Globalisation, innovation activities and the technology gap between Sub-Saharan Africa and the industrialised countries

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Abstract: Previous empirical studies focus on the impact of globalisation on economic growth. This paper contributes to the empirical literature by examining the hypothesis that globalisation widened the technology gap between Sub-Saharan Africa (SSA) and the industrialised countries from 1980 to 2002. To investigate this hypothesis, the measures of technology gap and globalisation are identified and the Least Squares Dummy Variable (LSDV) and Seemingly Unrelated Regressions (SUR) panel data models are used. Our main result shows that globalisation widens the technology gap between SSA and the rest of the world. This result may be due to the weakness of technology inflows and innovation and imitation activities in the SSA.

1 Introduction

> "Recent findings indicate that almost 60 per cent of the differences in income levels between Sub-Saharan African (SSA) and the industrialized countries can be attributed to differences in the stock of knowledge." (UNESC, 2006, p.3)

United Nations Economic and Social Council (UNESC, 2006) defines the technology gap as "the divergence between nations and communities in their abilities to access, diffuse, and use scientific and technical knowledge". United Nations Conference on Trade and Development (UNCTAD, 2003) indicates a growing technology gap between African countries and the rest of the world. This growing and large gap is mainly due to the weakness of technology activities, technology inflows, human capital level, and industrial performance in African countries. UNCTAD (2005) shows that the share of Africa in R&D expenditure in developing countries dropped from 2.2% in 1996 to 1.9% in 2002. In addition, the UNCTAD Innovation Capability Index (UNICI), which captures two main dimensions: technological activity and human capital, shows that Sub-Saharan Africa (SSA) is at the bottom of the ranking. In other words, the UNICI indicates a large technology gap between SSA and other developed and developing regions.

Previous studies did not extensively discuss the impact of economic globalisation on the technology gap between rich and poor countries in both theoretical and empirical points of view. They focused on the impact of globalisation on economic growth (see, for example, Dreher, 2006; Elmawazini *et al*., 2007). To avoid this limitation this study will empirically investigate globalisation as a channel of the technology gap between SSA and developed and developing regions. To achieve this goal, this paper proceeds in the following way. Section 2 discusses the empirical difficulties in testing the technology gap between poor and rich poor countries. Section 3 is the empirical specification. Section 4 is the data. Section 5 is the empirical findings. Section 6 is the conclusion and recommendations.

2 The empirical difficulties in measuring the technology gap between SSA and other developed and developing countries

> "The technology gap approach, following Schumpeter [27–29] analyses economic growth as the combined result of two conflicting forces; innovation which tends to increase technological gaps, and imitation or diffusion which tends to reduce them." (Fagerberg, 1987, p.92)

This section will discuss the measures of technology gap. Technology gap between poor and rich countries can be measured in terms of innovation activities, technology licensing, human skills, and technological structure of manufactured exports (UNCTAD, 2003). In addition, some previous studies uses total factor productivity as measures of technology gap between poor and rich countries. We will discuss the limitations of these measures in the following subsections.

2.1 Innovation and imitation activities

> "The monopolistic structure of the international market for technology tends to result in a cumulative widening of differences in technological capabilities between developed and developing countries." (Griffin and McKinley, 1993, p.2)

R&D is considered a main indicator of innovation and imitation activities. R&D expenditure to GDP may reflect the role of governments in creating and diffusing technology. The increase in spending on R&D may improve the technological capabilities of local firms. There is a difference between the role of host governments in developing and developed countries. In developed countries, business enterprises have a significant role in R&D activities. R&D expenditure of private enterprises is about 60% of total R&D expenditure in developed countries in 1995 (Lall, 2001). Lall (2001) indicates that governments in developed countries often help these enterprises that carry out R&D by providing financial assistances.

In contrast, in most developing countries, the government laboratories and universities dominate the significant part of R&D activities where most R&D activities are performed and funded by government institutions. This indicator suffers from two problems. First problem is the poor quality data and the annual time-series before the early of 1990s are not available for most developing countries (World Bank, 2005). The second is that adding military R&D will lead to misguided results in the case of cross-country comparisons (Fagerberg, 1987). For example, Japan will obtain a lower rank relative to other developed countries if we add military R&D to the total R&D expenditure.

R&D expenditures in the USA, Japan, Germany, France, and the UK equal 85% of all R&D expenditures in all OECD countries (Griffin and McKinley, 1993). At the same time, the number of scientists and engineers in R&D in OECD countries is more than 17 times their numbers in developing countries during the period 1987–1997 (UNDP, 2001). In general, high R&D concentration and expenditure in developed countries are considered the main reason for the significant difference in technological levels and capabilities between developed and developing countries and regions. Innovation and R&D activities are considered the engine of economic growth (Jones, 1998). Lall (2001) mentions the following facts to explain the domination of FDI companies in R&D and innovation activities:

- Fifty Multinational Enterprises (MNEs) (from over 41 thousand) dominate more than half the R&D activities in USA.
- Four MNEs account for 70% of R&D in the Netherlands.
- Only three MNEs dominate more than 80% of R&D in Switzerland.

The above examples show that not only does the international market for technology has a monopolistic structure but also do local markets.

2.2 Technological structure of manufactured exports

High-technology exports as a share of manufactured exports can reflect the level of technology diffusion (UNDP, 2001). It can also reflect the technological and competitive capabilities of local firms. Hejazi and Safarian (1999) show that Foreign Direct Investment (FDI) and international trade are concurrent sources of international technology diffusion. Similar results can be found in Lichtenberg and van Pottelsberghe del la Potterie (1998). UNCTAD (2003) indicates that the share of SSA in developing countries' high technology exports declines from 1.3% in 1980 to 0.3% in 2000. In terms of export structure, the high-technology exports as a share of manufactured export in East Asia and Pacific, Latin America and Caribbean, South Asia, SSA in 2004 is 33%, 13%, 4%, and 4% respectively (UNDP, 2006). This implies that the technology diffusion level in SSA lags behind many all other developing regions, except South Asia.

2.3 Technology licensing

Receipts of royalties and license fees from abroad per 1000 people can reflect the ability of a country to create advanced technology. It measures the successful innovations made by individuals and firms. With this in mind, this indicator can also measure the technology gap between developing and developed countries (UNDP, 2001).

Both R&D and the receipts of Royalties and license fees are considered as measures of technological level. However, there is a difference in the scope of the measurement. R&D is considered a 'technology input' measure; it measures the innovation and imitation capabilities (Fagerberg, 1987). On the other hand, receipt of Royalties and license fees from abroad per 1000 people is considered a 'technology output' measure; it only measures innovation activities and capabilities. It is well-known that technological innovation may affect economic growth through productivity gains. However, developing countries may generate their technological capabilities by imitation rather than innovation (Barro and Sala-i-Martin, 1997).

2.4 Human skills

Many previous studies measure measured the human capital level by male secondary school attainment in the population over age 25 (*e.g.*, Borensztein *et al.*, 1998; Xu, 2000). It is well-known that Human Development Index (HDI) measures human capabilities and poverty reduction. Technological achievements and productivity gains have a high correlation with the human development index (UNDP, 2001). Moreover, the relationship between HDI and productivity is stronger than that between HDI and economic growth (CSLS, 2003).

HDI can be considered an indicator to evaluate the success of government policies in poverty reduction and in developing the human skills base. Therefore, HDI is a more general indicator than average years of secondary schooling in the male population (Elmawazini, 2005). It is clear that the human skills can be acquired not only by formal education but also by training and work experience (Jones, 1998). On the other hand, HDI not only reflects the level of education, but also healthcare and economic conditions. Healthcare and economic conditions may affect productivity and technology diffusion by providing an environment that makes people more innovative (UNDP, 2001). This may explain why HDI is more general than average years of secondary schooling in the male population.

2.5 Productivity and income gaps

Li and Liu (2005) use GDP per capita as a measure of technology gap. However, it is clear that this measure is not good proxy for the technological capabilities of a country. For example, many oil exporter countries have high income per capita (*e.g.*, Arab Gulf countries) but the technological capabilities of local firms in these countries are very weak. Some previous studies (*e.g.*, Kokko, 1994; Girma *et al.*, 2001) measure the technology gap by the labour productivity gap. The main result of these studies is that domestic firms may not benefit from the technology diffusion from foreign firms if the technology gap between them is significant.

Xu (2000) uses total factor productivity for a country relative to total factor productivity of the USA as a measure of technology gap. Jones (1998) found that the residual from growth accounting in France, the USA, and Japan are similar to Hong Kong, Taiwan, and South Korea respectively in 1990. Jones concludes that it is more accurate to name this residual as total factor productivity level 'instead of' technology level. Similar conclusion can be found in Lipsey and Carlaw (2000).

The above discussion in this section reveals that the receipts of royalties and license fees from abroad per 1000 people is more appropriate than other measures to captures the technological capabilities of a country. In the following section, the impact of globalisation on the technology gap between SSA and the rest of the world will be examined using panel data analysis.

3 Empirical specification

To examine the impact of economic globalisation on the technology gap between the SSA countries from 1980 to 2002, we use the following panel data regression is:

$$Tech\_Gap_{it} = \sum_{J=1}^{N} \beta_{0j} D_{jt} + \beta_1 \text{ Glob\_Index}_{1,it} + e_{it}. \quad (1)$$

GAP is the relative technology gap between US and African countries, measured by the receipts of royalty and license fees. The measures of technology gap are discussed in the previous section. D_{jt} are cross-section dummy variables. When j = i, $D_{jt} = 1$ and otherwise $D_{jt} = 0$. Glob_Index is the globalisation index that is constructed by Dreher (2006). Previous studies focus on individual sub-dimensions of globalisation (*e.g.*, Borensztein *et al.*, 1998; Dollar and Kraay, 2001). To overcome this limitation, this study uses Dreher (2006) globalisation index to examine the overall impact of globalisation on the technology gap between SSA and industrialised countries. The construction of this index will be discussed in the next section.

4 Data

The dataset of this study contains data for five SSA countries: *Côte d'Ivoire, Kenyea, Madagascar, Sengal, and South Africa*. *Tech_Gap* variable is the receipts of royalty and license fees collected from World Bank (2005). IMF (1993) defines the receipts of Royalties and license fees as "The receipts by residents from non-residents for the authorized use of intangible, non-produced, non-financial assets and proprietary rights and for the use, through licensing agreements of produced originals of prototypes."

We use data from Dreher (2006) for globalisation index. Principal components analysis is used to determine the weight for each variable. Dreher (2006) globalisation index captures the economic, social, and political dimensions of globalisation. Each dimension has number of variables. The weights of economic, social, political dimensions are 36%, 38%, and 26% respectively. Economic dimension is calculated based on two indexes: actual flows and restrictions. The actual flows index is calculated based on the following variables: trade openness, foreign investment, and income payments. The restriction index is calculated based on hidden import barriers, mean tariff rate, and taxes on international trade.

Social dimension is calculated based on three sub indexes: personal contact index, information flows index, cultural proximity index. To construct the personal contact index, the following five variables are used: outgoing telephone traffic, transfers, international tourism, foreign population, and international letters per capita. To construct information flows index, the following five variables are used: internet hosts per 1000 people, internet users per 1000 people, cable television per 1000 people, trade in newspapers, and radios per 1000 people. The cultural proximity index is calculated based on the following three variables: number of McDonald's restaurants (per capita), number of IKEA per capita, and trade in books.

Political dimension is calculated based on three variables: embassies in country, membership in international organisations, and participations in UN Security Council Missions. It is clear that this index allows us to measure the overall impact of globalisation on developing and developed countries. Table 1 is the Dreher (2006) globalisation index for five SSA countries.

Table 1 Globalisation index

Year	*Côte d'Ivoire*	*Kenya*	*Madagascar*	*Senegal*	*South Africa*
1980	29.22	29.76	15.69	31.51	38.83
1981	29.27	28.52	15.81	33.77	38.17
1982	30.04	27.94	14.97	33.69	37.31
1983	30.70	29.46	15.63	31.73	35.82
1984	31.24	28.57	17.03	34.25	34.08
1985	32.34	29.73	15.78	31.35	33.31
1986	32.79	29.47	16.92	30.25	34.86
1987	33.44	29.84	17.87	29.88	34.98
1988	33.21	32.85	17.95	34.79	35.59
1989	32.47	35.14	18.55	35.40	35.37
1990	33.24	35.62	18.24	34.35	35.95
1991	34.56	39.87	19.78	35.33	38.17
1992	33.71	39.45	19.54	36.99	38.94
1993	35.52	43.40	20.21	35.53	37.59
1994	37.22	42.80	20.38	39.69	38.59
1995	38.03	43.36	20.89	39.52	45.96
1996	38.64	41.65	21.86	39.87	48.22
1997	39.58	41.36	23.96	43.24	52.37
1998	43.04	41.16	23.96	43.13	53.22
1999	43.89	42.08	25.74	45.08	59.65
2000	43.80	44.38	27.91	47.00	60.96
2001	45.32	45.67	32.43	46.31	64.08
2002	46.52	47.40	28.13	49.73	61.92

Source: Dreher (2006)

5 Empirical findings

The data for the five SSA countries from 1980 to 2002 are pooled. Since our data set has time periods relatively large to cross sections, Least Squares Dummy Variable (LSDV) model generates *very similar results* to the random effects model (Kmenta, 1986). However, both models do not consider the cross section correlation. This may lead to inefficient results (Greene, 2000). To avoid this limitation, we use Seemingly Unrelated Regressions (SUR) model. LSDV and SUR models are discussed in Greene (2000). Table 2 presents results from LSDV and SUR panel data models.

Table 2 Presents panel data regressions results for the *technology gap* variable

Regression method	*LSDV model (Regression 5.1)*	*Seemingly Unrelated Regressions (SUR) (Regression 5.2)*
Glob_Index variable	0.17495E-04	0.84049E-05
	(2.850)	(3.454)
R^2	0.7489	0.5080*
DW	1.2996	2.0371
Von Neumann ratio	1.3110	2.0549
Number of observations	115	115

Notes: * Buse Raw-Moment R^2.
Values in parentheses are t-statistics.

The Lagrange multiplier test for cross-section heteroskedasticity, Durbin-Watson (DW) test, and Von Neumann ratio indicate that there is an evidence to reject the hypotheses of homoskedasticity and no serial autocorrelation. In addition, Breusch-Pagan LM test for diagonal covariance matrix shows that there is an evidence of contemporaneous correlation. The misspecification of the LSDV model may lead to the autocorrelation, cross-section heteroskedasticity, and contemporaneous correlation problems.

To overcome the misspecification of the LSDV model, seemingly unrelated regressions model is used. The results of regressions (5.1) and (5.2) indicate that globalisation widens the technology gap between the five SSA countries and the USA. This result may be due to the weakness of technology inflows, human capital level, and innovation and immitation activities in the SSA (see Section 2). This result supports the results of some previous studies (Stiglitz, 2001; Elmawazini *et al.*, 2007). In addition, the result supports the results of UNESC (2006), which argues that the income gap between SSA and the industrialised countries is due to the differences in the stock of knowledge.

6 Conclusion and recommendations

Previous studies did not empirically investigate globalisation as a channel of the technology gap between developing and industrialised countries. This paper attempts to overcome this limitation by investigating the overall impact of globalisation on the technology gap between SSA and industrialised countries during 1980–2002. The seemingly unrelated regressions panel data model shows that globalisation contributes to the growing technology gap between SSA and industrialised countries. This result supports Joseph E. Stiglitz, the 2001 Nobel laureate, who argues that globalisation, leads to a growing gap between rich and poor countries.

IMF (2008) indicates that the slowdown of the world economy, the increase in oil and food prices, and the political instability are the main challenges for many SSA countries, especially non-oil exporters' countries. This may widen the gap between SSA and the rest of the world. The role of government is crucial to narrowing the income and technology gaps between SSA and the rest of the world. The governments must increase their expenditure on education, training, and on imitation and innovation activities. This task could be too difficult if rich countries and international organisations do not increase their financial and technical assistances to poor countries. It is well-known that most rich countries have failed to spend 0.7% of their GNI on Official Development Assistance (ODA) since 1970. The long-term financing is essential for poor countries to improve their basic infrastructure, human capital level, and the technological capabilities of local firms. Similar and other recommendations can be found in Lall (2001), UNCTAD (2003), and IMF (2008).

SSA countries

According to World Bank (2005), the SSA region includes 48 countries: Angola, Gabon, Niger, Benin, Gambia, Nigeria, Botswana, Ghana, Rwanda, Burkina Faso, Guinea São Tomé and Principe, Burundi, Guinea-Bissau, Senegal, Cameroon, Kenya, Seychelles, Cape Verde, Lesotho, Sierra Leone, Central African Republic, Liberia, Somalia, Chad, Madagascar, South Africa, Comoros, Malawi, Sudan, Democratic Republic of Congo, Mali, Swaziland, Congo, Rep, Mauritania, Tanzania, Côte d'Ivoire, Mauritius, Togo, Equatorial Guinea, Mayotte, Uganda Eritrea, Mozambique, Zambia, Ethiopia, Namibia, and Zimbabwe. As a result of the unavailability of data, this study examines the impact of globalisation on the technology gap between industrialised countries and the following five SSA countries: Côte d'Ivoire, Kenyea, Madagascar, Sengal and South Africa.

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