDO MVA database

The structure of the paper is as follows: an introductory section presents an overview of Africa's economic development in the last three decades and purpose of this paper, followed by a brief introduction of input-output tables and their economic implications in Section 3, with a focus on determining economic linkages among sectors and between regions. Databases including the World Input-Output Database and the UNIDO INDSTAT database are described in Section 4. Section 5 presents the analytical results and discusses a future research agenda, while Section 6 concludes.

## 3. Input-output tables: Tools for determining economic linkages

Since Nobel Laureate Wassily Leontief published his seminal work on input-output tables in the early 1930s, the methodology has been applied to economic planning and policymaking. The input-output framework's main objective is to analyse the interdependence of industries in an economy. The methodology was rediscovered in the last two decades to analyse economic linkages between countries, which are one of the consequences of deepening globalization, especially in terms of linkages between sectors among different countries.

An input-output framework for a single region can generally be expressed as follows (Miller and Blair, 1985). If we assume that there are *n* sectors in a given economy and if $X_i$ denotes the total output (production) of sector *i* and $Y_i$ the total final demand for sector *i*'s products, we can conclude:

$$X_i = z_{i1} + z_{i2} + \cdots + z_{in} + Y_i \tag{1}$$

*z* refers to the inter-industry sales by sector *i*, that is, the total of the right-hand side of equation (1) is the sum of all sector *i*'s inter-industry sales and its final demand. For the other sectors, equation (1) can be extended to arrive at the following equation (2):

$$\begin{aligned}
X_1 &= z_{11} + z_{12} + \cdots + z_{1n} + Y_1 \\
X_2 &= z_{21} + z_{22} + \cdots + z_{2n} + Y_2 \\
&\vdots \\
X_i &= z_{i1} + z_{i2} + \cdots + z_{in} + Y_i \\
&\vdots \\
X_n &= z_{n1} + z_{n2} + \cdots + z_{nn} + Y_n
\end{aligned} \tag{2}$$

Let $a_{ij}$ be the direct input coefficient (or input-output coefficient), which means the input of sector *i* to produce one unit of sector *j*.

$$a_{ij} = \frac{z_{ij}}{X_j} \tag{3}$$

Then, equation (2) can be written as:

$$\begin{aligned}
X_1 &= a_{11}X_1 + a_{12}X_2 + \cdots + a_{1n}X_n + Y_1 \\
X_2 &= a_{21}X_1 + a_{22}X_2 + \cdots + a_{2n}X_n + Y_2 \\
&\vdots \\
X_i &= a_{i1}X_1 + a_{i2}X_2 + \cdots + a_{in}X_n + Y_i \\
&\vdots \\
X_n &= a_{n1}X_1 + a_{n2}X_2 + \cdots + a_{nn}X_n + Y_n
\end{aligned} \tag{4}$$

which in matrix form is represented by the following equation (5):

$$X = AX + Y \tag{5}$$

Following equation (3), the regional direct input coefficient for the regional input-output tables is derived in equation (6), denoting the economic meaning of the direct input coefficient within region *L* (Isard, 1951).

$$a_{ij}^{LL} = \frac{z_{ij}^{LL}}{X_j^L} \tag{6}$$

While the inter-regional direct input coefficient is derived in equation (7), which represents the direct input of sector *i* imported by region *L* from region *K* to produce one unit of sector *j*'s output in region *L*.

$$a_{ij}^{KL} = \frac{z_{ij}^{KL}}{X_j^L} \tag{7}$$

If the inter-regional direct input coefficient cannot specifically be attributed to one region, the general imported input coefficients are derived in equation (8), which denotes the imported direct input coefficient of sector *j* from other regions of sector *i*.

$$a_{ij}^{\bullet L} = \frac{z_{ij}^{\bullet L}}{X_j^L} \tag{8}$$

For region *L*, equation (6) represents the element of matrix $A^D$ to express the domestic direct input coefficient matrix for region *L*, while equation (8) denotes the element of matrix $A^M$ as the general imported direct input coefficient matrix for region *L*.

Applying the input-output methodology, Hummels et al. (2001) measure the vertical linkages of production to determine the degree of vertical specializations (hereafter: VS), the use of imported inputs in producing exported goods in one economy. In general, the VS share of total exports in one economy can be expressed as follows:

$$\text{VS share of total exports} = \mu A^M [I - A^D]^{-1} X / X \tag{9}$$

where $u$ is a 1x*n* vector of 1's, $A^M$ is the *n* x *n* imported direct input coefficient matrix, $A^D$ is the *n* x *n* domestic direct input coefficient matrix, $A^M [I - A^D]^{-1} X / X_k$ is 1x*n* vector of exports and $X_k$ is total exports of a country. Note that in equation (9), the attractive feature of input-output tables with element $[I - A^D]^{-1}$ allows us to calculate the export of imported intermediate goods[1] .

Linkage analysis based on input-output tables is generally deemed a crucial aspect of industrial policy formation (Chenery and Watanabe, 1958; Hirschman, 1958; Rasmussen, 1956). Let *A*= $[a_{ij}]$ be a matrix of direct inputs in the usual input-output system, $B = (I - A)^{-1} = [b_{ij}]$ the associated Leontief inverse matrix in which $b_{ij}$ denotes the total input of sector *i* producing one unit of sector *j*.

Let $B_{\cdot j}$ and $B_{i\cdot}$ be the column and row multipliers of this Leontief inverse, which are defined as:

$$B_{\cdot j} = \sum_{i=1}^{n} b_{ij}, \quad B_{i\cdot} = \sum_{j=1}^{n} b_{ij} \tag{10}$$

Let V be the global intensity of the Leontief inverse matrix:

[1] Uchida and Santoshi (2009) extended the VS analysis by decomposing the VS into two parts based on Asian input-output tables: (1) imported components produced for foreign countries, and (2) import components produced for domestic use nationally.

$$V=\sum_{i=1}^{n}\sum_{j=1}^{n}b_{i\ j} \tag{11}$$

Rasmussen (1956) proposes two types of indices drawing on entries in the Leontief inverse. First, the power of dispersion for the backward linkages $BL_j$ is defined as follows:

$$BL_j=\frac{\frac{1}{n}\sum_{i=1}^{n}b_{i\ j}}{\frac{1}{n^2}\sum_{i,j=1}^{n}b_{i\ j}}=\frac{\frac{1}{n}B_{\cdot j}}{\frac{1}{n^2}V}=\frac{B_{\cdot j}}{\frac{1}{n}V} \tag{12}$$

Secondly, the indices of the sensitivity of dispersion for forward linkages $FL_i$ are defined as:

$$FL_i=\frac{\frac{1}{n}\sum_{j=1}^{n}b_{i\ j}}{\frac{1}{n^2}\sum_{i,j=1}^{n}b_{i\ j}}=\frac{\frac{1}{n}B_{i\cdot}}{\frac{1}{n^2}V}=\frac{B_{i\cdot}}{\frac{1}{n}V} \tag{13}$$

The usual interpretation is to propose that if $BL_j$ >1, a unit change in final demand in sector will generate an above-average increase in activity in the economy; similarly, for $FL_i$ >1, it is asserted that a unit change in all sectors' final demand will create an above average increase in sector *i*. A key sector is usually defined as one in which both indices are greater than 1, with other options to define a key sector under different circumstances (Beyers, 1976; Hewings, 1982; Hewings et al., 1989; Sonis et al., 1995, 2000; Cai and Leung, 2004, among others).

## 4. The databases: WIOD and UNIDO INDSTAT

The WIOD (World Input-Output Database) is the outcome of a project funded by the European Commission, and has been developed to analyse the effects of globalization on trade patterns[2]. The schematic outline of a world input-output table using three regions is illustrated in Table 1. The world input-output tables are constructed from national supply and use tables and are based on tables which combine trade information (Timmer, 2012).

[2] See www.wiod.org for further information.

**Table 1 Schematic outline of World Input-Output Table (WIOT), three regions**

| | | Country A Intermediate *Industry* | Country B Intermediate *Industry* | Rest of World Intermediate *Industry* | Country A Final domestic | Country B Final domestic | Rest of World Final domestic | Total |
|---|---|---|---|---|---|---|---|---|
| Country A | *industry* | Intermediate use of domestic output | Intermediate use by B of imports from A | Intermediate use by ROW of imports from A | Final use of domestic output | Final use by B of exports from A | Final use by ROW of exports from A | Output in A |
| Country B | *industry* | Intermediate use by A of imports from B | Intermediate use of domestic output | Intermediate use by ROW of imports from B | Final use by A of exports from B | Final use of domestic output | Final use by ROW of exports from B | Output in B |
| Rest of World (ROW) | *industry* | Intermediate use by A of imports from ROW | Intermediate use by B of imports from ROW | Intermediate use of domestic output | Final use by A of exports from ROW | Final use by B of exports from ROW | Final use of domestic output | Output in ROW |
| | | Value added | Value added | Value added | | | | |
| | | Output in A | Output in B | Output in ROW | | | | |

*Source*: Timmer (2012), Figure 2

The database covers 27 EU countries and 13 other major countries for the period 1995 to 2009, as well as an additional region – the rest of the world (ROW[3]) – as shown in Table 2. The 40 countries in the WIOD cover most of the GDP and MVA in the world.

**Table 2 List of countries/regions in the WIOD**

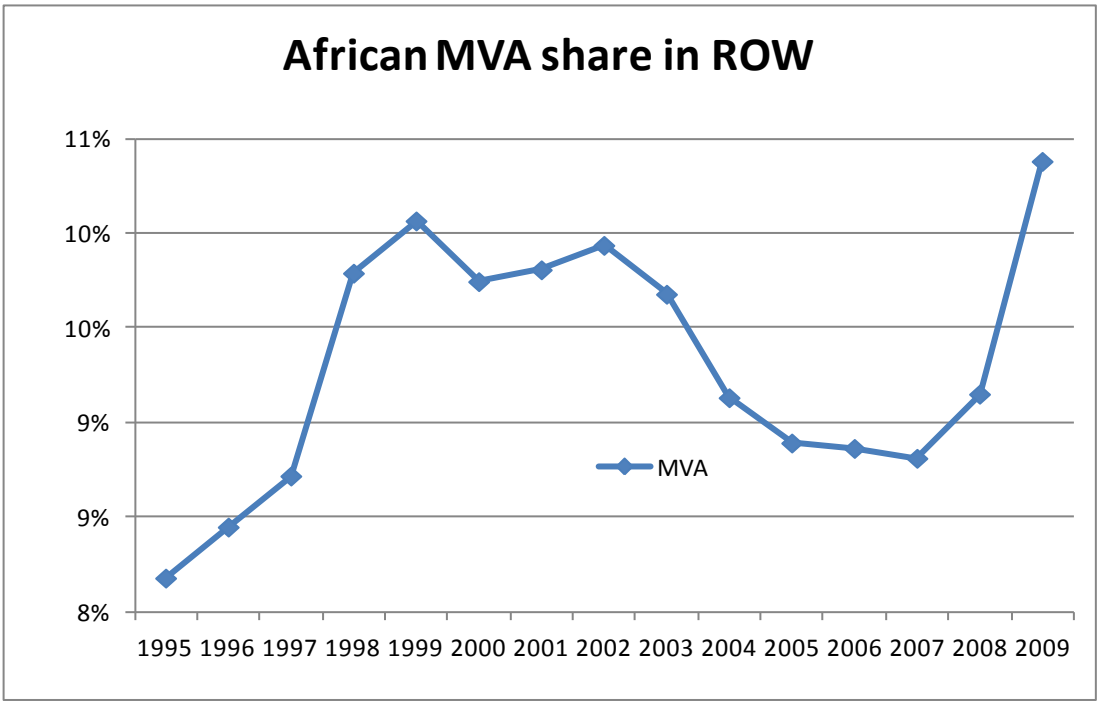
| **Regions** | **Country** | **Region** | **Country** |
|---|---|---|---|
| European Union | Austria | European Union | Portugal |
| | Belgium | | Romania |
| | Bulgaria | | Slovak Republic |
| | Cyprus | | Slovenia |
| | Czech Republic | | Spain |
| | Denmark | | Sweden |
| | Estonia | | United Kingdom |
| | Finland | North America | Canada |
| | France | | United States |
| | Germany | Latin America | Brazil |
| | Greece | | Mexico |
| | Hungary | Asia and Pacific | China |
| | Ireland | | India |
| | Italy | | Japan |
| | Latvia | | South Korea |
| | Lithuania | | Australia |
| | Luxembourg | | Taiwan |
| | Malta | | Turkey |
| | Netherlands | | Indonesia |
| | Poland | | Russia |

*Source*: Timmer (2012)

[3] In this paper, we assume that the ROW represents the African economies.

According to the UNIDO MVA database, the MVA of the countries included in the WIOD accounts for nearly 90 percent of total world MVA as shown in Figure 2. The decreasing trend of the share of MVA of the 40 countries indicates that that of the ROW is growing.

**Figure 2 MVA share of WOID countries in the world (in %): 1995 - 2009**




*Source*: Author's calculation based on the UNIDO MVA database

The WIOD is constructed from the national supply and use tables with additional assumptions (Timmer, 2012). The number of sectors in each country included in the WIOD is standardized to 35 sectors according to the national sectors of each country and the structure of ISIC Rev. 3 as listed in Table 3. The industrial sectors are represented by sectors 2 to 17.

UNIDO maintains a variety of industrial statistics databases, which are used internally and made available internationally. INDSTAT4 is the most detailed industrial statistics database produced for cross-country economic analysis. UNIDO statisticians develop data sets that are comparable and consistent across countries and over time. The database contains seven key indicators of industrial statistics:

1. Number of establishments
2. Number of persons engaged/employees
3. Wages and salaries
4. Output
5. Value added
6. Gross fixed capital formation
7. Number of female employees.

**Table 3 The 35 industries and descriptions in WIOD**

| | Industry | ISIC Rev.3 |
|---|---|---|
| 1. | Agriculture, Hunting, Forestry and Fishing | |
| 2. | Mining and Quarrying | 10-14 |
| 3. | Food, Beverages and Tobacco | 15,16 |
| 4. | Textiles and Textile Products | 17-18 |
| 5. | Leather and Footwear | 19 |
| 6. | Wood and Products of Wood and Cork | 20 |
| 7. | Pulp Paper, Paper, Printing and Publishing | 21,22 |
| 8. | Coke, Refined Petroleum and Nuclear Fuel | 23 |
| 9. | Chemicals and Chemical Products | 24 |
| 10. | Rubber and Plastics | 25 |
| 11. | Other Non-Metallic Minerals | 26 |
| 12. | Basic Metals and Fabricated Metal | 27,28 |
| 13. | Machinery n.e.c. | 29 |
| 14. | Electrical and Optical Equipment | 31-33 |
| 15. | Transport Equipment | 34,35 |
| 16. | Manufacturing n.e.c.; Recycling | 36-37 |
| 17. | Electricity, Gas and Water Supply | 40-41 |
| 18. | Construction | |
| 19. | Sales, Maintenance and Repair of Motor Vehicles and Motorcycles; Retail Sales of Fuel | |
| 20. | Wholesale Trade and Commission Trade Except of Motor Vehicles and Motorcycles | |
| 21. | Retail Trade Except of Motor Vehicles and Motorcycles; Repair of Household Goods | |
| 22. | Hotels and Restaurants | |
| 23. | Inland Transport | |
| 24. | Water Transport | |
| 25. | Air Transport | |
| 26. | Other Supporting and Auxiliary Transport Activities; Activities of Travel Agencies | |
| 27. | Post and Telecommunications | |
| 28. | Financial Intermediation | |
| 29. | Real Estate Activities | |
| 30. | Renting of M&E and Other Business Activities | |
| 31. | Public Admin. and Defence; Compulsory Social Security | |
| 32. | Education | |
| 33. | Health and Social Work | |
| 34. | Other Community Social and Personal Services | |
| 35. | Private Households with Employed Persons | |

*Source*: Timmer (2012)

The INDSTAT4 database maintains time series data from 1990 onwards. Data are available by country, year and at 3- and 4-digit levels of the International Standard Industrial Classification of All Economic Activities (ISIC) Revision 3, which comprises 151 manufacturing sectors and sub-sectors. All data are initially stored in national currencies at current prices. The system allows for data conversions from national currencies into current US dollars, using the average period exchange rates as provided by the International Monetary Fund's International Financial Statistics (IFS). To supplement statistical data, relevant metadata are collected from national data suppliers and the OECD, which is available to users in a highly flexible form.

Aside from the INDSTAT4 database, INDSTAT2, which includes data arranged at the 2-digit level of ISIC, is derived from the two already existing databases INDSTAT3 ISIC Rev. 2 and INDSTAT4 ISIC Rev 3. INDSTAT2, which is the largest industrial statistics database of its kind, combines historical time series data from 1963 to 2007 for 162 countries and 23 industries. Data are presented in the same format as in INDSTAT4, together with metadata. INDSTAT2 has been providing data based on a single classification standard for over 40 years, making it particularly valuable for long-term structural analyses. INDSTAT2 also presents data for seven key indicators as in INDSTAT4. Value figures are presented at current prices. The database also includes index numbers of industrial production, which show the real growth of the volume of production at the 2-digit level of ISIC Rev. 3.

## 5. Analytical results[4]

### 5.1 Backward, forward linkages and key sectors

The two types of economic linkages within the framework of the input-output tables are backward and forward linkages, and were illustrated in the equations earlier. If the values of both backward and forward linkages of a given sector in an economy are greater than 1, the sector is considered a key sector in the economy. The key sector has a higher than average impact on the whole economy if final demand in the economy changes accordingly. Within the framework of the WIOD, the backward and forward linkages of a country can be evaluated from three different perspectives: (1) to evaluate the backward and forward linkages within the world economy, i.e. at *international* level; (2) to evaluate the linkages within a single economy, i.e. at *national* level; and (3) to evaluate the linkages within the domestic production structure, i.e. at *domestic* level.

We conduct the linkage analysis of a country at international level using the WIOD in order to position the country's economic linkages within the global production framework. Specifically, we aim to determine how each sector (35 according to the WIOD) in each country (40 countries, plus ROW) is related to the others within the global production framework. Hence, if we take the WIOD as representing one input-output table of a single region with 1,435 sectors, we can identify the backward and forward linkages of all 1,435 sectors, covering 15 years from 1995 to 2009.

#### *5.1.1 Linkages from an international perspective*

Backward linkages are established when the growth of one industry leads to growth among industries which supply it, while forward linkages evolve when the growth of one industry leads

[4] All results are attained using R Open Source software (www.r-project.org).

to the growth of industries that use its output as inputs. The average forward and backward linkages of China's and Africa's key sectors during the period 1995 to 2009 are presented in Table 4. Key sector in our case refers to those sectors which have both forward and backward linkages that are greater than 1 in value. Based on this definition, half of China's 35 sectors are key sectors of the world economy, most of which are manufacturing sectors. In the case of Africa, only the manufacturing sectors (sectors 3, 6-10, 12-15, 17) as well as the hotel and restaurant sector are key sectors of the world economy.

**Table 4 Average backward and forward linkages of Africa and China between 1995 and 2009**

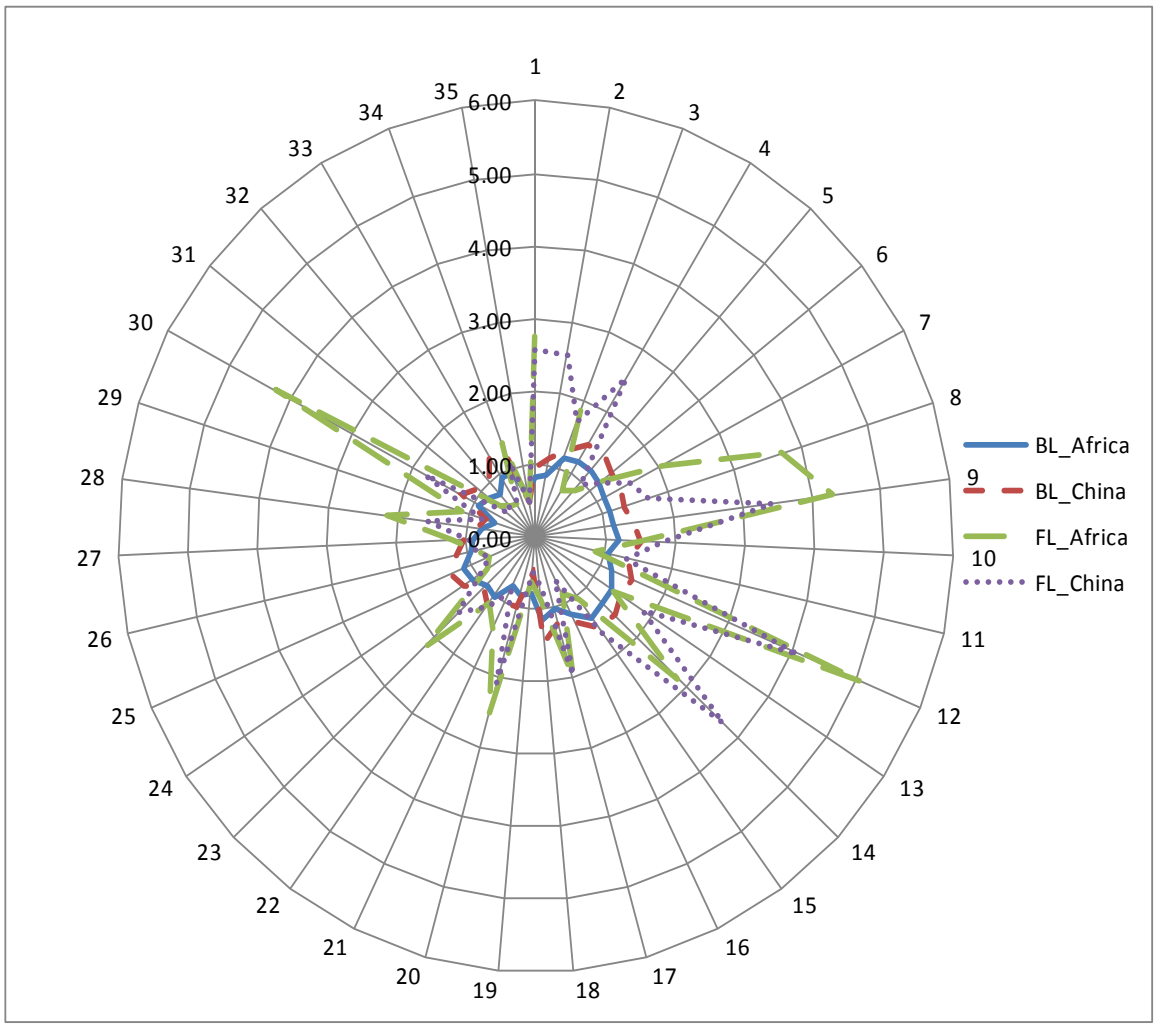
| Sector | Africa_ BL | Africa_FL | CHN_ BL | CHN_FL | Key Sector Africa_ international | Key Sector Africa_ international |
|---|---|---|---|---|---|---|
| 2 | 0.85 | 18.29 | 1.09 | 2.53 | -- | 1 |
| 3 | 1.16 | 1.85 | 1.27 | 1.67 | 1 | 1 |
| 4 | 1.19 | 0.74 | 1.46 | 2.53 | -- | 1 |
| 6 | 1.17 | 1.22 | 1.40 | 1.18 | 1 | 1 |
| 7 | 1.13 | 2.09 | 1.38 | 1.54 | 1 | 1 |
| 8 | 1.13 | 3.71 | 1.33 | 1.69 | 1 | 1 |
| 9 | 1.13 | 4.30 | 1.43 | 3.43 | 1 | 1 |
| 10 | 1.19 | 1.45 | 1.52 | 1.82 | 1 | 1 |
| 11 | 1.06 | 0.89 | 1.35 | 1.34 | -- | 1 |
| 12 | 1.17 | 5.07 | 1.51 | 4.11 | 1 | 1 |
| 13 | 1.30 | 1.35 | 1.47 | 1.83 | 1 | 1 |
| 14 | 1.31 | 2.82 | 1.56 | 3.71 | 1 | 1 |
| 15 | 1.37 | 1.07 | 1.56 | 1.64 | 1 | 1 |
| 17 | 1.04 | 2.00 | 1.21 | 1.98 | 1 | 1 |
| 20 | 0.83 | 2.52 | 1.01 | 2.08 | -- | 1 |
| 22 | 1.02 | 1.12 | 1.17 | 1.19 | 1 | 1 |
| 23 | 0.96 | 2.18 | 1.03 | 1.52 | -- | 1 |
| 30 | 0.92 | 4.25 | 1.22 | 1.80 | -- | 1 |
| 34 | 0.92 | 1.37 | 1.16 | 1.10 | -- | 1 |
| Average | 1.10 | 3.07 | 1.16 | 2.04 | --- | --- |

*Source*: Calculation by author

Taking the example of backward linkages of sector 3 (Food, beverages and tobacco) for Africa, if the sector's final demand increases by US$ 100 million, the world's total output will increase by US$ 116 million; if the final demand of sector 3 for China increases by US$ 100 million, the total output of the world will increase by US$ 127 million. In the case of forward linkages, if final demand from all sectors in the world economy increases by US$ 100 million, the output of sector 3 of Africa will increase by US$ 185 million to meet that demand. With regard to average sectoral linkages, the backward linkages in China are higher than those in Africa, while forward linkages are higher in Africa than in China. This implies that Chinese industries' inputs stimulate the growth of output producing industries of other countries (with other countries' industries providing output to China's industries as input), while Africa plays a more important

role in terms of providing input to industries in other countries. China had far more average backward linkages between 1995 and 2009 than Africa, as shown in Figure 3.

**Figure 3 Average backward and forward linkages of China and Africa: 1995 – 2009**



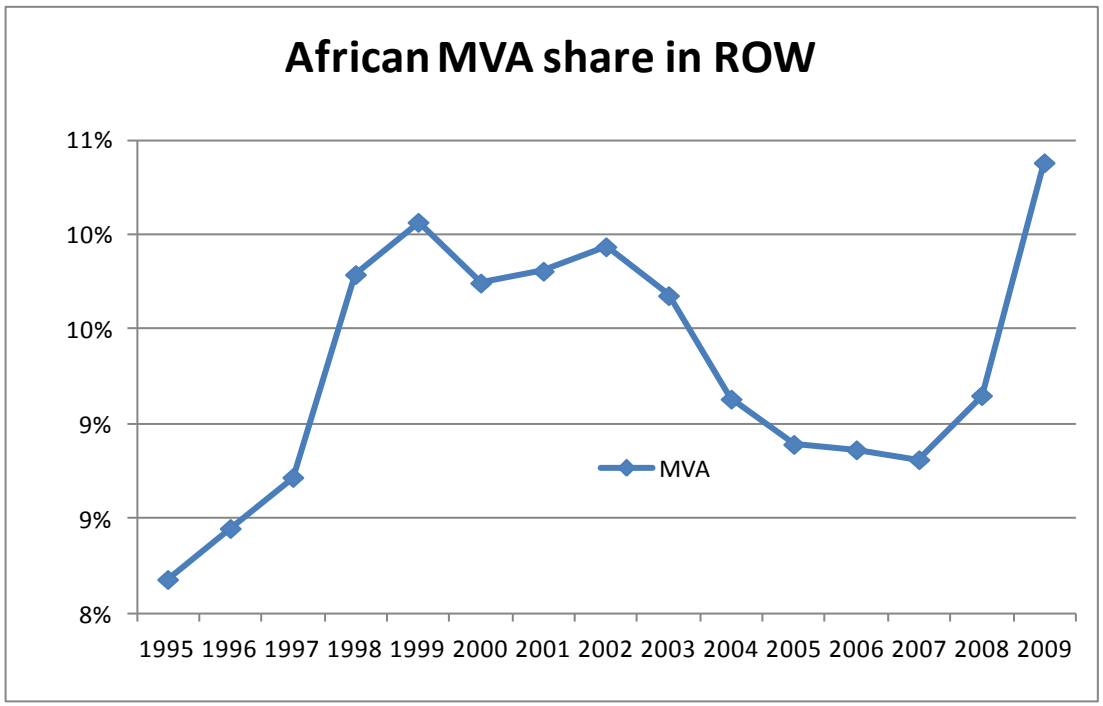

*Source*: Calculation by author

On average, China has larger values of both backward and forward linkages under the framework of global economy than Africa, which indicates that changes in final demand from China's key sectors would impact world output more than changes in final demand from Africa's key sectors[5]. Africa has far more forward linkages than China with industries such as sector 7 (pulp paper, paper printing and publishing), sector 8 (coke, refined petroleum and nuclear fuel), sector 9 (chemicals and chemical product), sector 12 (basic metals and fabricated metal), sector 20 (wholesale trade), sector 23 (inland transport), sector 28 (financial intermediation) and sector 30 (renting of machinery and equipment and other business-related

[5] As mentioned earlier, we assume that the ROW represents the African economies. However, we take Africa's MVA share in the ROW as shown in Figure 4, the impact of African economy to the world would be even lower.

activities). However, this does not conceal the fact that Africa and China have a similar number of key sectors, most of which are manufacturing sectors (sector 3, 6-10, 12-15, 17).

**Figure 4 MVA share of Africa in the ROW (1995 – 2009)**




*Source*: Calculated by author based on UNIDO MVA database

On the other hand, some service sectors from both China and ROW are relatively more important because they represent key sectors of the world economy, and in China include Whole sales (sector 20), Hotels and restaurants (sector 22), Inland transportation (sector 23), Machinery and equipment rentals (sector 30), while only one service sector from Africa is a key sector in the world economy.

### *5.1.2 Linkages from a national perspective*

To analyse a country's linkages from a national perspective, we examine the country's production framework, including both its domestic and imported intermediate inputs. According to WIOD, there are only 35 key sectors with linkages within the national production framework, which are presented in Table 5 for both China and Africa. Note that the value of the linkages is based on the average backward and forward linkages between 1995 and 2009 in Africa and in China.

The same applies to backward linkages; an increase of US$ 100 million in final demand from sector 3 (Food, beverages and tobacco), would result in an increase in total output by US$ 114 million in Africa and by US$ 111 million in China. What makes the different from the impact of

backward and forward linkages from the international perspective? From international perspective, the impact will generate changes in output at international level, i.e. the world output, while from the national perspective; the impact of backward linkage and forward linkage will generate changes of output at national level, i.e. the national output. In this case, China or Africa, if we take Africa to be a special country as defined in the WIOD as ROW, which we assume to represent Africa in this paper.

Manufacturing sectors are key sectors for both China and Africa, though China has more key sectors than Africa, as shown in Table 5. For example, sector 3 (Food, beverages and tobacco) is not a key sector in China, but not in Africa. The key economic sectors at international level do not necessarily correspond to the key sectors at national level, as the case of sector 3 in Africa demonstrates. In the case of China, key manufacturing sectors at national level are the same as those at international level.

**Table 5 Africa and China's key economic sectors: 1995-2009 average**

| Sector | Africa_BL | Africa_FL | CHN_BL | CHN_FL | Key Sector Africa_national | Key Sector China_national |
|---|---|---|---|---|---|---|
| 3 | 1.14 | 0.93 | 1.04 | 1.18 | - | 1 |
| 4 | 1.15 | 0.78 | 1.21 | 1.20 | - | 1 |
| 7 | 1.12 | 1.23 | 1.15 | 1.15 | 1 | 1 |
| 8 | 1.12 | 1.00 | 1.01 | 1.21 | 1 | 1 |
| 9 | 1.12 | 1.10 | 1.14 | 1.22 | 1 | 1 |
| 10 | 1.17 | 1.03 | 1.20 | 2.28 | 1 | 1 |
| 12 | 1.16 | 1.63 | 1.27 | 2.48 | 1 | 1 |
| 13 | 1.30 | 0.89 | 1.24 | 1.27 | - | 1 |
| 14 | 1.33 | 1.42 | 1.35 | 1.87 | 1 | 1 |
| 15 | 1.40 | 1.51 | 1.31 | 1.10 | 1 | 1 |
| 17 | 1.03 | 0.96 | 1.01 | 1.36 | - | 1 |
| average | 1.19 | 1.13 | 1.18 | 1.48 | --- | --- |

*Source*: Calculation by author

### *5.1.3 Linkages from a domestic perspective*

We have identified the economic linkages of Africa and China both from an international and a national perspective. If we only consider a country's key economic sectors from a *domestic* perspective, i.e. if we assume that the given country uses domestic resources only, we gain a different picture of the key sectors in China and in Africa.

As shown in Table 6 all of China's manufacturing sectors are key sectors, while there are fewer key manufacturing sectors in Africa, namely only 5 compared to 12 key manufacturing sectors in China. Interestingly, sector 2 (mining and quarrying) and sector 30 (renting of equipment and machinery and other business-related activities) are key sectors in Africa, while this is not the case in China. Without imported inputs, Africa would primarily depend on mining and

quarrying (sector 2) and on the services sector (sector 30) to increase domestic output, while China would continue to depend on its manufacturing sector for further growth. This means that China's manufacturing sectors can play an important role in the domestic economy, even if no economic linkages exist with the rest of the world. The Africa's key manufacturing sectors, however, are more dependent on economic linkages with other countries.

**Table 6 Africa and China's key sectors under each domestic economy: 1995-2009 average**

| Sector | Africa_BL | Africa_FL | CHN_BL | CHN_FL | Key Sector_Africa_dom | Key Sector China_dom |
|---|---|---|---|---|---|---|
| 2 | 1.00 | 2.70 | 0.92 | 1.63 | 1 | -- |
| 3 | 1.27 | 1.11 | 1.11 | 1.27 | 1 | 1 |
| 4 | 0.94 | 0.78 | 1.20 | 1.19 | -- | 1 |
| 7 | 1.16 | 1.25 | 1.14 | 1.17 | 1 | 1 |
| 8 | 1.22 | 0.94 | 1.01 | 1.21 | -- | 1 |
| 9 | 1.02 | 0.86 | 1.15 | 1.95 | -- | 1 |
| 10 | 1.09 | 1.01 | 1.21 | 1.12 | 1 | 1 |
| 11 | 0.95 | 0.77 | 1.14 | 1.01 | -- | 1 |
| 12 | 1.05 | 1.23 | 1.23 | 2.19 | 1 | 1 |
| 13 | 0.99 | 0.78 | 1.18 | 1.19 | -- | 1 |
| 14 | 0.96 | 0.84 | 1.15 | 1.34 | -- | 1 |
| 15 | 0.84 | 0.91 | 1.26 | 1.13 | -- | 1 |
| 17 | 1.04 | 1.15 | 1.02 | 1.40 | 1 | 1 |
| 30 | 1.00 | 1.34 | 0.98 | 1.02 | 1 | -- |
| average | 1.04 | 1.12 | 1.12 | 1.34 | | |

*Source*: Calculation by author

From the earlier analysis on forward and backward linkages for both China and Africa based on the world input-output table and from three different perspectives – international, national and domestic, China's manufacturing sectors are clearly the dominant sectors in the national and global economy. This may be evidence that China's production framework is relatively mature and that its manufacturing sectors can drive China's long-term economic growth. When we look at the average economic linkages of key sectors from each perspective, i.e. the international, national and domestic perspective, the degree of economic linkages differs: China's key manufacturing sectors have a significant impact on the global economy, but only a minimal one on the domestic economy. This implies that China's manufacturing sectors will have a positive effect on the global economy if the economic linkages between China and other countries remain.

Africa will have a more positive impact on the global economy if its economic linkages with other countries remain in place, however, this would not only involve Africa's manufacturing sectors as some of its services sectors are also key sectors in both African and in the global economy. Meanwhile, more manufacturing sectors can exert more positive effects to Africa

only if the manufacturing sectors maintain its economic linkage with other countries. Moreover, resource-based sectors in Africa, such as mining and quarrying, continue to be crucial for both African and the global economy –inputs from the Africa's mining and quarrying sector play a more important role than those from any other sector in Africa (see Table 4).

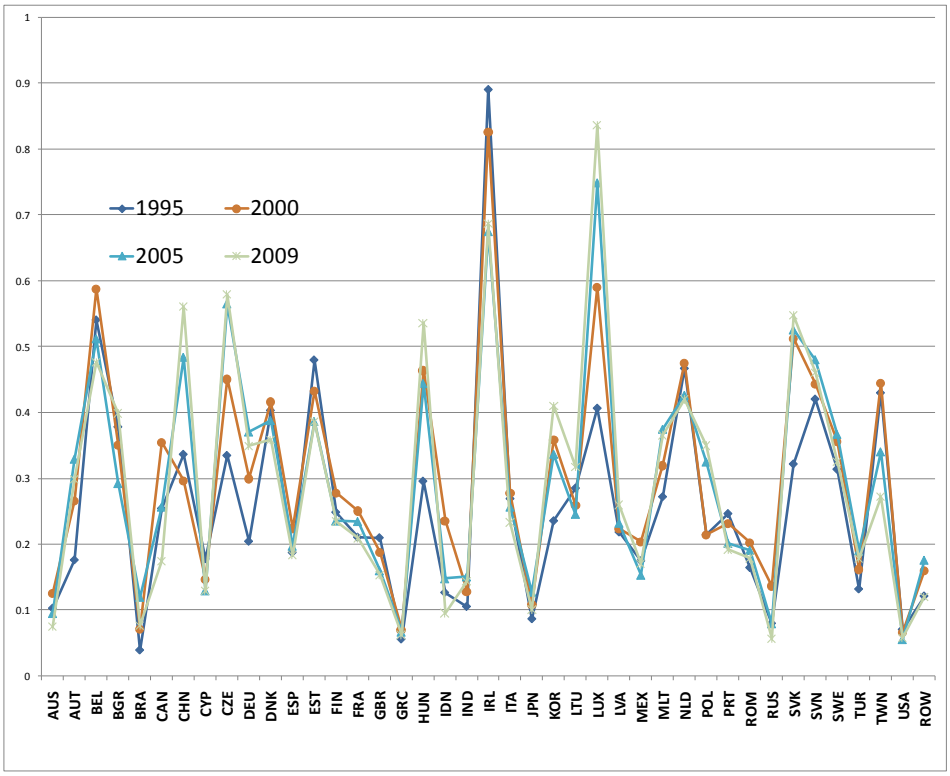
## 5.2 Share of vertical specification

The previous section examines the economic linkages of Africa (represented by the ROW in WIOD assumed in this paper) and of China from the perspective of key sectors in the economy (international, national and domestic). This section investigates the economic linkages in terms of the production stages expressed as a vertical specification share, which is defined earlier in equation (9). Note that vertical specification share may also refer to the imported content of exports (OECD, 2011), which indicates the status of international fragmentation of a given country.

In general, the VS share depends on the size of the economy – the smaller the economy, the larger the VS share is. As shown in Figure 5, the relatively small countries or regions, such as Belgium, Hungary, Czech Republic, Ireland, Luxembourg, and Taiwan, Province of China, have relatively large VS shares, while relatively larger countries, such as USA, Russia, Japan, and Brazil have relatively smaller VS shares. The VS share of most countries in the WIOD increased from 1995 to 2009, indicating enhanced production linkages between different countries during this period. In the case of China, which is a special case because it is a large country with a relatively higher than average VS share than other large countries, the government's industrial policy of actively promoting investment, particularly foreign direct investment, in the last 30 years by taking advantage of the country's relatively cheaper labour force has contributed to this development.

Figure 6 depicts the values of the VS share of both China and Africa from 1995 to 2009. China surpassed Africa in 1995, with its VS share peaking in 2008, when the financial crisis broke out. This indicates that China's production process has played a much more significant role in the rest of the world than Africa's in the last two decades. The VS share dropped to its lowest point in 2009 due to the strong reverberations of the 2008 financial crisis.

**Figure 5 VS share of 41 countries (regions) in WOID in select years**

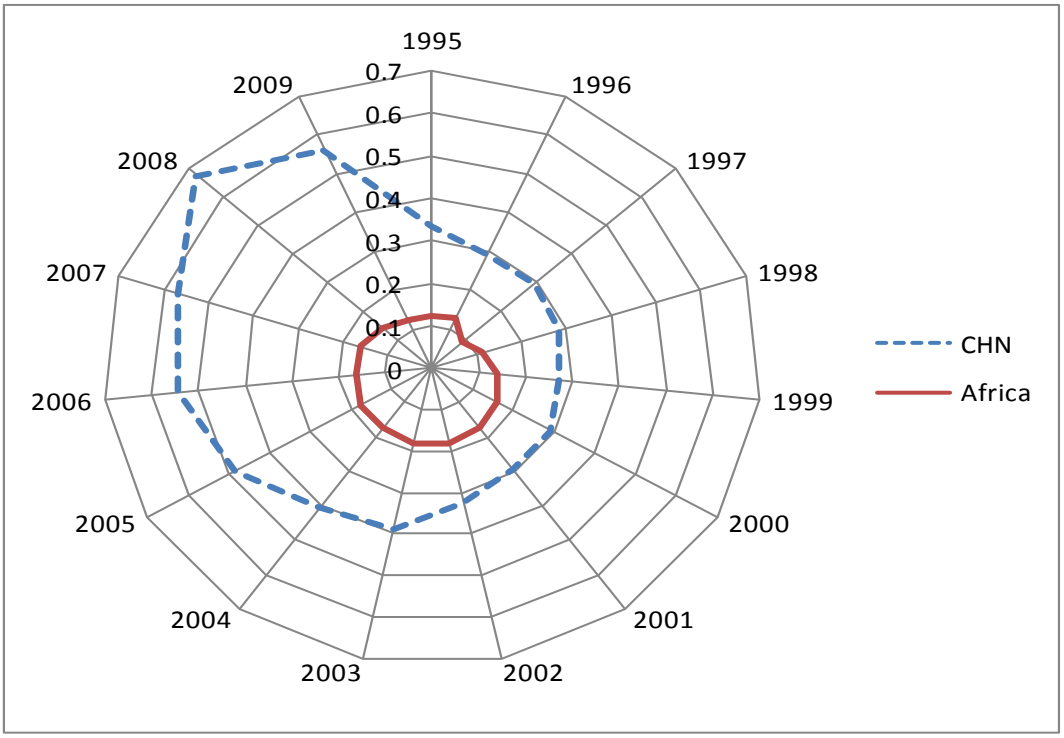



*Source*: Calculation by author

When looking at the growth rate of the VS share from 1995 to 2009, Africa's share grew much faster than China's from 1997 to 2001, but China picked up the pace in 2002 and its VS share has surpassed that of Africa since (Figure 7). However, the growth trend of the VS share has been declining for both China and Africa since 2002, and reached its lowest point in 2009 following the economic crisis in 2008, which demonstrates the strong impact of the economic crisis on the global economy.

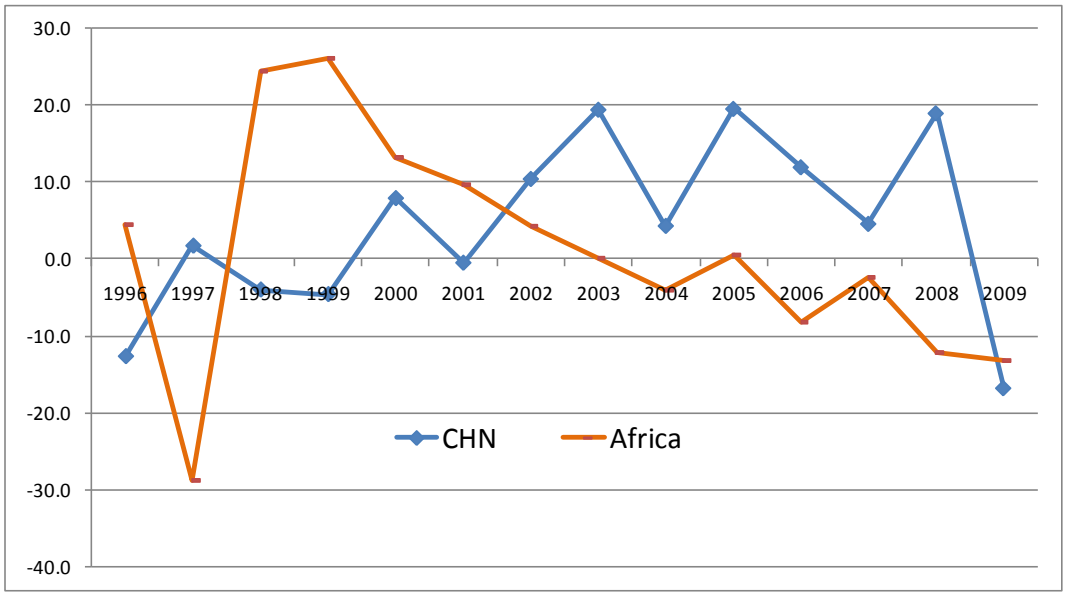
According to Nixon (2012), a low VS share may indicate that the manufacturing sector is not well developed, that is, it mainly produces for the domestic market. A higher VS share may indicate a shift towards more sophisticated manufacturing or processing activities, and a high degree of import density. The development of the VS share in China from 1995 to 2009 corroborates Nixon's statement, namely China has advanced into sophisticated assembly and processing activities with increasing VS shares. Africa's manufacturing sector is still developing and has not yet moved into more sophisticated processing activities. VS share could prove to be a useful tool for future industrialization and development policy formulation.

**Figure 6** **Vertical specification share between China and ROW: 1995-2009**




*Source*: Calculation by author

**Figure 7** **VS growth rate of China and Africa: 1996-2009 (in %)**




*Source*: Calculation by author

The key sectors analysis for China and Africa in the previous section identified China's and the Africa's most important sectors in terms of the global and the national economy. The linkage analysis shows that the key sectors are more closely linked to the global economy than other sectors. Do these key sectors hence have a higher VS share than the other sectors?

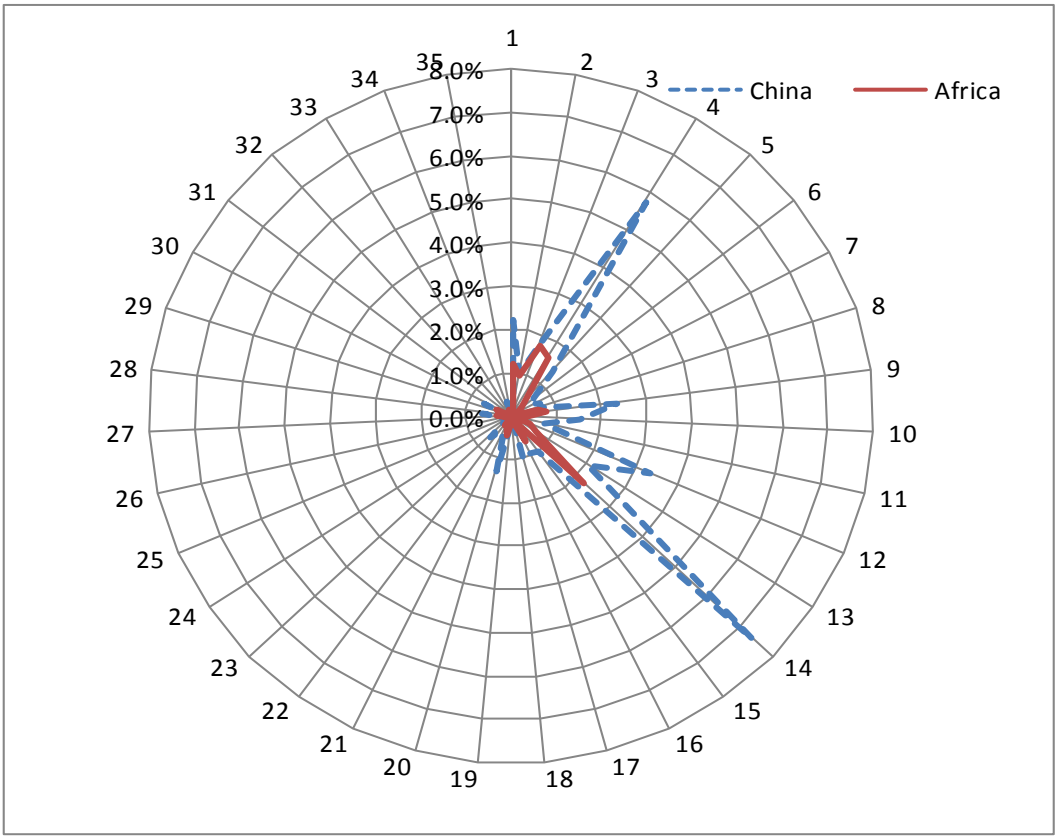
We calculate the VS share of China and Africa at sector level from 1995 to 2009. The average VS share is presented in Figure 8. The average level of VS share by sector is much higher in China than in Africa. Both China and Africa have similar sectors with a relatively higher VS share, with some sectors in China recording higher values, including sector 1 (Agriculture, Hunting, Forestry and Fishing), sector 3 (Food, Beverages and Tobacco), sector 4 (Textiles and Textile Products), sector 9 (Chemicals and Chemical Products), sector 12 (Basic Metals and Fabricated Metal), sector 13 (Machinery n.e.c.), sector 14 (Electrical and Optical Equipment) and sector 20 (Wholesale Trade). The key sectors of China and Africa in the world economy (Table 4) are not all necessarily sectors with a higher VS share, such as sector 1 and sector 20. The reason why non-manufacturing sectors have a higher VS share may be attributable to their high degree of import density. However, the sectors with a higher VS share in China and Africa are in fact key sectors either in the global or in the national economy.

Our earlier analysis confirms that international and national economies benefit from sectors in China and Africa which, at the global level, are closely linked economically. This is reflected in the annual growth rate of China's economy of 9.9 percent in the last three decades (Lin, 2010). Other developing countries could derive some lessons from China and participate in the international production process to accelerate the pace of their economic growth.

## 6. Conclusion and research extension

This study has analysed the economic linkages of Africa and China based on the most recent World Input-Output Database (WIOD) and UNIDO INDSTAT database. Since the MVA of 40 out of the 41 countries/regions included in the WIOT account for more than 90 percent of world MVA, we assume that the ROW represents Africa's developing countries. Building on the recent release of the World Input-Output database, we examine the economic linkages of countries based on two channels by applying input-output techniques: key sector analysis and VS share calculation. By comparing the level of Africa's and China's economic linkages with other countries, this paper also aims to depict China's successful development experience from which developing countries can draw lessons.

**Figure 8 Average VS share at sector level in China and Africa from 1995 to 2009**




*Source*: Calculated by author based on UNIDO MVA database

The analyses show that both China's and Africa's key manufacturing sectors benefiting the world and national economies. In addition to the manufacturing sectors, Africa's agricultural sector and some services sectors are important to their national economy. China's manufacturing sectors, on the other hand, are the leading sectors in the global and in their national economy. Fostering economic linkages with other countries benefits both the global and national economies.

To determine the extent of a country's economic linkages with other countries, the vertical specialization (VS) share is used. The VS shows the degree to which China and Africa are involved in the global production process. The results indicate that both China's and Africa's key manufacturing sectors have relatively higher VS shares than the other sectors. This, in turn, implies that countries benefit more from manufacturing sectors with a higher degree of involvement in the global production process. Our results also show that China's manufacturing sectors, which have higher VS shares than Africa, has moved into more sophisticated assembly and processing activities. Given the fact that China's GDP rate has been rapidly growing in the last three decades, developing countries could draw important lessons from China's development experience.

Applying input-output techniques, this paper seeks to investigate Africa's economic linkages with other countries to provide input for further policy development to promote economic growth. A number of issues need to be considered for further analysis. This study has only applied Leontief's demand-driven input-output model to define the key sectors in an economy and to analyse the level of a country's participation in vertical specialization. Further research could extend the analysis to include the supply-side by applying Ghoshian's input-output model. On the other hand, data limitation prevents in-depth analysis for certain African countries, making it difficult to gain further insights and a more detailed picture of the extent of economic linkages. Therefore, developing African countries' capacity to produce their own input-output tables will be a long-term challenge.

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