1. Introduction

The development and political problems arising from the choice of different economic and social investments in a Metropolitan area are not only complicated by different and often opposing interests (usually large and entangled ones), but also by the presence of technical difficulties.

Generally, in most countries the policy objective is to overcome shortages of labor in skilled occupations. As well, in the last two decades, the need for more specific analysis of employment and manpower problems in developing countries, particularly with regard to local markets, has greatly increased.

The fact is that the best possible performance of any planning depends upon a large number of decisions. Obviously, the performance may be that of motor car, a business, a chemical process or a machine. In terms of planning and economy, the question is how to choose the "best" set of decisions in order to achieve a particular objective.

However, we focus on the structure of the manpower and the changes in mobility patterns in the Cairo Metropolitan area. In addition to the results obtained from applying the Optimal Control Systems (OCS), the issue of education, training and manpower policy and their effects (direct & indirect) on the situation of Cairo are taken into consideration.

In short, this paper deals with the use of Optimal Control Systems (OCS) in order to achieve optimal distribution of manpower in the Cairo Metropolitan area for the various skill levels and over different time periods. The OCS enable us to quantify and predict the effects of any decision in order to find the "best" one. Also, the inputs and outputs are measured continuously in a given time period.

2. Objective of the Study

On the whole, this paper has three main goals:

(1) To deduce the alternatives of manpower distribution in Cairo with respect to the changes of mobility that could help the decision maker.
(2) To find out the effect of control factors on the mobility changes.
To deduce the objective function which could minimize the cost of welfare.

It should be noted that in this paper we use and link several economic and statistical methods in order to operate the Model (OCS) Life Cycle which enables us to achieve the above goals.

3. Manpower and Mobility

3.1. Principles of Manpower in Cairo

We assume that the manpower policy should contribute to national economic stability and growth in order to promote the full development of human resources. Consequently, the manpower policy embraces the forecasts and assessments of the demands and supplies for skills, specialization, jobs and so forth.

Therefore, the main three stages of development are as follows:

1) High Development Level

In this stage, the private sector and individual investments play a big role in development. Moreover, the individual workers seek socio-psychological satisfaction from their work places, work atmosphere and environment.

2) Intermediate Development Level

In this stage, public and union intervention has an important role, for instance, in coordination of corporate growth, manpower mobility and income distribution among different sectors of economy.

3) Low Development Level

In this level, the government should provide all the people's needs. Also, in this stage the role of individual investments and private sectors are neglected. In other words, the development is oriented basically towards the communist ideology.

3.2 Manpower Planning

Manpower planning is concerned with arranging for the right number of individuals within a group to be allocated to various well-defined activities. In brief, manpower planning in the narrow sense is concerned with matching the supply of people with the jobs available. In other words, it deals with numbers of people to be transferred, promoted and demoted.

Otherwhile, the utilization of the different kinds of manpower practices (i.e. recruitment and selection, training performance appraisal and promotion, etc.) depends on an interplay of external and internal factors such as impact of public labor policy, educational systems, regional traditions and customs, regional politics, level of technology, business and private sectors, management systems and so forth.

In regards to unemployment, it is difficult to determine exact numbers because a large portion of the population depends upon informal jobs (figure 1). But according to the census report of Egypt, the unemployment ratio between 1960-1976 was between 3.8%-6.2% for males and 9.4%-20.6% for females.

On the other hand, as a consequence of the present rapid economic growth and the
change of social norms, the participation of women in the economy will increase.

3.3 Mobility

People usually tend to stay longer in a given job when there are adverse economic conditions. Political conditions also affect the natural mobility of the labor force. Hence, an improvement in the economic situation will be reflected in a greater mobility of the work force.

Otherwise, job opportunities expand as aggregate production expands. Hence, the net expansion of job opportunities depends upon the system, speed and style of output expansion. So, the question is does a person prefers \( B \) to \( A \) because \( B \) is selected or because \( A \) is rejected? However, the problem that may be raised is what kinds of jobs are available? Also, what are the chances that a time will come when a trained man won't be able to get work?

Figures 2 and 3 show the difference between the terms mobility and migration. When
Figure 3  The difference between the terms mobility and migration

a person crosses the boundary (the definition of boundary differs from case to case, country to country, region to region, etc.) to seek a certain job in another place which satisfies his needs, this is called migration. On the other hand, when the movement occurs within the same boundary, we call this phenomenon mobility.

However, a mobility model describes how change takes place in the system, Promotion and demotion are under the direct control of management. Also, assumptions have to be made about the decisions which government planners will make in order to construct a forecasting model. The assumption about future government spending levels is based on a blend of historical data and by using a successive approximation method. In short, two assumptions are made regarding the “mobility” (Tan K.C. and Bennett R.J., 1984).

The first is called “Upward-Mobility” (i.e. the people who are in the lower class at time \( t \) are able to move to a job in a higher class at time \( t+1 \)).

The second is called “Downward-Mobility” (i.e. in some situations, because of slack labor demand, laborers from higher grades are forced to accept lower-grade jobs).

Specifically, the mobility term can be expressed mathematically as follows:

\[
Z(t+1) = a_{11}z(t) + a_{12}z(t)+a_{13}z(t)+a_{14}z(t)+b_{11}u(t_1) \\
Z(t+1) = a_{22}z(t)+a_{23}z(t)+a_{24}z(t)+b_{21}u(t_1)+b_{22}u(t_2) \\
Z(t+1) = a_{33}z(t)+a_{34}z(t)+b_{31}u(t_1)+b_{32}u(t_2)+b_{33}u(t_3) \\
Z(t+1) = a_{44}z(t)+b_{41}u(t_1)+b_{42}u(t_2)+b_{43}u(t_3)+b_{44}u(t_4)
\]

In other words, the above equations can be compactly represented as follows:

\[
Z(t+1) = A Z(t) + B U(t)
\]

Symbolically,

\[
A = \begin{bmatrix} a_{11} & a_{12} & a_{13} & a_{14} \\ 0 & a_{22} & a_{23} & a_{24} \\ 0 & 0 & a_{33} & a_{34} \\ 0 & 0 & 0 & a_{44} \end{bmatrix}
\]
where $Z(t+1)$ is the prediction value at time $(t)$, $Z(t)$ is the initial value, $A$ is the promotion matrix, $B$ is the demotion matrix and $U(t)$ is the control variable (policy) at time $(t)$.

4. Identification of the Potentials and Skill Level

4.1. Potential Supply of Manpower

The supply of labor is determined by the rate of population growth and the growth of existing employment opportunities in areas where demand exceeds the available local supply.

In any case, the pattern of labor supply and productivity depends on the nature of the production system, the physical qualities of the land, and capital resources. In general, labor and land are the principle inputs to Egypt's economy. The potential supply of labor is the population who are between the age of 10 and 60 years, economically active and currently available for the production and distribution of economic goals and services.

The following formula is used to calculate potential supply of labor force:

$$LS(t) = [LP(t) - (E + S + V)(t) + D(t)]$$

where $LS(t)$ is the total potential supply of labor force at time $(t)$, $LP(t)$ is the total population, $E(t)$ is the population under the age of 10 years, $S(t)$ is the population in the military services, $V(t)$ is the population over the age of 60 years and $D(t)$ is the number
of people who "drop out" from the non-labor variables and newly enter work force.

The definition of effective labor force is the potential labor force who are able and willing to work. The term does not cover those who are able to work and are neither willing nor seeking a job, (e.g. students and children).

Figure 4 shows the evaluation of labor force by types of economic activity. This figure shows that services and industry form the economic structure in Cairo.

4.2. Manpower by Skill Level

The need for vocational education and training programs, and the urgency to develop more of such programs in the near future, arise from the fact that in Cairo, there is an increasing demand for specific skills in the labor market (due to the concentration of the main economic facilities in Cairo).

For the purpose of constructing a model let us consider Cairo’s labor force, including new entrants to the labor pool, to be classified into four main “education skill” classes. The given number of workers in the four classes in 1986 (base year) are as follows:

(1) High Education  Class= 447,833
(2) Medium Education  Class=1,561,979
(3) Low Education Class=1,194,392
(4) Uneducated  Class=1,487,767

It should be noted that females represent about 90 percent of the last class (due to the

![Diagram of labor market, education system, and labor training facilities](image)
The Distribution of Manpower in Cairo Based on Optimal Control Systems

### Table 1 The Relation Between Target and Potential Supply

<table>
<thead>
<tr>
<th>Period</th>
<th>Year</th>
<th>Class 1</th>
<th>Class 2</th>
<th>Class 3</th>
<th>Class 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>First</td>
<td>1987-1991</td>
<td>$a \leq LS$</td>
<td>$a \leq LS$</td>
<td>$a \leq LS$</td>
<td>$a &lt; LS$</td>
</tr>
<tr>
<td>Second</td>
<td>1992-1996</td>
<td>$a &lt; LS$</td>
<td>$a = LS$</td>
<td>$a &lt; LS$</td>
<td>$a &lt; LS$</td>
</tr>
<tr>
<td>Third</td>
<td>1997-2001</td>
<td>$a = LS$</td>
<td>$a = LS$</td>
<td>$a &lt; LS$</td>
<td>$a &lt; LS$</td>
</tr>
</tbody>
</table>

Where; $a$ is the target value, $LS$ is the total potential supply.

- high percentage of migration from the rural areas to Cairo, the social norms and behaviors and drop out from training centers and schools).

Figure 5 shows the linkages and relationships between education, training and the labor market. Also, this figure explains why we used the education status as a standard of skill level. Especially in the case of Egypt, education is considered to be the most important factor affecting women's participation in the labor force.

Our target is to define the desired level of manpower requirements for each class. There are two reasons for selecting the target of manpower. The first is to follow the annual growth rate of the "Five Year Plan", but in our case, we aim to decrease the numbers in class three and class four by improving their skill levels. The second reason is to meet the estimation of potential supply of manpower. But in our case, in the first period of planning (1987-1991) the first, second and third classes will be equal or less than the potential supply.

For the second period (1992-1996) only the target of the second class will equal the potential because during this period the policy maker should make more effort to decrease the numbers in the third and fourth classes. For the last period of planning (1997-2001) the numbers in the first and second classes will equal the potential supply (because the development will be oriented towards high development level), while the third and fourth classes should continue to decrease (Table 1).

Mathematically speaking, we have to ensure that

$$\sum_{i=1}^{n} H_i(t) \leq LS(t)$$

(9)

Then

$$H1(t) + H2(t) + H3(t) + H4(t) \leq LS(t)$$

(10)

where $H_i(t)$ is the workers in class $i$ in time $(t)$, $LS(t)$ is the total potential supply of labor force in time $(t)$ and $n$ is total number of classes.

5. Optimal Control Systems (OCS)

5.1. Optimal Control Systems

Optimal control theory concerns the choice of a set of control factors to maximize or minimize a given objective function. However, the main objective of an optimal control
system is to reach "zonal balancing". On the whole, the system may be characterized by three elements: input, output, and the transition linking them. (Bennett R.J. and Chorley R.J., 1978)

The system is designed to operate on the input so as to yield the required output. The system also contains control variables that influence the stage of the simulation model. However, the idea of applying Optimal Control Systems to manpower planning is that the outcome is calculated by a mathematical model of the time path of input variables (some of which are subject to control as policy instruments). It should be noted that control systems do not mean that all the variables are going to be controlled. Figure 6 shows the schema of the system life cycle.

5.2. Control Variables

The controls are the variables which enable us to perform the required task by modifying the behavior of the outputs. The evolution of the controls in time are called policies or control trajectories and the time period of interest is called the horizon (it can be bounded or infinite).

The control variables which are used in the OCS are as follows:

(1) Self-finance of the social services sector.

(2) Investments in the social services by the public sector.
(3) Investments in the social services by the private sector.

(4) Net saving factor.

In our case, the term "social services" includes housing, public utilities and health services. The term "public sector" includes cooperatives and municipalities. The term "private sector" includes foreign companies, individual and private enterprises. The term "self-finance" implies reserves and allocation, down payments and letters of credit and other capital returns.

Symbolically,

\[ NSF = \{LN - (DC - EX)\} \]  

where NSF is the net saving factor, LN is the total Income, DC is the aggregate domestic consumption (foods, housing, health) and EX is the local taxes.

However, with these considerations in mind, a question may be raised about what things can be realistically achieved by the private sector? As we mentioned before, the investments and development by the private sector represent the high level of development.

Figure 7 shows the history of control factors in Cairo. This figure shows that the net saving factor represents the highest percentage, but unfortunately, this money is not oriented to development. Perhaps this money is used for buying gold or is kept at home or for another matters.

This situation emphasizes to us the need to consider the first and third control factors as the most important tools for high development level.

But we have to ensure that allocation of government spending on these control factors does not exceed a given amount (the budget allocated for economic programs).

\[ U1 + U2 + U3 + U4 \leq f(t) \]  

Figure 7  History of control factors in Cairo
Therefore, optimal control methods are used to determine the set of control variables \( u, \ldots u(t) \) which minimize an objective function when the control variables are subject to a set of independent linear equality constraints

\[
F(t)U(t) = f(t) \quad t=1, \ldots, T
\]

where \( U(t) \) is the control vector \((m \times 1)\), \( f(t) \) is the budget and \( F(t) \) is a matrix with all elements equal to unity. However we have also to make sure that the values of the first and third control variables are positive.

5.3. Successive Approximation Method (SAM)

With any new system there has always been the problem of establishing the use of the system once it has been developed. This fact is particularly true of computer systems and mathematical models. However, in order to operate the system life cycle (figure 6) the planner should select one design tool. Our tool is called SAM. Because of the simple relation between the SAM and Gauss-Seidel Method, we give a brief outline of the Gauss and Seidel Method.

It can be represented as follows:

\[
\delta Y^{(k)} = Y^{(k)} - Y^{(k-1)}
\]

(14)

where \( Y^{(k)} \) is the initial values, \( \delta Y^{(k)} \) is the correction adopted in the Gauss-Seidel method, \( K \) is the number of iteration and \( Y^{(k)} \) should be determined by Over-Relaxation, as

\[
Y^{(k)} = Y^{(k-1)} + \omega \delta Y^{(k)}
\]

(15)

However, the formula,

\[
Y^{(k)} = Y^{(k-1)} + \omega \delta Y^{(k)}
\]

(16)

is called Successive Over Relaxation

Where \( \omega \) is a relaxation factor

Typically \( \omega \) is fixed for all \( K \) at a value suitably chosen somewhere between 1 and 2.

According to the Gauss-Seidel method the range of \( K \) should be between 10 and 100. In our case, we considered the “best” solution to be the solution with minimum error, whether the \( K \) value was in the Gauss range or not. (Mason J.C., 1984)

However, the application of the iteration method has many advantages. For instance, iteration methods are simple to operate the program. Most iteration methods do not need to start from a good approximation of initial value (\( Y \)). Also, iteration methods are effectively not subject to rounding error, since solutions are “corrected” at each iteration.

In this paper the Successive Approximation Method (SAM) is used to obtain the value of \( Z \) by an iterative process. The purpose is then that each approximation should be better than the previous one, so that the sequence of approximation converges to the true solution.

For instance, we maximize a function \( f(A) \) of a point \( A \) in \( n \)-dimensional space in order to achieve a good hill and in turn we achieve the optimal values. Needless to say
5.4. Evaluation of Historical Simulation of Manpower

In our point of view, it would be useful to have a measure of performance associated with the Optimal Control Model. In other words, in order to examine our design tool we can test the link between SAM and OCS. Additionally, we can find out if the data fit the model or not. To do this, we found a useful model related to the Root Mean Square (RMS) simulation error. This tool is called Theil coefficient. (Pindyck R.S. and Rubinfeld D.L., 1987).

Theil’s equation can be presented as follows:

\[
\frac{1}{T} \sum (Y^s_t - Y^a_t)^2 = (\bar{Y}^s - \bar{Y}^a)^2 + (\sigma_s - \sigma_a)^2 + 2(1-\rho)\sigma_s\sigma_a
\] (17)

where \(\bar{Y}^s\), \(\bar{Y}^a\), \(\sigma_s\) and \(\sigma_a\) are the means and standard deviations of the series \(Y^s_t\) and \(Y^a_t\) respectively, and \(\rho\) is their correlation coefficient. Also, \(Y^s_t\) denotes the simulation value and \(Y^a_t\) is the initial value.

In our study, we used the proportions of Theil’s equation to measure the simulation error. The proportions \(T_b\), \(T_v\) and \(T_c\) are called the bias, the variance and the covariance proportions, respectively.

These measurements are shown as follows:

\[
T_b = \frac{(\bar{Y}^s - \bar{Y}^a)^2}{(1/T)\sum(Y^s_t - Y^a_t)^2}
\] (18)

\[
T_v = \frac{(\sigma_s - \sigma_a)^2}{(1/T)\sum(Y^s_t - Y^a_t)^2}
\] (19)

\[
T_c = \frac{2(1-\rho)\sigma_s\sigma_a}{(1/T)\sum(Y^s_t - Y^a_t)^2}
\] (20)

S.T.

\[T_b + T_v + T_c \leq 1\] (21)

5.5. Feedback and Loop System

The feedback system is presented by the following equation

\[
Z(t+1) = -p\{z(t)-a(t)\}
\] (22)

where \(z(t)\) is the system input, \(Z(t+1)\) denotes the output and \(a(t)\) is the target weighted by parameter \(p\).

When the output with respect to any input tends to a finite steady value (after the input assumes a constant value), the loop said to be stable. The stability of a control system is an important aspect of the feedback system design. In other words, the main goal of a feedback design is actually to stabilize a system if it is initially unstable.

If we suppose that the complete state can be accurately measured at all times, it is possible to implement a linear control law of the formula
\[ EI(t) = -F(t)Z(t) + I(t) \]  

where \( EI(t) \) is the input, \( F(t) \) is a time-varying feedback gain matrix and \( I(t) \) is the new input.

### 5.6. Structure of the Model

In order to develop control solutions the structural form of the model is defined by the following equations.

\[ Z(t+1) = AZ(t) + BU(t) \]  
\[ Y(t) = R(t)Z(t+1) + d(t)U(t) \]

where \( Z(t) \) is the initial state, \( A \) and \( B \) are coefficient matrices and are assumed to be known, \( U(t) \) is the control variable (Policy) and \( Y(t) \) is the output. When the matrix \( R(t) \) equals the identity matrix, the matrix \( d(t) \) equals the null matrix, then \( Z(t+1) \) equals \( Y(t) \).

Therefore, the optimal control model can be represented in the following formula

\[ Z(t+1) = \begin{pmatrix} A & B \end{pmatrix} \begin{pmatrix} Z(t) \\ U(t) \end{pmatrix} + \begin{pmatrix} X(t) \end{pmatrix} \]

where \( X(t) \) is the \( n \times 1 \) vector (exogenous variables) which are not subject to control (uncontrolled input), and \( Z(t) \) is the initial state.

Also, the value of \( Y(t) \) can be obtained from the following formula:

\[ Y(t) = MZ(t+1) \]

where \( M \) is the expectation operator or measurement matrix and is defined by the following matrix

\[ M = \begin{pmatrix} 1, 0, 0, 0...0 \end{pmatrix} \]

However, the exogenous variables are composed of two sets, those which are amenable to control and those which are not. The optimal control is determined by using the Successive Approximations Method using a combination of the control costs and system costs in an objective function.

The objective function (cost of welfare) is to minimize

\[ W^* = \sum_{t=1}^{T} \left[ aC1(t)[(Y(t) - a(t)] + \beta C2(t)[(LS(t) - a(t)] + \lambda C3(t)U(t) \right] \]

Subject To:

\[ \sum_{i=1}^{n} Y_i(t) \leq LS(t) \]  
\[ \sum_{j=1}^{m} U_j(t) \leq f \]  
\[ CH_1(t) + CH_2(t) \leq CH_3(t) + CH_4(t) \]  
\[ 0 < \beta < 1 \]
0 < \lambda < 1 \\
Q(t)U(t) \geq 0 \hspace{1cm} (34) \\
Q(t)U(t) \geq 0 \hspace{1cm} (35)

where

\[
Q(t) = \begin{bmatrix}
1 \\
0 \\
1 \\
0 \\
0 \\
\end{bmatrix}
\hspace{1cm} (36)
\]

\(U(t)\) is the control variable, \(a(t)\) is the target, \(C1(t)\) the cost of target, \(C2(t)\) the cost of unemployment, \(C3(t)\) the cost of control, \(f\) the parameter denoting the damage of unemployment, \(\lambda\) the parameter denoting the rate damage of cost of control, \(f\) denoting the budget, and \(H\) denoting the class and \(C\) denoting the total cost. The value of the parameter \(\alpha\) is obtained from the following formula

\[
a = (LG/g)^2 \hspace{1cm} (37)
\]

where \(LG\) is the value of largest target variable and \(g\) is the target value of variable in \(n\) th class.

Needless to say, it is difficult in socio-economic and ecological systems to decide appropriate values for the objective function terms of \(C1, C2, \) and \(C3\). However, in most cases, the response to feedback reactions consists of either producing new sources of data (inputs) to meet system needs, or of identifying the constraints and factors which may be causing unfavorable feedback.

6. Simulations and Results

In this section we look at the operation of the whole system in order to evaluate the effects of different variables and different options of distribution of manpower in Cairo.

Firstly, in the estimation of potential supply of manpower, the variable \(LP(t)\) in [equation 8] is obtained by using "Rapid Demographic Projection Model", (Hesham, A.M., Yamamura, E. and Kagaya S., 1989). The variable \(S(t)\) refers only to males (because the military service in Egypt is obligatory for males).

For the variable \(D(t)\) we assume that 15 percent of the population represented by variable \(S(t)\) will enter the labor market in the year 1987 (due to the peace treaties and the adopted policy which is oriented towards comprehensive development). Also, we assume that percentage will continue to increase by one percent every year to reach 30 percent by the year 2001.
As a result, the value of the variable $D(t)$ is 25,048 in 1987 and 54,000 in the year 2001. This number represents an additional potential supply of manpower. In addition, these numbers represent effective workers (due to the intensive training in the military services).

On the other hand, the analysis has shown that 22.6 percent of the total potential supply is under 15 years of age, 16.3 percent under age 30 and 48.2 percent is between 30 and 60 years of age (this represents the actual effective labor force).

<table>
<thead>
<tr>
<th>Year</th>
<th>Class 1</th>
<th>Class 2</th>
<th>Class 3</th>
<th>Class 4</th>
<th>Total</th>
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</tbody>
</table>

Figure 8 Percentage of potential supply of manpower in Cairo, 1987-2001
Table 3 Target of Manpower in Cairo from 1987 till 2001

<table>
<thead>
<tr>
<th>Year</th>
<th>Class 1</th>
<th>Class 2</th>
<th>Class 3</th>
<th>Class 4</th>
<th>Total</th>
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<td>1195691</td>
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<td>766981</td>
<td>759775</td>
<td>5235197</td>
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</table>

On the whole, the outputs of applying the equation [8] are shown in table 2, while figure 8 shows the percentage of potential supply per class from 1987 till 2001.

Table 3 shows our target of manpower in Cairo per class from 1987 till 2001. These targets are selected according to the estimation of potential supply (Table 1) and also consideration of the Egyptian Five Year Plan. Figure 9 shows the percentage of target per class from 1987 till 2001.

Figure 9 Percentage of target of manpower in Cairo, 1987-2001
Table 4 shows the simulation of equations [18], [19] and [20] using the historical data from 1976 to 1986. Also, these equations were used to examine the model "runs" and to see if the data fit the model. After the adjustments errors, the resulting data was used as new inputs.

This table also shows that the bias value is not so small (due to the lack of training facilities and detailed information about education services with respect to the lower classes). This situation enforces the need to minimize the numbers of the last two classes as much as possible in order to make development in Cairo more efficient.

Now let us switch to show the simulation of the (OCS). Firstly, there are some factors and assumptions are used to identify the matrices (A & B) of equation [24] and the policy $U(t)$.

The most important factors regarding the local and regional effects of the different classes (groups), are as follows:

1. Degree of the technology and innovation in Cairo.
2. Job stability in every class.
3. Job availability in other regions.
4. Average income per employee.
5. Occupational level (i.e. the proportion of skilled and unskilled workers).

It should be mentioned that income is a function of skills and qualifications.

For the objective function [equation 29], all the values are measured in monetary units (Egyptian Pound (L. E.)). It should be noted that, in 1990 ¥100 equaled L. E. 1.85. Therefore, the average income per person for each class determines the values of C1, C2 and C3.

Therein, the values of the parameters of equation [29] are weighted on scale of zero to one as follows:

For the first period of planning (1987-1991)

<table>
<thead>
<tr>
<th></th>
<th>Class 1</th>
<th>Class 2</th>
<th>Class 3</th>
<th>Class 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\beta$</td>
<td>0.4</td>
<td>0.2</td>
<td>0.3</td>
<td>0.3</td>
</tr>
<tr>
<td>$\lambda$</td>
<td>0.3</td>
<td>0.5</td>
<td>0.5</td>
<td>0.6</td>
</tr>
</tbody>
</table>
For the second period of planning (1992–1996)

<table>
<thead>
<tr>
<th>Class</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>β</td>
<td>0.5</td>
<td>0.3</td>
<td>0.4</td>
<td>0.4</td>
</tr>
<tr>
<td>λ</td>
<td>0.2</td>
<td>0.4</td>
<td>0.4</td>
<td>0.5</td>
</tr>
</tbody>
</table>

For the third period of planning (1997–2001)

<table>
<thead>
<tr>
<th>Class</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>β</td>
<td>0.6</td>
<td>0.6</td>
<td>0.5</td>
<td>0.5</td>
</tr>
<tr>
<td>λ</td>
<td>0.2</td>
<td>0.3</td>
<td>0.3</td>
<td>0.4</td>
</tr>
</tbody>
</table>

The weights of parameter (α) vary as a function of time.

The assumptions regarding the parameter (β) and in turn the costs of unemployment (units in L.E.) are as follows:

For the first class: The government gives an incentives to the people (refers to the income) in order to avoid depression of creativity level (research technique and know-how, for example).

For the second class: Increase in movement of people who cross the boundary, which leads to the migration problem.

For the third class: Shortage of productivity, especially in small scale industry.

For the fourth class: Spreading of marginal jobs and increase the social problems (crime, for example).

On the other hand, the assumptions of parameter λ (cost of control) are the following:

For the first control factor: Shortage of housing supply, sectorial agencies not willing to coordinate with each other.

For the second control factor: No linkage between wages and productivity, which affects the (GDP).

For the third control factor: Vocational and training programs not effective, people not willing to change their misbehavior.

For the fourth control factor: limited means (tools) of encouraging and attracting new investments.

In this simulation, we investigate such questions as: what is the effect of increasing one control factor on the mobility changes, when the other control factors remain constant.

Figure 10 shows the effect of control factors on the upward mobility. An increase in the first control factor, result in an increase in the opportunity for class four to move to an advanced class by (0.10) and (0.10) for the third class and (0.9) for the second class.

The third control factor also has a high ability to improve the situation in the second, third and fourth classes by (0.10) per class.
Figure 10 The effect of control factors on the upward mobility. Figure 10 shows the effects on the upward mobility when the first and third control factors increase by 10% and the other control factors remain constant.
The Distribution of Manpower in Cairo Based on Optimal Control Systems

Figure 11 The changes of manpower in Cairo from 1987 till 2001

Transition Matrix 1

\[
\begin{bmatrix}
0.90 & 0.10 & 0 & 0 \\
0.06 & 0.64 & 0.30 & 0 \\
0.04 & 0.26 & 0.30 & 0.40 \\
0 & 0 & 0.40 & 0.60
\end{bmatrix}
\]

Figure 12 Target of manpower achieved in Cairo from 1987 till 2001
Figure 13  The changes of manpower in Cairo from 1987 till 2001

Figure 14  Target of manpower achieved in Cairo from 1987 till 2001
Figure 15 The changes of manpower in Cairo from 1987 till 2001

Figure 16 Target of manpower achieved in Cairo from 1987 till 2001
However, the model presents five options for distribution of the manpower in Cairo from 1987 till 2001 (15 years period of time).

Figure 11 shows the first option for the changes of manpower from 1987 until 2001. This simulation corresponds to the transitional mobility matrix (matrix 1). Figure 12 shows the manpower targets achieved by this option. It shows that classes three and four have a rapid increase which could not meet the desired targets.

Figure 13 shows the second option of changes of manpower in Cairo from 1987 till 2001 corresponding to matrix 2. Figure 14 shows the target achieved with respect to this option.

Figure 15 shows the third option of the changes of manpower. Also, matrix 3 shows the reaction of the promotion and demotion which is associated with this option.

Figure 16 shows that class three has exceeded the target and has continued to increase. This situation has a negative impact on the whole process of development.

The third option is very close to the current Egyptian growth, which focuses on increasing all the classes without taking into consideration the real demand of the labor market in Cairo (the situation in Cairo is different from other parts of Egypt).

At the present and for the long term, the labor market in Cairo geared towards a high skill level and high quality of workers' careers (due to the investments of many foreign companies which apply high technology in their process of development).

Figure 17 shows the fourth option of the changes of manpower from 1987 till 2001. Matrix 4 corresponds to the changes of this option, while figure 18 shows the target of manpower achieved.

This option comes closest to our desired targets. We believe that the second class forms the vital pool for satisfying the demand of the labor market in Cairo. Additionally,
The Distribution of Manpower in Cairo Based on Optimal Control Systems

Transition Matrix 4

\[
\begin{bmatrix}
0.88 & 0.12 & 0 & 0 \\
0.08 & 0.69 & 0.23 & 0 \\
0.04 & 0.19 & 0.36 & 0.41 \\
0 & 0 & 0.41 & 0.59
\end{bmatrix}
\]

Option 4

Figure 18 Target of manpower achieved in Cairo from 1987 till 2001

Figure 19 The changes of manpower in Cairo from 1987 till 2001
Transition Matrix 5

\[
\begin{pmatrix}
0.44 & 0.56 & 0 & 0 \\
0.36 & 0.23 & 0.41 & 0 \\
0.20 & 0.21 & 0.38 & 0.21 \\
0 & 0 & 0.21 & 0.79
\end{pmatrix}
\]

Figure 20 Target of manpower achieved in Cairo from 1987 till 2001

Figure 21 Skill improvements per L.E. one Mn. of investments
the third and the fourth classes should continue to decrease.

The minimum cost [objective function, equation 29] related to this option is as follows:

1. Class 1 = 210.7 (units in L.E. Mn.)
2. Class 2 = 597.7 (units in L.E. Mn.)
3. Class 3 = 195.6 (units in L.E. Mn.)
4. Class 4 = 750.5 (units in L.E. Mn.)

Figure 19 presents the fifth option of changes of manpower from 1987 till 2001. Matrix 5 shows the transitional mobility matrix that interacts with this option, whilst, figure 20 shows the target of manpower achieved from 1987 till 2001.

In our point of view, this option can be considered as the second choice for the policy maker.

Figure 21 indicates the number whose skill is improved per L.E. one million of investment (concerning the investments by the private sector).

Figure 22 indicates the number whose skill is improved per L.E. one million of investment (concerning the investments by the public sector).

7. Conclusion

In this paper, we present a model to determine the effects of government policy on the mobility changes and in turn on the distribution of the manpower over four labor-skill categories.

Also, we investigate the effect of increasing one control factor on the mobility changes, when the other control factors remain constant.

By applying Optimal Control Systems we get the new distribution for the four classes from 1987 till 2001. The probability of a person working in one class and intend to move
to another class in order to fill a job is identified.

The minimum cost [objective function, equation 29] concerning the selected alternative for the distribution of manpower in Cairo from 1987 till 2001 is as follows:

(1) Class 1 = 210.7 (units in L.E. Mn.)
(2) Class 2 = 597.7 (units in L.E. Mn.)
(3) Class 3 = 195.6 (units in L.E. Mn.)
(4) Class 4 = 750.5 (units in L.E. Mn.)

There is an increase in the number of workers in the first and second classes affected by the first and third control factors. Moreover, there is a decrease in the number of workers in the third and fourth classes. Also, an improvement in training and educational techniques is shown to be highly influential towards decreasing numbers in the third and fourth classes by the year 2001.

Concerning manpower policy and programs in Cairo, in our point of view, the government should adopt new programs for improving technology, increasing the skill level and improving attitudes towards mobility especially in the lower classes. Here, we could call this kind of program “Effective Manpower Program for Rehabilitation and Training” (EMPRT).

References