CODESRIA

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Agricultural Productivity and Rural-Urban Migration: The Case of Senegal

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Abstract

Rural-urban migration in Sub-Saharan African countries has been increasing since the 1960s. In Senegal, it has been growing at a rate of 7 % per year from 1961 to 1996. The labour market in the modern industrial and service sectors is so depressed that urban workers face high rates of unemployment and poverty and live in hard conditions in the fringe urban sector. This study was aimed at examining policies to reduce rural-urban migration using selected agricultural investments.

Based on a recursive system of equations, rural-urban migration elasticities from agricultural inputs were estimated. The model combined a Cobb-Douglas agricultural production equation and rural-urban migration equation which has the agricultural output as an explanatory variable. The period of study is 36 years, from 1961 to 1996.

The findings support hypothesis that rural-urban migration is a positive function of the urban-rural wage ratio, proxied by the ratio of the urban per capita income to the rural per capita income. It also justifies the foundation of a policy aimed at reducing rural-urban migration flows by increasing per capita earnings by means of increased agricultural investments. The results show that 1 % increase of fertiliser and infrastructure capital will increase agricultural output by 0.2 % or 0.28 % respectively, which lowers rural-urban migration by 2 % in the case of fertiliser and 3.2 % in the other case. If we can extrapolate these results, fertiliser and infrastructure need to be increased respectively by 36 % and 32 % to reduce rural-urban migration to 2 %, the level of industrial labour demand.

Résumé

L'exode rural en Afrique Sub-Saharienne a explosé depuis les années 1960. Au Sénégal, l'exode rural a crû à un rythme annuel de 7 % entre 1961 et 1996. La crise de l'emploi en milieu urbain plonge les travailleurs urbains dans un chômage chronique et dans une pauvreté matérialisée dans le secteur informel.

Cette recherche propose une politique de réduction de l'exode rural par un accroissement des investissements agricoles. À partir d'un modèle d'equations récursives, ayant d'une part une équation de production agricole du type Cobb-Douglas, et d'autre part, une équation d'exode rural incluant la production agricole comme variable indépendante, les élasticités de l'exode rural par rapport aux facteurs de production agricole ont été estimées avec des données de 1961 à 1996.

Les résultats obtenus sont conformes à l'hypothèse selon laquelle l'exode rural dépend positivement de la supériorité du revenu du travailleur en milieu urbain sur celui du travailleur agricole. Un accroissement de 1 % des engrais ou des infrastructures agricoles rehausseraient, *ceteris paribus*, la production agricole de 0.2 % et de 0.28 % respectivement, ce qui réduirait l'exode rural de 2 % si le choix portait sur les engrais et de 3.2 % dans l'autre cas. Pour ramener l'exode rural à 2 %, soit le taux de croissance de la demande du travail industriel, l'usage des engrais devrait croître de 36 % et celui des infrastrucutres de 32 %.

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Map, Figure, Graphs, Tables, Appendix and Abbreviations

Lists of Graphs

Lists of Tables

Appendices

Abbreviations

CODESRIA: Counsel for Development and Social Sciences Research in Africa
DCs: Developed countries
FAO: Food and Agriculture Organization of the United Nations
FCFA : Franc de la Communauté Financière Ouest Africaine.
GDP: Gross Domestic Product
IMF: International Monetary Fund
LDCs: Less Developed Countries
UNESCO: United Nations for Educational and Scientific Organisation
UNECA: United Nations Economic Commission for Africa
UNIDO: United Nations Industrial Organisation
USAID: United States Agency for International Development

TABLE OF CONTENTS

CHAPTER I. INTRODUCTION

The modernisation of Sub-Saharan African initiated a strong movement of rural-urban migration. While, in Developed countries, this phenomenon took place in response to the high labour demand by the booming industrial sector, in many African countries, much of rural-urban migration coincided with high unemployment and poverty rates in the urban areas.

During the second half of the twentieth century, economic development theorists have tried to understand this paradoxical situation in Less Developed Countries (LDCs). The classical economic theories such as the one introduced by Lewis (1954) and his followers were of limited help because they expected that the economic growth path of LDCs would be industrially-pulled as that of Developed Countries (DCs), and so would be the rural-urban migration rate. Todaro's work (1969) marked a turning point in development economics involving urban-oriented labour movement. He stated that rural-urban migration depends on economic reasons, especially on the difference between the per capita earnings in both sectors and on the chances for a migrant to obtain an urban job.

Although other sociological and/or political factors may be significant, as far as economic analysis is concerned, human mobility should be seen as a rational choice among activities that maximise the use of labour, regardless of where they are located.

This study is built upon the idea that rural-urban migration in LDCs can be effectively reduced by agricultural investments in strategically selected inputs. In fact, since migration flows toward urban zones are driven by higher per capita income in urban areas compared to rural areas, one could slow down migration by increasing the per capita earning in the rural sector, relative to that in the urban sector by undertaking appropriate agricultural investments.

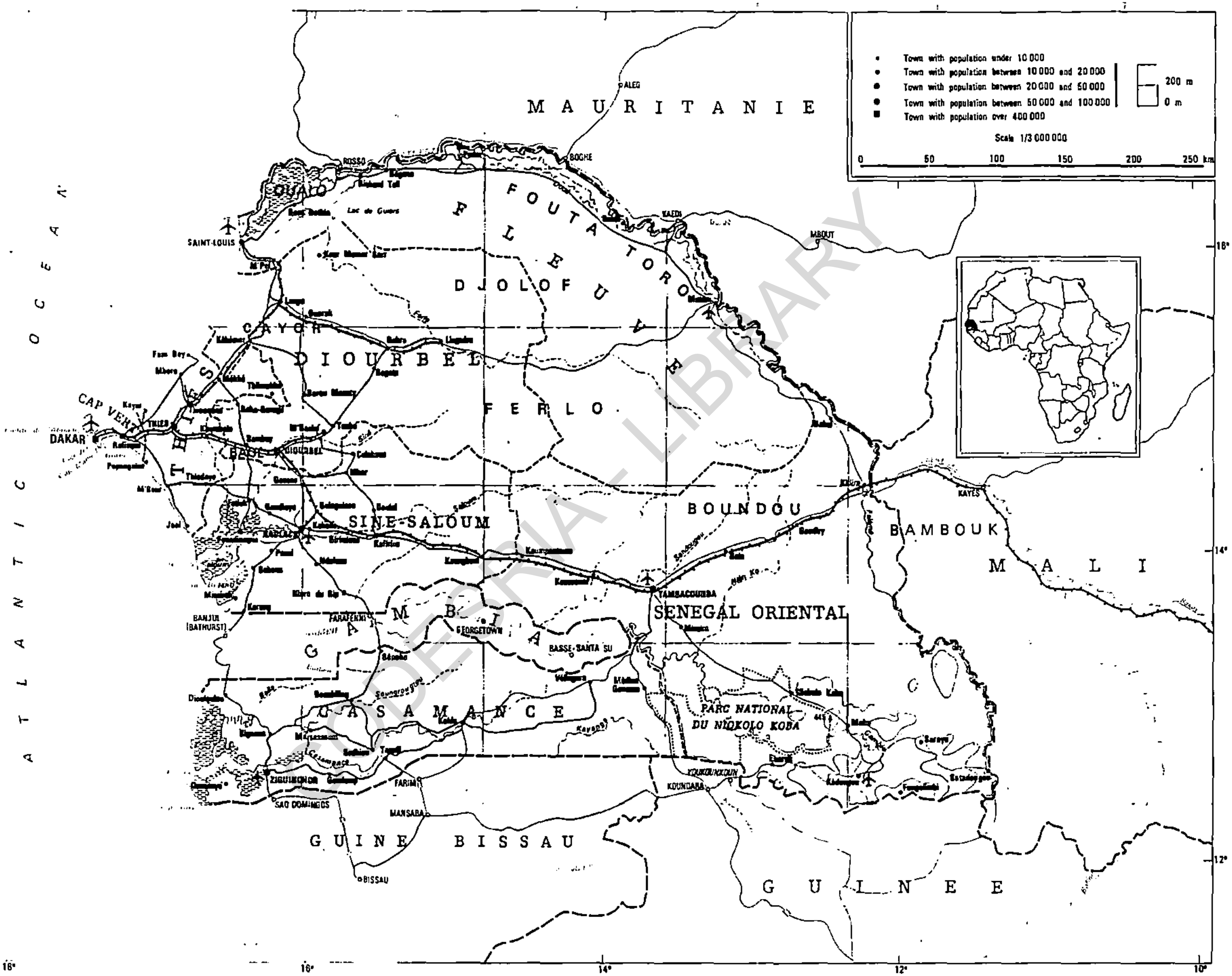
The choice of this policy is natural, because traditional urban policies such as improving infrastructure or investing in industrial activities are always weighted down by additional migrants from rural areas who interpret them as signals of better life in cities. Other remedies to curb rural-urban migration, such as equating rural and urban per capita income by wage subsidies are difficult to implement because they introduce heavy taxation, penalise urban workers and causes economic distortions. A logical migration policy that could bring urban policies to success is to hold rural workers in agriculture by increasing their wage earnings.

Chapter II. RESEARCH BACKGROUND

II.1. Senegal as a Case Study

The area of research interest is the Sub-Saharan Africa zone. In particular, the Senegalese situation is used to illustrate the scope of rural-urban migration problems. Senegal economic and demographic data are used to estimate the econometric relationships and to suggest a policy for reducing rural-urban migration.

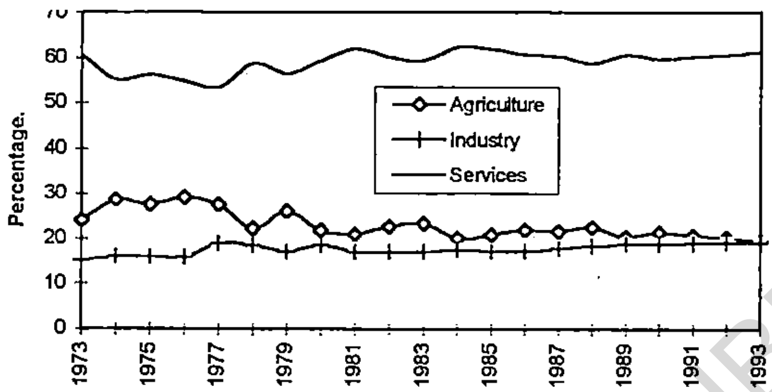
Senegal is located in western Africa and spans on 19,722 km^2, surrounded by Mauritania (north), Mali (east), Guinea and Guinea-Bissau (south) and the Atlantic ocean (map on the next page). It is drained by the Senegal and the Casamance rivers. It has a relief of sandy plain except in the north-east, which is dominated by the Fouta-Djalon mountain chain (at 581 m altitude). The north, with its sahelian climate, has a steppe vegetation, while the Centre of Senegal has sahelo-sudanian climate. The south has a tropical humid climate with the corresponding vegetation.


Town with population under 10 000
Town with population between 10 000 and 20 000
Town with population between 20 000 and 50 000
Town with population between 50 000 and 100 000
Town with population over 400 000
200 m
0 m
Scale 1/3 000 000
0 50 100 150 200 250 km
M A U R I T A N I E
ATLANTIC OCEAN
FOUTA TORO
FLEUVE
DJOLOF
CAYOR
DIOURBEL
FERLO
CAP VERT
DAKAR
THIES
SAINT-LOUIS
ROSSO
BOGHE
ALEG
KAEDI
MBOUT
KAYES
BAOL
SINE-SALOUM
BOUNDOU
BAMBOUK
M A L I
KAOLACK
TAMBACOUNDA
SENEGAL ORIENTAL
GAMBIA
BANJUL (BATHURST)
FARAFENNI
GEORGETOWN
BASSE-SANTA SU
CASAMANCE
PARC NATIONAL DU NIOKOLO KOBA
ZIGUINCHOR
SAO DOMINGOS
FARIM
MANSABA
KOUNDARA
YOUKOUNKOUN
G U I N E B I S S A U
BISSAU
G U I N E E
16°
14°
12°
10°
18°

In 1998, Senegal's GNP was $US 4.8 billion, with a GDP that increased at 2.6 % per year between 1988 and 1998, 5.2 % in 1997 and 5.7 % in 1998 (World Bank, 1999). These recent economic improvements are credited to the success of the structural adjustment policy (*ibidem*). As in many LDCs, the Senegalese economy is characterised by an overpopulated rural sector with low productivity, an embryonic industrial sector and an important service sector mainly composed of governmental services.

The share of the agricultural sector in total GDP had been declining from 26% in 1960-1965 to 21 % in 1984-1992. The share of the industrial sector increased from 15 to 20 % for the same period. As for services, they accounted for 60% of GDP. Within the primary sector, the share of the crop production fell from 64% in 1980-1983 to 53.5 % in 1984-1992. Its contribution to total GDP dropped from 17 % in 1960-1966 to 10% in 1991-1992 (Thsikala, 1998) (Figure 1).

Figure 1: Senegal, Shares of Each Sector in GDP



Source: Calculated from World Bank, World Tables 1976,1995.

II.2. The Scope of Rural-Urban Migration in Senegal

The demographic transition of Senegal is characterised by a high population growth rate. Migration from rural to urban areas is increasing, even though urban industries are doing poorly. As a result, the country faces high rates of urban unemployment and urban poverty.

II.2.1 A Country in Demographic Transition

In 1998, Senegalese population was estimated at 9 million (World Bank, 1999), with a natural annual growth rate of 2.7 %. The fertility index has been decreasing from 7.1 children per woman in 1978 and 6.6 children in 1986 to 6 children in 1992 (Duruflé 1994, Kante et al 1994). Infant mortality has also been falling from 117 per thousand in 1978 and 86.4 per thousand in 1986 to 68 per thousand in 1993 (*ibidem*). It appears that the birth/death balance displays an early demographic stage for the country.

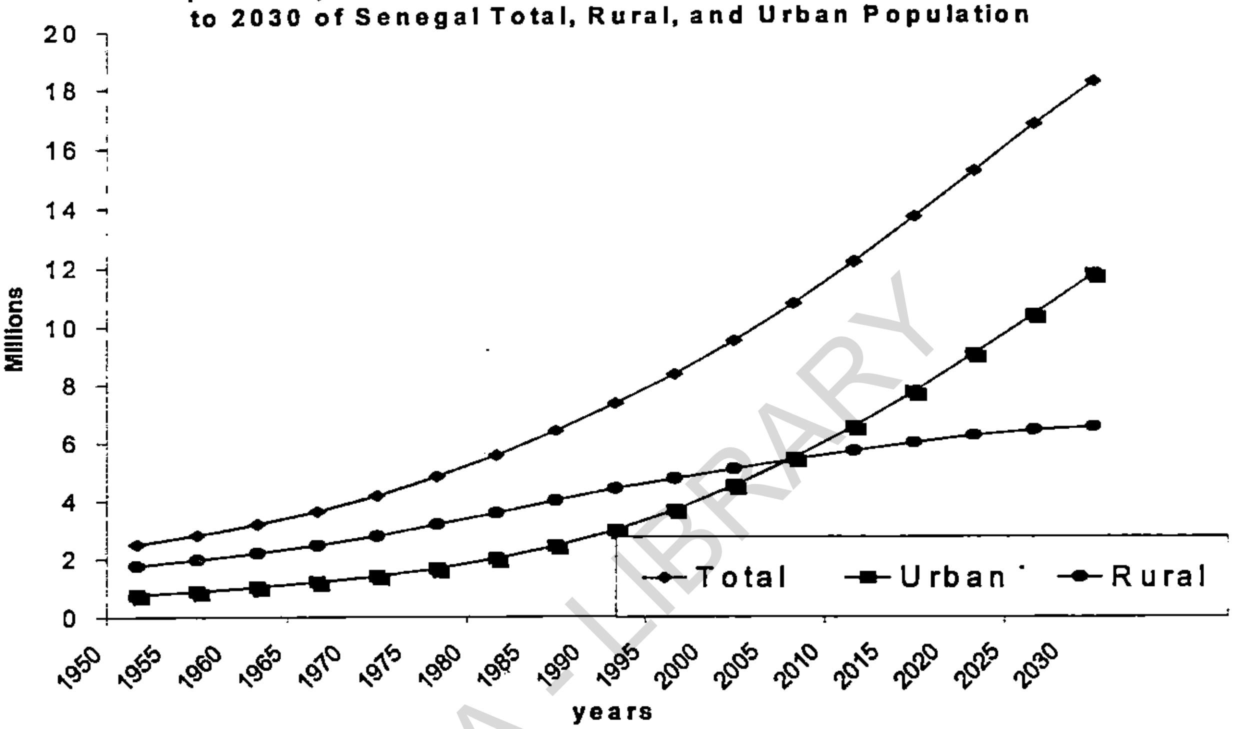
The structure of the Senegalese population shows overwhelming proportion of young people. In 1995, 46.6 % of the population was less than 15 years of age (World Bank, 1997).

II.2. 2. Migration towards Cities

Rural population has decreased from 70 % in the mid-1960s to 60 % in the 1990s. On the other hand, urban population has been increasing at a rapid pace. In 1993, 43 % of the population was living in urban areas, against 30 % in 1970 (FAO, 1999). More than half of this population is living in the capital, Dakar, which represents 5 % of the national territory. Dakar and Thiès regions contain 35 % of the total population. The national average population density is 39.2 inhabitants/km^2. But it is of 2,728 inhabitants/km^2 in Dakar and 142 inhabitants/km^2 in Djiourbel (Kante et al, 1994).

From 1950 to 2030, the annual growth rate of rural population is estimated at 1.76 % and that of urban population at 3.72 %. During the same period, urban population will be increase 15.7-fold, while rural population will only increase by 3.7-fold (FAO, 2000). These trends are portrayed in graph 1.

Graph 1. Population of 1950 to 1998 and Projection from 1998 to 2030 of Senegal Total, Rural, and Urban Population



Source: FAO On-line Data (http://www.fao.org)

Dakar is the final destination of migrants. Estimation of Dakar population's growth rate remains high, as underlined by various studies. It was 3.22% from 1904 to 1988 and 6.14 % from 1958 to 1988 for Becker and Mbodj (1994). Antoine & Savane (1990) had estimated it at 9 %. UNDP (1995) has projected, in 5 million of people will be living in Dakar in 2015 with 56 % living in cities. These higher growth rates are related to rural-urban migration. The Programme de Gestion Urbaine (1991) had estimated that about 32.5 % of the Dakar population was born out of the city, 64 % of the migrants were 15-44 years of age and 50% of migrants have been living in Dakar for over ten years. The study showed also that the number of rural-urban migrants had increased fivefold from 1976-77 to 1988-89.

II.3. Problems Related to Rural-Urban Migration in Senegal

What matters is not the number of people in cities but their living conditions. In Senegal, the high speed of urbanisation has led to infrastructure inadequacy and to high poverty and unemployment rates.

II. 3.1. Infrastructure Deficit and Urban Poverty

The national capital, Dakar, holds most urban social infrastructure, and it is in good shape in the Escale and Thierno Kandji districts, where civil servants and employees from larger firms live. The situation is different in the poorer districts such as Cité Ouvrière, Cheik Ibra, Keur Goumak and others. For example, in the Colobane district there are three health posts for 168,852 people. In the Grand-Yoff, there are four health posts and two maternity hospitals for a population of 183,847 (UNDP, 1995). The UNDP study also showed that malaria, respiratory diseases, diarrhoea and other diseases are frequent, due to poor sanitary conditions and promiscuity. Water supply and treatment are greatly insufficient in many Senegal cities. People face malnutrition in poor districts. In Tambacounda, on a sample of 3,347 people, 29 % were declared moderately to badly nourished, which led the UNDP (1995) to declare that:

> "Many people are very poor because they don't work, they have nothing to eat. All the districts are poor and people don't eat enough. Children as well as parents suffer from malnutrition" (p.28).

II.3.2. High Urban Unemployment

In the public sector, there has been a decrease of employment due to structural adjustment program measures. Between 1988/89 and 1989/90, governmental employment fell by 3.2 % (Programme de Gestion urbaine, 1992). The fall has accelerated since 1984 to meet with SAP requirements. The reduction of the public employment service occurred in an already depressed urban labour market. The unemployment rate in Dakar was 24.4 % in 1992 (Kante et al 1994). Among the urban unemployed, the proportion of young people is high. For the 15-29 age group, the rate was at 27.7 % in 1988 and 34.6 % in 1991. It was estimated at 44.3 % for women between the ages of 20 and 24 (Programme de Gestion Urbaine, 1992).

II.3.3. The Fringe Sector.

As far as the job market is concerned, structural adjustment measures had reduced the size of the public sector, the cost of labour and reformed labour legislation. Thus, the modern public and private sectors can no longer create enough jobs or fast enough for an increasing urban labour force. As a result, the unemployed have tried to make a living by working or creating new economic activities in the "non-official urban sector", also called the "fringe", the "murky" or the "informal" sector. This urban sub-sector includes all the non-registered jobs, productive or not, like car repair, haircut, shoe shining, street peddler, prostitution, etc.

A study of USAID (1988) showed that during the late 1980s, in Dakar there were 3,000 units in the fringe sector dealing with 85 kinds of businesses and employing 57,000 workers. 72 % of these were in commercial businesses (market stalls, small shops and street peddlers) and used 42 % of the urban workers; 28 % were in productive businesses (house building, transportation services, car repair, electric equipment repair etc.). Kante et al (1994) and UNDP (1995) arrived at similar figures when they found that on average, 60 % of Dakar's economically active population worked in the fringe sector. In the poorest districts, that proportion exceeded 70 %. According to Kante et al

(1994), the fringe sector employs around 23 % of the economically active, urban population. The fringe sector should not be considered as a panacea to solve urban unemployment because it faces numerous obstacles such as few job opportunities for an increasing labour force, lack of skills, lack of interest from the financial market, and most of all lack of health-sanitation and other basic infrastructure. A closer look at the agricultural and industrial performances can improve the understanding of the urban problems.

II.4. The Agricultural Crisis in Senegal

The country has five main agricultural regions that are unequally fertile and populated. To compensate for food deficits, farmers have adopted a subsistence food strategy, while the government has been allowing more and more food imports, mainly paddy rice to feed urban populations.

II.4.1. The Five Agricultural Regions

According to Ba (1994), Senegal has five homogeneous agricultural regions. The groundnut Basin (centre-west) where cereals (sorghum and millet) and groundnuts are mainly cultivated. It is subjected to frequent droughts and its soil is very degraded. It holds 100 inhabitants/km^2 and has no more additional land for cultivation.

The regions of Dakar and Niayes produce mostly vegetables and fruits that are high in demand in the neighbouring cities. These regions have to support the important and increasing demographic pressure from semi-rural and semi-urban populations, which is estimated at 2.5 million (*Ibidem*).

In the region of Eastern Senegal (27 % of total area) land is still available but the climatic conditions do not attract agricultural activities. That is why there is only 8 to 9 inhabitants/km^2 (Ba, 1994).

The basin of Senegal River (15 % of total land) is occupied by 8 % of the total population. Finally, Casamance, which accounts for 15 % of the total area located in the rainy zone, holds 14 % of the total population, but civil war slows down its agricultural expansion.

II.4.2. Food for Subsistence First.

Subsistence crops have increased in the agricultural output, while the crops for export have decreased substantially. During the 1960s and 1970s, groundnuts and cotton constituted 51 % of the total agricultural production. Their share fell to 38 % in 1988-1990. In the 1980s, the groundnut acreage was 16.3 % lower than in the 1970s. In general, during the 1980s, the land devoted to food crops increased by 8 % (Tshikala 1998, Duruflé 1994).

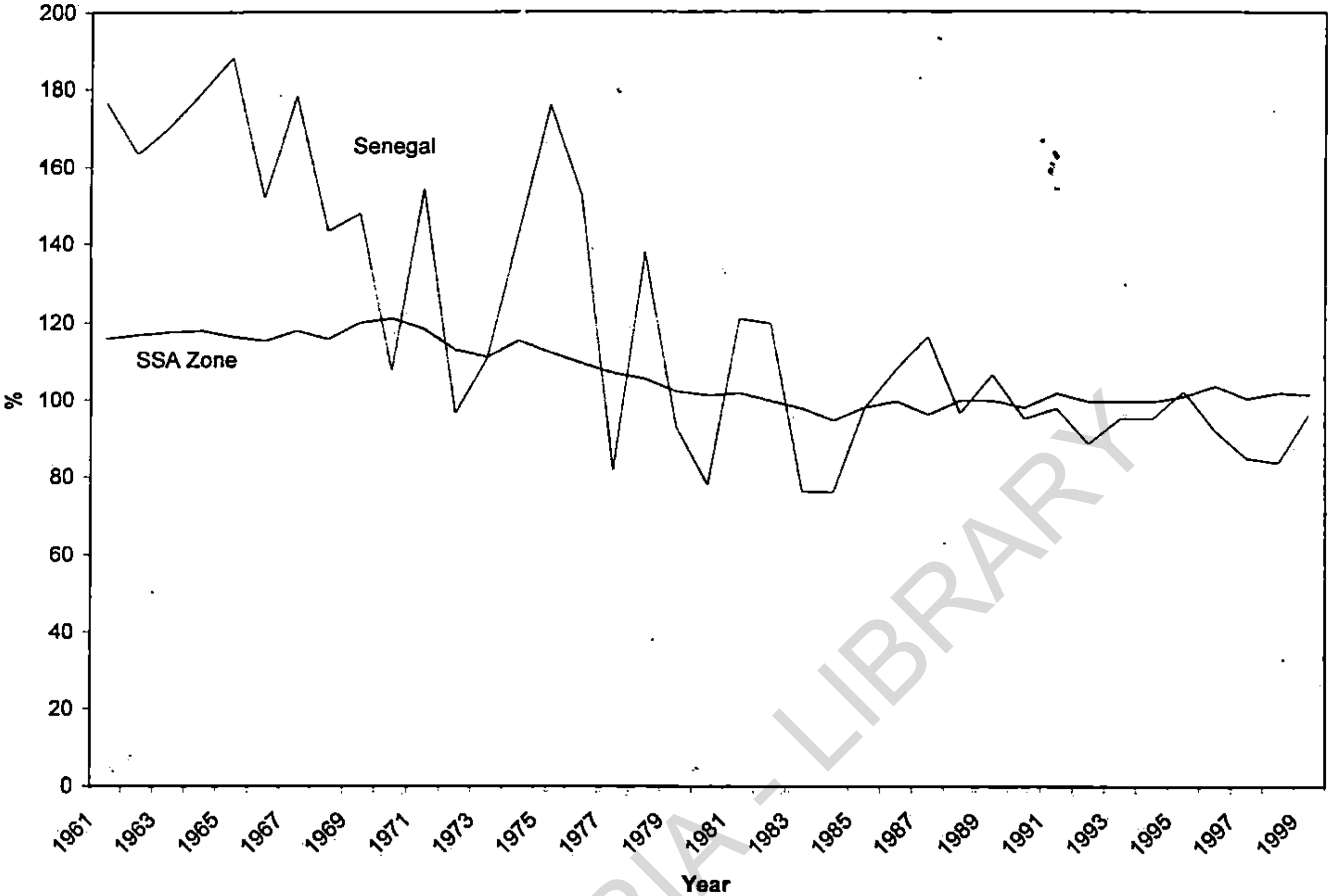
Since 1967, there has been a 1.6 % decrease in groundnut production and traditional cereals (millet and sorghum) rotated on the same land. Moreover, to avoid food deficits, farmers managed to cultivate marginal lands in the south and the east of the country. They have also substituted paddy rice and maize for traditional cereals like sorghum and millet (Duruflé, 1994). Therefore, by shifting the production process and by cultivating crops that can be stocked in the ground (cassava, potato), farmers have managed to keep the annual growth rate of cereal production at 2 %, mainly for subsistence purposes.

Other authors are more pessimistic. Kante et al (1994) estimate the overall annual growth rate of food production at 1 % from 1967 to 1991, which is far below the 2.7 % annual growth rate of the population. The World Bank (1987) has estimated the growth rate of Senegalese agricultural output at 1.3 % from 1960 to 1986. Diagne's (1998) estimation of the growth rate is even lower (0.7 % in the 1980-1992 period). This poor performance had pushed USAID (1991) to call for an improvement of soil management, as they claim that otherwise the rural sector and food production will continue to decrease.

This decrease in food sold to the market had pushed the government to allow for more food imports, in order to feed the growing urban population. From 1960 to 1990, the annual growth rate of food imports was of 3% (Kante et al 1994) but it is 4% (1970-1992) for cereal imports (Ministère de l'Économie et des Finances, 1992).

As a result, the per capita food production has been falling over the last three decades. The index used to portray that long run fall is constructed with the aggregate volume of the disposable agricultural production for each year at the base period of 1989-91 (FAO, 2000). It shows that the index has decreased by almost 50%, falling from 176.1% in 1961 to 96 % in 1999. It is represented on graph 2.

Graph 2. Per Capita Agricultural Production Index (base = 1989-91) for Sub-Saharan Africa and for Senegal



Source: FAO On-line Data (http://www.FAO.org)

II. 4. 3. Some Reasons for the Crisis

According to Diagne (1998), Kante et al (1994), Ba (1994) and the World Bank (1987), Senegal agricultural output has been declining because of natural factors and economic pressures. Among the natural causes is climate; average annual rainfall has been less than 600 mm for many years. Due to the lack of rainfall and powerful winds, arable land in Senegal is subjected to heavy erosion. Continuous droughts have reduced agricultural activities in the northern region. While fighting against desert expansion, the government had to protect the rain forest against cultivation and had to declare some areas reserved for pasture.

Population pressure in the Groundnut Basin has led to continuous cultivation in a zone, without additional fertiliser. Even plant cover such as the *acacias albidas* whose fertilising effects are well known has decreased considerably. In general four economic factors are to be blamed for the current agricultural situation.

First, due to the reduction in both production and price of groundnuts, rural monetary income has been eroding. Between the early 1960s and the early 1980s, real price per kilogram of groundnut decreased by 40 %, which caused a drop of half in the total commercial production (Kante et al 1994).

Second, the terms of trade between the main source of export receipts, groundnuts, deteriorated mainly due to lower prices of substitute products (Duruflé, 1994) such as soya oil and corn oil.

Third, In 1968, the preferential trade agreement between France and its former colonies came to end[1], and France did not cover any more the loss of export receipts.

Four, because the government financed its budget mainly by groundnut export receipts, the depressed international prices led to increased export taxes, which penalised farmers. For example, the value of groundnut production fell by 7 % between 1977-78 (at 22.1 billion FCFA) and 1982-83 (at 20 billion FCFA) but at the same time, the share received by producers dropped from 66 % to 43 % of these totals. Meanwhile, government receipts increased dramatically from 7 % to 41 % (Ba, 1994).

II.5. The Crisis of the Industrial Sector

Additional urban workers face a depressed urban job market due to the crisis of the industrial sector. Since the political independence, the Senegalese industrial sector has been facing two major problems, namely small domestic demand and lower productivity compared to other countries. In the 1950s,

[1]L'Afrique Occidentale Française (AOF) and France had an agreement which consisted of preferential access of French products. In return France had to guarantee a fixed price to AOF export products. The final act of this privileged relationship ended with the devaluation of the CFA francs in 1994 when France focussed its efforts on the European Economic Community.

following the import-substitution model of development, Senegal created firms to supply all the Afrique Occidentale Française. But the end of colonial rule rendered the strategy uneconomical and inefficient because each country created its own industrial sector, leaving Senegal with a small industrial market and high production costs. Furthermore, firms created under the French umbrella of fixed exchange rate and protected market, faced a rise of their production costs with the currency devaluation in 1994.

Table1 shows the manufacturing value added (MVA) in Senegal. The MVA is an index used by the UNIDO (1999) to compare industrial country productivity. For Senegal, real MVA annual growth rate, per capita MVA and MVA's share in GDP indicate that the industrial sector has poor performances. Even if Senegal's per capita MVA exceeds Africa's, it remains far below the other LDC levels. MVA's average growth is low in the 1970s and 1990s. The growth rate of real per capita MVA is negative. The share of MVA in GDP is between 10 and 13 %.

Table 1 **Senegal, Manufacturing Value Added (MVA) ($1990 price).**

Indicator	Period	Senegal	Africa	LDCs	DCs
MVA/capita (US$)	1980 1990 1996 1997	82.0 102.0 96.0 97.0	76.0 83.0 76.0 78.0	161.0 203.0 276.0 290.0	3704.0 4430.0 4641.0 4817.0
Real average growth of MVA (%)	1970-80 1980-90 1990-97	1.9 4.6 1.8	3.5 4.3 1.4	6.8 5.3 7.3	2.9 2.8 2.0
Real average annual growth rates of per capita MVA (%)	1970-80 1980-90 1990-97	-1.0 1.7 -0.8	1.4 1.3 -1.1	4.5 3.2 5.5	2.0 2.1 1.3
Share of MVA in GDP (%)	1980 1990 1996 1997	10.9 13.1 12.7 12.5	11.0 12.7 11.9 12.0	19.5 21.3 23.6 24.0	22.8 22.3 21.7 21.9

Source: UNIDO, 1999, (http://www.unido.org) Country statistics, Senegal.

The industrial sector is not creating enough jobs for the growing urban labour force. Looking at a sample of twenty-eight manufacturing activities, it becomes clear that the labour market is deeply depressed (see Table 2). From 1985 to 1996, the annual growth rate of employment was negative in half of the industrial branches, including food products, textiles, petroleum refineries, etc.

Table 2. **Senegal, Average Annual Growth Rate of Employment (1985-1996) in Selected Manufacturing Activities**

Foods Products	-7.5	Others chemicals	-13.7
Beverages	-8.8	Petroleum refineries	-7.98
Tobacco	-3.1	Misc. petroleum and coal products	6.67
Textiles	-9.5	Rubber products	-14.5
Wearing apparel (except footwear)	7.14	Other non-metallic mineral products	10.36
Wood products (except furniture)	3.76	Fabricated metal products	-9.41
Furniture (except metal)	9.37	Machinery (except electrical)	-18.9
Paper and products	4.2	Machinery electric	-8.68
Printing and publishing	0	Other manufactured products	-68.3
Industrial chemicals	-0.2	Plastic Products	12.4

Source: UNIDO, (http://www.unido.org), country statistics, Senegal, 1999

The demographic situation described above shows that rural-urban migration causes problems of unemployment, poverty and management in Senegalese cities. These problems cannot be disconnected from the crisis in the agricultural sector. Rural workers who face a long-run decrease in their per capita income choose to leave the agricultural sector because they expect the per capita urban income to be greater than what they earn from agricultural activities. The industrial sector is depressed and the size of the public service sector has been reduced by structural adjustment policy measures, both of which increase urban unemployment and poverty.

Despite the bleak situation in urban areas, the rural-urban migration continues to increase, as migrants expect their fates to be improved by moving to the city. Most new migrants work in the fringe sector upon their arrival and are oftentimes under-employed; awaiting a better opportunity in the formal sector. In urban areas, migrants can buy cheap import food and/or be temporarily supported by employed workers.

II.6.Research Motivations

By taking away young and healthy workers from the agricultural sector, rural-urban migration contributes to the reduction of agricultural production. It also contributes to urban problems by increasing unemployment and poverty in urban areas. The main question to be tackled in this research is how to reduce rural-urban migration and thereby contribute to lessening urban problems.

Four types of policies to reduce rural-urban migration have been employed in many developing countries (Sabot, 1979). The first is a shadow pricing policy intended to equate urban and rural wages. Another is physical restriction on the movement, that is prohibiting people from leaving the countryside. The third policy involves labour-intensive urban projects, aimed at reducing urban unemployment. Finally, labour-intensive rural projects, primarily for modern infrastructure building, attempted to curb rural-urban migration

The first policy involves the use of heavy taxation and subsidies while the second raises moral issues, in addition to difficulties of enforcement. The third one has the perverse effect of increasing rural-urban migration, as the additional urban jobs created by these projects are interpreted as a signal of labour demand increase. For example, in the 1960s and 1970s, the Senegal government controlled migration by fighting against " human nuisance: (déchets humains) with police officers and removing more than 200,000 people from Dakar to the north-east side of the country (Collignon, 1984). This measure obviously did not halt rural-urban migration.

This research will first test the Todaro's hypothesis (1969) that the excess of the urban per capita income over the agricultural per capita earning drives rural-urban migration. Second, the research will suggest a policy aimed at reducing rural-urban migration based on agricultural investments.

The research will particularly investigate the use of investments in the agricultural sector to slow down migration, based on the assumption that agricultural inputs have indirect negative effects on rural-urban migration. In fact, per capita agricultural income is derived from agricultural output, which is determined by the level of agricultural capital, the agricultural labour force and rural infrastructure. The study will therefore determine the agricultural inputs, which are required to increase rural income up to a level where per capita income is the same in both rural and urban zones. Once these are equated, economic incentives to migrate will be removed.

Those direct and indirect relationships will be determined using a model of recursive equations that combines agricultural and migration functions.

The remaining part of the study will be organised as follows: Chapter three and four will review both theoretical and empirical literature; chapter five will present the empirical analysis, while chapter six will discuss variable definition and data sources. Chapter seven will discuss the estimated results, and the final chapter will offer general conclusions.

Chapter III. THEORETICAL LITERATURE REVIEW.

III.1. Rural-Urban Migration

III.1.1 Two Traditional Theories of Internal Migration

Ravenstein (1889) is the first author to elaborate the laws of migration. He argued that migration is negatively related to distance, and that it follows a step-wise process, that is, migrants make halts throughout their journey in order to collect means for the next step. He stated that each migration stream produces its counter stream even if net migration is in favour of rural-urban direction. Rural residents have a higher propensity to migrate, where this mobility increases with the improvement in the means of transportation, manufactures and commerce. For Ravenstein, the decision to migrate always stems from economic reasons.

Lee (1966) showed that migration results from a competition among negative and positive factors in the origin and the destination areas, and depends on the individual abilities to overcome intervening obstacles between the two locations. Therefore, his migration model consists in identifying and quantifying those factors and assigning them with "plus, minus, zero" coefficients as well as the intermediary obstacles. For the Lee, the zero factors are those balances between the positive and the negative factors exert neither an attractive nor a repellent force and towards which people are essentially indifferent. Therefore, migration is a selective process in the sense that individuals who respond to plus signs of the destination are positively selective (age, health, education, ambition...) and negatively selective with respect to minus signs (rural wage, traditional customs etc..). He also noted that the degree of positive selection increases with the difficulty to overcome intervening obstacles.

The main criticisms of Lee's theory are the following. First, it has a high degree of generality and interdependence of many of its hypothesis (Todaro 1976), which makes it impossible to quantify and to model. In fact, the plus, minus factors and intervening obstacles do not have the same weight for different groups and classes of migrants. Second, the zero factors could be listed up to the infinity. Finally, the theory doesn't take into account the possible trade-off between plus and minus factors or their magnitude.

III.1.2. Rural-urban Migration in Dual Economic Models

During the 1950s and 1960s, the Lewis model (1954) extended and formalised by Fei and Ranis (1961) (L-F-R) was designed for developing country with a growing industrial sector, even embryonic. The model assumed a two-sector economy, the traditional subsistence agricultural sector, characterised by zero or very low productivity of labour and a high labour productivity urban industrial sector into which workers from the subsistence sector are gradually transferred. Due to continual population increase with constant cultivated land, the marginal product of labour in agriculture becomes zero, or even negative. Since wages in industry, generally located in the cities, are higher than agricultural wages, the surplus of labour force in agriculture will transfer from rural to urban areas continuously. Rural-urban migration and urban expansion follows the output growth in the modern sector. Since profits are reinvested in the profitable urban sector, rural-urban migration speed is driven by the rate of industrial capital accumulation in that sector. As long as wage levels in the industrial sector are determined at a fixed premium over the subsistence agriculture wage, rural-urban migration plays an equilibrating force of rural and urban labour markets. The process carries on until all labour force surpluses in the agricultural sector are absorbed into the urban industrial sector. After this stage, additional labour transfer implies a loss of productivity in the agricultural sector and even a higher minimum urban wage. Then rural-urban migration ceases.

The L-F-R model rests upon the assumption of high demand for labour by a dynamic, but small, industrial modern sector. It assumes that there is a low unemployment rate in that modern industrial sector. However, for Sub-Saharan Africa countries, the situation is different in the sense that labour transfer, in the form of rural-urban migration grows up, even with high unemployment in the modern industrial sector. The L-F-R model fails to explain such a situation and cannot offer a background for an economic development policy for developing countries (Todaro, 1994).

III.1.3. High Levels of Rural-Urban Migration with Urban Unemployment

The Todaro model (1969) extended by Harris and Todaro (1970) offered, since the 1970s, the theoretical foundation of the coexistence of important rural-urban migration flows with high urban unemployment. Like in the L-F-R model, the authors also assumed a two sector economy model, where the fixed minimum urban wage is greater than the rural wage. This urban minimum wage is institutionalised by powerful unions and hence cannot shift downward to suit the increasing urban labour force. Rural-urban migration continues as long as the urban wage exceeds rural wages and more importantly, as long as there exists a positive probability for migrants to secure urban jobs. The model assumes the existence of a labour turnover equal to one, because for each new position opened in the modern sector, there is a migrant waiting for it, even after bearing some waiting costs.

In mathematical form, the H-T model can be specified as follows:

- An agricultural wage (W_A) which is equal to the value of the marginal productivity of labour Y'_A.

$$W_A = P \cdot Y'_A \qquad (1)$$

- A minimum urban wage (W_U), fixed by unions ($\overline{W}_U$)

$$W_U = \overline{W}_U \qquad (2)$$

The expected urban wage W_U^E for migrant is equal to urban wage times the probability of securing an urban job :

$$W_U^E = \overline{W}_U \left(\frac{N_{UE}}{N_{UT}} \right) \qquad (3)$$

Where N_{UE} and N_{UT} are respectively urban employed and total urban workers.
In conclusion, migration (M) from rural to urban areas is a positive function of the wage differential between the two sectors, keeping other factors like transportation and relocation costs constant :

$$M = f\left(W_U^E - W_A\right) \qquad (4)$$

Rural to urban migration ceases when the equation (4) is equal to zero.

Johnson (1971) improved on the H-T model by introducing a variable for wage sharing between urban employed and urban unemployed workers. For him, the expected per capita urban income [$E(Y_U)$] is equal to the urban wage (W_U) discounted by the proportion (α) allocated to urban unemployed workers.

$$E(Y_U) = (1-\alpha)W_U + \alpha W_U .n \qquad (5)$$

Where n is the urban unemployment rate.

Also, he reduced the maximum job turnover rate assumed by the H-T model. The growth of urban employment is equal:

$$\dot{E}_U = \lambda E_U + \beta E_U \qquad (6)$$

where λ is the growth rate of urban employment, $\beta \leq 1$ is the rate of job turnover and E_U is the urban emplyoyed labour.

Gugler (1973) also found criticised the assumption of a random job selection, which reallocates periodically equal chances for each new migrant to secure a job. Fields (1975) questioned the H-T model that implicitly assumes that all jobs turn over every period. Such a maximum turnover rate predicts a higher unemployment rate in equilibrium than would be expected in a situation with a finite rate of labour turnover. The actual urban unemployment is lower in Fields's view than in H-T's.

Kelley and Williamson (1984) disagreed on the assumption of such labour lottery, since most highly demanded urban jobs are offered through nepotism, favouritism and unions. Moreover, they found unrealistic the idea of a fixed minimum-manufacturing wage because when expressed in real terms, such wage must correspond to the real market labour price. They modified the H-T model by inserting costs of living, property rights and level of education, but overall, their findings did not refute the hypothesis of income differential of the H-T model.

Fields (1975) generalised the urban job search process by introducing the probability for a rural worker to obtain an urban job. By computing the probability of securing an urban job for urban residents, the H-T model implied higher urban equilibrium unemployment rates than in the generalised case, which included potential workers from both sectors. However, although rural residents do have access to information on urban job availability, it is thought to be lower than that of their urban counterparts.

Secondly, he introduced the "murky sector" or subsistence urban sector in the H-T model and the possibility of urban underemployment for rural-urban migrant. When waiting for a better job in the modern urban sector, new migrants can voluntarily choose to be underemployed in the urban murky sector, even if the earnings are less than those of the rural sector. The only determinant is the positive chance for a migrant to become employed in the modern sector.

Thirdly, Fields improved the H-T model by introducing education since educated workers have preferential treatment in the modern sector. Cole and Sanders (1985) agreed with Fields on the inclusion of education in the H-T model as well as on the higher probability for a migrant to obtain a job in the murky urban sector than in the modern one.

- The expected urban wage for uneducated worker ($E(W_{U/UNEDUC})$) is equal to

$$E(W_{U/UNEDUC}) = W_U \left(\frac{N_{UT} - N_{U/EDUC}}{N_{U/UNEDUC}} \right) \qquad (7)$$

Where $N_{U/EDUC}$ = Educated urban workers

- The expected rural wage for uneducated workers remains equal to the agricultural wage defined above in the H - T model.

- Thequilibrium between the two labour market for uneducated workers occurs when the agricultural wage is equal to urban wage for uneducated workers.

The equilibrium employment rate for uneducated workers is equal to

$$\left(\frac{N_{UT} - N_{U/EDUC}}{N_{U/UNEDUC}} \right) = \frac{W_A}{W_U} \qquad (8)$$ It is equal to 1 for educated workers.

Corden and Findlay (1975) extended the H-T model by allowing capital mobility between rural and urban sectors as a response to the differential in returns to capital. They showed that capital mobility, due to rental differentials between the agricultural and industrial sector, raises the marginal product of labour and attracts additional workers, coming from the non-productive area. Regardless of where capital accumulation or technical progress takes place, it contributes to reduce urban unemployment directly, by creating urban jobs and indirectly, by attracting urban workers to the agricultural sector.

Based on the above theoretical literature, the Harris-Todaro model offers a strong background for the coexistence of high rural-urban migration flows and high urban unemployment rate in Sub Saharan African countries, like Senegal. The model estimated in the research will measure the relationship between rural-urban migration and the income differential between the two sectors. After that relationship is established, one can suggest a policy to reduce rural-urban migration.

III.2. Policy to Reduce Rural-Urban Migration in Developing Economies

III.2.1. A Wage Subsidy Policy

Because the minimum urban wage is greater than the marginal productivity of labour in the manufacturing sector, the first policy suggested by Harris and Todaro was a wage subsidy to urban firms to incite them to hire more workers at a wage equal to the opportunity cost of a rural worker. At that uniform wage, rural and urban workers would then have an equal marginal rate of consumption, which removes the incentives to migrate.

Baghwati and Srinivasan (1974) showed that this policy is equivalent to granting a subsidy to agricultural production, such that the marginal rate of substitution in production is the same in both sectors. These shadow pricing policies are difficult to implement because they introduce distortions and budget deficit in the economy. More over, they lead to high bureaucratic costs for little benefits, as Sabot (1979) found it for Kenya and Tanzania.

III.2.2. Physical Restriction of Rural-Urban Migration

According to Hutt (1971), Sabot (1979) and Colligon (1984), many developing countries have used physical restrictions as a rural-urban migration policy. Despite the moral issues it raises, some authors have analysed its economic rationale (Harris and Todaro (1970), Baghawati and Srinivasan (1974)). To some extent, it is equivalent to a subsidy to agricultural production, with lower labour costs. However, the economic costs of holding people in the countryside are generally higher than those due to an excess supply of urban labour. They also lead to a misallocation of the labour factor (Sabot 1979).

III.2.3. Labour Intensive Urban Project

Many developing countries have experimented reducing urban unemployment and poverty by implementing labour-intensive projects in cities (Sabot 1979). But in the long run, they failed to absorb the excess urban labour supply because rural workers had interpreted them as a signal of higher probabilities of obtaining urban jobs (Todaro 1994).

Stiglitz (1969), Todaro (1976), Byerelee (1974) and Sabot (1979) underlined the relationship between agricultural productivity and rural-urban migration. Holding rural workers in the agricultural sector by improving agricultural productivity is the best policy. First, unlike the wage subsidy policy, it avoids economic distortion. Second, it does not raise ethical issues like physical restrictions. Finally, by slowing down rural-urban migration flows, urban employment policies can become effective because additional migrants from the rural area will not weight them down.

III.3. Strategy for Improving Agricultural Productivity

III.3.1. The Zero Investment Strategy

Lewis (1954, *op cit*) has created a general equilibrium model of a two-sector economy with zero investment in the agricultural sector. Since the industrial modern sector has positive marginal labour productivity, unlike the agricultural sector, the model recommends to reinvest industrial profits in that productive sector until the point where industrial wage equals food price (Fei and Ranis 1961, Jorgenson 1961).

The application of the Lewis model in development economics had led to a hoarding of investments in the modern industrial sector to the loss of the agricultural sector. The reasons advanced were based first on Engel's law, which states that the income elasticity for unprocessed food demand is less than one and decreases as income increases. Second, agriculture's share in GDP falls with general economic improvement, while the modern industrial sector's share in GDP rises (Eicher and Staatz, 1990).

Hirschman (1958) introduced the concepts of linkages as a tool investigating how investment in one type of activity induced subsequent investment in other income generating activities. He asserted that the agricultural sector displays a lack of direct stimulus to the setting up of new activities through linkages, while the superiority of the manufacturing sector in this respect is evident.

III.3.2. Recognising the Profitability of Agricultural Investments

Mellor (1961) called for substantial investments in human capital such as nutrition, health and family planning services as well as for technical changes appropriate to small farms, rather than exclusively invest in a minority of large farms to raise agricultural output and rural income.

It is Schultz (1964) who stated clearly that the agricultural sector is profitable under specific conditions. According to him, it is only when farmers of traditional agriculture are provided with new and more productive factors of production, especially new agricultural technologies and new skills, that a country can achieve major increases in per capita agricultural output. Traditional agriculture, characterised by a secular use of the same means of production, is efficient and has exhausted the profitable production possibilities since it already allocates efficiently its available inputs. Any increase in the existing stock of factors will not augment productivity, since the costs of production would exceed the generated income. Therefore, as an agricultural development strategy, a country must invest in a new set of factors of production that differs from the set formerly employed, and whose benefits cover their adoption costs.

Hayami and Ruttan (1970, 1971,1985) formalised and tested Schultz's idea with a world-wide sample. The authors stated that each country must base its agricultural growth path on the natural endowment in factors of production in order to take advantage from the abundant and hence cheap factors. As Schultz, they also supported the notion that a country must adopt modern technical inputs as well as improve human capital if it wants to reach the potential benefits embodied in the abundant factors.

For example, Australia, USA, New-Zealand and Argentina have based their agricultural support programs on one abundant factor – land - and saved a scarce factor - labour - by introducing machinery that allows an individual worker to cultivate large land areas. On the other hand, Japan, Taiwan and South Korea, increased agricultural output per unit of scarce resource - land - by using the abundant factor –labour - plus appropriate land management infrastructure, such as irrigation or modern labour-demanding inputs such as high yielding varieties, fertiliser and pesticides. Therefore, SSA-countries should choose which growth path or growth path combination to follow in their agricultural investment policy.

From Mellor's contribution, investing in small farms, which are the most observable farm type in Sub-Saharan African countries, would rise the total agricultural output. Schultz (1964) and Hayami and Ruttan (1985) offered both a theoretical and empirical foundation of additional investments in agriculture, as long as they are coming from outside the sector. The study follows these authors to identify agricultural inputs that are able to increase agricultural output.

Chapter IV EMPIRICAL LITERATURE

IV.1. Migrant Characteristics

Based on rural-urban migration studies in Africa and Asia, (Beals et al. 1967, Sabot 1979, Caldwell 1969, Byerlee1974, Rempel 1974, Lipton 1980) migrants have some characteristics that are common regardless of their country of origin.

They are young, most of them in the 15-30 age group (Lipton 1980). In Ghana, Caldwell (1969) found the mode of migration flows being in the 15-19 age group, while in Kenya, Rempel (1974) found it in the 20 and 25 age group. It appears that rural-urban migration takes the strongest workers and innovators out of agriculture, which decreases agricultural output. Schultz (1971) found that migration for the 10-25 age group is significant in Colombia and so did Abaysekera (1984) in Sri Lanka. In India, Reddy (1998) found that 70 % of migrant household heads were less than 30 years of age and 21 % of them belonging to the 30-35 age group. Mazur (1984) found that in Mali, a country close to Senegal, migration was moderately high for the 14-19 age group, highest for the 20-24 age group and low for those of over the age of 25.

Even if earlier stages of rural-urban migration were male-dominated, the number of the women migrants has rapidly increased to catch up with the male proportion (Sabot 1979). All authors cited above have underlined that educated people have a higher propensity to migrate to cities than the uneducated because the former have better chances of obtaining urban jobs. Finally, migration involves transportation and survival costs, which only the wealthy rurals or those who have contacts in urban zones can afford.

IV.2. Modelling Rural-Urban Migration in Developing Countries

Migration is a selective procedure based on individual characteristics and economic opportunities offered by the destination area. Hence, econometric studies on migration have to identify and quantify these variables in order to estimate their effects on rural-urban migration flows. Migration research is divided in two fields: micro and macro studies.

IV.2.1 Micro Migration Functions

At the micro level, the estimation is aimed at answering the question of what is the probability for an individual to migrate from a rural to an urban area, given his socio-economic characteristics as well as the economic possibilities offered by the urban areas (Todaro 1976). In that sense, the migration decision is estimated following binary choice models (Schultz 1977), that is, which individuals migrate or are likely to migrate, given their characteristics (age, gender, education, income, urban contacts, etc.) In mathematical form, the probability that an individual migrates from place *i* to place *j* depends on a linear combination of *Z*'s conditions, that is, the origin and destination conditions (X_i, X_j) plus the distance (D) between the two locations.

$$P_{ij} = \frac{e^{Z_{ij}}}{\sum_j e^{Z_{ij}}} \qquad (9)$$

Where $\sum_j P_{ij} = 1$ and $Z_{ij} = \alpha_0 + \sum_i \beta_i \ln X_i + \sum_j \beta_j \ln X_j + \delta_{ij} \ln D_{ij}$

IV.2.2. Macro Migration Functions

Macro migration functions are designed to estimate the important determinants of aggregate migration flows from rural area *i* to urban area *j*, to calculate their relative importance, their possible trade-off and to predict migration based on the estimated elasticities (Todaro 1976 *op cit*). In general, the dependent variable (M) of the macro migration function at a time *t* is the rate of rural people who move to cities to the total population. The independent variables are wage or income levels in both areas (Y_A, Y_U), the unemployment rates (U), the population size in both areas (P_A, P_U), the degrees of urbanisation (*Z*). The indexes *A* and *U* refer to agricultural and urban areas respectively.

$$M = f(Y_A, Y_U, U_A, P_A, P_U, Z_U) \qquad (10)$$

Economic variables occupy a crucial role in studying and estimating migration functions. For example, Reddy (1998) found that, in India, urban income is four to five times the rural income and that rural-urban migrants had increased their income threefold. In Kenya, Huntington (cited by Yap, 1975) found that rural-urban migration was negatively related to rural wages and positively related to urban wages. Barnum and Sabot (cited by Yap, 1975) reached the same conclusion for Tanzania, so did Levy and Wadycki (1972) in Venezuela and Greenwood (1971) in India.

The algebraic form used in migration functions is generally the linear or double logarithmic of variables, because the expected wage hypothesis posits multiplicative interactions between wage rates and employment that are easily specified logarithmically. Moreover, in empirical research on migration, the logarithmic form of the conditions of origin and destination zones explained a larger share of the variance than other forms (Schultz, 1977, Fields 1979).

When studying the migration function, Hay (1974) and Schultz (1977) used the micro--economic approach. Hay (1974) estimated the probability of migration using a rural survey of 220 households with at least 80 households having no migrants. He specified the migration probability as dependent on education, age, marrital status, cultivated land per active male and annual individual disposable monetary income. Levy and Waycki (1972), Beals, Levy and Moses (1967), Sahota (1968), Godfrey (1973) and Krishna (1984) used the macro approach to study rural-urban migration. Godfrey (1973) specified migration as dependent on the wage differential and on the difficulty of getting a job in the modern sector. Krishna (1984) specified migration as dependent on the wage differential and on the past year's migration rate. In most LDC macro migration studies, the implicit function are as equation (11) (Yap L. 1975). In this research, the macro migration function will be used because the objective is to design a policy of reducing rural-urban migration for the whole country. More over, the type of data used had been collected on a nation wide level. Micro migration estimation supposes prior demographic and economic surveys in both rural and urban areas.

IV.3. SUMMARY OF THE LITERATURE REVIEW

According to theories of rural-urban migration in less developed countries, economic motivations are the guiding force behind migration flows. More specifically, it is the wage differential between rural and urban sectors that motivates an individual to migrate. Other variables such as age, education, distance, and urban contacts, also influence one's decision to migrate.

Although there are many types of policy measures to reduce rural-urban migration, the most consistent one should be built upon the improvement of the agricultural per capita earnings. Rural-urban migration and agricultural performance are tied together because rural workers compare their income to that of their urban counterparts. Thus, such a relationship can be estimated using a recursive system of two equations linked together by the agricultural output variable. One can then obtain indirect elasticities of rural-urban migration from agricultural inputs. Once these elasticities are known, one is better equipped to devise an appropriate policy to reduce labour migration.

Chapter V. EMPIRICAL ANALYSIS.

Before estimating indirect elastcities, one needs to choose the functional and algebraic forms to use in agricultural and in migration relationships. Then, the estimated model can be specified as a recursive system of equations.

V.1. Choice of the Agricultural Production Function

Production functions translate the relationship between output and variable inputs. They can be used to derive production elasticities with respect to individual inputs. According to Dillon and Heady (1961) and Dillon and Hardaker (1993), the choice of a particular production function depends on the production process, the function's ability to estimate and its flexibility it terms of economic analysis.

For multifactor studies, the Cobb-Douglas or the transcendental production functions are often used. The latter is not recommended for studies involving small samples, because one might loose degrees of freedom when measuring the interaction effects. The Cobb-Douglas is easy to implement and to estimate because it can be simplified in linear form when all variables are expressed in logarithms.

V.1.1. The Cobb-Douglas Production Function

Its creators, Douglas and Cobb (1927), assumed that the aggregate production function could be expressed as an output (Y) depending on capital (K) and labour (L). They also assumed that total output was shared among workers and capital owner, which indicates that the function exhibits constant returns to scale.

$$Y = f(K,L) = K^{\alpha} L^{1-\alpha} \qquad (11)$$

One can use this function to derive production elasticities (α and $1-\alpha$) with respect to each factor, which shows how output is sensible to factor changes, as indicated by the coefficient of each factor.

V.1.2. The Final Form of the Cobb-Douglas Production Function Used

The Cobb-Douglas function has been widely used in empirical research in agricultural economics to measure the relationship between output and inputs, either marginal products or production elasticities (Dillon and Heady (1961), Dillon and Hardaker (1993)). For example, Hayami and Ruttan (1970) used the same form to conduct intercountry comparisons of agricultural productivity. They specified total agricultural output (Y_A) to be a function of traditional conventional capital inputs: land (A) and livestock (S), of modern conventional capital inputs: fertiliser (F) and machinery (Mc). They also included conventional labour inputs: the agricultural labour force (L) and a modern non-conventional labour input: education (E). One can add a more diffused factor called agricultural capital infrastructure (IK). Infrastructure represents agricultural utilities like electricity and power, water systems, water management facilities (irrigation, drainage), rural markets, transport facilities (roads, bridges, boats...), storage (silos, warehouses) and processing (machinery equipment, buildings) facilities. It includes research, experiments and extension services and all institutions, modern or traditional that are beneficial to agriculture. For example, rural roads, market systems and storage facilities that allow not only non-perishable goods but also perishable goods to arrive on the market on time and in good condition play an important role in agricultural development.

Therefore, agricultural infrastructure should be treated as a form of modern capital input, as it allows to produce and/or to distribute inputs as well as handling output. In many LDCs, mainly the government and its sub-sectors provide agricultural infrastructure. Hence, that input is determined outside the farm level and is correlated with the scale of output growth, a situation that is empirically observable in developed countries.

The Cobb-Douglas agricultural production function is expressed in the implicit and explicit forms as follow:

$$\begin{aligned} Y_A &= f(A, L, F, Mc, S, E, IK) \\ &= \alpha_0 A^{\alpha A} L^{\alpha L} F^{\alpha F} M^{\alpha M} S^{\alpha S} E^{\alpha E} IK^{\alpha IK} \end{aligned} \qquad (12)$$

V.2. The Recursive System of Equations

The main economic driver for rural-urban migration is the rural-urban wage differential. Moreover, even migration characteristics such as distance, age and contacts only really reflect the fact that wage and productivity disparities exist. As such, rural-urban migration would cease once agricultural wages increase to the level of those in urban areas. On the other hand, agricultural wages are determined by the size of agricultural output, which in turn is determined by the amount and the combination of various agricultural inputs.

It thus follows that an improvement in agricultural output brought about by an increase in agricultural inputs will have the effect of narrowing the gap between rural and urban per capita income, and hence reduce rural-urban migration. The nature and level of those agricultural inputs that have a positive and significant effect on rural-urban migration can be measured by combining the agricultural production function (equation 13) and the rural-urban migration function (equation 10) in a recursive system of two equations. The indirect effects of agricultural inputs on migration will be measured by the rural-urban indirect elasticities with respect to agricultural inputs.

$$\begin{cases} Y_A = f(A, L, F, Mc, S, E, IK) \\ M = g(Y_A, Y_U, U, P_A, P_U, G) \end{cases} \qquad (13)$$

where Y_U is the urban output, P_A and P_U are agricultural and urban population respectively, M is the rural - urban migration flow and G is the age proportion.

When the system of equations (13) is expressed explicitly and put in logarithmic form, the agricultural production function is of a linear Cobb-Douglas type and the migration function takes the log linear form suggested above by Schultz (1977) and Fields (1979).

$$\begin{cases} \ln Y_A = \alpha_0 + \alpha_A + \ln A + \alpha_L \ln L + \alpha_F \ln F + \alpha_{Mc} \ln Mc \\ \qquad + \alpha_S \ln S + \alpha_E \ln E + \alpha_{IK} \ln IK + \varepsilon_1 \\ \ln M = \beta_0 + \beta_{YA} \ln Y_A + \beta_{YU} \ln Y_U + \beta_{PA} \ln P_A + \beta_{PU} \ln P_U \\ \qquad + \beta_U \ln U + \beta\ G \ln G + \varepsilon_2 \end{cases} \quad (14)$$

For a recursive system of equations as above, estimation procedures such as the 2 or 3 Stages least squares and Full information maximum likelihood (FIML) are preferred to ordinary least squares estimation (Todaro, 1976). A recursive system model is a form of simultaneous equations in the sense that a change in one equation causes changes in the following equations. It does not have the simultaneity bias because the independent variable, formerly dependent in the previous equation, is not correlated with the error term in the estimated equation (Gujarati, 1995).

The estimation procedure could use ordinary least squares for a single equation at a time. The estimated values for the dependent variable would then be plugged into the next equation to be estimated, and so on, until the last equation of the system is estimated. However, the linear estimation procedure is only valid for large samples. In this study, the estimation procedure will be FIML, because it yields the structural parameters contemporaneously, or the direct and indirect coefficient elasticities in one single step.

V.3. Rural-Urban Migration Indirect Elasticities of Agricultural Inputs

It appears in the system that agricultural output is a dependent variable in the first function, but becomes an independent variable in the migration function. Therefore, increase of agricultural output generated by increases of agricultural inputs will improve agricultural income, which lowers the ratio of urban to agricultural wage, and therefore reduces rural-urban migration.

As mentioned earlier, it is crucial to determine those agricultural inputs that have a negative effect on rural-urban migration. In that sense, the sensibility of migration with respect to agricultural investments is given by the indirect agricultural input elasticities of migration, derived following the chain rule. Letting X_i be the agricultural input variable, and keeping all other variables X_j constant, the rural-urban migration elasticity of X_i is:

$$\eta_{MIG,Xi/Xj} = \left(\frac{\partial MIG}{\partial X_i}\right)\frac{X_i}{MIG} = \left(\frac{\partial MIG}{\partial WR}\frac{\partial WR}{\partial Y_A}\frac{\partial Y_A}{\partial X_i}\right)\frac{X_i}{MIG}$$

$$= \left[\left(\frac{\partial MIG}{\partial WR}\frac{WR}{MIG}\frac{MIG}{WR}\right)\left(\frac{\partial WR}{\partial Y_A}\right)\left(\frac{\partial Y_A}{\partial X_i}\frac{Xi}{Y_A}\frac{Y_A}{X_i}\right)\right]\frac{X_i}{MIG} \qquad (15)$$

Where WR is the wage ratio and is equal to the quotient of the urban to the agricultural wages.

The estimation procedure will use a recursive system of two equations, a Cobb-Douglas agricultural production function and log linear rural-urban migration functions. The agricultural inputs that could have a negative effect on rural-urban migration will be extracted using the chain rule, since the rural-urban migration function includes agricultural output as an independent variable.

Chapter VI. ESTIMATION AND RESULTS

In the present chapter, demographic and economic data of Senegal are used to measure the impacts of agricultural investments on rural-urban migration, based on the model developed in the previous chapter. Before the estimation, the variables are defined and the data sources are specified.

VI.1. Definition of Variables and Data Sources

As stated before, this research uses demographic and economic data for Senegal. The study covers a period of 36 years, from 1961 to 1996. All variables have been transformed into natural logarithms, following the empirical foundation presented in the previous chapter. Agricultural output and inputs have been expressed per units of arable land, at the exception of education. Land is expressed in hectares and is defined as the sum of land used for arable and permanent crops, permanent pasture, forest and woodland. The sources are Duruflé (1994) and FAO (1999).

VI.1.1. Agricultural Output (Y_A)

Agricultural output is measured as the sum of crop, livestock, fishery and forestry production. The source is World Bank (1995 and earlier issues) and Economist Intelligence Unit (1998). The series are published in current local currency (CFA Francs). They are converted into $US by using official annual average exchange rates from IMF(1998 and earlier issues), then expressed in constant thousands $US (1982-84) using the US consumer price index (Statistical Abstracts of United Stated, 1994, 1997).

VI.1.2. Labour (L)

Labour represents the number of those economically active in agriculture, aged between 15 and 64. In many Sub-Saharan African countries, the agricultural sector involves traditional means of production and produces mainly for subsistence purposes. In that form of agriculture, the family provides the labour and the workload is shared. The farmer's household retains a significant proportion of the farm's output for consumption. This family farming system, characterised by work and income sharing and work-income sharing, has been theorised by Ghatak and Ingerscent (1985). It explains why visible unemployment is absent in traditional agriculture. Therefore, it is reasonable to utilise the economically active population in agriculture as agricultural labour used in Senegal. The source for this data is FAO (1999).

VI.1.3. Fertiliser (F)

Fertiliser is measured as the quantity of nitrogen, potassium and phosphorous utilised. It is expressed in hundred of grams per hectare. Increased use of fertiliser corresponds to the adoption of modern capital and is one of the conditions for increasing productivity (Schultz 1964, Hayami and

Ruttan 1985). The amount of fertiliser used is also a reliable index of progress in the adoption of yield-increasing technologies (Arnon, 1987). The source for the data is FAO (1999).

VI.1.4. Machinery (Mc)

Machinery is measured as the number of tractors in use and the source for the data is FAO (1999). Machinery, like fertiliser, represents capital supplied by the modern industrial sector. But contrary to fertiliser, machinery is associated with large land areas and low amounts of labour (Schultz 1964, Hayami and Ruttan 1985). According to Binswanger and Pingali (1988), tractors have done little to increase agricultural output in SSA-countries because farming systems require different types of operations depending on the variety of crops produced. Tractors become valuable when larger tracts of land are involved and/or cropping becomes more specialised. Equally important in limiting the supply and implementation of machinery is the lack of efficient credit markets. Credit markets are critical not only for equipment acquisition but to finance the ongoing costs of repairs and parts purchases. Tools commonly used in traditional farming systems are the hoe and the machete, which allow land to be prepared for planting at most 0.5 hectare per worker (Arnon 1987) or two hectares per family (FAO 1981). In high temperature countries such as in Senegal, with a diet of 1500kcal/day, a farmer cannot work for many hours. Consequently, essential agricultural operations are delayed or are not well executed. On the other hand, machinery might have positive indirect effects on the usage of modern inputs like fertiliser and irrigation (Binswanger 1982).

VI.1.5. Livestock (S)

Livestock as part of the agricultural productivity equation is the number of animal units available for agricultural production. It represents a production input in the form of long-run internal capital supplied from within the agricultural sector. When feeding the animals with agricultural grassland, the farmer increases the animal's value without requiring external supplies from the industry and service sectors. Specifically, livestock contributes four inputs towards agricultural production.

First, it produces meat, milk and hide. Second it provides crops with fertilizer in the form of manure.

Third, animal traction is use in the production process. In some developing countries like Ivory Coast (Arnon, 1987), Pakistan (Binswanger, 1982) or Gambia (FAO, 1981), animal traction is used for cultivation and transportation. Animal traction technology is simple to adopt and requires little education to implement. It also involves simple tools supplied within the agricultural sector with only a few parts (hoes and nails) supplied industrially (Arnon, 1987). The initial capital investment required is low, as are operating and repair costs. However, animal traction does allow an increase in the acreage per worker, but not necessarily an increase in crop yield, as only marginal lands often remain available for cultivation. Sometimes, it requires an increased use of fertiliser. For example, in Gambia, animal traction allowed an increase of 20-25 % tillable land but it only resulted in increased productivity after fertiliser application (FAO 1981).

Finally, animal contributes to farm economy by stocking financial liquidity in the form of savings and investment. Indeed, due to a lack of financial means, farmers use livestock as savings, selling animals occasionally to buy agricultural inputs like seeds, chemical fertiliser or pesticide (Banque Monidale, 1992). Even poor farmers manage to have one goat or pig that they sell periodically to buy food, seed or to finance minimum required expenses.

By providing financial liquidity and organic manure to agricultural production, livestock represents a specific input different from all other production factors, whose effects are observable in a short period of time. To avoid double counting, the livestock variable excluded milk, meat or skin production, which are included in the agricultural output variable.

In order to estimate livestock's contribution to output, following Hayami and Ruttan (1985), each animal has been assigned a weight to obtain equivalent animal units: 1.1 for camels, 1.0 for horses and mules, 0.8 for cattle and donkeys, 0.1 for sheep, goats and pigs and 0.01 for poultry. The yearly livestock data originate from FAO (1999).

VI.1.6. Education (E)

The education measure attempts to capture the quality of agricultural labour (Zvi Grilichies, 1970). For lack of more appropriate measure and data availability, literacy rate is used as a proxy for farmers' education. UNESCO defines the literacy rate as the proportion of the population over the age of fifteen that can read and write a short statement of their everyday life. The sources are UNESCO (1996), UNDP, Human Development Index (1997 and earlier issues) and UNECA (1987 and earlier issues).

VI.1.7. Infrastructure Capital Stock (IK)

Infrastructure contains expenditures and investments in rural utilities, irrigation and drainage, rural markets, transport facilities, commodity storage and processing facilities. It also includes monies directed to the research stations and extension services. Agricultural infrastructure represents a modern capital asset that allows traditional inputs to produce to their maximum level. In many LDCs, the government provides much of the infrastructure. For that reason, the national agricultural budget, converted to constant US dollars 1982-84 using the US consumer price index, is used as a proxy for the net annual investment flow in agricultural infrastructure. It is expressed in thousands of dollars. The sources for this data are Ministère de l'Économie, des Finances et du Plan du Sénégal (1986) and Ba (1994). The last two years were obtained by a linear extrapolation. From that annual flow data, an infrastructure capital stock is constructed using the perpetual inventory method (Brown, 1972) and Aboagye (1999):

$$IK_t = IK_{t-1}(1-\delta)+I_t \qquad (16)$$

where IK_t and IK_{t-1} are capital stock at time t and time t-1 respectively, I_t is the annual investment flow at time t, and δ is the depreciation rate of capital.

Capital stock at the first period was obtained by:

$$IK_0 = \frac{I_0}{(g+\delta)} \qquad (17)$$

where IK_0 is the infrastructure capital stock at time t_0, I_0 is the investment flow at time 0 and g is the estimated average growth rate of real It and is equal to 8 %. Brown (1972) set δ to 7 % for Ghana. Aboagye (1999) set it a 10 % for the whole Sub-Saharan Africa zone. In this research, the higher depreciation rate of 10 % will be used. The infrastructure capital stock variable is once lagged because it takes one period for newly acquired capital to come productive. Hence, stock from period t-1 is available for use in production during time t (Barro and Lucas, 1994).

VI.1.8. Rural-urban migration (M)

The rural-urban migration level is measured as the total urban population at time t (P_{Ut}) less the portion of urban population derived from natural population increase between successive periods, that is

$$M_t = P_{U_t} - (1+g)P_{U_{t-1}} \qquad (18)$$

where *g* is the natural population growth rate.

In most in countries, there is no regular collection of data related to rural-urban migration. The use of census data as in the formula above assumes that there is zero immigration into the country and urban population grows at the same rate as total population. The rural-urban migration variable used is the ratio of rural migrants to total rural population. The source is FAO (1999).

VI.1.9. Implicit Agricultural Wage (W_A)

The agricultural wage is approximated by the average productivity of the family labour force, not by the marginal productivity of a single worker. According to Ghatak and Ingerscent (1984), traditional agriculture is characterised by work sharing with quasi-unemployment and by farm income sharing. Therefore, the implicit agricultural wage is defined here as the quotient of agricultural output and the total agricultural population. Agricultural population is quoted from FAO (1999).

$$W_A = \frac{Y_A}{P_A} \quad (19)$$

VI.1.10. Implicit Urban Wage (W_U)

The urban wage is approximated by per capita urban output, where the output is equal to the sum of industrial and service production. This definition is adopted for several reasons. First, there is no published urban wages or specific industrial wages in Senegal. There is also a lack of data for index-linked guaranteed minimum wage in most SSA-countries, including Senegal. Unfortunately, this ratio will not capture the output of the fringe sector. To produce these activities, individuals do not interact with government institutions, but instead draw support form each other in the form of income sharing (Johnson 1971). Therefore, the implicit urban wage defined as the quotient of the urban output to the urban population, remains the best available proxy.

$$W_U = \frac{Y_U}{P_U} \qquad (20)$$

The sources for service and industrial outputs are World Bank (1995 and earlier issues) and Economist Intelligence Unit (1998). Data are published in current local currency, then converted in $US by using the official annual average exchange rates from the IMF(1998 and earlier issues) and put in constant $US 1982-84 using the US consumer price index (Statistical Abstracts of United Stated 1994, 1997). The population data was taken from FAO (1999).

VI.1.11. Age proportion (G)

Age proportion is defined as the percentage of those aged between 15 and 25 in the total population. It is used to account for the youth factor in the migration function. If the proportion of young people in the entire population was to increase, one would expect rural-urban migration to rise. The data sources are UN Demographic Yearbook (1997 and earlier issues) and UNECA (1996 and earlier issues). Missing values were extrapolated from a linear trend fitted from the existing data.

VI.2. The Model Estimated.

Based on the available data, the unique characteristics of the Senegal economy, the second equation of the model (14) has been simplified to yield an estimable model presented (equations 21).

$$\begin{cases} \ln Y_A = \alpha_0 + \alpha_L \ln L + \alpha_F \ln F + \alpha_M \ln Mc + \alpha_S \ln S + \alpha_E \ln E + \alpha_{IK} \ln IK + \varepsilon_1 \\ \ln M = \beta_0 + \beta_{WR} \ln WR + \beta_{AP} \ln G + \varepsilon_2 \end{cases} \quad (21)$$

Where $WR = \dfrac{\frac{Y_U}{P_U}}{\frac{Y_A}{P_A}}$ and is the Wage Ratio

VI.3. Identification.

To estimate the structural parameters of a recursive system of equations, one needs to check if the mathematical formulation satisfies the identification condition. First, the model must be complete, that is, the number of independent equations must be equal to the number of endogenous variables.

Second, within an independent equation, there must be no linear combination among variables. The order and the rank conditions ensure that the model is identified. Most empirical studies do not verify the rank condition because it is awkward (Kennedy 1993, Gujarati, 1995) or because all economic studies are built on an incomplete number of variables (Koutsoyiannis, 1977).

The order condition requires counting included and excluded variables in each equation. It is met when the number of excluded variables from a particular equation is greater than or is equal to the number of endogenous variables minus one. In the model above, there are two equations and two independent variables. It has ten variables (endogenous and exogenous). The first equation satisfies the order condition because it has seven variables. The second equation also satisfies the order condition because it has three variables.

VI.4. Stationarity

The estimation uses time series data. In order to yield reliable estimates, the variables must be independent of time. This can be verified by looking at the correlation between successive lagged values for each variable, called the autocorrelation function (ACF), and the correlation between the first value and its lag, called the partial autocorrelation function (PACF) (Jonhson and Di Nardo, 1997). A computation of the different ACF shows that their p-values are all equal to zero. For the PACF, only the first value has a zero p-value equal to zero. Therefore, the series are stationary.

VI.5 Multicollinearity and Heteroscedasticicty.

At the exception of fertiliser, pairwise correlation between some explanatory variables of the agricultural production function is high, a situation common for studies involving time series individual country data. One should note however that simple correlation coefficients may not be very illuminating in a multiple regression context and high correlation coefficients do not necessarily imply strong multicollinearity or vice versa. A further investigation is needed to assess if multicollinearity will affect the estimates.

Based on the highest computed variance inflation factor (VIF) and which is greater than 10, one can see that multicollinearity will affect the estimated results. The computed VIF for the agricultural output equation exceeds ten, which indicates that inferences from the estimated model should be done with cautious. To reduce multicollinearity, the first difference form of the Cobb-Douglas output equation has been estimated. Based on the F statistic and on the correlation coefficient, it appeared that the transformation did not improve the estimation. Moreover, dropping a variable may have led to specification errors and would not have been supported by the use of a Cobb-Douglas type of function.

In conclusion, one has to bear in mind that estimated coefficients in the presence of high multicollinearity are unbiased and have correct standard errors, though high (Achen 1982). High standard errors is essentially a sample size problem, a constrain that cannot be avoided in a study involving time series single country data (36 year observations).

In the migration equation, pairwise correlation between varibles of the migration question is low and the VIF are below 10, which indicates that multicollinearity is not a problem in that case. The correlation matrices are presented in appendix 2.

None of the two equations is affected by the presence of heteroscedasticity. Moreover the Full information maximum likelihood method of estimation uses iterations, which makes he jacobian matrix constant across cases.

VI.6. Estimation Procedure

There are two approaches for estimating a recursive system of equations; the single equation method, which estimates the reduced-form coefficients and uses them to retrieve the structural parameters, and the system method, which estimates all parameters of the model jointly. Following Johnson and Di Nardo (1997), the latter way is more appropriate, provided that the system specification is correct.

The FIML method used in the research is a system method because it is applied to the whole system and yields estimates of the structural parameters contemporaneously. FIML assumes full knowledge and complete specification of all equations in the model, as well as an appropriate choice of the mathematical form of each equation. It also assumes the error terms of each equation to be normally distributed with zero mean and constant variance. (Kotsouyiannis A, 1977 op cit).

In an econometric relationship like the one under study, the dependent and independent variables are jointly distributed, which assumes that their multivariate distribution follows the normal density function.

The objective is to choose the values of the parameters that maximise the likelihood of observing the values of the dependent variables. To obtain the total probability of observing the values of the sample for all the endogenous variables, one needs to transform each equation by expressing the error terms as a function of the dependent variables. From that transformed function, one obtains the joint probability of any of the values of the dependent variables by the product of the joint probability of any of the values of the error terms and the partial derivatives of the transformed function with respect to each dependent variable. The second term of that product is termed the Jacobian determinant, and has to be positive definite for estimation purposes.

$$P(Y_{1t},...Y_{kt}) = P(\varepsilon_{1t},...\varepsilon_{2t})\left(\frac{\partial(\varepsilon_{1t}...\varepsilon_{kt})}{\partial(Y_{1t},...Y_{kt})}\right) \qquad (22)$$

The likelihood of observing the maximum values of the dependent variables is equal to the likelihood function of the whole sample of observations:

$$L = \left|J^K\right|\left\{\frac{1}{\sqrt{2\pi}}\right\}^K\left\{\frac{1}{\sigma_{1t}^2\sigma_{2t}^2\cdots\sigma_{kt}^2}\right\}^K\left[\exp\left\{-\left(\frac{\sum\varepsilon_{1t}^2}{2\sigma_{1t}^2}+...+\frac{\sum\varepsilon_{kt}^2}{2\sigma_{kt}^2}\right)\right\}\right] \qquad (23)$$

Where J is the Jacobian determinant or the second term of the right-hand-side of (22), and *K* is the number of equations.

When equation (23) is converted to logarithms, it becomes linear and easier to estimate. The structural parameters that maximise the likelihood of observing the values of the dependent variables are obtained when the partial differentiation of L with respect to the individual structural coefficient is set equal to zero. They are consistent, asymptotically efficient and normally distributed (Jan Kmenta, 1986).

VI. 7. Estimated Results and Interpretation

The model specified in the system of equations (21) has been estimated following the FIML method and run with Gaussx, version 3.6 designed by Breslaw (1997). The structural parameters estimated provide answers to three types of issues. Do the wage ratio and the age proportion have a direct positive influence on migration? What agricultural inputs have a positive and significant effect on agricultural output? Based on the indirect elasticities of agricultural inputs on migration, what are the agricultural inputs that have the effect of lowering rural-urban migration?

To choose the final result of the estimated models the following estimations had been tried. First, the model was estimated using the Almon distributed lag values of annual investments in infrastructure. The Almon distributed lag model could not better express the concept of stock embodied in the infrastructure variable. After choosing the infrastructure capital stock as the best approximation of the infrastructure variable, current and one-year lag of infrastructure capital stock were used in the estimation with current, one-year lag and six months-lag of livestock capital.

Based on the correlation coefficients, as well on the degree of significance of the estimated parameters, the selected estimated model includes one-year lag of infrastructure and current year livestock capital. The results are presented in table 3 at the next page. Except for the Almon distributed lag model, the alternative models tried are presented in appendix 3.

The total number of observations is equal to 35, as the number of annual observations from 1961 to 1996 is reduced by one, reflecting the lagging procedure of infrastructure capital.

Table 3: Estimated Structural Elasticities.

Agricultural Output Equation		Migration Equation	
Variables	Elasticities	Variables	Elasticities
Labour	-0.5746 (-1.118)	Wage Ratio	1.0851** (2.618)
Fertiliser	0.2042* (1.986)	Age Proportion	2.9857 (0.908)
Machinery	-0.3682 (-0.607)		
Livestock	1.2644** (2.655)		
Education	-1.1079 (-0.8312)		
Infrastructure	0.2812** (2.4056)		
R-Sq	0.537	R-sq	0.66

** Significant at 5% level, * significant at 10 % level. The t statistics are in parentheses.
Log Likelihood = 0.458
Convergence achieved after 9 iterations.
Mean of Agricultural output variable = 5.75 Mean of Migration variable = 1.31
Std Errors of estimates, equation 1 = 0.15 Std Errors of estimates, eq. 2 = 0.38
Std Dev of Agricultural output = 0.81 Sdt Dev of Migration variable = 0.66
The estimation method is Full Information Maximum Likelihood.
The software used is Gaussx version 3.6.

VI.7.1. Direct Agricultural Output Elasticities

The estimated results for fertiliser, livestock and infrastructure elasticities on agricultural output are positive and significant. The model estimates that a one-unit increase of fertiliser use would increase agricultural output by 0.20 point. This is consistent with the literature on fertiliser use in LDCs. Not only is productivity enhanced by the nutritive properties of the input, but fertiliser is readily adopted, requiring little capital and can be applied by individual workers.

One-unit increase in the amount of resources devoted to agricultural infrastructure increases agricultural output by 0.28 point, indicating the importance of infrastructure capital as a building block for the rural economy.

As for livestock, one-unit increase in the stock of animals raises total agricultural output, which include the value of livestock production by 1.26 point. However, by no means should the conclusion be made that Senegal can rely on the increase of number of animals to modernise its agricultural production. In this arid and semi-arid environment, the number of animals is limited by the amount of pasture land available. The climate limits the quantity of organic manure that livestock contribute to agricultural output. However, part of the impact of livestock on agricultural output may be due to the financial aspects of livestock in the economy, thus signalling the importance of rural banking reforms and increasing liquidity on agricultural output.

In order to succeed these improvement of agricultural output, one has to keep in mind that the three structural reasons of the agricultural crisis, presented in the second chapter, (section II.4) have to be removed first.

The sensitivity of agricultural output due to a change in the size of the labour force is not significantly different from zero. Therefore, the model indicates that in Senegalese agriculture, additional workers do not necessarily increase output. This means that the marginal agricultural labour productivity is not statistically different from zero. This finding has intuitive appeal, as it indicates that economic incentives are a key driver of rural-urban migration.

The effect of machinery on agricultural output too was not significantly different from zero. This is not suprising as for example the role of tractors in the agricultural economy is extremely small, that is, 0.3 tractors per thousand hectares. Also, irrigated land represents less than 2 % of the total land (computed from FAO, 1999), rural education is low and fertiliser utilisation is only about 8 kg/ha.

Surprisingly, the elasticity of education on agricultural output is not significantly different from zero. This is probably because of lack of sufficient variation over time since the literacy rates do not drastically change from year to year. May be the data on farmer education, such as the years of schooling, would have been a better measure. The proportion of agronomists or workers involved in extension services influencing farmers and their families to adopt new technologies would also have been another method to try and capture the role of farm education on production. Moreover, according to UNESCO's standard, to make the literacy rate a reliable measure of education, workers must have completed at least four years of schooling and also have had to maintain their basic skills in reading, writing, and computing. Many times this is difficult in LDCs, because traditional rural lifestyle discourages reading and the availability of reading materials is low.

VI.7.2. Direct Rural-Urban Migration Elasticities

The elasticity of the wage ratio with respect to the rate of rural urban migration is equal to 1.085 and is significant at the 5 % level. For one-point increase in the wage ratio, migration increases by 1.085 point, thus is elastic. This finding supports the fundamental hypothesis of this research, and is consistent with the literature, which argues that rural-urban migration is a positive function of the ratio of the urban per capita income to the rural per capita income. More importantly, it gives weight to a policy aimed at reducing rural-urban migration flows by increasing per capita rural earnings by means of increased agricultural investments.

The results suggest that the elasticity of the rural-urban migration rate due to a change in the age proportion is not significantly different from zero. The model did not detect any influence from age variation on migration flows. This finding reflects the minimal growth of the age proportion during the sample period (0.78 % per year).

–2.05. In other words, 1% increase of chemical fertiliser will reduce rural urban migration by 2 %.

The same computation is conducted with the infrastructure variable:

$$\eta_{MIG,IK} = \left\{ \left[\left(\frac{\partial MIG}{\partial WR} \frac{WR}{MIG} \right) \frac{MIG}{WR} \right] \left(\frac{\partial WR}{\partial Y_A} \right) \left[\left(\frac{\partial YA}{\partial IK} \frac{IK}{Y_A} \right) \right] \frac{Y_A}{IK} \right\} \frac{\mathrm{IK}}{\mathrm{MIG}} \qquad (27)$$

And is equal to –3.22. This implies that 1% increase of agricultural infrastructure will reduce rural-urban migration by 3.2 %.

Improvements in agricultural productivity would appear to be effective in reducing the flow of migration from rural to urban communities in Senegal. Using the migration data from the study period (1961-1996), rural-urban migration has annually increased by 7.56 %. From migration theory, it has been established that the job opportunities in urban areas play a key role in motivating rural-urban migration. Even if it has low performances, the Senegal industrial sector still has a positive labour demand. By assuming this labour demand equals to the industrial growth rate of 2 % (UNIDO, op. cit), to target rural-urban migration rate to that level, the quantity of fertiliser used need to be increased by 35.88 % or infrastructure capital need to be increased by 32 %.

CHAPTER VII. CONCLUSION

In many Sub-Saharan African countries, rural-urban migration has been increasing since the early 1960s. Poor agricultural performances have pushed many agricultural workers to leave the countryside for cities, because the per capita income differential is in favour of urban workers. However, low industrialisation and limited employment opportunities in the public services have led to high levels of unemployment and poverty, and have caused urban infrastructure deficits.

Rural-urban migration continues to increase because urban workers can be under-employed in the fringe urban economy, buy affordable import foods and/or be supported by employed workers. This labour movement does not follow the classical pattern of rural-urban migration, because it is not responding to a specific labour demand by a booming modern industrial sector; it is rather an escape from degrading economic conditions in the agricultural sector.

To be successful, a policy of reducing urban unemployment must narrow the income differential between the two areas, otherwise, it will attract more migrants, which will discount its positive effects. Among all the possible policies for reducing rural-urban migration, one that increases agricultural productivity, and thus, indirectly increases agricultural incomes, is thought to be best.

This research has introduced the reader to a recursive system of equations of rural-urban migration, using a Cobb-Douglas agricultural production function and a migration function with Senegal economic and demographic data.

The findings support the hypothesis that rural-urban migration is a positive function of the wage ratio of urban per capita income to rural per capita income. Moreover, it justifies the foundation of a policy aimed at reducing rural-urban migration flows by increasing per capita earnings by means of increased agricultural investments.

Additional use of fertiliser and improvements in agricultural infrastructure will increase agricultural output, per capita agricultural earnings, and thus will reduce rural-urban migration.

While statistically significant, other research has shown that there most likely are other significant drivers that our model does not capture. Nonetheless, the model does support theory, which suggests that there is an important relationship between agricultural productivity and urban poverty, via a migration phenomena.

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Appendix 1 Table of Data Used in the Estimation

Year	Land (1000ha)	Agric Output ($1000 Ct)	Econ Agric Pop. (in 1000)	Fertiliser 100 gr/ha)	Tractors (# per 100,000ha)	Livestock (number)	Literacy rate (%)
1961	2085	754650	1328000	33	8	1587760	17
1962	2070	728374	1357000	33	7	1720180	18
1963	2238	767835	1388000	40	8	1911530	18
1964	2285	818039	1419000	42	9	2097700	19
1965	2410	765695	1452000	58	11	2159072	20
1966	2405	761437	1486000	81	11	2415444	21
1967	2661	773813	1522000	113	11	2593850	21
1968	2496	658869	1558000	52	12	2634416	22
1969	2481	743861	1596000	33	12	2698600	23
1970	2284	598600	1636000	34	13	2722100	24
1971	2296	716337	1674000	58	13	2814700	25
1972	2256	655696	1713000	67	14	2874100	25
1973	2361	634580	1753000	98	14	2726300	26
1974	2484	680065	1794000	165	15	2506100	27
1975	2574	1065059	1835000	202	16	2578870	28
1976	2530	1014985	1877000	170	16	2649100	28
1977	2368	889966	1920000	199	17	2727800	28
1978	2516	710966	1963000	151	18	2830370	29
1979	2277	903942	2007000	124	19	2844000	30
1980	2428	689854	2053000	83	20	2809780	31
1981	2462	486635	2095000	104	20	2596760	31
1982	2411	581207	2138000	79	20	2655130	32
1983	2136	535127	2181000	114	20	2682220	33
1984	2135	380616	2226000	78	20	2585130	34
1985	2297	449107	2272000	88	20	2913330	34
1986	2130	765917	2380000	90	20	3225065	35
1987	2207	877265	2366000	90	20	3358195	36
1988	2240	945065	2414000	111	21	3311590	37
1989	2146	722750	2462000	54	21	3409730	38
1990	2242	866672	2508000	51	21	3620540	38
1991	2103	788350	2565000	66	21	3837900	38
1992	2355	867050	2661000	73	24	3951310	39
1993	2350	779035	2677000	107	24	4154050	40
1994	2365	1150409	2734000	85	23	4230350	42
1995	2265	669905	2677000	71	24	4321300	43
1996	2226	703320	2734000	67	24	4336520	44

Appendix 1 Table of Data Used in the Estimation

Infrastr. Stock ($1000Ct)	Rural Population	Urban Output $1000 Ct)	Urban Population	# of Rural-Urban Migrants	15-25 aged per 100,000 people
86644	2737000	799360	1012000	4199	1676
29632	2804000	815564	1044000	4750	1683
29632	2874000	814170	1077000	5986	1690
29632	2946000	880764	1111000	5539	1697
30836	3020000	801070	1145000	5421	1703
32173	3098000	886467	1172000	5973	1837
32173	3178000	876907	1209000	5502	1844
32173	3261000	903325	1247000	6036	1851
35923	3349000	822548	1286000	5216	1858
38860	3439000	834327	1339000	6742	1865
37530	3531000	833054	1393000	6550	1872
39309	3626000	997758	1449000	6686	1876
81002	3724000	1624847	1507000	7145	1879
120794	3825000	1499177	1568000	6585	1786
122680	3928000	1655698	1643000	7375	1793
123832	4032000	1576905	1705000	16481	1800
116589	4138000	1598581	1758000	17637	1807
121285	4246000	1833150	1824000	18095	1815
130371	4357000	1950339	1894000	18182	1822
134859	4471000	2073584	1936000	19253	1829
147659	4576000	1809698	2001000	21923	1836
148119	4683000	1694108	2069000	22223	1843
124722	4792000	1904432	2150000	23690	1850
108082	4904000	1807483	2265000	24321	1860
150219	5019000	1882484	2318000	25374	1866
234606	5137000	2608651	2406000	31458	1894
286030	5258000	3115095	2497000	34086	1901
308725	5380000	3190234	2592000	48761	1890
300436	5501000	2999198	2691000	38114	1897
340256	5621000	3496478	2793000	47917	1897
410051	5746000	3352244	2742000	49700	1904
462064	5869000	3606606	2858000	52635	1929
512257	5993000	3214376	3251000	92464	1936
557546	6121000	4130202	3389000	16620	1943
487212	6254000	2524239	3555000	54948	1950
380132	6394000	2587520	3729000	58101	1957

Appendix 2. Correlation Matrix

Agricultural Output Equation.

	lnYA	ln L	LnF	lnMc	LnS	lnE	lnIK
lnYA	1.0000						
lnL	0.1289	1.0000					
lnF	0.0813	0.1464	1.0000				
lmMc	0.0061	0.8892	0.4296	1.0000			
lnS	0.2474	0.9104	0.0437	0.8198	1.0000		
lnE	0.0998	0.9586	0.3088	0.9690	0.9016	1.0000	
lnIK	0.2840	0.9229	0.2477	0.8353	0.8226	0.9163	1.0000

Migration Equation

	ln M	lnWR	lnG
lnM	1.0000		
lnWR	0.8014	1.0000	
lnG	0.6084	0.6277	1.0000

Appendix 3. Some Alternative Models Tried

a. Estimated Structural Elasticities with Current year Livestock and Infrastructure capital stock

Agricultural Output Equation		Migration Equation	
Variables	Elasticities	Variables	Elasticities
Labour	-0.711 (-0.87)	Wage Ratio	1.124** (3.07)
Fertiliser	0.17* (1.64)	Age Proportion	2.78 (0.87)
Machinery	-0.682 (-1.33)		
Livestock	0.770 (1.91)		
Education	-0.860 (-0.68)		
Infrastructure	0.39** (2.08)		
R-Sq	0.55	R-sq	0.67

** Significant at 5% level, * significant at 10 % level. The t statistics are in parentheses.

b. Estimated Structural Elasticities with one-year lag Livestock and current year Infrastructure capital stock

Agricultural Output Equation		**Migration Equation**	
Variables	Elasticities	Variables	Elasticities
Labour	-0.504 (-0.849)	Wage Ratio	1..119** (2.62)
Fertiliser	0.118 (0.993)	Age Proportion	2.08 (0.515)
Machinery	-0.752 (-1.33)		
Livestock	1.015** (2.536)		
Education	-0.382 (-0.680)		
Infrastructure	0.29** (2.70)		
R-Sq	0.50	R-sq	0.65

** Significant at 5% level, * significant at 10 % level. The t statistics are in parentheses.

c. Estimated Structural Elasticities with Six-months lag of Livestock and Infrastructure capital stock

Agricultural Output Equation		Migration Equation	
Variables	Elasticities	Variables	Elasticities
Labour	-0.573 (-0..89)	Wage Ratio	1.163** (2.878)
Fertiliser	0.129 (1.12)	Age Proportion	2.45 (0.69)
Machinery	-0.582 (-1.10)		
Livestock	0.938** (2.197)		
Education	-1.083 (-0.923)		
Infrastructure	0.404** (2.877)		
R-Sq	0.55	R-sq	0.65

** Significant at 5% level, * significant at 10 % level. The t statistics are in parentheses.

d. Estimated Structural Elasticities with one-year lag of Livestock and one-year lag of Infrastructure capital stock

Agricultural Output Equation		Migration Equation	
Variables	Elasticities	Variables	Elasticities
Labour	-0.270 (-0..48)	Wage Ratio	1.145** (2.694)
Fertiliser	0.196* (1.69)	Age Proportion	2.57 (0.508)
Machinery	-0.767 (-1.28)		
Livestock	0.912* (1.788)		
Education	-0.339 (-0.242)		
Infrastructure	0.192** (1.49)		
R-Sq	0.42	R-sq	0.65

** Significant at 5% level, * significant at 10 % level. The t statistics are in parentheses.

e. Estimated Structural Elasticities with six-months lag of Livestock and one year lag of Infrastructure capital stock

Agricultural Output Equation		Migration Equation	
Variables	Elasticities	Variables	Elasticities
Labour	-0.368 (-0.692)	Wage Ratio	1.112** (2.689)
Fertiliser	0.1206 (1.92)	Age Proportion	2.846 (0.818)
Machinery	-0.529 (0.861)		
Livestock	1.165** (2.39)		
Education	-0.898 (-0.632)		
Infrastructure	0.238* (1.91)		
R-Sq	0.48	R-sq	0.66

** Significant at 5% level, * significant at 10 % level. The t statistics are in parentheses.