NEW CONSTRUCTION, SUBSIDIES, AND FILTERING OF DWELLINGS IN TUNISIA: A VACANCY-CHAIN AND LINEAR PROGRAMMING ANALYSIS

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ABSTRACT

NEW CONSTRUCTION, SUBSIDIES, AND FILTERING OF DWELLINGS IN TUNISIA: A VACANCY-CHAIN AND LINEAR PROGRAMMING ANALYSIS

By

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Housing problems exist in developed and less developed countries, under capitalist and non-capitalist regimes.

In less developed countries where housing is generally poor, planners have two main objectives:

1) Build the maximum number of new dwellings because of the shortage existing in the housing sector.

2) Improve housing quality and housing conditions by building average quality dwellings while reducing the number of nonauthorized dwellings and the number of homeless households.

Which strategy or combination of strategies should planners use in order to achieve both objectives, quantity and quality? Whether the poor are to be helped directly with new construction or indirectly through filtering is the main issue. The objective of this dissertation is mainly to try to give an economic answer to this issue.

We tried to answer this question by learning how the housing stock is reallocated after new construction.

First, we held an inquiry on filtering in the district of Tunis in order to test whether filtering existed, and if it

did, to determine its nature and its importance.

Second, we build a linear programming model, taking into account the filtering concept and constraints on investments, subsidies, and the number of dwellings to be developed by the public sector. The model shows what the consequences of different policies are for households and for the total quality of the housing stock.

The inquiry on filtering in the District of Tunis gave us two main conclusions.

1) Filtering down is taking place in the district of Tunis.

2) High quality dwellings and average quality dwellings have about equal "filtering effects" in the district of Tunis.

The linear programming models applied to the Tunisian case gave us the following conclusions: In a less developed country such as Tunisia, where a high percentage of the households are homeless and where investment in housing is a limiting constraint, a filtering strategy based on high quality dwellings is not adequate and will not benefit the lowest income group or the homeless households. However, a filtering strategy based on the construction of average quality dwellings constitutes a good long run housing policy.

Finally, some other housing issues related to the Tunisian case are answered in this dissertation with more or less precision, such as the particular problems of the old town of Tunis (The Medina), a typical case of housing renewal and filtering.

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TO ABDELLAZIZ AND SOPHIE,
WITH LOVE AND GRATITUDE

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CHAPTER I

INTRODUCTION

Housing is the most important durable consumer good in the economy and has unique characteristics compared with other products. Housing is tied to land, stays in one place, and is generally subject to neighborhood effects which are one type of externality. Housing is a bulky commodity and requires on-site production (except for mobile homes). Since more than ninety percent of the housing services consumed in a given year come from the existing housing stock, no sound housing policy or strategy can ignore the characteristics of the existing housing stock. Housing is expensive relative to personal income, and as a consequence, home buyers and owners of rental units usually make their purchases on credit. Housing therefore is tied to the money market and all related institutions. Finally, the housing industry is one of the most complex in any economy. It derives its complexity from the great number of partitipants involved -- the user or client, the design team, the manufacturer of building materials, the contractors and sub-contractors, the building material merchants, the banking and financing institutions, the approving authorities, etc.

For all these reasons, housing problems exist in developed and less developed countries, in capitalist and non-capitalist

regimes. Housing was the first major sector in capitalist countries where market decisions were limited by planning constraints.

In less developed countries where housing is generally poor, planners have two main objectives: (1) To build the maximum number of new dwellings because of the shortage existing in the housing sector; and (2) to improve housing quality per household by building at least average quality dwellings and reducing uncontrolled settlements or slums and the number of homeless households.

A sound housing investment strategy is not only concerned with allocating newly built dwellings to their occupants. Many of these occupants vacate dwellings that will be occupied by others who, in turn, may leave vacancies. This "vacancy chain" ends when a newly formed or migrant household takes possession or when a vacated dwelling is demolished. The disappearance of a household through death or emigration, like new construction, creates a vacancy and starts the chain. Rising incomes also make families wish to move from a cheaper to a better dwelling. These economic and demographic processes go on continually, and a housing investment strategy must be appraised in terms of its effect on total housing supply and use.

Which strategy or combinations of strategies should the planners use in order to achieve both objectives (quantity and quality)? Whether the poor are to be helped directly with new construction or indirectly through filtering is the main issue. The objective of this dissertation is mainly to try to give an

economic answer to this issue. However, before explaining the purpose of this study, let us define the filtering concept. What is filtering?

The meaning of the concept of filtering is not clear. Traditionally, filtering has been defined in terms of changes in the real value of an existing unit of the housing stock. For some economists such as Lowry (1), Ratcliff (2), Fisher and Winnick (3), and Rodwin (4), filtering exists because the real value of a given housing unit declines over time. For example, Ratcliff defines filtering down "as the changing of occupancy as the housing that is occupied by one income group becomes available to the next lower income group as a result of decline in market price" (2). Lowry defines filtering "as a change in the real value (price in constant dollars) of an existing dwelling unit" (1). By this definition, the dwelling unit can filter up in value as well as down. The divergence between Ratcliff and Lowry is mainly due to the definition of the notion of quality decline; while Ratcliff has stressed the role of style and technical obsolescence, Lowry has stressed physical deterioration of the dwelling as the main cause of the real value decline which leads to the filtering down of the housing unit.

Another definition of filtering given mainly by Smith (5, 6) and Strassmann (7) takes into account the fact that the households occupying the dwelling before and after the move belong to different income groups without considering the change in the real value of the dwelling. For example, Strassmann writes, "A dwelling has

filtered if it is used by a different income group than that of the initial occupants for who it was built" (7). If the dwelling was intended for an average income household and is now occupied by a high income household, the dwelling has filtered up. Also, if the dwelling is presently occupied by a low income household, then, it has filtered down. Throughout this dissertation, we will use this definition of filtering. We will assume that each type of dwelling is intended for a particular income group considering the average income per household and its capacity to pay for housing and the average value of that type of dwelling. Whenever a dwelling is occupied by a higher income group than the one it was built for, we have filtering up, and whenever it is occupied by a lower income household than the one it was built for, we have filtering down. Assuming the cost of housing occupancy as being constant, if the real income of the household increases, this household is expected to upgrade its housing by moving into a higher quality dwelling. If it does not move (because it cannot or it refuses) we have a case of filtering up, although no physical movement of the household took place. On the other hand, if the real income of the household decreases and this household does not move to a lower quality dwelling, the present dwelling unit of the household filters down.

With this definition of filtering, the theoretical number of filtered dwellings (upward and downward) can be much higher than the observed number changing occupants in the housing market.

The empirical analysis of filtering can be approached in several ways. The main approach would examine the sequence of moves which are generated as a result of the construction of a new housing unit. This approach has been used to study filtering in U.S. cities by Kristof (8), Clifton, Lansing and Morgan (9) and the City of Detroit (10) and will be used in this dissertation to study filtering in the District of Tunis (Tunisia). The process of filtering has previously been unexplored in less developed countries.

Purpose of the Study

Our purpose is to explore the indirect effects of a housing investment strategy in terms of its effects on total housing supply and use. If upper income groups are allowed to build for themselves and if lower groups are helped with credit and subsidies, a complex pattern of upward and downward transfers or "filtering" will result. A housing strategy should anticipate these chain of transfers so that it may aim at a realistic optimum, given constraints on resources.

The problem is complex but not insoluble. The complexity may be reduced by abstracting from urban location and family size and other matters that encumber the SMALA model (12) used in France. If a number of relations may be assumed linear with constant returns to scale, then linear programming techniques may be used for the solution.

Another objective of this study is to try to give an economic answer to the question whether in a less developed country

such as Tunisia the poor are to be helped directly with new construction or indirectly through filtering. Should the new dwellings be of high quality, average quality, or low quality? Should all subsidies be given to the lowest income households, helping them to get new dwellings or should subsidies go to the average income groups? What are the indirect consequences of new construction? If rich people move to new housing, do poor people benefit indirectly by moving into vacancies farther along in the sequence?

We will try to answer these questions in two stages:

First: We will hold an inquiry on filtering in the district of Tunis, in order to test whether filtering exists and if it does, to determine its nature and its importance.

Second: We will build a linear programming model taking into account the filtering concept with other constraints on investment, subsidies, the number of dwellings developed by the public sector, demand, etc., and see what the consequences of different policies are for the housing conditions of households and on the quality of the housing stock.

We shall try to show in this dissertation how in a less developed country the two objectives that the planners want to reach (quantity and quality) are not completely contradictory, and how a public policy of a minimum number of subsidized dwellings constitutes the best housing strategy.

We will also show how a filtering strategy based on high quality dwellings is not adequate for a less developed country such

as Tunisia and will not give any benefit to the lowest income group or to homeless households.

Finally, some other housing issues related to the Tunisian case are answered in this dissertation with more or less precision, such as the particular problems of the Medina of Tunis[a] and its future, which is a typical case of housing renewal and filtering.

Chapter Arrangement

Chapter II gives the reader background for the application of the model to the Tunisian case. In this chapter we describe the housing stock and supply in Tunisia. Then we estimate the housing needs and the income elasticity of the demand for housing. Finally, we will describe housing finance and the role of the government in housing.

In Chapter III, the inquiry on filtering in the District of Tunis is reported. In this chapter, we ask what the nature of filtering in Tunis is. What is its importance? What are the dwellings and the households that participate in this chain of moves?

Chapter IV is a special case study of housing renewal and filtering in the Medina of Tunis. We mainly analyze the consequences of different renewal policies for the Medina and its population.

In Chapter V, we build our linear programming models and explore the different consequences of housing policies for households

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(a) Medina = old town of Tunis (c.f. Chapter IV).

and the quality of the dwelling stock.

Finally, in Chapter VI, the main results of this dissertation will be summarized and discussed.

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CHAPTER II

HOUSING IN TUNISIA

Since the model that is going to be developed in this dissertation will be applied to Tunisia, a presentation and a description of the housing sector in Tunisia is necessary.

Housing data, statistics and literature are inadequate for Tunisia, but one study was carried out in 1973 for both US/AID and Societe Nationale Immobiliere de Tunisie (SNIT) by a group of American economists (J.W. Christian, F.J. Senold, J. Stafford and A.N. Notaw) (1). This study is the most complete survey of the housing sector in Tunisia, but even it is mainly descriptive and not very analytical.

Another important study was carried out by the I.N.S. or National Institute of Statistics (2) on consumption and expenditures of the households in Tunisia between 1965 and 1968. For the first time an income elasticity of demand was estimated for Tunisia. Existing statistics and data are mainly provided by the I.N.S. census in 1966 (3) and by different commissions and reports of the Ministry of Planning (4, 5).

Finally, special case studies carried out for SNIT, such as one about "Cite Ibn Khaldoun" by SCET-I (6) could provide us with some information about the housing section in Tunisia.

We will present the housing stock and supply in section one, showing how bad housing conditions are in Tunisia.

In section two, an estimate of the absolute needs in housing for the period 1973-87 will be carried out, and an attempt to estimate the income elasticity of demand for housing will be made. Finally, a description of housing finance and of the role of the government in the shelter sector will be carried out in section four.

Section 1. Housing Stock and Supply

This section contains a profile of the housing stock of Tunisia.

1. Housing Conditions in 1966:

According to the last nationwide census conducted in 1966, the housing stock of Tunisia (1966 population of 4.72 million persons) was estimated at 874,000 units. Tables 1 - 3 contain a detailed presentation of the 1966 housing stock by type of housing unit, form of occupation, size, and housing installations.

A. Dwelling Types:

Note: One dinar is equal approximately to two U.S. dollars (1 dinnar = US $2.00).

Table II-1 (a). Housing Stock of Tunisia, 1966 (Dwelling types) (Number of dwelling units)

Dwelling Types	Number of Dwelling Units	%
Single Family	355,171	40.6
Apartments	34,018	3.9
Semi-detached dwellings (b)	99,836	11.4
Gourbis (c)	347,105	39.7
Others (d)	37,819	4.4
Total	873,949	100.0

(a) Source: National Institute of Statistics, 1966 Census, Tunis.

(b) Semi-detached dwellings include all the traditional dwellings existing in the old towns (Medinas). Many are oukalas (c.f. Chapter 4, pp. 76 for the definition of an oukala).

(c) Gourbi is a semi-permanent hut of brush or other readily available materials.

(d) The census specified "other" units as tents, ruins, buildings not intended for housing, and other unacceptable types of permanent accommodation.

Notice the relative importance of "single-family" dwellings (40.6 percent) and "gourbis" (39.7) percent). If we define as non-authorized dwellings those that are built without a construction permit given by the Ministry of Housing of the local municipality, we estimate the total number of nonauthorized dwellings to be 385,000 units or 45 percent of the housing stock. (These dwellings are the last two categories in Table 1 = gourbis and other units.)

The total number of apartments is equal to 34,000 units and represents only 3.9 percent of the total stock. This low share is explained by the fact that apartment life is still unfamiliar to most Tunisian households. Seventy-five percent of all apartments are located in the District of Tunis.

B. Size: The latest information available (1966 census) indicates that the vast majority of the dwelling units which make up the Tunisian housing stock are one-room and two-room units. This type of dwelling accounts for approximately 85 percent of the total housing stock. A detailed breakdown is given in Table 2.

Table II-2. Distribution of dwellings according to number of rooms (3)

Number of Rooms	Number of Dwellings	Percentages	Cumulative Percentage
1	530,000	60.6	60.6
2	212,200	24.2	84.8
3	79,500	9.1	93.9
4	29,600	3.5	97.4
5	8,700	1.0	98.4
6 and more	5,800	0.7	99.1
Undetermined	8,100	0.9	100.0
Total	873,900	100.0	

If we take as an acceptable maximum two persons per room and since the average Tunisian household is composed of 5.2 persons, therefore 85 percent of the Tunisian dwellings (units having less than three rooms) are overcrowded.

C. Housing Installations: We shall study the quality of housing in Tunisia by observing availability of potable water and electric power supply which are considered necessary in any dwelling with a minimal level of comfort.

1) Potable water supply: The 1966 census reveals that only 14.7 percent of dwelling units were supplied with potable water through a public (pressure) piped system; 33 percent of the units obtained their water from cisterus and 52 percent of the units had access only to individual or communal wells.

2) Electric power supply: Also as of 1966, only 23.8 percent of housing units have electric power in Tunisia. Seventy-six percent of the units do not have electric power.

D. Mode of Tenure: As shown in Table 3, the Tunisian housing stock is largely owner-occupied, with 72 percent of the units falling into this tenure.

Table II-3. Forms of Occupation (3)

Mode of Tenure	Number of Dwellings	Percentage
Owner	620,000	71.2
Tenant	133.000	15.3
Supplied by Parents	51,000	5.9
Supplied by Employers	30,000	3.4
Other (a)	40,000	4.2
Total	874,000	100.0

(a) We include in "other" about 1,046 institutional units existing in 1966.

Notice that more than 80 percent of the squatter houses are owner-occupied. This form of ownership is very particular since the squatter house is generally built on land which does not belong to the squatter.

§2. Housing Supply

The combined efforts of the public and private sector over the 1962-72 period resulted in the construction of 105,412 housing units, as shown in Table 4.

Table II-4. Housing Production, 1962-72
(Number of units) (4)

Numbers Per Sector / Periods	Public Sector	Private Sector	Total	Annual Number
1962-64	14,800	15,300	30,100	10,033
1965-68	11,100	20,200	31,300	7,825
1969-70	7,473	11,600	19,073	9,536
1971-72	12,742	12,097	24,839	12,219
Total (1961-72)	46,115	59,197	105,312	10,531

Between 1962 and 1972 the average investment in housing was 12.3 percent of national investment (gross domestic capital formation) and 2.9 percent of gross national product (G.N.P.). According to the UN yearbook of housing statistics (7) a number of 8 to 10 dwellings per year per thousand persons is considered as minimum in order to improve the housing conditions of a country. Tunisia has only built an average of two dwellings per year per thousand inhabitants.

§3. Estimation of the Housing Stock and Conditions in 1972

Since for all our projections in this dissertation (c.f. Chapter 5), 1972 is going to be our base year, an estimation of the housing stock and conditions for this year is necessary.

In 1972, the Tunisian population was 5,303,000 persons, suggesting approximately 1,020,000 households (we assume as the National Institute of Statistics (3) that the number of persons per household is equal to 5.2). The number of authorized dwellings built between 1966 and 1972 with construction permits was 74,229 units (4). If we assume that households without authorized dwellings are either homeless or living in nonauthorized units, we can therefore estimate the housing stock and conditions for 1972 (c.f. Table 5).

Table II-5. Housing Stock in 1972 (4)

Periods	Authorized Units	Nonauthorized Units	Total
Stock 1966	488,900	385,000	873,900
Net New Units (1966-72)	74,200	71,900	146,100
Stock 1972	563,100	456,900	1,020,000

Notice that the estimation of the housing stock in 1972 is approximative because Tunisian statistics give only the total number of authorized dwellings (built with construction permits).

No statistics exist on dwellings built without permits (squatter-houses, gourbis, etc.).

Section 2. Estimation of the Housing Goals in Tunisia

Housing needs and housing demand of a particular country are different matters. Housing demand takes into consideration not only the household goals, but also income and ability to pay.

Wallace Smith (8) makes the distinction between housing needs and effective demand clear when he writes:

> Need may differ from effective demand, either because some of those who desire the commodity are not able to afford it, or because in someone else's judgement people who can afford the commodity are not acting in their own best interests... "Demand" is what is experienced in the market place, what actually happens, while "need" represents a judgement independent of the market place, what ought to happen.

In this section, we will estimate only the absolute goals of Tunisia during a 15 year planning period (1973-87). It is just an exercise to determine the dimensions of the housing deficit.

§1. Housing goals of the new households

A. Variables:

P_0 = population in the base year (1972)

P_t = population in the target year (1987)

F_0 = number of households in the base year

F_t = number of households in the target year

$\Delta F = F_t - F_0$ = net number of new households during the planning period

M = total number of migrants

r = population growth rate

a = number of persons per houshold

Therefore, the total number of new dwellings required in order to satisfy the goals of all the new households that will appear during

the planning period is:

$$\Delta F = F_t - F_0 = (P_t \pm M)(\frac{1}{a}) = [P_0(1 + r)^t \pm M][\frac{1}{a}] - F_0 .$$

B. Different hypothesis for the Tunisian case:

1) Taking 1972 as a basic year, the Tunisian population has been estimated as 5,303,000 persons. Target year is 1987.

2) For the population growth rate we shall use a minimum rate equal to 2.5 percent and a maximum equal to 3 percent.

3) Migration to Europe and Lybia is presently estimated by the Ministry of Planning (1) as 20,000 persons a year. For our study we will assume a minimal level of 15,000 migrants a year and a maximum of 25,000. Migration from abroad to Tunisia is supposed to be zero. We will ignore migration within Tunisia because rural-urban migration has not yet been thoroughly estimated.

4) We assume 5.2 persons per household (a = 5.2) after subtracting emigration abroad.

C. Housing goals of new households:

$$\Delta F = [P_0(1 + r)^t \pm M][\frac{1}{a}] - F_0 .$$

1) Minimum hypothesis:

$$\Delta F = [5,303,000(1 + 0.025)^{15} - 375,000][\frac{1}{5.2}] - 1,020,000$$

$$\Delta F = 384.000 \text{ households}$$

2) Maximum hypothesis:

$$\Delta F = [5,303,000(1 + 0.03)^{15} - 225,000][\frac{1}{5.2}] - 1,020,000$$

$$\Delta F = 523,000 \text{ households}$$

3) Average hypothesis:

$$\frac{384,000 + 523,000}{2} = 453,500 \text{ new households}$$

§2. Housing goals with "Degourbification" policy:

Degourbification policy means replacing all insalubrious dwellings in slums or in the forms of squatter houses by new dwellings of better quality.

We have estimated the total number of nonauthorized dwellings in 1972 as 456,900 dwellings. Not all the nonauthorized dwellings are insalubrious and have to be replaced. We assume that 50 percent of the nonauthorized dwellings are insalubrious and therefore have to be replaced (maximal hypothesis) or 33 percent (minimal hypothesis).

This replacement can be carried out at an increasing rate. The housing goals for "degourbification" policy

1) Minimum hypothesis: $(456,900)(0.33) = 151,000$

2) Maximum hypothesis: $(456,900)(0.5) = 229,000$

3) Average goal: $\frac{151,000 + 229,000}{2} = 190,000$

§3. Housing goals in order to replace old dwellings after normal

Since we have already counted the nonauthorized dwellings in the preceding paragraph, we will only estimate the goals for replacement of the authorized units. We have estimated our housing stock to be 1,020,000 units in 1972 and the authorized stock equal to 563,100 units. We will assume three different rates of depreciation: a maximal rate (2 percent per year), an average rate (1.5 percent) and a minimal rate of 1 percent. We

take into account the authorized stock plus the nonauthorized stock which is not counted in the "degourbification" policy.

1) Minimum hypothesis: The housing goals in order to replace old dwellings after normal deterioration are 7,900 units per year or 118,500 units for the entire planning period.

2) Maximum hypothesis: The housing goals in order to replace old dwellings after normal deterioration are 8,690 units per year or 130,300 units for the planning period.

3) Average hypothesis: $\frac{130,300 + 118,500}{2} = 124,400$ units for the planning period, or 8,300 units per year.

§4. Housing goals in order to decrease overcrowding

We have estimated that the total number of rooms existing in 1972 was 1,663,000 or an average of 3.18 persons per room. Our objective is to decrease this rate of overcrowding to a lower rate of 2.6 persons per room (minimum hypothesis) or 2 persons per room (maximum hypothesis).

1) Minimum hypothesis: Our objective is to have in 1987 no more than 2.6 persons per room or a minimum of 2 rooms per dwelling and per household of 5.2 persons. The total number of rooms required in 1972 in order to have no more than 2.6 persons per room is $P_0/2.6$ or $\frac{5,303,000}{2.6} = 2,040,000$ rooms. Therefore the 1972 deficit was equal to 2,040,000 - 1,663,000 = 377,000 rooms or 188,500 dwellings (if we assume an average of 2 rooms per dwelling). However, since in the degourbification policy program we counted the replacement of 151,000 dwellings (minimum hypothesis) if we assume that the new dwellings built under the "degourbification" policy will respect our maximum number of 2.6

persons per dwelling, then only 37,500 new units have to be built during the 1972-87 period in order to reduce overcrowding from 3.18 persons per room to 2.6 persons per room.

2) Maximum hypothesis: Our objective is to have no more than 2 persons per room in 1987, or a minimum of 2.6 rooms for an average household (5.2 persons). The total number of rooms needed in 1972 in order to achieve this objective is 2,651,000 units. The shortage was therefore equal to 988,000 rooms or 380,000 dwellings (each unit have at least 2.6 rooms). With the maximum hypothesis of the degourbification policy, our goal is then estimated to be 151,000 new units during 1973-87 in order to reduce overcrowding from 3.18 to 2 persons per room.

§5. Recapitulation

Table II-6 shows our estimated absolute goals for housing in Tunisia during the planning period 1973-87.

Table II-6. Housing Goals in Tunisia (1973-87)
(Number of Dwelling Units)

Types of Housing Goals	Total Planning Period			Average Goals Per Year		
	Min. Hyp.	Max. Hyp.	Average	Min. Hyp.	Max. Hyp.	Average
New Household Goals	384,000	523,000	453,500	25,600	34,900	30,200
Degourbification	151,000	229,000	190,000	10,100	15,300	12,700
Replacement	118,000	130,000	124,000	7,900	8,700	8,300
Overcrowding Decrease	37,000	151,000	94,000	2,400	10,100	6,300
Total Goals	690,000	1,033,000	861,500	46,000	69,000	57,500

Then, the average annual goals for housing in Tunisia is equal to 57,500 units, or 10.8 dwellings per thousand people. The other estimations of the housing goals in Tunisia carried out by the Ministry of Planning (5), La SCET/I (6), and by US/AID (1) do not include some of the squatter settlements (or gourbis) as part of the housing stock. They consider all the nonauthorized dwellings (gourbis and squatter houses) as insalubrious and to be replaced.

In general, all the estimates of the housing goals of a particular country suffer from the pitfalls of subjective normative standards as to what constitutes an acceptable housing unit or overcrowding. Most of the standards adopted come from advanced countries and have sometimes little relevance with the economic, social or cultural patterns of a particular less developed country.

Section 3. The Income Elasticity of the Demand for Housing in Tunisia

A. Introduction:

Since the economic behavior of man is assumed to depend upon prices, preferences, and incomes, and since if one of these is constant, measurement of another enables one to reach conclusions about the third, knowing the income elasticity of demand will help one to predict activities in the housing market. Since income is by far the most important determinant of the demand for housing, it is important to know whether housing is in Tunisia a normal, a luxury or an inferior good, i.e., whether the income elasticity of the demand for housing is equal to, more than, or less than one. When a family's income increases by a certain percent, by what percent does that family increase its expenditures on housing?

This question is important to us because we wish to predict future housing demand. However, it is a very difficult question to answer.

Many economists have made estimates of the income elasticity of the demand for housing: Morton (9), Winnick (10), Muth (11), Lee (12), Reid (13), Clifton (14), Herbolzeimer (15), and others. These economists have mainly estimated the income elasticity of the demand for housing in U.S. cities. They found that the value of the income elasticity varies drastically, however, depending on the method used to measure income or housing expenditures.

The first basic problem is what measures of income should be used. Some economists have used "permanent" or "normal" income (mainly Margaret Reid). Others have used the current reported annual income (example: Lee) and finally, other economists have used as income a battery of measures related to the ability to spend of the household (example: Morgan).

The second basic problem is what measurement of housing expenditures should be used. Some economists use the owner's estimate of the value of his home (Morgan, Reid, Lee). However, this measure sometimes ignores certain housing costs (maintenance, insurance, taxes). Another problem is how to compare the housing expenditures of owners and renters and the use of a "transformation function" is required (c.f. Chapter 3).

B. I.N.S. Study:

In Tunisia, the National Institute of Statistics has carried out the only study on consumption and expenditures of the different households between 1965 and 1968, where an income elasticity of the

housing demand has been estimated (2). This study covered the expenditures of 7,150 households. It defines as "housing expenditures" all those that include rent, housing taxes, operating costs (heating, water, lights etc.), maintenance costs, costs of buying a new dwelling, and all other expenditures related to housing. The study considers as income the total household expenditures, or it assumes that saving is equal to zero.

The INS study has estimated the following income elasticities of the housing demand in Tunisia.

National level	E = 1.35
Big cities	E = 1.25
Small towns	E = 1.37
Rural areas	E = 1.27

C. Our estimation:

Since we have collected some data on housing expenditures and incomes for our inquiry on filtering in the District of Tunis (c.f. Chapter III), we are going to use these data (182 interviews) in order to estimate the income elasticity of the housing demand in the District of Tunis.

1. Hypothesis:

a. We have separated new dwellings from old dwellings and since a very high percentage of the new dwellings are owner occupied (92%) and a high percentage of the old dwellings are tenant occupied (74%) therefore, it is as if we had separated owners from renters in the housing market.

b. We have taken the current reported income as our estimation for income.

c. We have used the current rent paid by the tenant as a measurement of the housing expenditures when the dwelling was tenant occupied. However, when it was owner occupied (mainly new dwellings) we used first the monthly payment of the household to pay back his mortgage unadjusted for the downpayment, as a measure of housing consumption. Second, we adjusted the monthly payments for the downpayment. We have assumed an opportunity cost of 6 percent of the downpayment (c.f. Chapter III for more details on the transformation function used and the adjustment of the monthly payments).

2. Results:

Table II-7. Rent as a function of income

Different Groups	E_d	Number of Units	Income	Mean Rent	R^2	Rent = a + b (income)	
						a	b
a) Monthly payments unadjusted for downpayment:							
All dwellings	1.34	143	65	19	0.63	-6.62 (1.85)	0.399 (0.025)
New dwellings	1.45	91	75	23	0.67	-9.22 (2.76)	0.436 (0.035)
Old dwellings	0.92	45	55	17	0.52	1.699 (2.57)	0.277 (0.035)
b) Monthly payments adjusted for downpayment:							
All dwellings	1.065	152	65	24.7	0.65	-1.77 (1.76)	0.405 (0.023)
New dwellings	1.038	96	75	31	0.708	-1.251 (2.38)	0.429 (0.028)

Note: E_d = income elasticity of housing demand at the mean of each group

R^2 refers to the coefficient of determination and is an indicator of the goodness of fit of the regression. A perfect fit would correspond to a value of $R^2 = 1.0$.

( ) estimated standard errors of $\hat{a}$ and $\hat{b}$.

The evidence presented here suggests that the income elasticity of demand for housing is substantially superior to one when monthly payments are not adjusted for downpayment (for new dwellings $E_d = 1.45$; for all dwellings, new and old, $E_d = 1.34$). The income elasticity of demand for housing is equal to one (but always > 1) when monthly payments are adjusted for down payment (for all dwellings $E_d = 1.065$) and for new dwellings $E_d = 1.038$). Finally, the income elasticity of old dwellings is equal to 0.92.

When monthly payments (for new dwellings) are not adjusted for down payments our elasticities are close to those found by the National Institute of Statistics ($E_d = 1.25$) for big cities) (2).

We can conclude that housing is a normal good in Tunisia, i.e., the elasticity of income with respect to housing expenditure is close to one ($E_d \approx 1$) (taking the opportunity cost of downpayments into account).

However, our estimation is incomplete since we have only taken into account the income of the household. Income is the most explanatory variable, but other variables such as education, age, downpayment, maturity period, size of the households and locations are sometimes significant.

A complete analysis of demand for housing in Tunisia is necessary and has to be carried out in order to better understand the behavior of the different households on the housing market, which is needed for building new programs and policies.

Section 4. Housing Finance in Tunisia and Public and Private Institutions Concerned with the Shelter Sector

The government is extremely active in the financing of shelter sector activities particularly in the low and middle income price ranges.

Directly or indirectly, the programs of the government financed 27 percent of the investment in housing over the 1962-72 period. The residual of 73 percent was financed in the private sector.

We will study in two paragraphs the availability of funds for housing investment and the subsidy programs and role of the government in the housing sector.

§1. Availability of funds for housing investments:

A. Sources of Funds:

There is no financial institution other than the Societé Tunisienne de Banque (S.T.B.) which is engaging in long term financing of residential construction. The financing of housing in the private sector is therefore derived from relatively average term commercial bank loans to individuals, from loans made by relatives or friends, from current income, and from accumulated savings. Therefore, it is difficult to arrive at reasonably accurate estimates of the availability of funds for housing investment. We will discuss consecutively the operations of the S.T.B., the other commercial banks and the new savings bank for housing, the Caisse Nationale d'Epargue Logement (CNEL) which is designed to become an additional source of long term housing finance.

1) Societé Tunisienne de Banque (S.T.B.)

The STB was established on January 18, 1957, and it was intended to be the nation's leading financial institution. The government retains 52% of the STB's capital and exercises effective control over the policies of the bank.

STB does not provide long-term loans for housing which are not connected with the government's guaranteed loan program. In the earlier years of the government guaranteed loan programs, the role of the STB was more important than it is currently. In 1970, the guarantee program was limited to one million dinars per year and in 1973, the ceiling was increased to 1.5 million dinars per year.

The existence of a ceiling on the guaranteed loan program derives from three main policy considerations:

a) The government allows the STB to discount a guaranteed housing loan at the Tunisian Central Bank (BCT) during the first five years of the term of the mortgage. Unrestricted issuance of loans guarantees would, therefore, weaken the government's control over the money supply.

b) At the end of the first five years of the term of a mortgage, the STB must repay any borrowing from the BCT based on that security. During the remainder of the term, the STB is permitted to issue and sell securities backed by guaranteed mortgages on the open market. To the extent that these securities are not absorbed by the market, the STB is permitted to borrow from the Treasury on a short term basis. Thus, unrestricted loan guarantee issue could also expose the government budget to unanticipated pressures.

c) The third restriction on the guaranteed loan program is that the BCT limits the volume of discounts of STB home loans outstanding to 5 million dinars. 13.9 million dinars was the amount of the STB housing lending under the guaranteed loan program in 1971.

2) Other Commercial Banks:

The second source of financing for residential investment is loans made to individuals by commerical banks. The Christian report (1) estimates the total amount of these loans at 82 million dinars in 1971.

3) Caisse Nationale d'Epargue Logement (CNEL):

The National Saving Bank for Housing (CNEL) was created in 1973 and is not yet fully operating. The project calls for a contract saving system. Saving contracts will run for four years, with deposits yielding 4 percent interest compounded annually. Upon completion of the four year saving contract, the government will pay the saver a bonus equivalent to an additional 2 percent interest on the account. The saving contract is in the amount of 33 percent of sales price of economic dwellings, currently constructed by SNIT. Savings accounts can be opened only in connection with a home-loan contract.

CNEL is going to be an important additional source of long-term housing finance in Tunisia.

B. Downpayments:

Downpayments under the government sponsored housing finance programs are currently 30 percent of the purchase price. An estimate of 40 percent self-financing in the nonassisted private sector is not exceptionally high. The Christian study (1) considers 40 percent as a minimum downpayment since no real long term loans exist outside the government sponsored programs.

C. Term to Maturity:

The mortgages issued by STB under the government guaranteed loan program have a maximum of 20 years to maturity, which is the same as the government subsidy program. Information on the term to maturity of loans granted by other commerical banks for housing finance is not available. These loans are generally short term loans with an understanding between the bank and the borrower that the loan is subject to renewal.

D. Interest Rates:

Under the government guaranteed loan program, the rate of interest paid by the borrower during the first 5 years of the loan is 5.5 percent. After the first five years the rate rises to 7.65 percent for the remainder of the term to maturity. For the other commerical banks, no precise determination of the interest rates on housing loans can be made. We can estimate the interest rate to be between 7.25 and 8 percent (medium term credits).

The main conclusion is that except for the case of the STB which only gives government guaranteed loans, there are no real long term housing finance institutions and policies in Tunisia. The recently created National Saving Bank for Housing (CNEL) is going to have an important role in the future.

We will discuss in detail in the next paragraph the government subsidy program and its role in the shelter sector in general.

§2. Subsidy programs and role of the government in the housing sector

The government participates directly in the housing sector

in Tunisia in three different ways: housing production, housing finance and housing support and regulatory activities.

A. Housing production:

Direct construction by the government has been limited to "social" housing for low income families, financed under very favorable terms.

According to the National Commission on Housing and Town Planning (4) the direct and indirect participation of the government in the housing sector represented 43.7 percent of the units built during the period 1962-72 and 27 percent of the aggregate investment, as shown in Table II-8.

Table II-8. New housing construction in Tunisia (1962-72)

Public or Private Sector	Number of Units	Value (millions of Dinars)
Direct Public Construction	39,200	36.6
Loan Guarantee Program	6,915	19.5
Private Sector	59,197	150.8
Total	105,312	206.9

Most dwellings developed by the public sector were built by the Societe National Immobiliere Tunisienne (SNIT).

SNIT is an independent state corporation created in 1957. Its role is the development, finance, construction, sale and lease of low cost dwellings. Since its reorganization in 1967, SNIT has been the sole government agency for the promotion and construction of rural and urban low and moderate income dwellings.

The financial resources available to SNIT are derived from five sources:

1) Capital: SNIT's capital of 110,000 dinars has been provided exclusively by the government.

2) Government Advances: This is the major source of SNIT financing in the past. Total amount of the advances was 7.3 million dinars in 1972.

3) Downpayments: The 30 percent downpayment required of prospective purchasers is paid to SNIT as much as 18 months prior to occupancy and, thus, constitutes a significant source of working capital.

4) Amortization of Government Advances: The government has permitted SNIT to retain repayments of principal by the lease-purchaser of housing constructed under earlier programs.

5) Private Borrowings: SNIT undertook its first major borrowing on the private market in 1970 (5 million dinars). In addition, SNIT has frequent recourse to medium term bank credits.

B. Financial Role of the Government:

The finance of housing by the government has three different forms: direct subsidies and budgetary support, guaranteed loans, and the government participation in creating the National Savings Bank for Housing.

1) Direct Subsidies and Budgetary Support: We have three types of direct assistance to the shelter sector.

a) Construction Advances: These advances for state sponsored housing projects are given to SNIT which is the sole agency for the promotion and the construction of low cost dwellings.

b) Construction Subsidies: These subsidies are available to individuals or corporations who undertake the construction, extension, or rehabilitations of housing units for owner occupancy or for rent at less than certain specified ceilings. The amount of the subsidy is based on the type of construction.

c) Home Improvement Loans: These loans are granted through the Fonds National pour l'Amerioration de l'Habitat (FNAH). The main source of funds for the FNAH is a real estate tax equal to 4% of the actual or imputed rental value of the property and the amortization of loans made previously. The sole purpose of these loans is the improvement of the existing housing stock. Loans currently range up to 400 dinars with maturity of up to five years. Interest rates range from zero to 3 percent depending on the income of the borrower. This agency has not been playing an important role in improving the quality of the housing stock in several neighborhoods where this type of operation is needed. We will see in Chapter IV how the FNAH could play a more important role in the future in order to safeguard the Medina.

2) Guaranteed Loans: The second form of financial intervention of the State in housing is the guaranteed loans. The administration of this loan guarantee program for housing construction was assigned to the Societe Tunisienne de Banque (STB). During the 1962-72 period, the STB made 7,110 mortgage loans guaranteed by the government, totaling 19 million dinars. Since the initiation of this program in 1959, the STB has never had to call on the guarantee.

3) The third state intervention in housing finance was in the creation in 1973 of the National Savings Banks for Housing (CNEL) which is going to play an important role in the future (c.f. §1 of this section).

C. Support and Regulatory Activities of the Government:

The government has a number of bureaus and services performing shelter sector functions not always with complete coordination: Ministry of Planning, Minstry of Finance, Ministry of Public Works and Housing and within this last Minstry, the housing division, the town planning division, the division for land development, etc. Town planning and development are still weak in Tunisia, for instance, a certain number of master plans remain inoperative. The government has a national building code, supplemented by various municipal codes. The government also approves housing projects by giving construction permits through different commissions. Finally, one of the most important pieces of legislation passed in 1973 provides for the establishment of three land agencies for the development of tourism, industry and housing. The purpose of the housing land agency of "agence fonciere de l'habitat" is to acquire reserves of land, in part to dampen the speculative rise in land prices, which has been substantial in recent years. The land so acquired will subsequently be urbanized and sold at cost for housing developments in accordance with plans approved by the government.

Conclusion:

In this chapter we have described the housing stock and supply in Tunisia, then we estimated the housing goals and the income

elasticity of the demand for housing; finally we described housing finance and the role of the different public and private institutions concerned with the shelter sector. This is only an introductory and descriptive chapter. Its purpose is to give the reader background for the application of the model to the Tunisian case (c.f. Chapter V). The survey of housing in Tunisia is not complete since the construction industry which is an important factor in housing supply is not treated in the study.

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CHAPTER III

INQUIRY ON FILTERING IN TUNIS

Section 1. Introduction

The concept of "filtering" suggests that as well-to-do families acquire new houses, they will allow good but older dwellings to filter down to low income households. An understanding of the process of filtering is one of the basic inputs of a coherent housing policy. A knowledge of all the consequences is necessary for the intelligent selection of a housing program. A study of the concept of filtering and of its importance in Tunisia is necessary. The analysis of this concept can be approached in three different ways:

1) The first approach would examine the sequence of moves which are generated as a result of the construction of a new housing unit. When new housing units are built and occupied for the first time, the families which move into them usually leave their former homes for occupancy by others, who in turn may free homes. A chain of moves is therefore created. The effects and importance of filtering can be observed by following the succession of households and housing units. In general, a sequence of moves starts whenever there is a vacancy, and these appear in three different ways: By the construction of new housing units, by the death or dissolution of a formerly existing family unit, or by the emigration of households from a dwelling in the housing market being studied to another.

2) The second way to study filtering would be to select part of the housing market area (such as a neighborhood) and examine the changes in occupancy which occur through time.

3) The third approach for studying filtering would be to select a household and trace the changes in housing which have occurred during its life time. In this approach the constant is not the housing unit as it is in the second one, but the household.

Out of these three approaches to study filtering, the first one seems more complete since it allows us to study both moves of housing units and of households following a vacancy created by the construction of a new dwelling. It is this approach that we are going to attempt to apply in this chapter. There have been earlier studies of sequences of moves in the United States -- Frank S. Kristof in New York City in 1965 with a sample of 64 new dwellings (1), Lansing, Clifton and Morgan (2) in 17 geographical areas in the country in 1965 and 1966, with a sample of 1,139 new units, and a study by the City of Detroit (3) in 1967 (169 cases).

§1. Objectives of the Inquiry:

This inquiry examines the changes in occupancy pattern of the existing housing stock which can be directly attributed to the impact of new residential construction. The object of this study is the indirect consequences of new construction. It has the specific aims of providing empirical measures of vacancy turnover.

What is the number of moves which could be directly attributed to the construction of a single new unit?

How does a new housing unit affect the availability of units in the existant stock? Does the construction of a new housing unit

have any effect on the housing condition of the poor?

If rich people move into new housing, do poor people benefit indirectly by moving into vacancies farther along in the sequences? Or, do the sequences stop before they reach low income people? Are the sequences which start with expensive dwellings longer than those which start with moderate priced housing?

§2. The Sample:

The first step in the study was to collect a sample of new housing units built during recent years in Tunis. Only the area of Tunis and its suburbs (the District of Tunis) constitute the market area of the present study.

The district of Tunis is relatively important since it contains twenty percent of the total number of new dwellings built between 1962 and 1971. The rate of population growth is approximately 5.5 percent, which the national rate is between 1.5 and 3 percent.

A sample of 100 new dwellings built in the district of Tunis was selected taking into consideration three different proportions: The first proportion taken into account in choosing the sample was the number of new dwellings built in the suburbs and those built in the center. In our sample, 61 new dwellings were chosen in different communes of the suburbs, and 39 in the commune of Tunis. The second division was between the different values of new dwellings. This criterion is needed to determine if more expensive dwellings have longer vacancy chains. In our sample, the dwellings values vary between 800 dinars and 10,000 dinars, but most of the new dwellings chosen in the sample are of average quality (58% have values inferior or equal to 3,000 dinars and 83% have values inferior to 5,000 dinars).

This is mainly due to the difficulty of having complete interviews with rich households living in high quality dwellings. The third division was between the number of dwellings built by S.N.I.T. (4) and those built by private builders. In our sample, 39 new dwellings were built by SNIT, 15 built by the Municipality of Tunis, and 46 built by private builders.

All the dwellings were built during the years 1971 and 1972 and occupied either in 1972 or in 1973. The only exceptions were 15 apartments from Sidi-Bechir project which was built a few years ago, but which is important to our sample since it is the only project built in downtown Tunis (after the demolition of a part of the Medina).

One hundred eighty-two interviews were carried out during the whole survey; 100 during the first round, 60 during the second, 17 during the third and 5 during the fourth round.

§3. The Questionnaire:

The occupants of each new unit selected in the sample were interviewed directly. Once the interviews of the 100 new dwellings finished, a determination of the number of dwellings left vacant by the households is done, and the second round of the survey starts. During the second round, the same questions were asked to the present occupants of the dwellings left vacant by their former occupants, these interviews provided information for a third round, etc.

The questions of the survey were divided into 3 different groups.

1) Questions concerning the household-head directly: His name, age, sex, civil status, his birthplace, the date he came to

the district of Tunis (if he was not born in Tunis), his job, his income, etc.

2) Questions concerning his present dwelling: Number of rooms, housing installations, the purchasing price of the dwelling or the monthly rent, and reasons for choosing this dwelling.

3) Questions concerning the previous dwelling of the household: The exact address of the dwelling if it is located in the district of Tunis, this question is very important in order to continue the survey; was the preceding dwelling an apartment, a single family unit, an oukala? Was the household living with parents or friends? Was he a tenant or the owner of his former dwelling? What was the monthly rent paid or the selling price of the dwelling? Why did the household leave their former dwelling?

Section 2. General Characteristics of the Sequences of Moves

When a new dwelling is built in the district of Tunis it is occupied by a household belonging to one of the following categories:

1) A household which was living in the district of Tunis and which has left a vacancy.

2) A household which has left no vacancy because it was either an immigrant or a new household.

3) A household whose former dwelling was taken out of the housing stock for various reasons.

Out of these cases, only the first creates a vacancy and therefore contributes to the filtering sequences.

We are going to study in this section the length of the sequences of moves in the district of Tunis, how these sequences end,

and we shall see whether the length of these sequences depends on the value of the initial new dwelling.

§1. The Length of the Sequences of Moves:

What is the average length rate of the sequences of moves? We could estimate this rate by dividing the total number of finished interviews by the initial number of new dwellings chosen in the sample:

-- Total Number of Finished Interviews	182
-- Total Number of New Dwellings	100
-- Average Length Rate of the Sequences of Moves in the District of Tunis	1.82

However, the sequence is longer than that if we take into account the number of interviews unfinished because the dwelling was still empty, part of a large oukala, located in a squatter area, or because no contact could be made at the given address.

In order to estimate the real length rate of the sequences of moves, we have to compute as Lansing, Clifton and Morgan [2, pages 83-85] the different loss rates at different positions. This is shown in Table III-1.

Table III-1. Number of sequences which theoretically survive to indicated positions, from an initial 100 new dwellings, based on estimated loss rates.

Position	Number at this Position	Estimated loss Rates	Loss
1	100	40%	40
2	60	51%	31
3	29	61%	18
4	11		7
5	4	60%	3
6	$\frac{1}{205}$		$\frac{1}{100}$

The average length equals 2.05, or for each new dwelling built in the district of Tunis, approximately two vacancies are created in the existing housing market. Notice that our response rate (total number of finished interviews (182) over the total number of possible interviews (205) is equal to 88.7 percent.

If we compare our ratio (2.05) to the U.S. ratios of Kristof (2.4), Lansing, Clifton and Morgan (3.5) and the City of Detroit (1.5), we notice that the number of vacancies created in the District of Tunis is not very different from the U.S. numbers; it is even bigger than the number of vacancies estimated in Detroit.

§2. How the Sequences End?

The length of the sequences of moves is more important if we understand why and how the sequences end. A sequence ends when it does not create a vacancy. In our case, this occurred when the former dwelling was removed from the housing stock, or when the household comes from outside the District of Tunis, or when someone is still living in the previous dwelling. The move, therefore, did not create a vacancy. The importance of these different reasons are shown in the following table.

Table III-2. Why the sequences of moves end, distribution of reasons.

Distribution of Reasons	Round I	Round II	Round III	Round IV	Total
Total number of interviews	100	60	17	5	182
Number of vacancies created	60	17	5	0	82
Moves without vacancies	40	43	12	5	100
The household is an immigrant	4	7	1	0	12
Newly formed household in dwelling	22	9	4	2	37
Previous unit has been demolished	14	0	3	0	17
"Oukala" or a squatter area	0	10	2	3	15
Dwelling was still empty	0	6	1	0	7
Present unit no longer in H/stock	0	2	0	0	2
No contact could be made	0	9	1	0	10

The most important reason why the sequences of moves end is that the present unit is occupied by a newly formed family. This means a household which has left no vacancy, leaving their last dwelling still occupied by someone. We have in this category all the households which were living with their parents either before the marriage or even after. Thirty-seven of the endings are due to this reason in all rounds. In the first round this rate is higher (55%) and due to the fact that a large number of newly married couples in Tunisia prefer to live with parents after the marriage (the husband's parents in general) until they save enough money to have a new dwelling built for them. Since these households

living with their parents do not pay rent in general, they can save a higher percentage of their incomes and move in a shorter time than those with equal incomes not living with their parents into new dwellings.

The second important reason why sequences end is that the previous dwelling has been demolished. This means that the structure has been physically destroyed deliberately to clear site for a new use (construction of a new residential area, build a road, a garden, a shopping center, etc.). This reason represents seventeen percent of the ends in all the sequences. This rate is higher in the first round (35 percent) because many households who had their dwellings destroyed deliberately in one area, were given new dwellings in other areas of the city. For example, in the Sidi-Bechir project where the new apartments were built after a demolition of a whole block in the Medina, 4 out of 7 ends (57 percent) are due to the demolition factor.

The third reason why the sequences of moves end is that the household was either living in an "Oukala" or in a gourbiville (a squatter area). Since an oukala is a large traditional house in the Medina of Tunis where the rooms are occupied by different families having in common the central area of the dwelling (patio or inner court) the bathroom, and sometimes even the kitchen, therefore it is very difficult to know exactly which room was vacated, who is living there now, etc.

We will show in the next chapter the importance of the Medina as a transient quarter playing the same role as a squatter area.

No household has left a squatter house or an oukala to a new dwelling directly because of their low incomes. They have to move to another old, but better quality dwelling in the Medina or a modest suburb, and finally move from there to a new dwelling, if their incomes increase.

The fourth reason why the sequences end is that the household is an immigrant coming from outside the District of Tunis. Twelve percent of the ends are due to this factor. This immigration factor exists in all rounds, which means that the immigrant is not always poor, as not only poor migrate. The District of Tunis is the political, cultural (the only University of the country) and the economic center of the country. If we take into consideration the birthplaces of the household heads who were interviewed, we notice that 65 percent of them were not born in the area of Tunis.

Seven percent of the ends are due to the fact that the dwelling was still vacant at the period of the interview. The vacancy rates are equal successively to 10 percent and 6 percent in the second and third rounds. No vacancy existed in the fourth round. Therefore, the vacancy rate (vacant dwellings/total number of dwellings) is decreasing.

Note that 10 percent of the ends are due to the fact that no contact could be made at the given address (nonexistent numbers in the street, nonexistent street, etc.). However, this loss is probably not important since it only represents 5.4 percent of the total number of interviews.

§3. Does the length of the sequences depend on the value of the new dwelling?

Our sample of new dwellings includes units having different values (between 800 and 10,000 dinars). We are now concerned with the relation between the price of a new dwelling at position one and the length of the sequence, in order to know whether the sequences starting with expensive dwellings are longer than those starting with moderate priced ones.

Table III-3. Length of sequences and value of new houses

Values of the New Dwellings (D)	Number of New Dwellings (1)	Total Number of Moves (2)	Length of Sequences (3)
0 - 1,500	12	14	1.17
1,501 - 3,000	46	82	1.75
3,001 - 5,000	25	51	2.04
More than 5,000	17	35	2.06
	100	182	1.82

NOTE: Column 3 is obtained by dividing (2) by (1). The number of new dwellings is included in the total number of moves.

As shown in Table 3, inexpensive houses (less or equal to 1,500 dinars) initiate short sequences (only 1.17 moves per dwelling) while relatively expensive dwellings (more than 5,000 dinars) initiate longer sequences (2.06 moves per dwelling). However, dwellings values between 3,000 dinars and 5,000 dinars and those valued more than 5,000 dinars initiate sequences having approximately the same length.

Therefore, average quality and good quality dwellings have longer sequences than low quality units. However, high quality dwellings (valued more than 5,000 dinars) do not have longer sequences than the average quality ones (between 3,000 and 5,000 dinars). This result will be important for our application of the linear programming model to the Tunisian case (c.f. Chapter 5).

Section 3. Characteristics of the Dwellings at Different Sequences

If filtering down is taking place, the successive housing units involved in the sequence of moves ought to be characterized by successively lower values on the average and by lower quality dwellings. Also to be verified is whether dwellings at different positions in the sequences differ systematically in their locations within the district of Tunis. We will see in this section what are the different types of dwellings existing at different positions? What is the rent or selling price of successive dwellings? What is the quality of successive dwellings? What is the location within the District of Tunis of successive dwellings?

§1. Different dwelling types:

Table III-4. Different Dwelling Types at Different Positions

Positions	Detached Units		Semi-Detached Units		Apartments		Total	
	Numbers	%	Numbers	%	Numbers	%	Numbers	%
1 (New)	46	46	39	39	15	15	100	100
2	16	40	14	35	10	25	40	100
3	6	35	5	30	6	35	17	100
4	0	0	4	80	1	20	5	100
Total	68	42	62	38	32	20	162	100

Notice that the relative importances of different dwellings at different positions has not changed very much. Because of the density requirements imposed by the Municipality of Tunis and since the sequences develop inward toward the center of the city (c.f. §4 of this section) the percentage of single units (detached units) over the total number of dwellings passed from 46 percent at position one to respectively 40 percent, 35 percent, and zero percent in positions 2, 3, and 4. We will study in section 4 the percentage of households moving from one type of dwelling to another and whether these different types of dwellings constitute different housing markets or are in the same housing market.

§2. The rent or selling price of successive dwellings:

Dwellings can be either purchased or rented, therefore, we have two basically different pricing arrangements for housing. We cannot break the housing market down into two housing markets, this is not entirely satisfactory because housing units can and do change from one market to the other. A dwelling may change from owner occupied to tenant occupied. To estimate changes in "price" for a transition we have to solve the important problem of capitalization.

Since a housing unit is a long lived economic good which yields a stream of receipts and expenses over its useful life, capital theory can be useful to find its net discounted present value.

Clifton (5) says that the net discounted present value of owning the home is the sum of the net discounted present value of the receipts stream plus the net discounted value of the expenditures

streams or $NDPVH_0 = NDPVR_0 + E_0$ where $NDPVH_0$ is the net discounted present value of owning the home, $NDPVR_0$ is the net discounted value of the receipts stream and E_0 is the net discounted value of the expenditures stream (at time 0).

$$NDPVR_0 = \frac{(1-D^n)}{1-D} R + D^n HV_n$$

where D is the discount rate per month $(D = \frac{1}{1+i})$

R = the monthly rental value

HV_n = the value of the house in year n (when it is sold)

$$E_0 = -HV_0 - \sum_{j=0}^{n} D_j (C_j + I_j + T_j)$$

HV_0 = the current price of the home

C_j = maintenance expenditures

I_j = expenditures of insuring the home

T_j = taxes expected to be paid

Our purpose is this paragraph is not to solve the problem theoretically, but to find a transformation function that could be used in this chapter for the conversion of dwelling values into monthly rents.

If we assume that the value of the housing services provided by a dwelling every month is represented by its monthly rent, therefore a transformation function is only needed for owner occupied dwellings. In our sample 107 dwellings are owner-occupied; 92 (or 86%) are new units belonging to position one and have never been rented before. The 15 other dwellings have not been rented recently (after the moves). Therefore, we cannot use a recent rent and compare it to the selling price of the dwelling in order to

estimate the transformation function.

Since 86% of the owner occupied dwellings are new, we can use a transformation function taking into account the monthly payment made by the new owner to pay back his mortgage, plus the opportunity cost of the downpayment, or $R = C + B$ where R is the monthly rent we want to estimate, B is the monthly payment made by the new owner of the dwelling to pay back his mortgage and C is the opportunity cost of his downpayment.

If we assume that the value of a new dwelling (V) is equal to the downpayment (D) plus the mortgage credit obtained from the bank (M), or $V = D + M$ where $D = a\,V$ with $0 \leq a \leq 1$ and $M = (1 - a)V$ then,

$$B = \left[\frac{(1-a)V(r)}{1-(1+r)^{-n}}\right]\left[\frac{1}{12}\right]$$

where r = the annual rate of interest of the mortgage

n = the duration of the mortgage (years)

and i = the rate of interest of the opportunity cost (yearly rate)

and $C = [(i)aV]\left[\frac{1}{12}\right]$.

Then $R = C + B = \left[(i)aV + \frac{(1-a)V(r)}{1-(1+r)^{-n}}\right]\left[\frac{1}{12}\right]$.

In the case of Tunisia, if we assume $a = 0.3$ (downpayment equal to 30 percent of the value of the new dwelling), $i = 6\%$ (the rate of interest of the opportunity cost equal to 6 percent per year), $r = 8\%$ (the mortgage interest rate equal to 8 percent, which is

the most used rate in case of home construction) and if $n = 15$ years, then $R = 0.88$ percent of V, or the monthly rent of a new dwelling is equal to 0.88 percent of its value.

If we consider that the real mortgage rate of interest in a country like Tunisia where capital is scarce must be superior to 8 percent and assume that it is equal to 12 percent, then R will be equal to $0.01V$ or to one percent of the value of the new dwelling. Notice that this percentage corresponds exactly to the rule of thumb which states that monthly rent is equal to one percent of the value of the dwelling.

In our study, we will use $R = 0.01V$ as our transformation function.

If we compare the average monthly rent of a new dwelling with the rent of the one at the last position in the sequence we will notice a decrease of 47.6 percent.

Table III-5. Rent of the last dwelling in the sequence of moves compared to the rent of the first one.

Number of Moves	Average Monthly Rent of the New Dwelling (D)	Average Monthly Rent of the Last Dwelling in Sequence	% Decrease	Number of Cases
2	33.4	16.6	51.3	41
3	37.3	24	33.7	11
4	35	14.8	52.8	5
Total	34.3	18	47.6	57

Filtering down is taking place since the successive housing units in the sequences of moves are indeed characterized by successively lower values.

Since the average monthly rent of the last dwelling in the sequence of moves is not lower than 14.8 dinars, we may conclude that although filtering down exists and is actually taking place, it only influences middle income group households, it does not reach very low income groups since they could not pay such rent. This conclusion will be tested when the income of successive households is analyzed.

Notice that the owners of the rented dwellings take the opportunity of a move in order to increase rent. Out of 40 cases, 27 tenants are paying higher rents than the previous ones for the same dwellings (67.5 percent) only 4 tenants pay the same rent (10 percent) and 9 tenants pay lower rents (22.5 percent). The average rent increase is approximately equal to 50.7 percent. Units with average monthly rents equal to or below 15 dinars had higher increases (56.6 percent) than units with average monthly rents above 15 dinars where rents increased by 34.8 percent. We may explain this situation by the fact that since rents are only raised after moves, and lower cost houses are those where that hasn't happened in a long time, therefore the increase in rent is expected to be higher. Another explanation is that the demand for low cost housing is more important in the District of Tunis than the demand for relatively more expensive dwellings.

§3. Quality of successive dwellings:

We are going to assume that the quality of a dwelling is represented by two criteria: the first one is the size of the dwelling (the number of rooms) and the second one is the housing

housing installations (w.c., kitchen, water room[a], bathroom).

Successive housing units are smaller in size since the average number of rooms per newly built dwelling is equal to 3.18, while the average of the last dwelling in the sequence (position 4) is equal to only 2 rooms per dwelling. This decline is one more indication that filtering down is taking place. However, the average number of rooms per dwelling never goes below 2 while 60 percent of the dwellings in Tunisia have less than 2 rooms. This fact may confirm our precedent conclusion that the filtering phenomenon does not influence the lowest income groups.

Table III-6. Distribution of dwellings according to the number of rooms at different positions

N of Dwellings at Position \ N of Rooms	1	2	3	4	5	Total	Average N of Rooms Per Dwelling
Position 1	0(0)	8(8)	72(72)	14(14)	6(6)	100(100)	3.18
Position 2	1(2.5)	18(45)	15(37.5)	4(10)	2(5)	40(100)	2.7
Position 3	3(17.6)	9(52.9)	2(11.7)	2(11.7)	1(5.8)	17(100)	2.3
Position 4	1(20)	3(60)	1(20)	0(0)	0(0)	5(100)	2.0
( ) are percentages							

(a) Water room = a small room with a faucet used as a laundry room and as a bathroom.

Table III-7. Housing installations of successive dwellings

Housing Installations N of Dwellings at Different Positions	a	b	c	d	Total
Position 1 (new)	0(0)	5(5)	55(55)	40(40)	100(100)
Position 2	6(15)	17(42.5)	11(27.5)	6(15)	40(100)
Position 3	6(35.2)	7(41.1)	4(23.5)	0(0)	17(100)
Position 4	4(80)	1(20)	0(0)	0(0)	5(100)

( ) are percentages

a = w.c. only
b = w.c. and kitchen
c = w.c., kitchen, and water room
d = w.c., kitchen, and fully equipped bathroom

Notice that 95 percent of the new dwellings have housing installation of type c or d, and only 5 percent have only w.c. and kitchens. In position 2, 57.5 percent of the dwellings have neither water rooms nor bathrooms, and 15 percent of the dwellings do not even have kitchens. In position 3, 76 percent of the dwellings have housing installations of types a or b, and 35 percent are not even equipped with kitchens. Finally, in position 4, no dwelling is equipped with a water room or a bathroom, and 4 units out of 5 have no kitchens.

Therefore, successive dwellings have lower housing installations, which means that filtering down is not only taking place but is also improving the housing stock of the District of Tunis.[a,b]

(a) When a household does not have a kitchen, it cooks its meals in the inner court of the house, since most of the dwellings without kitchens are traditional and therefore have an inner court (or patio) which plays a big role in the daily life of the household.

(b) Public baths (or Turkish baths) play an important role in

§4. The location within the District of Tunis of successive dwellings:

The objective of this paragraph is to answer the following questions: Do dwellings at different positions in the sequences differ systematically in their locations within the District of Tunis? Does a policy of encouraging new construction in suburban areas have an indirect impact upon crowded conditions in the center of Tunis? Is there a tendency for the sequences to develop inward toward the center of the city as they become longer?

Table III-8. Approximate distances from the center of Tunis

Locations	Distances from the Center (km)
Medina	0
New town	1
Khadra	4
Tahrir	4
Zouhour	4
El Menzah	4
Bardo	5
Denden	7
Ariana	8
Rades	15
Goulette-Kram	15

Note: I assume the center of Tunis is the old town (the Medina)

Tunisia, and are relatively inexpensive, which could explain the high percentage of Tunisian households without private bathrooms in their homes.

Table III-9. Mean distances from the center of Tunis at different positions. (in kilometers)

Positions	Mean Distances from the Center
1 (new)	7.46
2	6.51
3	2.23
4	0.25

New construction in the District of Tunis is mainly taking place on the edges of the commune of Tunis, since the mean distance at position one is equal to 7.46 kilometers.

These new buildings do have an indirect consequence on crowding in the central city (the Medina) since the mean distance of the last position is equal to 0.25 kilometers.

Then, dwellings at different positions in the sequences differ systematically in their location within the District of Tunis, and there is indeed a tendency for the sequences to develop inward toward the Medina which is playing an important role as a transitional area.(a)

Section 4. Characteristics of the Households at Different Sequences

Successive households involved in the sequences of moves which begin with the construction of new dwellings ought to be characterized by successively lower incomes if filtering down is taking

(a) The District of Tunis is divided in 13 communes: the communes of Tunis, Ariana, Bardo, Ben Arous, Carthage, Ezzahra, Goulette, Hammam-Lif, Manouba, Marsa, Megrine, Rades, Sidi Bou Said.

place. The purpose of the present section is to verify this hypothesis and to study the other characteristics of households occupying dwellings at different positions.

§1. Owners and tenants:

Table III-10. Owners and tenants at different positions

Tenures Positions	Owners	Tenants (percent)	Total
1 (new)	92	8(8)	100
2	12	28(70)	40
3	4	13(76)	17
4	0	5(100)	5
	107	54	162

There is a big difference between the nature of tenure of new dwellings and of old ones. Ninety-two percent of the new dwellings but only 26 percent of the old ones are owner occupied. Out of these 92 units, 73 are under the category "Location-Vente" and their occupiers will be paying back mortgages during periods between 5 and 15 years.

In general, Tunisian households prefer to live in their own dwellings, especially when they are new, and as it will be shown at the end of this section, a high percentage of the moves in position one are due to this characteristic.

§2. Changes in dwelling types:

We will estimate approximately the number of households which shifted from one type of dwelling to another and try to discover if households prefer one type of dwelling to another.

Table III-11. Changes in Dwelling Types

Present Unit Precedent U.	Detached Units	Semi-Detached Units	Apartments	Total
Detached U.	20(76)	4(15)	3(11)	27(100)
Semi-Det. U.	6(19)	19(62)	6(19)	31(100)
Apartments	25(54)	11(24)	10(22)	46(100)
Oukalas	7(18)	10(40)	8(32)	25(100)
Squatter U.	3(50)	3(50)	0(0)	6(100)
Total	61(45)	47(35)	27(20)	135(100)

Notice that 74 percent of the households which were living in detached dwellings (villas) move to other detached dwellings. Only 15 percent move to semi-detached dwellings and 11 percent to apartments. However, households which were living in apartments do not prefer moving to other apartments, they move in preference to detached dwellings, since 54 percent of them move to detached dwellings and only 21 percent move to other apartments.

In general, detached dwellings and apartments are relatively more expensive than semi-detached dwellings which are mainly located in the Medina and in other popular neighborhoods, therefore, households which were living in semi-detached dwellings could not afford to move into detached dwellings and into apartments: 61 percent of those who leave semi-detached units move to other semi-detached ones.

Households living in apartments are less stable than those living in detached dwellings, since 34 percent of the moves come from apartments compared with only 20 percent from detached dwellings.

§3. The incomes of the households at different positions:

If filtering down is taking place, the average income of the households at each position is expected to decrease.

Table III-12. Average incomes at different positions

Positions	Average Income at the Position (Dinars)	Percentage Decrease/ to Position One	Number of Cases Involved
1 (new)	71	--	93
2	68	3%	35
3	57	18.5%	16
4	48	31.4%	5

The successive households involved in the sequences of moves which begin with the construction of new dwellings are indeed characterized by successively lower incomes which proves that filtering down is taking place. This decrease in average income is not important between the first and the second position, but is relatively significant in positions three and four.

The average income at position four is equal to 48 dinars. If we assume that the poorest income group in Tunisia is having an average monthly income equal to or inferior to 25 dinars (c.f. Chapters 2 and 5), therefore we may conclude that the present filtering down which is taking place in the District of Tunis does not reach the poorest income group. This verifies our finding in section three.

Fifty-eight percent of the households occupying the dwelling at the time of the interview have lower incomes than the preceding occupiers. Thirty-five percent have higher incomes and seven percent

have the same income as the preceding household. If we estimate the various rent-income ratios (R/Y) by positions, we get the following results:

Table III-13. Rent-Income ratios per positions

Positions	Average Income at Position (D)	Average Rent at Position (D)	Rent-Income Ratio (%)
1 (new)	71	32	45
2	68	21	30.8
3	57	19	33.3
4	48	15	31.2

Notice that the households in position one, where we only have new dwellings put up to 45% of their incomes in housing. This percentage is high for two main reasons:

1) We have taken into account the opportunity cost of the downpayment in our estimation of the monthly rent (c.f. Section III). If we only take into account the actual amount paid by the new owner to the bank without consideration of the opportunity cost of the downpayment, the average rent at position one decreases from its presnet level of 32 dinars to a new level of 21 dinars and the new rent income ratio will be equal to 30 percent.

2) The second reason why the rent income ratio is high in position one, is that most of the new owners have under-estimated their incomes during the interviews. This has been noticed mainly with the new owners of dwellings valued over 5,000 dinars. In positions two, three and four where the actual rent paid by the tenant was used (75 percent of dwellings are occupied by tenants)

the rent-income ratio varies between 30.8 percent and 3.33 percent.

§4. Ages and birthplaces of the household heads at different positions:

It is important to know the ages of the household heads in order to see if there is a difference in the stage of the family life cycle at different positions and if these differences influence the housing behavior of the households.

The average age of the household heads at all the positions together is 42 years. However, the average age of the owners of new dwellings is 45 years and is higher than the other positions.

-- Average age in position one = 45 years

-- Average age in position two = 39 years

-- Average age in position three = 42 years

-- Average age in position four = 37 years

Only 18 household heads are less than 30 years old and 9 are 60 and over 60 years old.

These findings may be explained by the following facts existing in Tunisia:

1) Before their marriage most of the persons live with their parents in Tunisia (when the parents are in the same area).

2) After the marriage, a high percentage of the boys continue to live in their parents homes with their wives in order to save more and to move directly to a new dwelling or to an old one of better quality than the one they would have moved in if they moved after the marriage.

These two facts explain why only 18 household heads (or 11 percent of the total number) are less than 30 years old.

3) When the parents get old (60 years and over) they prefer generally to live with their children which could explain the very low number of household heads being 60 years old and older.

Almost all the households are male (only three exceptions) and 94 percent are married, the others being divorced, widowers or singles.

Therefore, no significant differences exist between the stages of the family-life cycles of the households at different positions and most of the household heads involved in the sequence of moves are relatively young (42 years old). About thirty-six percent of the household heads were born in the District of Tunis, sixty-four percent are immigrants coming from the south of Tunisia (21 percent) from the east coast or Sabel, (22 percent) and from the northwest or Tell (21 percent).

Contrary to expectations, there is no differences between the percentages of immigrant households at different positions.

-- Position one = 66 percent

-- Position two = 70 percent

-- Position three = 53 percent

-- Position four = 60 percent

Therefore, the area of Tunis does not only attract poor people who live in the squatter areas around the city. Households belonging to different income groups migrate to Tunis for various reasons.

§5. Why do households move?

In general, when people move from one dwelling to another they improve their housing conditions (better dwelling or better neighborhood). We have asked the household heads for what reasons

they think they have moved, and we have grouped these reasons in five different categories.

1) Seventy-six percent of the households which moved in position one did it in order to become owners of their dwellings. This reason is by far the most important one given by the households occupying the new dwellings at position one. In phase two, only 6.6 percent of the households moved for this reason.

Table III-14. Reasons for moves at different positions (in percentages)

Reasons for Moves	Position 1	Position 2	Position 3	Position 4
Access to Ownership	76	6.6	0	0
Centrality	5	16.6	29.4	0
No other Opportunity	0	40	58.1	100
Better Neighborhood	5	19	0	0
Former Dwelling has been demolished	12	0	0	0
Other Reasons	2	17.8	12.5	0
Total	100	100	100	100

Therefore, most of the people who occupy new dwellings say they moved in order "to become owner, to have a property." In general, the decision to buy, the mortgage, the neighborhood and the type of dwellings are related, and the choice of the household head is very limited. This is the case of most of the households which had their dwellings developed by SNIT, the municipality or their employers.

2) The second reason why people say they moved is that they like to be centrally located. Five percent of the households

in position one chose the location of their dwellings and moved in order to decrease the distance between homes and their work places. This is the case of the persons working in the harbour of "La Goulette" and who chose new dwellings in "Le Kram." Notice that the moves at position two and three are more influenced by the location of the dwellings than in position one and four. 16.6 percent and 29.4 percent of the households moved in order to decrease the distance between their homes and their work places in position two and three. However, in position one the households prefer the access to ownership to the location of their dwellings in comparison with their work place.

3) the third reason why people say they moved is that they desire to improve their housing conditions by moving in better neighborhoods. This reason represents 5 percent of the cases in position one, but 19 percent of the cases in position two.

4) The fourth reason why people say they moved is that their former dwellings have been demolished. Twelve percent of the households in position one moved for this reason but no household did in the other positions. In general, when dwellings are demolished in Tunis, the households have a priority in a new residential area developed by SNIT or Municipality. This explains the 12 percent of position one. Since most of the demolitions took place in the Medina (old town, near the business area) and the new dwellings of the removed households are in the suburbs, a majority of the interviewed households which moved for this reason are not completely satisfied and find their new dwellings far from the center of the city where many still have their jobs.

5) The fifth reason why people say they moved and chose their dwellings is that they could not do otherwise. In general, these people had to move for various reasons and could not stay any more in their former homes (immigrants, new households, the owner of their former dwelling wants it back, etc.). A large percentage of these people are not happy with the dwellings they are occupying now and they only accepted them because they had no better opportunity. In general, these households have not yet reached their housing equilibrium and they will move as soon as they can get better dwellings and neighborhoods. No household is in this situation in position one, but 40 percent are in position two, 58 percent in position three and 100 percent in position four (5 cases). All these households constitute a potential demand in the future, and will participate in the filtering process as long as their housing conditions are not satisfactory in regard to their housing options and income.

If we assume that people only move when they know that their housing conditions are going to be improved (being an owner, better quality dwelling, better neighborhood, closer to the work place, etc.) therefore all the households which have moved with the exception of those which had to move (fifth reason) are better off now than before the move. These households represent 81.4 percent of the total number of the households which have moved (132/162). Only 18.6 percent of the households are not satisfied with their moves.

Although most of the household heads rationalize (they have in general moved in their present dwellings during 1973, and some households before) their answers are credible. There is no doubt about the fact that the main reason why people moved in position

one was the desire of access to ownership. In general, these households are very satisfied with their new homes. The distance between the home and the work place plays a small role in deciding the households of position one about the location of their new dwellings, which is contrary to our expectations. Since most jobs are still in the downtown area of the city (administrations, banking, trade, services, etc.) and new dwellings are built more and more farther from the city, the distances from the home to the work place is always increasing.

Section 5. Conclusion

The purpose of this study has been to trace the indirect consequences of new construction. It has the specific aim of providing empirical measures of turnover vacancies.

Three main questions have to be answered:

-- First, if filtering down is taking place in the District of Tunis, what is its nature and what is its importance?

-- Second, do poor people benefit indirectly by moving into vacancies further along in the sequence?

-- Third, does the length of the sequences of moves depend on the value of the new dwellings?

Filtering down is taking place in the District of Tunis, as verified by the following findings:

1) Successive households involved in the sequences of moves are characterized by successively lower incomes (average monthly income per household at position one is 71 dinars and 48 dinars at position four).

2) Successive housing units involved in the sequences of moves which begin with the occupancy of new dwellings are characterized by successively lower values. Average monthly rent of a new dwelling equals 34.3 dinars and at the last position, 18 dinars.

3) Successive dwellings have less equipment and are smaller. Average number of rooms per dwelling is successively equal to 3.18 and 2.00 in position one and four.

4) Dwellings at different positions differ systematically in their location within the District of Tunis. There is a tendency for the sequences to develop inward toward the Medina which is becoming a low income neighborhood and playing an important role as a transitional area (c.f. Chapter IV).

If we define as the lowest income group the households whose average monthly incomes are lower or equal to 20 dinars and those which live in one room dwellings or are homeless (living in non-authorized dwellings such as squatter houses) we can, therefore, conclude that this lowest income group does not benefit indirectly by moving into vacancies farther along in the sequences of moves which begin with the occupancy of new dwellings. In fact, their rent should be lower because they have less competition from the next higher class for their housing.

Therefore, on one hand the lowest income group does not benefit indirectly by moving into vacancies further along in the sequence; on the other hand, they should get an indirect advantage because they have less competition from the next higher income group for their housing. Given the importance of the housing needs at different income groups and given the particular characteristic of

the District of Tunis which is growing rapidly (population growth equals 5.5 percent), it is normal that filtering plays only a limited role and that sequences stop before reaching low income groups. One way to make this filtering process more effective and more profitable for the lowest income group would be to increase the number of new dwellings that have to be built every year.

The third question that had to be answered in this chapter was wehther the sequences of moves depend on the value of the new dwellings? Our conclusion is that, although average quality and good quality dwellings have longer sequences than low quality dwellings, high quality dwellings (valued more than 5,000 dinars) do not have longer sequences than average quality units (between 3,000 and 5,000 dinars). This result has very important policy implications since it states that a filtering strategy in Tunisia could maximize the sequences of moves without necessarily emphasizing on the highest quality dwellings. Average quality dwellings and high quality dwellings have approximately the same "filtering" effect. We will study in Chapter V filtering as a variable in a housing strategy and describe the policy actions that have to be taken in order to make the lowest income group benefit from these sequences of moves.

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CHAPTER IV

A SPECIAL CASE OF HOUSING RENEWAL AND FILTERING IN THE MEDINA OF TUNIS (1)

Introduction:

If we define a slum as a "concentration of low quality blighted structures that yield very low levels of housing services" [2], the Medina is becoming a slum area. Brown [2] distinguishes two general schools of thought on how slums originate:

1. The traditional argument [3] states that slums form because as older housing filters down to increasing numbers of low income groups near the business district of cities, externalities and market imperfections more or less ensure that landlords will under-amintain their structures and low income persons will continue to live in these low quality housing areas.

2. The non-traditional view [4] says that slums form more directly because of poverty and the low income of the inhabitants of the blighted areas.

Both the traditional and the non-traditional views help to explain the formation of slums in the district of Tunis. The case

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(1) Medina is the Arabic word for city. The Medina of Tunis is the old town of the city of Tunis. I have worked in]973 (January - December) with the Association to Safeguard the Medina (A.S.M.) and most of the studies of A.S.M. have not yet been published.

of the Medina could be explained by the traditional argument, while the case of all the other squatter areas around the commune of Tunis may be explained by the non-traditional view.

We will only study in this chapter the case of the Medina of Tunis (the old town). We have chosen the Medina for two main reasons:

1. The Medina whose area is equal to 270 hectares (6.5 percent of the total area of the Commune of Tunis) but whose population is equal to 140,000 persons (30 percent of the total population of the Commune of Tunis) plays an important role as a transit quarter in the whole filtering process of the District of Tunis.

2. The future of the Medina is the subject of big debate and discussion at different levels of the Tunisian administration and government.

In this chapter, we will study successively the existing filtering process in the Medina (T_e) and the prospective new filtering (T_p).

Section 1. The Existing Filtering Process in the Medina

§1. Description of this Filtering Process:

The Medina is the old town in Tunis. For its central part the layout was defined during the 13th and 14th centuries. Until the French colonization of Tunisia in 1881, the Medina was the political, religious, cultural and economic capital of Tunisia. It was the residence of the elite and the ruling class of the country. After French colonization, the Medina started to lose its equilibrium. The coordination which existed between the morphology of the Medina

and its population (the container and the concents) stopped. The French rules did not live in the Medina; they created their own new "European" town outside. All the political power and a large proportion of the cultural and economic power moved from the Medina to this new town, where industries and new types of activities and trades appeared.

This historical event created an important process of population movement in and out of the Medina (F_1); and in about 70 years, the Medina, which was the residence of the rich and the elite, became the residence of the poor and is becomeing a slum in the downtown portion of the capital.

The Tunisian elite and ruling class started to progressively move out of the Medina to the new town and the suburbs for two main reasons:

1. The will of the Tunisian elite to follow the economic and political power which switched from the Medina to the new European town with the new industries, banking, new services, modern types of trade and new educational systems.

2. The traditional houses in the Medina which were intended for traditional family structures (extended families) are not suitable for modern family structures (nuclear families).

This population movement out of the Medina was even accelerated after the Tunisian independence in 1956, when most of the French rulers had to leave their homes in the European town and the suburbs. A study of the Association to Safeguard the Medina (A.S.M.) on a sample of 25 landlords of dwellings in the Medina shows that five are living in the new town (20 percent), seventeen are living in the suburbs

(68 percent) and only three reside in the Medina (12 percent) [5]. Most of the non-resident landlords have higher incomes and education than those who still live in their dwellings in the Medina. Note that in our inquiry on filtering in the district of Tunis 24 percent of the sample dwellings outside the Medina were occupied by households which left empty units in the Medina (38/162).

The second part of the present filtering process is the occupation of the evacuated houses of the Medina by poor immigrants, coming generally from rural areas.

Table IV-1. Different Income Groups in the Medina in 1970 [6]

Income Groups (D)	Average Monthly Income Per Household (D)	Number of Households (units)	Percentages of Households
(A) 12 - 27	19,500	13,890	48.5
(B) 28 - 55	44,500	8,250	28.8
(C) 56 - 100	79,000	4,950	17.3
(D) 101 and +	150,000	1,550	5.4
		28,640	100.0

Sixty-five percent of these households are immigrants (born outside the district of Tunis). They came into the Medina, attrached by the new opportunities created by the establishment of new industries and services in the area. The household heads of income group A are disguised unemployed workmen without permanent jobs and salaries. Between 1956 and 1966, 147,000 foreigners left the district of Tunis and were directly and indirectly, through the filtering process, replaced by about 150,000 immigrants [7].

In the central part of the Medina, the relative importance of immigrants passed from 30 percent in 1956 to 63 percent in 1968. Forty-six percent of the immigrants counted in 1968 came after 1956 [8].

Table IV-2. Immigrants in the Medina in 1940, 1956 and 1968

Number of Immigrants	1940	1956	1968
Number of Immigrants	1,200	3,530	5,960
Percentage of Immigrants Over Total Population	--	30	63

Another characteristic that indicates the Medina is a real transient area is the high masculinity rate that it has. For the population group between the ages of 15 and 65, the masculinity rate (number of males over number of females) is equal to 1.079. This high rate is due to the fact that more than 17 percent of the immigrant workers living in the Medina are without their families.

The third characteristic that shows how the Medina is a transient area is the tenure system. Sixty-two percent of the households are renters, ten percent are squatters (they neither pay rent nor own the dwelling) and only 28 percent are landlords. Note that the national percentage of renters is equal to 15 percent.

§2. The Consequences of the Present Filtering Process on Housing in the Medina

The first consequence is the "oukalization effect" of the Medina[(a)]. Since most of the 15,000 dwellings existing in the Medina

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(a), (b) "Oukalization" comes from "oukala". Traditionally, an oukala

are relatively large (3.5 rooms per dwelling) because they were intended for extended families and since most of the immigrants are poor, houses were rented room by room to different households having in common some housing installations (kitchens, water-closets, etc.).

Table IV-3. Number of Oukalas in the Central Medina in 1956 and 1966 (b)

Types of Oukalas	1956		1968	
	No. of ouk.	No. of rooms	No. of ouk.	No. of rooms
Total number of oukalas and of rooms	54	1,460	730	6,650
Traditional oukalas	35	910	40	810
Oukalized houses	19	550	690	5,840
8-12 households	--	--	210	3,230
4-7 households	--	--	480	2,610

This system of oukalization is acceptable to the immigrants who cannot afford to rent a whole dwelling, and it is more profitable for the landlords, since the total rent of an oukalized dwelling is higher than the rent of the dwelling to only one household.

The second consequence of the filtering process in the Medina is the high gross density rate which is equal to 114 persons per hectare. In some parts of the Medina where the percentage of

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was a special house working as a hotel in the Medina for non-resident males (travelers and seasonal labor). Hedi Eckert defines an oukalized house as one having more than four households, not from the same family. Hedi Eckert, Medina de Tunis, A.S.M., May, 1970.

immigrants is very high (over 70 percent of households) the density is even between 650 and 950 persons per hectare.

The third consequence of this filtering process in the Medina is the deterioration of the housing stock. This is due to three main interrelated reasons.

1. The overpopulation of most of the dwellings in the Medina since more than 46 percent of the households live in single rooms, and the average number of persons per dwelling is about 9.33 (140,000 persons in 15,000 dwellings).

2. The second reason for this deterioration of the housing stock is the very low incomes of their occupants. 48.5 percent of the households have incomes inferior to 20 dinars per month and per household and can hardly pay their rents, when they pay.

3. The third reason for this deterioration is the lack of incentive for landlords to maintain dwellings. The other squatter areas are in general located far outside the city.

Rothenberg and Brown [3] have given a similar explanation on why the slumlords and the owners of low quality housing in the American slum areas find it profitable to undermaintain the stock of housing. The major reason is the negative externalities or neighborhood effects which result in a breakdown of the market mechanism. The other reason is that since low income groups have few if any substitutes for slum housing near business districts, their demand for slum housing is inelastic, so when prices increase, the total revenues of the landlords will also increase. Another reason why the landlords do not maintain their dwellings in the Medina is the bad tenure system. Many dwellings are owned by more

than one person. They are under the judicial system of "indivision".[a] Therefore, as long as the heirs do not agree with each other on selling or supporting the maintenance costs, their dwellings in the Medina continue to deteriorate.

A.S.M. has estimated that 50 percent of the housing stock in the Medina is relatively in good condition; 44 percent is in bad condition and 6 percent in very bad condition. Giving different rates of depreciation of the structures of the dwellings and the installations, and taking into account the different qualities of the dwellings, we estimated an over-all depreciation of 1.9 percent per year. If we value the total housing stock in the Medina at 24.6 million dinars, the annual depreciation is equal to 464,000 dinars per year [9].

Section 2. The Future of the Medina and Prospective Filtering

A policy to safeguard the Medina is the subject of large debate between authorities at different levels in the Tunisian Administration.

Three main tendencies exist. The first is against any special intervention of the state in the Medina. The second position is for an extreme policy of renewal in the Medina, and the third position

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(a) "Indivision" is a French legal word describing a situation when a real estate (land or a house) is owned by more than one landlord. It is different from a company or an association ownership. It only exists through inheritance. For example, a man dies and leaves a house for his four children. The children are all responsible and have equal rights on the whole house.

is for a moderate policy. We will analyze the three positions and evaluate their respective consequences.

§1. No Policy to Safeguard the Medina:

In this case, the existing filtering process will continue, and the deterioration of the housing stock in the Medina will not be interrupted until it becomes a real slum. This is in my opinion the worst alternative, since a capital of 15,000 dwellings (many of them having historical and cultural values) will be lost in a few years.

§2. An Extreme Policy of Renewal in the Medina:

Since the Medina is in the center of the metropolitan area and the land value is high in downtown Tunis, this policy is aiming toward the demolition of the present housing stock in the Medina and its replacement by new modern apartments of better quality for higher income groups.

This policy, if it were carried out, would create an important new filtering process (T_p) since all the poor households residing in the Medina would have to leave and would be replaced by new households of higher income groups.

In the test zone of "Hafsia" in the Medina[(a)], the demolition of a whole block would make 188 households homeless (1,090 persons). Fifty-one percent of them belong to income group A (monthly income inferior to 27 dinars per household) and twenty-nine percent to income group B (between 28 and 55 dinars per month and per household). The

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(a) Note: The data and the study have not yet been published by A.S.M.

average price per new apartment in the same zone, after demolition, has been estimated to be approximately 6,000 dinars. Therefore, less than five percent of the households of the demolition zone would be candidates for the new apartments (households of income group D). For this test zone, more than 178 households would have to leave; they would be replaced by about 69 households from income group D (only 69 new apartments of high quality could be built after the demolition).

If this type of operation was generalized to the entire Medina, about 26,000 households of income groups A, B and C would have to leave the Medina. They would be replaced by approximately 9,900 new households of income group D, coming from outside the Medina.

Since one of the objectives of this policy is to decrease the high density of the Medina, and because of the change in the morphology of the Medina, the density would decrease from its present rate of 539 persons per hectare to a lower rate of 190, closer to the actual rate of the commune of Tunis.

The different costs of this policy are very high.

1. The economic costs of demolishing most of the housing stock in the Medina are very important. For example, in the "Hafsia" test zone, the cost of having a free square meter after demolition and different compensations, has been estimated to be 65 dinars. Although, urban renewal is a joint effort of local government and private developers, the true beneficiaries will be the land developers and the landlords.

2. The social costs of this policy may be more important, since 60 percent of the total number of households that would leave

the Medina could not be on the authorized housing market, because of low incomes. They would either move to any squatter area around Tunis or start a new slum zone in downtown Tunis. In general, in order to be close to their jobs, these displaced families must find low quality dwellings nearby. Thus, we find a conversion of the properties near the renewal site to low quality housing.

Even if an effort to provide low income families displaced by urban renewal with adequate housing in other neighborhoods exists, the poor are still worse off in their new neighborhoods, because if markets operated somewhat efficiently they could have moved without urban renewal programs, and they did not. For example, in the "Hafsia" test zone, more than 70 percent of the households would move to another zone inside the Medina in case of demolition.

3. The cultural costs of this policy are also important since a real "life museum" would be destroyed, even if the estimated 700 monuments having a historical and cultural value were preserved.

§3. A Moderate Policy of Renewal in the Medina and Conclusion

The objective of this policy is to improve the housing conditions and the quality of the housing stock in the Medina by minimizing the economic, social and cultural costs of such a policy. First, we should help people choose the Medina as a permanent residence, not as a transient area. Second, we should minimize the number of households that would have to leave the Medina in case of renewal by minimizing the number of demolitions.

The main problem that has to be solved in order to fix people in the Medina is the tenure one. Sixty-two percent of the households

living in the Medina are renters, ten percent are squatters (they neither pay rent nor own the dwelling) and only twenty-eight percent are landlords. (Note that the national percentage of renters is equal to fifteen percent.) A.S.M. has found that houses owned by absentee landlords are generally in worse condition than those owned by Medina residents. Sternlieb [10] has also found that "resident-ownership plays a critical role in the maintenance of decent housing", in U.S. slum areas.

Then we can conclude that the factor of ownership is the single most basic variable which accounts for variations in the maintenance of slum properties. We must make it feasible for more households living in the Medina to become owners, because ownership is the most stabilizing factor and is in a certain way a guarantee for an improvement of the housing stock. However, how could we help the occupants of the Medina to buy and improve their dwellings since they are poor? An intervention of the State is necessary.

The State should help the households buy and improve their dwellings by financing some of these operations and by allowing subsidies and favorable credits through institutions such as the National Fund to Improve Housing (F.N.A.H.).

However, the households to not only need financial help, they also need advisory services in home improvement and finance. A.S.M. (The Association to Safeguard the Medina) must have more responsibility in helping the households on deciding what types of improvements should be carried out, how they should present their demands to F.N.A.H., what types of operations should be carried out by a group of households in common, how the judicial and administrative problems could be solved, etc.

Finally, the Municipality of Tunis must increase its services in the Medina by providing more street lighting, more garbage collection and more cleaning services.

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CHAPTER V

A LINEAR PROGRAMMING MODEL IN HOUSING

Section 1. Introduction

In less developed countries where housing is generally poor, planners have two main objectives: (1) Build the maximum number of new dwellings because of the housing shortage, and (2) improve housing quality by building at least average quality dwellings, while reducing the number of nonauthorized dwellings and reducing the total number of homeless households. Which strategy or a combination of strategies fits these objectives?

Anthony Downs (1) describes the basic existing strategies, which are:

1. The filtering strategy -- strict enforcement of high quality standards for all new construction; therefore, new construction will not be occupied by poor households. Poor households receive decent units through filtering down of older units from higher income households.
2. Laissez faire -- no enforcement of any housing quality standards.
3. The low income subsidy strategy -- strict enforcement of high or moderate quality standards for all new construction with large-scale public housing subsidies for low income groups.

For a less developed country, a pure filtering strategy based on the construction of only high quality dwellings may miss both objectives (number and quality) since the housing stock will deteriorate in such a way that the high quality newly built dwellings will not be able to offset deterioration because of their small number (since investment is limited).

The laissez faire strategy will increase the number of the substandard dwellings built by occupants, and therefore the quality improvement objective will not be achieved.

The low-income subsidy strategy, which helps the poorest income groups with new dwellings of average quality through subsidies, will be limited by the total subsidies available, especially when the average subsidy per household must be high.

What we will show in this chapter is how the combination of filtering and a public housing policy based on subsidies for a minimum number may constitute a good strategy. We will use a linear programming model to illustrate this combination of filtering and a public housing policy can determine the different types of dwellings to be built.

Another objective of this chapter is to estimate the amount of investment required to achieve a certain objective in housing. The U.N. reports (2) recommend the construction of 10 dwellings per 1,000 persons in order to overcome the housing problem, but they specify neither the objectives nor the housing quality required. The Prakash and Spillane study (3) is more precise in assisting LDC's to plan comprehensively for housing investments over a given period. Our objective is to estimate, not only the minimum amount of

investment required in housing in order to attain a certain improvement or deterioration for each income group during the planning period, but also to find the minimum number of dwellings of type j to be built, given the housing conditions in the base year for each income group.

The stock-user matrix of a particular country gives us the distribution of the housing stock in relation to the distribution of the population. It shows how the total number of families of a country are housed in a particular year.

Table V-1. Housing Stock-user Matrix, Tunisia, 1972 (units)

Dwelling types / Households (income month)	H_0	H_1	H_2	H_3	H_4	H_5	$\sum_{i=0}^{5} F_i$
F_0 0 - $52	420,800						420,800
F_1 $53-$108	36,200	165,000	300				201,500
F_2 $109-$182			190,900				190,900
F_3 $183-$399			53,800	92,000	12,500		158,300
F_4 $400-$799					16,000		16,000
F_5 $800 and more					12,500	20,000	32,500
$\sum_{j=0}^{5} H_j$	457,000	165,000	245,000	92,000	41,000	20,000	1,020,000

Table V-1 shows how one million and twenty thousand Tunisian families were housed in 1972. Note that about 45 percent of the housing stock (H_0) consisted of units in uncontrolled settlements or slums below the minimum tolerable level. At the same time 41 percent of the families (F_0) were in the lowest income category, earning 26 Tunisian dinars (US $52) per month or less. If the rate of population growth in Tunisia during the planning period (1973-1987) is 2.75 percent and if the rate of the income growth per capita is 4.75 percent, what would be the indirect effects of a housing investment strategy?

For example, what would be the indirect effects of a housing investment strategy of leaving the stock unchanged while incomes and the number of households grow? Without controls on buying, selling, and rental levels, the 599,000 acceptable dwellings (H_1-H_5) would "filter" up. All recognized housing would be occupied by the upper income families F_5, F_4, and F_3. Those are the indirect effects of a housing investment strategy of leaving the stock unchanged while population and income grow.

Now if upper groups are allowed to build for themselves and if lower groups are helped with credit and subsidies, a complex pattern of upward and downward transfers or "filtering" will result. A housing strategy should anticipate these chains of transfers so that it may aim at a realistic optimum, given constraints on resources.

If a number of relations may be assumed to be linear with constant returns to scale, then linear programming techniques may be used for the solution. One important assumption is that we can analyze the housing stock in terms of dwellin units, rather than value. An extra unit H_1 for a homeless household with income level F_1 is

as good as an H_5 for a new F_5 household. But if the new unit H_5 releases an H_4 for a household that releases an H_3, and so on to H_2 and H_1, then building for F_5 improves the housing of five families. If a new H_1 releases nothing, then H_5 will be five times as good for improving housing. Cost enters in because an H_5 is much more expensive than an H_1, the case of Tunisia, sixteen times as expensive. Per dinar (or dollar) building H_1's still improves housing more than three times as much.

The essence of the procedure, therefore, is to maximize filtering up and down subject to an investment constraint. This calculation gives the types of new dwellings that will be built, D_j, to be added to the housing stock, H_j. With a knowledge of D_j for the period, the final stock user matrix can be computed.

Linear programming is the analysis of problems in which a linear function of a number of variables is to be maximized (or minimized) when those variables are subject to a number of restraints in the form of linear inequalities, therefore, linear programming could be used to solve housing problems as they are presented here. It is mainly a resource allocation problem. Our housing model seeks the best utilization of national resources (investment and subsidies) to attain the best possible results, and linear programming precisely is concerned with finding optimal production plans with the help of some specified quantities of resources involved. Linear programming implies that limiting factors are used in fixed proportions along a "process ray". It implies that each process involves constant returns to scale and that relative factor prices are constant. In our application of linear programming to

housing, the concepts of filtering, investments and subsidies were easily put in the form of linear equations.

We will present in section 2 of this chapter the theoretical model, and we will try to apply it to the Tunisian case in section 3.

Section 2. The Model

We will present in five paragraphs the different variables involved in the model, the assumptions, the objectives, the constraints, the implications and the possibilities of the model.

§1. Different Variables:

We have three types of variables concerning the dwellings, the households, and the national economy.

A. Variables Concerning the Dwellings: D_j is the number of dwellings of type j to be built during the planning period. We will choose six different quality levels = $j = 0,1,\ldots,5$.

D_0 = minimal quality dwellings. We will assume that this type of dwelling is not authorized by the government, but they are built anyway, especially in countries where housing conditions are poor such as in the developing countries.

D_1 = low quality

D_2 = average quality

D_3 = good quality

D_4 = high quality

D_5 = luxurious

D_1, D_2, D_3, D_4 and D_5 are all authorized dwellings built with a construction permit delivered by local housing administrations or municipalities.

However, in most less developed countries and in some developed countries, we have two different sectors in housing, a private sector and a public one. By public sector, we do not signify dwellings owned by the state, but we mean all dwellings developed by public central or local institutions and which benefit by direct subsidies given by the State. Therefore, we have D_j's as the number of dwellings of type j to be developed during the planning period by the public sector, and $D_{j,p}$ as the number of new dwellings of type j to be developed by the private sector. Then,

$$D_j = D_{j,s} + D_{j,p}.$$

A certain number of dwellings have to be removed and replaced by new ones. We will call R_j the number of old dwellings of type j to be removed during the planning period.

We will call T_j the total number of dwellings of type j that will filter or transfer from one income group to another or within the same income group.

I_j is the amount of investments in real terms needed to build one dwelling of type j, whether it is developed by the public or the private sector.

S_j is the amount of direct subsidy given by the state for the construction of one dwelling of type j by the public sector.

$H_{j,b}$ is the initial stock of dwellings of type j existing in the base year b (the initial stock of dwellings).

$H_{j,g}$ is the final stock of dwellings of type j existing in the target year g.

$a_{i,j,b}$ and $a_{i,j,g}$ are respectively the number of dwellings of type j occupied by households of type i, in the base and in

the target years.

If, in order to simplify the analysis, we assume that there are no vacancies, therefore:

$$H_{j,b} = \sum_{i=0}^{n} a_{i,j,b}$$

by definition

$$H_{j,g} = \sum_{i=0}^{n} a_{i,j,g}$$

and

$$H_{j,g} = H_{j,b} + D_j - R_j \quad . \tag{1}$$

Equation (1) means that the stock of dwellings of type j in the target year g is equal to the stock of dwellings of type j in the base year b, plus the new dwellings of type j built during the planning period net of the removed ones.

B. Variables Concerning the Households Involved: We will define the different income groups by their capacities to buy new dwellings of different types in 1972. Then we have six different income groups F_i $(i = 0,1,\ldots,5)$.

$F_{i,b}$ is the total number of households of type i existing in the base year and which are able to buy new dwellings of type j with j inferior or equal to i $(j \leq i)$. For example, $F_{3,b}$ is the total number of households of type 3 which are able to buy new D_3, D_2 or D_1.

$F_{i,g}$ is the total number of households of type i existing in the target year.

ΔF_i is the net total number of new households of type i that will appear during the planning period.

$$F_{i,g} = F_{i,b} + \Delta F_i \ .$$

ΔF_i is function of the population growth rate, the income growth rate of the country, and the income distributions in the base year and in the target year.

Since we have defined $a_{i,j,b}$ and $a_{i,j,g}$ as the number of dwellings, occupied by households i in the base year and in the target year, and just as we assumed no vacancies we also abstract from the existence of homeless or doubled up households for the time being, therefore:

$$\sum_{j=0}^{n} a_{i,j,b} = F_{i,b}$$

$$\sum_{j=0}^{n} a_{i,j,g} = F_{i,g} \ .$$

We can also define

$$d_{i,j,b} = \frac{a_{i,j,b}}{\sum_{j=0}^{n} a_{i,j,b}} \qquad \text{and}$$

$$d_{i,j,g} = \frac{a_{i,j,g}}{\sum_{j=0}^{n} a_{i,j,g}}$$

as the ratios of households of type i living in dwellings of type j in the base and the target years.

With all the preceding variables we can build up two stock-user matrices for the base year and for the target year which will facilitate the analysis of the results of our model on the quality of the housing stock and the housing conditions of the households by comparing $a_{i,j}$ and $d_{i,j}$ in the base year and in the target year.

C. Variables Concerning the National Economy:

GNP_b is the gross national product in the base year.

$\overline{GNP}$ is the average gross national product during the planning period.

$\bar{I}$ is the average annual investment in housing during the planning

$\bar{S}$ is the average annual direct subsidy in housing during the planning period.

$\sum_{t=b}^{g} I_t$ = the total amount of investments available for housing (public plus private) during the planning period.

$\sum_{t=b}^{g} S_t$ = the total amount of subsidy available during the planning period.

α = the importance of the average investments in housing relative to the average $\overline{GNP}$, $\alpha = \frac{\bar{I}}{\overline{GNP}}$.

β = the importance of the average direct subsidy in housing relative to the average housing investment, $\beta = \frac{\bar{S}}{\bar{I}}$.

§2. Important Assumptions:

We assume that the prices of the new dwellings are constant in real terms during the planning period for two main reasons. First, no study on housing prices, the fluctuations, and price-elasticities has been carried out so far in Tunisia. Second, the use of linear programming models requires constant prices during the planning period. Since the different income groups are defined by their capacities to pay for new dwellings of different types in the base year (1972), the relative prices of the different types of housing have to be constant. For example, we assume for the case of Tunisia that the average price of a new D_j is fifty percent the price of a new D_{j+1}.

If new D_1's are intended for households F_1, new D_2 for F_2, new D_3 for F_3, etc., therefore, in order to see the filtering process working in the models, a household F_3 must be indifferent between a new D_3 or an old D_4 that filtered down from F_4, and so on. In other words, the value of a new D_j is equivalent to the value of an old D_{j+1}, or, if we assume that a new D_{j+1} is valued twice as much as a new D_j, then the value of an old D_{j+1} is fifty percent the value of a new one. The distinction in the model between new dwellings and old ones is important. By definition a household F_i cannot buy a new D_{j+1} (assuming $i = j$). Only old dwellings filter down, new D_{j+1} can never filter down to F_i. We assume that their excessive construction would be an avoidable error.

To know whether a dwelling is new or old requires much information on the physical rate of depreciation of the different types of units, their economic rates of replacement, their qualities and their durabilities. In our case we will assume that all the dwellings built during the planning period are considered as new and will not filter down, while the housing stock existing in the base year (1972) is assumed to be old during the planning period and could therefore filter down. This assumption is far from being perfect since some dwellings existing in the base year are actually new, but in order for the model to work, a line has to be drawn between new and old housing units, and given the nature of the existing data and statistics in Tunisia the base year (1972) appears to be a "good" year to draw this line.

We assume no administrative constraints that forbid the occupation of certain types of dwellings to some households, no

no neighborhood or racial constraints which are relatively important in some housing markets such as in some American urban areas (5).

Average family sizes and other factors determining the housing conditions are assumed to remain the same for each income group during the planning period.

Finally, a household of type i can either buy a new D_j or an old D_{j+1}, these are its best (and equal) options. However, when there is a housing shortage, the household may have to accept either an old D_j or a new D_{j-1}. These are its second best options. When this household cannot carry out neither its best option nor its second best option, it must accept even less desirable dwellings. The determination of the different housing options open to each household on the housing market is important in order to understand the working of the filtering models. It is what the SMALA model calls "la determination du champ de choix" (4). Table V-2 is an example of the determination of the housing options and potential demands for the different types of dwellings. We only show in this example the best and second best options of each household.

Table V-2. Determination of the Housing Options and the Potential Demands for Different Types of Dwellings

Households of Different Income Groups \ Dwelling-Types (Old - New)		D_1		D_2		D_3		D_4		D_5	
		Old D_1	New D_1	Old D_2	New D_2	Old D_3	New D_3	Old D_4	New D_4	Old D_5	New D_5
F_0	V	x									
	W	x									
	X	D_0									
	Y	x									
	Z	(x)									
F_1	V	x	x	x							
	W		x	x							
	X	x									
	Y	x	x	x							
	Z	0		(x)							
F_2	V	x	x	x	x	x					
	W				x	x					
	X		x	x							
	Y		x	x	x	x					
	Z		Δ	0		(x)					
F_3	V	x	x	x	x	x	x	x			
	W						x	x			
	X				x	x					
	Y				x	x	x	x			
	Z				Δ	0		(x)			
F_4	V	x	x	x	x	x	x	x	x	x	
	W								x	x	
	X						x	x			
	Y						x	x	x	x	
	Z						Δ	0		(x)	
F_5	V	x	x	x	x	x	x	x	x	x	x
	W										x
	X								x	x	
	Y								x	x	x
	Z								Δ	0	

Notes for Table 2

a) Row V represents the dwellings that a household of type i could buy with its income (the income constraint).

b) Row W and X constitute the housing options of the households. Row W represents its best solution and row X its second best solution if it could not carry out its best choice because the housing supply is limited.

c) Row Y shows all the dwellings that a household of type i would buy. It is its potential demand. Notice that all the households which belong to F_4, F_3 and F_2 have four different possibilities on the housing market; H_5 and H_1 have three possibilities and H_0 only one possibility on the authorized market.

d) Row Z represents all the dwellings that participate in the filtering process. We have three types of filtering or transfers.

   1) Filtering down of old dwellings. A household of type i getting an old dwelling of type j+1 from income group i+1. In table ⊗.

   2) Filtering up of new dwellings. A household of type i getting a new dwelling of type (j-1) because it could not carry out its best solution. In table Δ.

   3) Horizontal transfers. A household of type i getting an old dwelling of type j. (In table 0.) The implication is that previously such a household was living in D_{j-1} or is a newcomer.

Notice that we have not introduced D_0 among the dwelling types because they are not authorized dwellings and are treated as residual, beyond conventional policy controls.

§3. The Core of the Model:

From all these assumptions we can see that:

$$D_j = \Delta F_i + R_j + T_j - T_{j+1} \tag{2}$$

where D_j is always positive or equal to zero. It represents the number of new dwellings of type j to be built during the planning period. $\Delta F_i = F_{ig} - F_{ib}$ is the number of new households of type i that will appear during the planning period. R_j is the number of removed dwellings; it is always positive. T_j when it is positive, represents the number of dwellings of type j that will filter down from income group i to income group $i-1$. When T_j is negative, it represents the number of dwellings of type $j-1$, that will filter up to income group i. T_{j+1} when it is positive, represents the number of dwellings of type $j+1$ that will filter down from income group $i+1$ to income group i. When it is negative T_{j+1} represents the number of dwellings of type j that will filter up from income group i to income group $i+1$. Notice that no vacant dwellings or changes in vacancy rates or numbers is assumed between the base year and the target year.

If we apply formula (2) to our case of five authorized dwelling types and five income groups, we get:

$$\begin{aligned} D_5 &= \Delta F_5 + R_5 + T_5 \\ D_4 &= \Delta F_4 + R_4 + T_4 - T_5 \\ D_3 &= \Delta F_3 + R_3 + T_3 - T_4 \\ D_2 &= \Delta F_2 + R_2 + T_2 - T_3 \\ D_1 &= \Delta F_1 + R_1 + T_1 - T_2 \end{aligned} \tag{3}$$

$$\sum_{j=1}^{5} D_j = \sum_{i=1}^{5} \Delta F_i + \sum_{j=1}^{5} R_j + T_1 \qquad (4)$$

or from (3) we have

$$\begin{aligned}
T_5 &= D_5 - \Delta F_5 - R_5 \\
T_4 &= D_4 - \Delta F_4 - R_4 + T_5 = D_4 - \Delta F_4 - R_4 + D_5 - F_5 - R_5 \\
T_3 &= D_4 - \Delta F_3 - R_3 + T_4 = D_3 + D_4 + D_5 - R_5 - R_4 - R_5 - \\
&\quad \Delta F_3 - \Delta F_4 - \Delta F_5 \\
T_2 &= D_2 - \Delta F_2 - R_2 + T_3 = D_2 + D_3 + D_4 + D_5 - R_2 - R_3 - \\
&\quad R_4 - R_5 - \Delta F_3 - \Delta F_4 - \Delta F_5 - \Delta F_2 \\
T_1 &= D_1 - \Delta F_1 - R_1 + T_2 = D_1 + D_2 + D_3 + D_4 + D_5 - R_1 - \\
&\quad R_2 - R_3 - R_4 - R_5 - \Delta F_1 - \Delta F_2 - \Delta F_3 - \Delta F_4 - \Delta F_5
\end{aligned} \qquad (5)$$

or

$$\begin{aligned}
\sum_{j=1}^{5} T_j = {} & 5(D_5 - \Delta F_5 - R_5) + 4(D_4 - \Delta F_4 - R_4) + \\
& 3(D_3 - \Delta F_3 - R_3) + 2(D_2 - \Delta F_2 - R_2) + \\
& D_1 - \Delta F_1 - R_1 \ .
\end{aligned} \qquad (6)$$

When no homeless households are assumed ($F_o = 0$) the aggregate number of units that are supplied by one segment of the market to another cancel out. This statement means that $T_1 = 0$ or $\sum_{j=1}^{5} D_j = \sum_{i=1}^{5} \Delta F_i + \sum_{j=1}^{5} R_j$ (from equation 4).

In our model, however, we do take into account the existence of homeless households ($F_o \neq 0$), so $T_1 \neq 0$ and $\sum_{j=1}^{5} T_j \neq 0$.

Our purpose is mainly to explore the direct and indirect effects of a housing investment strategy in terms of its effect on total housing supply and use. A complex pattern of upward or downward transfers or "filtering" will result from each housing

investment strategy, and our aim is to anticipate these chains of transfers so that a realistic optimum is approached, given constraints on resources.

The model is going to answer two important questions in housing --

Given the housing condition of a country in the base year as it is shown by its stock-user matrix, what is the minimal investment required in housing in order to improve the housing condition of at least one income group without having a deterioration in the housing condition of another income group?

Using linear programming models, including filtering in its objective function and/or in its constraints (with other constraints such as investments, subsidies, quality, etc.). We will estimate, in different options, the optimal numbers of dwellings of type j to be built during the planning period.

A. First Objective of the Model. Minimum amount of investment required in order to have the same housing conditions in the base year and in the target year: Knowing the housing improvement we want to reach in the target year, what is the minimum number of D_j needed and what is the minimum amount of investment required?

In this case, our purpose is to estimate D_j^* and $\sum_{t=b}^{g} I_t^*$, where D_j^* is the minimum number of dwellings of type j that is required in order to keep the housing conditions of each income group from deteriorating, and $\sum_{t=b}^{q} I_t^*$ is the minimum amount of investment required to build $\sum_{j=1}^{n} D_j^*$.

Our aim is that the housing conditions of each income group should either improve or stay the same. No income group should see its housing condition deteriorating between the base year and the target year. Therefore, any construction of D_j superior to D_j^* would create an improvement in the housing condition of at least one income group without creating a deterioration in the housing condition of any other income group. If we decide, at least, to keep the same housing condition in the target year as in the base year for each income group, D_j must be equal to D_j^*. And, if we decide to improve the housing situation of at least one income group without having the housing condition of another income group deteriorating, then D_j must be superior to D_j^*.

Then our conditions for non-deterioration of housing condition of any income group are:

$$D_j \geq D_j^*$$

and (7)

$$\sum_{t=b}^{g} I_t \geq \sum_{t=b}^{g} I_t^* \quad .$$

If the housing condition in the target year is going to be the same as in the base year for each income group, therefore for each income group i, the ratios of households i living in dwellings j must be the same in the years b and g. But for all the households together, because of a change in household composition by income, the share of poorly housed families may fall (or rise) although within each income stratum the share of the poorly housed remains unchanged. For example, assume that more households appear in a class with only 10 percent poorly housed,

while a class with 30 percent poorly housed falls. If the average poorly housed was 20 percent before, the proportion will now be below 20 percent.

From the user matrix existing in the base year, we estimate the ratios of households of type i living in dwellings j; we estimate

$$d_{i,j,b} = \frac{a_{ijb}}{\sum_{j=0}^{n} a_{ijb}}$$

In order to have the same housing condition for each income group in the base year and in the target year $d_{i,j,b}$ must be equal to $d_{i,j,g}$ where

$$d_{ijg} = \frac{a_{ijg}}{\sum_{j=0}^{n} a_{ijg}}$$

Therefore in the target year g, we have $d_{ijb} = \sum_{j=0}^{n} a_{ijg} = a_{ijg}$ we know that

$$H_{j,g} = \sum_{i=0}^{n} a_{ijg} \quad \text{or} \quad H_j^* = \sum_{i=0}^{n} [d_{ijb} \sum_{j=0}^{n} a_{ijg}] \tag{8}$$

We also know from equation (1) that the housing stock j existing in the target year is equal to the housing stock j of the base year plus the new dwellings D_j, less the removed ones R_j

$$H_{j,g} = H_{j,b} + D_j - R_j \tag{1}$$

or

$$H_{j,g}^* = H_{j,b} + D_j^* - R_j$$

or

$$D_j^* = H_{j,g}^* - H_{j,b} + R_j \quad .$$

We replace H_{fg}^* by its value in equation (8), and we get

$$D_j^* = \sum_{i=0}^{n} (d_{ijb} \sum_{j=0}^{n} a_{ijg}) - H_{j,b} + R_j \qquad (9)$$

The minimum amount of investments needed to build $\sum_{j=1}^{n} D_j^*$ is

$$\sum_{t=b}^{g} I_t^* = \sum_{j=1}^{n} I_j D_j^*$$

or

$$\sum_{t=b}^{g} I_t^* = \sum_{j=1}^{n} I_j [\sum_{i=0}^{n} (d_{ijb} \sum_{j=0}^{n} a_{ijg}) - H_{j,b} + R_j] \quad . \qquad (10)$$

Since we know $H_{j,b}$, R_j, and $\sum_{j=0}^{n} a_{ij}$ in b and g, we therefore estimate easily $d_{i,j,b}$, D_j^* and $\sum_{t=b}^{g} I_t^*$. We can estimate the minimum percentage of investment in housing relative to the gross national product, in order to achieve our first objective.

If we call $\alpha^* = \frac{\overline{I}}{\overline{GNP}}$, therefore $\alpha \geq \alpha^*$.

These estimates are made below in section 3.

B. The Second Objective of the Model. Maximizing Filtering (Up and Down) Subject to a Certain Number of Constraints on Resources: Our model will take into account filtering as a way of improving the quality of the housing stock and the housing conditions of the households by the end of the planning period.

In this linear progamming model we will show the indirect effects of a housing policy accelerating the filtering of the dwellings from one income group to another. What is our objective function and what are our constraints?

1) Objective Functions: Our objective is to maximize filtering up and down subject to some constraints. This calculation gives the types of new dwellings that will be built, D_j, to be added to the housing stock, H_j, in order to compute the final stock user matrix (for the target year). Therefore, the number of dwellings that will participate in the filtering process (T_{j_5}) must be maximized. Then our objective function is to maximize $Z = \sum_{j=1}^{5} T_j$, or if we replace $\sum_{j=1}^{5} T_j$ by its value from equation 6, our objective function will be to maximize

$$Z_1 = 5D_5 + 4D_4 + 3D_3 + 2D_2 + D_1 - 5(\Delta F_5 + R_5) - 4(\Delta F_4 + R_4) - 3(\Delta F_3 + R_3) - 2(\Delta F_2 + R_2) - R_1 - \Delta F_1 .$$

Notice that maximizing "filtering" gives automatically a certain priority to high quality dwellings in the objective function ($5 > 4 > 3 > 2 > 1$). Therefore, since D_5 is more valued than D_4, and the value of D_4 is superior to the value of D_3, etc. Maximizing "filtering" (maximizing $\sum_{j=1}^{5} T_j$) is equivalent to another objective function maximizing the quality of the new dwellings. There are only differences in the degrees of the coefficients of the different variables in the two objective functions. If we call V_j the value of D_j, we can have another objective function $Z_2 = \text{Maximize} \sum_{j=1}^{5} V_j D_j$ and compare its results with those of $Z_1 = \sum_{j-1}^{5} T_j$.

In Option 2, $Z_2 = \sum_{j=1}^{5} V_j D_j$, we maximize the total value of the new dwellings. But since this total value is fixed by the total amount of investments available during the planning period $\sum_{t=b}^{g} I_t$,

because we assume that the value of each unit is equivalent to the amount of investment incorporated in that unit, therefore, it looks as if we are maximizing something fixed in value. What we are mainly interested in is the number of dwellings of different types (D_j) obtained with this objective function, not the total value of the new dwellings.

Our objective functions are:

Option 1: Maximize $Z_1 = \sum_{j=1}^{5} T_j = 5D_5 + 4D_4 + 3D_3 + 2D_2 + D_1 - A$

where $A = 5(\Delta F_5 + R_5) + 4(\Delta F_4 + R_4) + 3(\Delta F_3 + R_3) + 2(\Delta F_2 + R_2) + \Delta F_1 + R_1$.

Option 2: Maximize $Z_2 = \sum_{j=1}^{5} V_j D_j$.

2) Constraints: Different housing strategies require different constraints. We will present these constraints and explain the various housing investment policies (or options) of our linear programming models.

Option a: Constraints for the Rich, Subsidies for the Poor.

The housing conditions of some income groups may improve while the housing conditions of other income groups may deteriorate freely. There is no constraint to prevent the deterioration of the housing condition of any income group. Our constraints are:

a_1 = The investment constraint:

$$\sum_{j=1}^{n} I_j D_j \leq \sum_{t=b}^{g} I_t$$

a_2 = The subsidy constraint for dwellings developed by the public sector:

$$\sum_{j=1}^{n} S_j D_{j,s} \leq \sum_{t=b}^{g} S_t \quad .$$

Notice that the number of dwellings built by the public sector $D_{j,s}$ plus those built by the private sector $D_{j,p}$ are equal to the total number of dwellings D_j. Or $D_j = D_{j,s} + D_{j,p}$.

a_3 = The minimum number of dwellings developed by the public sector:

$$\sum_{j=1}^{n} D_{j,s} \geq N \quad .$$

We assume that the public sector plans to develop a certain number of dwellings during the planning period at least equal to N.

a_4 = The nonfiltering of new dwellings constraint.

Since a household can either buy a new dwelling j or an old dwelling j+1, and cannot buy a new dwelling j+1 (by definition). Therefore the number of old dwellings of type j+1 that will filter down to income group i can either be inferior or equal to the total number of dwellings of type j+1 existing in the base year, net of the number of dwellings of type j that will be removed. $T_j \leq H_{j,b} - R_j$ or replacing T_j by its value in equation (5):

$$D_5 - \Delta F_5 - R_5 \leq H_{5,b} - R_5$$

$$D_4 + D_5 - \Delta F_4 - \Delta F_5 - R_4 - R_5 \leq H_{4,b} - R_4$$

$$D_3 + D_4 + D_5 - \Delta F_5 - \Delta F_4 - \Delta F_5 - R_3 - R_4 - R_5 \leq H_{3,b} - R_3$$

$$D_2 + D_3 + D_4 + D_5 - \Delta F_2 - \Delta F_3 - \Delta F_4 - \Delta F_5 - R_2 - R_3 - R_4 - R_5 \leq H_{2,b} - R_2$$

$$D_1 + D_2 + D_3 + D_4 + D_5 - \Delta F_5 - \Delta F_4 - \Delta F_3 - \Delta F_2 - \Delta F_1 - R_1 - R_2 - R_3 - R_4 - R_5 \leq H_{1,b} - R_1$$

a_5 = The non-negative constraints

$$D_j \geq 0 \qquad D_{j,s} \geq 0 \qquad D_{j,p} \geq 0 .$$

Option b: No Deterioration of Housing Conditions of income groups. Our principal constraint in this option is that no income group should see its housing condition deteriorating during the planning period. The housing conditions of some income groups may improve but no deterioration of housing condition is tolerated.

b_1 = The investment constraint: First we should test whether $\sum_{t=b}^{g} I_t$ is superior or equal to $\sum_{t=b}^{g} I_t^*$. If $\sum_{t=b}^{g} I_t$ is inferior to $\sum_{t=b}^{g} I^*_t$ which is the minimum investment required in order to respect the condition of non deterioration of the housing condition for each income group, then there is no feasible solution to our model.

Therefore: $\sum_{j=1}^{n} I_j D_j \leq \sum_{t=b}^{g} I_t$ and $\sum_{t=b}^{g} I_t \geq \sum_{t=b}^{g} I_t^*$.

b_2 = The subsidy constraint: as in option a

$$\sum_{j=b}^{n} S_j D_{j,s} \leq \sum_{t=b}^{g} S_t$$

b_3 = The minimal number of dwellings developed by the public sector constraint: (as in a)

$$\sum_{j=1}^{n} D_{j,s} \geq N$$

b_4 = The non filtering of new dwellings constraint: (as in a)

$$T_j \leq H_{j,b} - R_j$$

b_5 = The minimal number of dwellings of type j to be built in order to respect the non deterioration of the housing condition to any income group

$$D_j \geq D_j^*$$

b_6 = The non-negative constraints

$$D_j \geq 0, \quad D_{j,s} \geq 0, \quad D_{j,p} \geq 0$$

Option b': Minimum Preservation for All. This option is a variation of option b. If in option b, $\sum_{t=b}^{g} I_t$ is inferior to $\sum_{t=b}^{g} I_t^*$, and there is no feasible solution to our model, we can fix a maximum rate of deterioration of the housing condition for each income group. We do not assume any more as in b that $d_{i,j,b} = d_{i,j,g}$ but we will assume that $d_{ijg} = d_{i,j,b} - x\, d_{i,j,b}$ when $j \geq i$ or $d_{ijg} = d_{ijb}(1-x)$ when $j \geq i$.

x is the maximum rate of deterioration of the housing condition for income group i; $0 \leq x \leq 1$, or $1-x$ is the minimum rate or preservation.

For example, if we suppose that in the base year one hundred percent of the households i are well housed which means that $\frac{\sum_{j=1}^{n} a_{ijb}}{\sum_{j=0}^{n} a_{ijb}} = 1$, or that all the cases below the diagonal in the stock user matrix for imcome group i are empty. Suppose that in order to keep the same ratio in the target year, we need $\sum_{t=b}^{g} I_t^*$ and that $\sum_{t=b}^{g} I_t < \sum_{t=b}^{g} I_t^*$, therefore we can have as a constraint a maximal rate of deterioration of the housing condition of income group i. For

example, we might want to have in the target year $\frac{\sum_{j=i}^{n} a_{ijg}}{\sum_{j=0}^{n} a_{ijg}} \geq \frac{1}{2}$.

Therefore $d_{ijg} = d_{ijb}(1 - \frac{1}{2}) = \frac{1}{2} d_{ijb}$ for $j \geq i$.

b_1' = The Investment Constraint: If we call $\sum_{t=b}^{g} I_t'^*$ the minimal amount of investment in order to get a deterioration of the housing condition of each income group inferior or equal to x, therefore $\sum_{t=b}^{g} I_t \leq \sum_{t=b}^{g} I_t'^*$ and $\sum_{j=1}^{n} I_j D_j \leq \sum_{k=b}^{t} I_t'^*$. The other constraints (subsidy, minimum number and non-filtering of new dwellings) are as in option b. Only the constraint b_5' changes because the minimum number of dwellings of type j to be built, D_j, in order to respect the maximum deterioration of the housing condition of each income group is now $D_j'^*$ and D_j must be superior or equal to $D_j'^*$. $D_j \geq D_j'^*$.

Option c: All New Households are Well Housed. Our principal constraint is that all the new households that will appear on the housing market during the planning period must be well housed. Therefore we can only have downward filtering. $T_j \geq 0$.

We have the same constraints as in option a for investment, subsidy, demand, and minimal number of dwellings by the public sector, plus the following constraint: $c_5 = T_j \geq 0$ or

$$D_5 \geq \Delta F_5 + R_5$$

$$D_4 + D_5 \geq \Delta F_4 + R_4 + \Delta F_5 + R_5$$

$$D_3 + D_4 + D_5 \geq \Delta F_3 + R_3 + \Delta F_4 + R_4 + \Delta F_5 + R_5$$

$$D_2 + D_3 + D_4 + D_5 \geq \Delta F_2 + R_2 + \Delta F_3 + R_3 + \Delta F_4 + R_4 + \Delta F_5 + R_5$$

$$D_1 + D_2 + D_3 + D_4 + D_5 \geq \Delta F_1 + R_1 + \Delta F_2 + R_2 + \Delta F_3 + R_3 + \Delta F_4 + R_4 + \Delta F_5 + R_5$$

Option d: No Financial Constraints for the Rich; Subsidies for the Poor. One possibility is to assume that the rich in F_5 will find a way to get themselves 100 percent well-housed with new construction that does not have to come at the expense of building for anyone else. An appropriately lowered investment constraint applies to everyone else. Our new investment constraint is $\sum_{j=1}^{4} I_j D_j \leq \sum_{t=b}^{g} I_t^a$. $\sum_{t=b}^{g} I_t^a$ is inferior to $\sum_{t=b}^{g} I_t$ because it only applies to the other types of dwellings (not D_5). $\sum_{t=b}^{g} I_t^a = (1-u) \sum_{t=b}^{g} I_t$ where $u = \frac{V_5 H_5}{\sum_{j=0}^{g} V_j H_j}$, or u is the relative value of the housing stock of type 5 (luxurious housing) over the total value of the housing stock existing in the base year. The other constraints do not change.

Option e: Equal Support for Three Lower Levels. In order to make sure that the poor F_1's get some subsidized units, housing policy might direct that over the planning period, each of the three lowest categories that can afford a minimal house get equal numbers of subsidized units. Therefore, we have the same constraints as in option a, but we assume that for each type, the number of dwellings developed by the public sector are equal, or $D_{15} = D_{25} = D_{35}$.

Option f: No Subsidy and No Public Housing. We eliminate the public sector from our model. We have neither the subsidy constraint nor the minimum number of public housing constraints.

When we combine our two objective functions (options one and two) with the precedent seven different options related to the constraints of the model, assuming minimum and maximum hypothesis

for $\alpha = \frac{\bar{I}}{GNP}$, $\beta = \frac{\bar{S}}{I}$, and N (number of public housing), we get twenty eight possibilities. We will show these possibilities in Table V-3.

Table V-3. Different Combinations of Options

Constraints (options) / Objective functions	a: Free upward and downward filtering		b: No deteriorat. of housing conditions at any income group		b': Minimum preservation in housing conditions		c: No upward filtering only downward filtering		d: luxurious dwellings without invest. const.		e: $D_{15}=D_{25}=D_{35}$		f: No subsidy and no min. no. of public housing	
	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
Option 1 Maximize V_j (maximize total number of units that filter)														
Option 2 Maximize $\sum_{j=1}^{5} V_j D_j$ (maximize total value of new units)														

§4. The Implication and the Possibilities of the Model:

The model that we have presented in the preceding paragraphs includes many of the necessary factors that could be used to produce a theoretically optimal level and type of housing production.

It gives policy makers in developing countries and developed countries a method for estimating the minimum amount of investment required in order to:

1) keep the housing condition of any households from deteriorating during the planning period, or

2) to provide "good housing" to all new households that will appear during the planning period.

For any investment inferior to $\sum_{t=b}^{g} I_t^*$ required to keep the housing condition of each income group from deteriorating, at least one income group is going to be worse off in the target year relatively to the base year. Which income group will have its housing condition deteriorate, and which will have its housing improved depends on the objective functions of the models and the constraints. In most countries the relevant decisions are partly a function of the relative political power of each income group, and there seem to be no means for putting the local political climate into a formula in any reliable way.

If we call $\frac{\sum_{j=i}^{n} a_{ijb}}{\sum_{j=0}^{n} a_{ijb}}$ the percentage of well housed households in the base year, a simple comparison between $\frac{\sum_{j=1}^{n} a_{ijb}}{\sum_{j=0}^{n} a_{ijb}}$ and $\frac{\sum_{j=1}^{n} a_{ijg}}{\sum_{j=0}^{n} a_{ijg}}$ will tell us whether income group i had its housing condition improved or worsened during the planning period.

Another method to test whether the housing condition of one particular income group has improved or deteriorated during a planning period is to estimate the average value of housing per household for each income group and to compare these values in the base year and in the target year. If we call V_j the value of a dwelling D_j, therefore $\frac{\sum_{j=0}^{n} V_j a_{ijb}}{F_{i,b}}$ is the average housing value per household of type i. A comparison between $\frac{\sum_{j=0}^{n} V_j a_{ijb}}{F_{i,b}}$ and $\frac{\sum_{j=0}^{n} V_j a_{ijg}}{F_{i,g}}$ will tell us whether the households belonging to income group i have more or less housing in the target year than in the base year.

Section 3. The Application of the Model to the Tunisian Case.

§1. Different Hypothesis:

The housing situation in Tunisia is described in Chapter 2. However, in order to apply the linear programming model to the Tunisian case a certain number of assumptions have to be made concerning the planning period, the national economic growth, the future relative importance to the housing sector, the different types of dwellings to be built and the different income groups and households.

A. The Planning Period: Since our model involves filtering and housing replacement activities throughout the community, it is necessary to choose a long planning period. In general, a period of 15 years is considered as normal for housing planning. A shorter period will not show us any effect of the new dwellings on the housing stock of the initial year, and a longer period will involve more uncertainty about the economic growth of the country and other related variables. We will choose a 15 year planning period, our

base year will be 1972 (statistics for 1973 and 1974 are not yet available in Tunisia) and our target year will be 1987.

B. National Economic Growth and the Importance of the Housing Sector in the Economy: For the rate of growth of the gross national product (GNP) and of the national income (NY) we will choose the official rate used by the Ministry of Planning in Tunisia for the planning period 1973-81 [6]: 7.6 percent. This rate seems to be too high when compared with the average rate of growth between 1960 and 1970 which was equal to 4 percent, but it is not impossible to reach when we consider the economic boom that started in Tunisia in 1970. For example, the rates of growth in 1971 and 1972 were respectively 16 and 18 percent (6).

Since population is assumed to grow at a rate of 2.75 percent, then income per capita will grow at a rate of 4.75 percent per year during our planning period.

Between 1962 and 1971 the average investment in housing was equal to approximately 2.9 percent of the GNP ($\alpha = \frac{\bar{I}}{GNP} = 2.9\%$). During the 4th plan (1973-76) this ratio is expected to increase to 3.4 percent, and for our model we will take two hypotheses, a minimum hypothesis $\alpha_1 = 3.5$ percent and a maximum hypothesis $\alpha_2 = 4.5$ percent.

Between 1962 and 1972, the intervention of the State in housing took so many different forms that an adequate estimation of the relative importance of the direct subsidies in the housing sector is quite impossible. However, for the 4th plan (1973-76) the amount of these direct subsidies is clear and represents 4.3 percent of the total housing investments. For our model we will take two hypotheses,

a minimum one $\beta_1 = \frac{\bar{S}}{\bar{I}_1} = 4\%$ and a maximum one $\beta_2 = \frac{\bar{S}}{\bar{I}_2} = 5\%$.

Knowing that the gross national product for 1972 was equal to 1,028 million dinars [6], we can therefore estimate the total investment available for housing during the planning period $(\sum_{t=b}^{g} I_t)$ and the total direct subsidy $(\sum_{t=b}^{g} S_t)$. We will present these results in the table which follows:

Table V-4. Relative Importance of Housing Investments and Subsidies During the Planning Period 1973-1987 (Millions of Dinars) (1972 Prices)

GNP / NY / I / S — Periods	Total 1973-87	Average Per Year
Gross National Product	29,110	1,940
National Income	23,444	1,563
Investments in Housing $\bar{I}_1 = \alpha_1 \overline{GNP}$	1,019	68
Investments in Housing $\bar{I}_2 = \alpha_2 \overline{GNP}$	1,310	87.3
Direct Subsidy in Housing $\bar{S}_1 = \beta_1 \bar{I}_1$	40.7	2.7
Direct Subsidy in Housing $\bar{S}_2 = \beta_2 \bar{I}_2$	58.2	3.8

C. The Different Dwelling Types to be Built: We are going to define five different types of dwellings. They are all authorized dwellings built with construction permits given by the Ministry of Housing or by local municipalities. They all respect a minimal standard of quality, for instance, they are all equipped with electricity and running water. Notice that more than 70 percent of

the housing stock was not equipped with electricity and running in 1966.

D_1 = This type of dwelling in general has one room with the possibility for adding one or two more. The average investment per unit is about 700 dinars. The housing installations are limited since only a kitchen and a toilet are provided. Whey they are developed by public institutions (SNIT or municipalities) a 200 dinars subsidy is provided per each dwelling by the State.

D_2 = These dwellings generally have only 2 rooms; they are larger than D_1. They are equipped with a kitchen and a toilet. The average cost of D_2 is about 1,500 dinars. Whey they are developed by SNIT or local municipalities, a subsidy of 200 dinars is provided.

D_3 = These dwellings have three rooms and are equipped with a kitchen, a toilet and a bathroom. The average cost per unit is about 3,000 dinars. Whey they are built by SNIT or local municipalities a 100 dinars subsidy is provided per dwelling.

D_4 = These dwellings are of high quality, they have about four rooms, they are well equipped and their average cost is about 6,000 dinars. No such dwellings are developed by public institutions.

D_5 = These are luxurious dwellings, very well equipped, often with five or more rooms, costing approximately 12,000 dinars. These dwellings are only built by private developers.

If we assume that a household head who wants to buy a dwelling in the private sector of the housing market could obtain a mortgage on a 15 year period with an interest rate of 8 percent, and that a household head who buys a dwelling developed by the public sector

could obtain a 15 year mortgage with an interest rate of 5 percent, the respective monthly payments of the different dwellings would be as in Table 5.

D. The Different Income Groups and Households Involved in the Model: Since no complete studies exist on income distribution in Tunisia[(a)], we will assume that the income distribution existing in 1972 will not change in 1987; all the average incomes of the different income groups will grow at the same rate of 4.75 percent per capita and per year. However, since we have defined our income groups (F_i) by their capacities to pay for a new dwelling D_j in the base year; the distribution of households among the given income levels (F_i) will change between 1972 and 1987.

Table V-5. Housing Types, Costs, Subsidies and Monthly Payments (1972 dinars)

Dwelling Types $D_{j,s}$ $D_{j,p}$ $D_j = D_{js} + D_{jp}$	Investment/Unit I_j (D)	Subsidy/Unit S_j (D)	Monthly Payment (D)
D_{1s}	700	200	4
D_{1p}	700	--	7
D_{2s}	1,500	200	11
D_{2p}	1,500	--	15
D_{3s}	3,000	100	23
D_{3p}	3,000	--	30
D_4	6,000	--	60
D_5	12,000	--	120

Note: $D_{4,s} = 0$ $D_{4,p} = 0$

(a) Except one unpublished study by the Ministry of Planning, Note sur l'evolution des Revenus Tunis, May 1973.

We will present the different income groups, and their importance in 1972 and 1987 in the following table. Notice that we have assumed in section II that F_i are chosen in such a way that a household which belongs to F_i could not buy a new dwelling of type $j+1$ or $j+2$, etc. It could only buy either a new D_j or an old D_{j+1} (never a new one). For instance, a household head whose monthly income is between 92 dinars and 199 dinars and who belongs to income group 3, can either buy a new dwelling D_2 or D_1 or an old dwelling D_4, D_3, D_2 or D_1. This household can never buy a new D_4. It has an income constraint.

Table V-6. Different Income Groups in 1972 and 1987

Income Groups		Number of Households in 1972		Number of Households in 1987		Number of New Households ΔF_i
F_i	D (monthly)	Units	%	Units	%	
F_0	0-26	420,800	41.3	447,000	30.4	+ 26,200
F_1	27-54	201,500	19.8	160,200	10.8	- 41,300
F_2	55-91	190,900	18.8	179,500	12.2	- 11,400
F_3	92-199	158,300	15.5	436,200	29.6	+277,900
F_4	200-399	16,000	1.5	180,300	12.2	+164,300
F_5	400 and more	32,500	3.1	70,800	4.8	+ 38,300
$\sum_{i=0}^{5} F_i$	--	1,020,000	100.0	1,474 000	100.0	+454,000

It is possible to take the housing stock of 1972 and the total number of households to construct a stock-user matrix for Tunisia, in 1972, by making the following assumptions:

1) We will distinguish the different types of dwellings existing in 1972 by their number of rooms per dwelling. Although the quality of a dwelling is not only function of the number of rooms that it contains, there is in general a high correlation between its number of rooms (or the area of the dwelling) and its value. This assumption does not take into consideration the location and the land value of the dwellings which are especially important in determining the value of an old dwelling and its quality.

2) We assume that the households in higher income groups live in better dwellings.

Table V-7. Stock User Matrix of Tunisia in 1972

Households \ Dwelling Types	H_0	H_1	H_2	H_3	H_4	H_5	$\sum_{i=0}^{5} F_i$
F_0	420,800	0	0	0	0	0	420,800
F_1	36,200	165,000	300	0	0	0	201,500
F_2	0	0	190,900	0	0	0	190,900
F_3	0	0	53,800	92,000	12,500	0	158,300
F_4	0	0	0	0	16,000	0	16,000
F_5	0	0	0	0	12,500	20,000	32,500
$\sum_{j=0}^{5} H_j$	457,000	165,000	245,000	92,000	41,000	20,000	1,020,000

This table will facilitate the analysis of the results of our model when we will compare a_{ijb} with a_{ijt}, d_{ijb} with d_{ijt}, and $\frac{\sum_{j=i}^{n} a_{ijb}}{\sum_{j=0}^{n} a_{ijb}}$ with $\frac{\sum_{j=i}^{n} a_{ijg}}{\sum_{j=0}^{n} a_{ijg}}$.

E. The Number of Dwellings to be Replaced During the Planning Period: R_j = These numbers have been estimated in Chapter 2 and we will repeat the results in the following table (Table V-8).

Table V-8. Number of Dwellings to be Replaced Between 1972 and 1987

Types of Dwellings R_j	Number to be Replaced (units)
R_1	37,100
R_2	55,100
R_3	20,700
R_4	6,200
R_5	3,000

F. Minimal Number of Dwellings to be Built by the Public Sector During the Planning Period: The number of dwellings built by public institutions in Tunisia has fluctuated during the last decade because no long run public policy in housing existed.

Since 1972, public institutions such as SNIT have played a more important role in housing and seem to have a long range policy. More than 11,000 dwellings per year are to be build and developed by the public sector between 1973 and 1976. We are going to assume that this effort will continue after 1976, and that the average number of dwellings that will be built by the public sector will be between a minimum of 15,000 dwellings and a maximum of 20,000 units per year, during the period 1973-1987.

§2. The Model:

Now we are going to apply the linear programming model to the

Tunisian case.

A) Given the Tunisian housing condition in 1972 as it is shown by its stock-user matrix, what is the total number of dwellings D_j^* that has to be built and what is the minimal investment required in order to keep the housing condition of each income group from deteriorating?

We have seen in section one, that the conditions that will keep the housing situation of the different income groups from deteriorating between 1972 and 1987 are:

$$D_j \geq D_j^* \quad \text{where} \quad D_j^* = \sum_{i=0}^{n} (d_{ij,b} \sum_{j=0}^{n} a_{ijg}) - H_{jb} + R_j \qquad (9)$$

and $\sum_{t=b}^{g} I_t \geq \sum_{t=b}^{g} I_t^*$ where $\sum_{t=b}^{g} I_t^* = \sum_{j=1}^{n} I_j D_j^*$.

In order to estimate D_j^* and $\sum_{t=b}^{g} I_t^*$, we have to estimate in order d_{ij} for Tunisia in 1972, a_{ij} in 1987, $\sum_{i=0}^{n} (d_{ijb} \sum_{j=0}^{n} a_{ijg})$ and knowing H_j in 1972 and R_j, we can have D_j^* and finally $\sum_{t=b}^{g} I_t^*$.

1) Estimation of d_{ij} for Tunisia in 1972:

Table V-9. Estimation of the Different d_{ij} in 1972

Dwelling Types / Households	H_0	H_1	H_2	H_3	H_4	H_5	$\sum_{i=0}^{5} F_i$
F_0	100	0	0	0	0	0	100
F_1	18	81.85	0.15	0	0	0	100
F_2	0	0	100	0	0	0	100
F_3	0	0	33.9	58.1	0	0	100
F_4	0	0	0	0	100	0	100
F_5	0	0	0	0	38.4	61.6	100
$\sum_{j=0}^{5} H_j$	--	--	--	--	--	--	100

2) In order to have the same housing conditions for each income group in 1987 as in 1972, d_{ij} of 1972 must be equal to d_{ij} of 1987. Then, by applying d_{ij} of 1972 to the households F_i existing in 1987 we can obtain a_{ij} and $\sum_{i=0}^{n} a_{ij}$ which are respectively the number of dwellings j that have to be occupied by household i in 1987 in order to provide them with the same housing condition as in 1972, and $\sum_{i=0}^{n} a_{ij}$, the stock of dwellings of type j that should exist in 1987 in order to keep the housing conditions of the households i from deteriorating in respect to 1972.

Table V-10. Estimation of the Theoretical Stock-User Matrix for Tunisia in 1987 which will keep the Housing Condition of Each Income Group from Deteriorating

Households \ Dwelling Types	H_0^*	H_1^*	H_2^*	H_3^*	H_4^*	H_5^*	$\sum_{i=0}^{5} F_i$
F_0	447,000	0	0	0	0	0	447,000
F_1	28,800	131,200	0	0	0	0	160,200
F_2	0	0	179,500	0	0	0	179,500
F_3	0	0	147,900	253,400	34,900	0	436,200
F_4	0	0	0	0	180,300	0	180,300
F_5	0	0	0	0	27,200	43,600	70,800
$\sum_{j=0}^{5} H_j^*$	475,800	131,200	327,600	253,400	242,400	43,600	1,424,000

3) Since we know that

$$H_{jg}^* = H_{j,b} + D_j^* - R_j \qquad (1)$$

Then $D_j^* = H_{j,g}^* - H_{j,b} + R_j$. We have H_{jg}^*, $H_{j,b}$ and R_j, we can therefore estimate D_j^*.

Table V-11. Estimation of D_j^*

j	H_j^*, 1987 (units)	H_j^*, 1972 (units)	R_j (units)	D_j^* (units)
1	131,200	165,000	37,100	3,300
2	327,600	245,000	55,100	137,700
3	253,400	92,000	20,700	182,100
4	242,400	41,000	6,200	207,600
5	43,600	20,000	3,000	26,600
$\sum_{j=1}^{5}$	998,200	563,000	122,100	557,300

4) Estimation of $\sum_{t=b}^{g} I_t^* = \sum_{j=1}^{n} I_j D_j^*$.

Table V-12. Estimation of $\sum_{t=b}^{g} I_t^*$

j	D_j^*	I_j (1972 Dinars)	$I_j D_j^*$ (1972 Dinars)
1	3,300	700	2,310,000
2	137,700	1,500	206,550,000
3	182,100	3,000	546,300,000
4	207,600	6,000	1,245,600,000
5	26,600	12,000	319,200,000
$\sum_{j=1}^{n} j$	557,300	--	2,320,360,000

Therefore, in order to have the same housing conditions for each income group in 1987 as in 1972, the following conditions have to be respected:

$D_1 = 3{,}300$

$D_2 = 137{,}700$

$D_3 = 182{,}100$

$D_4 = 207{,}600$

$D_5 = 26{,}600$

and the total amount of investment in housing must be equal to 2,320 million dinars between 1973 and 1987. This amount represents an average annual investment equal to 7.9 percent of the gross national product.

If we call $\alpha^* = \frac{\overline{I}^*}{GNP}$, therefore $\alpha^* = 7.9\%$.

Notice that on the average, the housing condition of the households has improved between 1972 and 1987, although it has not changed for any income group. The overall percentage of not well housed households has decreased from 51.3 percent in 1972 to 44.1 percent in 1987. The main reason for this fall is the change in household composition. For example, in 1972, 100 percent of the households of income group 4 are well housed; in 1987, 100 percent of the households of income group 4 are well housed, but the difference is that income group 4 is much more important in 1987 than in 1972 relative to the total number of households (1.5 percent in 1972 and 12.2 percent in 1987). This increase is mainly due to the income growth of the country during the planning period.

B. Application of the Linear Programming Model to the Tunisian Case:

1) Option 1a (minimum hypothesis):

Maximize $Z = 5D_5 + 4D_4 + 3D_3 + 2D_2 + D_1 - A$ where $A = 5(\Delta F_5 + R_5) + 4(\Delta F_4 + R_4) + 3(\Delta F_3 + R_3) + 2(\Delta F_2 + R_2) + \Delta F_1 + R_1$

First, we estimate A which is equal to 1,876,500. Second, we make the distinction between dwellings developed by the public sector and dwellings developed by the private one.

$$D_1 = D_{1s} + D_{1p}$$
$$D_2 = D_{2s} + D_{2p}$$
$$D_3 = D_{3s} + D_{3p}$$

D_4 and D_5 do not change because we have assume that no high quality and luxurious dwellings are developed by the public sector.

Then, our objective function is:

$$\text{Maximize } Z = 5D_5 + 4D_4 + 3D_{3,p} + 3D_{3,s} + 2D_{2,p} + 2D_{2,s} + D_{1,p} + D_{1,s} - 1,867,500$$

subject to the following constraints:

a_1) Investment Constraint:

$$700D_{1s} + 700D_{1p} + 1500D_{2s} + 1500D_{2p} + 3000D_{3s} + 3000D_{3p} + 6000D_4 + 12000D_5 \leq 1,019,000,000$$

a_2) Subsidy Constraint:

$$200D_{1s} + 200D_{2s} + 100D_{3s} \leq 40,700,000$$

a_3) The Minimal Number of Dwellings Developed by the Public Sector:

$$D_{1s} + D_{2s} + D_{3s} \geq 225,000$$

a_4) The Non Filtering Down of New Dwelling Constraint:

$$D_5 \leq 58,300$$
$$D_4 + D_5 \leq 246,600$$
$$D_3 + D_4 + D_5 \leq 581,700$$
$$D_2 + D_3 + D_4 + D_5 \leq 744,000$$
$$D_1 + D_2 + D_3 + D_4 + D_5 \leq 677,800$$

a_5) The Non Negative Constraints:

$$D_{js} \geq 0 \ , \quad D_{jp} \geq 0 \ , \quad D_j \geq 0$$

We have 8 variables and 8 constraints in option 1a.

2) Option 1a (maximum hypothesis)

We have the same objective function as in 1, we have the same constraints, but we replace $\sum_{t=b}^{g} I_t$, $\sum_{t=b}^{g} S_t$ and N by their maximal values. $\sum_{t=b}^{g} I_t = 1{,}310{,}000{,}000^D$ (instead of $1{,}019{,}000{,}000^D$), $\sum_{t=b}^{g} S_t = 58{,}200{,}000^D$ (instead of $40{,}700{,}000^D$) and N = 300,000 units (instead of 225,000 units).

3-4) Option 1b (minimum and maximum hypothesis)

Our principal constraint in this option is that no income group should see its housing condition deteriorating during the planning period. We have the same objective function as in 1. However, before writing our constraints, we should test whether our linear programming model has feasible solutions by comparing $\sum_{t=b}^{g} I_t$ and $\sum_{t=b}^{g} I_t^*$. If $\sum_{t=b}^{g} I_t \geq \sum_{t=b}^{g} I_t^*$, there are feasible solutions. We have estimated $\sum_{t=b}^{g} I_t^*$ in the preceding paragraph and it was equal to 2,320,360,000 dinars, or 7.9 percent of GNP. Since our $\sum_{t=b}^{g} I_t$ is inferior to $\sum_{t=b}^{g} I_t^*$ ($\sum_{t=b}^{g} I_t$ is either equal to 1,019,000,000 dinars or 1,310,000,000 dinars, both inferior to 2,320,360,000 dinars required) then there are no feasible solutions for our option b, unless we assume $\alpha = \frac{\bar{I}}{GNP}$ is superior to 7.9 percent which is not realistic for Tunisia during the coming 15 years, given the average past rate which was fluctuating between 2.5 percent and 3.5 percent.

5-6) Option 1b' (minimum and maximum hypothesis)

This option is a variation of option b. In option b, $\sum_{t=b}^{g} I_t$

is inferior to $\sum_{t=b}^{g} I_t^*$ and there are no feasible solutions to our model. We are going to fix a maximum rate of deterioration of the housing condition for each income group. This maximal rate of deterioration of the housing condition will be fixed in order to get $\sum_{t=b}^{g} I_t \geq \sum_{t=b}^{g} I_t^*$. Where $\sum_{t=b}^{g} I_t'^*$ is the minimal investment required in order to get a deterioration of the housing condition of each income group inferior or equal to x. In our case we will choose $x = \frac{2}{3}$.

We estimate $D_j'^*$ and $\sum_{t=b}^{g} I_t'^*$ as we did in the preceding paragraph for D_j^* and $\sum_{t=b}^{g} I_j^*$, and we obtain:

$$D_1'^* = 35,400$$
$$D_2'^* = 210,200$$
$$D_3'^* = 133,300$$
$$D \quad D_4'^* = 90,700$$
$$D_5'^* = 0$$

and $\sum_{t=b}^{g} I_t'^* = 1,287,180$ thousand dinars.

Therefore in order to have a deterioration of the housing condition of each income group inferior or equal to 66.66 percent, but never superior to that ratio, D_j must be superior to $D_j'^*$ and $\sum_{t=b}^{g} I_t \geq \sum_{t=b}^{g} I_t'^*$. In our case $\sum_{t=b}^{g} I_t'^* = 1,287,180$ thousand dinars is inferior to 1,310,000 thousand dinars (maximal hypothesis) but superior to our minimum hypothesis. Then the program is only feasible with the maximum hypothesis.

We have the same constraints as in option 1a (maximum hypothesis) plus the following 4 constraints:

$$D_{1s} + D_{1p} \geq 35,400$$
$$D_{2s} + D_{2p} \geq 210,200$$
$$D_{3s} + D_{3p} \geq 133,300$$
$$D_{4} \geq 90,700$$

(With option 1b we have 8 variables and 12 constraints.)

7-8) Option 1c

Our next constraint is that all net new households that will appear on the housing market during the planning period must be well housed. We only have downward filtering. We have the same objective function and the same constraints as in option 1a, plus the following constraints: $T_j \geq 0$ or:

$$D_5 \geq 41,300$$
$$D_4 + D_5 \geq 211,800$$
$$D_{3s} + D_{3p} + D_4 + D_5 \geq 510,400$$
$$D_{2s} + D_{2p} + D_{3s} + D_{3p} + D_4 + D_5 \geq 554,100$$
$$D_{1s} + D_{1p} + D_{2s} + D_{2p} + D_{3s} + D_{3p} + D_4 + D_5 \geq 549,900$$

In order to satisfy the preceding constraints, we need a total investment in housing superior or equal to 2,563,650 thousand dinars. Therefore, with our options $\sum_{t=b}^{g} I_t = 1,310,000$ thousand dinars as a maximal hypothesis, option c has no feasible solution for Tunisia during the planning period 1973-87.

9-10) Option d

In this option we assume that the highest income group F_5 and the luxurious dwellings are not subject to any investment constraint.

We know from section one, that $\sum_{t=b}^{g} I_t^a = (1-u) \sum_{t=b}^{g} I_t$ with

$u = \dfrac{V_5 H_5}{\sum_{j=0}^{5} V_j H_j}$ in the base year.

From the stock user matrix existing in 1972, we estimate $u = 0.30$, therefore, $\sum_{t=b}^{g} I_t^a$ is equal to 713,300,000 dinars (minimum hypothesis) and to 917,000,000 dinars (maximum hypothesis).

Our new investment constraint is

$$700(D_{1,s} + D_{1,p}) + 1500(D_{2,s} + D_{2,p}) + 3000(D_{3,s} + D_{3,p}) + 6000D_4 + 0D_5 \leq 713,300,000 \text{ (or } 917,000,000) .$$

11-12) Option e.

We have the same constraints as in a, but we assume that

$D_{1,s} = D_{2,s} = D_{3,s} = \dfrac{225,000}{3} = 75,000$ units (minimum hypothesis) or

$D_{1,s} = D_{2,s} = D_{3,s} = \dfrac{300,000}{3} = 100,000$ units (maximum hypothesis).

13-14) Option f.

We eliminate the public sector, we have no subsidy and no minimum number of dwellings developed by the public sector. We have the other constraints as in option a.

15-28) For all options 2a, 2b, 2b', 2c, 2d, 2e, and 2f we have the same constraints as in 1a, 1b, etc. but the objective function is

$$\text{Maximize } Z = 700D_{1s} + 700D_{1p} + 1500D_{2s} + 1500D_{2p} + 3000D_{3s} + 3000D_{3p} + 6000D_4 + 12000D_5$$

Since options b and c have no feasible solutions in regard to the Tunisian case for the period 1973-1987, and since option b' has feasible solutions for the maximal hypothesis only, we have

therefore 18 feasible solutions out of 28 possibilities.

We will present the results of these linear programming models in the following paragraph.

Note: We will use the computer in order to solve our linear programming models. The program used was developed by Dr. R. Black and Dr. S. Harsh from the Agricultural Economics Department, Michigan State University.

§3. The Results of the Linear Programming Models:

We present the results of the linear programming models in Tables 13-16.

Whether our objective function was to maximize filtering $\left(\sum_{j=1}^{5} F_j\right)$ or to maximize the value of the new dwellings we want to build $\left(\sum_{j=1}^{5} V_j D_j\right)$ a priority was given to high quality dwellings. With both objective functions, we expected to have D_5 and D_4 (luxurious and high quality dwellings) built for the highest income groups (F_4 and F_5) who will vacate their old dwellings which will filter down to average and low income groups.

The results of the application of the model to the Tunisian case (which could be considered as a typical less developed country) shows us that because of the investment constraint (the most limiting constraint) the results of the model will be different from our expectations.

One might have expected to have the housing demand of the rich satisfied directly by the construction of new D_4 and D_5 and the housing demand of the poor satisfied indirectly through filtering down of old dwellings. What we have obtained is different.

Table V-13. Numbers of New Dwellings D_j to be Built During the Planning Period 1973-87. (Min. Hyp.)
(in units)

Options 1 Max T_j / Dwelling Types	Option 1a Max T_j with number and subsidy constraints	Option 1b' Max T_j with minimum preservation = 33%	Option 1d Max T_j with constraint but luxury dwelling without I constraints	Option 1e Max T_j with $D_{1s} = D_{2s} = D_{3s}$ = 75,000 units	Option 1f Max T_j without any subsidy or number constraints
D_{1s} = low quality, public	0		0	75,000	0
D_{1p} = low quality, private	77,750	no feasible solution	350,562	62,750	0
D_{2s} = Average quality, public	182,000		182,000	75,000	
D_{2p} = Average quality, private	375,050		43,938	390,050	676,267
D_{3s} = good quality, public	43,000		43,000	75,000	1,533
D_{3p} = good quality, private	0		0	0	
D_4 = high quality, private	0		0	0	0
D_5 = luxurious, private	0		58,300	0	0
Total ($\sum_{j=1}^{5} D_j$)	677,800		677,800	677,800	677,800

Table V-13. (continued)

Options 2 Max V_jD_j / Dwelling Types	Option 2a Max V_jD_j with N and S constraints	Option 2b' Max V_jD_j with min. preservation = 33%	Option 2d Max V_jD_j with const. but D_5 without I const.	Option 2e Max V_jD_j $D_{1s} = D_{2s}$ D_{3s} = 75,000 Units	Option 2f Max V_jD_j without N and S constraints
D_{1s} = low quality, public	0		0	75,000	0
D_{1p} = low quality, private	0		0	0	0
D_{2s} = Average quality, public	0		0	75,000	0
D_{2p} = average quality, private	0		0	0	0
D_{3s} = good quality, public	225,000		225,000	75,000	0
D_{3p} = good quality, private	0		0	0	0
D_4 = high quality, private	0		6,383	0	53,233
D_5 = luxurious, private	28,667		58,300	52,416	58,300
Total $(\sum_{j=1}^{5} D_j)$	253,667		289,683	277,416	111,533

no feasible solution

* options b and c do not have feasible solutions
option b = no deterioration in housing condition of any income group
option c = no upward filtering

Table V-14. Number of New Dwellings D_j to be Built During the Planning Period 1973-87 (Max. Hyp.) (in units)

Dwelling Types \ Options 1 Max T_j	Option 1a Max T_j with N and S constraints	Option 1b' with min preservation = 33%	Option 1d with constraints but luxurious units without Invest. Const.	Option 1e Max T_j with $D_{1s} = D_{2s} = D_{3s}$ 100,000 units	Option 1f Max T_j without any S or N constraints
D_{1s} = low quality, public	0	72,286	49,063	100,000	0
D_{1p} = low quality, private	0	0	0	0	0
D_{2s} = Average quality, public	282,000	94,414	232,937	100,000	0
D_{2p} = Average quality, private	200,267	115,785	319,500	228,933	482,267
D_{3s} = good quality, public	18,000	133,300	18,000	100,000	0
D_{3p} = good quality, private	177,533	0	0	148,867	195,533
D_4 = high quality, private	0	90,700	0	0	0
D_5 = luxurious, private	0	0	58,300	0	0
Total $(\sum_{j=1}^{5} D_j)$	677,800	506,485	677,800	677,800	677,800

Table V-14. (continued)

Options 2 Max V_jD_j / Dwelling Types	Option 2a Max V_jD_j with N and S constraints	Option 2b' with min preservation = 33%	Option 2d Max V_jD_j luxurious units without I constraints	Option 2e Max V_jD_j $D_{1s} = D_{2s} = D_{3s} =$ 100,000 units	Option 2f Max V_jD_j without N and S constraints
D_{1s} = low quality, public	0	35,400	0	100,000	0
D_{1p} = low quality, private	0	0	0	0	0
D_{2s} = average quality, public	0	122,693	0	100,000	0
D_{2p} = average quality, private	0	87,507	0	0	0
D_{3s} = good quality, public	300,000	141,906	300,000	100,000	0
D_{3p} = good quality, private	0	0	0	0	0
D_4 = high quality, private	0	90,700	2,833	15,067	101,733
D_5 = luxurious, private	34,167	0	58,300	58,300	58,300
Total $(\sum_{j=1}^{5} D_j)$	334,167	478,206	361,133	373,367	160,033

* options b and c do not have feasible solutions
option b = no deterioration in housing conditions of any income group
option c = no upward filtering

Table V-15. Number of Dwellings that will Filter Up (-) or Down (+) During Planning Period 1973-87
Min. Hyp. (in units)

Options 1 Max T_j / Types of dwellings that will filter up or down	Option 1a with N and S constraints	Option 1b' with min % of preservation	Option 1d luxurious units without constraints	Option 1e $D_{1s} = D_{2s} = D_{3s} =$ 75,000 units	Option 1f without any constraints
T_1	+127,800	no feasible solution	+127,900	+127,900	+127,900
T_2	+ 45,950		-226,862	- 14,050	+123,700
T_3	-467,400		-409,100	-435,400	-508,867
T_4	-211,800		-153,500	-211,800	-211,800
T_5	- 41,300		+ 17,000	- 41,300	- 41,300
$\sum_{j=1}^{5} T_j$	-546,650		-644,562	-574,650	-510,367
Options 2 Max $V_j D_j$ / Types of Dwellings	Option 2a	Option 2b'	Option 2d	Option 2e	Option 2f
T_1	-296,233	no feasible solution	-260,217	-272,484	-438,367
T_2	-300,433		-264,417	-351,684	-442,567
T_3	-256,733		-220,717	-382,984	-498,867
T_4	-183,133		-147,117	-159,384	-100,267
T_5	- 12,633		+ 17,000	+ 11,116	+ 17,000
$\sum_{j=1}^{5} T_j$	-1,049,165		-355,034	-1,155,420	-1,463 068

Table V-16. Number of Dwellings that will Filter Up (-) or Down (+) During Planning Period 1973-87. Max. Hyp. (in units)

Options 1 Max T_j / Types of Dwellings that will filter up or down	Option 1a with N and S constraints	Option 1b' with min % of preservation	Option 1d luxurious units without I constraints	Option 1e $D_{1s} = D_{2s} = D_{3s}$ = 100,000 units	Option 1f without constraints
T_1	+127,900	- 43,415	+127,900	+127,900	+127,900
T_2	+123,700	-119,901	+ 74,637	+ 23,700	+123,700
T_3	-314,867	-286,400	-434,100	-261,533	-314,867
T_4	-211,800	-121,100	-153,500	-211,800	-211,800
T_5	- 41,300	- 41,300	+ 17,000	- 41,300	- 41,300
$\sum_{j=1}^{5} T_j$	-316,367	-612,116	-368,063	-363,033	-316,367
Options 2 Max $V_j D_j$ / Types of Dwellings	Option 2a	Option 2b'	Option 2d	Option 2e	Option 2f
T_1	-215,733	- 71,694	-188,767	-176,533	-389,867
T_2	-219,933	-111,294	-192,967	-280,733	-394,067
T_3	-176,233	-277,794	-149,267	-337,033	-350,367
T_4	-177,633	-121,100	-150,667	-138,433	- 51,767
T_5	- 7,133	- 41,300	+ 17,000	+ 17,000	+ 17,000
$\Sigma_{j=1}^{5} T_j$	-796,665	-623,182	-664,668	-915,732	-1,169,068

1) Filtering down has appeared only in options one, in all other options upward filtering took place.

2) When filtering down appeared (options 1), it only took place between the average income groups and the low income groups. Filtering down has not started in the highest income group as expected.

3) In options one where the objective function was to maximize filtering, no high quality and luxurious dwellings (D_4 and D_5) were built as might have been expected. Instead, filtering was maximized by building average quality dwellings D_3 and D_2 from which two types of filtering took place.

a) A downward filtering of old D_2 and D_1 to income groups F_1 and F_0 or from average income groups to low income groups.

b) An upward filtering of old and new dwellings D_3 and D_4 to income groups F_3, F_4 and F_5 or from middle income groups to high income groups.

Notice that since we have seen that option c which only allows the existence of downward filtering did not have feasible solutions for Tunisia because of the investment constraint $(\sum_{t=b}^{g} I_t < \sum_{t=b}^{g} I_t^*)$ therefore whatever is our objective function or our constraint, we will always have upward filtering.

Let us compare the consequences of our different options on the quality of the housing stock and the housing conditions of different income groups in the target year 1987 relative to the base year 1972. We notice that options one (maximizing T_j) is relatively the best solution for a less developed country such as

Tunisia, because it emphasizes construction of average quality dwellings, not high quality or low quality ones.

Our objective was to build the maximum number of dwellings because of the shortage existing in the housing sector, and to improve the housing quality and the housing conditions of different income groups by reducing the number of nonauthorized dwellings and by diminishing the number of homeless households between the base year and the target year.

Three criteria exist in order to know whether the housing conditions of the different households have improved or deteriorated during the planning period.

1) The percentage of homeless households:

The relative number of households living in nonauthorized dwellings must decrease. This criterion is, in my opinion, most important for a long run housing policy. No housing policy, whatever its objective, should allow an increase in the percentage of dwellings below an objective minimum quality standard to protect the health and the security of its occupants. In our example $H_0 / \sum_{j=0}^{5} H_j$ must decrease during the planning period. First, we build up the stock-user matrix of our different options (Tables 17-34) then we compare $H_0 / \sum_{j=0}^{5} H_j$ in Table 35.

Table V-17. Stock-User Matrix in 1987. Option 1a (Min. Hyp.)

Dwelling Types / Income Groups	H_0	H_1	H_2	H_3	H_4	H_5	$\sum_{i=0}^{5} F_i$
F_0	355,300 (79.5)	91,700 (20.5)	0	0	0	0	447,000 (100)
F_1	0	113,950 (71)	49,250 (29)	0	0	0	160,200 (100)
F_2	0	0	179,500 (100)	0	0	0	179,500 (100)
F_3	0	0	436,200 (100)	0	0	0	436,200 (100)
F_4	0	0	85,000 (47)	95,300 (53)	0	0	180,300 (100)
F_5	0	0	0	19,000 (27)	34,800 (49)	17,000 (24)	70,800 (100)
$\sum_{j=0}^{5} H_j$	355,300 (24)	205,650 (14)	746,950 (51)	114,300 (8)	34,800 (2)	17,000 (1)	1.474,000 (100)

Table V-18. Stock-User Matrix in 1987. Option 1a (Max. Hyp.)

Dwelling Types / Income Groups	H_0	H_1	H_2	H_3	H_4	H_5	$\sum_{i=0}^{5} F_i$
F_0	355,300 (79.5)	97,700 (20.5)	0	0	0	0	447,000 (100)
F_1	0	36,200 (22.6)	124,000 (74.4)	0	0	0	160,200 (100)
F_2	0	0	179,500 (100)	0	0	0	179,500 (100)
F_3	0	0	368,700 (84)	67,500 (16)	0	0	436,200 (100)
F_4	0	0	0	180,300 (100)	0	0	180,300 (100)
F_5	0	0	0	19,000 (27)	34,800 (49)	17,000 (24)	70,800 (100)
$\sum_{j=0}^{5} H_j$	355,300 (24)	127,900 (9)	672,200 (46)	266,800 (18)	34,800 (2)	17,000 (1)	1,474,000 (100)

Table V-19. Stock-User Matrix in 1987. Option 2a (Min. Hyp.)

Dwelling Types / Income Groups	H_0	H_1	H_2	H_3	H_4	H_5	$\sum_{i=0}^{5} F_i$
F_0	447,000 (100)	0	0	0	0	0	447,000 (100)
F_1	160,200 (100)	0	0	0	0	0	160,200 (100)
F_2	172,200 (76)	7,300 (4)	0	0	0	0	179,500 (100)
F_3	0	120,600 (28)	189,900 (43)	125,700 (29)	0	0	436,200 (100)
F_4	0	0	0	170,600 (95)	9,700 (5)	0	180,300 (100)
F_5	0	0	0	0	25,100 (35)	45,700 (65)	70,800 (100)
$\sum_{j=0}^{5} H_j$	779,400 (53)	127,900 (9)	189,900 (13)	296,300 (20)	34,800 (2)	45,700 (3)	1,474,000 (100)

Table V-20. Stock-User Matrix in 1987. Option 2a (Max. Hyp.)

Dwelling Types / Income Groups	H_0	H_1	H_2	H_3	H_4	H_5	$\sum_{i=0}^{5} F_i$
F_0	446,000 (100)	0	0	0	0	0	447,000 (100)
F_1	160,200 (100)	0	0	0	0	0	160,200 (100)
F_2	91,700 (51)	87,800 (49)	0	0	0	0	179,500 (100)
F_3	0	40,100 (9)	189,900 (44)	206,200 (47)	0	0	436,200 (100)
F_4	0	0	0	165,100 (28)	15,200 (72)	0	180,300 (100)
F_5	0	0	0	0	19,600 (28)	51,200 (72)	70,800 (100)
$\sum_{j=0}^{5} H_j$	698,900 (47)	127,900 (9)	189,900 (13)	371,300 (26)	34,800 (2)	51,200 (3)	1,474,000 (100)

Table V-21. Stock-User Matrix in 1987. Option 2b' (Max. Hyp.)

Income Groups \ Dwelling Types	H_0	H_1	H_2	H_3	H_4	H_5	$\sum_{i=0}^{5} F_i$
F_0	447,000 (100)	0	0	0	0	0	447,000 (100)
F_1	107,900 (67)	52,300 (33)	0	0	0	0	160,200 (100)
F_2	0	111,000 (62)	68,500 (38)	0	0	0	179,500 (100)
F_3	0	0	331,600 (76)	104,600 (24)	0	0	436,200 (100)
F_4	0	0	0	108,600 (60)	71,700 (40)	0	180,300 (100)
F_5	0	0	0	0	53,800 (76)	17,000 (24)	70,800 (100)
$\sum_{j=0}^{5} H_j$	554,900 (38)	163,300 (11)	400,100 (27)	213,200 (14)	125,500 (9)	17,000 (1)	1,474,000 (100)

Table V-22. Stock-User Matrix in 1987. Options 1b' (Max. Hyp.)

Income Groups \ Dwelling Types	H_0	H_1	H_2	H_3	H_4	H_5	$\sum_{i=0}^{5} F_i$
F_0	447,000 (100)	0	0	0	0	0	447,000 (100)
F_1	79,600 (50)	80,600 (50)	0	0	0	0	160,200 (100)
F_2	0	119,600 (66)	59,900 (33)	0	0	0	179,500 (100)
F_3	0	0	340,200 (78)	96,000 (22)	0	0	436,200 (100)
F_4	0	0	0	108,600 (60)	71,700 (40)	0	180,300 (100)
F_5	0	0	0	0	53,800 (76)	17,000 (24)	70,800 (100)
$\sum_{j=0}^{5} H_j$	526,600 (35)	200,200 (14)	400,100 (27)	204,600 (14)	125,500 (9)	17,000 (1)	1,474,000 (100)

Table V-23. Stock User Matrix in 1987. Option 1d (Max T_j with D_5 without Inv. Const.) (Max. Hyp.)

F_i \ H_j	H_0	H_1	H_2	H_3	H_4	H_5	ΣF_i
F_0	355,300 (79.5)	91,700 (20.5)	0	0	0	0	447,000 (100)
F_1	0	85,263 (53.2)	74,937 (46.8)	0	0	0	160,200 (100)
F_2	0	0	179,500 (100)	0	0	0	179,500 (100)
F_3	0	0	436,200 (100)	0	0	0	436,200 (100)
F_4	0	0	51,700 (28.6)	89,300 (49.5)	34,800 (19.3)	4,500 (2.6)	180,300 (100)
F_5	0	0	0	0	0	70,800 (100)	70,800 (100)
ΣH_j	355,300 (24.1)	176,963 (12)	742,337 (50.4)	89,300 (6)	34,800 (2.4)	75,300 (5.1)	1,474,000 (100)

Table V-24. Stock User Matrix in 1987. Option 1d. Min. Hyp.

F_i \ H_j	H_0	H_1	H_2	H_3	H_4	H_5	$\sum_{i=0}^{5} F_i$
F_0	355,300 (79.4)	91,700 (20.6)	0	0	0	0	447,000 (100)
F_1	0	160,200 (100)	0	0	0	0	160,200 (100)
F_2	0	179,500 (100)	0	0	0	0	179,500 (100)
F_3	0	47,062 (10.8)	389,138 (89.2)	0	0	0	436,200 (100)
F_4	0	0	26,700 (14.8)	114,300 (63.4)	34,800 (19.3)	4,500 (2.5)	180,300 (100)
F_5	0	0	0	0	0	70,800 (100)	70,800 (100)
$\sum_{i=0}^{5} H_j$	355,300 (24.1)	478,462 (32.5)	415,838 (28.2)	114,300 (7.7)	34,800 (2.4)	75,300 (5.1)	1,474,000 (100)

Table V-25. Stock User Matrix in 1987. Option 1e (Max T_j with $D_{1s} = D_{2s} = D_{3s}$) Max. Hyp.

F_i \ H_j	H_0	H_1	H_2	H_3	H_4	H_5	ΣF_i
F_0	355,300 (79.5)	91,700 (20.5)	0	0	0	0	447,000 (100)
F_1	0	136,200 (85)	24,000 (15)	0	0	0	160,200 (100)
F_2	0	0	179,500 (100)	0	0	0	179,500 (100)
F_3	0	0	315,333 (72.3)	120,867 (17.8)	0	0	436,200 (100)
F_4	0	0	0	180,300 (100)	0	0	180,300 (100)
F_5	0	0	0	19,000 (26.8)	34,800 (49.2)	17,000 (24)	70,800 (100)
ΣH_j	355,300 (24.1)	227,900 (15.5)	518,833 (35.2)	320,167 (21.7)	34,800 (2.3)	17,000 (1.2)	1,474,000 (100)

Table V-26. Stock User Matrix in 1987. Option 1e. Min. Hyp.

F_i \ H_j	H_0	H_1	H_2	H_3	H_4	H_5	$\sum_{i=0}^{5} F_i$
F_0	355,300 (79.4)	91,700 (20.6)	0	0	0	0	447,000 (100)
F_1	0	160,200 (100)	0	0	0	0	160,200 (100)
F_2	0	13,750 (7.6)	165,750 (92.4)	0	0	0	179,500 (100)
F_3	0	0	436,200 (100)	0	0	0	436,200 (100)
F_4	0	0	53,000 (29.4)	127,300 (70.6)	0	0	180,300 (100)
F_5	0	0	0	19,000 (26.8)	34,800 (49.1)	17,000 (24.1)	70,800 (100)
$\sum_{j=0}^{5} H_j$	355,300 (24.1)	265,650 (18)	654,950 (44.4)	146,300 (9.9)	34,800 (2.4)	17,000 (1.1)	1,474,000 (100)

Table V-27. Stock User Matrix in 1987. Option 1f. (Max T_j without consts.) Max. Hyp.

F_i \ H_j	H_0	H_1	H_2	H_3	H_4	H_5	ΣF_i
F_0	355,300 (79.5)	91,700 (20.5)	0	0	0	0	447,000 (100)
F_1	0	36,200 (22.6)	124,000 (77.4)	0	0	0	160,200 (100)
F_2	0	0	179,500 (100)	0	0	0	179,500 (100)
F_3	0	0	368,667 (84.5)	67,533 (15.5)	0	0	436,200 (100)
F_4	0	0	0	180,300 (100)	0	0	180,300 (100)
F_5	0	0	0	19,000 (16.8)	37,800 (29.2)	17,000 (24)	70,800 (100)
ΣH_j	355,300 (24.1)	127,900 (8.7)	672,167 (45.6)	266,833 (18.1)	37,800 (2.3)	17,000 (1.2)	1,474,000 (100)

Table V-28. Stock User Matrix 1987. Option 1f. Min. Hyp.

F_i \ H_j	H_0	H_1	H_2	H_3	H_4	H_5	$\sum_{i=0}^{5} F_i$
F_0	355,300 (79.5)	91,700 (20.5)	0	0	0	0	447,000 (100)
F_1	0	36,200 (22.6)	124,000 (77.4)	0	0	0	160,200 (100)
F_2	0	0	179,500 (100)	0	0	0	179,500 (100)
F_3	0	0	436,200 (100)	0	0	0	436,200 (100)
F_4	0	0	126,467 (70.1)	53,833 (29.9)	0	0	180,300 (100)
F_5	0	0	0	19,000 (26.8)	34,800 (49.1)	17,000 (24.1)	70,800 (100)
$\sum_{j=0}^{5} H_j$	355,300 (24.1)	127,900 (8.7)	866,167 (58.8)	72,833 (4.9)	34,800 (2.4)	17,000 (1.1)	1,474,000 (100)

Table V-29. Stock User Matrix in 1987. Option 2d. (Max $V_j D_j$; D_5 without Inv. Const.) Max. Hyp.

F_i \ H_j	H_0	H_1	H_2	H_3	H_4	H_5	ΣF_i
F_0	447,000 (100)	0	0	0	0	0	447,000 (100)
F_1	160,200 (100)	0	0	0	0	0	160,200 (100)
F_2	64,767 (36)	114,733 (64)	0	0	0	0	179,500 (100)
F_3	0	13,167 (3)	189,900 (43.5)	233,133 (53.5)	0	0	436,200 (100)
F_4	0	0	0	138,167 (76.6)	37,633 (20.9)	4,500 (2.5)	180,300 (100)
F_5	0	0	0	0	0	70,800 (100)	70,800 (100)
ΣH_j	671,967 (45.6)	127,900 (8.7)	189,900 (12.9)	371,300 (25.2)	37,633 (2.5)	75,300 (5.1)	1,474,000 (100)

Table V-30. Stock User Matrix in 1987. Option 2d. Min. Hyp.

F_i \ H_j	H_0	H_1	H_2	H_3	H_4	H_5	$\sum_{i=0}^{5} F_i$
F_0	447,000 (100)	0	0	0	0	0	447,000 (100)
F_1	160,200 (100)	0	0	0	0	0	160,200 (100)
F_2	136,217 (75.9)	43,283 (24.1)	0	0	0	0	179,500 (100)
F_3	0	84,617 (19.4)	189,900 (43.5)	161,683 (37.1)	0	0	436,200 (100)
F_4	0	0	0	134,617 (74.7)	41,183 (22.8)	4,500 (2.5)	180,300 (100)
F_5	0	0	0	0	0	70,800 (100)	70,800 (100)
$\sum_{j=0}^{5} H_j$	743,417 (50.4)	127,900 (8.7)	189,900 (12.9)	296,300 (20.1)	41,183 (2.8)	75,300 (5.1)	1,474,000 (100)

Table V-31. Stock User Matrix in 1987. Option 2e. (Max $V_j D_j$; $D_{1s} = D_{2s} = D_{3s}$). Max. Hyp.

F_i \ H_j	H_0	H_1	H_2	H_3	H_4	H_5	ΣF_i
F_0	447,000 (100)	0	0	0	0	0	447,000 (100)
F_1	160,200 (100)	0	0	0	0	0	160,200 (100)
F_2	52,533 (29.2)	126,967 (70.8)	0	0	0	0	179,500 (100)
F_3	0	100,933 (23.1)	289,900 (66.5)	45,367 (10.4)	0	0	436,200 (100)
F_4	0	0	0	125,933 (69.8)	49,867 (27.6)	4,500 (2.6)	180,300 (100)
F_5	0	0	0	0	0	70,800 (100)	70,800 (100)
ΣH_j	659,733 (44.8)	227,900 (15.4)	289,900 (19.7)	171,300 (11.6)	49,867 (3.4)	75,300 (5.1)	1,474,000 (100)

Table V-32. Stock User Matrix in 1987. Option 2e. Min. Hyp.

F_i \ H_j	H_0	H_1	H_2	H_3	H_4	H_5	$\sum_{i=0}^{5} F_i$
F_0	447,000 (100)	0	0	0	0	0	447,000 (100)
F_1	160,200 (100)	0	0	0	0	0	160,200 (100)
F_2	141,484 (78.9)	38,016 (21.1)	0	0	0	0	179,500 (100)
F_3	0	171,884 (39.4)	264,316 (60.6)	0	0	0	436,200 (100)
F_4	0	0	584 (0.3)	146,300 (81.2)	33,416 (18.5)	0	180,300 (100)
F_5	0	0	0	0	2,384 (19.5)	69,416 (80.5)	70,800 (100)
$\sum_{j=0}^{5} H_j$	748,684 (50.8)	209,900 (14.2)	264,900 (17.9)	146,300 (9.9)	34,800 (2.4)	69,416 (4.8)	1,474,000 (100)

Table V-33. Stock User Matrix in 1987. Option 2f. (Max $V_j D_j$ without consts.) Max. Hyp.

F_i \ H_j	H_0	H_1	H_2	H_3	H_4	H_5	ΣF_i
F_0	447,000 (100)	0	0	0	0	0	447,000 (100)
F_1	160,200 (100)	0	0	0	0	0	160,200 (100)
F_2	179,500 (100)	0	0	0	0	0	179,500 (100)
F_3	86,367 (19.8)	127,900 (29.4)	189,900 (43.5)	32,033 (7.3)	0	0	436,200 (100)
F_4	0	0	0	39,267 (21.8)	136,533 (75.7)	4,500 (2.5)	180,300 (100)
F_5	0	0	0	0	0	70,800 (100)	70,800 (100)
ΣH_j	873,067 (59.2)	127,900 (8.7)	189,900 (12.9)	71,300 (4.8)	136,533 (9.2)	75,300 (5.2)	1,474,000 (100)

Table V-34. Stock User Matrix in 1987. Option 2f. Min. Hyp.

F_i \ H_j	H_0	H_1	H_2	H_3	H_4	H_5	$\sum_{i=0}^{5} F_i$
F_0	447,000 (100)	0	0	0	0	0	447,000 (100)
F_1	160,200 (100)	0	0	0	0	0	160,200 (100)
F_2	179,500 (100)	0	0	0	0	0	179,500 (100)
F_3	134,867 (30.9)	127,900 (29.3)	173,433 (39.8)	0	0	0	436,200 (100)
F_4	0	0	16,467 (9.2)	71,300 (39.5)	88,033 (48.8)	4,500 (2.5)	180,300 (100)
F_5	0	0	0	0	0	70,800 (100)	70,800 (100)
$\sum_{j=0}^{5} H_j$	921,567 (62.5)	127,900 (8.7)	189,900 (12.9)	71,300 (4.8)	88,033 (6)	75,300 (5.1)	1,474,000 (100)

Table V-35. Percentages of Homeless Households in 1987 (Households Living in H_0)

Different Options	Minimum Hypothesis		Maximum Hypothesis	
Option 1a (Max T_j, N and S Constraints)	24	(-20.8)	24	(-20.8)
Option 2a (Max V_jD_j, N and S Constraints)	53	(+ 8.2)	47	(+ 2.2)
Option 1b' (Max T_j, Min % preservat.)	-	-	38	(- 6.8)
Option 2b' (Max V_jD_j, Min. % preservat.)	-	-	35	(- 9.8)
Option 1d (Max T_j; D_5 without I const.)	24.1	(-20.7)	2 .1	(-20.7)
Option 2d (Max V_jD_j; D_5 without I const.)	50.4	(+ 5.6)	45.6	(+ 0.8)
Option 1e (Max T_j; D_{1s} = D_{2s} = D_{3s})	24.1	(-20.7)	24.1	(-20.7)
Option 2e (Max V_jD_j; D_{1s} = D_{2s} = D_{3s})	50.8	(+6)	44.8	(0)
Option 1f (Max T_j; without const.)	24.1	(-20.7)	24.1	(-20.7)
Option 2f (Max V_jD_j; without const.)	62.5	(+17.7)	59.2	(+14.4)

(...) relative to 1972. Notice that the percentage of homeless households in 1972 was equal to 44.8 percent.

The percentage of homeless households (those living in H_0) has decreased between 1972 and 1987 in all options one, where the objectiv objective function was to maximize the filtering process and to satisfy the housing needs of the very poor indirectly. The percentage of homeless households has increased between 1972 and 1987, with options

2 (maximizing the total value of the new dwellings). The only exception is option 2b' (maximize $\sum_{j=1}^{5} V_j D_j$ with minimum rate of preservation).

2) The second test of improvement or deterioration during the planning period is to compare housing values per household for different income groups in 1972 and 1987. (c.f. Tables 36 and 37).

First, we notice that the overall housing value per household has increased in all the options, with the highest increase given by options 2, whose objective was to maximize the total value of the new dwellings built between 1972 and 1987.

In options one (maximizing the filtering process) we have a net improvement in the housing values of income groups 0 and 1; the housing value of income group 2 does not change. We have a relatively small deterioration of the housing value of F_3, but a sharp deterioration for income groups 4 and 5. In all the other options, we have a deterioration of the housing value per household for all income groups, although the overall average value has increased.

Notice that the improvement of the housing value of F_0 and F_1 in options one is due to the existence of the filtering down process (T_1 and T_2 are positive) which has improved the housing value of these two income groups although no new dwellings were directly built for them ($D_1 = 0$ with the maximum hypothesis and 77,750 or 11 percent with the minimum hypothesis).

3) The third test of whether housing conditions have improved or not during the planning period is to estimate the percentages of inadequately housed households (not located on or above the

Table V-36. Housing Value per Household (1972 - Dinars). Max. Hyp.

Options one / Income Groups	1972	1987-1a Max T_j with free upward and downward filtering	1987-1b' Max T_j with minimum preservation	1987-1d Max T_j luxurious units without I const.	1987-1e Max T_j $D_{1s} = D_{2s} = D_{3s}$	1987-1f Max T_j without any const.
F_0	200	231	200	231	231	231
F_1	343	621	275	567	511	621
F_2	700	700	534	700	700	700
F_3	1,631	1,266	1,069	1,111	1,222	1,266
F_4	3,000	2,155	2,651	1,977	2,377	2,155
F_5	6,877	3,721	5,642	8,470	3,720	3,720
$\sum_{i=0}^{5} F_i$	801	1,040	1,007	1,195	1,042	1,039

Options two / Income Groups	1972	1987 2a Max V_jD_j	1987 2b' Max V_jD_j	1987 2d Max V_jD_j	1987 2e Max V_jD_j	1987 2f Max V_jD_j
F_0	200	200	200	200	200	200
F_1	343	200	249	200	200	200
F_2	700	273	700	296	306	200
F_3	1,631	1,046	1,085	1,157	834	442
F_4	3,000	2,874	2,686	2,932	2,418	2,714
F_5	6,877	6,618	5,642	8,470	8,470	8,470
$\sum_{i=0}^{5} F_i$	801	1,045	1,003	1,226	1,069	1,350

Table V-37. Housing Value per Household (1972-Dinars). Min. Hyp.

Income Groups \ Options	1972	1987-1a Max T_j with free upward and downward filtering	1987-1b' Max T_j with minimum preservation	1987-1d Max T_j luxurious units without I const.	1987-1e Max T_j $D_{1s} = D_{2s} D_{3s}$	1987-1f Max T_j without any const.
F_0	200	231	no feasible solution	231	231	231
F_1	343	536		350	470	621
F_2	700	700		600	699	700
F_3	1,631	1,055		858	700	1,088
F_4	3,000	1,521		2,081	1,654	1,500
F_5	6,877	3,721		8,470	3,720	3,339
$\sum_{i=0}^{5} F_i$	801	890		1,096	794	889

Income Groups \ Options	1972	1987 2a Max V_jD_j	1987 2b' Max V_jD_j	1987 2d Max V_jD_j	1987 2e Max V_jD_j	1987 2f Max V_jD_j
F_0	200	200	no feasible solution	200	200	200
F_1	343	200		200	200	200
F_2	700	206		236	232	200
F_3	1,631	834		929	659	442
F_4	3,000	2,517		2,844	2,090	2,716
F_5	6,877	6,153		8,470	8,221	8,470
$\sum_{i=0}^{5} F_i$	801	957		1,141	956	977

diagonal line in the matrix). Tables V-38 and V-39 give us these percentages.

Option b which would have kept the housing conditions of all income groups from deteriorating is not feasible for Tunisia because of the investment constraint. Therefore we expect a deterioration of the average housing condition in Tunisia during the planning period, given the demographic and the economic rate of growth, and given the low share of housing investment relative to the gross national product. Our maximum rate of investment ($\alpha = \frac{\bar{I}}{GNP}$) is 4.5 percent, while the rate required in order to keep the housing conditions from deteriorating is 7.9 percent. In general, options 1 ($\text{Max} \sum_{j=1}^{5} T_j$) give lower rates of deterioration than options 2.

Note that in order to have 100 percent of the households adequately housed in 1987, we built a stock-user matrix for the target year and we assume that all the cases below the disgonal line are empty, and we also assume no homeless households. (c.f. Table V-40). The number of dwellings of different types to be built during the planning period (1973-87) are:

$$D_1 = 468{,}900 \text{ units}$$

$$D_2 = 0 \text{ units}$$

$$D_3 = 364{,}900 \text{ units}$$

$$D_4 = 145{,}500 \text{ units}$$

$$D_5 = 53{,}800 \text{ units}$$

$$\sum_{j=1}^{5} D_j = 1{,}033{,}100 \text{ units}$$

The total amount of investments required to carry out this program is $\sum_{j=1}^{5} I_j D_j = 2{,}941{,}530{,}000$ dinars which represents 10.10

Table V-38. Percentages of Well Housed Households per Income Group - (1972-1987) Max. Hyp.

Options 1 / Different Income Groups	1972	1987 Option 1a Max T_j with N & S const.	1987 Option 1b' Max T_j min. % preservation	1987 Option 1d Max T_j, D_5 without Inv. constraint	1987 Option 1e Max T_j $D_{1s} = D_{2s} = D_{3s}$	1987 Option 1f Max T_j without const.
F_0	0	21 (+21)	0 (0)	20.5 (+20.5)	20.5 (+20.5)	20.5 (+20.5)
F_1	82	100 (+18)	50 (-32)	100 (+18)	100 (+18)	100 (+18)
F_2	100	100 (0)	34 (-66)	100 (0)	100 (0)	100 (0)
F_3	66.1	16 (-50.1)	22 (-44)	0 (-66.1)	17.1 (-48.1)	15.5 (-50.6)
F_4	100	0 (-100)	40 (-60)	21.9 (-78.1)	0 (-100)	0 (-100)
F_5	61.6	24 (-16.3)	24 (-37.6)	100 (+38.4)	24 (-37.6)	24 (-37.6)
$\Sigma_{i=0}^{5} F_i$	51.3	35 (-16.3)	22.1 (-29.2)	36.8 (-14.5)	38.6 (-12.7)	35 (-16.3)
Options 2 / Different Income Groups	1972	1987 Option 2a Max V_jD_j	1987 Option 2b' Max V_jD_j	1987 Option 2d Max V_jD_j	1987 Option 2e Max V_jD_j	1987 Option 2f Max V_jD_j
F_0	0	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
F_1	82	0 (-82)	33 (-49)	0 (-82)	0 (-82)	0 (-82)
F_2	100	0 (-100)	38 (-62)	0 (-100)	0 (-100)	0 (-100)
F_3	66.1	67 (+0.9)	24 (-42)	53.5 (-12.6)	10.4 (-55.7)	7.3 (-58.8)
F_4	100	8 (-92)	40 (-60)	23.4 (-76.6)	30.2 (-69.8)	78.2 (-21.8)
F_5	61.6	72 (+10.4)	24 (-37.6)	100 (+38.4)	100 (+38.4)	100 (+38.4)
$\Sigma_{i=0}^{5} F_i$	51.3	18.5 (-32.8)	21.4 (-29.9)	23.5 (-27.8)	11.6 (-39.7)	16.5 (-34.8)

(...) changes relative to 1972

Table V-39. Percentages of Well Housed Households per Income Group (1972-1987) Min. Hyp.

Options 1 / Different Income Groups	1972	1987 Option 1a Max T_j with N & S	1987 Option 1b' Max T_j Min. tion	1987 Option 1d Max T_j, D_5 without I const.	1987 Option 1e Max T_j $D_{1s} = D_{2s} = D_{3s}$	1987 Option 1f Max T_j without const.
F_0	0	20.6 (+20.6)	No feasible solution	20.6 (+20.6)	20.6 (+20.6)	20.6 (+20.6)
F_1	82	100 (+18)		100 (+18)	100 (+18)	100 (+18)
F_2	100	100 (0)		0 (-100)	22.4 (-7.6)	100 (0)
F_3	66.1	0 (-66.1)		0 (-66.1)	0 (-66.1)	0 (-66.1)
F_4	100	0 (-100)		21.8 (-78.2)	0 (-100)	0 (-100)
F_5	61.6	24.1 (-37.5)		100 (+38.6)	24.1 (-27.5)	24.1 (37.5)
$\sum_{i=0}^{5} F_i$	51.3	30.5 (-20.8)		24.6 (-26.7)	29.5 (-21.8)	28 (-23.3)

Options 2 / Different Income Groups	1972	1987 Option 2a Max $V_j D_j$	1987 Option 2b' Max $V_j D_j$	1987 Option 2d Max $V_j D_j$	1987 Option 2e Max $V_j D_j$	1987 Option 2f Max $V_j D_j$
F_0	0	0 (0)	No feasible solution	0 (0)	0 (0)	0 (0)
F_1	82	0 (-82)		0 (-82)	0 (-82)	0 (-82)
F_2	100	0 (-100)		0 (-100)	0 (-100)	0 (-100)
F_3	66.1	29 (37.1)		37.1 (-29)	0 (-66.1)	0 (-66.1)
F_4	100	5 (-95)		25.3 (-76.7)	18.5 (-81.5)	51.3 (-48.7)
F_5	61.6	65 (+3.4)		100 (+38.4)	80.5 (+18.9)	100 (+38.4)
$\sum_{i=0} F_i$	51.3	12.3 (-39)		18.9 (-32.4)	7 (-44.3)	11.1 (-40.2)

Table V-40. Housing Stock User Matrix - 1987 - 100% of Households Well Housed

F_i \ H_j	H_0	H_1	H_2	H_3	H_4	H_5	$\sum_{i=0}^{5} F_i$
F_0	0	447,000	0	0	0	0	447,000
F_1	0	149,800	10,400	0	0	0	160,200
F_2	0	0	179,500	0	0	0	179,500
F_3	0	0	0	436,200	0	0	436,200
F_4	0	0	0	0	180,300	0	180,300
F_5	0	0	0	0	0	70,800	70,800
$\sum_{j=0}^{5} H_j$	0	596,800	189,900	436,200	180,300	70,800	1,474,000

percent of the gross national product. This share of GNP for housing is not an outrageous amount, but it is more than what any country has been willing to allocate to housing on a sustained basis for a long period. Note that the annual rate expected in Tunisia between 1972 and 1987 is between 3.5% and 4.5%.

§4. Conclusion:

The American literature (1) on filtering strategies expects new constructions to be of high quality level and occupied by high income groups, while the demands of low and average income groups will be satisfied indirectly through the filtering process. In a less developed country where the housing conditions of most income groups are poor; where a high percentage of the households are homeless; and where investment in housing is still limited; a filtering strategy with a public housing program could constitute a good long run housing policy. However, contrary to what the American literature on filtering expects from such a strategy, new constructions would be of average quality level and would create a downward filtering towards the lowest income groups and an upward filtering towards the highest income groups. This type of strategy emphasizing average quality dwellings is expected to meet both objectives of LDC's, the number objective and the quality objective. The lowest income group which could not be on the authorized housing market because of its income constraint could have access to better dwellings through the filtering process. This strategy is better than any strategy emphasizing very high quality dwellings whose small number would not be able to offset the general deterioration of the housing stock in the planning period, since investment is limited.

What are the policy implications of a filtering strategy with a public housing program in an LDC?

Subsidies should not be given on the basis of how many dwellings of type j are developed by the public sector, but on the basis of how many households of low income groups which are in need of such subsidies, will occup these dwellings. With the existence of upward filtering, a new dwelling D_2 or D_3 subsidized by the State may be occupied by a new household F_3 or F_4 which does not need this subsidy and which accepts living in D_2 or D_3 because it could not carry out its best option (a new D_3 or an old D_4 for F_3, or a new D_4 or an old D_5 for F_4). Subsidies should not be tied only to new dwellings, they should be extended to old dwellings. For example, subsidies should be given to the lowest income group when they try to acquire old dwellings on the authorized market. Subsidies should also be given to the poor families which want to repair and maintain their old dwelling. This policy will make the filtering strategy more effective. In Tunisia, for example, the actions of an institution such as the National Fund to Improve Housing (F.N.A.H.)[(a)] should be improved and increased. However, the households do not only need financial help, they also need advisory services in home improvement and finance.

Under each of the housing strategies developed in this chapter, other allocations to new construction would ultimately give worse results. Some groups would be worse housed without another

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(a) c.f. Chapter II.

being better housed to an equal extent. It is easy to change initial construction and financing plans but difficult to forecast their indirect ramifications.

Although it depends on a number of untested assumptions, the linear programming approach is probably the best method so far available.

References to Chapter 5

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5. David M. Gordon, Problems in political economy - an urban perspective. D.C. Heath and Company, 1971 (page 406).

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CHAPTER VI

SUMMARY AND CONCLUSION

The main policy question raised in this dissertation was whether in a less developed country such as Tunisia the poor are to be helped directly with new construction or indirectly through filtering.

We tried to answer this question by learning how the housing stock is reallocated after new construction.

First, we held an inquiry on filtering in the District of Tunis in order to test whether filtering existed and, if it did, to determine its nature and its importance.

Second, we built a linear programming model, taking into account the filtering concept and constraints on investments, subsidies, and the number of dwellings to be developed by the public sector. The model shows what the consequences of different policies are for the housing conditions of households and for the total quality of the housing stock.

The inquiry on filtering in the District of Tunis gave us two main conclusions:

1. Filtering down is taking place in the District of Tunis. This conclusion is supported by the following estimates:

   a. The average length of the sequences of moves equals 2.05, or for each new dwelling built in the District of Tunis,

approximately two vacancies are created in the housing market.

b. Successive households involved in the sequence of moves are characterized by successively lower incomes. The average monthly income per household at position one is 71 dinars and 48 dinars at position four.

c. Successive housing units involved in the sequences of moves are characterized by successively lower values, smaller sizes, and less equipment.

2. The second main conclusion of the inquiry on filtering in the District of Tunis is that new high and average quality dwellings have longer sequences of moves or vacancy chains than low quality dwellings. However, high quality dwellings (valued at more than 5,000 dinars) do not have longer sequences than average quality dwellings (between 3,000 dinars and 5,000 dinars). Therefore, high quality dwellings and average quality dwellings have about equal "filtering effects" in the District of Tunis.

The linear programming model applied to the Tunisian case, used filtering and various constraints to develop stock-user matrices in the target year. The following were the conclusions.

In a less developed country such as Tunisia, where a high percentage of households are homeless and where investment in housing is a limiting constraint, a filtering strategy based on high quality dwellings is not adequate and will not benefit the lowest income group or homeless households. However, a filtering strategy based on the construction of <u>average quality dwellings</u> constitutes a good long-run housing policy. Therefore, contrary to the existing literature on filtering, new construction of average quality creates downward

filtering from the middle income group to lower groups and upward filtering to higher income groups.

We assumed throughout this model that each type of dwelling is intended for a particular group. Filtering down takes place if a dwelling is occupied by a lower income household than the one it was built for. Filtering up exists whenever this unit is occupied by a higher income group than the one it was originally intended for. Whenever a household's income increases and the household changes from one income group to a higher one, it is expected to upgrade its housing conditions by moving to a higher quality dwelling. If this household cannot or refuses to move, we have by definition, a case of filtering up, although no actual physical move took place. This type of theoretical upward filtering explains the relative high number of "filtering up" cases found in the application of the models to the Tunisian case. Since we have assumed an increase in income per capita of 4.75 percent per year, a high percentage of the well housed households in 1972 become badly housed in the target year (1987) without moving from their former dwellings.

To conclude, the principal economic issues that affect housing are:

-- First, what is the society willing to pay for housing construction in one way or another? What share of national product will, can, and should be assigned to improvint the housing stock?

-- The second issue is the location of new housing -- large cities, small towns, or new communities.

-- The third issue is the density of settlement. Costs of building high or densely must be compared with saving in transportation and other utilities.

-- The fourth issue that calls for a decision is the quality of new construction, including the issue of whether the poor are to be helped directly with new construction or indirectly through filtering.

The main contribution of this dissertation is in trying to give an economic answer to the fourth issue. The linear programming model that we have presented in the preceding chapter includes some of the elements needed to produce a theoretically optimal composition of housing production. It gives the policy makers in developing countries a method for estimating the quantity and general quality of new construction, the income group that should get the subsidies and the numbers and types of dwellings that the public housing agencies should develop. In my opinion, this is the most important issue in housing.

The model also gives the policy makers a method for estimating the minimum amoung of investment required to keep the housing conditions of any income group from deteriorating or to attain a minimum level of preservation.

The location of new houses and the density of settlement issues are not treated in the present paper. The application of the linear programming model to different regions and urban areas, taking into account demographic differences, inter-regional migrations, local employment opportunities, and the location of vacancies would be an important next step. It would give us both quality and location of new dwellings. We may well get different housing policies for different regions in most countries.

The contribution of this dissertation is modest when compared to the quantity of research that remains to be done in housing, especially in less developed countries.

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