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 from 1961 to 1996, it grew 7.6% per annum. Labour market in the modern industrial and service sectors is so depressed that urban workers face high unemployment and poverty rates, and live in substandard conditions in the fringe urban sector. The purpose of this study is to examine policies needed to reduce rural-urban migration through selected agricultural investments, especially given that a long run of low agricultural productivity has been a major cause of rural-urban migration flows.

Based on a recursive system of equations, an estimate was made of rural-urban migration elasticity caused by agricultural inputs and their impact on migration. The model used combines a Cobb-Douglas agricultural production equation along with a rural-urban migration equation with agricultural output as an explanatory variable. The study period is 36 years from 1961 to 1996.

Our findings support the hypothesis that rural-urban migration is a positive outcome function of the urban-rural wage ratio that is proxied by the ratio of urban per capita income to rural per capita income. The results justify the design of a policy aimed at reducing rural-urban migration flows through increasing per capita earnings by means of increased agricultural investments. For instance, 10% increase of fertiliser lowers rural-urban migration by 20.5% while 10% increase of agricultural infrastructure reduces rural-urban migration of about 32.2%. If one extrapolates these results, fertiliser and infrastructure need to be increased respectively by 36% and 25% or both inputs by 13.09% to reach rural-urban migration annual rate of 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 7.6% 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 parce que la basse productivité agricole a occasionné un important exode rural.

À partir d'un modèle d'équations récursives ayant une équation de production agricole du type Cobb-Douglas et 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 et leur impact sur l'exode rural ont été estimés 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 10% des engrais ou des infrastructures agricoles réduirait respectivement l'exode rural de 20.5 % et 32.2 %. 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 infrastructures de 25% ou de 13.09% pour les deux intrants.

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Abbreviations

CODESRIA:	Counsel for Development and Social Sciences Research in Africa
DCs:	Developed countries
FAO:	Food and Agriculture Organisation 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 Development Organisation
USAID:	United States Agency for International Development

Chapter 1

INTRODUCTION

The modernisation of Sub-Saharan Africa has led to a strong increase in rural-urban migration. While in developed countries (DCs) this phenomenon has occurred in response to high labour demands by the booming industrial sector, in many African countries much of the rural-urban migration has been characterised by high rates of unemployment and poverty 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). Classical economic theories such as the one introduced by Lewis (1954) and his followers were of limited help because they expected LDC economic growth patters would follow those of industrial development, just as in the DCs, and that the rural-urban migration rate would follow. Todaro's work (1969) marked a turning point in development economics by involving the urban-oriented labour movement. He stated that rural-urban migration depends on economic phenomena, and especially on differences between per capita earnings in both sectors, as well as the potential migrants have of obtaining employment in an urban milieu.

Although there may be some other significant sociological and/or political factors in terms of economic analysis, human mobility should be seen as a rational choice among activities maximising the use of labour, regardless of where the labour market is located.

This study will suggest that rural-urban migration in LDCs can be effectively reduced by investments in agricultural sectors among strategically selected inputs. This statement is based on the principle that labour migration toward urban zones is driven by the higher per capita income levels that exist in urban areas, compared to that of rural areas, and that migration could be slowed down by increasing per capita earnings in the rural sector by encouraging the appropriate agricultural investments.

The choice of this policy is natural and stems from the observation that traditional urban policies, such as those based on improving infrastructures or investments in industrial activities have always been weighted down by the arrival of additional migrants from rural areas who have interpreted them as signals of a better life in the cities. Other remedies for curbing rural-urban migration have been tried. An example is one that attempts to equate rural and urban per capita income by wage subsidies, but this was difficult to implement because it meant introducing heavy taxation, penalising urban workers and causing economic distortions. A more logical migration policy, and one that should be more successful, is to encourage rural workers to remain working in the agricultural sector by increasing their wage earnings.

This research will be focused on the Africa's Sub-Saharan zone in general, and in Senegal in particular. Senegal's current situation will be used to illustrate the scope of rural-urban migration problems and related economic and demographic data will be used to make estimates and models of econometric relationships. These will ultimately suggest a policy that when adopted, should reduce rural-urban migration.

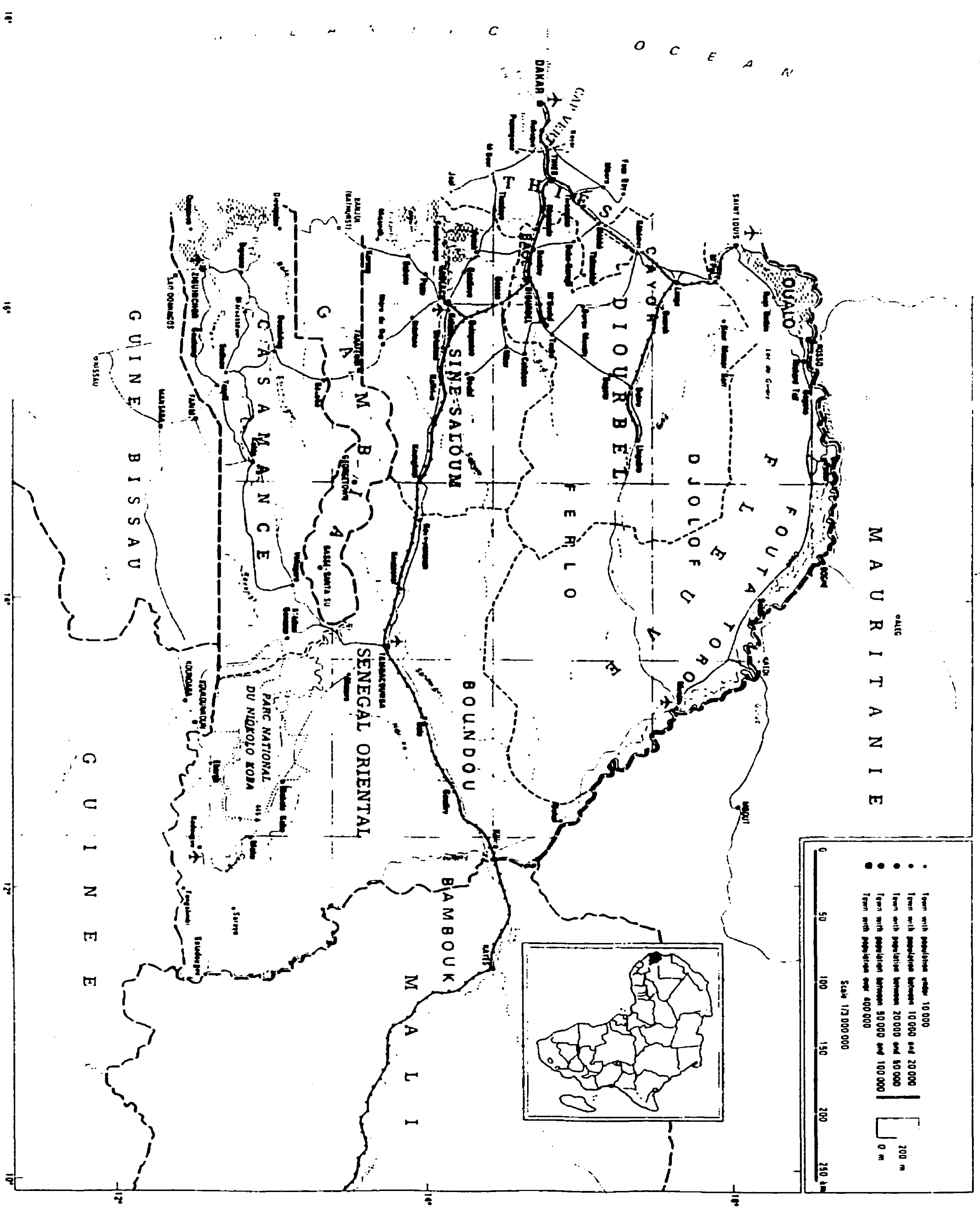
Chapter 2

RESEARCH BACKGROUND

2.1 Senegal as a Case Study

Senegal is located in Western Africa, with an area of 19,722 km^2. It is bounded by Mauritania to the north, Mali to the east, Guinea and Guinea-Bissau to the south and the Atlantic Ocean to the west (Figure 1). It is crossed by the Senegal and Casamance rivers, with sources located in the tropical and humid south. Senegal is part of the Sahel zone, located between Sudan and the Sahara Desert. This Sub-Saharan zone has a three to ten months dry season, frequent droughts (288-700 mm of rainfall), with severe droughts every third decade (*Encyclopedia Universalis*, 1999). Rainfall in the province of Louga, ranges from 156-486 mm (*ibid.*). Vegetation consists of trees such as *acacias, balanites, faidherbia, baobab* or *karite*, and grasses such as *cenchrus biflorus, panicum* or *eragrostis, etc.*, which do not completely cover the soil. Along the rivers and water sources of the south, close to the topical humid zone, Senegalese farmers cultivate cereals (mil, maize or rice) and practice seasonal livestock migration, in accordance with the rhythm of the rainfall.

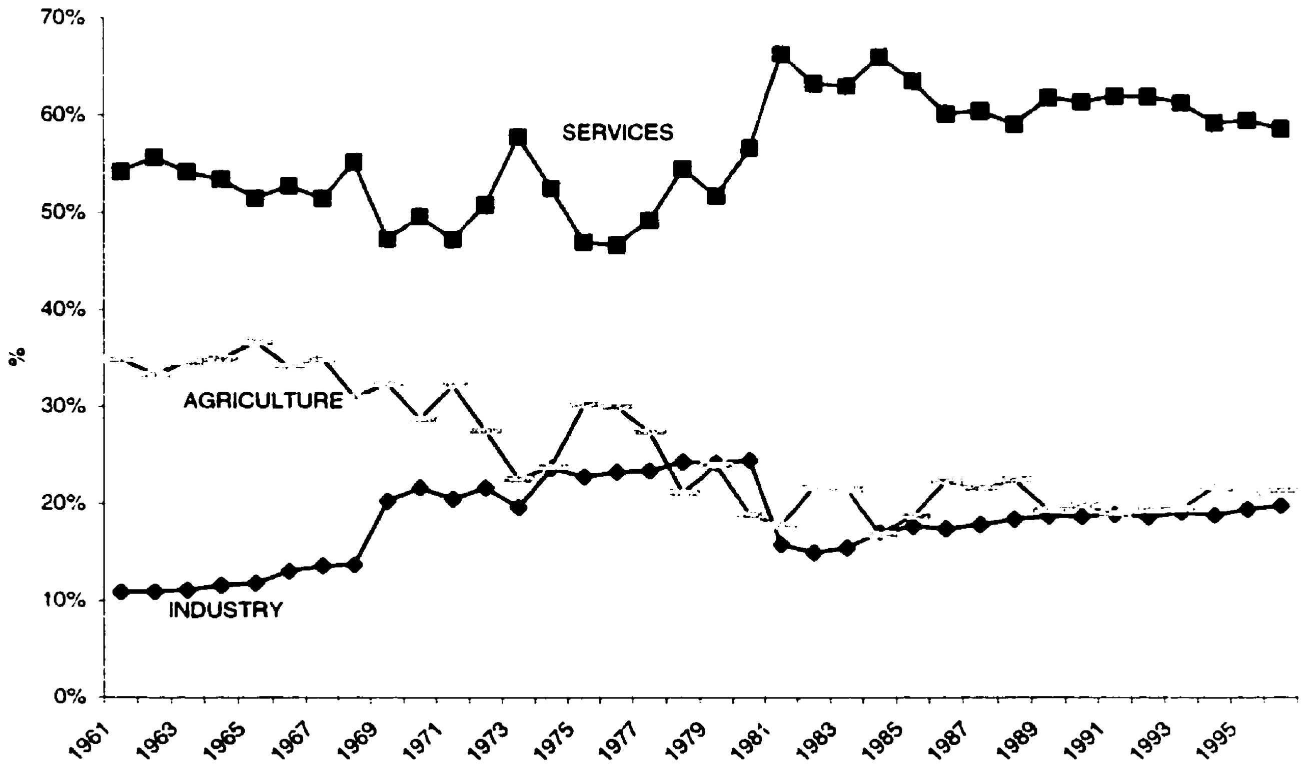
Figure 1: Map of Senegal



In 1998, Senegal's GDP was US$ 4.8 billion and increased by 2.6% annually 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 (*ibid.*). As in many LDCs, Senegal's economy is characterised by an overpopulated and unproductive rural sector, an embryonic industrial sector and a large service sector, mainly composed of governmental services.

The agricultural sector's share of total GDP declined from an average of 35% in 1961 to an average of 20% in 1995 (Figure 2). The industrial sector's share of the GDP only increased from 10% to 15% in the same period, while that of the service sector increased from 55 to 60%. Within the primary sector, the crop-production share fell from 64% in 1980-1983 to 53.5% in 1984-1992, with its contribution to total GDP falling from 17% in 1960-1966 to 10% in 1991-1992 (Thsikala, 1998).

Figure 2: Senegal, Shares of Different Sectors in GDP, 1961-1996



Source: Computed from World Bank, World Tables, 1997

2.2 The Agricultural Crisis in Senegal

2.2.1 Index of Agricultural Production

Per capita food production has been falling over the last three decades, as portrayed by the net agricultural production index and the net per capita agricultural index (FAO, 2000) (Figure 3). During the period of 1961 to 2000, the aggregate agricultural production index varied between 100% and 120%. The per capita agricultural production index decreased by almost 50%, falling from 180% to 85% during the same period. In the entire SSA area, the per capita agricultural production index decreased from 120% to 100% (*Ibid.*).

2.2.2 Some Reasons for the Crisis

According to Diagne (1998), Kante et al. (1994), Ba (1994) and the World Bank (1987) agricultural output in Senegal has been declining due to natural factors and economic pressures. One of the natural causes is climate, with an average annual rainfall of less than 600 mm for many years. Due to this lack of rainfall and also to powerful winds, arable land in Senegal has been subjected to heavy erosion. Continuous drought has reduced agricultural activities in the northern region. To fight against desert expansion, the government had to protect the rainforest against cultivation and declare some areas to be reserved for pasture. Population pressure in the Groundnut Basin has led to continuous cultivation in a single zone, without the addition of fertilisers. Even plant cover varieties such as *acacias albidas* that are well-known for their fertilising effects have decreased considerably.

In general four economic factors are to be blamed for the current agricultural situation. First, due to a reduction in both production and the price of groundnuts, rural monetary incomes have been eroding. Between the early 1960s and the early 1980s, the real price per kilogram for groundnuts has decreased by 40%, causing a 50% drop in total commercial production (Kante et al. 1994). Second, since the 1980s, the Senegal's export of groundnut decreased because the product faced competition from soya and corn oil produced by other countries at lower costs (Duruflé, 1994). Third, in 1968, the preferential trade agreement between France and its former colonies came to an end.[1] This meant that France no longer covered losses incurred from exports and Senegal lost a source of export receipts.

To compensate for this loss, the government chose to support its budget by increasing export taxes, a measure that penalised farmers, even indirectly. As an example, the value of groundnut production fell by 7% between 1977-78 (at 22.1 billion FCFA) and 1982-83 (at 20 billion FCFA) while 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).

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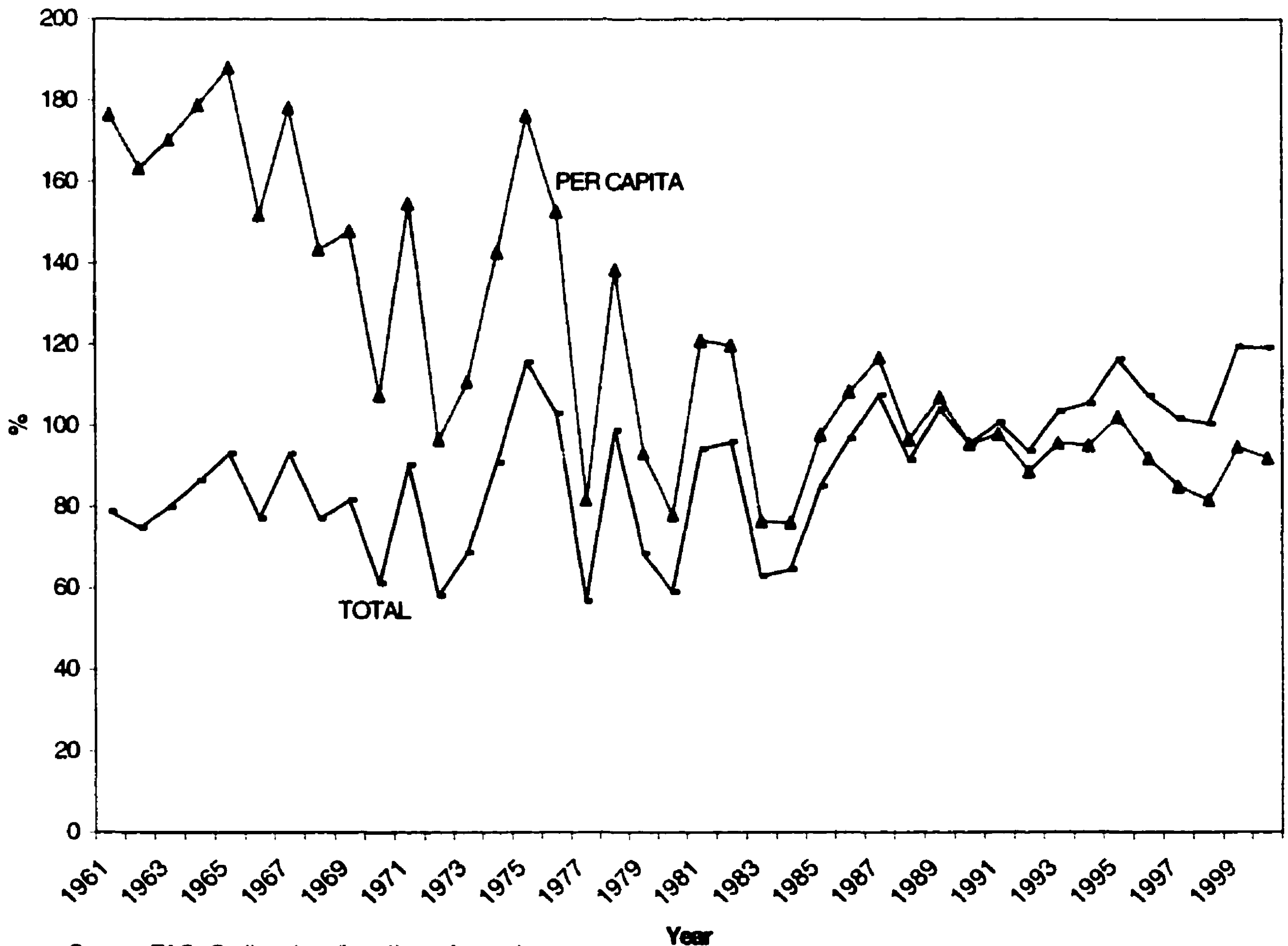
[1] L'Afrique Occidentale Française (AOF) and France had an agreement by which member countries had preferential access to French products. In return France had to guarantee a fixed price for AOF export products. The final act of this privileged relationship ended with a devaluation of the CFA franc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

2.2.3 *The Five Agricultural Regions*

According to Ba (1994), Senegal has five homogeneous agricultural regions. The Groundnut Basin (centre-west) is an area cultivating cereals (sorghum and millet) and groundnuts. It is subjected to frequent droughts and its soil has degraded a great deal. It has a population density of 100 inhabitants/km^2 and has additional land for cultivation. The Dakar and Niayes regions produce mostly fruits and vegetables, supplying the high demand that comes from the neighbouring cities. These two regions are required to support an ever-increasing semi-rural and semi-urban population. In Senegal's eastern region (27% of the country's total area) there is still land available but the dry climatic conditions do not allow for land cultivation. For this reason there are only 8 to 9 inhabitants/km^2 (Ba, 1994).

Figure 3: Senegal, Total and Per Capita Agricultural Production Index (base = 1989-91)



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

The Senegal River basin (15% of total land) is occupied by 8% of the total population. Finally, there is Casamance located in the Southwest, that accounts for 15% of the total area. It is located in the rainy zone and contains 14% of the total population. Civil war has affected its agricultural activities.

2.2.4 Food for Subsistence First

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

Since 1967, there has been a 1.6% decrease in the production of groundnut and the traditional cereals (millet and sorghum) cultivated in rotation with groundnut. Moreover, to avoid food deficits, farmers have 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 maintain an annual growth rate in cereal production of 2%, mainly used for subsistence purposes.

Other authors are more pessimistic. Kante et al. (1994) estimated the overall annual growth rate of food production to be 1% from 1967 to 1991, far below the 2.7% annual growth rate for the population. The World Bank (1987) estimated the growth rate of Senegal's agricultural output to be at 1.3% from 1960 to 1986. Diagne's (1998) estimated the growth rate to be even lower (0.7% in the 1980-1992 period). This poor performance pushed USAID (1991) to call for improvements in soil management, claiming that otherwise the rural sector and food production would continue to decrease.

The gap between food supplied and food demanded, especially in cities, was filled by cereal imports. From 1960 to 1990, food imports increased at an annual rate of 3% (Kante et al., 1994) and from 1970 to 1992 for cereal imports increased by 4% (Ministère de l'Économie et des Finances, 1992).

2.3 Scope of Rural-Urban Migration in Senegal

Senegal's demographic transition has been characterised by a high population growth rate. Migration from rural to urban areas has increased, even though urban industries were doing poorly. As a result, the country now faces high rates of urban unemployment and urban poverty.

2.3.1 A Country in Demographic Transition

In 1998, Senegal's population was estimated at 9 million (World Bank, 1999), with a natural annual growth rate of 2.7%. The fertility index has decreased from 7.1 children per woman in 1978, 6.6 children in 1986 to 6 children in 1992 (Duruflé 1994, Kante et al. 1994). Infant mortality has also fallen, from 117 per thousand in 1978, 86.4 per thousand in 1986 and 68 per thousand in 1993 (*ibid*). The fact that its birth rate is greater than its death rate indicates that Senegal is an early demographic stage.

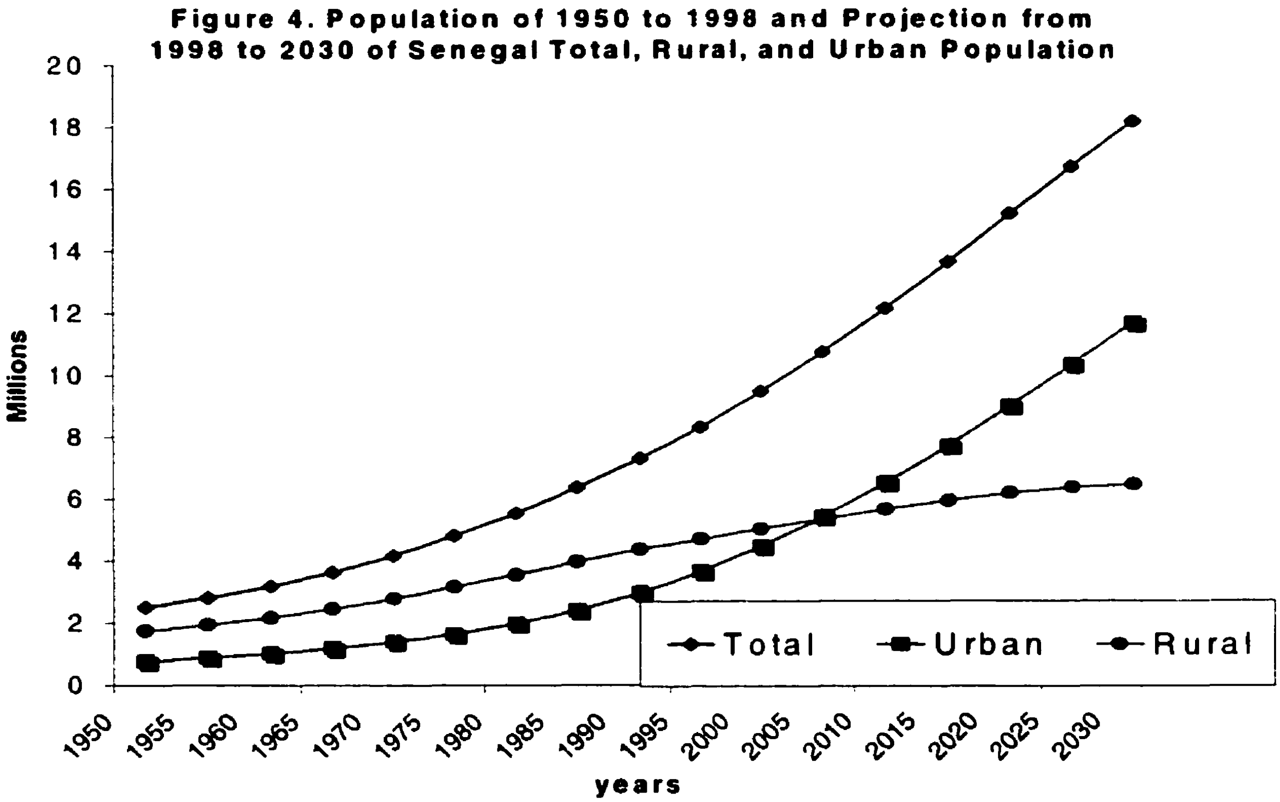
The current structure of Senegal's population reveals an overwhelming proportion of young people. In 1995, 46.6% of the population was less than 15 years of age (World Bank, 1997).

2.3.2 Migration towards Cities

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

From 1950 to 2030, rural population is estimated to have grown at an annual rate of 1.76% while for the urban population it will grow by 3.72%. During the same period, the urban population will have increased 15.7-fold, while rural population will have increased only 3.7-fold (FAO, 2000; Figure 4).

Dakar is the final destination for migrants and its estimated population growth rate remains high, as underlined by various studies. Becker and Mbodj (1994) reported it was 3.22% from 1904 to 1988 and 6.14% from 1958 to 1988. Antoine & Savane (1990) estimated it at 9%.



Source: FAO, 1999, On-line data (www.fao.org)

UNDP (1995) projected that in 2015 56% of the Senegal's population would be living in cities, with 5 million people living in Dakar. These higher growth rates are directly related to rural-urban migration. The Programme de Gestion Urbaine (1991) estimated that about 32.5% of Dakar's inhabitants were born outside the city, with 64% of migrants aged from 15-44 years and that 50% of all migrants had been living in

Dakar for over ten years. The study also showed that the number of rural-urban migrants has increased fivefold from 1976-77 to 1988-89.

2.4 Problems Related to Rural-Urban Migration in Senegal

One of the essential problems generally related to high population levels in cities is poor living standards. In Senegal, the rapid speed of urbanisation has been characterised by problems such as infrastructure inadequacy and by high rates of poverty and unemployment.

2.4.1 Infrastructure Deficit and Urban Poverty

The nation's capital Dakar comprises most of the country's urban social infrastructure. In the Escale and Thiemo Kandji districts, populated by civil servants and employees from larger firms the infrastructure is in good shape. The situation is different however 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 listed malaria, respiratory diseases, diarrhoea and other diseases are being frequent, due to poor sanitary conditions and promiscuity. In the capital and in many of Senegal's cities, water supplies and treatment are greatly insufficient and in poor districts, people face malnutrition. For example in the Tambacounda district, in a sampling of 3,347 persons, 29% declared themselves to be only moderately to insufficiently nourished, leading 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).

2.4.2 High Urban Unemployment

In the public sector, there was a decrease in employment due to measures introduced by the structural adjustment program (SAP). Between 1988/89 and 1989/90, government employment fell by 3.2% (Programme de Gestion Urbaine, 1992). This decrease has accelerated since 1984 and is directly related SAP changes. This reduction in public service employment occurred in within an already depressed urban labour market. For example in 1992, the unemployment rate in Dakar was 24.4% (Kante et al., 1994). Among the urban unemployed, the proportion of young people was high. For those aged 15-29, the rate was 27.7% in 1988 and 34.6% in 1991. It was estimated to be at 44.3% for women between aged from 20-24 years (Programme de Gestion Urbaine, 1992).

2.4.3 The Fringe Sector

Structural adjustment measures have reduced the size of the public sector and the cost of labour, and have reformed labour legislation. Thus neither the revised public sector nor the private sector could no longer create enough jobs, or at least do so fast enough to meet the demands of an increasing urban labour force. As a result, unemployed residents tried to make a living by working or creating new economic activities in the "non-official urban sector," also known as the "fringe", "murky" or "informal" sector. This urban sub-sector includes all non-registered jobs, be they productive or not, such as car repair, haircutting, shoe shining, street peddling, prostitution, etc.

A study by USAID (1988) showed that in Dakar during the late 1980s, there were 3,000 production units in the fringe sector, referring to 85 kinds of businesses and employing 57,000 workers. Of these, 72% were in commercial business (market stalls, small shops and street peddlers) and employed 42% of 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, stating that 60% of Dakar's economically active population worked in the fringe sector. In the poorest districts, this proportion exceeded 70%. According to Kante et al. (1994), the fringe sector employs about 23% of the economically active urban population. The fringe sector should not however be considered as a panacea for solving urban unemployment, because it faces numerous obstacles. For example persons working in this sector are faced with few job opportunities among an increasing labour force. They lack skills, there is a lack of interest from the financial market, and most importantly a lack of health, sanitation and other basic infrastructure services. A closer look at agricultural and industrial performances should improve the understanding of urban employment problems.

2.5 Crisis in the Industrial Sector

Additional urban workers face a depressed urban job market due to a current crisis in the industrial sector. Since Senegal's independence and compared to other countries, the industrial sector has faced two major problems, namely low domestic demand and productivity. In the 1950s while under French ruled, and based on the import-substitution model for development, large industrial firms were set up in Senegal in order to supply the entire French West African zone. The brutal end to colonial rule however rendered this choice uneconomical and inefficient, because each independent country proceeded to create its own industrial sector, leaving Senegal with a small industrial market and high production costs. Furthermore, firms created under the French umbrella were accustomed to fixed exchange rates and protected markets, and they faced production cost increases after currency devaluation in 1994.

Table 1 lists the manufacturing value added percentage (MVA) figures used by UNIDO (1999) to compare industrial country productivity. In

Table 1: **Senegal, Manufacturing Value Added (MVA) (1990 prices)**

Indicator	Period	Senegal	Africa	LDCs	DCs
MVA/capita (US$)	1980 1990 1996 1997	82.00 102.00 96.00 97.00	76.00 83.00 76.00 78.00	161.00 203.00 276.00 290.00	3704.00 4430.00 4641.00 4817.00
Real average growth of MVA (%)	1970-80 1980-90 1990-97	1.90 4.60 1.80	3.50 4.30 1.40	6.80 5.30 7.30	2.90 2.80 2.00
Real average annual growth rates of per capita MVA (%)	1970-80 1980-90 1990-97	-1.00 1.70 -0.80	1.40 1.30 -1.10	4.50 3.20 5.50	2.00 2.10 1.30
Share of MVA in GDP (%)	1980 1990 1996 1997	10.90 13.10 12.70 12.50	11.00 12.70 11.90 12.00	19.50 21.30 23.60 24.00	22.80 22.30 21.70 21.90

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

Senegal, the MVA annual growth rate was 1.8% from 1990 to 1997, whereas the per capita MVA annual growth rate had decreased by 0.8%. In the same period, the MVA's share of GDP was around 12.3%.

The industrial sector was 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 was deeply depressed (Table 2). From 1985-1996, the annual growth rate for employment was negative for 50% of the industrial branches, including food products, textiles, petroleum refineries, etc.

Table 2: **Senegal's Average Annual Employment Growth Rate in Selected Manufacturing Activities (1985-1996)**

Foods Products	-7.50	Others chemicals	-13.70
Beverages	-8.80	Petroleum refineries	-7.98
Tobacco	-3.10	Misc. petroleum and coal products	6.67
Textiles	-9.50	Rubber products	-14.50
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)	-18.90
Paper and products	4.20	Machinery electric	-8.68
Printing and publishing	0.00	Other manufactured products	-68.30
Industrial chemicals	-0.20	Plastic Products	12.40

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

The demographic situations described above show that in Senegalese cities, rural-urban migration caused problems in unemployment, poverty and management. These problems are not disconnected from the crisis in the agricultural sector, where rural workers faced long-term decreases in their per capita income. They thus chose to leave the agricultural sector because they believed their urban income would be greater than what they could earn from agricultural activities. The industrial sector was however depressed and the size of the public service sector has been reduced by structural adjustment policy measures, both of which increased urban unemployment and poverty.

Despite this bleak situation in urban areas, rural-urban migration continues to increase, as migrants expect their chances for employment and better lives to be improved by moving to the city. Migrants to urban areas are also able to buy cheap imported food and/or be temporarily supported by employed workers. Upon their arrival, most new migrants work in the fringe sector and are oftentimes underemployed while waiting for a better opportunity in the formal sector.

2.6 Research Motivations

By removing young and healthy workers from the agricultural sector, rural-urban migration contributes to the reduction of agricultural productivity and production. It also contributes to urban problems by increasing unemployment and poverty in urban areas. The main purpose of this research therefore is to discover ways of reducing rural-urban migration and contributing to a decrease in urban problems.

Four types of policies have been identified as being effective in reducing rural-urban migration, and they have been deployed in many developing countries (Sabot, 1979). The first policy applies wage subsidies to the manufacturing sector, allowing it to hire more workers at a wage rate equal to the one prevailing in the agricultural sector. By applying this shadow labour pricing, rural workers become indifferent when choosing between the two sectors of activities. The second policy introduces physical restrictions on movement such that people are prohibited from leaving the countryside. The third policy involves labour-intensive urban projects, aimed at reducing urban unemployment. Finally a fourth policy involves labour-intensive rural projects where the primary goal is to build modern infrastructures and thus attempt to curb rural-urban migration

The first policy is difficult to implement in the context of a two-sector economy where the agricultural sector is not very productive, since the latter would not generate enough surpluses to finance urban wages. It might typically be applied to situations where natural resources (gas or mines) or foreign financial aid are used as wage subsidies. The second policy raises moral issues, in addition to its inherent enforcement difficulties. The third policy has the perverse effect of increasing rural-urban migration, as the additional urban jobs created by these projects are interpreted as a signal for labour demands to increase. For example, in the 1960s and 1970s, Senegal's government controlled migration by fighting against "déchets humains" where police officers were charged with removing more than 200,000 people from Dakar to the north-eastern regions of the country (Collignon, 1984). This measure obviously was not successful in halting rural-urban migration.

This research supports the fourth policy, and to do so will test Todaro's hypothesis (1969) whereby an excess of per capita income in the urban sector over the agricultural sector will drive rural-urban migration. It also suggests that a policy be implemented to increase agricultural investments, and thus cause a reduction in rural-urban migration will.

More particularly, this research will investigate the use of investments in the agricultural sector to slow migration, based on the assumption that improvements in agricultural input productivity can help to reduce 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 infrastructures. This study will therefore determine which agricultural inputs are responsible for increasing rural incomes, up to a level where per capita income will be equalised in both rural and urban sectors. This effort will help remove some of the economic incentives that encourage labour to migrate. Those direct and indirect relationships will be determined using a model based on recursive equations that combine agricultural and migration functions.

The remaining part of the study will be organised as follows: Chapter 3 and Chapter 4 will review both theoretical and empirical literature; Chapter 5 will present an empirical analysis, while Chapter 6 will discuss variable definitions and data sources. Chapter 7 will discuss the estimated results and will offer some general conclusions.

Chapter 3

THEORETICAL LITERATURE REVIEW

3.1 Rural-Urban Migration

3.1.1 Two Traditional Theories of Internal Migration

Ravenstein (1889) was 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 the means for achieving the next step. Rural residents have a higher propensity to migrate, and their 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 how migration results from 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. His migration model therefore consists of identifying and quantifying those factors and assigning them with "plus, minus, zero" coefficients and also with intermediary obstacles. For Lee, zero factors are those balances between the positive and negative factors that exert neither an attractive nor a repellent force, and towards which people are essentially indifferent. Thus migration is a selective process in the sense that individuals who respond to positive destination signs 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 encountered in overcoming intervening obstacles.

The main criticisms of Lee's theory are the following. First, it has a high degree of generality and interdependence (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 infinity. Finally, the theory does not take into account any possible trade-offs between plus and minus factors or their magnitude.

3.1.2 Rural-urban Migration in Dual Economic Models

During the 1950s and 1960s, the Lewis model (1954), later extended by Fei and Ranis (1961) (L-F-R), was designed for those developing countries having a growing industrial sector, even if embryonic. This model assumed a two-sector economy, the traditional subsistence agricultural sector, characterised by zero or very low labour productivity and an urban industrial sector with high labour productivity to which workers from the subsistence sector are gradually migrating. Due to continual population increases yet a constant amount of 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 labour force in the agricultural sector will continuously migrate from rural to urban areas. Rural-urban migration and urban expansion follows, with output growths occurring in the modern sector. Since earnings are reinvested in the profitable urban sector, the speed of rural-urban migration is driven by the rate of capital accumulation in the industrial sector. As long as wage levels in the industrial sector are determined to have a fixed premium compared to that of the subsistence agriculture sector, rural-urban migration will serve as an equilibrating force between the rural and urban labour markets. This process continues until all labour surpluses in the agricultural sector are absorbed into the urban industrial sector. After this stage, additional labour transfers imply a loss of productivity in the agricultural sector and even a higher minimum wage in the urban sector, attracting more rural workers, and eventually migration has to cease.

The L-F-R model assumes high demands for labour by a dynamic, but small, modern industrial sector, accompanied by a low unemployment rate. In Sub-Saharan African countries however the situation is different. Labour transfers in the form of rural-urban migration have increased, even when high unemployment existed in the modern industrial sector. The L-F-R model fails to explain such a situation and is therefore not suitable as the background for an economic development policy in these developing African countries (Todaro, 1994).

3.1.3 High Levels of Rural-Urban Migration with Urban Unemployment

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

In its 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 $\dot{Y}_A$.

$$W_A = P.\dot{Y}_A \tag{1}$$

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

$$W_U = \overline{W_U} \tag{2}$$

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

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

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 relation costs constant.

$$M = f\left(W_U^E - W_A\right) \tag{4}$$

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.

$$E\left(Y_U\right) = (1-\alpha)W_U + \alpha W_U . n \tag{5}$$

where n is the urban unemployment rate.

Also, he reduced the maximum job turnover rate assumed equal to one by the H-T model. The growth of urban $\dot{E}_u$ employment is equal:

$$\dot{E}_U = \lambda E_U + \beta E_U \tag{6}$$

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 criticised the assumption of a random job selection, which assumes the existence of an urban job for each rural-urban migrant. 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 that an open labour lottery existed, since most highly demanded urban jobs are available through nepotism, favouritism and unions. Moreover, they found the idea of a fixed minimum manufacturing wage was unrealistic because when expressed in real terms, this wage must correspond to real market labour prices. They modified the H-T model by inserting costs of living, property rights and levels of education, but overall their findings did not refute the income differential hypothesis of the H-T model.

Fields (1975) generalised the urban job search process by introducing the probability that a rural worker might obtain an urban job. By computing the probability of securing an urban job for urban residents, the H-T model implied a higher urban equilibrium unemployment rate than in the generalised case, which included potential workers from both sectors. However, although rural residents have access to information on urban job availability, their access level is 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 among rural-urban migrants. 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 earnings are less than in 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 that a migrant might 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

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

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

- The expected rural wage for uneducated workers remains equal to the agricultural wage defined above in the H - T model.
- The equilibrium between the two labour markets 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:

$$\left(\frac{N_{UT} - N_{U/EDUC}}{N_{U/UNEDUC}} \right) = \frac{W_A}{W_U} \tag{8}$$

Corden and Findlay (1975) extended the H-T model by allowing for capital mobility between rural and urban sectors as a response to the differential in capital returns. 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 who originate from non-productive areas. Regardless of where capital accumulation or technical progress takes place, it contributes directly towards a reduction in urban unemployment by creating urban jobs, and indirectly by attracting urban workers to the agricultural sector.

Despite criticisms of the H-T model, it is the first one to introduce a new way of studying rural-urban migration phenomena of LDCs. It is especially interesting because it is linked to agricultural productivity along with important rural out migration in the presence of high urban unemployment, a situation common to many SSA countries, including Senegal. The model estimated in this research will be built upon the fundamental H-T hypothesis, and will attempt to measure the relationship between rural-urban migration and the income differential between the two sectors. After that relationship is established, a policy to reduce rural-urban migration will be suggested, which is the objective of this research.

3.2 Policy to Reduce Rural-Urban Migration in Developing Economies

3.2.1 A Wage Subsidy Policy

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

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

3.2.2 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 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 caused by having an excess labour supply in the urban sector. They also affect the misallocation of labour factor (Sabot 1979).

3.2.3 Labour Intensive Urban Project

In order to reduce urban unemployment and poverty, many developing countries have experimented with implementing labour-intensive projects in the cities (Sabot 1979). In the long run however they failed to absorb the excess urban labour supply because rural workers interpreted them as a signal for a greater probability 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. They believed that holding rural workers in the agricultural sector by improving agricultural productivity was the best policy. First, unlike the wage subsidy policy, it could avoid economic distortion. Second, it does not raise ethical issues such as the implementation of physical restrictions. Finally, by slowing down rural-urban migration flows, urban employment policies can be effective, because additional migrants from the rural area will not weigh them down.

3.3 Strategy for Improving Agricultural Productivity

3.3.1 The Zero Investment Strategy

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

The application of the Lewis model in development economics led to a hoarding of investments in the modern industrial sector and also to a loss in the agricultural sector. The reasons advanced were based first on Engel's law, which states that income elasticity for unprocessed food demands is less than one and decreases as income increases. Also, 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 linkage concepts as a tool for investigating how investment in one type of activity could induce subsequent investment in other income generating activities. He asserted that there is a lack of direct stimulus in the agricultural sector such that new activities are set up through linkages, while the superiority of the manufacturing sector in this respect is overwhelming.

3.3.2 Recognising the Profitability of Agricultural Investments

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

It was Schultz (1964) who stated clearly that the agricultural sector is profitable under specific conditions. According to him, a country can achieve major increases in per capita agricultural when farmers in traditional agriculture are provided with new and more productive factors of production, especially new agricultural technologies and new output skills. Traditional agriculture, characterised by a secular use of the same means of production, is inefficient and has exhausted any possibility of profitable production, since it already inefficiently allocates 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 would cover conversion costs.

Hayami and Ruttan (1970, 1971,1985) formalised and tested Schultz's idea with a world wide sample. The authors stated that each country, in order to take advantage of abundant and hence cheap factors, must base its agricultural growth path on its natural endowment in factors of production. As did Schultz, they 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 its 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 individual workers 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 infrastructures including irrigation or modern labour-demanding inputs, and high yielding crop varieties plus fertiliser and pesticides. In the process of development planning, SSA-countries have to specify the economic growth paths or combinations thereof that their agricultural investment policies require.

From Mellor's contribution, investing in those small farms most observable in Sub-Saharan African countries, would increase total agricultural output. Schultz (1964) along with Hayami and Ruttan (1985) offered theoretical and empirical foundations for additional investments in agriculture, in as much as they come from outside the sector. This study follows these authors to identify agricultural inputs that are capable of increase agricultural output.

Chapter 4

EMPIRICAL LITERATURE

4.1 Migrant Characteristics

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

They are young and most are in the 15-30 age group (Lipton 1980). In Ghana, Caldwell (1969) found the mode of migration flows to be in the 15-19 age group, while in Kenya, Rempel (1974) found it among the 20 and 25 age group. It appears that rural-urban migration takes the strongest workers and innovators out of agriculture, thus decreasing agricultural output. Schultz (1971) found that migration for the 10-25 age group was significant in Colombia, as did Abaysekera (1984) in Sri Lanka. In India, Reddy (1998) found that 70% of migrant household heads were less than 30 years of age, with 21% of them in 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 and highest for the 20-24 age group, and also low for those of over the age of 25.

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

4.2 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 need to identify and quantify these variables in order to estimate their effects on rural-urban migration flows (Todaro, 1976). This research is divided in micro and macro migration.

4.2.1 Micro Migration Functions

At the micro level, estimates are aimed at determining the probability that individuals might migrate from rural to urban areas, given their socio-economic characteristics and also the economic possibilities offered by urban areas (Todaro 1976). Micro migration is characterised by decisions following binary choice models (Schultz 1977), whereby individuals will migrate or are likely to migrate based on specific characteristics (age, gender, education, income, urban contacts, etc.) Micro migration estimation supposes prior demographic and economic surveys in both rural and urban areas. In its 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.

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

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

4.2.2 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) in the macro migration function at a time *t* is the rate at which rural people move to cities compared to the total population. The independent variables are wage or income levels in both areas (Y_A, Y_u), unemployment rates (U), population size in both areas (P_A, P_U) and 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 rural income and that rural-urban migrants increase their income threefold. In Kenya, Huntington (cited by Yap, 1975) found that rural-urban migration negatively related to rural wages and positively related to urban wages. Bamum and Sabot (cited by Yap, 1975) reached the same conclusion for Tanzania, as 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 form 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 origin conditions and destination zones explained a larger share of variances than did other forms (Schultz, 1977; Fields, 1979).

Hay (1974) and Schultz (1977) have provided good examples of micro-migration models. Hay (1974) estimated the probability of migration using a survey of 220 rural households of which at least 80 households had no migrants. He specified that migration probability is dependent on education, age, marital status, cultivated land per active male and on 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 that migration is dependent on the wage differential and on the difficulty of getting a job in the modern sector. Krishna (1984) specified migration as dependent on wage differentials and on the past year's migration rate. In most LDC macro migration studies, the implicit functions are similar to those in equation (11) (Yap L. 1975). The objective in this research being to design a policy for reducing rural-urban migration for the whole country, the macro migration function will be used. Moreover, the type of data used was collected on a nation wide level.

4.2.3 Summary of Literature Review

According to theories of rural-urban migration for 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 yet other variables including age, education, distance and urban contacts will also influence decisions to migrate.

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

Chapter 5

EMPIRICAL ANALYSIS

Before estimating the impact of agricultural investments on rural-urban migration, the functional and algebraic forms used must be specified, as well as the kind of relationships that exist between agricultural situations and rural-urban migration.

5.1 Choice of the Agricultural Production Functions

Production functions translate the relationship between output and variable inputs, and 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 make estimates 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 with small samples because degrees of freedom might be lost when measuring interaction effects. The Cobb-Douglas function is easy to implement and to make estimates because it can be simply expressed in linear form when all variables are expressed as logarithms.

5.1.1 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 owners, indicating that the function exhibits constant returns to scale.

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

This function can be used to derive production elasticities (α and $1-\alpha$) with respect to each factor, demonstrating how output is sensible to factor changes, as indicated by the coefficient of each factor.

5.1.2 Cobb-Douglas Production Function: Final Form Used

The Cobb-Douglas function has been widely used in empirical research in agricultural economics to measure relationships between output and inputs, either for 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), and of modern conventional capital inputs fertiliser (F) and machinery (Mc). They also included a conventional labour input agricultural labour force (L), and a modern non-conventional labour input education (E). A more diffused factor called agricultural capital infrastructure (IK) may be added. Infrastructure represents agricultural utilities like electricity and power, water systems, water management facilities (irrigation, drainage), rural markets, transport facilities (roads, bridges, boats, etc.), storage facilities (silos, warehouses) and processing facilities (machinery equipment, buildings). It includes research, experiments and extension services plus all modern or traditional institutions beneficial to agriculture. For example an important role is played in agricultural development by rural roads, market systems and storage facilities allowing goods (both non-perishable and perishable) to arrive at markets on time and in good condition. Agricultural infrastructure should therefore be treated as a form of modern capital input that allows for production and/or distribution of input as well as handling of output. In many LDCs, it is mainly the government and its sub-sectors that 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 follows:

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

where Y_A is agricultural output, A land area, L agricultural labour, F fertiliser, Mc machinery, S Livestock, E farm education and IK agricultural infrastructure capital.

5.2 The Recursive System of Equations

The main economic driver for rural-urban migration is the rural-urban wage differential. Moreover, other migration characteristics such as distance, age and contacts only really reflect the fact that wage and productivity disparities do exist. As such, rural-urban migration would cease once agricultural wages were increased 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.

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

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.

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, having 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.

When this 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).

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

For a recursive system of equations as above, estimation procedures such as the Two or Three 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.

5.3 Rural-Urban Migration: Indirect Elasticities of Agricultural Inputs

In the system of equations, agricultural output is a dependent variable. It becomes an independent variable in the migration function such that an increase in agricultural output generated by increasing agricultural inputs will improve agricultural income, lower the ratio of urban to agricultural wage, and therefore reduce rural-urban migration.

As mentioned earlier, it is crucial to determine which agricultural inputs have a negative effect on rural-urban migration. In that sense, the sensibility of migration with respect to agricultural investments is expressed by indirect agricultural input elasticities of migration. Since migration is expected to decrease when wage differential between urban and rural sectors is narrowed by agricultural investments, this chain process can be expressed as follows: $M = f(WR);\ WR = g(Y_A);\quad Y_A = h(X_i, X_j)$ where WR is the wage ratio between the two sectors (see Chapter 6 below), Y_A is the agricultural output and X_i and X_j are the agricultural inputs. This relationship can be derived with the following chain rule and is interpreted as indirect elasticities of rural-urban migration from individual agricultural input. Letting X_i be the agricultural input variable, and keeping all other variables X_j constant, the rural-urban migration indirect elasticity of X_i is:

$$\eta_{M.Xi/Xj} = \left(\frac{\partial M}{\partial X_i}\right)\frac{X_i}{M} = \left(\frac{\partial M}{\partial WR}\frac{\partial WR}{\partial Y_A}\frac{\partial Y_A}{\partial X_i}\right)\frac{X_i}{M} = \left[\left(\frac{\partial M}{\partial WR}\frac{WR}{M}\frac{M}{WR}\right)\left(\frac{\partial WR}{\partial Y_A}\right)\left(\frac{\partial Y_A}{\partial X_i}\frac{X_i}{Y_A}\frac{Y_A}{X_i}\right)\right]\frac{X_i}{M}$$

$$= \left[\left(\beta_{M.WR}\frac{M}{WR}\right)\left(\frac{\delta WR}{\delta Y_A}\right)\left(\alpha_{Y_A.X_i}\frac{X_i}{Y_A}\right)\right]\frac{X_i}{M} \tag{15}$$

Where, WR= wage ratio= 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 6

ESTIMATION AND RESULTS

In this 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 doing so, the estimation and the variables will be defined and the data sources specified.

6.1 Definition of Variables and Data Sources

As stated before, this research uses demographic and economic data from Senegal that covers a period of 36 years, from 1961 to 1996. All variables were transformed into natural logarithms, following the empirical foundation presented in the previous chapter. Agricultural output and inputs have been expressed in units of arable land, except for farm 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).

6.1.1 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) and are converted to US$ by using official annual average exchange rates from IMF (1998 and earlier issues), then expressed in constant thousands of US$ (1982-84) using the US consumer price index (Statistical Abstracts of United States, 1994, 1997).

6.1.2 Labour (L)

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

6.1.3 Fertiliser (F)

Fertiliser is measured as the quantity of nitrogen, potassium and phosphorous used, and 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).

6.1.4 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 is the fact that there is a lack of efficient credit markets and hence the supply and implementation of machinery is limited. Credit markets are critical not only for equipment acquisition but for financing the ongoing cost of repairs and parts. Tools commonly used in traditional farming systems are the hoe and the machete, with which land is prepared for planting at a rate of almost 0.5 hectares per worker (Arnon 1987) or two hectares per family (FAO 1981). In high temperature countries such as in Senegal and with a diet of 1,500 kcal/day, farmers 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).

6.1.5 Livestock (S)

Livestock as part of the agricultural productivity equation refers to 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 their animals' value without the need for external supplies from industrial and service sectors. More specifically, livestock furnishes agricultural production with three inputs. First, it provides crops with fertiliser in the form of organic manure. Second, animal traction is used 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) are supplied by the industrial sector (Arnon, 1987). The initial capital investment required is low, as are operating and repair costs. Animal traction does however permit an increase in acreage per worker, but not necessarily an increase in crop yield, as only marginal lands often remain available for cultivation and sometimes an increased use of fertiliser is required. For example, in Gambia, animal traction allowed an increase of 20-25% in tillable land but only led to increased productivity after fertiliser was applied (FAO 1981).

Finally, animals contribute to the farm economy by providing monetary security in the form of savings and investments. Indeed, due to a lack of financial means, farmers use animals as savings, selling them occasionally to buy agricultural inputs such as seeds, chemical fertilisers or pesticides (Banque Mondiale, 1992). Even poor farmers manage to have one goat or pig that they sell periodically to buy food or seed, or to finance minimum required expenses.

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

Following Hayami and Ruttan (1985), in order to estimate livestock's contribution to output and to obtain equivalent animal units, each animal has been assigned a weight: 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).

6.1.6 Education (E)

The measure for education attempts to capture the quality of agricultural labour (Zvi Grilichies, 1970). Since an appropriate measure and data are not readily available, the 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).

6.1.7 Infrastructure Capital Stock (IK)

The infrastructure includes expenditures and investments in rural utilities, irrigation and drainage, rural markets, transport, commodity storage and processing facilities. It also includes monies directed to research stations and extension services. Agricultural infrastructure represents a modern capital asset that permits traditional inputs to produce to their maximum level. In many LDCs, government provides much of the infrastructure. For this reason, the national agricultural budget, converted to constant US$ (1982-84) using the US consumer price index, is used as a proxy for the net annual investment flow in agricultural infrastructure and 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 using linear extrapolation. From this annual flow data, infrastructure capital stock is constructed using the perpetual inventory method (Brown, 1972) and Aboagye and Gunjal (1999):

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

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:

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

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 while Aboagye and Gunjal (1999) set it to 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 become productive. Hence, stock from period t-1 is available for use in production during time t (Barro and Lucas, 1994).

6.1.8 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.

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

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 above formula, 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).

6.1.9 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).

$$W_A = \frac{Y_A}{P_A} \tag{19}$$

6.1.10 Implicit Agricultural Wage (W_A)

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 are no published data on 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 from individuals in the fringe sector. In carrying out these activities, these persons 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.

$$W_U = \frac{Y_U}{P_U} \tag{20}$$

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

6.1.11 Age Proportion (G)

Age proportion is defined as the percentage of the total population aged 15 -25. It is used to account for the youth factor in the migration function. If the proportion of young people in the entire population were to increase, one would expect rural-urban migration to augment. 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.

6.2 The Estimated Model

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

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

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

6.3 Identification

In order to estimate the structural parameters of a recursive system of equations, it should be verified that the mathematical formulation satisfies identification conditions. 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 combinations 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 they use variables that are impossible to identify or difficult to quantify, and hence are likely to be built using 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 above model, there are two equations and two independent variables, plus ten endogenous and exogenous variables. The first equation satisfies the order condition because it has seven variables. The second equation with three variables also satisfies the order condition.

6.4 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) (Johnson and Di Nardo, 1997). A computation of the different ACF shows that all their p-values are equal to zero. For the PACF, only the first value has a zero p-value equal to zero. Therefore, the series are stationary.

6.5 Multicollinearity and Heteroscedasticity

With the exception of fertiliser, pairwise correlation between some explanatory variables for agricultural production functions is high, a situation common for studies involving time series with 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. Further investigation is needed to assess whether multicollinearity will affect the estimates.

Based on the highest computed variance inflation factor (VIF) that is greater than 10, it can be seen that multicollinearity will affect the estimated results. The computed VIF for the agricultural output equation exceeds ten, indicating that inferences from the estimated model should be done carefully. 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. It should be noted that estimated coefficients in the presence of high multicollinearity are unbiased and have correct standard errors, although they are high (Achen 1982). High standard errors is essentially problem of a sample size, a constraint that cannot be avoided in a study involving time series single country data (36 year observations).

In the migration equation, pairwise correlation between migration question variables is low and the VIF are below 10, indicating that multicollinearity is not a problem in that case. The correlation matrices are presented in Appendix 2.

Neither of the two equations is affected by the presence of heteroscedasticity. Moreover, the full information, maximum likelihood method of estimation uses iterations, which makes the Jacobian matrix constant across cases.

6.6 Estimation Procedure

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

The FIML method used in this 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 specifications for all equations in the model, as well as an appropriate choice of the mathematical form for 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 such as the one under study, dependent and independent variables are jointly distributed, which assumes that their multivariate distribution follows the normal density function.

The objective is to choose parameters values that maximise the likelihood of observing dependent variables values. To obtain the total probability of observing the sample values for all the endogenous variables, each equation must be transformed by expressing error terms as a function of dependent variables. From that transformed function, a joint probability is obtained for any of the dependent variables values from the product of the joint probability of any of the error terms values and 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.

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

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

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

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

When Equation 23 is converted to logarithms, it becomes linear and is 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 to zero. They are consistent, asymptotically efficient and normally distributed (Jan Kmenta, 1986).

6. 7 Estimated Results and Interpretation

The model specified in the system of equations (21) was estimated on the basis of 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, which agricultural inputs would produce the effect of lowering rural-urban migration?

To choose the final model and its results, various models were estimated using the Almon distributed lag values of annual infrastructure investments. The Almon approach is aimed at measuring the weight of previous years and the current year of infrastructure investments for agricultural output. In fact, agricultural infrastructure influences output when existing levels are generally installed during previous years. The Almon approach on infrastructure was estimated using the polynomial distributed lag (pdl) model of the agricultural output equation. Its results are not shown because the use of annual flow of infrastructure investments does not capture the concept of stock embodied in the infrastructure variable. The next models were estimated by combining current values and lagged values for livestock and infrastructure, and six months of lagged values for livestock. A six-month lag for livestock was used represent the fact that it does not take a year for all domestic animals to become productive.

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

All variables, dependent as well as independent, are in logarithmic form.
Therefore, the estimated coefficients are also estimated elasticities.

** 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, eq. (1)	=	0.15	Std Errors of estimates, eq. (2)	=	0.38
Std deviation of agricultural output	=	0.81	Sdt Dev of Migration variable	=	0.66

The estimation method is Full Information Maximum Likelihood (FML).
The software used is Gaussx version 3.6.

By comparing the estimation results, based on the F-statistics, the individual t-statistics and on the coefficients of determination, the final model used for estimation includes a one-year lag for infrastructure capital stock and the current value of livestock. The results are listed in Table 3 on the previous page. Except for the Almon and the distributed lag models, the alternative models described above are shown in Appendix 3.

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

6.7.1 Direct Agricultural Output Elasticities

The estimated resultant effect of fertiliser, livestock and infrastructure elasticities on agricultural output are positive and significant. The model estimates a 1% increase in fertiliser use would increase agricultural output by 0.20%, and this is consistent with the literature on fertiliser use in LDCs. Not only is productivity enhanced by input's nutritive properties, but fertiliser is readily adopted, requiring little capital and can be applied by individual workers. Similarly, a 1% increase in the amount of resources devoted to agricultural infrastructure increases agricultural output by 0.28%, indicating the importance of infrastructure capital as a building block for the rural economy.

As for livestock, a 1% increase in the animal stocks increases total agricultural output by 1.26%. By no means however should the conclusion be made that Senegal can rely on an increase in animal numbers to modernise its agricultural production. In this arid and semi-arid environment, the number of animals is limited by the amount of pasture available. The climate also limits the quantity of organic manure that livestock can contribute to agricultural output. Part of the impact of livestock on agricultural output may however 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 with these improvements in agricultural output, it must be kept in mind that the three structural reasons for the agricultural crisis, presented in the Chapter 2, (Section 2.4) 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, meaning that marginal agricultural labour productivity is not statistically different from zero. This finding has an intuitive appeal, since it indicates that economic incentives are a key driver of rural-urban migration.

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

Surprisingly, the elasticity effect of education on agricultural output is not significantly different from zero. This is probably because there is a lack of sufficient variation over time, given that literacy rates do not drastically change from year to year. It is possible that data on farmer education, such as the number of years of schooling, would have been a better measure. The proportion of agronomists or extension services workers to encourage farmers and their families to adopt new technologies would also have been another method to try, and thus capture the role of farm education in improving production. Moreover, according to UNESCO standards, in order to make the literacy rate a reliable measure of education, workers must have completed at least four years of schooling and also have maintained their basic skills in reading, writing, and computing. In LDCs this is often very difficult since traditional rural lifestyles discourage reading and the availability of reading materials is low.

6.7.2 Direct Rural-Urban Migration Elasticities

The elasticity of the wage ratio with respect to the rate of rural urban migration amounts to 1.085 and is significant at the 5% level. For a one percent increase in the wage ratio, migration increases by 1.085%, thus it 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 urban per capita income to rural per capita income. More importantly, it adds weight to a policy aimed at reducing rural-urban migration flows by increasing per capita rural earnings via 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).

6.8 Reducing Rural-Urban Migration

From the estimated results and the above interpretation, fertiliser, infrastructure and livestock/credit reform are all inputs that can exert a positive effect on agricultural output, and hence on the agricultural per capita income. It was shown earlier that livestock contributes to output by providing organic manure and financial security. The first function could also be achieved through additional use of chemical fertilisers while the second could be better realised through credit reform. In addition, the Senegalese climate is semi-arid and is subject to frequent droughts, which limits the success of any policy aimed at decreasing rural-urban migration through increasing the number of domestic animals. For these reasons, livestock is not taken into consideration when computing the impact of agricultural inputs on rural-urban migration.

The policy to reduce rural-urban migration by agricultural investments will thus be based on the improvement of fertiliser and agricultural infrastructure. By applying the chain rule formulated in Equation 15, the policy to reduce rural-urban migration with means of the two selected inputs is summarised as follow:

The indirect elasticity of rural-urban migration with respect to factor X_i, keeping all other factors constant, is equal to:

$$\eta_{M,X_i} = \left\{ \left[\left(\frac{\partial M}{\partial WR} \frac{WR}{M} \right) \frac{M}{WR} \right] \left(\frac{\partial WR}{\partial Y_A} \right) \left[\left(\frac{\partial Y_A}{\partial F} \frac{X_i}{Y_A} \right) \right] \frac{Y_A}{X_i} \right\} \frac{X_i}{M}$$

$$= \left[\left(\beta_{WR} \frac{M}{WR} \right) \left(\frac{\delta WR}{\delta Y_A} \right) \left(\alpha_{X_i} \frac{X_i}{Y_A} \right) \right] \frac{X_i}{M} \tag{24}$$

where, β_{WR} and α_{X_i} are the estimated coefficien ts of WR and Xi,

$\frac{M}{WR}, \frac{Y_A}{X_i}, \frac{X_i}{M}$ are average ratios computed from the sample data, and also

$$\frac{\delta WR}{\delta Y_A} = \frac{\delta \left(\frac{Y_U / P_U}{Y_A / P_A} \right)}{\partial Y_A} = -\left[\left(Y_U \frac{P_A}{P_U} \right) \frac{1}{Y_A^2} \right]$$

The indirect elasticity of rural-urban migration with respect to fertiliser is equal to –2.05. This implies that ten percent increase in the quantity of fertiliser used, measured in hundred grams per hectare would result in 20.5% decrease in rural-urban migration. From the present level of rural-urban migration of 7.6% in Senegal, this reduction would be equivalent to 1.5 percentage points (i.e. 7.6*20.5%), which would bring down annual rate of rural-urban migration to 6.1%. In principle, increase in fertiliser use would bring down rural-urban migration tc reach a target annual rate.

The rural-urban migration indirect elasticity with respect to agricultural infrastructure, keeping all other factors constant can also be calculated using the above formula. The indirect elasticy of rural-urban migration with respect to infrastructure capital is to –3.22. In other words, ten percent increase in per hectare investment on agricultural infrastructure items, measured in thousand dollars per hectare, would result in 32.2% decrease in rural-urban migration. From the present level of rural-urban migration of 7.6% in Senegal, this reduction would be equivalent to 2.4 percentage points (i.e 7.6*32.2%), which would bring down annual rate of rural-urban migration to 5.2%. In principle, increase investments in agricultural infrastructure would bring down rural-urban migration to reach a desired target annual rate.

From migration theory, it was established that job opportunities in urban areas play a key role in motivating rural-urban migration. Even with low performances (see Chapter 2 above), Senegal's industrial sector still has a positive labour demand. By assuming this labour demand equal to the industrial growth rate of 2% (UNIDO, op cit.) a policy aimed at reducing rural-urban migration could target the annual migration rate of 2%. Since every 10% increase in the quantity of fertiliser used per hectare would lower the annual rate of rural-urban migration by 1.5%, to reduce rural-urban migration from 7.6% to 2% would require raising the quantity of fertiliser used per hectare by 36%.

In the case of a rural-urban migration policy based on additional investments in infrastructure capital, to reduce annual rate of rural-urban migration from 7.6% to 2% would require to raise the level of agricultural infrastructure allocated per hectare by 25%.

If the rural-urban migration policy were based on additional use of fertiliser and on more investments in agricultural infrastructure items, then ten percent increase in both inputs would reduce rural-urban migration by 52.7%, that is the sum of the two indirect elasticities. This is equivalent to a reduction of 3.63 points in the annual rate of rural-urban migration. To reach the 2% level of the urban labour demand, investments in both inputs should be increased by 13.09%.

To become effective, this suggested policy depends on three major factors. First, the investments in fertiliser and agricultural infrastructure have to lead to an increase of the agricultural productivity in rural areas. Second other factors not captured in this research (adapting and making available technology, improving farm knoweledge, rural credit, etc...), may play a key role in improving agricultural productivity or even in allowing fertiliser and infrastructure to be productive. Third, the increase of agricultural productivity induced by fertiliser and rural infrastructure investments has to lead to rise in the agricultural wages. Moreover, rural wage and agricultural productivity improvements need to be sustainable so as to change the rural population attitudes about leaving the rural area.

Chapter 7

CONCLUSION

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

Rural-urban migration continues to increase because urban workers may become quasi-employed in the fringe urban economy, buy affordable subsidized import foods and/or be supported by employed workers. This labour movement is economically difficult to interpret because it does not necessarily respond to a specific labour demand from a booming modern industrial sector. It could be interpreted as an escape from degrading economic conditions in the rural sector.

To be successful, a policy to reducing rural-urban migration and by consequence reduce urban unemployment should narrow income differentials between the two sectors. Among several possible policies that can reduce rural-urban migration, one that increases agricultural productivity, and thus indirectly increases agricultural incomes, is thought to be the best. Such a policy would be based on the fact that rural-urban migration is rooted in poor performance from within the agricultural sector.

Using a recursive system of equations adapted to rural-urban migration, this research has performed a Cobb-Douglas agricultural production function and a migration function where inputs were derived form Senegal's economic and demographic data. The findings support the hypothesis that rural-urban migration is a positive function of the ratio of urban per capita income to rural per capita income. Moreover, the result justifies the creation of a policy aimed at reducing rural-urban migration flows through increases in per capita earnings derived from increased agricultural investment. The specific results of this study show how additional use of fertiliser and improvements in agricultural infrastructure will increase agricultural output, per capita agricultural earnings, and thus will reduce rural-urban migration. Even if livestock capital has a positive impact on agricultural output, and hence a negative effect on rural-urban migration, this research does not consider it as a policy tool for the reduction rural-urban migration. This is due to Senegal's climate limits and thus limits to any possible increase in the number of domestic animals. Moreover, chemical fertiliser and a livestock credit/reform could be substituted for livestock and thus make its contribution to output through organic manure and financial security.

Ten percentage increase in the quantity of fertiliser used per hectare results in 20.5% reduction in the rural-urban migration, which is equivalent to 1.5 percentage point decrease in the annual rate of rural-urban migration. To reduce the rural-urban migration annual rate its actual level of 7.6% to a target 2% per year, which is equal to the industrial labour demand, the quantity of fertiliser (100gr/ha) used per hectare should be increased by 36%. In the case of investments in agricultural infrastructure items, ten percent increase would result in 32.2% decrease in rural-urban migration, which is equivalent to a decrease of 2.4 percentage points in the annual rate of rural-urban migration. To reach an annual rate of rural out migration of 2%, investments in agricultural infrastructure should be increased by 25%. Moreover, if the rural-urban migration policy were based on both additional use of fertiliser and investments in agricultural infrastructure capital, then ten percent increase of each these inputs would lower rural-urban migration by 52.7%, which would be equivalent to 4 points decrease of the rural-urban migration annual rate. Thus, to set annual rate of rural-urban migration to 2%, one needs to increase both fertiliser use and infrastructure capital by 13.09%.

To achieve the expected results, the policy suggested in this research has to lead to sustainable improvments in agricultural productivity and rural wages, a condition that may depend in these and on other factors not captured in this study.

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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 (%)	Infrastr. Stock ($1000Ct)	Rural Population	Urban Output $1000 Ct)	Urban Population	# of Rural-Urban Migrants	15-25 aged per 100,000 people
1961	2085	754650	1328000	33	8	1587760	17	86644	2737000	799360	1012000	4199	1676
1962	2070	728374	1357000	33	7	1720180	18	29632	2804000	815564	1044000	4750	1683
1963	2238	767835	1388000	40	8	1911530	18	29632	2874000	814170	1077000	5986	1690
1964	2285	818039	1419000	42	9	2097700	19	29632	2946000	880764	1111000	5539	1697
1965	2410	765695	1452000	58	11	2159072	20	30836	3020000	801070	1145000	5421	1703
1966	2405	761437	1486000	81	11	2415444	21	32173	3098000	886467	1172000	5973	1837
1967	2661	773813	1522000	113	11	2593850	21	32173	3178000	876907	1209000	5502	1844
1968	2496	658869	1558000	52	12	2634416	22	32173	3261000	903325	1247000	6036	1851
1969	2481	743861	1596000	33	12	2698600	23	35923	3349000	822548	1286000	5216	1858
1970	2284	598600	1636000	34	13	2722100	24	38860	3439000	834327	1339000	6742	1865
1971	2296	716337	1674000	58	13	2814700	25	37530	3531000	833054	1393000	6550	1872
1972	2256	655696	1713000	67	14	2874100	25	39309	3626000	997758	1449000	6686	1876
1973	2361	634580	1753000	98	14	2726300	26	81002	3724000	1624047	1507000	7145	1879
1974	2484	680065	1794000	165	15	2506100	27	120794	3825000	1499177	1568000	6585	1786
1975	2574	1065059	1835000	202	16	2578870	28	122680	3928000	1655698	1643000	7375	1793
1976	2530	1014985	1877000	170	16	2649100	28	123832	4032000	1576905	1705000	16481	1800
1977	2368	889966	1920000	199	17	2727800	28	116589	4138000	1598581	1758000	17637	1807
1978	2516	710966	1963000	151	18	2830370	29	121285	4246000	1833150	1824000	18095	1815
1979	2277	903942	2007000	124	19	2844000	30	130371	4357000	1950339	1894000	18182	1822
1980	2428	689854	2053000	83	20	2809780	31	134859	4471000	2073584	1936000	19253	1829
1981	2462	486635	2095000	104	20	2596760	31	147659	4576000	1809698	2001000	21923	1836
1982	2411	581207	2138000	79	20	2655130	32	148119	4683000	1694108	2069000	22223	1843
1983	2136	535127	2181000	114	20	2682220	33	124722	4792000	1904432	2150000	23690	1850
1984	2135	380616	2226000	78	20	2585130	34	108082	4904000	1807483	2265000	24321	1860
1985	2297	449107	2272000	88	20	2913330	34	150219	5019000	1882484	2318000	25374	1866
1986	2130	765917	2380000	90	20	3225065	35	234606	5137000	2608651	2406000	31458	1894
1987	2207	877265	2366000	90	20	3358195	36	286030	5258000	3115095	2497000	34086	1901
1988	2240	945065	2414000	111	21	3311590	37	308725	5380000	3190234	2592000	48761	1890
1989	2146	722750	2462000	54	21	3409730	38	300436	5501000	2999198	2691000	38114	1897
1990	2242	866672	2508000	51	21	3620540	38	340256	5621000	3496478	2793000	47917	1897
1991	2103	788350	2565000	66	21	3837900	38	410051	5746000	3352244	2742000	49700	1904
1992	2355	867050	2661000	73	24	3951310	39	462064	5869000	3606606	2858000	52635	1929
1993	2350	779035	2677000	107	24	4154050	40	512257	5993000	3214376	3251000	92464	1936
1994	2365	1150409	2734000	85	23	4230350	42	557546	6121000	4130202	3389000	16620	1943
1995	2265	669905	2677000	71	24	4321300	43	487212	6254000	2524239	3555000	54948	1950
1996	2226	703320	2734000	67	24	4336520	44	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

	lnM	lnWR	lnG
lnM	1.0000		
lnWR	0.8014	1.0000	
lnG	0.6084	0.6277	1.0000

Appendix 3: Some Alternative Models

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) <u>Estimated Structural Elasticities with One-Year Lag Livestock and Current Year Infrastructure Capital Stock</u>

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) <u>Estimated Structural Elasticities with Six-Months Lag for Livestock and Infrastructure Capital stock</u>

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) <u>Estimated Structural Elasticities with One-Year Lag for Livestock And One-Year Lag Of Infrastructure Capital Stock</u>

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.