Ethiopian Journal of Economics

Volume XVII | Number 2 | October 2008

Ethiopian Journal of Economics

Volume XVII Number 2 October 2008

ETHIOPAN ECONOMICS ASSOCIATION

ISSN 1993-3681

Volume XVII Number 2 October 2008

Ethiopian Journal of Economics

A Publication of
THE ETHIOPIAN ECONOMICS ASSOCIATION
(EEA)

ETHIOPIAN JOURNAL OF ECONOMICS

VOLUME XVII NUMBER 2 October 2008

Published: August 2009

DETERMINANTS OF VERTICAL AND HORIZONTAL EXPORT DIVERSIFICATION: EVIDENCES FROM SUB-SAHARAN AFRICA AND EAST ASIA[1]

Aye Mengistu Alemu[2]

Abstract

This paper analyzes the main determinants of vertical and horizontal export diversification based on a balanced panel data for 41 countries from SSA and East Asia over the period 1975-2004; using FGLS estimation methods with corrected heteroskedasticity and autocorrelation. The results reveal that education, health, and income per capita, population size, infrastructural development and openness are crucial factors to induce vertical as well as horizontal export diversification. FDI was found to be a key factor to speed-up vertical and horizontal export diversification in East Asia, but only for vertical diversification in SSA. The elasticity's of human capital and FDI were much higher in East Asia than SSA. The intuition is that East Asian countries have devoted significant amount of investment on education, health, infrastructure and these in turn created a better conducive atmosphere for FDI inflow. The study also reveals domestic investment plays an important role to enhance vertical as well as horizontal export diversification for East Asia, while it only induces horizontal diversification for SSA. While 'arable land' resource has a positive and significant effect on vertical and horizontal diversification, 'oil' wealth was found to be negatively associated with export diversification. This implies that not all types of natural resource endowment have a 'Dutch disease' effect. While inflation, exchange rate, and foreign aid variables have a mixed effect on vertical and horizontal export diversification, political instability however has a strong adverse effect on export diversification; especially for SSA. The key lesson from East Asia to SSA is that investment on human capital and physical infrastructure through foreign investment as well as domestic capital formation are key ingredients, as are stable macro-economic and political environment, a stable and flexible exchange rate, and a fair and an open trading framework in order to accelerate vertical and horizontal export diversification and ultimately promote structural change on the economy. In line with this, SSA countries should follow a dual strategy of vertical and horizontal export diversification, mainly by supporting backward and forward linkages into higher value-added resource-based industries and gradually shift production and exports from customary products to more dynamic ones by developing competitive advantage in the world market.

Keywords: *Domestic Capital; Human Capital; FDI; Infrastructure; Inflation; Exchange Rate; Natural Resource Endowment; Foreign Aid; Vertical/Horizontal Export Diversification; Sub-Saharan Africa; East Asia*

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[1] The final version of this article was submitted in April 2009.
[2] PhD Candidate, Graduate School of Asia Pacific Studies, Ritsumeikan Asia Pacific University, Beppu-shi, Oita-ken, Japan
Postal Address: Kannawa-Miyuki, 5 Kumi, AP Matsumi (Room 202)
Beppu-shi, Oita-ken, 874-0045
E-mail: ayemeng@yahoo.com
*The author would like to thank the anonymous referee for his/her valuable comments which have improved my manuscript.

1. General background

The development experiences of East Asian countries are relevant for Africa today, because these countries at their early stages of development shared certain similarities with many African countries. At the time of their independence in the 1960s, income per capita in most Sub-Saharan Africa (SSA) was fairly comparable with that of East Asia. In fact, in the mid-1960's, the average income in sub-Saharan Africa was twice that of both South and East Asia while the average income in Africa is now well below half of that in East Asia (Commission for Africa, 2005). Accordingly, in the 1960s, much of the expectation was from SSA to perform more economic achievement than East Asia because of its large endowments of natural resources. As a matter of fact, in the early 1970s, many countries in Africa could point to significant progress in initiating process of economic and social development. Some level of industrialization had been initiated, levels of school enrolment had increased, new roads had been constructed, the indigenization of the civil service had advanced, and so forth. Furthermore, up to 1975, much of the investment in SSA was financed with domestic savings; thus, savings and investment during the period were relatively highly correlated (Mkandawire and Soludo, 1997).

Unfortunately, the prospect of African development that was promising in the 1960s and early 1970s couldn't be sustainable and suffered a huge set-back due to structural, institutional, political, and policy constraints that will be thoroughly discussed in this thesis. Although there are considerable differences among the East Asian economies, but as a group, the East Asian economies[3] consistently outperformed other developing regions since the 1960s, and their achievement has attracted the attention of policy makers everywhere. Hence, the East Asian economies have achieved a sustained and rapid growth in per capita income, undergone structural change on their economy and diversified their economic base over the last four decades. On the contrary, countries in SSA experienced with severe stagnation in the levels of per capita income, extreme poverty and trade volatility as a result of too much dependency on export of few primary commodities.

Hence, the annual growth in Real GDP per capita of SSA averaged about 0.44% over the period 1975-2004, compared to about 4.1% for East Asian economies during the same period. Thus, starting from quite similar per capita income in the early 1960s; East Asia and SSA have experienced a divergent development path and outcome.

[3] The 10 East Asian economies are China, Hong Kong, Taiwan, Indonesia, Japan, Korea, Malaysia, the Philippines, and Thailand. Japan is included because it made the transition to high-income status in the past four decades.

The growing divergence in income per capita for selected East Asian and SSA countries is more evident in Table 1 below.

Table 1: Per Capita income in 1965 and 2000 (in current US$)

Country	1965	2000	2000/1965
Sub-Saharan Africa			
Cameroon	140	580	4.1
Congo, Rep.	170	590	1.7
Congo, Dem. Rep.	330	90	0.3
Cote D'Ivoire	200	680	3.4
Ghana	230	330	1.4
Niger	180	180	1.0
Nigeria	120	260	2.2
Sierra Leone	160	130	0.8
South Africa	540	3,060	5.7
East Asia			
Japan	910	35,420	38.9
Korea, Rep.	130	9.010	69.3
Hong Kong, China	690	26,410	38.3
Singapore	540	23,350	43.2
China	100	840	8.4
Malaysia	330	3,250	9.8
Thailand	140	2,020	14.4

Source: World Development Indicators Database

In 1965, for instance, Korea Republic and Thailand had income per capita of $130 and $140 respectively; which had been lower than some SSA countries such as Ghana, Congo Republic, Cote d'Ivoire, Congo Democratic Republic and Sierra Leone. However, in year 2000, Korea and Thailand have registered a per capita income of $ 9,010 and $2,020 respectively. In the same time span, however, Ghana, Congo republic, Cote d'Ivoire have managed to increase their per capita income from $230, $170 and $200 only to $330, $590 and $680, respectively. In fact, Congo Democratic Republic and Sierra Leone didn't maintain the income per capita they had before 35 years and even went down from income per capita of $ 330 and $ 160 in 1965 to $90 and $130 in 2000, respectively. By the same token, South Africa which is regarded as the best economy in Africa and Singapore in East Asia had exactly equal income per capita of $ 540 each in 1965. In year 2000, however, South Africa registered a per capita income of $3,060 where as Singapore achieved a per capita income of $ 23,350 which was almost 7.6 times the performance of South Africa. Likewise, Sub-Saharan Africa's share in world exports fell from about 3.7% in 1980 to 1.5% in

2002, while East Asia's share in world exports increased from 17.9% to 23.3% in the same period. Similarly, Sub-Saharan Africa's share in world imports fell from 3.1 % in 1980 to 1.4% in 2002, while East Asia again increased its world import share from 13.1% to 20.8% in the same time span (Table 2).

Table 2: Shares of SSA and East Asia in World Merchandize Trade, 1980-2002

Year	Export			Import		
	World	East Asia	SSA	World	East Asia	SSA
1980	100	17.9	3.7	100	13.1	3.1
1985	100	15.6	2.5	100	15.2	2.1
1990	100	16.9	1.9	100	15.9	1.6
1995	100	21.6	1.5	100	21.9	1.6
2000	100	24.3	1.5	100	21.1	1.3
2002	100	23.3	1.5	100	20.8	1.4

Source: UNCTAD Hand Book of Statistics, UNCTAD database

Though many developing regions, particularly East Asia have been transformed from exporters of primary products to manufactured products for the last three decades, Africa hardly benefited from the boom in manufactured exports. At around 30 per cent in 2000, the share of manufactured exports in the continent's total merchandise exports had increased by only 10 percentage points compared to 1980 shares. The continent's share in world merchandise exports fell from 6.3 per cent in 1980 to 2.5 per cent in 2000 in value terms (Table 1.3). Similarly, Africa's share of total developing-country merchandise exports fell to almost 8 per cent in 2000, nearly a third of its value in 1980, while the share of world manufactured exports remained a little below 1 per cent. In contrast, East Asia's performance has been important with respect to both total merchandise exports and manufactures. Its share of global merchandise exports increased from 18 per cent in 1980 to 22 per cent in 2000, while its share of total developing-country merchandise exports increased from almost 60 to 72 per cent over the same period. Similarly, its share in global manufactures trade increased threefold, reaching 21.5 per cent in 2000 (Table 3). The value of East Asia's total exports recorded 7 per cent average annual growth over the period under review, compared to a mere 1 per cent for Africa.

Among all developing regions in the world, it is Africa that has the lowest share of manufacturing exports to total merchandise exports as shown in Figure 1. Whereas; East Asia has achieved a radical economic structural change and being 'center of excellence' in manufacturing products of all the developing world.

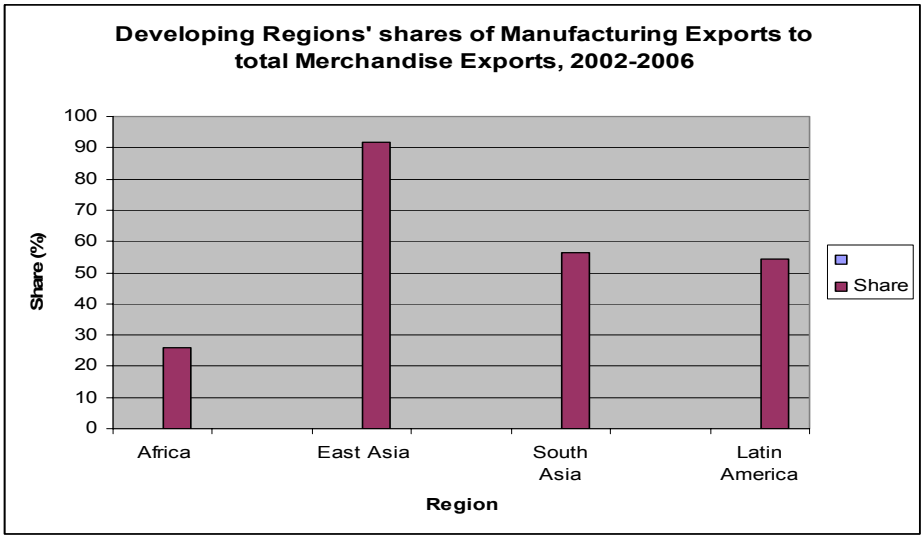
Table 3: Export structure of Africa and East Asia by product category, 1980 and 2000

Region	1980		2000	
	All Merchandise[a]	Manufactures[b]	All Merchandise[a]	Manufactures[b]
Africa share in:				
Global exports	6.3	0.8	2.5	0.8
Developing Countries	20.3	7.8	7.9	3.0
Developing Asia share in:				
Global exports	18.1	7.1	22.4	21.5
Developing Countries	58.5	66.9	72.0	79.0

Source: UNCTAD (2003)

'a' refers Standard International Trade Classification (SITC) 0–9., and **'b'** refers SITC 5–8, less 68.

Figure 1: Developing regions' shares of manufacturing exports to total exports, 2002-2006.



Source: UNCTAD (2008a)

What is more important is that the ratio of exports to GDP increased continuously in all East Asian countries in the past four decades as shown in Table 4. It is salient, for example, how Thailand increased its ratio of exports to GDP from 13 to 16, to 21 and to 31 and finally to 52 % (Table 4).

Table 4: East Asian Countries increases in exports with respect to GDP (in %)

Exp/GDP	Period				
	1961-70	1971-80	1981-90	1991-97	1998-2001
China	N/A	5.6	10.3	19.1	20.6
Hong Kong	55.6	64.1	90.0	116.8	114.6
Korea	5.5	22.8	30.9	25.1	37.5
Singapore	105.9	113.1	138.4	135.0	140.8
Indonesia	11.1	23.1	22.7	23.2	42.1
Malaysia	42.9	44.2	53.3	75.3	104.2
Thailand	13.8	16.3	21.6	31.6	52.4
Philippines	11.4	15.4	16.4	22.5	48.2

Source: Sandee and Wengel (2004)

In line with this, international competitiveness of selected countries in the two regions has been displayed in Table 5. Interestingly, it has been evident that most of the East Asian countries had a negative international competitiveness index in the 1960's, just similar to the African countries. However, East Asian countries have managed to overcome their structural constraints and become internationally competitive; while their African counterparts are still experiencing negative competitive indexes which confirm the country's position as net importers of consumer and capital goods.

Table 5: International competitiveness index for selected SSA & East Asian Countries, 1965 and 2004

Sub-Saharan Africa			East Asia		
Country	**1965**	**2004**	**Country**	**1965**	**2004**
Cameroon	-0.38	-0.06	Indonesia	-0.38	0.17
Ethiopia	-0.36	-0.62	Japan	0.07	0.1
Ghana	-.53	-0.70	Korea Republic	-0.33	0.06
Kenya	-0.25	-0.24	Malaysia	-0.01	0.07
Mauritius	-0.82	-0.69	Singapore	-0.11	0.08
Nigeria	-0.49	0.24	Thailand	-0.09	0.01
Senegal	-0.62	-0.21	Taiwan	0.09	0.11
South Africa	-0.04	0.06	The Philippines	-0.25	-0.04

Source: Own calculation based on the data obtained from UNCTAD Handbook of Statistics (2004)
Note: International Competitiveness Index (ICI) is expressed as: (X-M)/ (X+M) where X and M are exports and imports respectively.

Generally, the value-added export oriented activities that have driven many dynamic developing economies are conspicuously absent in SSA. Linkage between local

industries remains minimal and mostly superficial. The technological level of the existing industrial activities remains generally low.

The East Asia's success on one hand and the SSA's low performance on the other hand raises some crucial questions: Was the nature of policy package in East Asia very different from Sub-Saharan Africa? Were the effects of government interventions very different in East Asia? What might account for these differences between East Asia and Sub-Saharan Africa? Some economists argue that their rapid growth is explained by their ability to imitate foreign technologies. By adopting technology developed abroad, these countries managed to improve their production function substantially in a short period of time. In other words, these countries achieved a very rapid growth in total factor productivity (TFP). On the other hand, recent studies revealed that their exceptional growth can be traced to large increases in measured factor inputs: increases in labor-force participation, increases in the capital stock, and increases in educational attainment (Mankiw, 2003:234). However, although countries in East Asia had higher investment rates than others did, they had also a spectacular productivity growth far better than any developing countries (Thomas and Wang, 1997). Overall, East Asia's success was attributed to: (i) mobilization of domestic savings for investment including human capital and physical infrastructure; (ii) large FDI inflow used as alternative source of foreign currency and capital formation); (iii) shifting resources from less productive sectors to more productive sectors (vertical diversification); (iv) export-led growth; (v) sound macro-economic management (WB, 1993; Stiglitz et al, 2006) ; and (vi) Japan's role as a leading goose for East Asian development (Kwan, 1998).

On the other hand factors attributed for SSA's weak economic performance and poverty trap include: (i) the level of physical and human capital is so small that it falls below the threshold needed to start modern production process; (ii) very low levels of savings; (iii) high rates of population growth; (iv) a very low diffusion of technology from abroad (Sachs et al, 2004); (v) unfavorable economic policies; (vi) narrow based economy; and (vii) absence of a leading goose that may lead the flocks in the continent.

Furthermore, the macro-economic policies followed by most of SSA countries until the 1990's had been un-favorable to economic growth. Imports and exports were subject to severe restrictions and under state ownership or control, the high walls of tariffs and export taxes that restricted international trade, over-valued exchange rates, wide margins for marketing parastatals, price and quantity controls that were aimed primarily at reducing food prices for urban consumers.

One of the most remarkable features of growth in East Asian countries is that, it was accompanied by rising economic equality (Gerber, 2005). Since the 1950s pioneering work of the economist Simon Kuznets, it was thought that growth in developing countries would first result in falling economic equality, followed later by rising equality (U-Curve relationship between income and equality). While Kuznet's work was based on measurements from a large number of countries, the East Asian experience has called into question the idea that economic growth in developing countries follows a "Kuznet's curve," in which equality first declines and then rises. Although the conditions that led to greater income equality were rooted in the unique historical experiences of each country, it is also evident that each of the East Asian countries had a similar set of highly visible wealth-sharing mechanisms such as land reform, free public education, free basic health care, and significant investments in rural infrastructure.

For all regions, it is Africa where income is most un-equal as measured by the Gini coefficient of 0.51 (Table 6). Uneven distribution of income in turn has perpetuated poverty and alienation in SSA. An increasing income inequality in Africa is mainly caused by concentration of the handful economic establishments including those few industrial plants and modern infrastructure in one or two urban conglomerations. Such inequality existed not only along regional lines, class, and ethnicity, but also going gender lines and hence modern formal sector employment in Africa continued to be a largely male domain" (Mkandawire and Soludo, 1999). Moreover, where regions were conterminous with ethnicity, such an uneven development could only fan the flames of ethnic conflicts

Table 6: Income Inequality Measures by World Regions

Region	Gini Coefficient	Share of top 20 %	Share of Middle Class	Bottom 20 %
Africa	0.51	50.6	34.4	5.2
East Asia and Pacific	0.38	44.3	37.5	6.8
South Asia	0.32	39.9	38.4	8.8
Latin America	0.49	52.9	33.8	4.5
Industrialized Countries	0.34	39.8	41.8	6.3

Source: Deininger and Squire (1996)

Sub-Saharan African countries have still remained dependent on export earnings from a narrow base of few agricultural and mineral commodities for foreign exchange earnings (Table7) and have had to endure the consequences of all problems resulting from the fluctuation of commodity prices in world markets.

About 17 of the 20 most important export items of Africa are primary commodities and resource-based semi-manufactures. In 1965 for instance, primary products account for 92% of Africa's merchandise export, and in 1988 it was still 88%. On average, world trade in these products has been growing much less rapidly than manufactures. In fact, world trade in other primary commodities that account for an important proportion of total exports of Africa, particularly agricultural products such as coffee, cocoa, cotton and sugar, has been sluggish, with the average growth of trade in such products in the past two decades barely reaching one-third of the growth rate of world trade in all products (UNCTAD, 2003). World prices for many of the commodities that Africa exports declined between 1990 and 2000: Cocoa, Cotton, sugar and copper by over 25%, coffee by 9% and minerals overall declined by 14% (WTO, 2001). As noted by Ng and Yeats (2002), one-half of traditional products in SSA experience average price changes of 50 % or more during the 1990's.

Table 7: Main exports of selected Sub Saharan Africa countries

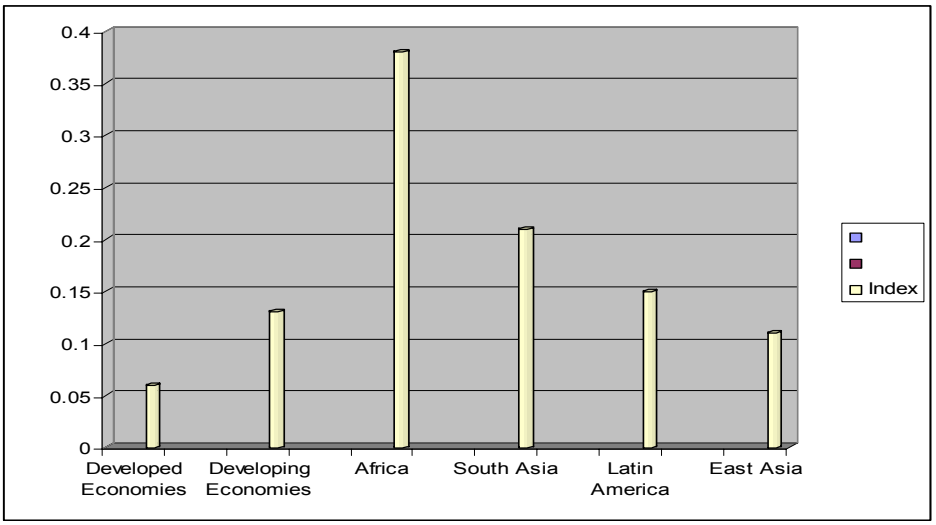
Country	Exports
Angola	Oil, Diamonds, Minerals, Coffee, Fish, Timber
Benin	Cotton, Palm oil
Botswana	Diamonds, Copper, Nickel, Beef
Burkina Faso	Cotton, Animal Products, Gold
Burundi	Coffee, Tea, Sugar, Cotton, Hides
Chad	Cotton, Oil, Livestock, Textiles
Congo, Dem. Rep	Diamonds, Copper, Coffee, Cobalt, Crude oil
Congo, Rep.	Oil, Timber, Plywood, Sugar, Cocoa, Coffee, Diamonds
Cote d'Ivoire	Cocoa, Coffee, Tropical woods, Petroleum
Equatorial Guinea	Petroleum, Timber, Cocoa
Ethiopia	Coffee, Hides, Oil seeds, Beeswax, Sugarcane
Gabon	Crude Oil, Timber, Manganese, Uranium
Kenya	Tea, Coffee, Horticultural products, Petroleum products
Mali	Cotton, Gold, Livestock
Mauritius	Sugar, Clothing, Tea, Jewelry
Niger	Uranium, Livestock products
Nigeria	Petroleum, Petroleum products, Cocoa, Rubber
Rwanda	Coffee, Tea, Hides, Tin ore
Senegal	Fish, Peanuts, Petroleum products, Phosphates, Cotton
South Africa	Gold, Diamonds, Metals & Minerals, Cars, Machinery
Sudan	Oil, Cotton, Sesame, Livestock & Hides, Gum Arabic
Zambia	Copper, Minerals, Tobacco

Source: Osakwe (2007)

Theoretical analysis suggests that agricultural commodity prices fall relative to manufacturing products, because of relatively inelastic demand and because of the

lack of differentiation among producers. On the demand side, the development of synthetic substitutes further displaces agricultural commodities as intermediate inputs, reducing at least the growth in demand. This drastic decrease of the SSA presence in world trade was not only the result of the deterioration of the terms of trades (due to low income elasticity of demand) in primary commodities, but also of the loss of competitiveness in manufactures. Consequently, Africa is the region that has the highest export concentration index in the world followed by South Asia (Figure 2). On the contrary, figure confirms that East Asia is one of the leading regions next to developed economies that have the lowest export concentration index.

Figure 2: Export concentration index by regions/economies of the World, 2006



Source: UNCTAD (2008a)

Africa's export concentration on few primary commodities has led the countries to be more vulnerable for external shocks in addition to low of efficiency and productivity that led the region for further under-development. In line with this, the success of East Asian countries to shift from producing a low productive primary commodities to producing a more productive manufactured products reflects *even latecomers are able to specialize in high growth areas if some of the pre-conditions are fulfilled*. Thus, as Masuyama and Vandenbrink (2001) noted, unless a country diversifies critical supporting industries, the development of few industries alone will not produce growth in the economy. Hence, as Pinaud and Wegner (2004) noted, African economies still lack proper "shock-absorbers" to withstand internal (e.g. drought, floods, and political instability) and external (e.g. volatility of commodity prices and exchange rates) shocks alike. Thus, this situation makes a wake-up call to sub-Saharan Africa to

re-evaluate the economic strategies and policies that have followed in the past with little achievement. Although diversification can't be expected to become the only panacea for SSA economic problems, it is one of the key measures for structural solutions (De Ferranti et al, 2002). Accordingly, the capacity of smoothing shocks highly depends on the ability of African policy makers to diversify their economies. That is why the economic report on Africa (2007) presents the theme of diversification as a new paradigm for Africa's development and the report argues that diversification is a prerequisite to achieving positive development in the continent. The case in point in this paper is, therefore, to examine and assess export diversification based on its vertical and horizontal dimensions and thereby to identify the relevant policy and institutional factors of vertical as well as horizontal export diversification.

1.1 Defining vertical and horizontal export diversification

There are two well-known forms/dimensions of export diversification from the supply side that may take place in developing countries, namely, *horizontal* and *vertical* diversification. Horizontal diversification can be materialized through (i) a larger mix of diverse and complementary activities within agriculture; and (ii) a movement of resources from low value agriculture to high value agriculture. On the other hand, an economy is said to be vertically diversified if and only if that country starts processing and exports value-added products that would have previously been exported in raw forms. Thus, *vertical diversification* involves a radical change in export structure and further uses of existing and new innovative export products by means of value-added ventures such as processing and marketing. Likewise, vertical diversification can also be more linked with higher learning possibilities that, in turn, may produce greater dynamic externalities than that of horizontal diversification. In other words, through forward and backward linkages, production of a diversified export structure is also likely to provide stimulus for the creation of new industries and expansion of existing industries elsewhere in the economy (Hirschman, 1958).

While both horizontal and vertical diversifications are targeted to attain three interrelated objectives: *stabilizing earnings*, *expanding export revenues*, and *upgrading value-added;* however, requirements for the two could vary considerably in terms of technological, managerial and marketing skills. Accordingly, it is vertical integration that may require more advanced technology, skills and initial capital investment than horizontal diversification. Hence, significant amount of investment on human capital through education and high rate of physical capital formation either by raising domestic savings or through FDI are pre-requisites for a country especially to achieve vertical diversification. Most often vertical diversification occurs when country's start processing commodities that were previously exported in raw form

(Cramer, 1999). Fore-example, vertical diversification takes place by moving up the value chain to produce manufactured products as in Korea, China, and Malaysia. This, therefore, put into question for the policy advices of some researchers such as Owens and Wood (1997) that proposed Africa's emphasis should be on horizontal diversification through increasing the number of primary export products. On the other hand, horizontal diversification is achieved by producing non-traditional dynamic exports such as cut flowers as it has been started to be largely produced in Kenya, Uganda and Ethiopia to supplement or partially replace the traditional exports like coffee and tea. Thus, the goals, dimensions and forms of export diversification are clearly shown in Table 8 below.

Table 8: The goals, dimensions and forms of export diversification at country level

Dimension/Goal	Stability-Oriented		Growth-Oriented	
	Based on existing commodities	**Add new commodities**	**Based on existing commodities**	**Add new commodities**
Horizontal Diversification	Adjust export shares based on co-variation of export earnings from individual commodities	Add new commodities (and possibly dispose of existing commodities) based on co-variation of export earnings from individual commodities.	Adjust export shares based on growth rates of export earnings from individual commodities.	Add new commodities based on growth rates of world prices and market niche.
Vertical Diversification	Adjust export shares based on a commodity's ability to be marketed in raw or processed forms in both international and domestic markets.	Add new commodities based on their flexibility to be marketed in raw and processed forms, and to serve international and domestic markets.	Introduce or expand value-added activities and import substitution.	Choose new commodities based on value-added and import substitution potential.

Source: Ali, Alwang and Siegel (1991)

1.2 Research objectives

The main objectives of this study are the followings: (i) it develops a model for identifying the main determinants of vertical and horizontal diversification for East Asia and SSA economies; and (ii) by identifying the main determinants of export diversification, the study will figure out the specific areas in which the differences occurred and recommend the policy measures to be taken based on the major findings.

1.3 Research questions

(a) What are the key determinants for vertical and horizontal export diversification that require policy interventions?
(b) Over the past thirty years, most developing regions, especially East Asia have diversified their exports. Nevertheless, Africa is not part of this transformation. Why has Africa not diversified out of primary commodities?
(c) What would be the lessons from East Asia to SSA with regard to diversification in particular and economic growth in general?

Thus, in order to address the above research questions, the following research hypotheses have been tested in this study.

1.4 Research hypotheses

(a) Higher value of domestic capital and investment on education (human capital) may positively and significantly induce vertical and horizontal diversification and economic growth;
(b) FDI can increase competition, making domestic companies more efficient and stimulates sectoral and product diversification ;
(c) Human capital including education as well as health may positively enhance vertical and horizontal export diversification. However, since the levels of human capital and FDI are below the threshold level in SSA, thus their contribution to export diversification may not be satisfactory in SSA compared to East Asia;
(d) Natural resource endowment especially oil resources may negatively affects economic diversification through the 'Dutch Diseases' effect. However, if a country is endowed with more arable land then the ability of the economy to diversify is also high;
(e) The Country's level of development as measured by real per capita income as well as the domestic market size as measured by the size of population may positively induce export diversification;

(f) Macroeconomic stability such as low inflation rate, openness, and a flexible and stable exchange rate system in a given country may create favorable conditions for export diversification;
(g) Political Instability is inversely related with export diversification due to the fact that rate of saving and investment tends to be low in countries with frequent wars.

1.5 Significance of the study

(i) Previous studies in this field have mostly treated 'export diversification' in aggregate forms, but this study is expected to fill the gaps in literature by examining diversification from its vertical and horizontal dimensions and contribute to the enhancement of knowledge in this area;
(ii) This study is also timely because almost African policy makers and UN agencies in their reports such as the Economic Report on Africa (2007) presents the theme of diversification as a new paradigm for Africa's development and they claim that, diversification is a prerequisite to achieving positive development in the continent;

1.6 Limitation of this study

This study may have some limitation such that few East Asian countries including Taiwan, China, Vietnam, Cambodia, Laos and Mynamar are not included in the study, mainly because of lack of consistent and complete data throughout the years that the study covers. The same is true for some African countries which are not included in this study because of lack of complete panel data throughout the study period.

Accordingly, the rest of this thesis is organized as follows: Section two deals with the theoretical framework and previous empirical works on export diversification; section three is going to identify and discuss the key determinants of export diversification; section four explains the research methodology and estimation methods; section five will come up with empirical analysis and main findings; and finally section six provide concluding remarks and policy considerations.

2. Theoretical framework and previous empirical studies on export diversification

The concept of international trade as an engine of 'economic growth' dates back to the time of Adam Smith. However, since the 1980s openness, trade liberalization and out-ward oriented policies became popular policy prescriptions among economies and policy makers for achieving economic growth. Parallel to the outward-orientation

paradigm, another hypothesis related to structural changes in exports and increased diversification of exports gained even greater popularity in the literature (e.g. Ali and Siegel, 1991; Amin Gutierrez de Pineres and Ferrantino, 1997). Hence, the question that has to be asked is: what are the theoretical reasons that export diversification is conducive to economic growth?

Firstly, the traditional argument for export diversification is based on its role in reducing export earnings instability caused by cyclical fluctuation in international commodity prices. Many countries that are commodity dependent often suffer from export instability arising from inelastic and unstable global demand so export diversification is one way to alleviate these particular constraints. Because of its impact on domestic demand, export instability could discourage necessary investments in the economy by risk-averse firms, increase macroeconomic uncertainty and be detrimental to longer term economic growth. Export diversification could therefore help to stabilize export earnings in the longer run (Ghosh and Ostry, 1994; Bleaney and Greenaway, 2001).

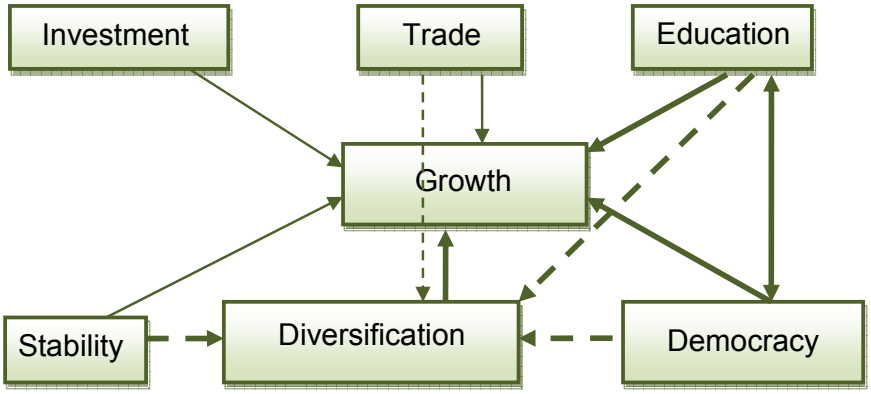
In a similar line of reasoning, Love (1983) that the more highly concentrated a country's exports, the lower is the probability that fluctuations in one direction in some of its exports will be offset by counter fluctuations or stability in others. Hence, the need for diversification which has tended to be equated with the expansion of manufactured exports. By the same token, Labys and Lord (1990) states that export diversification offers a means by which countries can combat earnings uncertainty, when these earnings derive from a few primary commodities and, at the same time, can increase their revenues from investment in the production of products with market growth potential. Studies have been also revealed that unstable export earnings make it difficult for a country to plan capital imports, destabilize consumption, and can adversely affect export earnings trends (Maizels, 1987).

Secondly, the relatively new arguments mainly derived from the endogenous growth theory are based on the fact that export diversification is beneficial not only for offsetting export earnings fluctuations, but it has also a very strong and dynamic comparative advantage. Hence, the dynamic elements of export diversification include demand and supply changes, industrial capability, risk aversion, environmental considerations, and changes in commercial policies (Ssemogerere et al., 1994). The argument on the demand side is that exporters facing autonomous factors such as rising incomes and change in taste would push countries to diversify their exports towards income-elastic ones. Similarly, the supply side argument is in terms of production structure adjustment to changes in production technology and input mix, better land utilization, the introduction of new skills, changes in the availability of

imported inputs, in response to potential competitors. All these factors enable a country to diversify into products of different price elasticity of export supply. In short, endogenous growth theory suggests that export diversification affects long-run growth with its accompanying increasing returns to scale and dynamic spillover effects as a result of new techniques of production, management or marketing practices potentially benefiting other industries (Amin Gutierrez de Pineres and Ferrantino, 2000).

Endogenous growth models such as Matsuyama (1992) emphasize the importance of learning-by-doing in the manufacturing sector for sustained growth. Related to export diversification, there could be knowledge spillovers from new techniques of production, new management, or marketing practices, potentially benefiting other industries (Amin Gutierrez de Pineres and Ferrantino, 2000). Similarly, Agosin (2007) develops a model of export diversification and growth and finds that countries below the technological frontier widen their comparative advantage by imitating and adapting existing products. By the same token, Glyfason (2002) identifies the key factors of economic growth and also the link between those factors and export diversification using the model as shown in Figure 3.

Figure 3: Six determinants of growth



Source: Glyfason (2002)

The model above explains that there are about six different kinds of producible capital that are needed to sustain economic growth. *First*, saving and investment are obviously necessary to build up physical capital. *Second*, education is needed to build up human capital. *Third*, macroeconomic stability encourages the accumulation of financial capital, i.e. financial depth, which helps lubricate the wheels of production

and thus increases economic efficiency and growth. *Fourth*, increased trade with the rest of the world helps to technology transfer as well as to strengthen the capital base of domestic activity. *Fifth*, increased democracy can be viewed as an investment in social capital by which is meant the infrastructural glue that hold society together and keeps it working harmoniously. *Sixth*, diversification is expected to increase income by expanding the possibilities to spread investment risks over a wider portfolio of economic sectors. Moreover, through forward and backward linkages, production of a diversified export structure is also likely to provide stimulus for the creation of new industries and expansion of existing industries elsewhere in the economy. Furthermore, the model indicates that factors that are good for growth are also good to stimulate export diversification.

The structural models of economic development propose that countries should diversify from primary exports into manufactured exports in order to achieve sustainable growth (Chenery, 1979; Syrquin, 1988). Similarly, the Prebisch-Singer thesis postulates that 'vertical export diversification' could reduce declining terms of trade for commodity-dependent countries. Al-Marhubi (2000) in a conventional cross-sectional country growth regression adds various measures of export concentration to the basic growth equation and does find that export diversification promotes economic growth, and these findings are robust to different model specifications. Also in a cross-sectional regression, Agosin (2007) finds that export diversification has a stronger effect on per capita income growth when a country's exports grow faster than alone. Lederman and Maloney (2007) in a dynamic cross-country panel model also find evidence in support of diversification-led growth. Likewise, within country studies by Amin Gutierrez de Pineres and Ferrantino (1997) as well as Herzer and Nowak-Lehmann D. (2006) have examined the link between export diversification and economic growth in Chile, and their findings do suggest that Chile has benefited greatly from diversifying its export base. Models in the product cycle literature (Vernon, 1966; Krugman, 1979; Grossman and Helpman, 1991) also imply a link between export diversification and growth.

Furthermore, Hausmann and Rodrik (2003), Hausmann, Hwang, and Rodrik (2006), and Hausmann and Klinger (2006) analyze the benefits of export diversification and exports in general for economic growth, both empirically and theoretically. In their framework, *economic growth is not driven by comparative advantage but by countries' diversification of their investments into new activities*. An essential role is played by the entrepreneurial cost-discovery process. According to the model of Hausmann and Rodrik (2003), entrepreneurs face significant cost uncertainties in the production of new goods. If they succeed in developing new goods, the gains will be socialized (information spillovers) but the losses from failure end up being private. This leads to

an under provision of investments into new activities and a suboptimal level of innovation. The bottom line is that according to Hausmann and Rodrik (2003), the government should play an important role in industrial growth and structural transformation by promoting entrepreneurship and creating the right incentives for entrepreneurs to invest in a new range of activities.

It is also evident that there are knowledge spillovers or learning by doing from export diversification (Amin Gutierrez de Pineres and Ferrantino, 2000).The basic thrust underlying such a hypothesis was based on “product cycle” models. In this context, innovative activity by the north (developed countries) leads to an increasing diversity of products, while *imitative* activity by the south (LDC) leads to an increasing diversity of products being produced and exported from low-wage locations (Amin Gutierrez de Pineres and Ferrantino, 1997). By the same token, the product life cycle theory of Vernon (1966) argued that as the result of imitative activities, the comparative advantage of many developing countries has shifted from the export of primary products to manufactured products over time from one country to another. This happens because these goods go through a product life cycle. Once the product is invented, then overt time becomes more standardized as consumers and producers gain familiarity with its features. One of its strength is that it can explain exports of sophisticated manufactured goods from countries that have shortages of skilled labor and capital. Standardized manufacturing routines are increasingly common, using low-skilled and semi-skilled labor in assembly type operations.

Moreover, according to the catching-up product cycle theory, industrial structure evolves as an economy develops, from the simplest (imported) technology to more and more sophisticated functions of the production cycle. The sequential upgrading of production technology and industrial structure is called the “flying geese” model because the industrial structure evolves in a pattern resembling the V-formation of a flock of flying geese (Kwan, 1998). This same flying geese model is typically used to describe the relationship among the economies in the East Asia region. The image captures the connections between the industrial structures of the Asian economies at different stages of development and the dynamic, sequential nature of their development. Japan leads the East Asian flock, followed by Korea and Taiwan, and then the other, later-developing economies of the region. Thus, the flying geese model depicts the latecomers replicating the development experience of the economies ahead of them. Generally, the product cycle theory emphasizes that commercial successes of consumer durables depend on product development mainly based on cost-cutting mass production and the use of known technology, rather than on technological breakthroughs. In this case, the East Asian development experience is a good example of how late-comers can develop through *imitation*, as long as they put

the necessary pre-conditions in places, such as human capital, physical capital, infrastructure, and so forth.

Thus, the volume of total exports in real terms is determined by the three main factors: the world demand for exports of the given commodity, competitiveness of the given product and the degree of export diversification of that country (Athukorala, 1991). For instance, in the 1960s, agricultural export performance was similar among Indonesia, the Philippines and Thailand, both in nominal and real value terms. But in the decades since then, the three countries have shown different performances in agricultural exports. The main important factor resulting in the differences is the ability of diversification and adjustment of agricultural exports when the market conditions changed.

There are more empirical works which verify how export diversification induces growth. Agosin (2005) conducted a cross country study on the effects of export diversification on growth in a group of Latin American and Asian countries and found that controlling for other variables that affect growth, export diversification, alone and interacted with per capital export volume growth, is found to be highly significant in explaining per capita GDP growth over the 1980-2003 period. Similar empirical research findings by Sachs and Warner (1997), or more recently by Glyfason (2004) and De Ferranti et al. (2002) suggest that export concentration is indeed statistically associated with slow growth, in particular when export concentration reflects the predominance of primary products, as it usually does. Herzer et al (2004) also found a long-run statistical association between growth and export diversification on the basis of time-series data from Chile.

Generally, various literatures on export diversification indicate two ways of transmission channels from export diversification to growth. The first argument is that developing countries exports tend to be concentrated on a few products, often commodities, with very volatile demand. This translates into high income instability, which in turn provokes high growth volatility. Export diversification in this setting has the advantage of creating a more stable income inflow. The second effect is associated with the dynamic benefits generated by diversifying comparative advantages in terms of the spillovers in the economy as a result of having a more diversified production structure (Hausmann and Klinger, 2007). In sum, diversification from the supply side can take place in developing countries either vertically or horizontally; but mainly through both dimensions.

Export diversification may also result more endogenously from a growing *demand* for a variety of goods as a country's income increases (Imbs and Wacziarg, 2003:82). In other words, production patterns respond to changes in the structure of demand and then generate increasing sectoral diversification through the "Engel" effect. The most

influential research on diversification by Imbs and Wacziarg (2003) has identified two stages of diversification in the process of economic development. First, poor countries tend to diversify as their incomes rise; then, the level of diversification will reach to a turning point and later begin to become more specialized. In this case, the diversification of an economy could be related to its development level, measured by GDP per capita, through an *inverted-U shaped* relation. Therefore, a country ought to undertake investment in such a way that this turning point occurs as a result of attaining deep diversification. Because, it is only after the attainment of deep diversification that countries can shift to the second stage that tends towards specialization. Thus, the stages of diversification will follow the following steps:

The two-stage diversification process from economic history has been registered both in open and closed economies. The difference between the two is that the turning point after reasonable and sustainable development has been achieved at a much earlier point for open economies compared to the case for closed economies (Imbs and Wacziarg 2003). Similarly, Carrere et al. (2007), have studied the pattern of export diversification of 159 countries over 17 years and confirmed that re-concentration of exports after successful diversification will start above a threshold of PPP$24'000. This implies that diversification occurs mostly at the extensive margin for low- to middle-income countries, as new export items multiply and are marketed at increasingly large initial scales. This implies that most developing countries are actually in the diversifying stage over the course of their development path. Whereas, almost all developed countries today are in the stage of re-concentration after they successfully passed the diversification stage in the past. From a policy perspective, it thus appears as a key element of the economic development process in developing countries. In actual fact, export diversification in developing countries implies the broadening of comparative advantages into new sectors. It is only if countries first diversify and then specialize in activities in which a country has comparative advantage can lead to greater efficiency allocation. W*hat therefore explains the two stages of diversification?*

According to the neoclassical economic theory, when a relatively poor country starts accumulating capital and enters the *cone of diversification*, the Rybczynski effect will occur: the share of the capital-intensive aggregate should go up. This makes the aggregates shares more equal and, because the country starts producing capital-intensive goods, this should reduce industrial concentration. Another reason is related to the structure of preferences argument that if agents have non-homothetic

preferences, their consumption pattern will change as income grows. These Engel effects are generally understood as implying an expanding diversity of the goods consumed. In other words, production patterns respond to changes in the structure of demand and then generate increasing sectoral diversification. According to Acemoglu and Zilibotti (1997), development goes hand in hand with the expansion of markets and with better diversification opportunities. Saint-Paul (1992) also presents a model where limited access to financial markets affects the pattern of domestic production in developing countries, and hence *sectoral diversification* is the only available means to diversify away sector-specific income shocks and smooth consumption. On the other hand, in the endogenous growth models, greater diversifications of exports occur through learning-by-doing and learning-by-exporting and through imitation of developed countries (Amin Gutierrez and Ferrantino, 1997:376). In the same token, what appears to be crucial is also creating an environment that creates competition and thus to acquire new skills and this can be performed through exports. Without the pressure from outside competitive forces, acquisition of human capital, and thus overall economic growth, may be slow (Husted and Melvin, 2007).

At this juncture, a genuine question may arise such that *if countries get back to re-concentration, why should they need to diversify?* The point is that, there is a fundamental difference between countries that are in the first stage of concentration and countries that come-back to re-concentration. The main difference is that the former specializes largely in primary products whose relative prices are falling from time to time; whereas the latter specializes in high value added and knowledge intensive products whose relative prices are on a rise from time to time. Theoretically, this argument can be supported by the famous “Stolper-Samuelson” specialized –factor pattern theorem as follows: (i) the more the factor is specialized, or concentrated, in the production of a product whose relative price is rising, the more this factor stands to gain from the change in the product price; (ii) the more the factor is concentrated into the production of a product whose relative price is falling, the more it stands to loose from the change in product price.

Therefore, combining the findings of new trade and endogenous growth theory suggests that the interplay of economies of scale, externalities and national or international spillovers of knowledge and technology can be crucial for the diversification experience of "late-comers". Hence, diversification is not a phenomenon that contradicts the notion of comparative advantage especially in the case of for developing countries. Instead, it implies the acquisition of new comparative advantages or broadening comparative advantages into new sectors. In other words, diversification should be seen as a dynamic process, not as a static one. There are three keys to a successful industrialization and economic diversification strategy. One

is to have a clear government strategy - not to be confused with direct state involvement in running industries, which we all acknowledge to be a thing of the past. It is a well-known fact that in South East Asia, governments took an active role in promoting industrialization, intervening at strategic points through regulation and incentives and mobilizing resources where appropriate. The second factor in promoting industrialization and diversification is regional integration. The third is a robust private sector response. Stable and predictable macroeconomic and political and regulatory environments, as well as a fair and open international trading framework, are among the basic requirements of the development process.

Hence, the ability to shift production and exports from customary products to more dynamic ones without losing the expertise obtained in the former is a crucial ingredient for breaking the vicious cycle of dependence and turning it into a virtuous cycle of dynamism and development. A stable economic environment at the macro level, a supportive international trading system and entrepreneurial drive at the micro level are prerequisites but, these by themselves, are not sufficient to spur the structural transformation of economies. Governments have to act on certain critical areas, and entrepreneurs have to adopt modern business strategies consciously.

In sum, motivated by the desire to spread risks, raising capacity utilization and increasing total export proceeds, export diversification has been the concern of most developing countries. Despite such a concern, however, very few developing countries in East and South East Asia as well as developing America (such as Brazil, Mexico, Argentina, and Chile) have actually managed to achieve a diversified export structure with greater volume of manufacturing products. On the contrary, the overall performance of Africa (except few countries such as Mauritius, South Africa, Seychelles, Tunisia, and Botswana) in terms of export diversification has been far from satisfactory and most countries continued to be totally dependent on a few agricultural and mineral exports. The prime barriers of effective export diversification in Africa include policy distortions, poor infrastructure services, high risks and high transaction costs that inhibit competitiveness. Thus, diversification requires substantial physical and human capital (investment on education), stable and predictable macroeconomic and political environments, as well as a fair and an open trading framework. In line with this, the ability to shift production and exports from customary products to more dynamic ones without losing the expertise obtained in the former is a crucial ingredient for breaking the vicious cycle of dependence and turning it into a virtuous cycle of dynamism and development.

Generally speaking, most researchers would agree that export diversification matters for economic growth and it is especially important for developing countries

(Amurgo-pacheco and Pierola, 2008) to attain three interrelated objectives: *stabilizing earnings*, *expanding export revenues*, and *upgrading value-added*.

3. Determinants of vertical and horizontal export diversification

Based on the theoretical analysis discussed above as well as some related empirical works such as: Osakwe (2007); Gylfason (2002); Bebczuky and Berrettoni (2006); Elbadawi (1999); Wood and Mayer (2001); Munemo (2007); Herzer and Nowak-Lehmann (2006); Parteka and Tamberi (2008); and others; the following determinants for export diversification have been identified:

(i) Physical capital

Traditional growth theory looks at capital accumulation as the most important determinant of export diversification. The physical capital of a given country (capital stock) consists of domestic-owned physical capital and foreign-owned physical capital. Accordingly, gross fixed capital formation as a share of GDP is used to capture the influence of the domestic investment in a similar fashion as Olofsdotter (1998) and others. Similarly, foreign capital is often captured by the ratio of ratio of FDI to GDP. Thus, it is imperative to further breakdown physical capital into domestic and foreign capital and examine their separate effects on both vertical and horizontal diversification.

ii) Domestic investment

Unless a country commits a sufficient portion of its national income to building domestic capital stock, it is unlikely to be able to diversify. Ben Hammouda et al (2006), underlines that investment is vital for an economy to diversify; since as the level of investments increases, there is a tendency for economies to become more diversified. While increasing the level of domestic investment helps promote diversification, the sectoral allocation of investment is also crucial. To boost diversification, governments should therefore design incentive mechanisms to encourage domestic investment in new activities. Accordingly, there is empirical evidence that a country which invests a bigger proportion of its output in capital formation is likely to accumulate the necessary infrastructure and equipment more rapidly to allow the country to diversify its production basis (Habiyaremye and Zeisemer, 2006). Chile and Botswana provide a good example for such reasoning, where the accumulation of domestic capital is related to developing other sectors than the exploitation of their primary commodities.

Likewise, the UN Under Secretary-General and Executive Secretary of the UN Economic Commission for Africa, Abdoulie Janneh (2009), argued that, "for the

business sector in Africa to grow and contribute to poverty reduction and economic development, domestic investment as a proportion of GDP must improve from an average 18% in Sub-Saharan Africa to between 25% and 30%, which is the average rate in East Asia.

iii) Foreign direct investment (FDI)

There are proponents and opponents about the benefits of FDI in an economy. In the standard neo-classical model, opening international capital markets generates flows from capital-abundant towards capital-scarce countries, thereby accelerating convergence (hence short term growth) in the poor countries. In a more sophisticated context, productivity may also increase since capital inflows may relieve the economy from credit constraints and thus allow agents to undertake more productive investments (Acemoglu and Zilibotti, 1997). Similarly, Saint-Paul (1992) and Obstfeld (1994) suggest that international capital mobility may affect productivity independently of investment, by promoting international risk diversification which induces more domestic risk taking in innovation activities, thereby fostering growth. Thus, FDI has many benefits for economies, particularly developing economies. Accessing foreign savings can help economies grow faster and, in the case of developing economies, catch up with rich economies (Barro, 1997). FDI can increase competition in the host economy, making domestic companies more efficient and stimulates sectoral and product diversification. It is also evident that FDI is an important vehicle for the transfer of technology, contributing relatively more to growth than domestic investment.

On the other hand, there are also some arguments against the benefits of FDI such that FDI could be a threat to young growing companies/firms with limited capital outlays as compared to the multi-national corporations (MNCs); since the young domestic firms will be unable to compete with the MNCs with huge capital outlays. As a result, this could possibly lead to the extinction of such small local firms. However, the experience of emerging economies especially FDI driven economies in East Asia confirm that FDI and domestic investment are, in fact, complementary with each other. For instance, FDI would play a complementary role with domestic investment by working together with local firms in the form of 'joint ventures'.

All in all, there is a common consensus that the benefit aspects of FDI outweigh the cost. Nevertheless, the higher productivity of FDI holds only when the host country has a minimum threshold stock of *human capital*. Thus, FDI contributes to export diversification only when a sufficient absorptive capability of the advanced technologies is available in the host economy. However, the African region has not been successful in attracting a large amount of FDI compared to East Asia and Latin

American regions; mainly due to the fact that Africa has lack of adequate skilled labor force that may participate in the investment sectors.

iv) Human capital

Human capital is part of the investment climate of an economy and is generally considered as complementary factor of physical capital. In this study, human capital has been proxied by the '*education*' variable as well as '*health*' variable. The education component of human capital refers skilled labor, that is, skills acquired by individuals through a process of investment in education and training. Likewise, the health component of human capital which is often proxied by 'life expectancy' at birth is also expected to play a positive role for enhancing export diversification and growth in a country's economy. For example, from 1975 to 2000, GDP per capita in Southeast Asia tripled while life expectancy rose from 54 years to 67 years (ADB 2001).Thus, it then becomes logically imperative that human capital should indeed be treated as a factor input just like physical capital and labor (Roskamp and Mc Meekin, 1968). Accordingly, the new trade and endogenous growth theories have emphasized human-capital accumulation and technological innovations are the main engines of *structural diversification* and *growth*. Human capital in the form of knowledge is said to make the difference between poverty and wealth. As World Bank (1999:1) noted:

> "Ghana and the Republic of Korea started with almost the same GNP/capita in 1960. Thirty years later the Korean GNP/capita had raised more than six times, the Ghanaian GNP/capita was still hovering at the same level (in 1985 prices). Accordingly, the evidence shows that half the gap could be explained in terms of traditional factor inputs (in classical economic terms: land, labor, and capital), the other half was attributed to knowledge as a factor of production."

Development policy targeting technology acquisition and the reduction of the technology gap must be aimed at facilitating the interaction between technology flows and human skills (Abramovitz, 1986). That was why East Asian countries have been successful in narrowing the technology gap in a few decades, and their educational attainment is credited for much of this achievement (Lall, 1992). Hence, as Nelson and Phelps (1966) suggests, a large stock of human capital makes it easier for a country to absorb the new products or ideas that have been discovered elsewhere. As a result, a follower country with more human capital tends to grow faster because it catches up more rapidly to the technological leader.

By the same token, endogenous growth theory has shown that differences in the level of countries' human capital lead to differences in their capacity (i) to invent new technologies, (ii) to adapt and implement technologies developed elsewhere, and (iii)

to attract other factors such as investment in physical capital, which also contribute to economic growth and development.

v) Infrastructure

It is obvious that infrastructural development in any country would reduce production costs, increase efficiency and productivity and thereby to maximize profitability. Moreover, adequate infrastructure provides a very significant stimulus to private sector development, sectoral and product diversification. Moreover, good infrastructure is a necessary condition for foreign investors to operate successfully (Wheeler and Mody, 1992).

The combined effects of low investment levels and poor infrastructure, together with dependence on primary commodities in SSA, has led to very low productivity levels and a correspondingly low level of capital accumulation that has been insufficient to trigger a sizable manufacturing activity (Sachs et al, 2004). Cross-country studies by Canning and Bennathan (2000) indicates that infrastructure; particularly *telecommunications infrastructure* significantly increases economic growth. Thus, new market access alone would not spur investment in new supply capacity unless it is supported by decent roads, efficient ports, and the technical capability to produce and distribute goods of sufficient quality which collectively called 'exporting infrastructure'(Stiglitz, 2006). In this case, Infrastructural development is one of the key pre-requisites for better diversification.

vi) Inflation

Macroeconomic stability plays a key role for the success of diversification efforts. Moreover, macroeconomic stability provides the private sector with a stable environment in which entrepreneurs and consumers are able to plan and invest and focus on production and performance rather than the environment in which they operate. In other words, macroeconomic stability is central to sustained growth. Otherwise, macroeconomic instability such as high levels of inflation damage diversification prospects and the tendency under such circumstances is for increased concentration with little opening-up to new export sectors. Similarly, a high inflation environment is not conducive to the development and maturation of new sectors, nor is it supportive of an environment that fosters other determinants of diversification so that they have significant impact. Because, a high rate of inflation is generally harmful to growth because it raises the cost of borrowing and thus lowers the rate of capital investment; but at low, single-digit levels of inflation, the likelihood of such a trade-off between inflation and growth is minimal. At the same time, highly variable inflation makes it difficult and costly to forecast accurately costs and profits, and hence investors and entrepreneurs may be reluctant to undertake new projects. However, a

moderate but a stable inflation may not slow down diversification. It is only an inflation rate which is quite high such as in the 15 to 40 percent range may become prejudicial to growth (Bruno and Easterly, 1995).

vii) Exchange rate

It has been assumed that a depreciating currency is an appropriate macroeconomic fundamental to support increases in existing exports and ease potential exportable products into new markets. Such a result supposes two elements. First, it pre-supposes that the country already has export potential and that the depreciation has the price effect of making the exports cheaper for the foreign markets. It further assumes price-elastic export demand. Second, it also assumes that depreciation is supported by sound macroeconomic fundamentals and can maintain competitiveness in the international market.

The classical approach to devaluation as a remedy for a balance of payments deficit cites shifts on both expenditure and production; expenditure shifts away from imports toward domestic products, and production shifts out of goods and services for domestic use into exports. Both shifts contribute to the reduction in domestic absorption required to eliminate the balance of payments deficit. Opponents of the classical view make two apparently contradictory arguments about the effects of nominal devaluation. Much of the structuralism literature argues that nominal devaluation leads to contraction of demand and output. But another body of literature focuses on inflationary consequences. However, it is evident that inflation is mainly caused by the expansionary fiscal and monetary policies rather than the exchange rates.

Although policy prescriptions have generally assumed that exchange rate depreciation would stimulate exports and curtail imports, it is not always true in all cases. For instance, Abeysinghe and Yeok (1998) empirically investigated the impact of currency appreciation on exports in the case of Singapore and found that in the presence of high import content, exports are not adversely affected by currency appreciation because the lower import prices due to appreciation reduce the cost of export production. This implies that the cushioning effect outweighs that of the effect of productivity gains on export competitiveness. Accordingly, Singapore is a particularly interesting case study as it has been experiencing sustained export growth despite an appreciating currency.

viii) Degree of openness

Generally, there is a growing consensus that suggests trade liberalization is vital; but it should follow a gradual approach. The Proponents of a gradual approach to trade liberalization point out that there are inherent constraints in countries that limit their

ability to build a competitive advantage to export new products in a short period of time. As such, they argue for policy space that would allow them to pursue policies conducive to diversification through industrialization (Economic Report on Africa, 2007). Similarly, the catching-up theory explained that other things being equal, the faster the rate of innovation in advanced economies, the higher the scope of growth via imitation for laggard economies. Given that technology flows from the leader to the follower via international trade, *ceteris paribus*, the higher the degree of trade liberalization (openness), the faster the diffusion process will be (Baumol et al., 1994). Similarly, the World Bank (1993) found that openness had a statistically positive impact on total factor productivity (TFP) growth in its study of 51 countries for the 1960-89 periods. As a result, openness is positively associated with diversification.

ix) Income per capita

The level of development, as measured by real per capita income, is also one of the control variables. The idea is that countries at higher levels of income are likely to be more diversified than those at lower levels of income (Imbs and Wacziarg, 2003). However, at a certain stage of income per capita; usually when a country reaches to high income developing countries or further into developed countries, diversification becomes decreasing and a the economy will start to re-concentrate on selected specialized products. However, since almost all countries in this study except Japan are classified as developing countries, the relationship between income per capita and export diversification is expected to be positive.

x) Foreign aid

The relationship between foreign aid and export diversification is not conclusive. The traditional justification for foreign aid is that it eases the resource constraint of developing economies, especially on the supply side (Munemo et al., 2007). In this case, therefore, foreign aid is expected to have a positive coefficient for export diversification.

However, foreign aid can also harm export diversification; due to its potential impact on the real exchange rate. The idea is that large aid inflows have the potential to increase the price of non-traded goods leading to a real exchange rate appreciation and loss of export competitiveness. This effect is likely to be more severe in economies with capital market imperfections and in the manufacturing sector - where there are externalities such as learning-by-doing (Osakwe, 2007). Consequently, by appreciating the real exchange rate and reducing output in the export sector, aid leads to a loss of productivity and so has a negative effect on the development and expansion of manufacturing activities. According to Van Wijnbergen (1985), one of the explanations for lack of export diversification in Africa is due to the negative role of foreign aid. From the

preceding discussion, therefore, it can be assumed that the foreign aid variable may have either a positive or negative relationship with export diversification.

xi) Political stability

Both political stability and macroeconomic stability are essential if markets are to work effectively in guiding resource allocation and fostering confidence of economic agents in the economy. Almost all the rapidly growing East Asian countries experienced periods of political stability during the key development years and such political stability has enabled governments in East Asia to materialize long-term plans into reality and to avoid short-termism. On the contrary, political instability in most of SSA countries was one of the factors for Africa's poor economic performance for the last 3-4 decades. For instance, a relatively better political stability combined with sound macro-economic policies in Africa in recent years have resulted an encouraging economic performance.

xii) Market size

The domestic market size of a country can be proxied by the size of its population. Endogenous growth theory indicates that, countries with a larger population and a larger market size are expected to grow faster because of scale economies. Countries with larger population sizes are more likely to develop varied skills that can be deployed in different fields. Likewise, countries with population spread over large geographical areas can benefit from distinct regional specialization, by extension, to large mix of national export diversification. Although working age population (between 15 and 65) is the best variable to measure the scale effects, the data on labor force have major problems of measurement, especially for the poorer countries. In this case, therefore, the total population instead of the working age population can be considered (Barro. and Sala-i-Martin, 1999).

xiii) Natural resource endowment

Natural resource endowment in this study is proxied by two variables: *Arable land ratio* and '*oil dummy'*. Although World Bank (2002) advocates that resource abundance could bring about technological progress and new knowledge, various studies including Sachs and Warner (2001) find a negative relationship between resource abundance and growth. According to Glyfason (2001) natural resource-based economies might not have the incentives to heavily invest in human capital accumulation. The Rybczynski theorem also suggests that development of new natural resources, such as oil or gas may retard development of other lines of production, such as manufactures through the "Dutch Diseases" effect. The 'Dutch Disease' effect was named after the experience of the Netherlands, where increased

oil and gas revenue s in the late 1950s resulted in the appreciating of the Dutch Guilder and loss of export markets and de-industrialization. Similarly, Wood and Mayer (1998) have emphasized that the concentration of Africa's export on un-processed primary products is caused largely by the region's combination of low levels of education and abundant natural resources. An economic irony is that those countries blessed with abundant natural resources tend to grow more slowly than their resource-poor counterparts (Sachs, 2001).

Reliance upon oil and other commodities is deeply problematic for African nations wishing to avoid the typical 'resource curses' that tend to accompany overdependence on one particular commodity and/or to move beyond being suppliers of primary products. 'One risk is that even if there is a commodity boom, it might prevent governments from undertaking the necessary measures to make growth sustainable in the medium term (i.e., investment on human capital, infrastructure, institutional reform, etc.). Over-reliance on commodities such as oil threatens to make African nations even more vulnerable to negative price shocks. Furthermore, if receipts accrue from oil exports, there is a very real temptation from the local elites not to diversify their economies (Taylor, 2006). Moreover, natural resource endowment and currency overvaluation usually go together and this undermines the competitiveness of export-oriented manufacturing sectors.

However, this doesn't mean that natural resource abundance is always a curse. In fact, resource rich low income countries could diversify into resource based manufacturing or processing of primary commodities instead of following the conventional path of low skill manufacturing (Bonaglia and Fukasaku, 2003). For instance, Sweden and Finland at the beginning of 20th century and Thailand and Malaysia very recently are good examples of how resource-rich countries could diversify into value-added agro-industries and resource-based manufacturing. Accordingly, Malaysia pursued the development of its resource-based sectors mainly palm oil and rubber; while Thailand focused on the diversification of agriculture and fishery-resource- based manufacturing, before both countries moving into other types of manufacturing exports such as clothing and electronics.

xiv) Regional dummy

It is also important to include a regional dummy variable in panel data analysis to capture other factors that are not included in the model on the dependent variable's outcome. Based on past experiences, the SSA 'dummy' variable is expected to have a negative relationship with export diversification.

To sum up, the above-mentioned determinants, their expected relationship with export diversification, and the respective data sources are summarized in Table 9.

Table 9:- Independent variables, their expected signs and data sources

Variable	Indicator	Expected sign	Data Sources
Domestic Capital	Ratio of GFCF to GDP	+	WDI Database
FDI	Ratio of net FDI to GDP	+	WDI Database
Human Capital	1. Secondary School Enrollment Ratio to total population with age 15 and above.	+	Barro- Lee (2000); and WDI for some countries and for years beyond 2000 for all countries in the sample.
	2. Life Expectancy at Birth	+	WDI Database
Quality of infrastructure	Number of fixed and mobile telephone per 1000 person	+	WDI Database
Inflation	The rate of change of the GDP deflator;	-/+	WDI Database
Exchange Rate	Exchange rate of local currency with that of US$	+	Summer et al (2006) Penn World Table Version 6.2
Openness	Degree of openness based on Sachs and Warner (1995)	+	Summer et al (2006) Penn World Table Version 6.2
Income/capita	Real per capita GDP (PPP based)	+	IMF Database
Political Instability	Collier and Hoeffler's (2004) 'War dummies' for countries suffered from war during the period under study.	-	Collier and Hoeffler (2004) war index tables
Aid per capita	Official development assistance/capita	+/-	WDI Database
Labor force	Size of population	+	Summer et al (2006) Penn World Table Version 6.2
Resource Endowment	1. Oil Dummies'	-	Various Statistics of each countries
	2. Arable Land Ratio	+/-	WDI Database
Regional Dummy	Africa dummy	-	

In line with this, list of countries included in this study are shown in Table 10. The selection criterion for the countries is mainly due to the availability of data from 1975-2004.

Table 10:- Countries included in the study

Sub-Saharan Africa	East Asia
Benin, Burkina-Faso, Burundi, Cameroon, Central Africa Republic, Chad, Congo Democratic Republic, Congo Republic, Cote Devoir, Ethiopia, Gabon, Gambia, Ghana, Kenya, Madagascar, Malawi, Mali, Mauritania, Mauritius, Mozambique, Niger, Nigeria, Rwanda, Senegal, Seychelles, Sierra Leone, South Africa, Sudan, Tanzania, Uganda, Zambia, and Zimbabwe	China, Hong Kong, Indonesia, Japan, Korea Republic, Malaysia, Philippines, Singapore, Taiwan, and Thailand.

4. Research methodology and estimation methods measuring diversification

There are quite few methods, which explain either export concentration (i.e. specialization) or diversification in a given time and space by a single indicator. The common measurement is the Herfindahl-Hirchmann Index (HHI) which can be available from UNCTAD's Hand Book of Trade and Development Statistics, and is measured at the three-digit SITC level. Although this indicator is detailed enough, it doesn't capture the essence of both vertical and horizontal diversification (Agosin, 2005). Thus, considering the objective of examining the impacts of physical and human capital on vertical and horizontal export diversification, the following approach has been used like previous researchers.

4.1 Vertical export diversification

An increasing export orientation of the manufacturing sector, accompanied by a rising share of manufactures in total exports, is part of the "normal" pattern of structural change in the growth process of developing countries. Since vertical diversification (VDIV) mainly implies out of primary into manufactured exports, it can be measured by the share of manufactured exports to total exports [Elbadawi, 1999; Wood and Mayer, 2001; Munemo et al., 2007; Osakwe, 2007; and others]

$$VDIV=(TMX)/(TX) \quad (1)$$

Where, VDIV is the index of vertical diversification, TMX is value of total manufactured exports, and TX is value of total exports.

4.2 Horizontal export diversification

Similar to the works of Herzer and Nowak-Lehmann (2006) as well as Feenstra and Kee (2004), horizontal diversification (HDIV) in this study has been proxied by the *number of export commodities (varieties)* classified by the Standard International Trade Classification (SITC) at the three-digit level. As Dennis and Shepherd (2007:5) noted, using a direct measure, namely a count of the number of products that a country exports is not as simple as it seems because individual "products" identified in the trade data usually map in reality to a number of distinct varieties. In other words, this simplified method can clearly measure how far a country has broadened the range of its products for export. Thus, the maximum value of the index is 239, and its minimum (theoretical) value is zero, for a country with no exports. UNCTAD annually present the number of products, with those products that are greater than $100,000 or more than 0.3 per cent of the country total exports.

4.3 The basic econometric model for export diversification

Based on the theoretical justifications made to identify determinants of export diversification that have been discussed earlier, and by following similar approaches such as: Osakwe (2007); Glyfason (2002); Bebczuky and Berrettoni (2006); Elbadawi (1999); Wood and Mayer (2001); Munemo (2007); Herzer and Nowak-Lehmann (2006); Parteka and Tamberi (2008); Elbadawi (1999), Agosin (2007), the econometric model that allows the explanatory variables explaining vertical and horizontal export diversification in a given country (i) at period t takes the form:

$$\mathbf{VDIV_{it}/or\ HDIVit = X_{it}\ \beta + \varepsilon_{it}} \qquad \mathbf{(2)}$$

Where β is a vector of regression coefficients to be estimated; X_{it} is a matrix of explanatory variables displayed in Table 9; and ε_{it} is a vector of disturbances or random error terms. Accordingly, the simplified specification of this model will take the functional form:

$$\mathbf{DIV_{it}/orHDIV_{it}=\beta_0+\beta_1 HUMCAP_{it}+\beta_2 DOMINV_{it}+\beta_3 FDI_{it}+\beta_4 INFR_{it}+\beta_5 Z_{it}+\varepsilon_{it}} \qquad \mathbf{(3)}$$

Where, α, β_1, β_2 are constants, i indexes the countries under study, t denotes the year, while VDIV and HDIV refer the vertical and horizontal diversification indexes, respectively and they can be estimated one after the other; HUMCAP and DOMINV, FDI, and INFR are the measures of human capital stock, domestic capital, FDI, and infrastructure, respectively; and Z_{it} represents the set of additional explanatory variables as mentioned in Table 9, and ε_{it} is the error term to account stochastic and measure.

Additionally, there is a sensible presumption that investments on physical capital, human capital and other explanatory variables have mostly a delayed impact on diversification (Bebczuk and Berrettoni, 2006). In this case, explanatory variables with *one-year lag values* can be used in the model. The use of lagged explanatory variables has an additional advantage to deal with their potential endogeneity problems provided that future values of the export diversification index have no influence whatsoever on the control set. Thus, the export diversification model finally takes the form:

$$\mathbf{VDIV_{it}/HDIV_{it}=\beta_0+\beta_1 HUMANCAP_{it-1}+\beta_2 DOMINV_{it-1}+\beta_3 FDI_{it-1}+\beta_4 INFR_{it}+\beta_5 Z_{it-1}+\varepsilon_{it-1}} \qquad \mathbf{(4)}$$

In order to choose the more appropriate estimation techniques, it is first important to conduct specification tests including Hausmann specification test, test of heteroskedasticity, test for serial correlation, and stationarity test.

Accordingly, Hausmann's (1978) specification test was conducted and the result confirms fixed effect model estimation method is not appropriate for this particular study. Similarly, a White's General Test for heteroskedasticity was conducted and the result rejected the null hypothesis of homoskedasticity. Similarly, Wooldridge's tests for autocorrelation in panel data have been conducted and the null hypothesis that there is no first order autocorrelation was rejected. It implies that both heteroskedasticity and serial correlation are detected.

According to Wooldridge (2002), if heteroskedasticity is detected but serial correlation is not, then the usual heteroskedasticity-robust standard errors and test statistics from the pooled OLS regression can be used. However, if both heteroskedasticity and serial correlation are detected with a strict exogeneity assumption, it is reasonable to consider a Feasible General Least Square (FGLS) analysis. Likewise, Gujarati (2003) suggests that FGLS estimator accounts for a known structure of the error variance (heteroskedasticity), serial correlation pattern in the errors, or both, via a transformation of the original model.

Thus, FGLS estimator that accounts for a known structure of the error variance (heteroskedasticity), serial correlation pattern in the errors, via a transformation of the original model has been performed using STATA software. In line with this, 'Levin-Lin-Chu panel unit root test has been performed and the null-hypothesis of non-stationarity was rejected at 1 percent significance level. In other words, the data are stationary. For that matter, unit root test for panel data is a recent phenomenon and it was only practiced in pure time series data analysis until very recently (Baltagi, 1996).

5. Empirical results and main findings

5.1 Descriptive statistics

Summary statistics

The mean values of the dependent and independent variables used in the analysis for the full sample have been displayed in Table 11. Accordingly, the average vertical diversification index as measured by the share of manufactured export to total export was found to be 26.8 % with a sample range of 0 (minimum) and 100 % (maximum). Similarly, the average horizontal diversification as measured by the number of export products in the SITC classification of international trade at three digits is 94 with a minimum range of 2 and a maximum range of 231. The ratio of GFCF to GDP has a mean value of 20% with a range of a -24 % (deficit) and 61 % (maximum). The average value for the ratio of FDI to GDP is nearly 2% and ranges from -29% (minimum) to 47 % (maximum). The education component of human capital as measured by the secondary school enrollment ratio has an average value of about 18% that varies from 0.1% (minimum) to 62% (maximum), indicating the wide gap among countries with regard to investment on human capital. Likewise, the health component of human capital as measured by life expectancy at birth has a mean value of 54 years, but with a range of 36 years (minimum) and 82 years (maximum). In the same way; the mean, minimum, and maximum values of the remaining explanatory variables for the full sample are shown in Table 11.

Table 11: Descriptive statistics of variables for the full sample

Variable	Mean	Std. Dev.	Min	Max
Vertical Diversification	26.805	29.938	0	100
Horizontal Diversification	94.007	76.557	2	231
Domestic Investment	20.129	9.317	-24	61
Foreign Direct Investment	1.995	4.064	-29	46.7
Education	17.769	15.114	0.1	61.9
Health (Life Expectancy)	54.304	10.905	36	82
Level of Development	3.158	0.484	2.2618	4.471
Population (log population)	4.027	0.720	1.772	6.110
Quality of Infrastructure	0.987	0.846	0	3.241
Degree of Openness	72.946	61.287	0.85	425.34
Inflation Rate	49.247	31.941	11.88	371.85
Oil Dummy	0.146	0.354	0	1
Arable land Ratio	39.007	20.655	1	91
Aid per capita	8.787	10.223	0	99
Exchange Rate	1.532	1.848	-11.777	4.376
Political Instability	0.293	0.455	0	1
Africa Dummy	0.146	0.354	0	1

In order to examine the wide gap in East Asia and SSA's performances, it is much better to look the descriptive statistics of the sub-samples (SSA and East Asia) in depth as shown in Table 12. Accordingly, as measured at the mean, East Asia sub-sample exhibits a vertical diversification of 70% while SSA has a mean vertical diversification of nearly 15%, verifies that East Asia has made a very significant and dynamic transformation on its economy towards manufacturing sector; whereas SSA has achieved very little in economic structural change and as a result the manufacturing exports from total exports in SSA accounts only 15 % compared to 70% in East Asia. Again, the average number of export products in East Asia is found to be about 202 while in SSA, it is only about 64, which implies that countries in SSA are still much dependent on the export of few commodities. The same is true regarding the ratio of gross fixed capital formation to GDP which is about 30% in East Asia while it is only 17% in SSA, which implies the low domestic savings and investments in SSA, while the opposite is true for East Asia. Another striking point is the secondary school enrollment ratio which is about 35% in East Asia, while it is only 13% in SSA.

Table 12: Descriptive statistics of variables for the Sub-Saharan Africa and East Asia

Variable	Sub-Saharan Africa				East Asia			
Variable	Mean	Std. Dev.	Min	Max	Mean	Std. Dev.	Min	Max
Vertical Diversification	14.633	15.936	0	81	70.081	27.946	2	100
Horizontal Diversification	63.734	54.402	2	256	201.641	36.436	86	235
Domestic Investment	17.421	8.186	-24	61	29.757	6.201	16	48
Foreign Direct Investment	1.464	3.5628	-29	46.7	3.883	5.063	-3	37.1
Education	13.075	11.739	1	57	34.458	13.936	6.9	61.9
Life Expectancy	49.938	7.291	36	73	69.83	6.617	47	82
Level of Development	3.013	0.370	2.262	4.249	3.671	0.490	2.302	4.471
Population (log population)	3.847	0.6027	1.772	5.127	4.665	0.740	3.348	6.11
Quality of Infrastructure	.727	.6395	0	2.956	1.911	0.847	0.301	3.241
Degree of Openness	61.201	31.534	0.85	209.34	114.706	106.644	9.6	425.34
Inflation Rate	48.015	31.367	11.88	371.85	53.628	33.597	12.12	193.8
Oil Dummy	0.156	0.363	0	1	0.111	0.315	0	1
Arable Land Ratio	43.160	19.999	8	91	24.237	15.575	1	60
Aid Per Capita	11.119	10.441	0	99	0.496	0.678	0	3
Exchange Rate	1.551	2.017	-1.777	4.376	1.461	1.043	.149	4.011
Political Instability	.313	.464	0	1	0.222	0.417	0	1

This again indicates how East Asia remarkably invested on education; whereas SSA's investment on education has been found to be very minimal. Likewise, the mean life expectancy at birth in SSA is estimated to be about 50 years, whereas it is about 70 years in East Asia. This implies that East Asia's performance both in education and health aspects of human capital has been extremely impressive while the opposite was true for SSA's performance in human capital formation for the last three decades. By the same token, the mean arable land ratio to total land is about 43 % in SSA; while it was only about 24 % in East Asia. This highlights SSA has a large natural resource endowment in arable land that would have been utilized for more agricultural production and related sectors. The same comparison for all variables confirms the huge gap that exists between the performances of the two regions (Table 12).

Figures 4, 5, 6, and 7 demonstrate the divergence performance of East Asia and SSA countries between 1975 and 2004, related to vertical and horizontal diversification, MVAD and income per capita, respectively. It is therefore evident that except South Africa and Mauritius in SSA, all other countries have achieved very little in increasing either their income per capita or MVAD from 1975-2004. By the same token; though SSA's performance to diversify horizontally is better off compared with the vertical ones, and yet a lot has remained to catch-up with East Asia.

Figure 4: Vertical export diversification in Sub-Saharan Africa and East Asia (1975-2004)

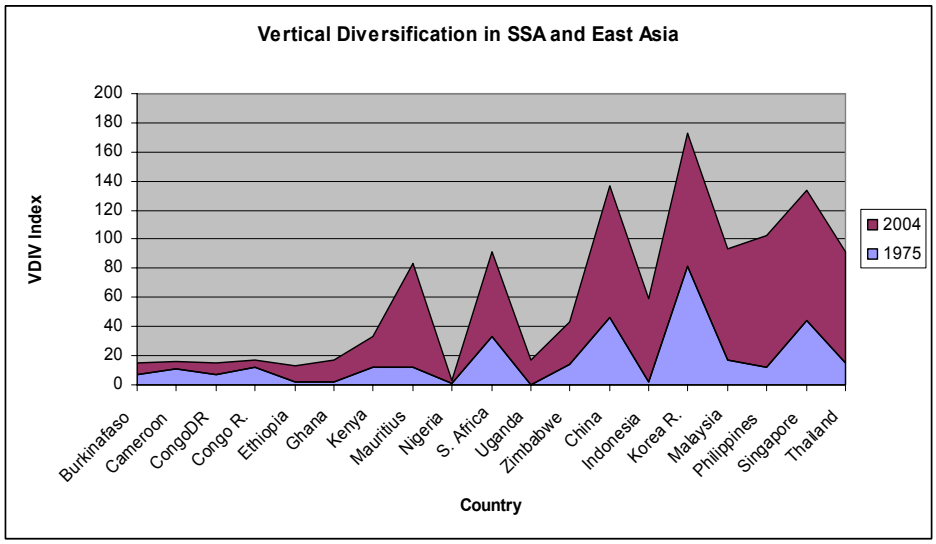


Figure 5: Horizontal export diversification in Sub-Saharan Africa and East Asia (1975-2004)

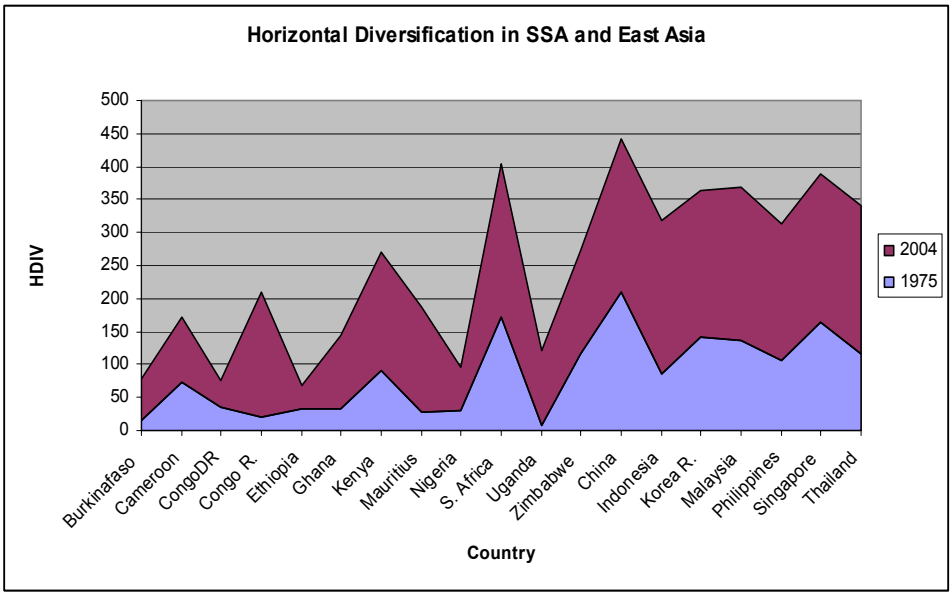


Figure 6: Manufacturing value added in sub-Saharan Africa and East Asia (1975-2004)

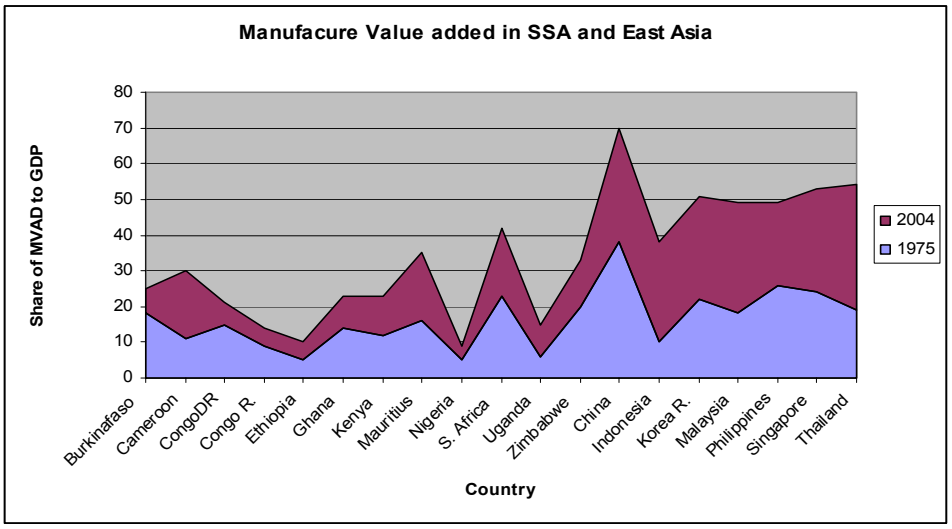
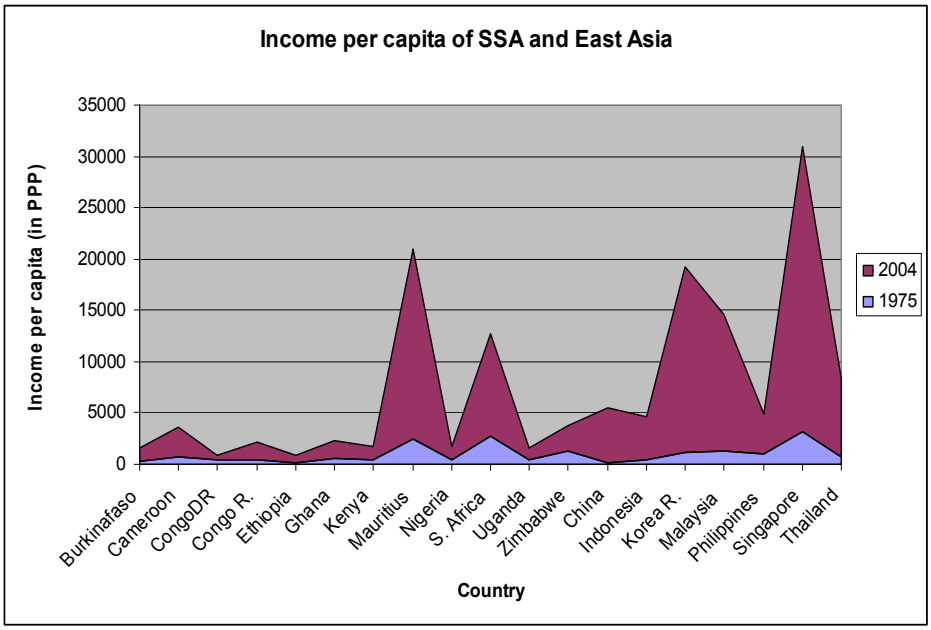


Figure 7: Income per capita in sub-Saharan Africa and East Asia (1975-2004)



Partial correlations

The correlation coefficients of vertical export diversification as well as horizontal export diversification with all independent variables have been estimated and shown in Table 13. Hence, it has been evident that FDI, education, income per capita, population size, degree of openness, depreciating exchange rate are all positively and significantly correlated with vertical as well as horizontal export diversification. Quality of infrastructure and oil dummy variables have been found to be positively and negatively correlated with vertical diversification, respectively. On the other hand, arable land ratio and aid per capita are both found to be positively and significantly correlated with horizontal export diversification.

Table 13: Partial correlation of VDIV and HDIV with the independent variables

Variable	VDIV		HDIV	
	Corr.	Sig.	Corr.	Sig.
Domestic Investment	0.0423	0.141	0.0238	0.408
Foreign Direct Investment	0.0722	0.012**	0.0915	0.001***
Education	0.0687	0.017**	0.1651	0.000***
Life Expectancy	0.0435	0.129	0.0440	0.126
Income per capita	0.1936	0.000***	0.2650	0.000***
Population (log population)	0.2033	0.000***	0.5681	0.000***
Quality of Infrastructure	0.1214	0.000***	0.0030	0.917
Degree of Openness	0.0598	0.037**	0.3221	0.000***
Inflation Rate	0.0309	0.282	0.0268	0.350
Oil Dummy	-0.2995	0.000***	-0.0179	0.533
Arable Land Ratio	-0.0368	0.1999	0.1453	0.000***
Aid Per Capita	0.0228	0.427	-0.0835	0.004***
Exchange Rate	0.0867	0.002***	0.0861	0.003***
Political Instability	-0.0299	0.297	-0.2158	0.000***
Africa Dummy	-0.2961	0.000***	-0.1482	0.000***

Note:

* refers statistically significance at 10% level.

** refers statistically significance at 5% level.

***refers statistically significance at 1% level.

Moreover, an attempt has been made to examine the relationship between income per capita and export diversification (both vertical and horizontal) so as to test the validity of Imbs and Wacziarg (2003) hypothesis, based on the evidence from four low income SSA countries (Ethiopia, and Ghana) , two developing economies from East Asia (China and Thailand), A fully developed economy (Japan).

Accordingly, Figure 8-12 below demonstrate that income per capita and export diversification especially horizontal export diversifications are all increasing in the four SSA countries. Likewise, income per capita, vertical and horizontal export diversification have become increasing in emerging economies of China and Thailand. However, the evidence from Japan confirms the relationship between income per capita and export diversification had been positive until it was fully developed and then it is on decline. Therefore, this verifies the validity of Imbs and Wacziarg (2003) hypothesis that export diversification increases as income per capita increases mostly in developing countries; whereas for developed countries, the economy will start to re-concentrate on specialized products and services as it has been evident from Japan's experience.

Figure 8: Trend of export diversification and income/capita in China

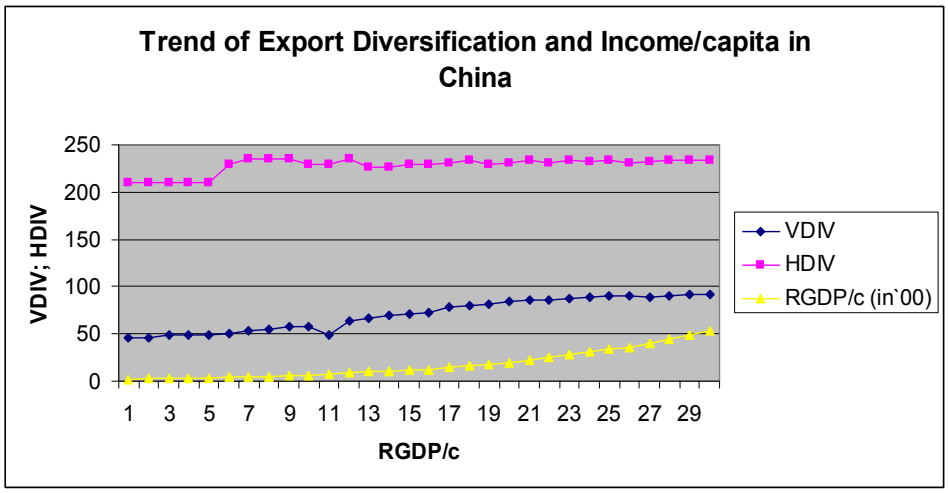


Figure 9: Trend of export diversification and income/capita in Thailand

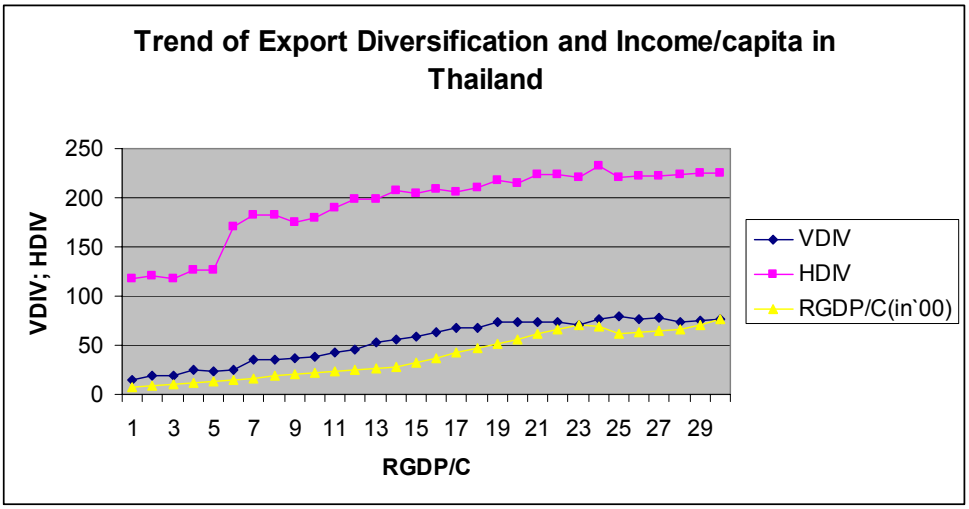


Figure 10: Trend of export diversification and income/capita in Japan

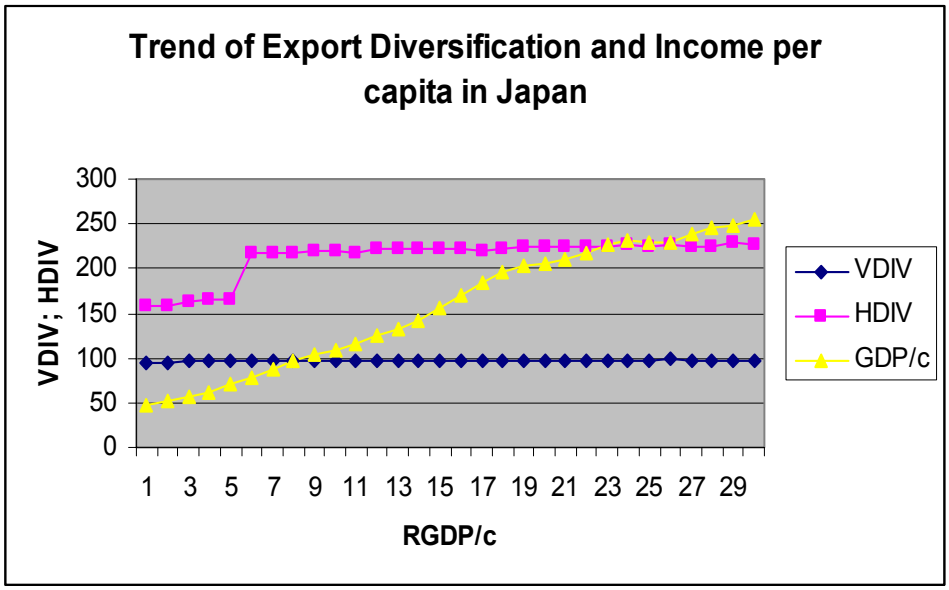


Figure 11: Trend of export diversification and income/capita in Ethiopia

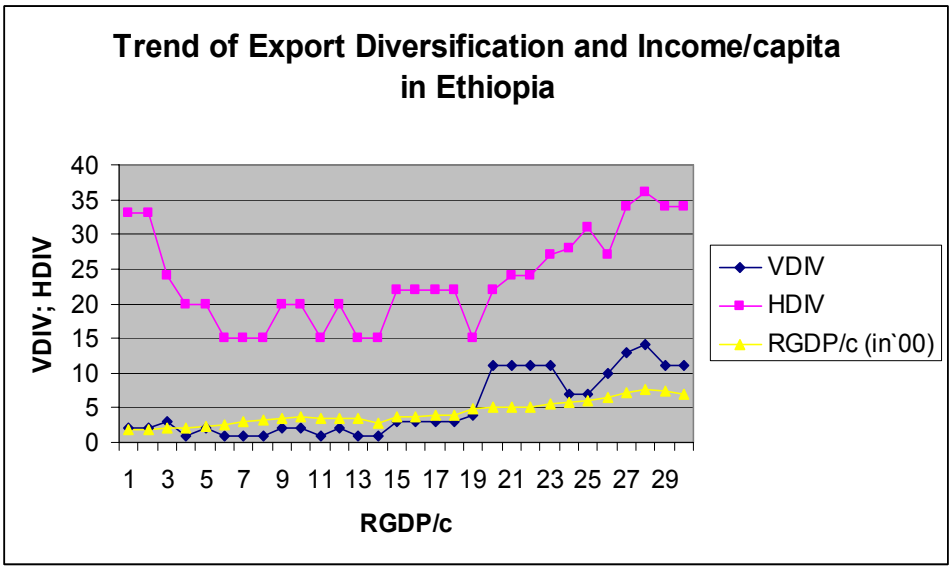
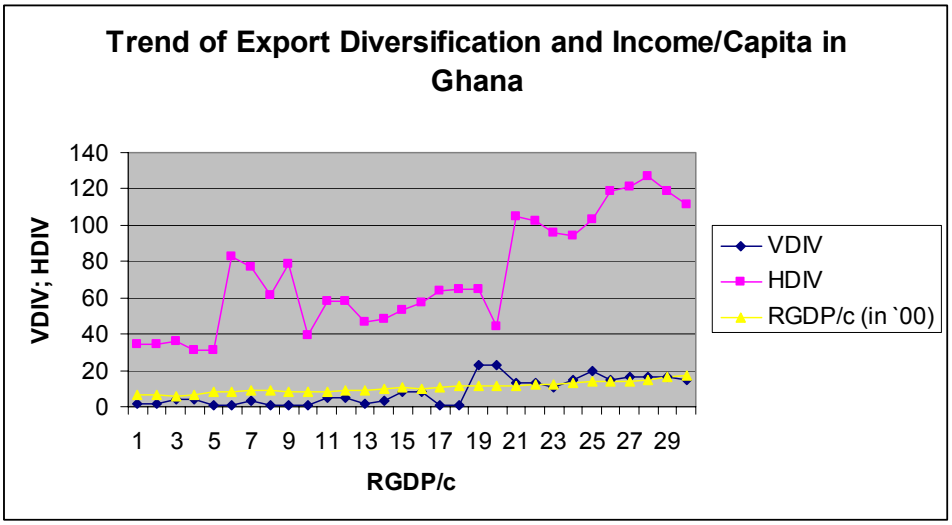


Figure 12: Trend of export diversification and income/capita in Ghana



Regression results and main findings

The empirical results from the full sample (Table 14) confirm FDI, education, life expectancy, income per capita, population size, infrastructure, openness, arable land ratio, depreciating exchange rate are the most significant and positive determinants to induce vertical as well as horizontal export diversification. On the other hand, it was evident that 'oil dummy' and 'Africa dummy' have been found to be negatively and significantly affecting vertical as well as horizontal export diversification for the full sample. Likewise, it has been found that domestic investment and political instability are positive and negative determinants for horizontal export diversification, respectively. The 'Africa Dummy' which is a proxy to capture regional differences as a result of factors which are not included in model has been found to be a negative and significant determinant to affect vertical as well as horizontal export diversification in SSA.

Table 14: Cross-sectional time-series FGLS regression results for all countries

Variables	Vertical Diversification	Horizontal Diversification
Domestic Investment	.0056 (.0062)	.0541*** (.0132)
Foreign Direct Investment	.0653*** (.0114)	.0512* (.0288)
Education	.1830*** (.0210)	.1405** (.0691)
Life Expectancy	.0779*** (.0136)	.1923*** (.0419)
Income per Capita	17.129*** (.7423)	51.169*** (2.0465)
Population	3.7947*** (.8918)	47.381*** (1.3612)
Quality of Infrastructure	3.3884*** (.3811)	2.758*** (.9653)
Degree of Openness	.024*** (.0026)	.1554*** (.0097)
Inflation Rate	-0.0039 (.0020	.0699*** (.0115)
Oil Dummy	-9.472*** (1.1775)	-18.0729*** (2.0405)
Arable Land Ratio	0.1028*** (0.169)	.0843** (.0397)
Aid per capita	.0160*** (.0050)	-.0296 (.0153)
Exchange Rate	0.9223*** (.1245)	2.7667*** (.2605)
Political Instability	-1.9465 (1.3912)	-21.484*** (1.3766)
Africa Dummy	-10.0032*** (2.1707)	-41.7382*** (3.9299)
Constant	-54.007*** (5.1672)	-236.0684*** (11.6148)
No. of Observation	1230	1230
No. of Groups	41	41
Time periods	30	30
Wald Chi2 (14)	1621.62	10269.66

Note:-

* refers statistically significance at 10% level.

** refers statistically significance at 5% level.

***refers statistically significance at 1% level.

The robustness of the above results as well as the implications for each finding is investigated along with the findings from the sub-samples analysis (Table 15). Accordingly, the evidence from the sub-samples analysis revealed that, domestic investment plays an important role to induce vertical as well as horizontal export diversification in the case of East Asia, while it plays a significant role only to promote horizontal diversification in the case of SSA. The reason might be the fact that domestic capital formation which is mainly driven by domestic savings are still at lower stage in many SSA countries and hence its contribution to enhance vertical diversification and exporting high value-added manufactured exports is insignificant. On the contrary, the evidence confirms East Asian countries have been successful in domestic capital formation mainly through domestic savings and this in turn significantly contributed for promoting vertical as well as horizontal export diversification. By the same token, FDI has been found to be positively and significantly affecting vertical and horizontal export diversification in East Asia; but it only induces vertical diversification in the case of SSA; verifying one of the research hypotheses that FDI in SSA is still under the threshold level and its contribution to export diversification wouldn't be as satisfactory as compared to East Asia. Additional explanation why the outcomes of FDI to be different in the two regions may be the fact that educational level, development of local financial markets, and other local conditions are not adequate enough to attract FDI and play a positive role and materialize vertical export diversification in SSA. Thus, the implication is that SSA countries have to make a strong effort not only in creating a conducive atmosphere to motivate domestic capital accumulation, but also a wide range of activities should be made in attracting foreign capital to be used as alternative sources of capital formation and thereby for vertical as well as horizontal export diversification.

By the same token, the educations as well as the health components of human capital have been found to be highly significant determinants for promoting vertical and horizontal diversification in East Asia, implying again countries in this region have significantly invested on education and health care system. On the other hand, the evidence from SSA sub-sample analysis has confirmed the education factor was very important to enhance both vertical and horizontal diversification, but the health variable has been a significant factor only for promoting vertical diversification in SSA. Again, this implies that SSA has to do more in investment on education as well as health so as to achieve a radical change on its economy, specifically to achieve a significant change in vertical and horizontal export diversification as it has been witnessed in East Asia.

Table 15: Comparison of Sub-Saharan Africa and East Asia countries

Variables	Vertical Diversification		Horizontal Diversification	
	SSA	East Asia	SSA	East Asia
Ratio of GFCF to GDP	.0056	0882*	.0236***	.2146**
	(.0047)	(.0498)	(.0059)	(.1103)
Ratio of FDI to GDP	.0593***	1431**	.1411	.1201***
	(.0093)	(.0646)	(.1074)	(.0098)
Education	.0582***	646***	.2715***	.464***
	(.0208)	(.0768)	(.0372)	(.1499)
Life Expectancy	.0581***	2751**	.1604	.2001***
	(.012)	(.1376)	(.2899)	(.023)
Income per Capita	13.838***	13.352***	53.1515***	39.833***
	(.6698)	(2.5383)	(.9725)	(8.829)
Population	2.8721***	8.1605***	55.7658***	15.123***
	(.5868)	(2.8984)	(1.0122)	(4.8256)
Quality of Infrastructure	2.5586***	2.5873***	7.9446***	4.2215**
	(.2999)	(1.3180)	(.5389)	(2.5154)
Degree of Openness	.0086***	0508***	.1823***	.0768***
	(.0025)	(.0139)	(.0039)	(.0227)
Inflation Rate	-.0041*	.0041	.1143***	-.0622**
	(.0022)	(.0143)	(.0052)	(.0304)
Oil Dummy	-6.6847***	-44.8368***	-15.3397***	-24.838***
	(.5004)	(5.6653)	(.8530)	(9.2097)
Arable Land ratio	1539***	.2019**	.1163***	7314***
	(.0177)	(.0879)	(.0182)	(.2396)
Aid per capita	0322***	1.637***	-.0357***	7305
	(.0038)	(.5293)	(.0083)	(1.0766)
Exchange Rate	2471***	11.6265***	2.5855***	-3.6277*
	(.0502)	(1.4578)	(.1548)	(1.9314)
Political Instability	-4.8529***	-.5743	-15.711***	-27.4911***
	(.7379)	(3.5833)	(1.2452)	(6.5411)
Constant	-45.5182***	-88.449***	-326.1033***	-57.77*
	(3.5547)	(16.4292)	(5.498)	(35.773)
No. of Observation	960	270	960	270
No. of Groups	32	9	32	9
Time periods	30	30	30	30
Wald Chi2 (13)	3065.74	3254.07	12367.85	201.03

Note:

* refers statistically significance at 10% level.

** refers statistically significance at 5% level.

***refers statistically significance at 1% level.

Although the standard results of the main determinants are fairly robust for both Sub-Saharan Africa and East Asia, the magnitudes of coefficients vary across the two regions. The effects of human capital, domestic capital, and FDI both on vertical as well as horizontal export diversification have been highest in East Asia and less in Sub-Saharan Africa sub-sample, implying a similar ranking of investment in human capital and the marginal product of capital in the two regions. For instance, the estimated elasticity of education and health components of human capital for vertical diversification in East Asia was found to be 0.646 and 0.2751, respectively; while they were only 0.0582 and 0.0581 for SSA sub-samples, respectively. In the same token, the elasticity of education and health for horizontal diversification in East Asia were found to be 0.464 and 0.2001, respectively; while for SSA were only 0.2715 and 0.1604, respectively. The same is true for the elasticity's of FDI and domestic capital with regard to their effects on vertical as well as horizontal export diversification in the two regions as shown in Table 15. Thus, the East Asian experience shows that domestic physical capital, investment on human capital and FDI are complements not substitutes with each other, and all positively and significantly contribute to both vertical as well as horizontal export diversification.

Income per capita which is a proxy for level of development has been found to be statistically significant at 1 % level for both SSA as well as East Asia. This is again consistent both in the full-sample as well as in the sub-samples analyses that verified the research hypotheses proposed earlier that income per capita and export diversification have a positive relationship mainly in developing countries. In fact, the elasticity's of this variable is high in the case of SSA rather than East Asia, perhaps in line with the arguments by Imbs and Wacziarg (2003) that diversification initially increases as per capita incomes increases and then it becomes decreasing. In other words, though most of the East Asian countries in the sample except Japan are still classified as developing countries, most of them have achieved high income per capita and hence it is expected that the rate of increase in export diversification to become less and less.

As expected, 'degree of openness' has been found to be an important and statistically significant factor for export diversification both in the full sample and sub-samples analyses, implying a step-by step liberalization and opening the economy is one of the pre-requisites in order to enhance vertical as well as horizontal export diversification. In line with this, 'infrastructure' is also positively associated with vertical and horizontal diversification and the result is also consistent both in the full-sample analysis as well as the sub-samples analyses. Thus, the results support the widely held view that the quality of infrastructure and openness to foreign markets are critical to diversification. Furthermore, population size has been found to be significant and positive

determinants for both vertical and horizontal diversification in the full sample as well as in the sub-sample analyses; implying domestic demand is one of the driving factors for a country to diversify both vertically and horizontally. This is also in line with the proposition of 'endogenous growth theory' that countries can benefit from larger scale such that with a larger population and a larger market size. In other words, countries are expected to grow faster because of scale economies.

Inflation has a mixed effect on vertical and horizontal diversification both in the full-sample as well as the sub-samples. For instance, inflation is negatively associated with vertical diversification; but positively associated with horizontal diversification in the analysis of the full sample (Table13). However, the sub-sample analysis in Table 14, confirms that inflation is negatively correlated in SSA's vertical export diversification and East Asia's horizontal diversification. On the other hand, the evidence shows inflation has a positive significant effect on SSA's horizontal export diversification. Generally, the results are not conclusive and the intuition is that moderate level of inflation can be sometimes associated with economic growth. For that matter, a low and single-digit level of inflation doesn't have a negative effect on either export diversification in particular or to economic growth in general. However, it should be noted that high levels of inflation damage diversification prospects and the tendency under such circumstances is for increased concentration with little opening-up to new export sectors.

Similar to pervious works by others, natural resource endowment proxied by oil resource has a negative and significant effect on both vertical and horizontal export diversification for the full sample as well as the sub-samples. However, natural resources endowment proxoed by 'arable land ratio' has been found to be an important positive determinant to enhance vertical and horizontal export diversification both for the full-sample as well as the sub-samples. The results therefore don't support the generalized view, that resource abundance can have a negative effect on diversification as well as growth. Therefore, SSA has a relatively large proportion of arable land compared to East Asia and this would be an advantage to diversify not only horizontally, but also vertically towards value-added agro-industries and related manufacturing sector through utilizing its abundant agricultural raw materials.

Likewise, it is not surprising to find political instability to be a negative and statistically significant factor for the full sample as well as the sub-samples analyses; since a more stable and durable political regime is vital to improve the prospects for successful diversification in any country. Interestingly, this variable has become significant at 1 % level and negatively affects vertical and horizontal diversification for SSA sub-sample; where as it negatively affects only horizontal diversification in East Asia. In other words, there is no indication that political instability has a significant effect on vertical diversification for East Asia sub-sample. This was because of countries in East Asia

are not this much suffered from political instability for the last three decades, and this makes the 'war dummy' variable to be statistically insignificant factor to explain vertical export diversification, which is the dominant type of export diversification in East Asia. Conversely, Sub-Saharan Africa has tremendously suffered from the consequences of prolonged war for the last three decades and it is not surprising to find out a very significant and negative relationship between political instability and vertical and horizontal export diversification for SSA sub-sample.

Foreign aid has been found to be statistically significant at 1 % level and positively affecting vertical diversification; but statistically insignificant for horizontal diversification for the full sample analysis. A detailed analysis for the sub-samples shows that foreign aid has still a positive and significant effect on vertical export diversification both in SSA and East Asia, but it is negatively affecting horizontal diversification in SSA. The empirical results, therefore, indicate that unlike previous assumptions, foreign aid can't always have an anti-export bias due to a 'Dutch disease' effect by causing an appreciation of the real exchange rate. In fact, the results indicate that if properly managed, foreign aid can play a positive role in promoting vertical export diversification.

A depreciating and stable exchange rate has a significant and positive effect at 1% significance level on vertical and horizontal export diversification in the full sample as well as for SSA's sub-sample; which is in line with the theory indicating a depreciating currency is an appropriate macroeconomic fundamental to support increases in existing exports and ease potential exportable products into new markets. However, this is not always true in the case of East Asia. The empirical analysis from the East Asian sub-sample indicates depreciation was positively associated with vertical export diversification, while horizontal diversification was associated with currency appreciation. Similar results have been recorded by Abeysinghe and Tan Lin (1998) that Singapore's economic growth was associated with continued currency appreciation for the last three decades. Especially, if a country's export inputs are mainly imported as the case of Singapore and Japan, currency appreciation may have more positive effects on economic growth rather than currency depreciation. All in all, however, the empirical results for the full-sample as well as the sub-samples except East Asia's horizontal export diversification confirm the importance of a depreciating and stable exchange rate as one of the key factors to promote export diversification.

Finally, the 'Africa Dummy' which is a proxy to indicate regional differences in export diversification as a result of factors which are not already included in the model has been found to be significant with negative signs. There are at least two interpretations for this result. One interpretation is that there are higher levels of technology spillovers in East Asian countries, mainly because of their geographical proximity to Japan;

whereas such kind of economic power is absent in the case of SSA. Another explanation could be the cultural factors in East Asian countries that *Confucius* teachings and philosophies have deep influence in personal and government morality such as justice and sincerity, loyalty, hard workingness, saving, environmental protection, etc. These factors are, however, relatively loose and very low in Africa compared to East Asia and ultimately affecting SSA negatively for its diversification effort.

6. Concluding remarks and policy implication

To sum up, most of the empirical results of the variables under consideration are consistent between the full sample and the separate estimations of the two regions. The empirical results from the full sample as well as the sub-samples confirm education, health , income per capita, population size, infrastructural development, openness, arable land ratio, depreciating exchange rate are the most significant and positive determinants to induce vertical as well as horizontal export diversification. Though FDI was found to be a key positive determinant of vertical as well as horizontal export diversification in East Asia, the evidence from SSA however confirms that FDI was significant only in the case of vertical diversification for SSA. Moreover, the elasticity's of those determinants such as human capital and FDI were much higher in East Asia than SSA. This may be explained that East Asian countries have devoted significant amount of investment on education, health, infrastructure and these in turn created a better conducive atmosphere for FDI inflow into those countries. By the same token, the study revealed that domestic investment plays an important role to induce vertical as well as horizontal export diversification in the case of East Asia, while it was significant only for horizontal diversification in SSA. This implies that East Asian countries were also successful in raising domestic savings and creating adequate domestic capital that might have contributed to intensify export diversification.

The study also confirms a country's level of development, population size, quality of infrastructure, and degree of openness are also significant and positive determinants for vertical as well as horizontal export diversification in the analysis of the two sub-samples. Likewise, natural resource wealth especially arable land in which SSA is better endowed has also a positive and significant effect for diversification and this implies that not all types of natural resource endowment have a 'Dutch disease' effect as sometimes generalized by some researchers. However, the oil dummy variable was negatively associated with vertical and horizontal export diversification in SSA and only with vertical diversification in East Asia. Interestingly, oil wealth is positively associated with horizontal export diversification in the case of East Asia. Again, this

implies that the 'Dutch disease' effects of oil wealth are mostly notable in the case of vertical export diversification rather than horizontal diversification. While inflation, exchange rate, and foreign aid variables have a mixed effect on vertical and horizontal export diversification, political instability was found to be a major key negative factor for vertical as well as horizontal export diversification; especially for SSA. This may prove the hypothesis we set at the outset that in a country with political instability and frequent war, the level of saving as well as investment become very low and this in turn may negatively affects export diversification. Finally, the 'Africa Dummy' which is a proxy to indicate regional differences in export diversification as a result of factors which are not already included in the model has been found to be significant with negative signs. The first reason is perhaps East Asian countries are in advantageous positions to benefit from technology spillovers from Japan due to their geographical proximity. Whereas; such type of economic power is absent in the SSA. Secondly, the cultural factors in most of East Asia are deeply influenced by the *Confucius* teachings and philosophies that has a wide impact on personal and government morality such as justice and sincerity, loyalty, hard workingness, saving, etc. These factors are, however, relatively loose and very low in Africa compared to East Asia.

The policy implications of this study are relatively straightforward. The lesson from East Asia to SSA is that investment on human capital and physical infrastructure through foreign investment as well as domestic capital formation are key factors, as are stable macro-economic and political environment, a stable and flexible exchange rate, and a fair and an open trading framework are all crucial ingredients to accelerate vertical and horizontal export diversification and ultimately promote structural change on the economy. In line with this, this study recommends SSA countries to follow a dual strategy of vertical and horizontal export diversification, mainly by supporting backward and forward linkages into higher value-added resource-based industries and gradually shift production and exports from customary products to more dynamic ones by developing a competitive advantage in the world market. Although export diversification can't be expected to become a panacea for SSA's deep-rooted economic problems which are a result of three/four decades stagnation, it is however one of the key measures for structural solutions and a prerequisite to achieving a sustained and rapid economic development.

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RESPONDING TO AN INCOME SHOCK THROUGH INCREASING FOREST EXTRACTION: SURVEY EVIDENCE FROM ETHIOPIAN COFFEE FARMERS[1]

Degnet Abebaw[2],*, John Mburu[3], Karin Holm-Müller[4]

Abstract

The worldwide turndown in coffee revenue to the majority of resource poor primary producers has become a serious threat to sustainable development. There is however inadequate knowledge with respect to mechanisms used by resource poor coffee farmers to stave off situations of economic hardship. Using cross-sectional household survey data from southwest Ethiopia, the present study investigates whether or not farmers use forests to even out variability associated with risky coffee income. A zero-inflated negative binomial model was used to explain farmer frequency of firewood collection trips as a response to income shock and risk in coffee farming. The empirical results indicate that a rise in household forest extraction effort for firewood is strongly associated with shortfalls in current coffee income and with income uncertainties prevailing in the coffee sector. The study draws policy implication from the perspectives of development and environment.

Keywords: Income shock; coffee farming; forest extraction; Ethiopia, Africa

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[1] The final version of this article was submitted in March 2009.
[2] Ethiopian Economic Association/Ethiopian Economic Policy Research Institute, P.O. Box 34282, Addis Ababa, Ethiopia
* Corresponding author:
E-mail: degnet2003@yahoo.com; Tel. No.: 0116-453200; Fax No.: 0116-453020
[3] Center for Development Research (ZEF), University of Bonn, Walter-Flex Str. 3, D-53113 Bonn, Germany
[4] Institute for Agricultural Policy, Market Research and Economic Sociology
University of Bonn, Nussallee 21, D-53115 Bonn, Germany

1. Introduction

Worldwide, coffee farmers are typically confronted with low and unpredictable coffee income (ICO, 2004; Ponte, 2002; Vakis, Kruger, and Mason, 2004; Varangis, Siegel and Lewin, 2003). Most of these studies show that the main sources of vulnerability to coffee income risk include, inter alia, fluctuation of green coffee prices, crop diseases and pest attack, government policies and legislations, and weather-related factors. Exposure to risks and adverse income shocks in developing countries, including Ethiopia, leads to declines in farmers' well-being due to the lack of well-functioning insurance and credit markets to smooth consumption when income falls (Maitra, 2001; Morduch, 1999, Dercon, 2002).

Given this state of affairs, individuals and households in the developing countries of Africa, Latin America and Asia keenly explore self-insurance mechanisms to counteract these shocks (Alderman and Paxson, 1992; Dercon, 2002). For example, individuals (households) may engage in activities such as crop diversification (Fafchamps, 1992), off-farm employment (Rose, 2001; Mishra and Goodwin, 1997; Rose, 2001), intercropping (Godoy and Bennett, 1991), or spread their crop sales over time (Goodwin and Kastens, 1996) to reduce the risk of facing variable income, ex ante. Further, they may resort to borrowing (Udry, 1995), asset sales including livestock and land (Rosen and Masset, 2003; Rosenzweig and Wolpin, 1993), past savings (Deaton, 1990), out-migration and remittances (Rosenzweig, 1988), temporal off-farm work (Kochar, 1999) or pull children out of school to work (Jacoby and Skoufias, 1997) to smooth consumption ex post, albeit imperfectly. However, at the present, there is a paucity of relevant information about the mechanisms used by the small coffee farmers to deal with income risk ex ante or address adverse income shocks ex post (Vakis, Kruger and Mason, 2004).

This paper provides an impetus to test the hypothesis that farmers use forests as a safety net by increasing the supply of their family labor for the extraction of firewood.[5] Our study differs from most of the previous studies in several ways. First, previous studies largely focused on sources of production or market risks or of fluctuations in yield or price separately. In contrast, the present study focuses its attention on income risk since it appears to be more important than just yield or price risks for a cash crop (coffee) producer. Second, we give an explicit account of how a farmer's subjective rate of time preference apart from socioeconomic and demographic factors alters his/her

[5] As a reviewer pointed out, we also recognized that, as in other countries, forests are important sources of food, medicine, timber, and other ecosystem services in Ethiopia. However, our exclusive focus in this paper is on its importance as a risk coping strategy in the study areas.

forest extraction and risk coping behavior. Furthermore, we specify and test the effects of a wide range of other risk coping mechanisms in rural areas including inter alia membership to a farmers' group, off-farm employment, crop diversification, and social-ties or demographic history.

The empirical data for the study were drawn from a cross-sectional survey of 195 coffee farmers in Yayu and Gewata districts in southwest Ethiopia. The study sites border with the de jure mountain forests of southwest Ethiopia. There are several reasons as to why Ethiopia is an important case for the present study. Firstly, Ethiopia is one of the coffee producing countries most affected by recent downturn of green coffee prices (Oxfam, 2002).[6] Second, smallholder farmers produce over ninety five per cent of Ethiopian coffee,[7] using on average less than a hectare of land (Tessema, 2001). Third, Ethiopia is one of the poorest countries in the world and the vast majority of farmers in rural areas tend do not have adequate access to essential services such as credit, education and agricultural extension. Likewise, rural insurance markets are missing (Dercon, 2002). Essentially, it would be in the farmers' interest to self-protect their welfare against income risk with their own scarce resources and knowledge. Fourth, coffee is the main agricultural investment and also a prime source of cash income to estimated 700 to 800 thousand farmers in Ethiopia. The outcome of uncertain events, thus, can make the difference between survival and starvation (Ellis, 1993). Finally, in southwest Ethiopia a large number of small coffee farmers are located close to remaining mountain forests, which among others used to provide a natural habitat for populations of wild Coffea arabica and other biological resources (Agrisystems Limited, 2001).

Evidence presented elsewhere indicate that forests are used as buffer stocks to farmers and most of these studies are of the opinion that forest conservation strategies success requires an improvement of farmers' ability to mitigate risks (Fisher and Shively, 2003; Reardon and Vosti, 1995; Takasaki et al., 2004). Thus, the outcome of this study would be useful to policy makers and governments in guiding their efforts in integrating development strategies with forest conservation objectives.

The rest of this paper is organized as follows. In Section Two, we outline the theoretical framework and derive key hypothesis of the study. In Section Three, the empirical model to estimate the impact on forest pressure of coffee income risk and other variables is specified. Section Four describes the survey procedure and source of data used for this study. Section Five then presents the results and discussion of the study

[6] For instance, in 2001 Ethiopia's export income suddenly declined by forty-four percent from the previous year, despite the fact that exported volume remained on the rise.
[7] The type of coffee variety cultivated in Ethiopia is *Coffea arabica*.

by mainly focusing on the socioeconomic profile of the sample households and the determinants of their forest extraction behavior. Conclusions and policy implications of the paper is given in Section Six.

2. Conceptual framework and hypothesis

Adjustment in labor use via resource extraction has been one of the key behavioral responses to an income shock among poor rural households in developing countries (Baland and Francois, 2005; Byron and Arnold, 1999; Fisher and Shively, 2003; Pattanayak and Sills, 2001; Takasaki, Barham and Coomes, 2004). There are several reasons why asset-poor households in rural areas turn to draw upon forests as a safety net. First, besides requiring labour, forest extraction demands physical capital (ibid.). Second, tropical forests are biodiversity-rich hot-spots such that they provide a wide range of opportunities for exploitation by humans. Third, labor productivity allocated to common-pool or open-access resources such as forests is relatively homogeneous in comparison with productivity outside (Baland and Francois, 2005). It is for these reasons that governments make efforts to protect these forests from rapid exploitation by humans even though, in fact, they often are de facto open access resources.

For low income households facing widespread market imperfections in rural areas of developing countries (de Janvry, Fafchamps and Sadoulet, 1991), activity choice cannot be fully understood without due consideration of consumption preferences and tastes (Singh, Squire and Strauss, 1986). The implication of this is that asset (natural, physical, social, human and financial) endowments matter to one's choice of livelihood activities and risk coping strategies (Reardon and Vosti, 1995; Ellis, 1998).

The decision problem of a farmer is to maximize the expected utility. In this framework, it is presumed that a household forms rational expectation and that it is confronted with coffee income risk. We also explicitly split the agricultural period into wet and dry seasons to set up a farmer's farm management plan under risk. In the wet season, the farmer fully realizes risk outcomes from the previous dry season, but yet remains uncertain regarding outcomes of its current input use decisions, including labor, in the coming dry season. In other words, the farm households' reaction to risk in the wet season depends on both the state of realized event in the previous season and the expected decision outcomes in the next season. Household participation in forest extraction is seen as a safety net, and may therefore be associated with a host of farm and farmer characteristics, location, and infrastructure, since farmers do not have an insurance market or lack adequate access to consumption credit. As a result, solving the constrained maximization problem subject to budget and time constraints, the

reduced form equation for a farmer's labor supply in the forest extraction can be specified as:

$$L_f = l\left(P_f, r, R, Z, \Theta_1, \Theta_0\right)$$

where, L_f is the optimal amount of forest extraction labor used by the household in the wet season; P_f is price of a forest good gathered; r is a wage rate; R is a vector of household characteristics; Z is a vector of infrastructure and location attributes; Θ_1 is an indicator of riskiness of coffee income; and Θ_0 is an indicator of shortfall in coffee income. Controlling for other differences, the equation specified above predicts that forest extraction trip, a proxy for effort, is associated with shortfalls of coffee income and its exposure to risk. Proxies are used for some of the variables which are included in the reduced for equations. For instance, the variable P_f is not used due to lack of adequate variation in the cross-section. Instead, it is proxied by the distance to the nearest road. Distance to the nearest forest and education of household head are assumed to bear a direct relationship with the opportunity cost of time spent in the forest extraction activity. It is also worthwhile to note that participation in a paid off-farm employment in the previous season may predict risk management or risk coping in the current season via labor market participation thereby increasing the opportunity cost of labor in forest extraction, all else equal.

The key interest of the paper is to test the hypothesis that coffee farmers use forests as a safety net to recoup adverse income shocks and as a precautionary tool against future uncertain income. A host of other variables such as households' time preferences, resource endowments, location and demographics are incorporated into the model so as to capture household differences in risk management and risk coping on the one hand and to account for other motives for undertaking forest extraction on the other hand.

3. Empirical methods

To empirically test the theoretical relationship specified in the previous Section, data on household frequency of firewood collection in the wet-season are used. The dependent variable is constructed by eliciting the total number of trips made by the household to collect firewood from the nearest de jure state forests. Stated in other words, the dependent variable takes a non-negative integer values and hence a count data. As suggested by Gurmu and Trivedi (1996) a Poisson regression is a good starting point to

analyze data of this kind. In analyzing data by a count data model, one may have to account for different data generating processes within one particular count, not compatible with a standard count data model (Melkersson and Rooth, 2000). The most common feature of this kind is a relative excess of zeros (e.g. Gurmu and Trivedi, 1996). As will be discussed later in this paper, our forest extraction data manifest clear signs of over-dispersion and high incidence of zero observations, violating key assumptions of the Poisson model. As a result, we turned to use a zero-inflated negative binomial regression (ZINB) for our estimation procedure (Cameron and Trivedi, 1998; Haab and McConnel, 1996).

In a zero-inflated count data model, zero observations are assumed to originate from two different data generating sources. One source, as represented in this study, arises due to households who have not made any firewood collection effort from the de jure protected forests at the study sites. The other zeros originate from households who reported not having any forest extraction trips in the sample period, perhaps on account of a mere chance, misreporting or shortness of the observation period of the study. In building the ZINB model, a household is assumed to make a two-stage decision: the decision on whether or not to engage in forest extraction, and the decision on the frequency of forest extraction, with a possibility of making no extraction. Logit and negative binomial regression models are, respectively, used to jointly explain these decisions within the ZINB modeling framework.

4. The study area and data sources

This study was carried out along the boundary of two mountain forests; namely Geba Dogi and Boginda-Yeba. Respectively, these forests are found in Yayu and Gewata districts (locally called Woredas) of southwest Ethiopia. In these areas, agriculture is the major source of livelihood and coffee farming is the prime source of cash income to many families. Maize, sorghum, and teff[8] are the main food crops. Livestock, particularly oxen, are a prime source of traction power. Most forests within the region officially belong to the state, even if their exploitation by the local population continues to be commonplace and appear to be on the rise (Beshir, 2002; Tadesse, 2003).

The database for this study came from a random sample of 195 coffee farmers (115 from Yayu and eighty from Gewata) in southwest Ethiopia. The field survey was carried out between August 2002 and January 2003.[9] Semi-structured questionnaires and

8 Teff (Eragrostis abyssinica) is a cereal crop, a staple food in Ethiopia (particularly in the Urban areas) and indigenous to Ethiopia.

9 This period was an unusually bad year to most of the coffee farmers we surveyed. As a consequence, caution should be made in generalizing household labour allocation decisions which were observed during

trained enumerators were used to interview respondents. The questionnaire was pre-tested. Respondents were interviewed on a wide range of topics that included basic data on household and individual characteristics, farm characteristics, and demographic history. Furthermore, the dataset contains farmers' evaluation of risk and risk management strategies associated with coffee farming. Respondents also gave their evaluation of the importance of participation in forest extraction as means to stabilize income and to smooth consumption in the face of adverse income shocks involved in coffee farming. Furthermore, data on labor used in gathering forest products over the three months preceding the onset of the survey (wet season in the study areas), were collected, using respondents' recall.[10]

To identify the extent of income risk involved in coffee farming, respondents were asked to define their situation in terms of coffee income in the year 2001/02. The respondents identified this period as the "worst", since it had the lowest income. On the other hand, they rated 1994/95 cropping season as the "best" of the past seven years to the survey period. Respondents were further motivated to report coffee yield and price in these two cropping seasons so that coffee income was inferred indirectly. Respondents were also able to reflect coffee yields and price during normal cropping seasons. As a result, intermediate data on the extent of income shortfalls in coffee farming in 2001/02 was constructed by computing how much additional income could the farmer have obtained had 2001/02 been a normal or typical year. Furthermore, riskiness of coffee income was proxied by coefficient of variation of coffee income and was constructed following the procedure specified by Anderson and Dillon (1992).[11]

our survey period to normal periods and other locations. However, studying farmers' risk coping behaviour requires observing their actual behaviour when such an even unfolds. We are indebted to an anonymous reviewer for pointing out this concern to us.

[10] As a reviewer noted, the reliability of the self-reported data is subject to the usual caveats that apply when responses are based on one's recall. A mixture of strategies was used to minimize (un)intentional over- or under-reporting bias. At the outset, we told respondents that their participation in the survey is absolutely voluntarily and that their identity will be kept anonymous in any analysis of the survey data. Next, in responding to our recall question, respondents were asked to recollect all relevant information about firewood gathering activities by their family members.

[11] Using a triangular distribution function, Anderson, & Dillon (1992) provides specifications for estimating mean $(E[x])$ and variance $(V[x])$ of crop income given its modal or most likely value (m), the lowest possible (l), and the highest possible (h) as: $E[x] = \frac{(l+m+h)}{3}$, and $V[x] = \frac{[(h-l)^2 + (m-l)(m-h)]}{18}$.

5. Results and discussion

5.1 Summary of the main explanatory variables used in the regression analysis

The sample households of this study bear heterogeneous characteristics. Table 1 summarizes the main variables used in the regression. On average, household heads in the sample are forty-four years of age. A closer accounting of the data shows that nearly seventy-six percent of the households are native to the study areas whereas the rest (twenty-four percent) migrated to the study areas over the last thirty years. The non-native households comprise of households that originated from central and northern Ethiopia and also from the neighboring and non-coffee growing districts in south and southwest Ethiopia. Those from the central and northern highlands arrived in the 1980s and largely constitute to government-sponsored resettlers in the study areas.

Regarding land, the respondents, on average, hold 2.36 hectares. Of this, nearly forty-one percent is grown with coffee. Land in the study areas belongs to the state and farmers cannot sell it to insulate consumption against adverse income shocks. At the study sites crop diversification is a common practice. For instance, in 2001/02 a typical household in the sample cultivated three different crops, located roughly on four different fields. The survey results also show that households in the sample possess about three heads of cattle, on average. Like in other regions in Ethiopia, agriculture is rain-fed and labor-intensive at the study sites. A typical household in the sample has about six household members. Males head ninety percent of the sample households. Access to formal credit is very limited, and road infrastructure is poorly developed. On average, a household in the sample travels fifty-one minutes and twenty-one minutes to reach nearest forest edge and an all-weather road, respectively. Nearly forty-five percent of the respondents do not have membership to farmers' cooperatives, and, hence, do not have the chance to exercise and benefit from collective bargaining power in the market place. In fact, our field observation indicates that the farmers' cooperatives in the study areas are engaged in various interrelated agricultural activities such as distribution of farm inputs, marketing of farm products such as coffee, lending credit and conservation of natural resources.

The survey results also reveal that forest products are important sources of livelihood in the study areas. For instance, a typical household in the sample had made six round trips of forest extraction in June to August. In fact, this average masks interesting inter-household differences (variance of forest extraction trips = 37.69) existing in the

sample. About twenty five percent of the sample households did not make any of such trips during the reference period.

5.2 Perceived importance of some coffee income risk coping strategies

On average, in 2001/2002 a household in the sample received about 321 Ethiopian Birr and about seventy-four Ethiopian Birr, respectively, from crop and livestock sales. Approximately 256 Ethiopian Birr was earned from coffee sales, which is nearly eighty percent of the crop cash income. What this means is that farmers are disproportionately heavily dependent on coffee. Had the 2001/2002 not been a "bad" year for coffee, this share might have even been higher. Farmers in the sample, on average, had experienced a shortfall of about 1619 Birr from coffee income. The descriptive results also show that farmers on average are exposed to a high level coefficient of variation of coffee income (40%).[12] Since this result is computed primarily based on recall data provided by respondents, the result should be taken only as a suggestive insight into the issue. What is interesting is perhaps the fact that the result indicates the widespread incidence of heterogeneity in farmers' risk exposure. This may call for differentiated household targeting for risk mitigation and coping policies. Farmers have different perceptions of risk coping strategies. Table 2 provides the list of certain strategies and farmers perceptions towards them. Of the 195 sample respondents, about sixty-one percent of them saw forest extraction as important or very important for helping them cope with adverse income shocks. Out-migration to cities was seen as the least important among the risk coping strategies considered. About seventy four percent of the sample farmers perceive risk coping via livestock sales as important or very important. Similarly, a large number of the sample respondents (sixty eight percent) perceive risk coping through drawing on household savings as relevant. Interestingly, risk coping by pulling out children from school to work was seen as one of the least relevant. A large number of respondents perceive public (government) support as a relevant risk coping mechanism. Reducing food consumption as a risk coping mechanism is seen as important or very important by about fifty eight percent of the sample farmers.

[12] Coefficient of variation of coffee income was computed following Anderson and Dillon (1992) with sample data covering seven years preceding the survey.

5.3 Determinants of forest extraction

In Table 3 results of ZINB[13] model are presented. The data used in the estimation of the model revealed no significant sign of multi-collinearity. Factor changes are estimated along with the model coefficients in order to make the interpretation of parameter estimates easier (see Long and Freese, 2001).[14] The model results consist of two subsets of parameter estimates. As indicated in Table 3 these coefficients include the logit and the NBRM equations of the ZINB model. The signs of the estimated coefficients carry differing interpretations between the two equations. A plus sign to an estimated coefficient in the logit equation implies an increase in the likelihood of no forest extraction whereas the same sign in the NBRM reflects a rise in the expected count of forest extraction trips. Referring to the results in Table 3, subjective discount rate (TM) and coefficient of variation of coffee income (CV_C) have negative and statistically significant effects on the odds of being in the always no forest extraction. In other words, a household in the sample is more likely to make forest extraction trips as values of these explanatory variables increase. For instance, a one-unit rise in the value of the CV_C variable reduces the odds always making zero forest extraction trips by a factor of about 0.9. On the other hand, household perception of price risk to coffee beans (PR_R) exerts a significant positive effect on the likelihood of having no extraction trips.

[13] As a priori identification of the appropriate model for an event count data is often difficult, several variants of an event count model such as the Poisson, Zero-inflated Poisson, Negative binomial regression models were tried besides the ZINB model, with STATA 8.0. These models were compared and contrasted using several criteria of goodness of fit. In particular, validation tests using Akaike's information criterion (AIC), Bayesian information criterion (BIC) and log-likelihood function at convergence favour the ZINB model over others. Moreover, the ZINB model has passed two further tests. First, the Vuong-statistic $(V = 3.39)$ is positive and significant at less than one percent probability indicating the rejection NBRM in favor of the ZINB model. Second, the dispersion parameter (α) is statistically significant and positive, after the excess zero issue is addressed, indicating the presence of over-dispersion in the data, in turn favoring a ZINB model rather than a ZIP model.

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The estimated results indicate that five explanatory variables are statistically significant $(p \leq 0.10)$ to explain the count of forest extraction trips taken by households. Consistent with a priori expectation, the coefficient of variation of coffee income (CV_C), a proxy for riskiness of coffee farming, has a statistically significant and positive impact on the expected count of forest extraction trips taken by the households in the sample. More particularly, an increase in the volatility (i.e. a decrease in reliability) of income from coffee farming significantly contributes to an increase in household labour allocated to forest extraction in the study areas. For instance, a unit increase in the coefficient of variation of coffee income raises the expected number of forest extraction trips by a factor of 1.06. This supports the assumption that coffee farmers are risk averse and that they increase their labor use in forestry to deal with coffee income risk ex ante.

Consistent with economic theory and our anticipation, the estimated results reveal that household forest extraction trip is strongly driven by undesirable income shocks facing coffee households (SHK_C) in the study areas. Specifically, forest extraction appeared to increase with the size of adverse income that faced many coffee farmers in 2001/02. For instance, for a unit increase in SHK_C variable, the expected number of forest extraction trips increases by a factor very close to one. The implication of this is that forests found in economically vulnerable areas are also vulnerable to human impacts since they are drawn upon to make up for shocks. In other words, these results provide evidence that forest extraction affords insurance to coffee farmers in the montane forest regions of southwest Ethiopia.

The results of this study also indicate that the effect of household size (FAMSZ) on the expected count of forest extraction trips is statistically significant and positive. The expected count of forest extraction trips increases by a factor of about 1.1 as the size of the household increases by one member. This suggests that, ceteris paribus, large households are likely to take more forest extraction trips than small households. The results also show that the frequency of forest extraction was positively and significantly associated with the respondents' rate of private time preferences (TM).[15] This is consistent with the theoretical prediction and results reported by Gunatilake and Chakravorty (2003). Controlling for other differences, households with larger private discount rates have higher expected count of forest extraction trips than their colleagues with smaller private discount rates. This is congruent with the theoretical arguments that when the decision maker values the present more than the future; and

[15] Factor change in expected count for unit increase in x is computed as $\exp(b)$. In other words, an increase in x would multiply the fitted mean forest extraction trip by the $\exp(b)$.

activities differ in their pay-back periods, a household with a relatively higher rate of time preference participates on the activity that generates more immediate returns to its effort. In the context of the present study, coffee farmers' labor allocation to forest extraction yields immediate returns while labor used in the wet-season in coffee agriculture waits until harvest to get returns.

Contrary to the a priori expectation, native households appear to more frequently participate in a forest extraction than non-natives to smooth consumption against adverse income shocks. The unexpected effect of the variable BIRTH on household forest extraction trips may be accounted for by two facts. In the first place, non-natives may be less familiar with forest-based livelihood or risk coping strategies. As such, these households might view the insurance value of forests as less important. Second, non-natives may be more likely to have received economic support, when a misfortune strikes, from relatives or friends who remained in the migrants' place of origin.

Table 4 indicates the sensitivity of forest extraction trips to changes in values of explanatory variables that are statistically significant. The predicted number of forest extraction trips increases by about twenty four percent and three percent if risk involved in coffee income and short-term shock (coffee income loss), respectively, facing the typical coffee-growing household increases by ten percent. Similarly, a ten percent rise in household size induces about five percent rise in the expected count of forest extraction trips in the study areas.

The statistically non-significant effects obtained for the other explanatory variables used in the econometric analysis are as follows. Notably, the coefficients to landholding (LAND) and cattle ownership (CATT) variables, which are key measures for wealth, are negative as expected but their effects are not statistically significant. Similarly, the effects of crop diversification (DIVSN), off-farm wage employment in the previous season (OFF), the distance from nearest all-weather road (DISR), membership to farmers' cooperative (COOP) and education (EDUCHH) on forest extraction were, as anticipated, negative but again their impacts were not statistically significant. Conversely, the influences of the district dummy (LOCA), age of the household head (AGEHH) and male headship of the household (SEXHH) on forest extraction were positive. However, their impacts were not statistically significant.

6. Conclusions and policy implications

This paper has examined household labor supply responses via forest extraction as insurance against adverse coffee income. The estimated results show that households facing a high variability of coffee income are more likely to draw on forest resources to

protect their welfare against risk. This study has also revealed that forest extraction increases further as magnitude of adverse coffee income shock confronting households in the sample increases in the study areas. Therefore, it is essential that the Ethiopian government, non-governmental organizations, local and international donors, etc. give particular attention to coffee income risk facing smallholder coffee farmers so as to facilitate its strong management under farmers' conditions and circumstances. Along this, ex post risk coping is crucial to survival of smallholder farmers, since, in agriculture, undesirable decision outcomes are the norm rather than the exception. More importantly, the development of contingency markets and safety net programs may be useful mechanisms to lessen household vulnerability to consumption shortfalls and also to take pressure off the forests following adverse income shocks. Public-work programs in the form of work-for-food or work-for-cash schemes might be useful means in this regard, to reduce the impact of risk on people and to redirect labor away from forest extraction.

The survey evidence also reveals that for any given level of income shortfall, households with high time preference are more likely to both participate in and draw more intensively on forest extraction. This suggests that forest extraction as a safety net is more pronounced among the poor households who lack liquidity when misfortune strikes. Thus, designing policies that in one way or the other reduce farmers' liquidity constraints would help lessen forest pressure. Such policies would include government investments in the provision of off-farm enterprises, technical education and infrastructural developments to improve access to wage employment, and other services such as markets and credits.

Similarly, forest extraction as a safety net among the survey participant households appears to be more pronounced with indigenous households than non-natives. Thus, policy interventions and incentive provisions need to be cognizant of differences in demographic history and associated socioeconomic behaviors among the local population. The other important demographic feature that would condition incentives for the reduction of forest extraction is the size of the household. Controlling for other explanatory variable, it was found that forest extraction effort was significantly higher among larger households than the smaller ones. On this point, it may be said, therefore, that policy measures aimed at reducing rapid population growth or fertility could contribute to the slowing down of the currently observed forest extraction pressure in the study areas.

In a nutshell, this paper confirms the risk mitigation role of the montane forests to smallholder coffee farmers in southwest Ethiopia Thus, policies which stimulate and enable farmers to hold on successful risk management and risk coping mechanisms

would (i) protect farmers' welfare from likely crop income shortfalls and (ii) reduce household pressure on forests as a safety net such that forest degradation and biodiversity loss as a consequences of human action will decline over time.

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Table 1: Summary statistics and definitions of explanatory variables

Variables	Definition and measurement	Mean	Std.dev.
AGEH	age of the household head in years	44.31	13.92
SEXH	% male-headed respondents	90.0	0.29
EDUCH	% literate respondents	47.0	0.50
FAMSZ	total number of members in the household	5.67	2.29
AD_F	number of adult females in the household	1.53	0.83
AD_M	number of adult males in the household	1.62	1.04
BIRTH	% native households	0.76	0.43
LAND	landholding in ha	2.36	1.66
LOCA	% households located in Yayu	59.0	0.49
TM	subjective discount rate, 1 = low, 2 = medium, 3 = high	2.03	0.78
CATT	number of cattle holding	2.76	2.94
CV_C	coefficient of variance of income from coffee	39.75	4.48
SHK_C	adverse income shock to coffee in 2001/02 in Birr	1619.0	1710.0
DISF	distance to the nearest forest in minutes	51.19	33.39
DISR	distance to nearest all weather road in minutes	20.69	21.46
OFF	% with wage income in the dry season of 2001/02	34.0	0.47
PR_R	perceived coffee price risk, with 1 not important to 5 very important	3.91	1.24
DIVSN	number of crop enterprises	2.84	1.64
COOP	% with membership to farmers' cooperative	55.0	0.49

Source: Own survey data, 2001/02.

Table 2: Farmers' perception of importance of risk coping strategies

Type of strategy	Number of respondents who considered strategy as important or very important	Percent of total
Forest extraction	118	61
Out-migration to cities	17	9
Credit from friends	129	66
Reducing food consumption	113	58
Food aid	118	61
Drawing on household savings	132	68
Livestock sales	144	74
Remittances	109	56
Pulling out children from school to work	21	11

Source: Own survey, 2001/02.

Table 3: ZINB Regression Coefficients of Forest Extraction Frequency

Variablesa	Logit (inflation) equation			NBRM equation		
	Coefficient	Std. error change	Factor	Coefficient	Std. error change	Factor
AGEH	-0.0126	0.0189	0.9875	0.0068	0.0053	1.0068
SEXH	0.3431	0.7239	1.4094	-0.0651	0.2209	0.9370
EDUCH	-0.2345	0.5499	0.7910	-0.0426	0.1458	0.9583
FAMSZ	-0.1058	0.1058	0.8996	0.0838***	0.0287	1.0875
BIRTH	-0.7441	0.5506	0.4752	0.4395**	0.1747	1.5519
LAND	-0.3489	0.3142	0.7054	-0.0850	0.0774	0.9185
CATT	-0.1404	0.1126	0.8690	-0.0207	0.0227	0.9795
DIVSN	0.0146	0.1672	1.0147	-0.0022	0.0474	0.9978
OFF	-0.2611	0.5546	0.7702	-0.0658	0.1531	0.9364
COOP	0.3118	0.5715	1.3658	-0.1431	0.1431	0.8667
DISF	0.0044	0.0065	1.0044	-0.0004	0.0018	0.9996
DISR	-0.0124	0.0144	0.9876	-0.0023	0.0038	0.9977
LOCA	0.3338	0.8150	1.3963	0.0417	0.1955	1.0426
CV_C	-0.1026**	0.0526	0.9025	0.0533***	0.0182	1.0547
SHK_C	-0.00004	0.0003	1.0000	0.0002***	0.00006	1.0002
TM	-0.5543*	0.3129	0.5745	0.2288***	0.0886	1.2571
PR_R	0.5061*	0.2768	1.6588	0.0751	0.0527	1.0780
Intercept	4.1067	2.7125		-1.8479*	0.9991	
Ln alpha	-1.0916	0.2023***				
Alpha	0.3357	0.0679				

Vuong test: ZINB vs. NB: Z = 3.39*** LR or Wald- χ^2 (17) = 44.93***;
Log-likelihood function = -516.86 AIC (=-2lnL + k) = 5.68; BIC (=-2lnL + (ln n)k) = 200.59

***, **, and * stand for statistical significance at the 1%, 5% and 10% levels, respectively. For definitions of the variables see Table 1.

Table 4: Sensitivity of a household's forest extraction trips

Explanatory variables	% change in predicted number of forest extraction trips for a 10% increase in the values of explanatory variables
FAMSZ	5.7%
CV_C	27.8%
SHK_C	3.1%

Source: Derived from the results presented in Table 3.

FUEL EFFICIENT TECHNOLOGY ADOPTION IN ETHIOPIA: EVIDENCE FROM IMPROVED "MIRT" STOVE TECHNOLOGY: A CASE IN SELECTED KEBELES FROM "ADEA" WEREDA[1],[2]

Dawit Woubishet[3]

Abstract

The increasing scarcity of biomass and the increment of the number of people who use biomass, particularly firewood, threaten the capability of the country even to maintain the already existing low income and living standard of the people. Therefore, the need for adopting improved "Mirt" stove technology not only enables the households to use fuel efficiently, but it will enable them to curb the problems caused by using traditional and open fire stoves as well as biomass energy related problems. It can also mitigate the impacts on the users' health, the overall environment and natural resources brought by using those traditional and open fire stoves.

With two estimated equations, that is information and adoption equation. This study result reveals that improvement in socio economic conditions of the people have positive impact on information acquisition and access in urban and rural households. Moreover, the result supports the "energy Ladder" hypothesis as theoretical and functional useful framework to explain the fuel use and improved technology adoption in the study area. The findings also reveal that socio-economic improvement have direct and significant impact on adoption decision. This finding also reinforces the role of government and non-government organizations to play a major role in information diffusion and to enhance the adoption decision of the people to protect the country's natural resources and to resolve environmental problems that arise due to excessive utilization of biomass resources.

Keywords: improved stove, information, adoption and "energy ladder"

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[1] The final version of this article was submitted in March 2009.

[2] Derived from author Masters Thesis, Addis Ababa University, Addis Ababa

[3] E-mail: hello3days@yahoo.com

I. Introduction

Poor people are both the agents and the victims of environmental damage. Fuel-wood gathering can lead to land degradation, biomass combustion to indoor air pollution, dirty fuels to outdoor air pollution and through green house gas emission, global warming. In all those cases, poor people both contribute to the environmental damage through their actions and suffer from its consequences. Moreover, the energy sector has a significant part to play in reducing the environmental damage and its harmful effects by introducing renewable energy source, supplying modern cooking fuels, and substituting cleaner fuels for dirty ones and increasing energy efficiency.

Energy is vital to economic development. Without fuel that power cars, trains and planes, and without electricity, light and heating, life in industrialized countries would be considerably less comfortable. In developing countries, however, it is not just a question of comfort. Poverty could not be reduced without the greater use of modern forms of energy. Even now, around two billion people have no access to electricity, relying instead on traditional fuels such as dung and fuel-wood. Those who are fortunate in developing countries enough to have electricity, on average spend 12% of their income on energy; more than five times the average for people living in OECD countries. At the same time, the provision of energy services, especially the combustion of fossil fuels and biomass can have adverse effects on the environment (WB, 2000).

Ethiopia has significant energy resource. This resource endowment is said to be enough to meet the present need and long-term energy requirement of the country. Overall, only some of this endowment is being presently exploited (EEA, 1994). The main endogenous sources of energy are biomass, hydropower, fossil fuel (natural gas, coal), geothermal, solar and wind. The country's energy use and/or consumption are 95.6% from traditional source and only 4.4% from modern source. In terms of the level of sectoral use; household accounts for about 91.3% of the total final energy consumption. And the biomass fuel account 98.5 % while the modern energy only takes 1.5%. Within the household sector the rural and urban household energy consumption accounts for 92 and 8%, respectively. (Asres, 2002)

In Ethiopia, few studies have attempted to investigate the problems, constraints and factors affecting the household decision to adopt fuel efficient technology with the context of environment and natural resource protection. Tadelech (2001), considered the problem of population pressure and rural-urban migration and their impact on energy need in urban areas and analyzed the determinants of fuel-efficient technology adoption. She only looked at demographic and socio economic variables and her

study were limited to two kebeles with in Addis Ababa. Hence, this study focuses on both rural and urban households. It is obvious that the rural household takes a significant share in energy consumption and the adoption of this technology is extremely low. Along with the socio-economic and demographic factors; dwelling characteristics, information diffusion and attitudinal or perceptions of the household to the technology are considered. The paper also provides knowledge and information with regard to promoting fuel-efficient technology and conserving energy, forest resource and environment.

The major objective of this study is to analyze the nature, problems and main determinant factors in household decision to adopt improved fuel-efficient technology, the factors that determine to acquire information about the technology and their impact on environment, fuel scarcity, household time and income. And also to drive policy implications and interventions on environment, natural resource and energy/

The findings may also help to rehabilitate policy regarding energy, environment, natural resource and information. In addition, the results have anticipated in assisting development practitioners, both governmental and non-governmental organizations that are interested in alleviating poverty, satisfying the energy need of poor households and protecting natural resources.

In Ethiopia, projects involvement in this particular activity has not well developed. One of the projects involved in production and dissemination of improved stove is an improved ("*Mirt*") "injera"[22] stove, which is undertaken by GTZ- Household Energy and Protection of Natural Resources Project with the participation of private sectors in production and commercialization of the stove.

The Ministry of Agriculture and GTZ, The German Development Cooperation, in 1998 have launched an improved stove dissemination program to promote biomass energy efficiency in households. The main objective of the project is to enhance efficient use of biomass resources by integrating household energy measures into development plan. Moreover, the overall goal of the project is to contribute to environmental protection and sustainable environmental development. The project focuses on the dissemination of improved ("Mirt") stove fuel saving for "ingera" baking. The technology choice has been taken on the ground that baking "injera" alone takes a significant share of the primary energy consumption.

[22] "Injera" is the traditional food in major Ethiopian households, and mostly prepared from "teff".

The improved ("*Mirt*") stove has been under extensive research and testing by the Ethiopian Rural Energy Development and Promotion Center (EREDPC) in the beginning of 1990s, when the stove was introduced in Addis Ababa market. The improved ("*Mirt*") stove has certain features that make it particularly suitable for commercial dissemination approach. Among the desirable features include it can save fuel expense for the households, accommodate different types of fuel, and it has a modern design and create clean kitchen environment.

2. Theoretical background

From the mid 1970's onwards, the rapidly increasing cost of all forms of energy, led by the world oil price, stimulated the development of new analytical tools and policies (Munasinghe, 1980). First, the need became apparent for greater coordination between energy supply and demand options. Second, energy-macroeconomic link began to be explored more systematically. Third, the more disaggregate analysis of both supply and demands within energy sector offered greater opportunities for inter fuel substitution (especially away from oil). Fourth, the analytical and modeling tools for energy sub-sector planning became more sophisticated. Fifth, in the developing countries, greater reliance was placed on economic principles, including the techniques of shadow pricing. Finally, heightened environmental concerns have led to a better understanding of energy – environment interactions.

The environmental and health consequences associated with various cycles of energy production and consumption is, for a large part, very similar among energy sources. Differences may exist mainly in terms of the magnitude of those effects. Major disruptions in the environment and health impacts are linked to biomass energy from gathering and combustion.

Gathering of fuel-wood and removal of crop residues or animal manures in the course of using biomass as fuel have; for instance, been argued to contribute to serious deforestation in the long run, increased incidence of floods, stream sedimentation, and decreased water yields from watersheds. Excessive removal of agricultural residues or animal dung affects soil fertility, and exposes soil to increase wind and water erosion. Biomass combustion has the potential to create indoor air pollution, if wood stoves are improperly installed. Among the emission control method, improved stove technology is one of the alternatives for most developing countries because biomass is the most important source of energy and its use is wide spread, especially by the poor.

2.1 The energy ladder hypothesis

The most comprehensive hypothesis regarding energy use pattern of households focuses on the concept of "energy ladder". The energy ladder depicts various combinations of fuels used by a household at its different stage of development. With movements up the ladder, fuel mixes are generally considered as clean and efficient. This is also directly correlated with income growth, bringing about an increased use of modern fuels and less use of biomass (Israel, 2002). The basic assumption of energy ladder is that a household is faced with a range of different energy supply choices, which can be classified in order of increasing technological sophistication.

Households use fuel for a variety of activities, including cooking, water heating, lighting, and space heating. The order of different fuel types on the energy ladder can vary according to this end use. For cooking Munasinghe and Meier (1993), for example arranged the range of different energy leader as follows: first, dung and crop residues (which are inferior quality biomass fuels, and grouped at the bottom of the ladder); second, fuel-wood and charcoal (relatively higher quality biomass fuels and placed in the next step); third, kerosene; forth, Liquefied Petroleum Gas (LPG); and finally, natural gas and electricity.

As the economic status of a household rises, reduced use of lower quality fuel type and switch to consumption of relatively higher quality ones occurs. As a result, the household is said to move up in the energy ladder. If, on the other hand, the economic status of a household declines, then it is expected to consume a relative inferior quality fuel. In this regard, Hosier and Dowd (1988) point out that energy ladder acts as a stylized extension of the economic theory of a consumer. That is, as household's income increases, it makes a decision not only to consume more of the same good, but switches towards consuming other goods of higher quality.

2.2 Theoretical background on energy conservation determinants

Economic theory suggests that, in order to gain comfort and time, households are becoming excessive energy users, neglecting the environmental impact of their choices. According to household production theory, households are treating as productive units organized to provide services for the occupants; energy is treat as input in the provision of a range of household services. Consumers' choices define the utility they can derive (Becker, 1965; Muth, 1966). The extent of service that we can derive from a given amount of energy depends not only on the efficiency of the

technology but also the consumers' lifestyle. Several theoretical and empirical studies focused on households' energy conserving behavior and its links with socio-economic parameters, which hint at lifestyle changes.

In the context of residential energy use, lifestyle should reflect the understanding that environmental responsibility and concern for energy sources go part and parcel with our daily energy based actions (Held, 1983). This demand-conscious lifestyle does not necessarily imply curtailment or sacrifices as far as the level of comfort or the quality of living are concerned. On the contrary, this approach is centered on an altered awareness of energy consumption in our daily lives.

As Coomer (1977) claimed a significant decrease in energy consumption may mean a perceived lifestyle change and should not be identified by means of reduced quality of life or social status, and as Leonard-Barton (1981) defined in a discretionary change of lifestyle, a low energy lifestyle is characterized by ecological awareness and attempts to become more self-sufficient users, known as voluntary simplicity lifestyle.

Van Raaij and Verhallen (1983) and Weber and Perrels (2000) specified that lifestyle approach should take into consideration a broader socio-cultural concept. In this concept, lifestyle patterns are shaped as a consequence or enduring activities with regards to time, housing, family and income conditions that households face and partly as a way or self-expression and self-realization.

3. Methodology

3.1 Data source and methodology

Adea is selected for this study as it is one of the major urban and rural centers of the country with severe forest degradation and fuel-wood and other energy source problems. The data type used in the study mainly includes primary and cross-sectional for the period of 2006. Data sources were mainly on survey conducted for this purpose and relevant documents from *Adea* Municipality and Rural Administration Office. The primary data were collected by making a household survey with questionnaire having five parts: household information; household energy pattern; fuel use; cooking pattern, kitchen environment and improved stove and household perception, and attitude towards the improved stove technology.

After designing the draft questionnaire, pre-testing of the questionnaire was conducted through a focused group discussion with municipality officials, producers of the improved stove, and fifteen randomly selected households. The purposes of the

pre-test were to make some possible modifications in the design of the questionnaire for the main survey, so that objectives of the survey can be met. Based on the pre-test the order of the questionnaire was restructured, making questions on household characteristics (particularly questions with economic characteristics, income, for which households were reluctant to give true responses).

First, the *Adea* wereda divide into rural and urban households. To identify the well informed households'; for urban households GTZ-SUN energy Project organized a demonstration activity about the improved ("*Mirt*") stove technology in different places and time. It is estimated that about 30000 household attend the demonstration activity in *Adea* wereda. For rural households the rural development agent's in collaboration with GTZ-SUN Energy Project provided training and demonstration about the stove in church, local people associations meeting and in extension training programs. According to GTZ-SUN energy in *Adea* wereda approximately 6,856 stoves are distributed of which 1,596 and 5,260 in rural and urban households, respectively.

For consistency of data analysis, for urban households those who attend the demonstration activity effectively had been considered as well informed and know very well about the improved ("*Mirt*") stove technology and those who did not attend the demonstration activity effectively are considered as not well informed about the technology. And for rural households, who are not actively participate in demonstration activity by development agents and weak in extension participation and training programs are considered as not well informed about the technology.

A Stratified and random sampling technique was used for the study. Due to lack of well documented information on number of households and their location for the newly established 9 urban and 27 rural kebeles from each settlement; three kebeles were randomly selected. The rural kebles' were selected from the surrounding eleven kebeles which is near to the town of "Debrezeit". Then from each selected urban and rural kebeles 30 and 40 households are randomly selected, respectively. Time and financial limitations were taken into account and random sampling technique employed to select a sample population of 210 households for this study.

3.2 Model specification

The model begins with the information held by the household, the potential adopters. It would be misleading to categorize the population of households into adopters and non-adopters; if not all members of the potential adoption community are informed. The adopting households are therefore those that are informed about the existence of

the technology and find it efficient. Thus, the adoption decision is conditional on the availability of information.

3.2.1 Information equation

A common practice in adoption studies is to divide the adoption population in to adopters and non-adopters without worrying about whether all members of household of the potential adoption population are informed about the existence and utilization the technology under the study. This usually results in inefficient and biased estimator. Then, if in any community, some potential adopters are not informed about the existence and how to use the technology, the information equation should be the first equation of adoption model (Seha. et al 1994).

Let us take a household with a level of information equal i* and let i^0 be the threshold of level of information that a household should have in order to be classified as informed. Then the household is informed if $i^*>i^0$

By defining the latent variable Y^{H^*} as $Y^{H^*} = i^*-i^o$ the condition to classify a household as informed becomes

$$\mathbf{Y^{H^*}= i(X^H)-i^O>O1} \qquad \mathbf{1}$$

Where superscript H stands for household who have heard that the technology exists and knows how to use it.
X^H= vector of household characteristics and attributes that could influence i*, say the supply and demand of information
Then the theoretical equation to be estimated is then.

$$\mathbf{Y^{H^*}= X^H.\ \beta^{H^*}+ \epsilon^{H^*}} \qquad \mathbf{2}$$

Where β^{H^*}= *Vector of parameter to be estimated*
ϵ^{H^*}= *error term*

i^*,i^o and consequently Y^{H^*}, are not observable. To estimate the information equation, we need to construct a variable that accounts for whether the household is aware of the technology and how to use it. Let us denote that variable by Y^H. Which takes the value **1** for a positive answer ($Y^{H^*}>0$) and **0** for a negative or null answer ($Y^{H^*} \leq 0$).

The theoretical Probit equation to be estimated is therefore

$$Y^H = \Phi\,(X^H . \beta^H) \qquad 3$$

Where β^H = *vector of parameter to be estimated*

3.2.2 Adoption equation

After the information equation formulate, the adoption equation conditional on information. If the household is not informed, it is not possible to consider adoption. Households may well be informed about the existence and use of the technology but there are different factors that affect the decision of the household whether to adopt or not. Therefore, adoption equation formulates to analyze only for informed households.

Dominich and Mc Fadden (1975) used a random utility approach, permit a more systematic look at the primary determinants of adoption behaviour and make possible a systematic sensitivity analysis of the predicted probabilities of adoption decision to changes in key explanatory variables. The model uses the random utility approach; the household chooses the technology because it provides a maximum expected utility among the available choices.

Haab and McConnell (2002) quoted Hanemann (1984) also developed the basic model to analyse dichotomous responses based on the random utility theory. The central theme of this theory is that although an individual knows his/her utility certainly, it has some components, which are unobservable from the viewpoint of the researcher. As a result, the researcher can only make probability statement about respondent's 'YES' or 'NO' responses or decisions.

The Probit Model is used to identify factors that affect the probability of adopting the improved ("Mirt") stove technology. In this study, households are informed about the existence and how to use the technology, which they may adopt or not. Hence, it is a single bounded dichotomous choice model to be framed under the random utility method (approach). The random utility model also provide convenient approach and the point of departure is a utility model that is composed of two parts, one observed by the analyst, the other treated as random.

Let us consider the decision of a household regarding whether he/she adopt the improved ("Mirt") stove or he/she adopt the traditional or open-earthed stove for the household baking appliance.

Let's define that indirect utility function for the jth household can be specified as follows:

$$U_{ij} = U_i\left(Z_j, H_j, C_j, D_j, \varepsilon_{ij}\right) \quad 1$$

Where D_j= j^{th} respondent's dwelling status.

H_j = vector of household socio economic and demographic characteristics and attributes.

Z_j = j^{th} household response about the compatibility and complexity of the technology.

C_j = j^{th} household cost (expense) for fuel, and members of household participate for collection of fuel-wood and other energy sources for the household energy need

ε_{ij}= random component of the given indirect utility

Equation (2) represents the household utility function with the baking appliance (stove) for the household is the improved ("*Mirt*") stove technology.

$$U_{1j}\left(Z_j, H_j, C_j, D_j, \varepsilon_{1j}\right) \quad 2$$

Equation (3) represents the household utility level with the baking appliance (stove) for the household is the traditional or open hearth stove technology.

$$U_{0j}\left(Z_j, H_j, C_j, D_j, \varepsilon_{0j}\right) \quad 3$$

The household is introduced about the improved ("*Mirt*") stove technology and knows improvement in household energy efficiency and environment; the household adopts the improved ("*Mirt*") stove technology if and only if:

$$U_{1j}\left(Z_j, H_j, C_j, D_j, \varepsilon_{1j}\right) > U_{0j}\left(Z_j, H_j, C_j, D_j, \varepsilon_{0j}\right) \quad 4$$

Then, for individual j, the probability statement is:

$$P(Yes) = \left[U_{1j}\left(Z_j, H_j, C_j, D_j, \varepsilon_{1j}\right) > U_{0j}\left(Z_j, H_j, C_j, D_j, \varepsilon_{oj}\right)\right] \quad 5$$

This probability statement provides an intuitive basis to analyse binary responses. Assuming that the utility function is additively separable in deterministic and stochastic preferences:

$$U_{ij}\left(Z_j, H_j, C_j, D_j\right) + \varepsilon_{ij} \qquad 6$$

Given the additive specification of the utility function the probability statement for respondent j becomes:

$$P(Yes) = \left[U_{1j}\left(Z_j, H_j, C_j, D_j\right) + \varepsilon_{1j} > U_{0j}\left(Z_j, H_j, C_j, D_j\right) + \varepsilon_{0j}\right] \qquad 7$$

This probability statement is the point of departure for the linear utility function in a set of covariates, which is assumed by our empirical model. However, the adoption decision of individual household is conditional on the acquisition of information. This procedure needs to be sequential and let denote the vector of explanatory variables that explain adoption decision by X^A. Then, we obtain the following theoretical model:

$$Y^{A*} = X^A . \beta^{A*} + \epsilon^{A*} \qquad 8$$

Where: B^{A*}, vector of parameters to be estimated,

ϵ^{A*}, error term

The latent variable Y^{A*} is not observable and we defined by its proxy Y^A taking a value **One (1)** for adopters and **Zero (0)** for non-adopters for the sub-sample of informed households (Y^H=1). Thus, the conditional Probit model to be estimated:

$$Y^A = \Phi\,(X^A . \beta^A) \qquad 9$$

Equation (3) and (9) are model of sequential, adoption of one technology based on information acquisition. This model of sequential adoption of one technology based on information acquisition is in essence different from that of Khanna (2001) as sequential adoption of components of technological package. Nevertheless, the statistical implications for econometric analysis of adoption are quite similar. As in Khanna (2001), under the study of sequential adoption components of technological packages and just making the substitution of technological component for decision. It is possible that, since decisions (information and adoption) are interrelated, single equation is inefficient because they ignore the correlation of error terms of equations that explain each decision. Thus, this correlation arises because the same unobserved characteristics may influence all inter-related decisions.

For the empirical estimation, let us assume that $(\varepsilon^H, \varepsilon^A,)$ has a bi-normal distribution. That is:

$$(\varepsilon^H, \varepsilon^A)\, BVN\,(0,0;1,1,\rho) \qquad \textbf{10}$$

Where: ρ is the correlation coefficient between ε^A *and* ε^H.

Under the above assumption, the conditional probability of the adoption decision given by equation (10) (see Seha et al., 1994; Maddala, 1983)

$$\begin{aligned}&\Pr ob\left(Y^A = 1/Y^H = 1\right)\\ &= E\left[Y^A/\left(i^* - i^0\right) > 0\right] = \Phi\left(X^A.\beta^A\right) + \rho.\frac{\phi\left(-X^H.\beta^H\right)}{1-\Phi\left(-X^H.\beta^H\right)}\end{aligned} \qquad \textbf{11}$$

$$Note\ \alpha = -X^H.\beta^H\ and\ \lambda(\alpha) = \frac{\phi(\alpha)}{1-\Phi(\alpha)};\ \lambda(\alpha) is\ the\ inverse\ of\ Mills'\ ratio. Then, we\ have$$

$$\Pr ob\left(Y_A = 1/Y_H = 1\right) = \Phi\left(X_A.\beta_A\right) + \rho.\lambda(\alpha) \qquad \textbf{12}$$

Φ and ϕ are the functions of cumulative distribution and normal probability density, respectively.

For traditional Probit and Logit estimations, only element $\Phi\left(X^A.\beta^A\right)$ is considered in equation (12), resulting in inconsistent estimators β^A. More importantly, application of traditional Probit and Logit estimations that ignore self-section would result in biased estimates of marginal effect on probability of adoption of a variable $\mathbf{X}_j$ that is common to vectors X^H and X^A.
From (12), we have:

$$\partial \Pr ob\,\frac{(Y^A = 1/Y^H = 1)}{\partial \chi_i} = \Phi\left(X^A.\beta^A\right)\beta_j^{\ A} + \rho.\beta_j^H.\left(\lambda\alpha - \lambda^2\right) \qquad \textbf{13}$$

If the possibility of self-section is ignored, the second element of the right side of equation (13) will be omitted. For all parameters to be identified, $\mathbf{X^H}$ and $\mathbf{X^A}$ should differ at least in one independent variable.

Therefore, the maximum likelihood estimates of parameters β^A, β^H, ρ can be obtained from maximizing the following log-likelihood function, which rests on the definition of conditional probability:

$$\ln L = \sum_{Y^A=1, Y^H=1} \ln \Phi_2\left[X^H\beta, X^A\beta^A, \rho\right] + \sum_{Y^H=1, Y^A=0} \ln \Phi_2\left[X^H\beta^H, -X^A\beta^A, -\rho\right] + \sum_{Y^H=0} \ln \Phi\left[-x^H\beta^H\right] \quad 14$$

4. Empirical findings: Results and discussions

4.1 Descriptive results

4.1.1 Socio-economic characteristics of the households

On average 11% of the rural households were female-headed and 89 % were male-headed while the proportions in urban areas were 64 and 34%, respectively. Household age ranges from 20 to 83 years and the sample average equals 47 and 50 years for rural and urban households, respectively. About 78 and 64% of the rural and urban households, respectively, were married. However, the average household consisted of seven individuals for rural areas, ranging from one to eighteen members and five individual for urban areas.

The education of the household head was categorized into four levels. Those who cannot read and write are categorized under illiterate group and constituted 37% of the rural households' heads. Nonetheless, those with a formal education of 1-6 grades are grouped under primary level education since they can read and write and constituted about 40%. Those with a formal education of between 7 and 12 grades accounted for 21% of the rural respondents and were grouped under secondary level. About 2% of the rural respondents have completed high school, and thus they are grouped under tertiary level. In rural areas female literacy level is very low; only 38% of the household wives are literate.

From among urban household heads, about 34% attended primary level education while 30 and 7% attended secondary and tertiary level, respectively. The remaining 29% are disappointedly illiterate. However, female literacy in urban areas takes 56%. The average monthly rural households' income is found to be 656.12 birr and 53% of the respondent rural households earn monthly income of less than five hundred Birr whereas in urban households, the average is only 506.72 birr and the majorities (74%) earn monthly income of less than five hundred Birr. Thus, the study indicates that the average income of the rural households is surprisingly greater than urban households.

The respondents stated that their income is not enough to cover their basic needs. Since the urban households were not interested to disclose their monthly income, expenditure on major items has been taken as a proxy of monthly income. For rural households their monthly income is estimated by considering the major crop they produce per annum, off-farm income source and livestock capital of the household. Currently, there are a number of microfinance institutions and other credit organizations that facilitate credits for dwellers, but only 52% and 58% of the urban and rural households have access to credit facilities, respectively.

Dwelling status is used to indicate the standard of living of the people. As per the survey result, 78% of the rural households live in their own house while the rest 22% live either with their relatives or in rental house. But, in urban households, only half of the sample households live in their own house while the rest reside in kebeles' house, temporary shelter or private rental house. The study found that housing problem is more severe in urban households than in rural households.

The average dwelling size and the kitchen environment are almost similar in both settlements, urban and rural. The great numbers of houses are built with mud, wood and corrugated iron, and they consist of three rooms on average. About 60% of the rural households bake and cook in separate kitchen. However, the remaining 40% bake and cook in open air and in their living rooms. Nonetheless, about 42% of urban households bake and cook in shared kitchen, open air and within their living rooms. Those households, who do not have separate kitchen, are faced problems related to cooking and baking activities such as accident to burning, heat and smoke problem.

About 44 and 51% of the rural and urban households who are interviewed are actively participating in local associations, such as "Idir", "Iqub" and "Mahiber", respectively. Participation in those associations is believed to enable households to get informal source of information.

4.1.2 Fuel consumption and related issues

Most of the interviewed households (92%) mentioned that they are using fuel-wood and cow dung as a major source of energy. About 37 and 44% of the households always use fuel-wood and cow dung as a substitute while facing shortage of any kinds of fuel sources, respectively. This result thus indicates that there is excessive utilization of biomass resources in rural and urban areas, which might cause a negative impact on the natural resources and environment.

Households collect fuel-wood and other energy sources from different areas. In rural areas, 31% collect energy sources from their back yards while 36 and 22 % collect from their own farm (field) and open field, respectively. The remaining 11%, however, purchase from their nearest fuel market. In urban areas 21% of the households collect from their back yard where as 20 and 15% collect from their own field and open field areas, respectively. The remaining 44% are using commercial means to meet their energy need.

The study has identified that households adopt different coping strategy to overcome fuel shortages: Storing of fuel and substituting one fuel source by other are some of the coping strategies to alleviate the problems. About 40 and 32 % of the urban households and 54 and 31 % of rural households use Storing of fuel and substituting strategies, respectively.

Concerning getting information about the new and improved stove technology, around 49% of the urban households obtain their information from demonstration activities undertaken by GTZ- SUN energy whereas 62 % of the rural households obtain from development agents demonstration. Thus, provision of information is important through informal channels to address all the population.

4.1.3 Time and effort involved in gathering fuel wood/dung and expense for fuel.

The responsibility of gathering fuel-wood and other energy sources lay on women and children in most developing countries. It is also known that collection and transportation of fuel involve tedious and tough work such as walking long distance with carrying loads and others that might cause health disorders on individuals. Similarly, the study indicates that those who collect fuel-wood and other energy sources have to cover long and tiresome distances at least two times per week and about sixteen hours per month to fulfill their energy consumption.

About 78% of the rural households meet their energy need from collection. On average, from two to three members of the family, participate in fuel gathering activities and 73% of the households, at least they travel two times per week and two of family members participate in fuel collection. Among the rural respondents who adopt improved stove and their main source of energy is through collection, about 77% of households collect fuel from their own farm to meet their needs and took less than half an hour. However, 45 and 62 % of non-adopters and non-informed households spent more than one hour for fuel collection, respectively. This indicates that the rural households spent a lot of their time for fuel wood collection.

However, 42% of urban respondents have to travel two times per week to collect fuel sources and 48% of the households, at least two member of the family, participate in fuel collection. Accordingly, the study has identified that the effort exerted and the time spent to collect fuel sources in urban areas are relatively less from that of rural areas. It might be because of the prevalent use of commercial energy sources in urban areas.

Since traditional and open fire stoves consume too much fuel, households are not able to meet their fuel need from their surrounding areas, non-informed and non-adopters of the improved stove are forced to move longer distance to find open field and backyard places in order to collect fuel sources. In those areas, fuel-wood and other energy sources are not easily accessible. About 57 and 45% of rural and urban households who use traditional and open fire stoves spent on average more than two hours for gathering energy sources on which at least two household members involve and they travel twice per week, respectively. Therefore, if a household collects fuel for nine months assuming that they may use the stock or any other means of energy need for the rest three months of a year, an individual member of the household will spend 135 working hours per year only for fuel gathering activities in those households. This indicates that children have to miss their school day and women are left less time to carry on other house chores.

The average monthly expenditure for fuel need is 41 and 17 birr in urban and rural households, respectively. Adopters of improved *Mirt* stove on average spent 29 Birr in urban households and 11 Birr in rural households. However, non-adopters of the stove spent 49 Birr in urban areas and 18 Birr in rural areas. In both settlements, the non-informed households mostly use collection of fuel as a source and they spent about 35 and 21 Birr for fuel in urban and rural households, respectively. Thus, if effort is made to distribute one million improved stoves in Ethiopia, it is possible to save on average 11.5 million Birr per month. This result indicates that the contribution of improved fuel saving technology towards households expenditure saving and directly to reduce impacts on fuel-wood and other biomass resources demand.

If this extra effort and time were to be put for some other productive use, it would surely help to reduce the burden of rural women and children in household activities and environment. It might also enhance the economic status of those women who participate in fuel collection. However, it is understood that not all of this time and effort can be put into productive and income earning activities due to many reasons such as child labour, low efficiency, low skill and lack of employment opportunity. Nevertheless, it will be possible for the households to generate income and reduce the burden of women should they utilize sixty percent of the extra time, which they spend to collect

fuel, for productive purposes. The children will also able to use the time for their education.

4.1.4 Reasons for not using improved stove

This study focuses on those who are well informed, but not yet adopt the technology. The result reveals that low purchasing power only evidenced by rural households, about 76% of the households responded that the meager income they get prevents them to adopt the improved stove. About 53% of urban households reported that their main reason that hinders them from adoption is financial constraint. About 42% of urban households responded that their housing or dwelling status was the other key reason not to adopt the improved stove, especially the absence of separate kitchen in their living compound for those resides either in kebele house, temporary shelter or in private rental house. Particularly, urban households who use shared kitchen complained that their stove is easily accessible to all who live in the compound and other outsiders. Therefore, improving the kitchen environment and dwelling status of the people may contribute a lot for the household's energy efficiency and usage of better energy appliance. By doing so, households will be able to move into the upper energy ladder.

4.2 The econometric results

The conditional probability functions are very similar for both Probit and Logit models, except in the extreme tails. The Probit model estimation is applied for this study. In order to check whether there is any serious multicollinearity among the explanatory variables, a correlation matrix was generated to drop some variables having higher multicollinearity.

It is worth nothing that the values of certain variable contrast greatly in size with other variables which may induce hetroscedasticity. A test for the presence of heteroscedasticity[23] problem in the model was also done. The test result shows that the null hypothesis of homoscedasticity is rejected implying that there is heteroscedasticity problem in the model as it is expected and common problem in cross-sectional data. To minimize this problem, the natural log of the monthly income of the household is considered in the model and heteroscedasticity-consistent Probit

[23] The LR test is 88.17 and 84.27 for rural and urban estimates, respectively. The critical value of the chi-square at each estimation degree of freedom is at 95% level. Comparison of the results (test statistics) with critical table value shows that all of the test statistics (computed values) are found to be larger than the critical table value. This implies that the null hypothesis of homoscedasticity is rejected, i.e. hetroscedasticity is the problem for the model.

models from STATA 9 program were applied. The empirical results of information and adoption equations of rural and urban households summarized in Annex Table A-1-A and A-1-B, respectively.

4.2.1 The information results

Many empirical evidences show that acquisition of information and adoption decision determined by the socio-economic status, demographic characteristics, modern source of energy, educational attainment and income. Hence, the study tries to analyze the factors that determine information acquiring and adoption decision on improved *Mirt* stove technology in both rural and urban households in the study area.

In rural areas, the probability of information acquisition is higher in female-headed households than in male-headed and significant (at 5%). This supports the common tradition practiced in Ethiopian rural households, women are responsible to prepare food and collect fuel. As a result, rural women are concerned about the improved stove technology information.

Surprisingly, family size has a positive and significant impact on information acquiring in rural households. At the margin, the increase of rural household member by one may raise the probability of information acquiring by 7.9%. This indicates that particular rural family household members may disseminate and pass information to their family.

As expected, household age has negative impact on information acquiring in both urban and rural households, yet it is not significant. An increase in household age causes a reduction on the probability of information acquiring. The result suggests that information acquiring about improved *Mirt* stove is higher in young-headed households than older-headed ones.

On the supply side of the information, the source of information is either formal or informal sources. Access to electricity means that households can attend television and radio programs; as a result the households may get access to formal sources of information. This variable is highly significant and has positive impact in rural households than in urban areas. The probability of information acquisition is higher in rural households that have access to electricity than those of without electricity access. Therefore, provision of electric service to rural areas plays a pivotal role to disseminate information through formal means.

Producers of the improved *Mirt* stove have been exercising different commercialization strategies and promotional activities to introduce *Mirt* stove. The activities of producers may indirectly enable the society to access information about the technology. Thus, the study has revealed that the presence of *Mirt* stove producers in the urban households' living area or market has a positive and highly significant impact on information acquisition. Being the urban households near to market the probability of information acquisition will increase by 45.1%. It has also positive impact on rural household's information acquiring despite its insignificant. The insignificance of this variable in rural households may be due to the inaccessibility of market for *Mirt* stove in the vicinity of the people. This study has also identified that the rural households mainly obtain information about *Mirt* stove from development agents.

Finally, Active participation in local associations such as "Idir", "Iqub" and "Mahiber" bring positive influence and highly significant for information acquiring in both settlements (at 1%). Both in rural and urban households who are actively participating in local associations have higher probability to acquire information than households who are not active in participation. Being active in local associations' participation will increase the probability of information acquiring by 71.4 and 71.8% in rural and urban households, respectively. Indeed, informal channels of information dissemination are more effective for those households who are active in local association participation. As a final point, participation in local association has a great role to acquire information than adoption decision, thus, it is used as an offset variable.

We can conclude, then, among other variables the probability of rural households' information acquiring relating to the improved *Mirt* stove technology are statistically explained by family size, sex of household heads, active participation of households in local associations, and availability of modern source of energy (electricity). Regarding to urban households, the study result has indicated that active participation in local associations, and market or presence of producer of *Mirt* stove technology are the main significant factors to acquire information. Therefore, the study results reveal that improvement in the socio economic status and facilitation of information provision in rural and urban households would bring positive impact on information acquisition.

4.2.2 The adoption results

The "energy ladder" hypothesis relates improvement in socio-economic status of the household with transition to more energy efficient stoves and higher quality and less polluting fuel appliance is often invoked as theoretical model for analyzing household energy demand practice. The finding of this study is consistent with *Barbara D and others (2000)* and *Hosier and Dowd (1987),* and *Reddy* (1995) who have studied in

Mexico, Zimbabwe and India, respectively. The energy ladder hypothesis was also discussed in Ethiopia, by *Tadelech* (2001) in Addis Ababa households and *Berhanu* (1998) in Nazareth town. Those studies tested the hypothesis and found that as socio economic status of the household increases, the households move up to the upper energy ladder.

Income is found to be one of the major variable which has a positive and highly significant (at 1%) impact in rural households. A 10% increase in income will increase the probability of adoption decision for improved *Mirt* stove technology by 0.05% in rural households. However, this variable has positive impact but it is not significant in urban households.

Contrary to the expectation of the study, the probability of adoption decision is higher in female-headed urban households than male-headed and it is highly significant. The finding is contrast to the result by *Tadelech* (2001). The plausible reasons in urban households' female are becoming decision makers, where as in rural households the probability of adoption decision is higher in male-headed household than female-headed and it is insignificant. The result indicates in rural households men are still decision makers on resources than female but for urban households female may have an influence on resource decisions for households' activities.

The coefficient of the household head age is negative, and it is significant in rural households. An increase in household head age causes a reduction in the probability of adopting improved stove. At the margin, an additional year of age reduces the probability of adoption decision by 1.8% and it has negative relation with urban households even if it is insignificant. Thus, the result reveals that the probability of adoption decision for improved *Mirt* stove is higher in younger rural households than older ones.

Similarly, marital status is positively related to household's adoption decision for improved ("Mirt") stove in urban household but due to collinearity problem this variable dropped from the rural households regression. The probability of adoption decision is higher in married urban households than unmarried ones and it is significant (at 10%). This may be due to married people are likely to have a responsibility for family members and mostly in urban areas; unmarried households may outsource their food consumption. Accordingly, family size also has a significant and positive influence on adoption decision of urban households. As the member increase by one, the probability of adoption of the technology will increase by 4.3 %.

Household's schooling has a large positive and highly significant effect (at 1%) on adoption decision of the urban households. The marginal contribution of completion of an additional schooling of the households head on the probability of adoption decision is 43.9%. Education also has significant effect in rural households too, with marginal effect, additional schooling on rural household result increase in the probability of adoption decision by 48.6%. Therefore, household's schooling or the educational level is one of the most important variable explaining the adoption decision of improved *Mirt* stove technology.

Another vital result from this study in relation to education is the literacy level of the rural household wives. This variable has a significant and positive influence on the adoption decision. This finding suggests that provision of education to female would result higher benefit for the rural areas and possible to get economic and environmental benefits that could derive from stove adoption.

The main source of fuel for rural households is through collection. If the rural households have a capacity to participate more of its members for fuel-wood and other energy source collection, the probability of adoption decision will decreased. This variable has a negative sign as expected and it is highly significant. In fact, as members of the family participate for fuel collection increased by one member, the probability of adoption decreased by more than ten percent. The result indicates the availability of labour force in rural areas is one factor that affects the adoption decision.

Households are the users of the technology product and it is important to note that their subjective preferences for the characteristics of new technologies affect adoption decision. Some of the desirable characteristics considered in this case: convenience of the stove, compatibility and a relative advantage. The households' perceptions about those characteristics may have impact on adoption decision. The result is expected because adopters and non-adopters of the technology differ based on their perception about the technology. The probability of adoption decision is higher in rural household that have considered the stove has relative advantage and compatible than those who do not have this perception, and it is insignificant (at 5%).

Existence of separate kitchen in households is the indicators of the household dwelling standing and their living standard. At the margins, the variable indicates that the passage from households whose habitat is without a kitchen room to those whose habitat is provided with separate external kitchen involves a rise of 14.1% in urban households' adoption probability and it is highly significant. The result indicates that the presence of separate kitchen enables the urban households' independent

utilization of their stoves and increase in socioeconomic status resulted in better kitchen and housing environment.

Since the majority of rural households may get advantage mainly for fuel storage, to decide on free space and others in their living compound, as a result the existence of separate kitchen may provide weak support for adoption decision in rural households. In addition, surprisingly, the probability of adoption decision is lower in households having external kitchen than households who do not have separate kitchen and it is insignificant variable for rural areas.

5. Conclusion and recommendations

5.1 Conclusion

A number of studies identified many of the population in developing countries are still primarily dependent on biomass energy for domestic use. Fuel efficient and convenient stoves therefore have important implications for a number of interrelated aspects of development including health, protection of natural resource and environment, and household economy. Indeed, various empirical studies reported that "energy ladder" relating improvements in socioeconomic status with transition to more efficient appliance and to higher quality fuels is often invoked as a theoretical model for analyzing household's energy management practice. Thus, the findings of this study also support the energy ladder hypothesis.

This study result reveals that household sector use significant share of energy consumption. The sector was highly dependent on biomass resources. Especially, in rural areas, the major source of fuel is through collection and it has adverse impact on natural resource and environment such as deforestation and soil erosion due to fuel-wood collection, loss of soil fertility due to animal dung used as a source of energy. Although in urban households due to an ever increasing price of electricity and Liquid Petroleum Gas (LPG), household back to use biomass sources. This indicates the need for efficient biomass stoves through promotion of technically simple and economically feasible that could be adopted by the majority of the people.

The result shows that acquiring of information relating to the improved *Mirt* stove technology are significantly explained by the socioeconomic variables that are family size, sex of household heads, active participation of households in local associations, and availability of modern source of energy (electricity). Regarding to the urban households, the study result has indicated that active participation in local associations, and market or presence of producer of *Mirt* stove technology are the

main significant factors to acquire information. Therefore, improvement in the socioeconomic status of households and facilitate the provision of information in urban and rural households would bring positive impact on information acquisition.

The study also shows the most important factors that determine the adoption decision of improved *Mirt* stove in rural and urban households. Educational level of the household head is the common significant variables. In addition to this variable, particularly for urban households' existence of separate kitchen, sex of the household head, family size and marital status are the main ones. In rural households members of the family participate in fuel collection, age, compatibility and educational level of the household spouse (wives) are found to be significant. Similarly, improving the dwelling status and cooking and baking environment for urban and rural households has positive impact for energy efficiency.

5.2 Recommendations

With those major findings of the study, the following are the implications of the results for policy:

- The household energy demand has significant adverse impact on natural resource and environment. Therefore, energy policy, programs and measures should give due attention and consideration to the households' rationale, especially, in fuel-wood and other biomass resources gathering and combustion.
- Decision makers should enhance the provision and disseminating information about the environmental and economic benefit of energy efficiency derived from improved stove technology. This would be an effective instrument for economic development. In particular, intervention through provision of information in local associations and demonstration programs are more important.
- Finally, adoption of efficient and improved stove technology has an important implication for natural resource conservation and environmental protection. To this end, policy makers and other stakeholders in energy sector should seriously consider the fact that provision of information and enhancement of the adoption decision for improved stove technology is as a means and ways to create viable economic benefit for the country. Particularly, improve the provision of education and income of the rural people and the dwelling status of the urban households.

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Appendix I

Table A-1-A: Probit estimation of sample selection for rural households

Number of obs	= 120	LR chi2(11)	= 88.17
Censored obs	= 62	Pseudo R2	= 0.5304
Uncensored obs	= 58	Wald chi2(11)	= 33.38
Log pseudolikelihood	= -53.3968	Prob > chi2	= 0.0005

Adoption	Coefficient	Marginal Effect	Standard Error	P>|z|	Mean
*Members participate for collection***	*-0.6808*	*-0.1689*	*0.2536*	*0.007*	*1.93333*
Family size	*0.1073*	*0.0266*	*0.0872*	*0.219*	*7.03333*
D[24] *Dwelling status*	*0.5499*	*0.1161*	*0.8081*	*0.496*	*.783333*
D separate kitchen	*-0.7334*	*-0.1909*	*0.6057*	*0.226*	*0.575*
*D compatibility***	*1.3820*	*0.3788*	*0.6815*	*0.043*	*0.4*
*D spouse education****	*1.3884*	*0.3991*	*0.8413*	*0.099*	*0.35*
*Age***	*-0.0734*	*-0.0182*	*0.0230*	*0.001*	*47.325*
D head of the household	*1.1136*	*0.1928*	*0.9436*	*0.238*	*0.80833*
D access to credit	*0.7870*	*0.1913*	*0.5150*	*0.126*	*0.525*
*D education***	*1.7467*	*0.4864*	*0.8403*	*0.038*	*0.60833*
*L income**	*2.2085*	*0.5479*	*0.6098*	*0.000*	*6.2065*
*_constant**	*-12.3860*	*-*	*3.1867*	*0.000*	*-*
D active participation	*(offset)*				
Information					
D marital status	*0.2955*	*0.0342*	*0.7271*	*0.684*	*0.89166*
*Family size***	*0.1920*	*0.0796*	*0.0753*	*0.011*	*7.03333*
D spouse education	*0.5304*	*0.2077*	*0.3647*	*0.146*	*0.35*
Age	*-0.0092*	*-0.0039*	*0.0135*	*0.494*	*47.325*
*D head of the household***	*-1.0584*	*-0.3803*	*0.4276*	*0.013*	*0.80833*
*D active participation**	*2.1819*	*0.7144*	*0.4050*	*0.000*	*0.441667*
D access to credit	*0.4047*	*0.1730*	*0.3509*	*0.249*	*0.525*
*D electricity access ***	*1.2242*	*0.4469*	*0.4451*	*0.006*	*0.60833*
D market	*0.0815*	*0.0730*	*0.5496*	*0.882*	*0.21666*
D education	*0.2426*	*0.0948*	*0.4593*	*0.597*	*0.597*
L income	*0.4331*	*0.1626*	*0.3012*	*0.150*	*6.2065*
*_constant ***	*-4.9715*	*-*	*2.1584*	*0.021*	*-*
athrho |	*0.6198*		*1.2219*	*0.612*	*0.612*
| rho |	0.5510		0.8509		

**** Significant at 10%* *** Significant at 5%* **Significant at 1%*

[24] D indicates for variables that are Dummy and level of significance refers to the Marginal effects.

Table A-1-B: Probit estimation of sample selection for urban households

Probit model with sample selection		Number of obs	= 90
LR chi (12) = 84.27		Pseudo R2	= 0.7183
		Censored obs	= 33
		Uncensored obs	= 57
		Wald chi2(12)	= 28.04
Log pseudolikelihood = -33.63697		Prob > chi2	= 0.0055

Adoption	**Coefficient.**	**Marginal effect**	**Standard Error.**	**P>|z|**	**Mean**
Age	-0.0593	-0.00759	0.0379	0.118	50.4333
D marital status ***	2.2639	0.29652	1.2361	0.067	.566667
Family size **	0.3366	0.04308	0.1729	0.052	5.31111
D dwelling status	0.2791	0.03603	0.8090	0.730	.488889
D separate kitchen **	1.1748	0.14142	0.8018	0.043	.577778
D compatibility	0.6088	0.07864	1.1171	0.586	.511111
D spouse education	0.5289	0.06928	0.8129	0.515	.488889
D head of the household **	-4.3273	-0.92108	1.4616	0.003	.677778
Fuel expense	0.0131	0.00168	0.0166	0.429	41.0444
D access to credit	1.1795	0.20348	0.7585	0.120	.344444
D education**	3.4843	0.43912	1.2413	0.005	.611111
L income	0.2721	0.03482	0.6331	0.667	5.88359
_constant***	-5.2242	-0.00759	3.1936	0.102	
D active participation	(offset)				
Information					
D marital status	-.4286643	0.07418	.8178782	0.600	0.5666
Family size	.1765413	0.03083	.136889	0.197	5.3111
D spouse education	1.048235	0.18711	.9874462	0.288	0.4888
Age	-.0221105	-0.00386	.0235583	0.348	50.433
D head of the household	-.9716964	-0.14128	1.147533	0.397	0.6777
D active participation *	3.65241	0.71873	.7598789	0.000	0.5111
D access to credit	-.8260403	-0.16356	1.114081	0.458	0.3444
D market ***	2.617077	0.45128	1.41075	0.064	0.4444
D electricity access	.8047146	0.18816	1.190112	0.499	0.7666
D education	.0949537	0.01405	.8640634	0.912	0.6111
L income	.8235751	0.14724	1.122381	0.463	5.8835
_constant|	-6.424711	-	6.698139	0.337	-
/athrho	.0848789	-	3.270068	0.979	-
rho |	.0846757	-	3.246622	-	

**** Significant at 10%* *** Significant at 5%* **Significant at 1%*

Table A-2-A: Descriptive summary for rural households

Variable	Mean	Standard deviation	Minimum	Maximum
Income	656.12	603.2842	95	5000
Marital status	0.89166	0.3121	0	1
Family size	7.03333	2.8252	0	1
Separate kitchen	0.5750	0.4137	0	1
Compatibility	0.40	0.4964	0	1
Spouse education	0.35	0.4789	0	1
Age	47.32	13.570	20	80
Sex of household head	0.8083	0.3952	0	1
Fuel expense	17.69	15.22	0	110
Active participation	0.525	0.5014	0	1
Credit	902.075	1102.36	0	4000
Access to credit	0.525	0.5014	0	1
Electricity	0.3666	0.4137	0	1
Market	0.2166	0.4137	0	1
Members for collection	1.93	1.11	0	6
Education	0.6083	0.4901	0	1
Log income	6.2064	0.7390	4.5538	8.5171
Dwelling status	0.78333	0.413709	0	1
Number of Observation	120			

Table A-2-B: Descriptive summary for urban households

Variable	Mean	Standard deviation	Minimum	Maximum
Income	506.72	586.89	85	3500
Marital status	0.5666	0.4983	0	1
Family size	5.31	2.56	1	12
Separate kitchen	0.5777	0.4966	0	1
Compatibility	0.5111	0.50267	0	1
Spouse education	0.48888	0.502677	0	1
Age	50.43	13.25	20	83
Sex of household head	0.6777	0.4699	0	1
Fuel expense	41.04	27.80	0	130
Active participation	0.5111	0.50267	0	1
Credit	489.76	1014.99	0	7000
Access to credit	0.3444	0.4778	0	1
Electricity	0.7666	0.4253	0	1
Market	0.4444	0.49968	0	1
Education	0.6111	0.4902	0	1
Log income	5.883	0.7701	4.4426	8.1603
Dwelling status	0.4888	0.5026	0	1
Number of Observations	90			

TABLE A-2-C: Factors Affecting household to acquire information and adoption decision for improved ("Mirt") stove

	RURAL HOUSEHOLDS		URBAN HOUSEHOLDS	
1. Head of the household	Frequency	Percentage	Frequency	Percentage
Male	106	88%	59	65%
Female	14	12%	31	35%
2.Dwelling status of the household				
Owners	84	70%	45	50%
Non-owners	36	30%	45	50%
3.Presence of separate kitchen in the house				
YES	72	60%	53	58%
NO	48	40%	37	42%
4. Source of fuel-wood and other energy sources				
Purchase	12	10%	40	44%
Collection and purchase	14	12%	28	31%
Collection	96	78%	22	25%
5. Presence of modern source of energy (electricity)				
YES	52	57%	69	77%
NO	68	43%	21	23%
6. Active participant in local associations and activities				
YES	50	42%	46	51%
NO	70	58%	44	49%
7. Spouse educated or not				
YES	45	38%	50	56%
NO	75	62%	40	44%
8. The stove is compatible				
YES	41	34%	48	54%
NO	79	66%	42	46%
9. Having access to credit				
YES	70	58%	47	52%
NO	50	42%	43	48%
10. Marital status				
Yes	93	78%	58	64%
NO	27	22%	32	36%

TABLE A-2-D: Description of variables.

Independent variable	Description
Age	Number of years the household heads live
Dummy foe sex of the household head	1 If the head is male , 0 otherwise
Income	Log of monthly income of the household head
Dummy for Availability of modern energy source (electricity) for household lightning	1 if the household have access to modern electric source (electricity), 0 otherwise.
Dummy for access to credit	1 if the household get credit during the current six month period, 0 otherwise.
Family size	The number of individuals who are the members in the family
Dummy for households participation in local associations	1 if the household actively participate and involvement in local associations as leader and moderator, 0 otherwise.
Dummy for location of household access to the market for improved ("Mirt") stove	1 if the households near to producers of improved stove or market, 0 otherwise
Dummy for dwelling status of the household	1 if the household is owner of the house, 0 otherwise
Dummy for existence of external and separate kitchen	1 if the household have separate external kitchen, 0 otherwise
Dummy for household response on technology which has a relative advantage, compatible and lower complexity	1 if the household believe that the stove has an advantage and compatible for users, 0 otherwise.
Members of the family who participate in fuel collection	Members of a family participate to collect fuel for the household fuel need or necessity.
Dummy for marital status	1 if the household head is married, 0 otherwise
Dummy for spouse education	1 if the household spouse(wife) is literate, 0 otherwise
Fuel expense	Average monthly expense for fuel need
Dummy for the household head education	1 if the household head is literate, 0 otherwise