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Modelling the Actuarial Projection and Valuation of the Egyptian Social Security Pension System

By

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"Modelling the Actuarial Projection and Valuation of the Egyptian Social Security Pension System"

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Declaration

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Abstract

This thesis is concerned with the projection and valuation of the Egyptian social security pension system which represents the first and main pillar in pension provision in Egypt. The system is officially a funded defined benefit one and is managed by two public Funds on behalf of the state. As a result of the pre-funding strategy, the two Funds have been accumulating a large amount of assets, which makes them important institutional investors with certain characteristics. Larger contributions from employees and/or employers or cutting back some benefits cannot be recommended by the system's actuary in the event of an actuarial deficit for many political, economic and social reasons. Actuarial deficits can be dealt with by two methods, the first is higher interest rates on the invested funds from the National Investment Bank (NIB). The second is a transfer from the Treasury to shoulder the actuarial deficit alongside the annual subsidy given to improve the level of benefits.

This strategy raises four very important questions. The first is whether the system's expected annual cash flow is sustainable under different demographic and economic scenarios, particularly whether the system will face any cash flow liquidity shortage in the near future. The second is how much the expected annual subsidy will be. The third is what is the required rate of interest on the invested funds to achieve the funding objective of covering 100% of the liabilities. The fourth is whether the current contribution rates are fair and adequate for new entrants at certain ages. In answering these questions a pension projection and valuation model is developed. This involves analysing and modelling the relevant demographic and economic factors in order to project them.

It is found that the system will face cash flow deficits unless it liquidates some of its assets over the projection period. It is also found that the current contribution rates are more than enough to cover the cost of new entrants, even with delays in starting work as a result of the high unemployment. It is also found that a moderate rate of interest of around 6-7% per annum with salary growth of around 8-9% per annum can keep the funding level at 100% of the liabilities. Finally, a set of recommendations are made for reforming the system to enable it to survive the changes it faces in an uncertain economic and demographic environment. Some suggestions for further work are also discussed.

Key to Symbols and Definitions

No.	Variable	Definitions
1. Population Variables		
1.	Base Date of projection	30^{th} of June 1997 is the base date of the projection (i.e. t = 0) and the projection will be carried out until 30^{th} of June 2025. This means that t takes values of t = 0, 1, …., 28. This allows a comparison between the model's results and the actual results over 1997-2000 in order to validate the model's projections over 2000-25;
2.	Coverage	The ESSPS covers 105% of the employed work force [1];
3.	s	Denotes sex and s = m for males and s = f for females;
4.	x, y, z	Age last birthday of male, female and orphan, respectively;
5.	$POP(x, t, s)$	Number of population of sex s and age x last birthday in year t;
6.	$LF(x, t, s)$	Number of labour force of age x last birthday and sex s in year t for $t \geq 1$ and $18 \leq x \leq 64$;
7.	$LFPR(x, t, s)$	Labour force participation rate for sex s and age x last birthday in year t for $t \geq 1$ and $18 \leq x \leq 64$;
8.	$TLF(t, s)$	Total labour force of sex s in year t for $t \geq 1$;
9.	$TLF(t)$	Total labour force of both sexes in year t for $t \geq 1$;
10.	$UEMR(x, t, s)$	Unemployment rate of sex s and age x last birthday in year t for $t \geq 1$ and $18 \leq x \leq 64$;
11.	$UEM(x, t, s)$	Number of unemployed of sex s and age x last birthday in year t for $t \geq 1$ and $18 \leq x \leq 64$;
12.	$EM(x, t, s)$	Number of employed of sex s and age x last birthday in year t for $t \geq 1$ and $18 \leq x \leq 64$;
13.	$TEM(t, s)$	Total number of employed of sex s in year t for $t \geq 1$;
14.	$TEM(t)$	Total number of employed in year t for $t \geq 1$
15.	M	Denotes particular scheme of the system where, M = H for the casual workers scheme, M = E for the self-employed scheme, M = W for the Egyptian working abroad scheme, M = C for the civil servants scheme, M = P for the public and private sector employees, M=GSF for the Government Sector Fund, M = PPSF for the Public and Private Sector Fund and M = ESSPS for the Egyptian Social Security Pension System;
16.	b, r	Denote entry age and Normal Retirement Age (NRA) respectively in scheme M where b = 18 for M = C, P, W

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[1] Any one who has joined any kind of jobs must join the ESSPS (except for the majority of the informal sector). Even if the individual changes the job he/she may stay in the same scheme or move to another scheme within the system. The only case, which might happen when the member moves to one of the jobs that have been contracted out in the 1970s, and this is a rare event. The coverage ratio of 105% was worked out from the experience of the ESSPS over 1990-1999. It is more than 100% because some of the unemployed workforce continuous to receive coverage in the year t because they were employed and contributed to system in previous years and potentially able to contribute to the system again in the following years.

		and b = 21 for M = E, H, the NRA = 60 for M = C, P, W and NRA = 65 for M = E, H;
17.	$PC(M, x, t, s)$	Proportion covered by scheme M of EM(t, x, s) in year t for $t \geq 1$ and $b \leq x \leq r$;
18.	$Act(M, x, t, s)$	Number of active members covered by scheme M of sex s and aged x last birthday in year t for $t \geq 1$ and $b \leq x \leq r$;
19.	$Act(M, t)$	Total active members covered by scheme M in year t for $t \geq 1$;
20.	$Act(t)$	Total active members covered by the ESSPS in year t for $t \geq 1$;
21.	$g(M, s)$	The constant assumed rate of increase (or decrease) in membership of scheme M of sex s over the projection period;
22.	$Z(M, x, t, s)$	Rate of increase (or decrease) in the membership of scheme M of sex s and age x last birthday in year t for $t \geq 1$ and $x_1 \leq x \leq x_2$ where x_1 = the youngest age at entry and x_2 = the assumed oldest age for entry;
23.	G	Denotes the cause of retirement where, G = N for normal old-age retirement benefit, R = remuneration benefit, G = E for early retirement benefit, G = I for invalidity retirement benefit, G = W for work or illness injuries retirement benefit, G = U for unemployment benefits and G = D for the death benefit;
24.	$G(M, x, t, s)$	Number of G beneficiaries of scheme M of sex s and aged x last birthday in year t for $t \geq 1$;
25.	$\mathrm{WI}(M, s, t, s)$	Number of widows/widowers of scheme M aged y (or x) last birthday in year t for $t \geq 1$;
26.	$\mathrm{Or}(M, z, t, s)$	Number of orphans of the scheme M aged z last birthday in year t for $t \geq 1$;
27.	$TNF(M, x, t, s)$	Number of beneficiaries of scheme M of sex s and aged x last birthday in year t for $t \geq 1$;

2. Cash-flow Variables

2.1. Income

28.	$P(M)$	Rate of compliance in scheme M which represents the overall proportion of active members who pay contribution to the scheme;
29.	$dc(M, x, t)$	The contribution density[2], which is the average fraction of the year during which contributions are effectively payable by an active member aged x last birthday of scheme M between time t and t+1 for $t \geq 1$ and $b \leq x \leq r$;
30.	$dc(M, t)$	The average contribution density for an active member of scheme M between time zero and t for $t \geq 1$ and $b \leq x \leq r$;
31.	$C(M, B/V)$	Contribution rate of scheme M for basic or variable salary;
32.	$SAL(M, x, B)$	The age-dependent salary scale of the basic salary of an

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[2] Although this should be a function of x, it is assumed in this thesis that it is independent of x as there is no available data to work out the relationship between contribution density and age.

		active member of scheme M aged x last birthday for $b \le x \le r$;
33.	$S(M, x, t, B/V)$	The basic/variable pensionable salary of active members aged x last birthday at $t = 0$ for $b \le x \le r$;
34.	$AS(M, x)$	Average pensionable salary of active members aged x last birthday at $t = 0$ for $b \le x \le r$;
35.	$AS(M, x+t)$	Average pensionable salary of active members aged x+t last birthday at time t for $t \ge 1$;
36.	$TS(M, t)$	Total insured salaries under scheme M in year t for $t \ge 1$;
37.	$PS(M, x+t, s)$	Total past service for an active member of scheme M and aged x+t last birthday in year t for $t \ge 1$;
38.	$NI(M, t)$	Projected net income of scheme M in year t for $t \ge 1$;
39.	$FI(M, t)$	Projected increase in funds of the two Funds (M = GSF and PPSF) in year t for $t \ge 1$;
40.	$F(M, t)$	Projected fund of the two Funds (M = GSF and PPSF) at the end of year t for $t \ge 1$;
41.	$TI(M, t)$	Projected total income to scheme M in year t for $t \ge 1$;
42.	$TE(M, t)$	Projected total expenditure of scheme M in year t for $t \ge 1$;
43.	$TS(M, t, B/V)$	Projected total basic/variable pensionable salaries for scheme M in year t for $t \ge 1$;
44.	$TC(M, t)$	Projected total contribution income for scheme M in year t for $t \ge 1$;
45.	$TTS(M, t)$	Projected total Treasury subsidy income to scheme M in year t for $t \ge 1$;
46.	$TIR(ESSPS, t)$	Projected total investment return to the two Funds (M = GSF and PPSF) on the invested funds in year t for $t \ge 1$;

2.2. Benefits

47.	$db(M, x, t)$	Denotes the benefit density[3], which is the proportion of the potential period of service for an active member aged x last birthday of scheme M in year t which is effectively reckoned for pension purposes for $t \ge 1$ and $b \le x \le r$;
48.	L	Denotes particular type of the pension amount where, L = B for the basic pension amount, L = V for the variable pension amount and L = I for the total pension increments;
49.	$GP(M, x, t, s, L)$	Average monthly pension amount of type L of a new G beneficiary of scheme M of sex s and aged x last birthday in year t for $t \ge 1$;
50.	$GL(M, x, t, s, L)$	Average lump sum amount of type L of a new G beneficiary of scheme M of sex s and aged x last birthday in year t for $t \ge 1$;
51.	$D_KB(M, x, t, L)$	Death benefit amount for deceased beneficiary of K status at death where K = Act for death in service and K =G, for death after retirement (where G = N, E, I & W), of pension amount of type L of scheme M of sex s and aged x last

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[3] The actual benefit density may exceed dc(M, x, t) due to crediting of non-contributory periods, however, it is assumed in this model that db(M, x, t) = dc(M, x, t).

		birthday in year t for $t \geq 1$;
52.	$D_KP(M, x, t, L)$	Average monthly death pension amount of type L for a new deceased beneficiary of K status at death where K = Act for death in service and K =G, for death after retirement (where G = N, E, I & W), of pension amount of type L of scheme M of sex s and aged x last birthday in year t for $t \geq 1$;
53.	$NDP(M, x, t, L)$	Total death pension amount of a new deceased member of type L of scheme M of sex s and aged x last birthday in year t for $t \geq 1$;
54.	$D_KLS(M, x, t, L)$	Death lump sum amount for new deceased beneficiary of K status at death where K = Act for death in service and K = G for death after retirement (where G = N, E, I & W), of scheme M of sex s and aged x last birthday in year t for $t \geq 1$;
55.	$DLST(M, x, t, L)$	Total death lump sum amount for new deceased beneficiary of scheme M of sex s and aged x last birthday in year t for $t \geq 1$;
56.	$Pro(x)$	Lump sum proportion paid in the case of the death or invalidity of the insured person of sex s and aged x last birthday in year $t \geq 1$ which is a function of the age at death or invalidity;
57.	$AS(M, x, t, s, B/V)$	Average pensionable salary for a member aged x last birthday of scheme M in year t for $t \geq 1$ and $r \leq x \leq b$;
58.	$FS(M, x, t, s, B)$	Final salary, based on the basic wage for a member aged x last birthday of scheme M in year t for $t \geq 1$ and $r \leq x \leq b$;
59.	$CAS(M, x, t, s, B/V)$	Career average salary, based on the basic or variable wage for a member aged x last birthday of scheme M in year t for $t \geq 1$ and $r \leq x \leq b$;
60.	$RF(M, x, s, B/V)$	Reduction factor for early retirement pension (basic/variable) of scheme M of sex s and aged x last birthday for $b \leq x \leq r$;
61.	$SurP(M, x, s)$	Survivors' benefits function used in the projection of the death benefits which gives the share in the deceased's pension for every category of survivor and the probability of getting this share in scheme M;
62.	β_t	The rate of pension increase (increments) of scheme M in year t for $t \geq 1$;
63.	$\phi(M, B)$	The constant rate of the promotional basic/variable salary scale for scheme M;
64.	$AF(H, t)$	The monthly flat pension amount for the members of the casual workers scheme (CSIS) in year t. It is assumed to be as follow: L.E.57over 1997-98, L.E.70 over 1998-99, L.E.80 over 1999-2000, and an assumed annual increase of $\beta_t = 8\%$ over 2000-2025[4];
65.	z_x	Average age (in years) of the youngest child of the

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[4] It has to be taken into account that β is replaced by zero when t = 1, 2 & 3 as the actual values of the pension amounts are available.

		deceased member (assumed to be female) with the assumption of an average of two children for every deceased member (the second is assumed to be male and older than the youngest by an average of 2 years) aged z and z + 2 respectively;
66.	z^*	The age limit for orphans' pensions (as 0 ≤ z ≤ *z) is assumed to be 31[5] for sons (unlimited for disabled son) and unlimited for unmarried daughter;
67.	y_s	Average age of the widow of a male dying at age x;
68.	d_x	The average age difference (in years) between husband and wife (as $y_x = x - d_x$);
69.	h_x, h_y	The proportion of married persons among those dying at ages x (male) and y (female) respectively;
70.	*FC(M, x, t, s)*	The total cost of funeral grants for the number of deaths cases of scheme M of sex s and aged x last birthday in year t for t ≥ 1;
71.	*DC(M, x, t, s)*	The total cost of death grants for the number of deaths cases of scheme M of sex s and aged x last birthday in year t for t ≥ 1;
72.	*TAC(M, t)*	Total projected administration cost in the two Funds (M = GSF and PPSF) in year t for t ≥ 1;
73.	*TGP(M, x, t, s, L)*	Total amount of pension of type L of G beneficiaries of scheme M of sex s and aged x last birthday in year t for t ≥ 1;
74.	*TGP(M, x, t, s)*	Total amount of pension (sum of the three pension amounts, basic, variable and increments) of G beneficiaries of scheme M of sex s and aged x last birthday in year t for t ≥ 1;
75.	*TGLS(M, x, t, s)*	Total lump sum benefits paid to G retiring members of scheme M of sex s and aged x last birthday in year t for t ≥ 1 and x = r;
76.	*TGB(M,x, t, s)*	Total amount of benefits (sum of the three benefit amounts, basic, variable and increments) of G beneficiaries of scheme M of sex s and aged x last birthday in year t for t ≥ 1;
77.	*TGB(M, t)*	Total benefit expenditure on G retirement of scheme M in year t for t ≥ 1;
78.	*TB(M, t, L)*	Total benefit expenditure of scheme M of type L in year t for t ≥ 1;
79.	*TB(M, t)*	Total benefit expenditure of scheme M in year t for t ≥ 1;

2.3. Service Table

80.	q_x^d, q_x^i, q_x^e, q_x^w q_x^u	The independent rate of decrements of mortality, invalidity, early retirement, invalidity as a result of work injuries and unemployment rates respectively of a member

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[5] It is currently 26 years, however, the Government has decided to increase it to 31 if the orphan has not found a job as a result of the high unemployment. It is also extended for daughters until they get married and sons and brothers if they are disabled.

		aged x last birthday;
81.	q_x^{id}	The independent rate of decrements of mortality of an invalid person aged x last birthday;
82.	$(ad)_x^d, (ad)_x^i$ and r_x	Number of exits due to death, invalidity and early retirement respectively between ages x and x+1;
83.	${}^*q_x^d,\ {}^*q_x^i, {}^*q_x^w$	The associated dependent rate of decrements of mortality, invalidity and invalidity resulting from work injury respectively of a person aged x last birthday;
84.	$\mu_x^{(d)}, \mu_x^{(i)}, \mu_x^{(e)}, \mu_x^{(id)}, \mu_x^{(w)}$	Forces of death, invalidity, early retirement, death after invalidity and work injury decrements respectively at age x related to the ESSPS service table;
85.	$\lambda(M, x, t, s)$	The proportion of insured persons who are effectively in contributory service of scheme M of an active member of sex s aged x last birthday in year t;
86.	${}_t(ap)_x$	Probability that an active member aged x last birthday will remain active at age x+t with respect to the modes of decrement;
87.	$(al)_x$	Number of survivors aged x last birthday in the double decrement table of the ESSPS;
88.	${}^*q_{z_f}^{d_m},\ {}^*q_{z_f}^{m_d}$	The associated dependent rate of decrements of mortality and marriage respectively of a female aged z_f last birthday;
89.	${}^*q_y^{d_{rm}},\ {}^*q_y^{rm_d}$	The associated dependent rate of decrements of mortality and remarriage respectively of a female aged y last birthday;

3. Valuation Variables

90.	i	Valuation interest rate;
91.	v	The reciprocal of (1+ i);
92.	δ	The uniform force of earned interest on invested assets;
93.	j	The assumed inflation rate;
94.	γ_t	The force of salary escalation in year t;
95.	δ_{eq}	The uniform force of earned interest on invested assets which can achieve a funding ratio (FR) of 100%;
96.	θ_t	The force of inflation in year t;
97.	$i_{eq(t)}$	The rate of interest rate equivalent to δ_{eq}, which keeps the *FR(M, t)%* at 100% constant over the projection period;
98.	$C(M)$	The contribution rate of scheme M which is a flat fraction of the pensionable income level per active member[6];
99.	$\bar{a}_x^i$ and $\bar{a}_x^r$[7]	Expected present value of income of one unit per annum, paid continuously to a life aged x on invalidity and on retirement respectively until death;
100.	$\bar{a}_{x-d_1}^W, \bar{a}_{z_x}^D, \bar{a}_{z_x+2}^S$	Expected present value of income of one unit per annum, paid continuously to widow, daughter and son aged $x-d_1$, z_x and $z_x + 2$ respectively on the death of a member of the ESIPS;

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[6] This is taken as a total paid by the employee and the employer together.

[7] The continuous annuity value is used as a convenient means of approximating the actual form of pension payment that is monthly. $\bar{a}_x^i$ is calculated using q_x^{id}.

101.	*PVC(M, t)*	Present value of future contributions of active members of scheme M at time t;
102.	*PVC(M, t, L)*	Present value of future contributions of active members of type L (B & V) of scheme M at time t;
103.	*PVS(M, t, L)*	Present value of future insured salaries of active members of type L (B & V) of scheme M at time t;
104.	*PVB(M, t)*	Total present value of liabilities (based on past + future service) of the members (active members and pensioners) of scheme M at time t;
105.	*PVB(M, t, L)*	Total present value of the liabilities (based on past + future service) of the members (active and pensioners) of type L (B & V) of scheme M at time t;
106.	*PVGB(M, t, L)*	Total present value of the liabilities (based on past + future service) of the members (active and pensioners) of G benefits of type L (B & V) of scheme M at time t;
107.	*PVGA(M, t, L)*	Total present value of the liabilities (based on past + future service) of the active members of G benefits of type L (B & V) of scheme M at time t;
108.	*PVGP(M, t, L)*	Present value of the liabilities of the pensioners of G benefits of type L (B & V) of scheme M at time t;
109.	*PVGAP(M, t)*	Present value of the pension liabilities of G benefits of the active members of type L (B & V) of scheme M at time t;
110.	*PVGAL(M, t)*	Present value of the lump sum liabilities of G benefits of the active members of type L (B & V) of scheme M at time t;
111.	*GR(M, t)*	End of service remuneration of G beneficiaries of scheme M at time t:
112.	*GL(M, t)*	Lump sum benefits of G beneficiaries of scheme M at time t;
113.	*DSL(M, t, L)*	Death in service lump sum benefits of scheme M of type L at time t;
114.	*DGL(M, t, L)*	Death after retirement lump sum benefits of G beneficiaries of scheme M of type L at time t;
115.	*PVBP(M, t, L)*	Total present value of the liabilities of pensioners and survivors of type L (B & V) of the scheme M at time t;
116.	*PVDPG(M, t, L)*	Present value of the death benefits of the pensioners of G beneficiaries (G ≠ D, U) of type L of scheme M at time t;
117.	*PVGA(M, t, L)*	Present value of the liabilities of G benefits of active members of type L (B & V) of scheme M at time t;
118.	*PVGAP(M, t, L)*	Present value of the pension liabilities of G benefits of active members of type L (B & V) of scheme M at time t;
119.	*PVWA(M, t, L)*	Present value of the liabilities of work injuries benefits of active members of type L (B & V) of scheme M at time t;
120.	*PVGAL(M, t, L)*	Present value of the lump sum liabilities of G benefits of active members of type L (B & V) of scheme M at time t;
121.	*PVDAS(M, t, L)*	Present value of death in service benefits of active members of scheme M of type L (B & V) at time t;
122.	*PVDASP(M, t, L)*	Present value of death in service pension benefits of active members of scheme M of type L (B & V) at time t;

123.	*PVDASL(M, t, L)*	Present value of death in service lump sum benefits of active members of scheme M of type L (B & V) at time t;
124.	*PVDAG(M, t, L)*	Present value of death after retirement benefits of active member G beneficiaries of scheme M of type L (B & V) at time t;
125.	*PVDAGP(M, t, L)*	Present value of death after retirement pension benefits of active member G beneficiaries of scheme M of type L (B & V) at time t;
126.	*PVDAGL(M, t, L)*	Present value of death after retirement lump sum benefits of active member G beneficiaries of scheme M of type L (B & V) at time t;
127.	*PVAC(M, t, L)*	Present value of the administration cost of the Fund M for M = GSF & PPSF of type L (B & V) at time t;
128.	*SurV(M, x, s)*	Survivors' benefits function used in the valuation of the death benefits which gives the share in the deceased's pension for every category of survivor and the corresponding annuity of this share in scheme M;
129.	*PVDLS(M, t, L)*	Present value of death lump sum liabilities of type L (B & V) of scheme M at time t;
130.	*PVDS(M, t, L)*	Present value of survivors (widows & orphans) benefits of scheme M of type L (B & V) at time t;
131.	*PVDW(M, t, L)*	Present value of widows benefits of scheme M of type L (B & V) at time t;
132.	*PVDO(M, t, L)*	Present value of orphans benefits of scheme M of type L (B & V) at time t;
133.	*SRP(M, t)*	Total survivors pension of scheme M in year t;
134.	*SRLS(M, t)*	Total survivors lump sum benefits (such as marriage, death and funeral grants) of scheme M in year t;
135.	*PVF(M, t)*	The present value of the fund at time t (to represent the assets in the fund at time t) for M = GSF & PPSF
136.	*Surplus(M, i, t)*	the value of surplus/deficit of the fund M for M = GSF & PPSF at time t using *i* valuation interest rate in the valuation;
137.	*FR(M, i, t)*	The funding ratio of the Fund M fund for M = GSF & PPSF at the end of year t using *i* valuation interest rate in the valuation;
138.	*ACR(M, t)*	Administrative cost ratio of the Fund M (for M = GSF & PPSF) at time t.

The Following Relationships Apply to the Above Variables:

$$LF(x, t, s) = POP(x, t, s) \times LFPR(x, t, s) \text{ for all } t \geq 1 \text{ and } b \leq x \leq (r-1); \tag{1}$$

$$TLF(t) = \sum_s \sum_x LF(x, t, s) \quad \text{for all } t \geq 1 \quad \text{and} \quad b \leq x \leq (r-1); \tag{2}$$

$$EM(x, t, s) = POP(x, t, s) \times LFPR(x, t, s) \times (1 - UEMR(x, t, s)) \tag{3}$$

$\text{for all } t \geq 1 \text{ and } b \leq x \leq (r-1);$

$$TEM(t) = \sum_s \sum_x EM(x, t, s) \quad \text{for all } t \geq 1 \text{ and } b \leq x \leq (r-1); \tag{4}$$

$PC(M, x, t, s) = Act(M, x, t, s) / EM(t, x, s)$ (5)

$TGP(M, x+1, t+1, s, I) =$

$[TGP(M, x, t, s, I) + TGP(M, x, t, s, B) \times \beta_t] \times (1 - q_x^d)]$ (6)

$TGP(M, x, t, s) = TGP(M, x, t, s, B) + TGP(M, x, t, s, V) + TGP(M, x, t, s, I)$[8] (7)

$TB(M, t) = TRB(M, t) + TEB(M, t) + TIB(M, t) + TDB(M, t)$ (8)

In the projection and for the death of a male member, the death benefits is assumed to be distributed between survivors according to the following general survivor function:

$SurP(M, x, t) = \left(\frac{1}{2} [1 - {}^*q_{y_x}^d - {}^*w_{y_x}] + \frac{1}{4} [1 - {}^*q_{z_f}^d - {}^*w_{z1_f}] + \frac{1}{4} [1 - q_{z_m}^d] \right)$[9] (9)

In the projection and for the death of a female member, the death benefits is assumed to be distributed between survivors according to the following general survivor function:

$SurP(M, y, t) = \left(\frac{1}{3} [1 - {}^*q_{z_{y_f}}^d - {}^*w_{z1_f}] + \frac{1}{3} [1 - q_{z_{y_m}}^d] \right)$[10] (10)

In the valuation and for the death of a male member, the present value of the death benefits is assumed to be calculated according to the following general survivor function:

$$SurV(M, x, t) = (\frac{1}{2} \overline{a}_{x+j-d_l}^W + \frac{1}{4} \overline{a}_{z_{x+j}}^D + \frac{1}{4} \overline{a}_{z_{x+j+2}}^S) \qquad (11)$$

In the valuation and for the death of a female member, the present value of the death benefits is assumed to be calculated according to the following survivor function:

$$SurV(M, y, t) = (\frac{1}{3} \overline{a}_{z_{y+j}}^D + \frac{1}{3} \overline{a}_{z_{y+j+2}}^S) \qquad (12)$$

$${}^*q_x^d = q_x^d (1 - 0.5\, q_x^i) \qquad (13)$$

$${}^*q_x^i = q_x^i (1 - 0.5\, q_x^d) \qquad (14)$$

$${}^*q_x^w = q_x^w (1 - 0.5\, q_x^d) \qquad (15)$$

$$(ap)_{x+1} = \{ [1 - {}^*q_x^d - {}^*q_x^i)] (1 - q_{x+1}^e) \} \qquad (16)$$

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[8] The amount of pension increments for every individual pensioner is increased every year at the rate of β_t of the basic pension amount, which takes place at the beginning of each financial year.

[9] This function assumes that pension of the deceased insured male is fully inherited by a widow and two orphans. The widow gets 50% of the pension and the two orphans (son and daughter), each gets 25% of the pension value.

[10] This function assumes that two-thirds of the pension of the deceased insured female is inherited by two orphans. The two orphans (son and daughter) each gets one-third of the pension value.

$$(al)_{x+1} = (al)_x \{[1 - {}^{*}q_x^d - {}^{*}q_x^i)](1 - q_{x+1}^e)\} \tag{17}$$

$$(ad)_x^d = (al)_x \times {}^{*}q_x^d \tag{18}$$

$$(ad)_x^i = (al)_x \times {}^{*}q_x^i \tag{19}$$

$$v = \frac{1}{(1+i)} = e^{-\delta} \tag{20}$$

Special Commutation Functions

There are series of sex-specific special commutation functions are needed for carrying out the valuation of the two Funds. These commutation functions are based on the ESSPS service table.

Functions Based on the Active Service Table (b ≤ x ≤ r-1)

$$D_x^a = (al)_x v^x, \qquad D_x^{as} = s_x D_x^a, \qquad \overline{D}_x^{as} = \frac{D_x^{as} + D_{x+1}^{as}}{2}$$

$$\overline{N}_x^{as} = \sum_{z=x}^{r-1} \overline{D}_z^{as} \qquad \overline{a}_x^r = \frac{\overline{N}_x}{D_x}$$

Functions based on the Life Table for the Invalids (b ≤ x ≤ ω)

$$D_x^i = (al)_x^i v^x \qquad \overline{D}_x^i = \frac{D_x^i + D_{x+1}^i}{2} \qquad \overline{N}_x^i = \sum_{z=x}^{\omega} \overline{D}_z^i$$

$$\overline{a}_x^i = \frac{\overline{N}_x^i}{D_x^i}$$

Functions based on the Double Decrement Table for Widows (y^*≤ x ≤ω)

$$D_y^w = (al)_y^w v^y \qquad \overline{D}_y^w = \frac{D_y^w + D_{y+1}^w}{2} \qquad \overline{N}_y^w = \sum_{z=y}^{\omega} \overline{D}_y^w$$

$$\overline{a}_y^w = \frac{\overline{N}_y^w}{D_y^w}$$

Functions based on the Double Decrement Table for Orphan Females (Daughters) $(0 \leq z_f \leq \omega)$

$$D^D_{z_f} = (al)^D_{z_f} v^{z_f} \qquad \overline{D}^D_{z_f} = \frac{D^D_{z_f} + D^D_{z_f+1}}{2} \qquad \overline{N}^D_{z_f} = \sum_{z=z_f}^{\omega} \overline{D}^D_{z_f}$$

$$\overline{a}^D_{z_f} = \frac{\overline{N}^D_{z_f}}{D^D_{z_f}}$$

Annuity Functions based on One Decrement Table for Orphan Males (Sons) $(2 \leq z_m \leq z^*)$

$$D^s_{z_m} = (al)^s_{z_m} v^{z_m} \qquad \overline{D}^s_{z_m} = \frac{D^s_{z_m} + D^s_{z_m+1}}{2} \qquad \overline{N}^s_{z_m} = \sum_{z_m=2}^{z^*} \overline{D}^s_{z_m}$$

$$\overline{a}^D_{z_f} = \frac{\overline{N}^D_{z_f}}{D^D_{z_f}}$$

For sons with $z_m > z^*$ the annuity employed will be the $\overline{a}^i_z$.

I. Introduction

In the early 1990s, economic and pension reforms were undertaken in many places in the world leading to substantial changes in the organising and financing of pension systems. Pension reform objectives should be the improvement of retirement income security, providing a satisfactory income to people in retirement and making sure that the retirement income of workers can be predictable (Daykin, 1999). The challenge in delivering a stable and predictable retirement income is that the world is changing and inherently unpredictable, which makes pension schemes subject to a variety of risks. As the economic, demographic and political situation in a country alters, some changes in retirement income schemes may also be required because of the interaction between pension schemes and these changes.

Delivering a satisfactory income in retirement can be achieved in a variety of ways, in arrangements established by the state (referred to as social security schemes), employers (occupational pension schemes), and individuals (personal savings and private insurance). Most countries aim for a mix of different types of retirement provisions. This depends on philosophies toward individual and private sector responsibilities versus the role of the state, and views as to the relative capabilities of the private and public sectors. Cultural, historical, political, social and economic factors have played a major role in shaping the different combinations of pillars of pension provisions in terms of their relative importance for the financial welfare of the elderly. Arguments regarding equity, redistribution, efficiency of delivery and security of retirement income have also played a major part.

Social security pension systems are regarded as one of the great social developments of the last hundred years and most countries have some form of state or public provision to provide the first pillar of pension provision. Although the importance of the state pension schemes vary from one country to another[11], such schemes play an important role in many economies as they are national in scope, mandatory and financed, in general, by contributions related to participants' earnings. Such schemes aim to provide income security in respect of a range of contingencies to the majority of the population through a comprehensive social insurance system. They can provide

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[11] In some industrialised countries the state scheme has been the main source of retirement income for pensioners, whereas less developed countries may have no state pension scheme at all.

a relatively high level of replacement of pre-retirement income, together with a basic level of income to all those who are not in remunerative employment[12].

With a state scheme, which is supposed to be compulsory in coverage for the whole country, the risks are shared across the nation and the system will eventually reach an advanced state of maturity. They have, traditionally, been unfunded[13] defined benefit schemes. However, methods of financing public retirement provisions vary between different countries, with schemes in developing countries often adopting various levels of pre-funding to finance benefits (Iyer, S., 1999). The state schemes are supposed to avoid the risk of insolvency in employer-sponsored schemes.

The first and perhaps foremost consideration is what constitutes "retirement provision" in the state schemes. Our interest concerns actuarial involvement in the state retirement systems and the objectives of actuarial projection and valuation in such systems. The purpose of managing a pension scheme is to control the scheme through applying actuarial techniques and other means in order to achieve its objectives. The problems of achieving a satisfactory balance between income and expenditure over a specific period of time are very different in PAYG schemes and funded schemes.

In the field of funded defined benefit pension schemes, the need for actuarial involvement arises from the requirement for information on the benefits promised before they are actually paid[14], so that the cost remains stable as a percentage of salary. It is also important to make sure that the assets are sufficient to cover the accrued liabilities. A funded scheme's financial status is adequate if projections and/or valuations indicate that the revenues plus assets are sufficient to meet liabilities. This will depend on many assumptions, such as the interest earned on the fund, the mortality of members, and the salary growth rate. Therefore, the valuation and projections of such schemes is central to actuarial applications.

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[12] The U.K has a low flat-rate retirement pension which is about 18% of national average earnings for a single person and 28% for a married couple, supplemented by an additional earnings-related pension.

[13] From the financing point of view, there are two types of schemes. A funded scheme, where the cost of providing a member's pension is met by accumulating a fund over the member's period of service before retirement. An unfunded scheme (referred to as pay as you go PAYG), where the cost of pensions is met directly by the contributions paid at the same time. This involves a transfer of money between different generations of members and there is no pool of assets in such schemes.

[14] Projecting when benefit payments are to be made (demographic projection) and projecting the level of benefits to be paid (economic projection).

II. Significance of the Research

The methods of financing income for retirement vary between different countries and the role of the state in financing social security from general taxation revenue is under debate everywhere. Many PAYG State pension schemes have been moving towards pre-funded schemes or privatisation. Theoretical concepts of a pension scheme can be illustrated by examining the essential elements of the state pension scheme in Egypt. This contributes to the development of the theory in the field of public pension schemes, as it gives insight into a different type of practice in the area of social security. It is important for future developments to examine different methods for the financing of social security and the respective roles of the state, employers and workers.

Why should we investigate the Egyptian Social Security Pension System (ESSPS)[15]?

The ESSPS is one of the most comprehensive social security pension systems in the developing world. It can contribute to the global experience in social insurance and to the current debate on reforming such systems around the world. The system arose from a special, if not unique, set of circumstances and is quite different from many other public pension systems. The circumstances that lead us to say that this scheme will continue and its design and experience are worthy of study are a product of the economic, political, and legal environments in which this system operates. There is also a general agreement in Egypt that the system has become a permanent feature of Egypt's financial structure and an essential element of economic stability so that the system would be maintained whenever governmental intervention should become necessary. However, there are some indications of a financing problem, both in the short and long term, unless particular issues are addressed in a reform programme.

The ESSPS is officially a funded defined benefit scheme and it is required that the assets held are sufficient to meet the promised liabilities. The system is currently facing some financial difficulties simply because of an inability to collect all the revenues due to it, to invest its assets wisely, and because of a changing economic and social environments and an accumulated deficit. It is recognised that such problems

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[15] The system consists of two Funds, the Government Sector Fund (GSF) and the Public and Private Sector Fund (PPSF).

need to be addressed to avoid severe stress on the pension system and their effects on the future actuarial soundness of the system.

The system needs to be investigated because of its growing cost, so the extent to which different factors contribute to this cost can be identified. This thesis deals with various aspects of cash flow projections, which is the first time that the cash flows of the system have been modelled using actuarial techniques. The model is also extended to valuations and other relevant issues. This involves investigating the economic and demographic experience of the system and making assumptions about the future trend of such factors. The method and assumptions used depend upon the purposes for which the calculations are being made and must be considered in the light of the environment for the provision of advice.

This thesis also explores the effect of changes in some of the important demographic and economic factors such as the increase in life expectancy, decrease in fertility rates, salary escalation, soaring level of unemployment and the rate of return on the assets. It investigates mortality trends within the national population and constructs an Egyptian life table, which is used in projecting the future population within the social security system.

To exercise control over defined benefit pension schemes, projection and valuation techniques have an important role through the choice of the valuation basis. Valuation results can be controlled by taking different views on assumptions such as the expected rate of return on the assets. The control of the valuation results of the ESSPS is mainly achieved by varying the rate of interest on the assets invested by the NIB[16], as the interest rate from this Bank controls the investment experience of the system. There is also a requirement that the cost remains stable, as a percentage of salary, not only for the active members but also for new entrants. Therefore, the contribution rates have to be tested to determine whether they are sufficient for new entrants.

III. Research Objectives

This thesis aims to achieve the following objectives:

1- Outline and examine the basic structure and the overall objectives of the retirement provision in Egypt (concentrating on the state arrangements and very

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[16] As well as a commitment from the government to shoulder the burden of any actuarial deficit which cannot be amortised.

briefly covering the available private arrangements) according to current legislation. Explore the range of benefits which are provided by the ESSPS and the methods of financing.

2- Investigate the cash flow statement experiences of the two Funds and the management experiences of the system.

3- Investigate the current investment strategy (including the roles of the NIB and the Treasury) and how it can be developed.

4- Analyse the demographic and economic experience of the system. This analysis is used for setting the best estimate of the demographic and economic assumptions for the valuation and projection. This includes the structure of active members, pensioners and dependants, salary and pension increases, the rate of return on the assets, mortality, normal and early retirement, invalidity, and other demographic and economic factors.

5- Examine the objectives of the actuarial valuation and past assumptions used;

6- Develop an actuarial model for the projection and valuation of the ESSPS consistent with the structure of the system and its method of funding by adopting realistic and practical methods of measuring cash-flows of the system.

7- Construct a mortality life table for the Egyptian population to be employed in the calculations in the rest of the thesis.

8- Project the future population of Egypt to be used in the projection of the population within the social security system.

9- Analyse and project labour force participation and unemployment rates.

10- Employ the model to project the expected annual cash-flows and assess the financial viability of the system over the projection period, based on the status quo of the system.

11- Investigate whether the system would have any cash-flow shortage (excess of expenditure over contributions) over the projection period.

12- Determine the valuation interest rate required for achieving the funding objectives[17] under the assumption of the sufficiency of the current contribution rates.

13- Test the implications of changing future interest rates and salary growth on the funding level of the system[18].

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[17] The assumed rate of investment return on the scheme's assets used in valuing the liabilities.

[18] (The assets + present value of contributions) / (Total projected liabilities)

14- Test the sufficiency of contribution rates for new entrants under a range of assumed interest rates and salary escalation.

15- Explores and assesses the strengths and weaknesses in the current structure of the system. Identify and discuss the problems facing the scheme and the degree of its success in meeting objectives. Put forward a set of recommendations to deal with its structural, managerial and operational problems.

IV. Research Methodology

This research will devise three main methodologies to accomplish its objectives.

Firstly: analyse the underlying conceptual framework of the pension system in Egypt explaining how the State pension Funds are managed under the current strategy (including financial structure and the investment strategy).

Secondly: an empirical methodology will be employed to collect, analyse and interpret data to refine and substantiate the analyses made and set the demographic and economic assumptions. Develop the actuarial projection and valuation model to be employed. This includes the construction of an Egyptian life table, the population projection model, the labour force and unemployment projections.

Thirdly: an analytical methodology for interpreting the results by means of a sensitivity analysis and find their effect on the economy. The main findings of the analysis are:

1. The expected future distribution of insurable earnings and number of contributors and beneficiaries.
2. The variation in future cash-flows according to the sensitivity analysis.
3. The valuation results, including the funding ratio and the level of contribution rates for new entrants under different rates of interest and salary growth.
4. Conclusions, summary and recommendations that are conducive to better theory and practice of the scheme's future management.

V. Outline of Chapters

Chapter 1

This chapter provides the historical background and the main conceptual framework of the current retirement provisions in Egypt. It also provides discussions about the structure of the different schemes within the ESSPS and their administration, together with the important related issues and problems facing the system.

Chapter 2

This chapter is concerned with the overall economic and demographic indicators of Egypt. The experience of the ESSPS, such as its investment performance, increases to pensions in payment, salary increases and Treasury subsidies to the system is discussed. It also discusses the structure of the membership of every individual scheme within the system and projection of future growth. It also provides the basis for setting the assumptions for different decrement rates and other economic and demographic assumptions employed in the projection and valuation of the ESSPS.

Chapter 3

A mathematical model for cash-flow projection and valuation of the system is developed and various aspects of actuarial funding are analysed in this chapter. The aims are to explore the future financial stability of the system and how to control the system's experience through varying future rates of interest and salary growth.

Chapter 4

This chapter deals with the mortality investigation and the construction of an Egyptian life table 1994-96 and the other relevant mortality indicators needed for modelling the ESSPS. It also discusses the experience of the English life tables employed in the valuations of the ESSPS compared with the 1994-96 investigation.

Chapter 5

This chapter deals with the projections of the national population of Egypt over 1997-2025.

Chapter 6

This chapter deals with the analysis and the projection of labour force participation, employment and unemployment rates in each age-sex category over the projection period. The population that will be within the ESSPS based on the levels of future fertility, mortality and unemployment (by sex and age) is estimated.

Chapter 7

This chapter presents and analyses the results of applying the model and carrying out a sensitivity analysis. This includes medium term financial estimates of future cash-flows and Treasury subsidy of the system. In the valuation, the accrued liabilities of the system and the surplus/deficit of the two Funds are calculated. The suitability of the current contribution rates for new entrants is assessed and a sensitivity analysis under different interest and salary growth rates is presented. The medium-term equilibrium of the system is investigated.

Chapter 8

Summary, findings, comments and conclusions are presented. Recommendations for solving some of the problems facing the system are suggested.

VI. Data and Program

Enormous amounts of statistical demographic and economic data were employed in achieving the objectives of this thesis. These data were taken from different sources which are mentioned in the statistics part of the references. A computer-based pension valuation and projection model was designed using S-Plus software package.

Chapter 1

The Conceptual Framework of the Egyptian Social Security Pension System (ESSPS)

1.1. Introduction

This chapter gives the framework of retirement income provision in Egypt. It describes the current provisions of social insurance protection entitlement and discuses the relevant aspects of the financing, managing and efficiency of the current system which provides the basis for the subsequent modelling of the system.

1.2. The Egyptian Social Security Pension System (ESSPS)

1.2.1. Historical Development of the System

The ESSPS began in 1854[1] when laws governing pensions for civil servants were introduced on the 26th of December by a 'Khedwial decree'[2]. These laws established an old age, death and invalidity insurance system for a few selected groups of permanent civil servants and also for a few categories of higher governmental employees. The more recent origins of the ESSPS have been traced back to the influence of the French and German schemes (with their reliance on the Bismarck system) in the last quarter of the 19th century.

In 1935, the pension scheme was extended to become a general scheme covering more risks and providing more benefits, but it was only available to a few categories of the Government employees. The first social security law for workers (as with many countries) was related to industrial accident insurance and was provided under Law 64 of 1936. Initially, insurance companies provided such insurance and casual and home workers were excluded from coverage under this Law.

Law No. 86, introduced in 1942, provided compulsory and non-contributory insurance against industrial injuries and the cost was entirely borne by employers.

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[1] The history of the Egyptian social protection system can be described from a much earlier starting point. It says that "the ancient Egyptians had a well developed system of charity which exempted endowed properties and funds from taxation; schemes existed for protection of workers; and a range of free services, such as education, shelter for the homeless, hospitals for the sick and cemeteries for the poor were established. Those who required to serve in the various temples were compensated for lost income. Emphasis was placed on support of the elderly and those in need" (ILO, 1997).

[2] The "Khedewi" was the name of the ruler of Egypt at this time.

Employers were required to insure their liabilities with an insurance carrier, with the employer and carrier being jointly liable for the payments of compensation to workers. The Minister of Social Affairs held primary responsibility for the supervision of the scheme and for fixing maximum premiums. Law No. 117, introduced in 1950, extended the scheme to cover contingencies due to occupational diseases.

In July 1950, a non-contributory social security scheme based on public social assistance rather than social insurance principles was established. Benefits were means-tested, made available to all those in need and not eligible for benefits from any other state pension scheme and were financed from the Government's general revenues. Benefits were made available not only to Egyptian nationals, but also to foreigners with at least 10 years of continuous residency in the country. Employers of a number of firms operating in Egypt established and supported provident funds to give protection to their employees. Benefits generally were in the form of lump-sum payments in the case of sickness, invalidity, death, or retirement.

The system changed substantially following the July 1952 revolution and expanded schemes of social security were established. It became widely stratified and extended to cover more citizens and more contingencies. An insurance fund was established in 1955 (the Provident and Insurance Fund) under the Organisation for Insurance and Saving[3], which took over the responsibility for supervising the beginnings of the modern social security system in Egypt.

Law No. 202, introduced in 1958, improved industrial injury benefits and made such insurance compulsory within the Social Insurance Organisation (SIO). At the beginning of the 1960s, a contributory old age pension scheme for civil servants was established. Law No. 79 of 1975 replaced the civil pension legislation for civil servants and also provided social insurance for public and private sector workers. Law No. 54 of 1975 allows the establishment of private pension funds (the vast majority are occupational pension schemes). Law No. 50 of 1978 provides benefits for Egyptians working abroad in the case of old age, death and invalidity.

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[3] It became the Organisation for Social Insurance in 1958, the General Organisation for Social Security in 1962 and the Public and Private Sector Fund from 1997.

The system also contains a pension scheme that represents a "safety net" of social security financed mainly by general taxes as well as some indirect resources (Law No. 112 of 1980). This Law provides coverage for casual workers who are not covered under any of the other social security laws. The system extends to non- Egyptian nationals working in Egypt for at least one year, provided that their governments offer reciprocal arrangements for the Egyptians.

1.2.2. The Characteristics and Structure of the ESSPS

The ESSPS reflects an underlying philosophy of the state that aims to achieve specific social, political and macroeconomic objectives. The Egyptian Constitution states that the state has "To guarantee social protection in the form of income security to all citizens in respect of the contingencies of old age, invalidity, death, sickness, injury and unemployment". On the other hand, the Government relies heavily on the system to support the national development plan by financing various national projects at low interest rates and so achieves some of its social and economic development aims.

The system is regulated and supervised by the state through the Ministry of Insurance and Social Affairs (MISAs) and managed by the National Organisation for Social Insurance (NOSI). The state is guaranteeing the benefits as well as providing funds in the event of a financial crisis and financing any additional benefits, such as pension increases, granted by political decisions. The NOSI operates two funds, the Government Sector Fund (GSF) and the Public and Private Sector Fund (PPSF).

The two main current sources for providing retirement benefits to members of the Egyptian population, who are no longer actively working, are the state pension system and private pension funds, which are mainly occupational pension funds. Although there are many supplementary schemes operated by employers, neither of these schemes nor commercial insurance, or private savings have yet played any significant role in the retirement income field. Opportunities for commercial insurance in pensions and savings are still very limited but occupational pension schemes are growing fast in Egypt. These are consistent with the state ideology, which advocates control of the retirement income system for the country and with the economic and labour market environment which the public sector still dominates. Labour mobility is limited and the vast majority of private sector enterprises are small.

1.2.3. Coverage

Coverage is defined as the extent to which the scheme is available to the entire working population. The State policy is based on extending social security protection to all its citizens, which extend in scope to virtually all the labour force (including self-employed, casual workers and domestic servants)[4]. The system is comprehensive in terms of coverage of workers and contingencies. The majority of the retired work force relies on the system to replace the major part of their income. This is clearly intended by the state and it is also intended to be in accordance with social insurance principles. The ESSPS is compulsory[5] for all workers between ages 18[6] and 60 (the normal retirement age (NRA), for both men and women). Job changing allows individual to stay in the same scheme or move to another scheme within the system.

In 1998-99, more than 24.3m persons were covered by the system (17.5m contributors and 6.8 beneficiaries), representing 38.5% of the total Egyptian population in that year (only 12% over 1970-75 and between 35-38.5% over 1980-99). The proportion of employees depending on the system for their retirement income was more than 98% in 1999. The total number of pensioners has increased from 0.3m in 1977 to 1.8m in 1998-99, which implies an annual growth of 8.8% over this period (3.7%[7] over 1984-99). The proportion of pensioners to the population aged 60+ has increased from 13.4% in 1977 to 45.5% in 1998-99, with an average annual growth of 7% (3% over 1984-99). The proportion of pensioners to contributors increased from 9.6% in 1975 to 12.1% in 1998-99, with an average annual growth of 0.97% over 1975-99.

1.2.4. Benefits

The system is a defined benefit arrangement[8] which offers salary-related benefits in return for salary-related contributions (which have also been stable over the last three decades). It comprises programmes for old age, death, invalidity, sickness, work injuries, and unemployment. Benefits are offered to the working population provided

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[4] These groups have been excluded by most developing countries and many middle income countries on account of administrative difficulties (ILO, 1999).

[5] The only two exceptions are when the member moves to one of the jobs that have been contracted out in the 1970s (and this is a rare event) or moves to informal sector, which has a very low coverage rate.

[6] This age is for regular employment in the private sector but there is no minimum age for workers in public institutions, public sector enterprises and civil servants.

[7] The number of pensioners have increased significantly in the 1990s (around 7% yearly) as a result of the significant increase in the early retirement (the rate is 3.2% without early retirement pensioners).

[8] Defined benefit indicates that all the benefits are defined in the rules. There are many types of defined benefit schemes depending on how earnings are treated in determination of benefits, namely: final salary schemes, career average schemes, revalued career average schemes, flat rate schemes.

that they satisfy the eligibility requirements. There has been continuous improvement in the scope and scale of benefits over the last two decades. New benefits have been added and the existing benefits have been improved. Benefits are not merely meant to prevent poverty: they are intended to provide a relatively high replacement rate for lost earnings. The system aims to provide a standard of living similar to that enjoyed during working life, but individuals have to take what is offered by the scheme.

1.2.5. Financing

The ESSPS has two different schemes from the financing point of view. The first is funded, according to insurance principles (the Egyptian Social Insurance Pension System, ESIPS). The second is financed from three sources: very small flat rate contributions paid by the contributors, some indirect resources and the balance from the general revenues. The second one provides pensions on the basis of means-tested rather than social insurance principles for the casual workers.

The ESIPS has been mainly operating on the basis that every generation is responsible for funding its own liabilities. Benefits are primarily financed by contributions from employers, employees and returns on the invested funds, although there has been a substantial subsidy from the Treasury. Members must contribute to the system to obtain a pension paid irrespective of means. Employers' and employees' monthly contributions represent the basic sources for financing the system. Contributions are fixed percentages of the pensionable salary for each year of service. The government contributes 1% of the payroll out of its general revenues, which goes towards old age, death and invalidity pensions, financing the annual increases in pension and being a back-up source to cover any deficit.

The ESIS aims to maintain an actuarial equilibrium for its two Funds which have had deficits over the last three decades as a result, mainly, of the investment strategy. The government is responsible for investing most of the funds through the National Investment Bank (NIB). The NIB finances national and local projects and the interest rates provided on deposits held in the bank were below market rates.

1.2.6. Categories Covered by the ESSPS

In order to achieve and ensure a guaranteed and adequate pension for each inactive member of the population, which is the fundamental principle for any social security system, the Government enacted some laws to organise and regulate the ESSPS. The provisions of the system are laid down in legislation in a group of primary laws, which cover the rights and obligations of individuals and establishments affected by the scheme, including the contributions to be paid and the benefits to be received. These Laws provide the information required for the analysis of the ESSPS and the classification of its beneficiaries (as insured members of the ESSPS constitute several distinct sub-populations), which are as follow:

1. Law No. 79 of 1975 for civil servants and workers in public and private sectors;
2. Law No. 108 of 1976 for employers and self-employed persons;
3. Law No. 50 of 1978 for Egyptians working abroad;
4. Law No. 112 of 1980 for casual workers;
5. Law No. 64 of 1980 for contracted-out schemes; and
6. Law No. 54 of 1975 for private pension funds.

In the following sections, the system is analysed according to categories of members, contingencies covered, contributions, benefits and conditions for eligibility of benefits and the place of every scheme within the overall system of retirement provisions.

1.3. Law No. 79 of 1975 (the Employees Scheme)

Law No. 79, introduced in 1975, is the primary Law affecting the social security pension system as a whole, as it represents the core and the most significant part of the ESSPS. It provides coverage for civil servants, workers in public sector enterprises and workers with regular employment in the private sector enterprises. Members of this scheme are provided with the following benefits:

(i) Normal old age, early retirement, invalidity and death benefits;
(ii) Work injuries and occupational diseases benefits;
(iii) Unemployment benefits; and
(iv) Sickness and maternity benefits.

Benefits take the form of pensions and lump sum payments provided to pensioners and their dependants. The ESIS has a specific definition for pensionable salary, which needs to be clarified before examining these provisions. (In what follows, the word salary is used interchangeably with earnings and wages).

1.3.1. Pensionable Salary

It is necessary to define whether the earnings concerned are basic pay, full taxable pay or pay on some other definition. From April 1984, the ESIS started to distinguish between two different parts of insurable salaries, basic and variable salaries, and each is subject to a separate ceiling[9]. This happened when massive increases in employees' wages took place in the 1970s and 1980s to deal with the sharp rise in inflation. These salary increases were created under the name of variable wages and were not pensionable according to the rules, which introduced a new type of contribution evasion. The problem was badly affecting pensioners as pensions were severely eroded by inflation as they are not yet properly indexed to inflation but adjusted at the discretion of policy makers. In July 1992, the definition of pensionable salary was extended to include the special annual salary increments, which came into effect from 1 July 1987 for the salary of civil servants and public enterprise workers. Contributions are now calculated on both basic and variable salaries and benefits are also paid in respect of both.

1.3.1.1. Basic Salary

The basic salary is directly derived from the remuneration due according to the labour legislation and it has to be in compliance with the regulations, particularly in relation to minimum salary. All employees have a basic salary defined by tables applicable to the relevant employment scheme for each category of government and public sector employment. A salary table prescribed by Law 53 of 1984 (see **Tables 1.1 Appendix 1**) determines the basic salaries for civil servants and public enterprise workers (without the special annual increments). In private sector, the salary is specified in the employment contract and must not be below the minimum basic salary set by the law.

1.3.1.2. Variable Salary

The variable salary is the additional payments received by the insured person, which is composed of some or all of the following elements:

(i) Bonuses, incentives, remunerations and shares of the firm's profit,
(ii) Commissions, gratuities, and other similar allowances and compensations,
(iii) Overtime wages or compensations for extra-ordinary efforts,
(iv) Social increases such as high cost of living increases,
(v) Amount in excess of the maximum of basic wage.

Variable salaries differ widely between the government, public and private sectors, but they are more significant in the public sector. Maximum earnings for contribution and benefit purposes consist of limits on combined basic and variable salaries. The establishment of benefit (and contribution) ceilings limits the state's responsibilities to

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[9] This inclusion contributed to increasing the system's contribution income significantly.

high-income earners, as the retirement pensions are restricted to the first tranche of earnings as explained in the following sections.

1.3.1.3. Salary Increments

A special annual increment came into effect from 1 July 1987 for the salary of civil servants and public enterprise workers. Each year the special increment is determined as a certain percentage[10] of the basic salary and is added to the variable salary. Since 1 July 1992, the increment introduced 5 years earlier is deducted from the variable salary and added to the basic salary every year. Therefore, the special increment of the next year applies to the increased basic salary. Yearly increments to the basic pension are also provided directly by the Government and are financed by the Treasury.

1.3.2. Contribution Rates

Contributions are paid by the employer, employees and the Government, and are fixed as a percentage of insurable earnings of both the basic and variable wages up to the specified ceiling. Table 1.1 shows the standard contribution rates for the three parties.

Table 1.1. Contribution rates as a percentage of salary for members covered by Law 79/1975

Contingency	Employer	Employee	Government	Total
Old-age, invalidity, death	15	10	1	26
Work injury[11]	3	-	-	3
Sickness	4	1	-	5
Unemployment[12]	2	-	-	2
Sub-total	24	11	1	36
End of service remuneration	2	3	-	5
Total	26	14	1	41

Source: Law 79/1975

However, under Law 79, the contribution rates actually paid to the scheme are different from those stipulated in the legislation. There are several deductions from the total standard contribution rate of 41% and the effective total contribution rate is actually around 35-40% for basic salary and 30-35% for variable salary, depending on the sector and contingencies covered. For example: More specifically:

- Contract workers (not permanent) and workers younger than 18 and older than 60 are not covered by the unemployment benefits;

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[10] It is announced every year on the budget day and it has been 10% for many years.

[11] Lower rates of contributions apply in the case of employment injury in Government (1%) and public enterprises (2%), and for sickness (3%) in both sectors.

[12] The government does not contribute to unemployment insurance for its employees.

- The employers' contribution rate for sickness and maternity benefits is reduced to 3% for civil servants and public enterprise workers.
- Employers can elect not to contribute towards the sickness and employment injury benefits if they pay these benefits directly to their workers[13].

The actual contribution rates on basic and variable salaries are shown in Tables 1.2 and 1.3 as follows:

Table 1.2. Contribution rates as percentage of the basic salary

	Government			**Public Sector**			**Private Sector**[14]		
	Employer	Worker	Total	Employer	Worker	Total	Employer	Worker	Total
Pension	15	10	25	15	10	25	15	10	25
Remuneration	2	3	5	2	3	5	2	3	5
Work injury[15]	1	-	1	2	-	2	3	-	3
Sickness[16]	3	1	4	3	1	4	4	1	5
Unemployment	-	-	-	2	-	2	2	-	2
Total	21	14	35	24	14	38	26	14	40
Transfer to POHI[17]			4.5			5			5

Source: Law 79/1975

Table 1.3. Contribution rates as a percentage of the variable salary

	Government			**Public Sector**			**Private Sector**		
	Employer	Worker	Total	Employer	Worker	Total	Employer	Worker	Total
Pension	15	10	25	15	10	25	15	10	25
Work injury	1	-	1	2	-	2	3	-	3
Sickness[18]	3	1	4	3	1	4	4	1	5
Unemployment	-	-	-	2	-	2	2	-	2
Total	19	11	30	22	11	33	24	11	35
Transfer to POHI			4.5			5			5

Source: Law 79/1975

In general, employees, employers and the government contribute 10%, 15%, and 1% respectively of the basic and variable pensionable salaries toward old age, death and invalidity, so in total 26% of salaries are allocated to the old age, death and disability pension benefits. This also indicates that the employer contribution constitutes the major part of the social insurance contributions. Contributions are calculated on the

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[13] This is the case with the Government, public sector, and private sector enterprises with 500 workers.

[14] For non-regular contributors in the private sector (contractor workers who are non permanent), remuneration, sickness and unemployment benefits are not payable; therefore, the contribution rate is reduced by 12% (5%: remuneration, 5%: sickness, 2%: unemployment).

[15] These rates are reduced to 0.5%, 1% and 2% for the Government, public sector enterprises and private sector enterprises respectively if the medical care is provided by the employer.

[16] The Government, as an employer, pays 3% and provides cash benefits directly to insured employees and private sector employers can pay 3% if they pay cash sickness benefits directly to their employees.

[17] The Public Organisation for Health Insurance (POHI)

[18] Workers employed in private enterprises with 500 workers or more and insured by another system for health insurance do not pay the sickness contribution of 5%.

basis of monthly wages for workers in Government and public enterprises, and on the basis of the January wage each year for workers in the private sector[19].

1.3.3. Old Age and Early Retirement Benefits

1.3.3.1. Qualifying Conditions and Calculations for the Basic Salary Pension

1. Normal retirement age (NRA) of 60 for both men and women[20];
2. A qualified contribution period of more than 9 years[21];
3. For early retirement, there is no specified minimum retirement age, but there is a qualifying contributory period of 20 years[22]; and
4. If a pensioner returns to insurable employment before age 60[23], the pension is suspended during the period of work. But if earnings from the job are less than those paid before the pension award, the difference is paid as pension entitlement.

The pension is calculated according to the followings:

1. The basic old age pension is determined as follows:

$$= \frac{1}{45} \; X \left\{ \begin{array}{c} \textit{Average monthly earnings during} \\ \textit{the last two years of service with} \\ \textit{a maximum of LE 550 per month} \end{array} \right\} X \left\{ \begin{array}{l} \textit{The number of} \\ \textit{contributory years up to} \\ \textit{a maximum of 36 years} \end{array} \right\}^{24} (1.1)$$

This gives a maximum replacement rate of 80%[25] of the average earnings over the last two years of service with a minimum of 50% if the qualifying period is more than 19 years or a pension value of LE 55[26] a month in 1997, whichever is greater[27];

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[19] The collection mechanism for the contributions integrates social security contributions with general tax collection, which seems to have reduced evasion considerably in the past.

[20] It is 65 for some other categories which are exempt from retirement at age 60, such as judges.

[21] In the case of normal retirement only, a proportion of a year is rounded up to an integer year if this gives eligibility to the pension.

[22] Scheme statistics suggest that there are approximately 19,000 pensioners younger than age 50 (16% of the total early retirement pensioners) in the PPSF. At present pensions claimed before pensionable age are only subject to a reduction of 1% per year and the reduction is imposed only in bands of five years which has the effect of encouraging people to exercise their retirement option at certain ages such as 45, 50, or 55.

[23] There are considerable opportunities for informal employment outside the scope of insurable employment covered by the ESSPS.

[24] The accrued rate is up to 1/40 for the hard jobs and 1/36 for the dangerous jobs, often in mining sector and the law determines such jobs. The LE 550 per month was the ceiling over 1999/2000 and this means that the maximum basic pension in 1999/2000 was LE 440.

[25] This represents full replacement of net earnings because about 20% of the earnings is deducted as taxes and social insurance contributions.

[26] LE denotes the Egyptian Pound and £1.00 Sterling was LE5.5 until the end of 2001 and LE9 thereafter as a result of the devaluation of the Egyptian currency at the end of 2002.

[27] LE70 per month for workers in Government and public enterprises and if the average monthly earnings over the last two years are less than LE70 per month the ratio is increased to 100%.

2. Additional contributory years can also be purchased if the contributor wants to satisfy the required number of contributory years in order to qualify for the old age retirement pension; and
3. For an early retirement, the pension at age 60 is reduced by a reduction factor varying between 5-15%, depending on the number of years left to reach age 60 following the suspension of employment. The reduction factor is 15% if the retirement age is less than 45, 10% if it is less than 50, 5% if it is less than 55 and there is no reduction for retirement at age 55 and over[28].

1.3.3.2. Qualifying Conditions and Calculations for the Variable Salary Pension

(1) Pension age of 60 for men and women and no entitlement to this pension before the age of 50 if early retirement has taken place before this age;

(2) A contributory period starting from 1st April 1984 until retirement age; and

(3) No minimum contribution period is required, however a minimum period of 22.5 years and a maximum period of 36 years is taken in the calculation of the pension.

The pension is calculated according to the following:

1. The monthly old age pension of the variable salary is determined as:

$$= \left\{ \begin{pmatrix} \textit{No. of contributory} \\ \textit{years with a Min.} \\ \textit{of 22.5 years and a} \\ \textit{Max. of 36 years} \end{pmatrix} \times \frac{\begin{bmatrix} 1 + (0.02 \times \textit{No. of} \\ \textit{contributory years)} \end{bmatrix}}{45} \right\} \times \begin{Bmatrix} \textit{Career average} \\ \textit{earnings with a} \\ \textit{maximum of LE} \\ \textit{500 per month.} \end{Bmatrix} \qquad (1.2)$$

2. This gives a replacement rate of 50-80% of the career average earnings with a maximum pension value of LE 400 a month in 1997;
3. The monthly average wage is increased by 2% simple for each contributory year;
4. For early retirement, the same rules are applied with a reduction in the pension of 5% for each year left until NRA.

The total pension is the sum of the basic and variable salary pensions. The maximum pension can not exceed 80% of the average monthly earnings with a maximum of LE 840 per month as from July 1997 (i.e. 80% of the maximum total pensionable salary of 12,600 in 1999/2000).

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[28] For example, if an insured person is to retire at age 54 instead of age 60, his/her pension will be less than the accrued pension value if he/she had worked until age 60 by a percentage = [(6/45) + 0.10] = 23.33%.

1.3.3.3. Lump Sum

1- If the insured does not qualify for a pension, two lump sums of 15% of the average annual earnings for every contributory year are payable and calculated as follow for basic and variable salaries respectively;

$$= 0.15 \times \left\{\begin{matrix} \text{Average yearly earnings during} \\ \text{the last two years of service with} \\ \text{a maximum of LE 550 per month} \end{matrix}\right\} \times \left\{\begin{matrix} \text{number of} \\ \text{contributory years} \end{matrix}\right\} \qquad (1.3)$$

$$= 0.15 \times \left\{\begin{matrix} 1 + (0.02 \times \text{number} \\ \text{of contributory years}) \end{matrix}\right\} \times \left\{\begin{matrix} \text{Yearly career} \\ \text{average earnings} \end{matrix}\right\} \times \left\{\begin{matrix} \text{number of} \\ \text{contributory years} \end{matrix}\right\} \qquad (1.4)$$

2- Over 36 years of contributions entitles a lump sum compensation calculated only for the basic salary according to the following formula;

$$= 0.15 \times \left\{\begin{matrix} \text{Average yearly earnings during} \\ \text{the last two years of service with} \\ \text{a maximum of LE 550 per month} \end{matrix}\right\} \times \left\{\begin{matrix} \text{Max [(contributory} \\ \text{years - 36), 0]} \end{matrix}\right\} \qquad (1.5)$$

1.3.3.4. End of Service Remuneration

The insured person receives "remuneration" before retirement if he/she qualifies for a pension or a lump sum benefit. This benefit was introduced in April 1984 and is financed by contributions on the basic salary only as explained before. The pensioner can replace this benefit with a monthly pension added to his/her variable salary pension. The remuneration is a lump sum calculated using the following formula:

$$= \left\{\begin{matrix} \text{Average monthly basic earnings} \\ \text{during the last two years of service} \\ \text{with a maximum of LE 550 per month} \end{matrix}\right\} \times \left\{\begin{matrix} \text{Max (No. of contributory} \\ \text{years, 10)} \end{matrix}\right\} \qquad (1.6)$$

1.3.4. Invalidity Benefits

Invalidity is the loss of capacity to carry out any remunerative activity and in the case of total and permanent invalidity of an insured member, an invalidity pension is payable. The qualifying conditions for invalidity pension are as follow:

1. Losing capacity to carry out any gainful activity permanently which arises during insurable employment or within one year of termination;
2. The insured had not received lump-sum compensation or reached retirement age;
3. A minimum contribution period of 3 consecutive months, or a total of 6 months[29].

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[29] This may be seen as a relatively short and generous qualifying period of membership for a long-term benefit, particularly when it is recognised that the medical test of invalidity is difficult to apply. However, a social security system sometimes subsidies vulnerable groups although it generally operates according to insurance principles.

The pension is determined as follows:

1. An invalidity pension of basic salary is calculated as[30]:

$$= \frac{1}{45} \times \left\{ \begin{array}{l} \textit{Average monthly} \\ \textit{earnings during the} \\ \textit{last year of service} \end{array} \right\} \times \left\{ \begin{array}{l} \textit{The number of contributory years} \\ + \textit{Min(3extra years, the remaining} \\ \textit{period to age 60)} \end{array} \right\} \qquad (1.7)$$

   An invalidity pension of variable salary is calculated according to the formula 1.2.
2. The pension from the above formula is compared with 65% of the average monthly earnings, and whichever is greater is payable;
3. The maximum total pension is 80% of the average monthly earnings, or LE 840 (from 1998) whichever is less. The minimum monthly pension amount is LE 40;
4. In the case of "partial" invalidity (less than 35% of "full" invalidity) a lump sum of four years' pension proportionate to the degree of invalidity is payable.

1.3.5. Survivor's Benefits

Survivors benefits entitlement is derived from the insured record of the deceased person and the satisfaction of the conditions for invalidity pension or having been a pensioner at the time of death. The death benefit (or the pension) is inherited by dependants and divided among them according to the rules specified by the Law given in **Table 1.2 of Appendix 1.** The system provides income protection to a broad range of surviving dependants, which include the following[31]:

1. Widow of any age, ex-wife[32] and disabled dependent widower;
2. Orphans and dependent brothers until age 21 (26 if they are in higher education[33]) and without any age limit if they are disabled;
3. Unmarried daughters[34] and dependent unmarried sisters until they marry;
4. Parents[35], sisters and brothers if they do not have any other source of income.

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[30] The extra period is added only in the case of the basic salary pension.

[31] Most of the actuaries in Egypt suggest that it is prudent to assume that in the case of the death of the insured person or the pensioner 100% of the pension will be divided between the survivors as a result of this long chain of eligible individuals (Abd-Alhamid M., 1997).

[32] She has this right under some very restrictive conditions such being forced to be divorced, living with her ex-husband for at least 20 years, having an income of less than the pension entitlement.

[33] Around 20% of the total survivors pensions goes to orphans aged over 20 years old. It is now proposed to extend the age of eligibility to 31 if they are unemployed.

[34] If after marriage, the husband dies (or divorce occurs) she may be able to regain eligibility for part of her father's pension. This happens under the condition that the total pension from both her husband and her father does not exceed the maximum amount she would have received from her father's pension only if that were higher. Pension from her husband takes primacy and her father's pension is just a supplement to her husband's pension.

[35] The mother of the insured member has the right to keep her share in the pension once awarded to her without cessation under any circumstances.

Survivors' benefits are provided subject to meeting some required conditions:

1. Either the deceased insured person would have qualified for an invalidity pension had he/she claimed such a pension on the date of death or was already in receipt of a retirement or invalidity pension at death;
2. The beneficiaries may be required to satisfy further conditions according to the rules applied to dependants, such as having attained a specified age, being disabled, not being remarried, or having the care of children, is not working or earning at least as much as the pension entitlement;
3. A survivor's pension is determined exactly as the invalidity pension and then divided among the dependants according to specified proportions as explained in Chapter 2;

1.3.6. Additional Rights

There are some other additional benefits, which include the following:

1. Marriage grants can be claimed by daughters and dependent sisters of the deceased member, equal to the maximum of one-year's pension and LE 200;
2. Lump sum payments are made to sons and daughters on reaching age 21 years[36];
3. Funeral grant of two months' basic salary or pension with a minimum of LE 200;
4. A death grant of three months' total salary or pension;
5. Lump sum payments are payable in the following cases[37]:
    i. Death and total and partial invalidity of an active member which results in the cessation of the occupation of the active member;
    ii. The death of a pensioner with no survivors eligible for a pension, paid to his/her ineligible relatives or carers[38].

This lump sum payment is calculated as:

$$= \left\{ \begin{array}{l} \textit{The average yearly} \\ \textit{earnings during the} \\ \textit{last contributory year} \end{array} \right\} x \left\{ \begin{array}{l} \textit{Percentage determined} \\ \textit{according to the age} \\ \textit{at death or disability} \end{array} \right\} \qquad (1.8)$$

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[36] It is 26 if he/she is a student.

[37] Calculated for both basic and variable salaries according to the proportions given in **Table 1.3 of Appendix 1.** It is reduced by 50% in the case of partial disability, increased by 50% if the death or invalidity resulted from a work injury or occupational disease and increased by 100% for the (ii) case.

[38] This is ignored in our model on the grounds that there is no available data to investigate it and it is assumed that 100% of the pension is paid on the death of the insured member.

1.3.7. Work Injuries and Occupational Diseases Insurance

Employees in Government, public and regular private sectors aged 18 and over are insured against the consequences of work injuries and occupational diseases.

1.3.7.1. Qualifying Conditions

There is no minimum contributory period. Eligibility for benefit following an accident deemed to be a work injury would be granted in any of the following cases:

1. Suffering one of the schedule occupational diseases as defined by law;
2. An injury due to an accident at work which happens during work time or because of work even if the accident happens in a different place and time[39];
3. Special rules apply in the cases of injury due to "hard work or tiredness in work". Injuries such as heart attacks or strokes that happen to the insured person before age 60 as a result of additional workload are covered as work injuries.

1.3.7.2. Monetary Benefits During Treatment

Employment injury insurance covers temporary invalidity benefits and the insured person is entitled to the following rights over the period of treatment:

1. Compensation of monthly earnings is payable from the 1st day of injury until recovery or permanent invalidity or the death of the insured person;
2. Medical benefits, including general and specialist care, surgery, hospitalisation, medicines, appliances, rehabilitation and compensation for transport expenses.

1.3.7.3. Permanent Invalidity or Survivors Benefits

If the period of treatment ends with death, or total or partial invalidity, then the insured person or his/her dependants is entitled to the following benefits:

1. In the case of death or total invalidity, a pension equivalent to a minimum of 80%[40] of average monthly earnings (basic and variable);
2. Pensions are increased by 5% every 5 years until age 60;
3. In the case of partial invalidity (35% or more), the insured is entitled to a partial invalidity pension (basic salary only) proportionate to the percentage of invalidity;
4. If the degree of permanent invalidity is less than 35%, then the insured person is entitled to a lump sum compensation calculated using the following formula:

$$= \textit{Degree of total invalidity} \times \textit{the monthly pension for total invalidity} \times 48 \qquad (1.9)$$

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[39] This is also includes an injury sustained during the journey to work or returning from work.

[40] It can reach but not exceed 100% when coupled with old age, survivors or invalidity pension.

1.3.8. Unemployment Insurance

The system has been complemented by unemployment benefits, but they are only available for permanently employed persons in the public sector (not government workers) and regular private sector employees for ages 18-60. The qualifying conditions for unemployment benefits are as follow:

1. Contribution period of 6 months, including the 3 months prior to unemployment;
2. Unemployment is not due to voluntary leaving (resigning), discharge for misconduct or dishonesty, refusal of a suitable job offer, or refusal of training; and
3. The insured person is able and willing to work, has a registration document and reports weekly to the Manpower Office of the Ministry of Labour.

Unemployment benefits are as follow:

(1) Compensation of 60% of the last monthly salary is payable for up to 16 weeks[41].

(2) Benefits are not payable in the following circumstance:

- After attaining age 60;
- Refusal of a suitable job offer [42]or vocational training;
- Receipt of a pension, which exceeds unemployment benefit (apart from industrial injury benefit).

Th protection against the consequences of unemployment in Egypt is not significant as the duration and levels of benefits are very limited and little is available in terms of retraining and job protection for workers in the case of forced or unfair redundancy. Unemployment benefits do not also have any significant role because the vast majority of unemployed persons are new entrants to the labour force[43] who do not qualify for such benefits, as explained in Chapter 6.

1.3.9. Sickness and Maternity Insurance

Health and medical care is provided by the POHI, which operates independently from the NOSI. The collected health insurance contributions are transferred to the POHI which in return provides health insurance benefits until the insured person recovers,

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[41] It may be extended to 28 weeks if the contributions were paid for the last 24 months. A waiting period of one-week is required before any benefit is payable.

[42] A suitable job offers include one where: the salary is at least 75% of the salary used for the unemployment benefits, the work is consistent with the qualifications, experience and physical and professional capacities of the individual and the work is within the area where the insured person used to work when he/she became unemployed.

[43] It was found that 94% of the unemployed in 1998 were in the age group 15-29.

becomes permanently disabled or dies. Only employees in Government, public and regular private sectors are covered by this insurance. It provides entitlement to cash benefits as a replacement for earnings lost through incapacity as a result of maternity or sickness and medical care. It also covers pensioners who want to be covered by the provisions of health insurance. The widow/widower of the insured person or pensioner has the right to health insurance provided that he/she is entitled to a pension and has no other pensions of his/her own. Widows/widowers have to contribute 2% of their pension and other pensioners contribute 1%.

The qualifying conditions for benefits are:

1. A contribution period of the last three months or 6 months including the last 2;
2. In the case of maternity benefits, the contributory period must include the last 10 months.

Cash benefits[44] in compensation for wages lost while the insured person is absent from work include the following:

1. 75% of the daily wage is paid during the first 90 days of sickness (without any waiting period), increased to 85% for a further 90 days in a calendar year[45];
2. Maternity benefit is a compensation of 75% of the average monthly earnings, paid for 90 days before and after confinement for Government employees, and for 50 days for public and regular private sector employees.

1.4. Law 108 of 1976 (Self-employed Persons Scheme)

From 1973[46], social insurance protection has been extended to employers and self-employed persons engaged in certain types of work in Egypt. This scheme established a contributory and obligatory social insurance pension scheme to cover persons working on their own account (employers who are working for themselves and have employees helping them) in commercial, industrial or agricultural activities. It also includes self-employed persons (working for themselves with no employees) and owners of property.

1.4.1. Characteristics of the Scheme

1. It was established as a fully funded scheme, however the Treasury funds its annual pension increments;

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[44] Benefits also include medical services offered by the general practitioner and specialists.

[45] 100% of earnings without any limit in duration is payable in the case of a specified chronic disease

[46] The first Law was No. 61 of 1973, which was amended to the current Law.

2. Contribution is a flat rate of 15% of the monthly pensionable income level and paid by the insured person only;
3. The scheme insures against old age, death, and invalidity contingencies;
4. The scheme is compulsory with an entry age of 21 and NRA of 65;
5. The coverage is based on one of 19 levels of insured income that range from[47] LE 100 to LE 1000 per month. The insured person can choose to contribute to any of these pensionable income levels[48] and to increase or decrease the level from January following the request of change until age 55.
6. The insured member can backdate an increase in pensionable income level to the date he/she entered the scheme at any time and pays the difference in contributions accumulated at 6% per annum over the whole period.

1.4.2. Qualifying Conditions

1. NRA of 65[49] with at least 120 months of contributions, the insured person can pay additional contributions at retirement to satisfy this condition;
2. Early retirement at any age with a required contributory period of 240 months for entitlement to a pension, otherwise a lump sum is payable;
3. In the case of death in service or permanent and total invalidity of the insured person before age 65, a contribution period of at least 6 months or the last 3 consecutive months is required[50] for entitlement to benefits.[51].

1.4.3. Old-Age Pension

1. An old-age pension is determined as:

$$= \frac{1}{45} x \begin{Bmatrix} \text{The monthly career average} \\ \text{pensionable income level} \end{Bmatrix} x \begin{Bmatrix} \text{Number of contributory} \\ \text{years up to a maximum} \\ \text{of 36 years} \end{Bmatrix} \qquad (1.10)$$

2. The minimum pension is LE35[52] and the maximum is 80% of the monthly average income. Over 36 years of contributions gives entitlement to a lump sum as:

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[47] This range came to force from 1/7/2001 as it was between LE50 and LE 900 before that date.

[48] A self-employed person who previously worked for others is required to choose an income level not less than 60% of their last pensionable salary. If the self-employed person has employees then he/she is required to choose an income level not less than the average of the wages of his/her employees.

[49] This NRA is higher than the NRA under Law 79, which might be in recognition of their capacity for a longer working life in their private business.

[50] It is assumed in this thesis that all death in service and total disability cases will be eligible for the pension. This is more prudent and consistent with the reality in the ESSPS for the majority of cases.

[51] Entitlement to invalidity and survivor's pension extends for one year from business termination.

[52] The Treasury transfers to the Fund the difference between the minimum required by the Law and the calculated pension if the later is less, except for early retirement when this minimum does not apply.

$$= 1.08 \times \left\{\begin{matrix} \text{The yearly career average} \\ \text{pensionable income level} \end{matrix}\right\} \times \left\{\begin{matrix} \text{Max [(contributory} \\ \text{years - 36), 0]} \end{matrix}\right\} \quad (1.11)$$

3. In the case of early retirement, the pension is reduced from the pension amount at age 65 by 5% - 20%, according to the age at retirement.
4. If the insured person does not qualify for a pension, a lump sum is calculated as:

$$= 1.44 \times (1 + 0.06 \times n) \times \left\{\begin{matrix} \text{The monthly career} \\ \text{average pensionable} \\ \text{income level} \end{matrix}\right\} \times \left\{\begin{matrix} \text{Number of} \\ \text{contributory} \\ \text{years} \end{matrix}\right\} \quad (1.12)$$

where n is the difference between the last contributory year and the year of attaining the NRA or death or invalidity in the case the insured member stops paying contribution before retirement.

1.4.4. Death and Invalidity Pension

1. The formula used for the old age pension applies for the invalidity and death in service pension except that the contribution service period is increased by 3 years (or the remaining period to NRA if less) and thus the pension is calculated as:

$$= \frac{1}{45} \times \left\{\begin{matrix} \text{The monthly career average} \\ \text{pensionable income level} \end{matrix}\right\} \times \left\{\begin{matrix} \text{The number of contributory years} \\ \text{+ Min. [3, (65 - retirement age)]} \end{matrix}\right\} \quad (1.13)$$

2. The pension has to be at least 65%[53] of the career average pensionable income or LE 35, whichever is greater;
3. In the case of death benefits, the pension is divided among the dependants, which is discussed later.

1.4.5. Additional Rights

They are the same as in Section 1.3.6.

1.5. Law 50 of 1973 (Egyptians Working Abroad Scheme)

This scheme offers Egyptians working abroad a contributory and voluntary[54] social insurance scheme, based on 17 different levels of insurable income. The coverage characteristics of the scheme are as follow:

1. Those persons who are aged between 18 and 60, working abroad under personal contracts and subject to the compulsory social insurance system inside Egypt;

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[53] It is 80% if the death or the total disability resulted from work injury or occupational diseases.

[54] The Government is planing to make it compulsory.

2. Egyptians working for international bodies and regional organisations inside Egypt and emigrants who keep their nationality;
3. The scheme provides coverage against old age, death and invalidity contingencies;
4. The insured person is not eligible to receive any of the scheme's benefits if contributions were not paid for 6 continuous months;
5. Insurable income levels range between LE 100 and LE 1000 and the insured person can select any of these levels but can not change it to a higher one unless it has been in the previous level for at least one year;
6. Contributions are paid at a rate of 22.5% of the chosen insurable income level with the Government making up any deficit;
7. The insured person may increase the expected pension on retirement by buying additional periods of non-contributory service following the age of 20[55];

1.5.1. Qualifying Conditions

1. Attainment of age 60 with at least 180 months of contributions;
2. In the case of early retirement, a contributory period of 240 months is required;
3. In the case of death or invalidity before age 60, a period of at least 3 continuous months of contributions is required.

1.5.2. Old Age, Death and Invalidity Pension

1. The pension is determined according to the Formula 1.10 with Min. pension of LE 35 and Max. of 80% of the monthly career average pensionable income level;
2. In the case of early retirement, the pension at age 60 is reduced by 15% if the age is less than 45, 10% if the age is less than 50 or 5% if the age is less than 55;
3. In the case of death or invalidity, the same formula as for the old age pension is applied, except that an extra 3 years (or the remaining period to age 60 if less) is added to the contribution period. The Min. pension is 65% of the monthly average insured income level or LE 35 whichever is greater and the Max. is 80%.
4. If the insured person does not qualify for a pension or in case of final departure from the country (emigration and other similar cases), a lump sum is payable. It ranges from 267% to 20% (144% on average) of the average monthly insured income level during the contribution period according to the age of the insured.
5. There are some additional rights, which are the same as in Section 1.3.6.

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[55] A lump sum or instalments to the scheme can pay off the cost of buying additional periods.

1.6. Law 112/1980 (The Casual Workers Scheme)[56]

This scheme is called the Comprehensive Social Insurance Scheme (CSIS) and it has the following characteristics

1. Applies to some of the working population not covered by any of the other social insurance schemes, which are collectively described as casual workers[57];
2. It is the unfunded tier of the ESSPS, which is supplementary to the funded part of the system (ESIS), and is a basic anti-poverty and means-tested scheme financed mainly from general revenues and other indirect resources;
3. Provides coverage against old age, death and invalidity contingencies;
4. It contains another pension arrangement called "Sadat Pension Plan (SPP)[58]" introduced in 1980 and operating under article No 5 of the scheme. The SPP provides a special pension to the poorest segment of the population[59] who have had no previous coverage by any of the other social insurance schemes in the past and no contribution is required;
5. The SPP provides benefits under the same conditions as the CSIS and benefits are financed completely from the State's budget. However, the SPP is now closed to new entrants who must join the main CSIS.

1.6.1. Financing the CSIS

The CSIS is supposed to be financed from the following sources[60]:

1. Very small contributions from the active members (apart from the members of the SPP) at a flat rate of LE 1 per month[61].
2. A subsidy from the Nasser Social Bank[62];

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[56] Law No. 112/1975, which established a non-contributory and obligatory scheme, was amended to the current Law.

[57] Casual workers do not, as a rule, have a fixed place of employment and this distinguishes them from the self-employed persons. Such workers are temporary workers, tenants of small agricultural lands, proprietors of buildings with annual revenue of less than LE 350, sailboat owners and owners of light transportation who employ no workers, travelling street vendors, rural social service workers and domestic servants and others.

[58] Sadat was the president of Egypt over 1971/81.

[59] The number of beneficiaries of this category has fallen from 1.43m in 1986-87 to 0.435m in 1998 and significant proportion of recipients are women. The reason for that is because the Government is integrating this category within the CSIS.

[60] Income from such resources is not stable and in general, it has been significantly declining over time.

[61] The Government is planing to ask the Parliament to increase it to LE 10 per month from 2002, as this is a very small proportion of contribution income for the scheme, even after investment.

[62] This is a social bank in Egypt, which finances some social security benefits. Nasser was the president of Egypt over the period of 1952-1970. However, after the privatisation of public sector enterprises the Bank was no longer able to contribute to this scheme.

3. A maximum of 2% of basic salary contributions under Law 79/1975 (the public and private sector employees only) to be decided by the management of the PPSF;
4. A social duty levied on landowners, which varies between LE 0.25 to LE 5 per acre, according to the kind of land usage;
5. Fees paid by land tenants at the rate of LE 0.2 per unit of cultivation;
6. 50% of the fishing licence fees for sailing boats and a charge of LE 1 for each work permit and;
7. The balance from the Treasury.

1.6.2. Qualifying Conditions and Benefits

1. NRA of 65 with a contributory period of 120 months (no contributions for SPP)[63].
2. Benefits are payable on the death or invalidity of an insured person before age 65 with at least 6 months of contributions (no contributions for the SPP).
3. Benefits take the form of a fixed amount of pension equal to LE 80 per month (from January 2001)[64];
4. A funeral benefit of LE 200 is also payable;
5. The SPP provides the pensioner with a fixed amount of pension of LE 45 per month (from January 2001).

1.7. Law No. 64 of 1980 (Contracted-out Scheme)

This Law on alternative social insurance schemes was introduced during the "open-door" period at the end of the 1970's when multi-national companies were encouraged to invest in Egypt. It governs the operation of the contracted-out schemes of the ESIS and meant to reduce the State's liability for providing retirement incomes and to give a chance for occupational pension schemes to maximise their role in this field. Contracting-out is a statutory arrangement under which members of a pension scheme that meets certain conditions obtain certain rights if the scheme replaces all of their earnings-related state scheme benefits. This involves replacing the entire state pension by a pension from the accumulated funds of each member. The contributions to the state scheme are refunded to the contracted-out scheme.

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[63] It can be also deducted from the first awarded pension if the member had not satisfied this condition.

[64] It was LE 63 before 2001.

1.7.1. Qualifying Conditions for Contracted-out Schemes

The Ministry of Insurance and Social Affairs (MISAs) was concerned with the approval, supervision and control of the contracted-out schemes. Approval was given under the following conditions:

1. The number of permanent working staff in Egypt must be at least 1000[65];
2. The actual issued share capital of the company is not less than LE 10 million;
3. The scheme must provide better benefits than the state scheme, with the employees' contribution percentage no higher than in the state scheme;
4. They must equal or better any enhancements that are made to the state scheme;
5. They must submit annual financial statements and a report on fund activities (including on the status of reserves and investments) each year to the MISAs;
6. They must submit actuarial reports on their financial status at least every 5 years;
7. They must contribute 1% of their contributions to the MISAs each year.

A statute had to be established by the contracted-out scheme and submitted to the MISAs. This statute must include the following data:

1. Types of benefits paid by the scheme, conditions for entitlement to benefits from the scheme and formulae used in calculating the benefits;
2. The resources for financing the benefits and contribution rates for the members;
3. The rules for the payment of transfer values to any other fund which is subject to the Employees Social Insurance Scheme (79/1975).

1.7.2. Management of Contracted-out Schemes

The management of contracted-out schemes is undertaken by a general assembly consisting of the members of the scheme and a board of directors appointed by the general assembly. By law, the funds can invest half of their money in assets such as listed equities or properties. But the other half of the funds must be deposited with the NIB in return for bonds (giving the same rate of return as that given on the GSF and PPSF assets). The government's stated reason for this requirement is to guarantee members' rights. However, another unstated reason may be to take advantage of using

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[65] This was also to cover international companies operating in Egypt who have large numbers of employees in total and only small part of them are working in Egypt. Most of the existing schemes now do not satisfy this condition although it was satisfied at the time of establishment.

these funds at lower interest rates than the prevailing in the market[66]. These schemes and their members obtain taxation privileges on all the scheme transactions (including contributions, investment proceeds and benefit payments). However, there is no treasury subsidy to the contracted-out schemes, unlike the ESSPS.

No new funds are now allowed to join this scheme and any new established scheme must co-exist with the State Scheme (Law 79/1975). This action has reduced the impact of this part of the Egyptian pension system in spite of its importance in reducing the dependency of employees on the State for providing income after retirement. The contacting-out option has been suspended for various reasons such as:

1. The state wants to have control of the pension system for the whole population through its own Funds;
2. The state wants to control the investment of the funds available;
3. The higher benefits and lower contribution rates available to members of these schemes seemed inequitable; and
4. The past experience of bankruptcy for some sponsoring employers[67].

Eight contracted-out schemes were established when the Law was introduced in 1980. Egyptian Banks with strong international affiliations operate most of these schemes as well as some large companies[68]. However, looking at the contracted-out companies, it can be noticed that they are financially strong and pay high salaries. Therefore, it can be argued that contracting-out would not only be contrary to the principle of solidarity, but would also weaken the income redistribution effect between the high-paid and low-paid workers.

1.8. Law No. 54 of 1975 (Private Pension Funds)

Individual organisations are allowed to have a complementary occupational pension scheme. This provides a second tier of social insurance protection for workers in public and private sector enterprises and institutions but it is not obligatory according to the Law. It can be argued that a comprehensive state pension scheme providing a

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[66] The average interest rate given by the NIB over the period of 1996-1998 was around 9% while the average interest rate on deposits in commercial banks was around 11-12%.

[67] In April 2001, the owner of an electronic company called "The Transistor Company" used the pension fund assets of his employees to finance his new projects and left the scheme without assets to finance its liabilities.

[68] They cover some 5,600 workers and invested assets amounted to LE 6992m at the end of 1999.

high level of benefits limits the need for extensive private/occupational provision[69]. Purposes for encouraging the development of private pension funds are to supplement the benefits available from the ESSPS and also to limit the reliance that individual members have on the state system. These schemes are operated and sponsored by employers for their employees and supervised by the Egyptian Insurance Supervisory Authority (EISA). They provide additional income protection against some contingencies, such as death, invalidity and old age, for the workers, particularly for those with low incomes. The majority of benefits that offered by these schemes to their employees take the form of a lump sum on retirement.

1.8.1. Experience of the Private Pension Funds

The number of private pension funds has been increasing steadily at about 4% every year and as at the end of 1999 there were 591 funds registered with the EISA (compared with 535 as at the end of 1995). Government authorities and public institutions, rather than private enterprises, have established the majority of the existing funds, as less than 10% of these funds were set up by private sector employers[70] as shown in Table 1.4.

Table 1.4. The value of assets of the private pension funds in Egypt over 1995-99

Fund's Assets (LE m)	**1995**		**1999**		**% change**
	No.	**%**	**No.**	**%**	
200 or more	3	0.56	6	1.02	0.46
100 - 200	2	0.37	5	0.85	0.48
50 – 100	8	1.50	15	2.54	1.04
10 – 50	42	7.85	79	13.36	5.51
1 – 10	219	40.93	246	41.63	0.7
Less than 1	206	38.51	219	37.05	- 1.46
Funds with less than one year in force	55	10.28	21	3.55	- 6.73
Total	535	100	591	100	

Source: EISA, annual reports over 1995-1999

The table shows the increasing trend of the number of private pension funds and the value of their assets over 1995-99. There were about 4m members covered by these schemes in 1998. Often contribution rules similar to the state scheme apply, but also to the higher tranche of earnings not covered by the ESIS. These schemes collected

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[69] However, countries such as Spain and Portugal have high social security benefits but a growing occupational pension sector, generally providing supplementary pension benefits to higher paid employees on a formula which integrates with the social security benefits.

[70] More details about the private pension funds in Egypt can be found in the report prepared by the Government Actuary Department (GAD) of the UK, 1997.

contributions of some LE 1,250m in year 1997/1998, LE 850m from employees and LE 400m from employers, and the total contributions to these funds have been increasing at an average yearly rate of 40% over the last five years. This amount of contributions was more than double the premiums made towards life insurance policies, which were LE 559m in 1998/1999. These schemes paid benefit payments of LE 1119.64m in 1999 compared with LE1047.23m in 1998. The total income of these funds in 1999 was LE 2264.4m compared with LE 2116.7m in 1998 with a net cash flow of LE 1036.2m in 1999 compared with LE 982.85m in 1998.

About 97% of these funds are classified as defined benefit, and the majority of them provide salary-related benefits in return for salary-related contributions made by employees and employers. Although entitlements are usually determined on the basis of certain proportions of final average salaries, benefits often take the form of lump sums with a minimum of 10 to 20 months' salary paid at retirement or death. The number of defined benefits scheme which are "lump sum only" was 570 out of 591 funds in 1999. There were just 12 defined contribution funds, which pay benefits in the form of a lump sum equal to the individual accumulated account, and only 6 funds out of the 591 provide their members with pension rather than lump sum benefits. These 6 funds are the largest regarding the number of members and also the amount of assets, and most of these funds belong to the public sector and mainly in the construction or industrial fields.

1.8.2. Investment Strategy

The investment policy of the private pension funds is limited by many restrictions imposed by the government, which affects their investment performance. The law sets up the investment regulations for private pension funds in order to protect the members' rights according to Article 14 of Law No. 54 of 1975. Restrictions are in relation to the types of assets which may be held and also in terms of the maximum or minimum allocation to particular types of asset. The investment rules strongly restrict foreign investments in order to safeguard the country's foreign exchange reserves.

The maximum and minimum proportions allocated for different investment instruments are defined in the regulations as follow:

1. At least 25% in securities guaranteed by the Government;
2. At most 60% in some or all of the following sectors:

(a) Ownership of real estate situated within Egypt,
(b) Ownership of listed shares up to a maximum of 50% of the fund,
(c) Deposits in one of the Egyptian banks offering a fixed rate of interest,
(d) Loans to the scheme's members in accordance with the fund's statutes,
(e) Any other investments of guaranteed return subject to EISA's approval.

3. At most 15% in a current account in one of the Egyptian banks.

In December 1999, these schemes had assets of LE 6991.4m (compared with LE 2,800m as at 30 June 1994) with an annual investment income of LE 809.4m. Investment returns in 1999 were 11-14%[71] (compared with 9-11% in 1997), assisted by privatisation issues in a buoyant stock market. Some 12 schemes control 50% of all these assets. The largest schemes include those provided by the Arab Contractors Company (with assets of LE 700m, 55,000 contributors and 18,000 pensioners as of 1997), the Suez Canal Authority, the Teachers Syndicate, and the National Bank.

The investments of these funds are predominantly in bonds or fixed interest assets, rather than equity-based assets. In 1999, 30.6% of the funds' assets were invested in fixed bank deposits and loans, another 61% were invested in government bonds and only 8.4% of the funds' assets could be regarded as being invested in equities and "real assets". This means that at least 91% of the funds held could be classified as fixed income or non-equity assets[72]. This is inconsistent with the investment philosophy that equities and real assets are expected to maintain their real values in times of high inflation and, therefore, are good match for salary-related liabilities.

1.8.3. Management of the Occupational Pension Funds

Every fund is managed by a board of directors appointed jointly by the members of the fund and the employer. The board of directors manages the fund and, in doing so, may undertake any action which realises the fund's objectives within the limits of the law and the fund's statutes. The EISA defines all the rules and assumptions required for calculating the funds' reserves. Private pension funds are exempt from all duties

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[71] The Complementary Scheme of the Arab Contractors Company, which is an example of a large complementary scheme, achieved an average rate of return on the invested funds of 16.25% in 1997. Its investment portfolio was spread across fixed deposits, NIB bonds, estates and shares.

[72] The World Bank has noted that "lack of professional management capacity for investment, the dearth of financial instruments and the risk-averse nature of these funds have been cited as the main reasons for the concentration of investments in bank deposits and government paper" (World Bank, 1998).

and taxes on their collected contributions, benefit payments, and investment proceeds. These funds can be fully integrated with the basic state system for administrative efficiency and customer service. For example, in the case of the Arab Contractors Company scheme[73], integrated payments are made to beneficiaries (with only the difference between contributions collected and benefits paid out on behalf of the basic state system being remitted to the NOSI).

There are major issues affecting occupational pension schemes in Egypt such as:

1. The legal and regulatory framework for the private pension funds needs to be revised and the supervisory capacity of EISA needs to be further developed (World Bank, 1998);
2. Inefficient management, particularly concerning the management of the funds' assets. Investment performance might be improved by managing the funds' assets through specialised institutions;
3. The majority of occupational pension schemes are lump sum only schemes with no significant market for annuities in Egypt;
4. Defined benefit plans can give very favourable benefits to employees who receive large pay increases close to retirement and this is an aspect which needs to be addressed in terms of financing the schemes;
5. Those private funds that provide pensions under the defined benefit system are effectively underwriting annuity business and, therefore, it would be possible to permit such funds to transact annuity business from other pension arrangements, particularly from defined contribution arrangements (GAD of UK; 1997).

1.9. Annuity Market

The insurance sector in Egypt comprises 15 insurance companies (4 of them are state owned and 11 are privately owned in which 2 of them are working in the free zones[74]) and has essentially been State-controlled and supervised by the EISA. There are only 7 insurance companies in the Egyptian market which are allowed to underwrite life insurance business. Life insurance coverage is not particularly extensive in Egypt, with only 614,606 individual policies in force at 30/6/2000 (mostly group insurance)

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[73] Its administrative costs represented 5.5% of the value of contributions in 1997.

[74] These special zones are governed by special laws, which are different from the laws governing companies operate outside these zones. Most of these zones are located in the ports and insurance companies working in such zones are not normally allowed to underwrite business outside these zones.

and the collected premium income was LE 595m (EISA, 1999-2000). There were only 910 annuity policies in force in 2000 issued by one company (probably issued for one group), as life companies are not providing a significant number of annuity policies. One of the reasons for this is that the insurance industry in Egypt is still under-developed and highly concentrated, although some of the insurance companies should already have a sufficient level of expertise to transact annuity business. In reality, most of these companies depend heavily on their foreign partners in providing most of the technical expertise, particularly in the pricing of individual policies.

New companies need to be formed in Egypt, especially for pension business, which might assist in the development of private pension schemes. Such companies might be restricted to transacting annuity business. It may be also desirable to have separate funds held within the other insurance companies for this class of business (to be easily supervised). In general, the insurance sector in Egypt is in the process of being opened up through privatisation and competition from international insurance companies.

1.10. Social Assistance Programmes

Social assistance to those in need is also provided by a wide diversity of organisations in Egypt. The MISAs manages a number of social assistance programs but these are not actually significant. However, the Nasser Social Bank, the Ministry of Al-Awqaf, non-Governmental organisations, various community development programs, and local organisations provide effective social assistance programs. This social assistance system has its unique financing characteristics, which are beyond this thesis.

1.11. Analysis of the System

The characteristics of the ESSPS imply that this system is expected to continue in the future with the same main structure. This conclusion is based on the economic, political, social and legal environment in which this system operates. However, there is a question needs to be answered: Is the ESSPS a good system? In order to analyse this question, we need to consider some critical points such as benefits, cost, redistribution, financing, adequacy of pension and impact of inflation, contribution evasion and administration. Therefore, the following sections focus on issues and problems that should be addressed to provide the basis for the formulation of recommendations for reform programme.

1.11.1. Benefits, Cost and Redistribution

The adopted pre-funding strategy makes entitlement to benefit payments independent from the State's financial position which increases the degree of certainty that the promised benefits will be paid, alongside the State guarantee of benefits. Looking at the eligibility requirements for benefits, it appears that the scheme rules treats different groups of members equitably regardless of their professions and do not distinguish between men and women, who are treated equally regarding retirement age, levels of benefits and contributions. The system may be seen as offering reasonable benefits in respect of termination of employment as a consequence of any of the insured contingencies, provided that the eligibility requirements are satisfied. The recent pension increases have resulted in a reasonable level of pension for those pensioners on low earnings (LE 355 and LE 285 on average for the GSF and PPSF respectively in 1997/98), provided a full contribution period has been made.

However, there are limitations in the scope of the benefits in most of these contingencies and they are not available to all of the insured categories. Benefits in respect of sickness, maternity, employment injuries, unemployment are in general, only available to people covered by Law 79/1975. It is found that the invalidity pension is usually the minimum pension because of the difficulties in determining medically whether someone is permanently incapable of work. The casual workers scheme does not provide an acceptable minimum income (flat rate pension of LE 60 per month). As a result, many provisions in the system as a whole are inadequate.

Also, those with an income above LE 12,000 per year in 2000 would need additional pension provision in order to maintain the lifestyle they enjoyed during their working lifetime. This could only be achieved through private pension plans, which are not generally available in Egypt and even the occupational pension schemes are not available in the majority of occupations. Therefore, a strategy of shifting some responsibility to the private sector by introducing some sort of private pension plans which target high-income earners and offer some tax incentives to encourage participation and widen the extent of coverage is urgently needed.

There is also a case for simplification of, and perhaps even for limiting the range of, survivors' benefits. The current provisions try to provide income protection for a broad range of surviving dependants. However, it seems inappropriate for the aggregate of the pensions payable to surviving dependants to exceed the pension entitlement of the deceased member[75], which is the case in many situations under the current provision. The early retirement provision also needs careful consideration and it is discussed in Chapter 2.

It is argued that the ESIS is relatively expensive for employers and employees as they pay high contributions rates with the employers pay approximately two-thirds of the total cost as explained before. These high rates may be due to the fact that the pension rights include a variety of benefits that are mainly funded through contributions and not by the state budget. It might also be as a result of the current poor investment strategy (discussed in Chapter 2), which yields a low return on the assets. However, the problem of high contribution rates, particularly for employers, is an important issue for the government to consider when encouraging multi-national companies to shift production to Egypt, as it raises the overall labour costs.

The ability of the system to accommodate individual needs does not exist as nearly all the benefits are predetermined and individuals have to take what is offered by the system. The system has the advantage of tax exemption, as contributions, investments, investment returns and benefits paid are all tax exempted. This advantage enables the system to increase benefits without any pressures are put on the shoulders of the insured person.

There is no special treatment to assist lower earners in the system, except for the minimum pension set by the State, which is very low and does not help much in improving their standard of living. Although the ceiling for the pensionable salary combined with the minimum pension may achieve some sort of redistribution, the ESSPS would need some improvement in order to be able to assist lower income earners and achieve the redistribution objective.

1.11.2. Funding or PAYG

The issue of whether the ESIPS should be operated on a PAYG basis or to maintain a specific degree of pre-funding of future liabilities[76] has been under debate for a long

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[75] The deceased's pension entitlement is supposed to be shared amongst the survivors within the overall maximum level limit of 100 %, however, it can exceed this percentage when a minimum pension value is imposed by the State on all pensions in payment.

[76] As stated before, the system was initially established to operate on a full funding strategy.

time. The system was established on the basis that the contributions from employers and workers with only a contribution rate of 1 % of the pensionable earnings from the Government (as well as its own contributions as an employer in respect of its employees) would fund its liabilities.

The rationale for funding is to achieve the long-term objectives of benefit security, contribution stability and flexibility and thus to increase the likelihood that the benefits will be paid in accordance with expectations[77]. In addition, pre-funding of the system may have contributed to the increase of aggregate national savings (and hence capital accumulation and growth), reduced the financial obligations of the state, and created a specific link between contributions and benefits. It also has averted any major increases in contribution rates over the last 3 decades. The gradual development of the system gives a strong indication that the government still intends to provide social security on a contributory basis and in accordance with insurance principles. Thus, pre-funding is a fundamental issue of the state strategy for the ESIPS.

There are many difficulties facing PAYG social security pension systems around the world, particularly for those countries in the transition period of their economic reforms[78] and those with unfavourable demographic trends (ageing populations) in the developed world. However, as the ESIPS was established as a pre-funded insurance-based system, this removes the system from the current debate regarding shifting from PAYG to pre-funded social security pension systems. These factors have led to growing support for keeping the current pre funding strategy.

It is only those workers who are unable to finance their future liabilities who are provided with benefits on an unfunded or even non-contributory basis. The Government has been providing significant resources to the system, particularly in financing pension increments and the CSIS, as analysed in Chapter 2. Therefore, this classical financial structure has been subject to three modifications:

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[77] This might not be the case for a state sponsored social security pension arrangement (particularly if it is a funded one), which is supposed to provide high level of security, particular regarding the continued existence of the system. However, the recent experiences of some countries showed that the need for security applies also to the state sponsored schemes, particularly when the availability of the promised level of future income, is in some doubt.

[78] The governments of certain countries (e.g. Chile and Australia) have introduced funded, defined contribution state pension schemes as a replacement for the PAYG. The future development of state pension systems in other countries may move in this direction.

1. Government subsidies are provided to finance the costs of incremental adjustment to pensions;
2. There is a personal subsidy to finance the casual workers scheme;
3. The responsibility for investment lies with the NIB.

As a consequence, the linkage between the source of the funds and their purpose in financing benefits has been obscured within the new mechanism. It is understood that there is a close link between the level of the non-contributory benefits and the level of resources available from general tax revenues to finance them. So provided that the tax base is broad and yields sufficient resources, increases in benefits provided on non-contributory basis may be extensive, as they do not dependent on individualised financing. Eventually, the ability of the Government to continue financing such obligations will depend on the performance of the economy.

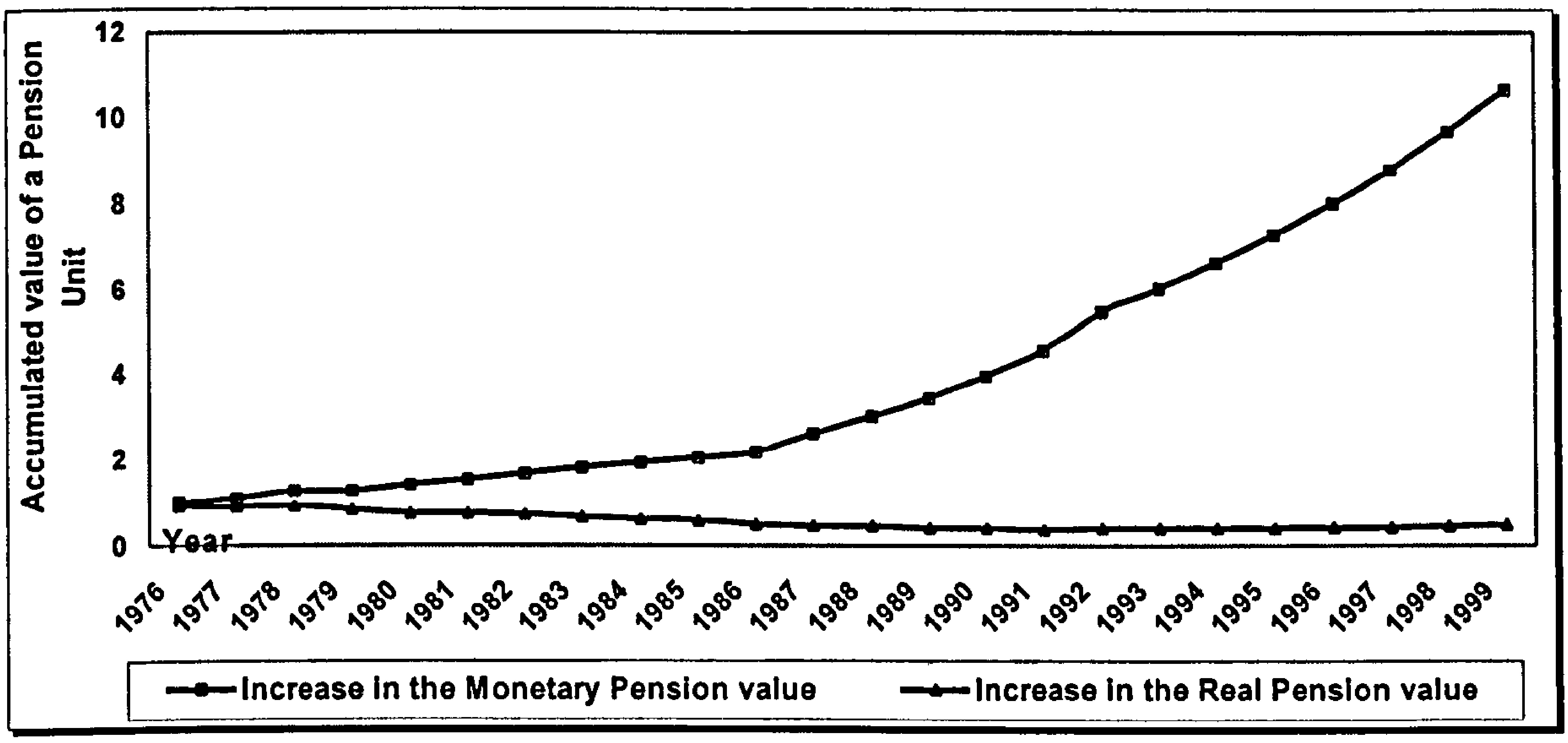
1.11.3. Pension Indexation and the Impact of Inflation

The backup for the benefit promises under a funded system is the system's ability to have enough resources to meet its liabilities. This should facilitate the protection of the elderly from different risks, such as those arising from the performance of the economy. One of the most important risks is the effect of inflation. Although the way of determining the pension on the basis of the average income during the last two years of the working lifetime tries to keep the standard of living for retired persons unchanged, pensions are not indexed to price or salary inflation. The legislation does not provide for pensions to be adjusted after award but rather are adjusted at the discretion of policy makers by statute.

The average inflation rate was about 20% and reached its highest level of 27% by the end of the 1980s. It was in the second half of the 1990s that inflation was brought under control and the rate declined to reach around 5% over 1997-99. These high inflation rates affected the real value of benefits very badly and made the real value of retirement incomes inadequate after few years of retirement, especially for people on low incomes who are the most vulnerable group. This effect can be seen when the monetary value of a unit of pension in 1976 is compared with the real value of this unit over 1977-98. It is found that the real value of a pension unit provided in 1999 was 48.4% of that unit in 1976 taking into account the entire pension increases over this period. This indicates that the real pension value has decreased substantially to less than 50% of its value in about 20 years as shown in **Figure 1.1.**

To deal with this problem and its effect on the real value of salaries and pension benefits, two measures were introduced. The first, was the redefinition of the variable salary as pensionable salary (as explained before). The second was the introduction of an annual increment in the pension[79], which is determined yearly on the budget date.

Figure 1.1. Monetary value versus real value of a unit of pension over 1977-98[80]



This annual increment is usually equal to the proposed increase in the salary of civil servants and public sector employees and it has been about 10% or more since 1987[81] as shown in Figure 1.2. However, these increases did not improve the real pension value until 1995, when inflation was brought down to around 5% and pension increases exceeded the rate of inflation.

High inflation created the necessity to level the inequalities of pensions granted in different years and to implement a system of inflation-related revaluation of pensions.

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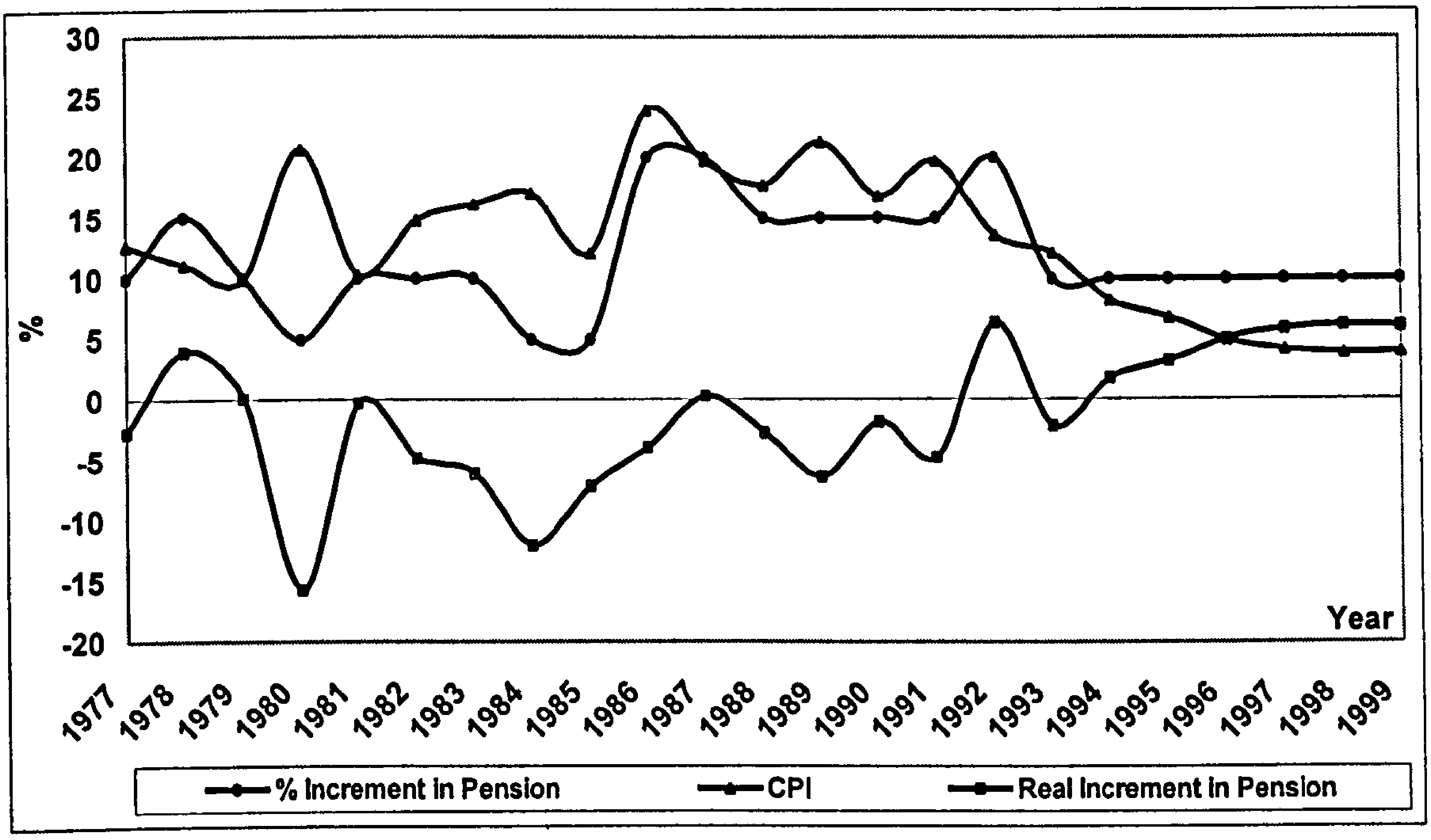
[79] The government is using some of the proceeds of privatisation to finance these annual pension increases which extended to include the self-employed and the Egyptians working abroad from 1992.

[80] Assuming that 1976 is the base year (1976 = 100), the real value of a pension unit over 1976-1999 was calculated using the following function: $\prod_{i=1976}^{year 1999}\left(\frac{(1 + API_i)}{(1 + CPI_i)}\right)$ as API_i is the annual pension increase and CPI_i is the annual consumer price index. The nominal value of a pension unit over 1976-1999 was calculated as the: $\prod_{i=1976}^{year 1999}(1 + API_i)$.

[81] Pensions were also increasing before 1987 but at lower rates and not on a regular basis. A 10% increase was declared for the year 2001/02 as over the last 15 years. The inflation rate over 1999/2001 was around 4% but it is estimated to be increase again over 2002/03.

Linking the benefit values to an index such as the Consumer Price Index (CPI) or an Average Salary Increase Index can reduce the inflationary impact on benefits. However, the Government is worried about indexing pensions to an index because of its inability to finance the increases at a time of high inflation such as experienced in the 1980s and 1990s. Given that the current investment strategy (discussed in Chapter 2) does not hedge against inflation, a compromise solution might be achieved by linking pensions to an index subject to an upper limit, such as price inflation up to 5% p.a. (as in the UK). By re-valuing the pension benefits yearly in this way, the scheme would maintain a proportion of standard of living for the pensioners.

Figure 1.2. Nominal and real annual pension increments of the average pension over 1977-99



1.11.4. Contribution Evasion

In some countries, low coverage is the result of widespread contribution evasion. Analysis of contribution income of the ESIPS (explained in detail in Chapter 2) shows that the system is experiencing an increasing widespread contribution evasion particularly in the PPSF as the role of the private and informal sectors of the economy grows[82]. This influences the financial status and the actuarial soundness of the system and it may seriously undermine the system with revenue falling far short of that sufficient to meet the current and future liabilities.

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[82] This was stated by the Minister of the MISAs in the Egyptian Parliament in March 2001. She suggested that there is a need for new legislation to deal with the change in environment from a predominantly public sector economy to a predominantly private sector economy.

Contribution evasion could be due to many factors such as high inflation, corruption, lack of trust in the system, high unemployment, low earnings, no efficient system of income tax or loose of connection between contributions paid and benefits received. In general, contribution evasion can occur if three conditions coincide:

1. Employers wish to evade, or to under declare the contributory earnings, or place a low priority on making social security contributions relative to other expenses;
2. Employees with non-payment of contributions are reluctant to report to the authorities in order not to upset the employer or loose their jobs;
3. Government enforcement tolerates evasion or is inadequate to prevent it.

There are some other factors and circumstances, which are relevant to this phenomenon in Egypt such as;

1. Contribution rates may regarded as high for employers and employees;
2. Having more than two million people working abroad and large informal sectors of the labour force[83] in which earnings cannot easily be monitored[84] or contributions collected with a growing trend among them not to be covered;
3. The rigidity of the labour legislation[85] with the low levels of earnings in the informal sector indicating a close relationship between the growth of the informal sector and the growth of evasion and exclusion from coverage;
4. As a result of the right given to these categories to choose the pensionable salary, they normally choose the lowest level throughout their career and would change it to a higher level before retirement;
5. Members of private sector have their benefits based on the average earnings of the last two years, therefore, they have every reason to under-reporting their pensionable income and minimise their contributions in all but the last two years;
6. Given the high rate of unemployment, some private sector employers force their employees to accept a lower pensionable salary than the actual salary or even provide no coverage at all[86].

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[83] A report by the US Embassy in Egypt in 1997, estimates that the informal sector accounts for at least 50% of the total economy: the rural and urban self-employed and the others who are employed, in one way or another, by informal sector enterprises. Definitions of the term 'informal sector ' are both difficult to formulate in aggregate and to apply to individuals.

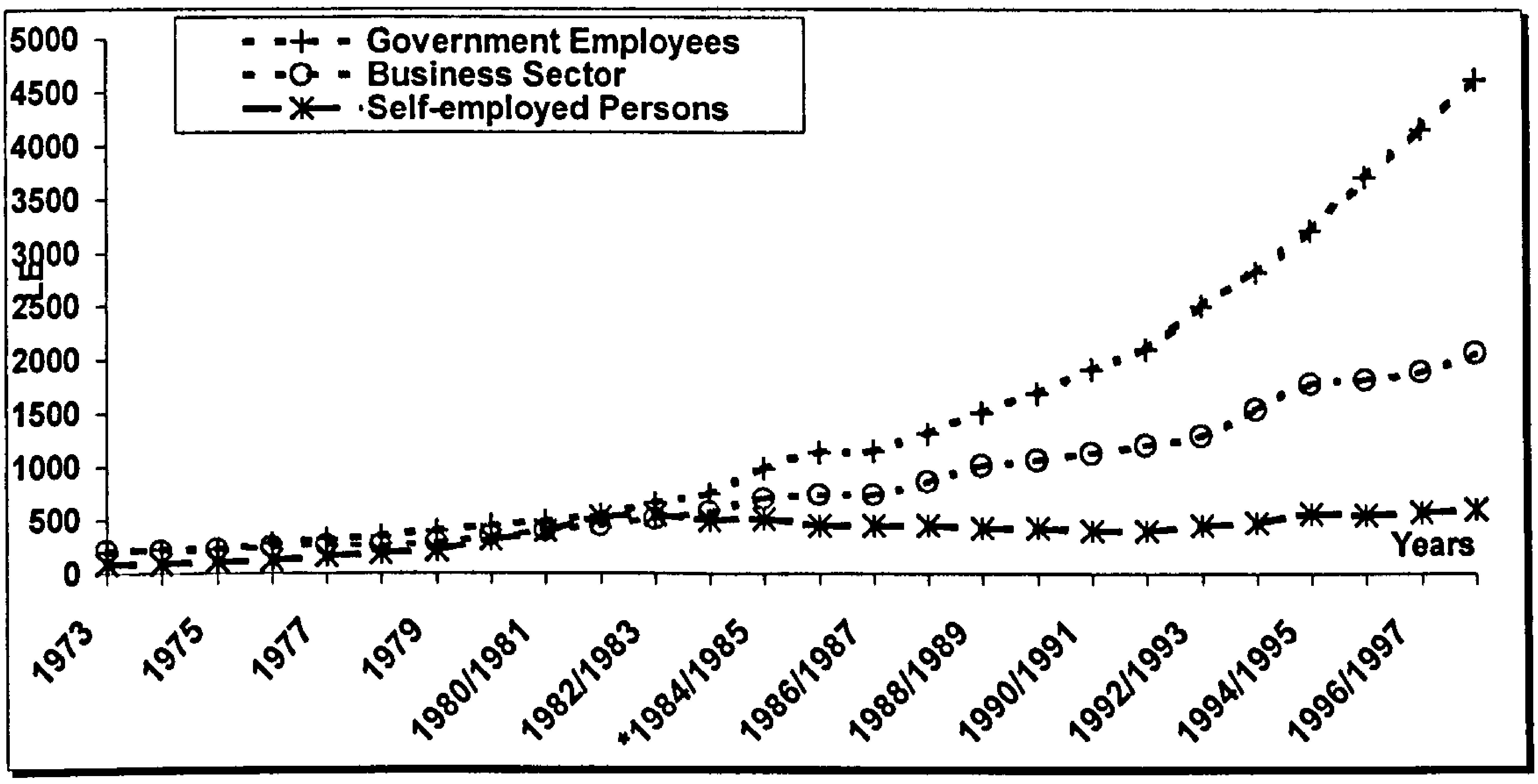
[84] Unrecorded salaries are a common phenomenon in Egypt particularly with the informal categories.

[85] The labour legislation and environment is examined in Chapter 6.

[86] Some employees accept this situation in order to keep their jobs. This problem may grow in the future with growing shift towards private sector, the increase in the number of workers in the informal private sector and the increase in the unemployment.

This phenomenon was reflected in the growth of the average pensionable salary, which is growing at a lower rate in the business (private) sector and the self-employed schemes than in the civil servants scheme as shown in Figure 1.3. The average pensionable salary of the civil servants is growing faster than in the business sector and much faster than in the self-employed persons' scheme.

Figure 1.3. Development of the average pensionable salary of different schemes, 1973-98



These differences emerged from the second half of the 1980s, which is the starting period of privatisation and the increase in the private sector role in the economy. This contradicts what is believed in Egypt that the private sector's salaries are much better than the Government's and public sector's salaries. It was found that 96% of the regular private sector employees' insured salaries were less than L.E. 200 per month in 1999. It was also found that 77% of the members of the self-employed persons scheme who aged 35+ have selected the minimum pensionable salary. To avoid low salary selection more stringent measures should be taken, for example, for a worker who used to be covered under Law 79, the contributory salary should not be less than 60 % of the last salary.

Although the legislation is comprehensive, considerable evasion occurs, in particular schemes and thus, a system which seeks to be redistributive and to provide earnings related benefits for earnings related contributions is undermined by weak compliance. This problem is expected to be a future critical issue, therefore, the system needs to be adjusted to be able to cope with an economy predominant with a formal and informal private sector. It is unrealistic to rely on a system for collecting contributions which was designed for the formal sector with the majority of contributions coming from the public sector and civil servants. The government needs to reconsider its responsibility to maintaining compliance which requires an enforcement policy and mechanism.

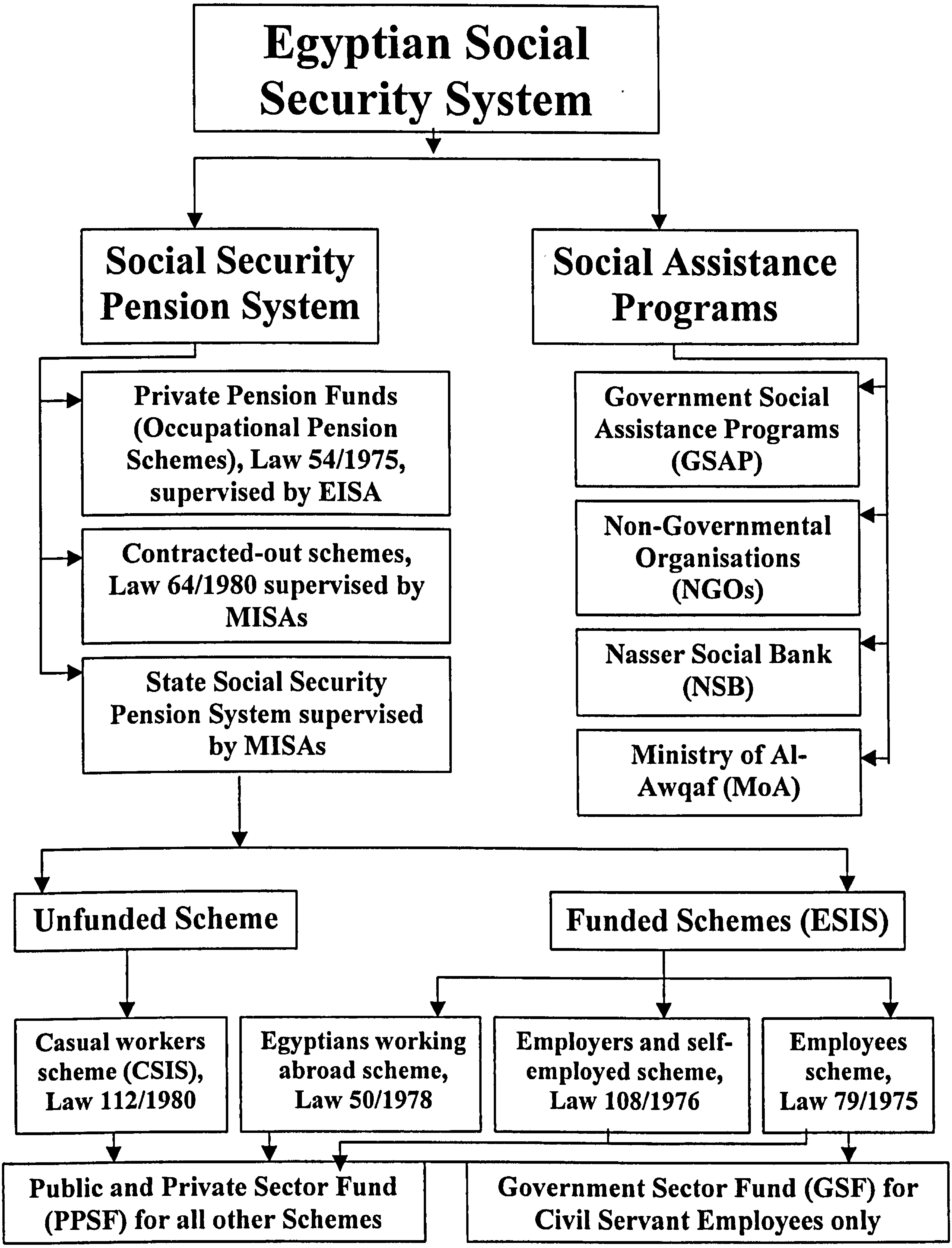
1.12. Conclusion

The social dimension has been given priority in the on-going economic reform in Egypt, which is regarded as a very critical factor for most developing countries, otherwise these reforms may not succeed and the country may have some internal unrest. The nature of the system makes the Government the main provider of pensions, while occupational pension schemes provide an extra income usually in the form of a lump sum on retirement. In addition, there is no provision of group pension policies in the Egyptian insurance market. Although there are supplementary schemes operated by larger employers, neither these nor private insurance play, as yet, a significant role.

The overall system is well established and sustainable under conditions of moderate economic growth and, although it has its weaknesses, it is far from experiencing an acute crisis. It is a relatively well-organised and mature system which has been operating for more than half a century. It is regarded as one of the most comprehensive social insurance systems, not only in Africa, but also in the Arab world and among developing countries. The system has been improving over time and has generally satisfied many of the criteria for a good pension system such as, redistribution, fairness, certainty, adequacy, and coverage.

However, demographic, economic and social developments in the 1980s and 1990s caused significant changes in addition to the system's internal problems, which need to be addressed in a reform program for the whole system. Only growing economies can guarantee adequate pensions, which are protected against inflation, as legislation alone can only improve benefits in short term. In the long term one of two situations might arise: either the benefits will again suffer from the effects of inflation or the cost of providing benefits will be too expensive. Therefore, the Egyptian economy has to grow and through this growth can better pensions be guaranteed.

The structure of the system is summarised in the following Diagram 1.4, which shows the ESSPS components.


Egyptian Social Security System
Social Security Pension System
Social Assistance Programs
Private Pension Funds (Occupational Pension Schemes), Law 54/1975, supervised by EISA
Contracted-out schemes, Law 64/1980 supervised by MISAs
State Social Security Pension System supervised by MISAs
Government Social Assistance Programs (GSAP)
Non-Governmental Organisations (NGOs)
Nasser Social Bank (NSB)
Ministry of Al-Awqaf (MoA)
Unfunded Scheme
Funded Schemes (ESIS)
Casual workers scheme (CSIS), Law 112/1980
Egyptians working abroad scheme, Law 50/1978
Employers and self-employed scheme, Law 108/1976
Employees scheme, Law 79/1975
Public and Private Sector Fund (PPSF) for all other Schemes
Government Sector Fund (GSF) for Civil Servant Employees only

Chapter 2

Demographic and Economic Experience of the ESSPS

2.1. Introduction

A state pension scheme is one of the comprehensive socio-economic and political institutions which functions within an environment of national demographic and economic significance. The future development of such schemes depends on the economic and demographic characteristics not only of the population covered by the scheme but also for the whole country, because the structure of every scheme has obvious links to that in the whole country.

The financial management of such schemes on the basis of a sound long-term financial perspective is crucial for the their viability. The future income, outgo and actuarial liabilities of such schemes depend on many factors. Such factors as labour force growth and participation, employment, productivity, inflation, fertility, mortality, net migration, marriage, divorce, retirement patterns, and disability incidence and termination. Income will depend on how these factors affect the size and composition of the working population and the general level of earnings. Similarly, future outgo will depend on how these factors affect the size and composition of the beneficiary population and the general level of benefits.

In general, all pension projections and valuation models require data on demographic and economic developments. Their effects are crucial, as well as the pension schemes themselves. Demographic and economic factors are usually regarded as exogenous factors for pension projections. Assumptions about them are usually derived from outside the schemes. However, the structural factors related to the schemes themselves are endogenous factors, which are obtained from within the schemes. Development of the factors contributing to the costs of the pension scheme have to be investigated and the results are used in the projection and valuation of the future income and expenditure of the scheme.

To develop ranges for cost projections, assumptions about the future behaviour of the demographic and economic factors have to be made in an objective manner according to current understanding. Therefore, the aims of this chapter are to analyse the demographic and economic construction and experience of the ESSPS over 1975-99[1]. This analysis constructs the current demographic and economic structure of the system and extrapolates a new structure for each projection year. The analysis with expected future changes is used in setting the assumptions needed to build a discrete-time model for the projection of possible future scenarios of the system. These assumptions will form the basis in the model for the projection and valuation of the ESSPS over 1997-2025.

The issues explored in this chapter relate to:

1. The main economic and demographic indicators of Egypt;
2. The administration and financial management experience of the ESSPS as a whole, the two Funds[2] and every individual scheme of the system[3];
3. Trends in the cash flow of the two Funds and past actuarial valuation results;
4. The investment policy of the system's assets in connection with the NIB;
5. The past returns on the invested funds experienced over 1977-99;
6. Coverage and compliance rates and membership stability;
7. Salary and pension increases;
8. Survivors' benefits experience and assumptions;
9. Marriage rates and age differences within the Egyptian families;
10. Mortality, invalidity, early retirement and unemployment decrements.

2.2. Factors Affecting the Projection and Valuation of Pension Schemes

Haapa-aho (2000) grouped the factors affecting the actuarial valuation and projection into three groups: demographic, economic and scheme-specific.

2.2.1. Demographic Factors

Demographic factors have a decisive influence on the development of pension schemes and their financial balance, particularly in long-term projections. Population projections are needed to provide a basis for estimating the numbers of the active

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[1] Data before and after this range of years is used whenever it is available and appropriate, as the data is not available for all the indicators for the same period of time.

[2] Every Fund is an autonomous organisation, and there is no financial transfer between the two Funds except in the case of an employee is moving from the GSF to the PPSF

[3] This approach is consistent with the actuarial projection and valuation of the system as carried out.

population and pension recipients and consequently forecasting the scheme income and expenditure. Estimates of current and future liabilities of the state pension system require assumptions about many demographic factors, such as trends in future population growth. Therefore, the relevant models for demographic projections have to produce projections about the following components:

1. Mortality rates in the base year (Life table);
2. Mortality improvement factors;
3. Fertility rates and net migration;
4. National population;
5. Other relevant demographic assumptions such as marriage statistics and age differences within the families;

These points are covered in details in Chapters 4 & 5.

2.2.2. Economic Factors

The general economic situation affects pension schemes in a variety of ways, therefore, economic assumptions are critical to the projection and valuation models and the results they produce. Such economic variables are:

1. Labour force participation rates;
2. Employment and unemployment rates;
3. Estimation of the insured population:
4. Salary growth, average salary, legal minimum and maximum pensionable salary,
5. Inflation, interest rates and average rate of return on the invested funds;
6. Growth Domestic Product (GDP) growth rate;
7. Pension increases etc.

Some of these factors are needed to estimate the size of the active population and project income and expenditure levels. Changes in earnings and labour force participation rates relate directly to the income from contributions. Depending on the revaluation rules applied to pensions, inflation and changes in the earnings level also affect the level of expenditures. In a funded system such as the ESIPS, interest rates play a key role in forecasting investment returns. Variables 1 and 2 are covered in detail in Chapter 6 while other variables are covered in this chapter.

2.2.3. Scheme-Specific Factors

The unique features of each pension scheme affect the pension projections and the interdependencies between individual variables and schemes. These dynamics can be quite complicated. Identifying internal and external dynamics and dependencies requires careful evaluations of different statistical data about the schemes. The analysis of the structural factors of pension schemes depends on the objectives of the projections and valuations, good statistical data available and sophisticated analytical tools. The crucial point is to be able to use the analysis to identify the main structural features of the schemes and their interdependencies.

2.3. Main Economic and Demographic Indicators of Egypt[4]

Although Egypt has enjoyed economic stability in the 1990s, it remains a relatively poor country with 23% of its population living below the poverty line[5] (ILO, 1999). Macroeconomic stabilisation since the early 1990s led to GDP growth accelerating from 4.7% in 1995 to 5.3% in 1997: an average of 2.5% per capita during 1996-97. But it has declined since then to less than 4% in 2000-01. The Gross National Product (GNP) growth rate over 1997-98 was 5.1% (4.9% in 1996-97) which ranked Egypt as number 40 in the world in that year (World Development Report, 2000). The inflation rate declined from 20% at the end of the 1980s to 14% during 1991-95, to 6.2% in 1997 to around 4% in 1998-99 as explained in Chapter 1.

Egypt's demography has moved from a period of high fertility and mortality in the 1970s and 1980s to a period of declining fertility and mortality from the beginning of the 1990s. The total population increased from 41m in 1980 to 66.55m in 1999 with a young population structure. The average population growth rate has declined from more than 2.6% p.a. during the 1970s and 1980s to around 2.1% p.a. over 1995-2000[6]. The young population structure is reflected in the proportion of population

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[4] Sources: UN, World Population Prospects, 1997 Revision, ILO 1999 and CAPMAS, 1990-98.

[5] With a per capita income of LE 3811 in 1996, Egypt took a moderate position in international ranking. The 1996 Egypt Human Development Report has established several poverty lines to assess the incidence and severity of poverty in Egypt. The overall poverty line ("lower expenditure poverty line") is estimated to be LE 4,168 per household and LE 814 per capita in 1995/96 (=21% of per capita income). A second, ""food based" poverty line of LE 3,148 per household and LE 594 per capita (=16% of per capita income) is used to determine the "ultra poor". Some 22.9% of the Egyptians (13.9m) are estimated to fall below the expenditure-poverty line, with some 7.4% (4.4m) considered to be ultra poor. A further 25.1% are considered to be living in "mild poverty".

[6] A recent report published in May 2001 by the CAPMAS warned that Egypt's population is growing faster than expected and warns that it could double to 123 million by 2029.

aged 0-14, which represented 39.0% in 1998, although it has declined from 43.0% in the 1960s. It is also reflected in the median age[7], which stood at 21.4 years in 1998, increasing from 18.4 in the late 1960s, but still relatively young.

The proportion of the population aged between 15-64 was around 57% over 1970-99. The proportion of the population aged 60+ increased from 1.5% in 1958 to 3.8% in 1998. The Dependency Ratio (DR)[8] has been around 11-12% since 1950s, though it was between 10.5-11.0% over 1985-1995 but it increased again to 11.1% in 1998. The workforce was estimated to be 18.3m in 1998-99 with around 2.3m Egyptians working abroad, mainly in the Arab Gulf states. In 1998, the work force was broken down as follows: Government and public sector 36.0%, agriculture 34.0% and private sector 30.0%. Unemployment as a percentage of the workforce, according to official sources, was 9.6 % in 1995, 8.3 % in 1997-98 and 9.5% in 1998-99, but unofficial estimates are higher than these figures. Some other demographic indicators are included in **Table 2.1 of Appendix 2.**

Indications show that the population of Egypt has undergone a change in its demographic structure in the 1990s. This is having a major impact on the overall future development of the country's demographic and economic situation, particularly on the ESSPS. It is known that the growth of new members in the state pension system is mainly affected by the growth in the workforce, labour force participation, and employment rates, theses are analysed and projected in Chapter 6. Growth of membership of the ESSPS is analysed and assumptions regarding the future growth in new entrants of each scheme are projected separately in this Chapter.

2.4. Administration of the ESSPS

The ESSPS is managed by the GSF and the PPSF and each Fund is responsible for the social insurance of specific categories of the population. Every Fund keeps an account of the income and outgo of every scheme and for every covered contingency. The two Funds are responsible for collecting contributions, paying benefits and carrying out the required actuarial valuations. They work independently from each other in respect of finance, management, assets allocated (including those from the State's budget) and actuarial valuation results.

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[7] The Median age is the age such that the populations above and below that age are equal.

[8] Measured as the total of the population aged 60+ as a percentage of the total population aged 15-60.

According to Law 79 of 1975, all the schemes within the system, except the CSIS, are required to operate on a full funding basis. This resulted in large funds accumulating over time which became a permanent feature of Egypt's financial structure and an essential element of economic stability. The assets of the system are separated from the state budget, this is desirable to secure the pension benefits independently of the financial health of the state's economy. However, the investment policy of the funds is subject to political interference. The Government relies heavily on these funds as the main sources of income for the NIB as explained later.

2.5. Financial Framework and Cash-Flow Statement

The relationship between the Treasury, the NIB and the two Funds is an essential factor for understanding the financial structure of the ESSPS. The flow of funds between these three parties is presented in Figure 2.1. This shows income, expenditure and cash-flow surplus and explains many of the policy issues in the system. The Figure shows that to finance expenditure, every Fund receives four sources of income: contributions, Treasury transfers (subsidy) to the Funds[9], investment return, and other indirect resources (such as fines and legal compensation).

Table 2.2 of Appendix 2 summaries the transactions of both Funds over 1977-99 together with the trends of some financial indicators. The following subsections present an analysis of income, expenditure, surplus, reserves and main financial indicators.

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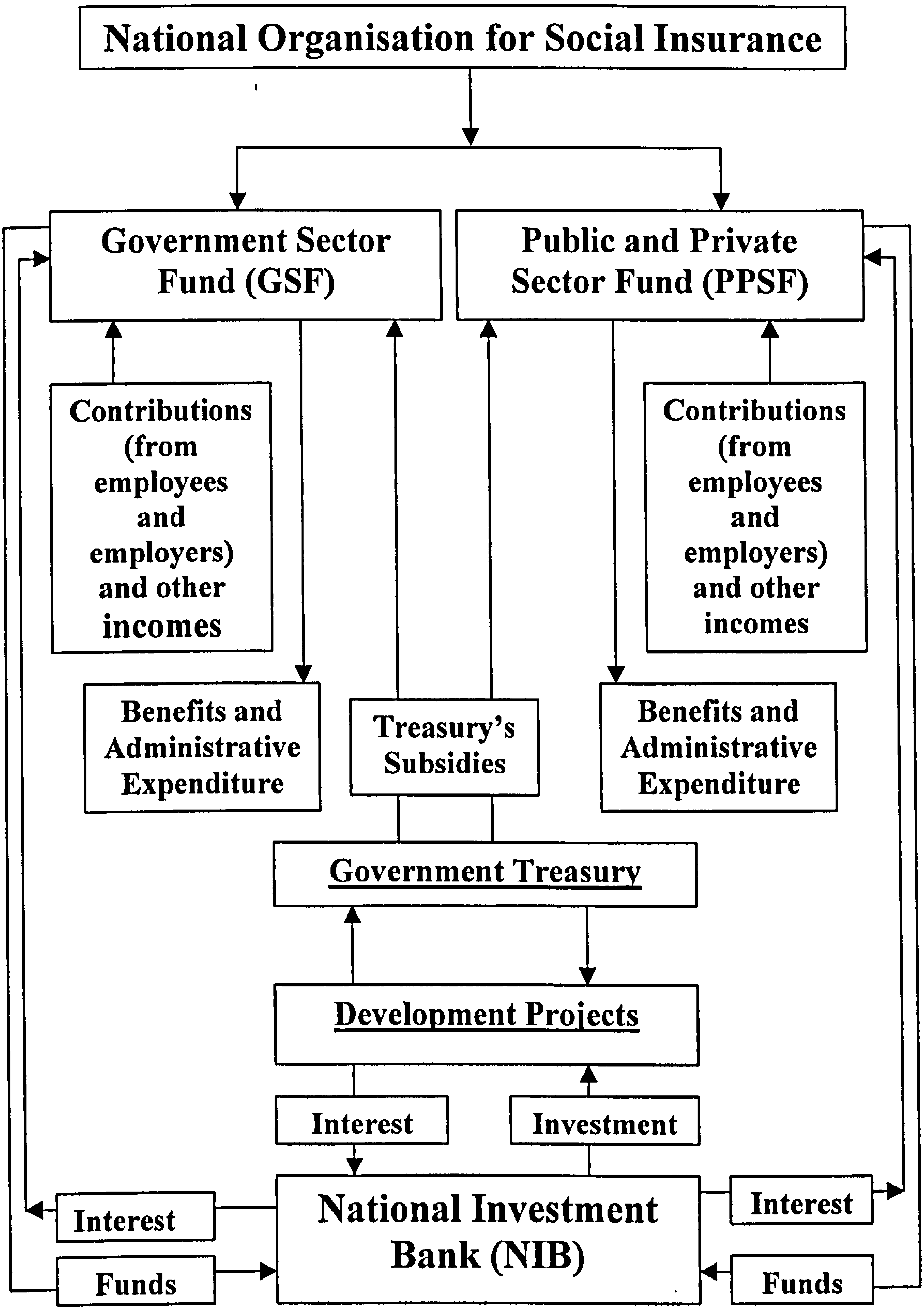
[9] The two Funds pay all the benefits including the special increments and other unfunded promises, and the Treasury transfers the required subsidy on a monthly basis to them.

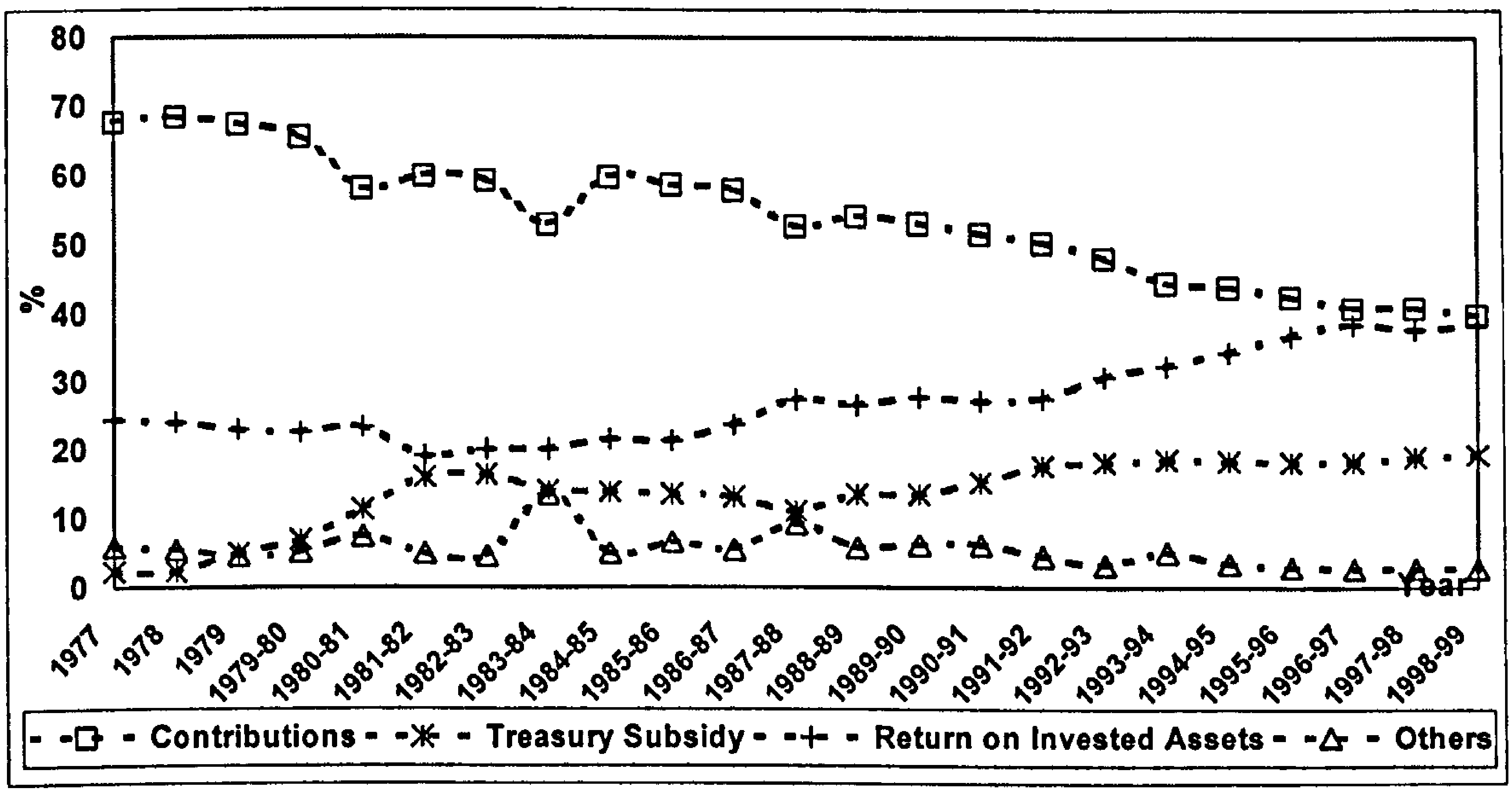


2.5.1. Income

During the fiscal year 1998-99, the system had a total income of LE 28.5 billion (LE 13.7 billion for the GSF & LE 14.8 billion for the PPSF) which represented 9.43% of GDP (at market prices) in that year. The total income comprised LE 11.3 billion of contributions by insured workers and their employers (LE 6.0 billion for the GSF & LE 5.3 billion for the PPSF), which represented 3.73% of GDP.

There was LE 5.5 billion of subsidy from the Treasury in respect of the special increments, increasing the minimum pension level and financing the CSIS (LE 1.9 billion for the GSF & LE 3.6 billion for the PPSF), which represented 1.82% of GDP. There was LE 10.9 billions of earned interest on the invested funds (LE 5.6 billion for the GSF & LE 5.3 for the PPSF), which represented 3.61% of GDP. There was also LE 0.8 billion of other incomes such as compensations and fines (LE 0.3 billion for the GSF & LE 0.5 for the PPSF). The development of the distribution of the annual income between these four sources over 1977-99 is shown in Figure 2.2.

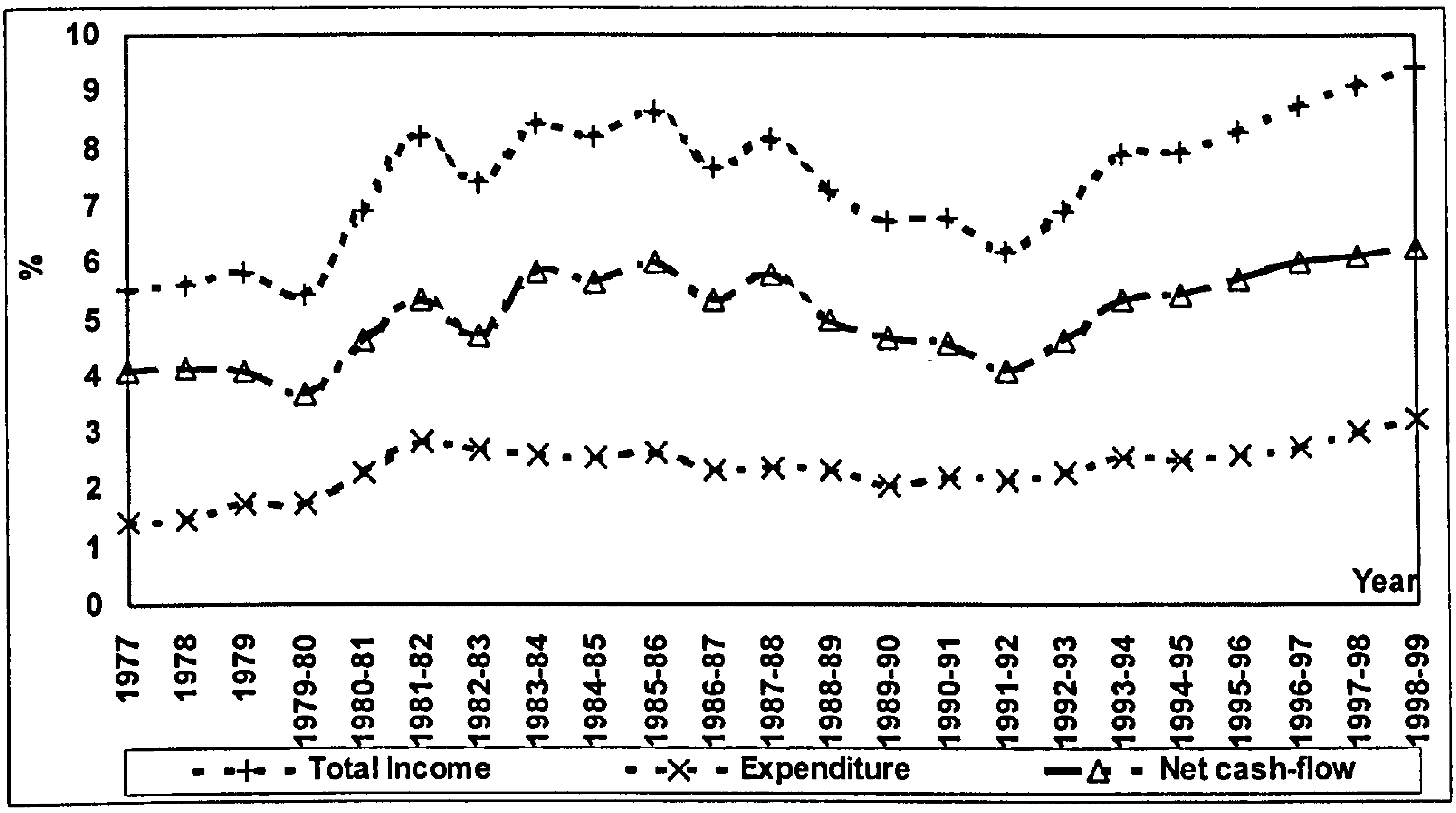
Figure 2.2: Distribution of annual income of the ESSPS over 1977-99.



This Figure shows that income from contributions as a proportion of the total annual income has decreased from 67.5% in 1977 (67.4% for the GSF & 67.7% for the PPSF) to 39.6% (43.4% for the GSF & 36.1% for the PPSF) in 1998-99. It can also be seen that the income from the Treasury has increased from 2.1% of total income in 1977 to 19.3% in 1998-99. These recent changes to the financial structure of the system have let some researchers to say that the system has moved from a fully to a partially funded system (Ibrahim F. et al., 1994).

However, the most rapidly growing source of income is the return on invested funds. It represented 38.3% of the total income in 1998-99 (40.6% for the GSF & 36.2% for the PPSF) which is very close to the income from contributions. This explains why the investment strategy of the accumulated funds will be crucial for the solvency and stability of the system in the future. This is also reflected in the increasing ratios of the total income and net cash-flow to GDP (at market prices) since 1991-92, which is the same year the investment return started to increase as shown in Figure 2.3.

Figure 2.3: Income, net cash-flow and expenditure as a percentage of GDP over 1977-99



2.5.2. Expenditure

Expenditure on benefits has been rapidly increasing at an average rate of 21.3% per year over 1977-99 (18.9% for the GSF & 23.4% for the PPSF), particularly in the 1990s when the rate of annual increase exceeded 20%. The expenditure in 1998-99 totalled LE 9.7 billion (LE 3.7 billion for the GSF & LE 6 billion for the PPSF) which represented 3.2% of GDP. It comprised LE 9.44 billion of benefit payments[10] and LE 0.26 billion of administration and other costs. This rapid increase in benefit expenditure creates cash-flow pressures on the income side, which is reflected in the ratio of expenditure to contributions as shown in Figure 2.4.

This ratio increased from 38% in 1977 (47.6% for the GSF & 29.7% for the PPSF) to 86% in 1998-99 (61.6% for the GSF & 113.4% for the PPSF). This means that the percentage of income from contributions which is invested has been decreasing rapidly over time and that there might be a need for more income to meet expenditure

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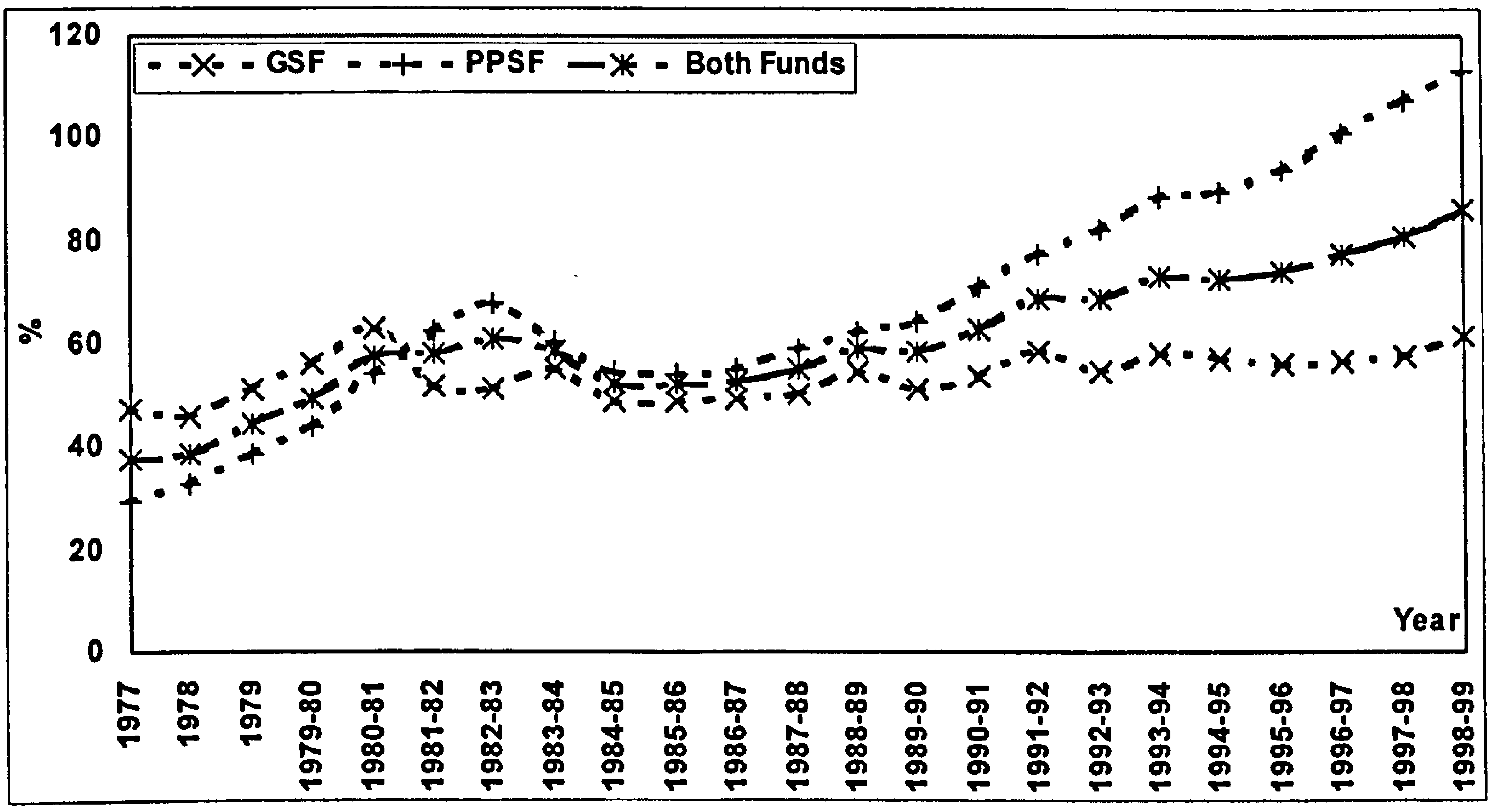
[10] Health care benefits, for which contributions are transferred to the POHI, are excluded and in the financial statements of both Funds, the health care contribution is reported on the income side as a deduction from total contributions.

in the coming years. In 1998-99, there were sufficient contributions to cover the total expenditure of the GSF but not of the PPSF. Part of the Treasury subsidy to the PPSF has been used to cover the shortage in cash-flow from contributions since 1996-97, although the Fund still has an overall cash-flow surplus.

Figure 2.4: Expenditure as a proportion of Contributions over 1977-99.



There is a growing indication that future cash shortages are likely to occur, particularly in the PPSF. The PPSF seems to be suffering growing imbalance between contribution and expenditure and needs considerable attention from the managers of the system, as its members have changed from predominantly public sector employees to predominantly private sector employees[11].

2.5.3. Treasury Role in the Financing Structure

The Government has committed itself to meet the following liabilities:

1. 1% of the total payroll towards old age, death and invalidity benefits;
2. The cash-flow deficit of the CSIS and all the liabilities of the SPP;
3. Pension increments including raising the minimum pension[12];
4. Grants for pensioners arising from political decisions, e.g. Labour Day Grant[13];

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[11] In the public sector, it was easy to treat the employee's entire earnings as pensionable salary. Contribution evasion in the private sector as a result of an inadequate collection mechanism for social security contributions can be regarded as one of the main reasons for this problem.

[12] The government finances all pension increases after pensions are awarded, as pensions are not automatically adjusted. These increases were extended to include the self-employed persons and Egyptians working abroad schemes after abolishing the upper limit for these pensions from 1/7/1992.

[13] It represents a special allowance equivalent to two-thirds of the monthly pension (up to a maximum of 75 LE per person in the fiscal year 1998-99) awarded on the 1st of May and paid to all pensioners.

5. Any actuarial deficit in the Funds, to be repaid to the Treasury when there is a surplus.

In the 1980s and 1990s, a rapid increase in the Treasury subsidy to both Funds has occurred and a substantial percentage of the Government expenditure was allocated to the ESSPS (about 21% of Government expenditure in 1998-99). Pension expenditures, financed by the Treasury, were growing at an average annual rate of 33.4% over 1977-99, which was much faster than the growth in GDP (6.3% over the same period). It grew by a rate of more than 19.3% per year over 1982-99[14] compared with average GDP growth of around 5.1% per year over the same period.

The ratio of pension expenditures financed by the Treasury to GDP rose from 0.12% in 1977 to 1.82% in 1998-99 as shown in Figure 2.4. The percentage of the Treasury subsidy relative to the total expenditure of both Funds has also increased from 8.2% in 1977 (7.8% for the GSF and 8.7% for the PPSF) to 56.7% in 1998-99[15] (52.5% for the GSF and 59.2% for the PPSF). The Treasury subsidy to the PPSF, particularly, represented 67.2% of the income from contributions and 48.8% of the total income in 1998-99. Some of the reasons for this dramatic change in the financial structure over the 1980s and the 1990s are:

1. Extending coverage to categories of the population who have no resources to finance their liabilities (the CSIS) and have to be financed by the Treasury;
2. Unfunded pension increments, which have been promised every year since 1987 and have an increasing effect over time on the State's budget.

The increasing Treasury subsidy to the system over time may be seen as contradictory to the objective of a fully funded system. But as the system has been forced to invest its assets in low interest loans to the NIB, the Government may have realised its responsibility to take care of financing the cost of extra benefits (including any pension increases) from its general revenues. The proceeds of its privatisation program may have helped the Government to finance annual pension increases of 10-15% p. a. However, its ability to do that in the future will depend on whether it will be able to find enough revenue from its budget to achieve that. But ultimately the

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[14] This period followed the introduction of the CSIS and SPP with about 90-95% of their finance coming from the Treasury. The rate of growth over 1979-82 only was 117% p.a.

[15] It can also be seen that the percentage annual increase in finance from the Treasury has risen from 2.7% in the 1970s to 6.9% in the second half of the 1990s.

Government subsidies to the two Funds are indirectly used as a source of income for the NIB and hence for financing public projects. Government subsidies that are not used to cover primary cash deficits simply increase the tax burden of future generations, without increasing the financial "safety" of the social insurance schemes. This is because the safety of the investments depends on the Government's ability to raise taxes or refinance the debt on the capital market.

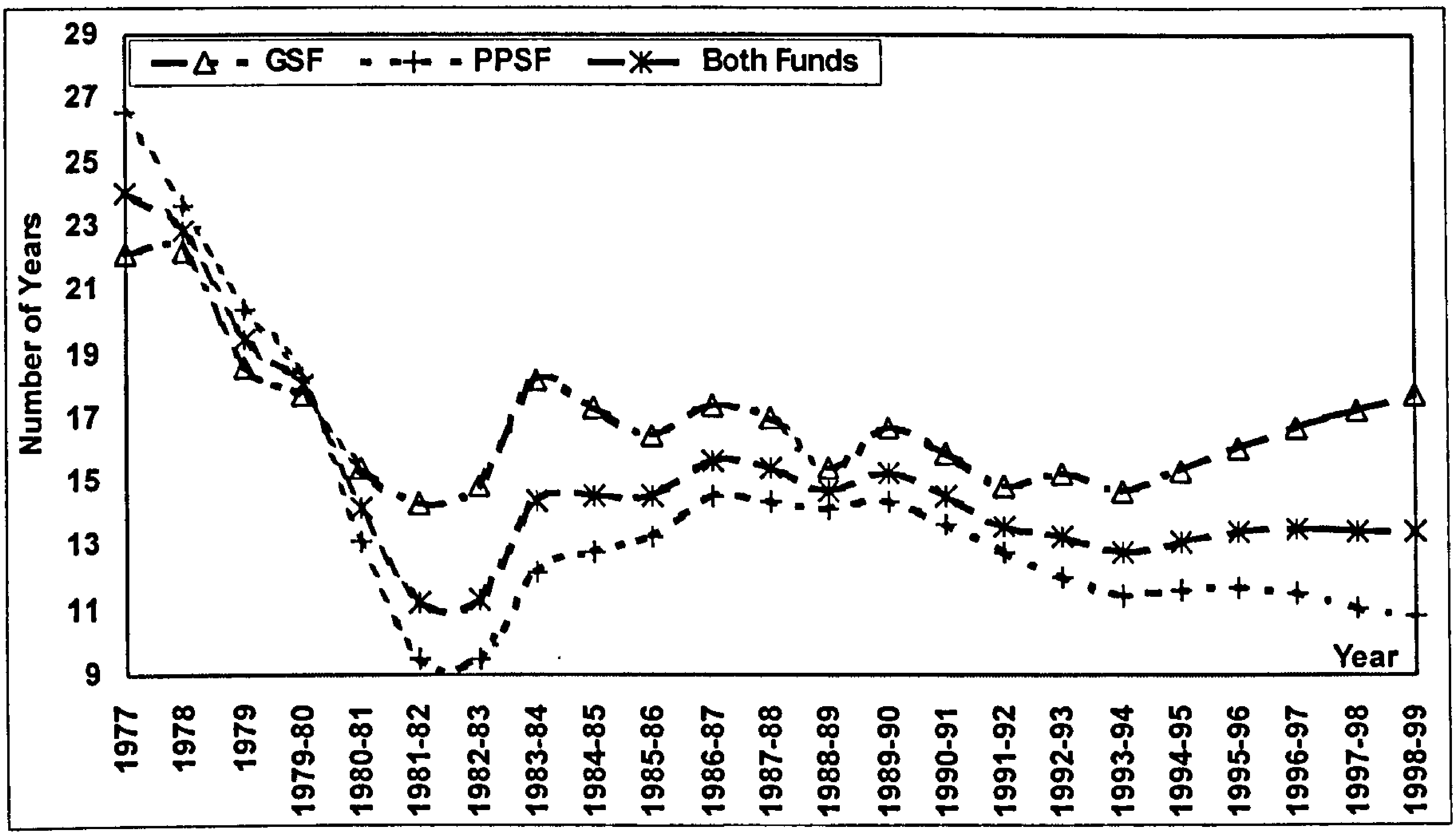
2.5.4. Cash-flow Surplus and Reserves

The excess of contributions over expenditure, the Government subsidy, the investment income and other sources of income are, in total, added to the accumulated funds. The two Funds have been showing a cash-flow surplus every year. In 1998-99, they had a total cash-flow surplus of LE 18.8 billion (LE 10 billion for the GSF and LE 8.8 billion for the PPSF) which represented 6.2% of GDP in that year. However, the proportion of annual cash-flow surplus to the total income has been decreasing over time particularly for the PPSF as shown in **Table 2.2 of Appendix 2.** This proportion has decreased from 74.4% in 1977 (79.9% for the GSF and 67.9% for the PPSF) to 65.9% in 1998-99 (73.3% for the GSF and 59.1% for the PPSF) which gives an indication of the expected future cash flow trends.

Each Fund has been accumulating a considerable amount of funds. At the end of the fiscal year of 1998-99, there was a total fund of LE 130.4 billion (compared with LE 3.4 billion in 1977). The total assets of both Funds (LE 64.7 billion for the GSF and LE 65.6 billion for the PPSF) represented 43.2% of GDP at market prices in 1998-99. This represents a significant share of assets invested in the national economy.

The increase in funds in the 1990s is mainly attributed to the earned interest rather than a significant excess of contribution income over expenditure, particularly in the PPSF. The assets of both Funds were equivalent to 13.4 years' annual expenditure in 1998-99 (17.7 years for the GSF and 10.9 years for the PPSF). Although this indicator has increased in the GSF (from equivalent 14.7 years in 1993-94 to 17.7 years in 1998-99) it has moved in the opposite direction in the PPSF (from equivalent 14.5 years in 1986-87 to 10.9 years in 1998-99) as shown in Figure 2.5.

Figure 2.5. Funds/Expenditure ratio over 1977-99



This confirms the growing concerns about expected future shortage of cash-flow for the PPSF over the coming years and the Treasury's ability to inject more subsidies into the system. Nagib, S. (1994) discussed this problem and attributed it to a trend of contribution evasion and under- stated pensionable salaries within the private sector[16]. He suggests that one of the main reasons for this problem is the high contribution rates, which either discourage private sector employees and employers from contributing or cause them to use the minimum possible pensionable salary. The GSF does not have this problem, as it covers only civil servants and has a 100% compliance rate, it is in a better financial position as shown in Figure 2.5.

2.5.5. The CSIS Financial Problem

The ratio of income from non-government sources to the total expenditure of the CSIS (including the SPP) has declined from 31.8% in 1989-90 to 5.4%[17] in 1998-99, which means that within a few years the Treasury may have to finance all the liabilities of this scheme. There are many reasons for this situation such as:

1. The member's contribution of LE 1.0 per month is not significant;
2. The income from other sources is not stable and has been significantly declining over time;

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[16] The PPSF covers mostly the private sector' workers, where the average rate of compliance is less than 50% as explained later.

[17] In 1998-99, contributions from active members, transfers from public and private sector schemes, and indirect sources represented 0.5%, 4.7%, and 0.2% of the total benefit expenditure respectively.

3. Members are not required to contribute for more than 120 months, and unpaid contributions can be deducted from the first pension payment if the member has not satisfied this condition,
4. The rapid increases in the expenditure of this scheme as a result of the annual pension increments and the increase in the minimum pension.

2.6. Current Investment Strategy

A funded scheme results in a pool of assets on behalf of the active members to provide for their future benefits. The important issue is how these assets are invested. The investment policy of the funds of a defined benefit scheme is crucial in determining the system's cost and its surplus/deficits. The investment of the ESIPS's funds has predominantly been made in government instruments and has been controlled by the Government. The two Funds are not responsible for investing the majority of their funds, as they have to be handed over to the NIB. There are very tight restrictions on private sector assets[18].

Prior to January 1976, the funds were invested in government loans and deposits in the National Investment Fund of Deposits and Insurance Funds, offering a very modest interest rate of 3.5% per annum, the system was obliged by the law to invest in these assets. Since the beginning of the 1980s, and in accordance with the Law No. 119 of 1980, most of the cash-flow surpluses of the two Funds, as well as the accumulated funds, have had to be deposited with the NIB[19]. As a result of this Law the percentage of total funds invested by the NIB has been increasing and reached 92.1% on 30/6/99 as shown in Figure 2.6.

The assets consist mainly of loans made to the NIB and the Treasury for various long-term development projects as shown in **Table 2.3 of Appendix 2**. The investments of the funds are predominantly in fixed interest assets (98% in 1998-99), rather than equity-based assets. Other types of investment, such as local authorities' bills, securities, various capital investments, Government bonds and loans to members have

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[18] In his actuarial reports in 1987 and 1992 to the Minister of MISAs, the Actuary of the GSF suggested that in order to improve the return on the invested funds and reduce the actuarial deficit, the Fund should be allowed to invest at least 25% of its funds in the private sector assets. This has recently been approved by the NIB and the Ministry of Finance, but for a very modest proportion of less than 5%.

[19] The NIB was a replacement of the National Investment Fund of Deposits and Insurance Funds. According to this Law if the rate of return on the invested funds is less than 4.5% in any year, the Government is committed to pay the difference in return to the two Funds.

always been, in total, less than 5% of the assets as shown in Table 2.1. It is perhaps surprising that only 1% of the assets are in equity related investments, which might be expected to match the long-term liabilities of the system, assuming that the value of equity related investments would increase broadly in line with inflation or/and economic growth.

Figure 2.6. Percentage of Assets Invested in the NIB over 1977-99

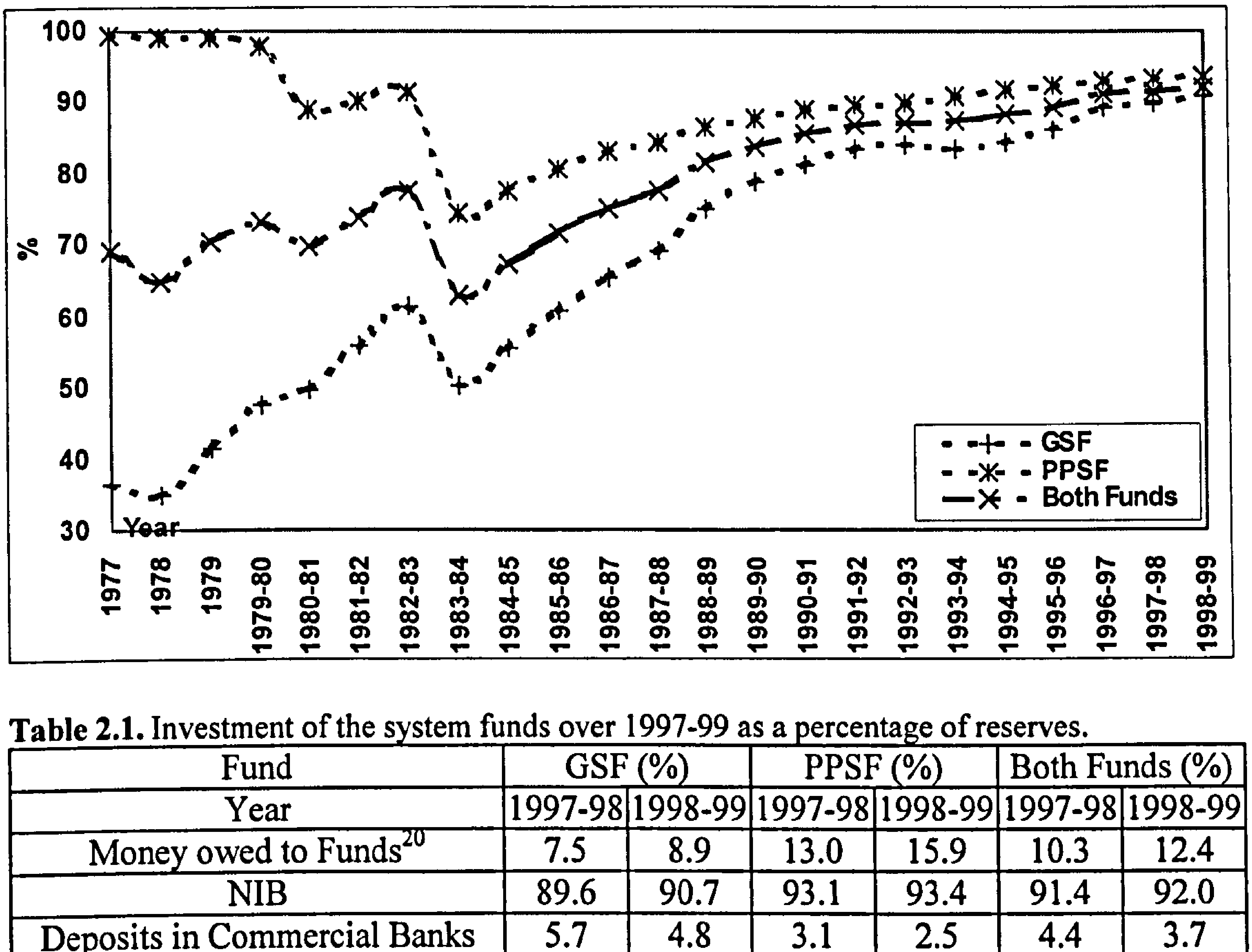

Table 2.1. Investment of the system funds over 1997-99 as a percentage of reserves.

Fund	GSF (%)		PPSF (%)		Both Funds (%)	
Year	1997-98	1998-99	1997-98	1998-99	1997-98	1998-99
Money owed to Funds[20]	7.5	8.9	13.0	15.9	10.3	12.4
NIB	89.6	90.7	93.1	93.4	91.4	92.0
Deposits in Commercial Banks	5.7	4.8	3.1	2.5	4.4	3.7
Treasury & Local Authorities Bills	3.3	2.8	2.8	2.5	3.0	2.7
Securities & Various Projects	0.7	1.2	0.7	1.3	0.7	1.2
Government Bonds	0.4	0.3	0.2	0.2	0.3	0.3
Loans to Members[21]	0.3	0.2	0.1	0.1	0.2	0.1
Total	100	100	100	100	100	100

Source: the MISAs' Report 1997-99.

It is understood that the system's assets are there for the purpose of providing benefits to the insured workers and therefore both liquidity and a reasonable rate of return are

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[20] This = 100 % – the percentage invested. The money owed to the Funds normally includes the money owed from the Government, employers, contributors, debtors and others.

[21] The system allows its members (active or pensioners) who are in desperate need as a result of some difficult circumstances to ask for a loan from the system. This loan is calculated as a percentage of the accumulated contributions or the present value of the accrued benefits. This loan must be repaid by instalments over a specific period of time. It is no surprise to find that the majority of such loans are taken by the government employees (76% on 30/6/1999), as it is easier to get such a low interest rate loan if you are a civil servant or work for a public enterprise than if you are in the private sector.

critical factors for reducing the burden on future generations. The current investment policy is not achieving reasonable returns and does not protect against the inflation risk. The assets may not be readily liquidated when needed to meet cash-flow requirements in the future and the system may face a liquidity crunch in such a case.

For those insured persons who pay both contributions and taxes at the same time, investment in Government financial instruments de facto represents a form of PAYG tax-financing for social insurance schemes. In the case of excess contributions over expenditure, they actually finance Government expenditure which would otherwise have to be financed through taxes. In the case of excess of expenditure over contributions, they have to finance the liquidation of Government-held assets through "additional" taxes, or refinancing of the debt through the capital market. The latter simply delays potential tax increases. Therefore, apart from some distributive effects, the total burden for taxes and contributions shouldered by the core group of tax payers (employees and employers) could be similar, or even equal to, the PAYG level.

This investment strategy has also resulted in the two Funds having neither the experience of formulating an investment strategy nor the capacity for investment management[22]. Therefore, if the system is to be allowed to invest a substantial amount of funds freely, then a significant effort to strengthen the development of the necessary investment expertise to manage these funds is required[23]. Also the Funds will need to devise alternative investment strategies for their assets and carefully consider in detail the financial and other ramifications of such strategies, using their experience of the limited direct investments that have already been made.

Improving the investment strategy requires the Government to stop forcing the management of the two Funds to credit the NIB with the majority of their funds and allows them some direct responsibilities to place a certain proportion of the funds in

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[22] The NOSI has lost LE 3,500 million from investing in the Egyptian Stock Market over 1995-2001.

[23] The board of directors of each Fund is allowed to decide on how to invest a very small proportion of assets (less than 1%). In 1997, the two Funds were allowed to invest part of the cash-flow surplus outside the NIB, but through investment companies approved by the NIB under the authority of the MISAs. In 1998, the following investments were made: some LE 175m were invested in the purchase of some 2 million shares (a 10% stake) in the Ameriyah Cement Company, some LE 200m investment (a 40% stake) in the Egyptian International Fund (a five year closed fund) was made with other stakeholders such as Misr Insurance Company and four public banks (the fund is managed by the New York based Concorde International Investment Group), three portfolios have been formed under the control of the MISAs consisting of LE 300m each and professional investment managers are contracted to manage the funds with a commission determined by their portfolio's performance. A fourth portfolio has been approved in co-operation with four public sector banks and consists of LE 500m.

more profitable investments. It is argued that the current investment strategy breaks the connection between the investment risks of the funds and the pension system, so the assets and the returns are kept guaranteed.

However, the funds could be invested in a way that guarantees safety, high yield and sufficient liquidity, which would have major impact on the structure of national investment planning in Egypt. If there were higher investment rates of return, then the Treasury subsidy would clearly be lower. But these are not equivalents from the macro-economic standpoint. This depends on whether the economic returns from the investments undertaken by the NIB would be higher or lower than the economic returns on alternative investments, including greater investment in the private sector.'

2.6.1 Current Role of the NIB

The NIB is responsible for investing the major part of the assets of the pension funds (including occupational pension schemes). The yearly cash-flow surplus of the two Funds is the main source of income for the NIB (more than 70% or some LE 105 billion in 1999 compared with LE 1.1 billion in 1975). The NIB provides cheap long-term finance for various national investment projects and public institutions, including central and local governments, and public utilities. If there had not been a cash-flow surplus in the two Funds, many of these projects would have had to be financed directly by the Government. This indicates that the NIB is in fact working as an agent for the Government in financing its development plan.

The NIB charges a fixed interest rate to recover operating costs and interest payable on its own debts. Prior to 1992, interest rates charged by the NIB to government projects and public enterprise were negative in real terms as a result of cheap loans and high inflation rates. Therefore, the NIB was offering an interest rate on the assets of the ESSPS at less than the market rate[24]. This was inadequate to meet the liabilities of the system. The interest rate, particularly prior to 1992, has usually been lower than that in commercial banks. After 1992 the NIB started to increase interest rates on its lending and borrowing.

The interest rate given by the NIB is influenced mainly by two factors: firstly, the prevailing market interest rates on bank deposits; secondly the size of the Funds'

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[24] It is negotiable after every actuarial valuation, but does not exceed the interest rate prevailing in the market on deposits.

deficit. Therefore one of the main functions of the actuary of the two Funds is to recommend the rate of return required on the invested funds to amortise any deficits, or at least maintain an equilibrium position. Although the required rate of return has always been less than the prevailing rates in the market, the NIB and the Government are not obliged to follow the actuary's recommendations.

In conclusion, pension funds' assets became a permanent feature of the country's financial structure and an essential element of economic stability. This reflects an underlying philosophy of the state that aims to achieve specific macroeconomic and social objectives, at a lower cost, by using the assets of the pension funds. It is argued that the ESSPS is actually giving a subsidy to the state rather than getting any subsidy from it. The use of pension funds for the State activities would be acceptable if they provided a reasonable rate of return[25].

Actuaries of social insurance schemes in many countries, such as UK and US, develop the basic parameters used in the projections and valuations of such schemes. They develop assumptions for parameters which represent the best and most realistic estimates reflecting the real world, and draw as accurate conclusions as possible. The starting point for arriving at the best estimate is the consideration of past experience and expected future changes in these parameters. Negotiations among social insurance experts and other relevant authorities also influence the recommended assumptions. In the following sections, analysis of the past experience of the main parameters used in the valuation and projection of the ESSPS is carried out and assumptions regarding expected future values of the parameters are obtained.

2.7. Past Return on the Invested Funds

The average rate of return on the invested funds was around 4.5% in the 1970s and 5.5% in the 1980s and, in general, it was less than 6.5% until 1992. In 1987, actuarial valuations of the two Funds were carried out assuming a rate of return of 6% p.a. and results were a very large actuarial deficit, which exceeded LE 1.0 billion in the GSF alone[26]. Also in the 1980s, the system experienced high salary escalation as a result of high inflation, and interest rates on deposits in commercial banks were rising

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[25] It is argued that such use may foster the growth of the economy and thus increase the future tax base, and so improve the quality of life of the citizens.

[26] The accumulated lost return over 1974-92 contributed significantly to this actuarial valuation deficit.

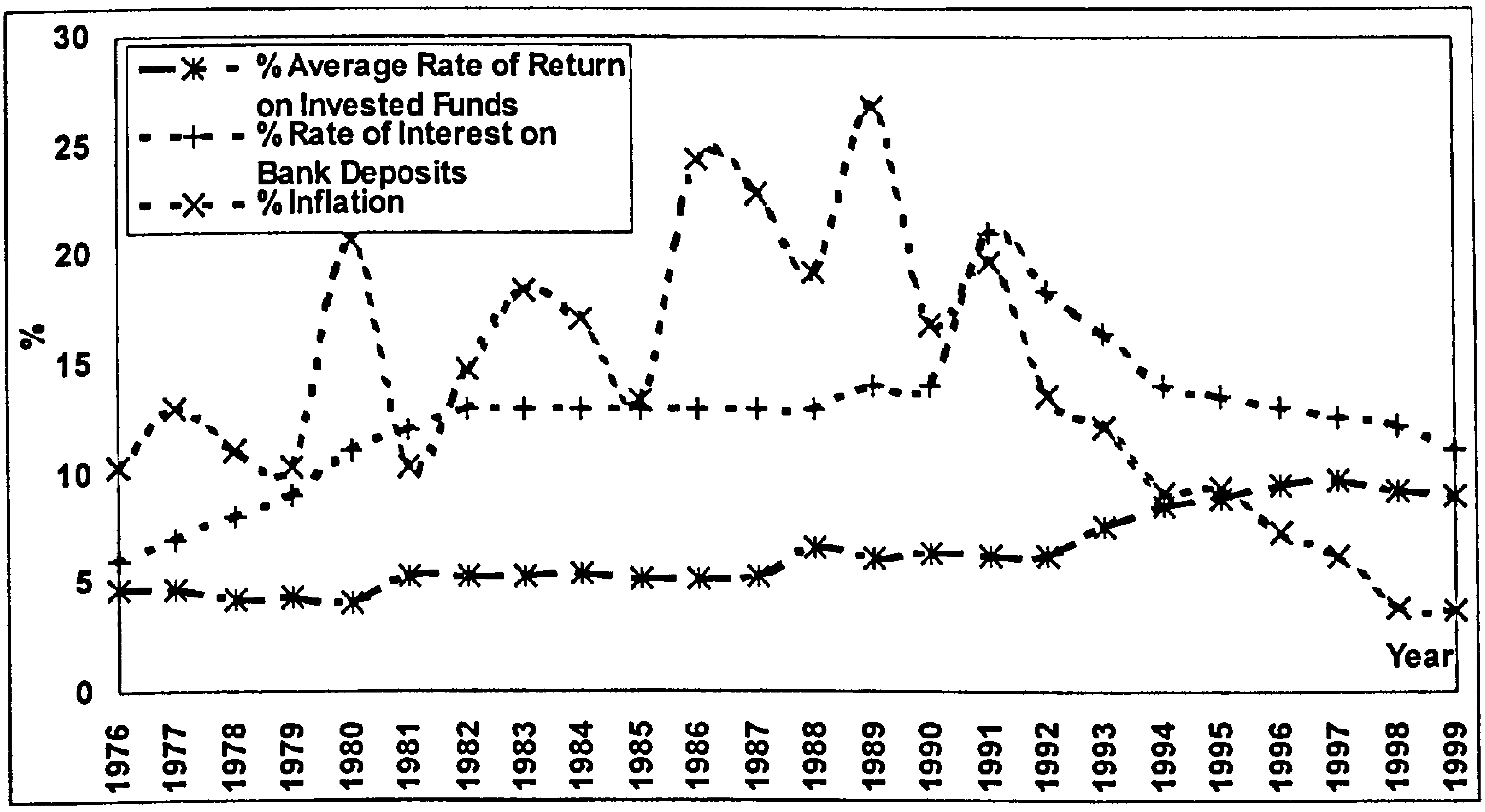
sharply[27]. This situation forced the Government and NIB to negotiate with the two Funds about the interest rates given on the Funds' assets.

After very long negotiations carried out over 1988-92, it was agreed to increase the interest given on the Funds' assets by the NIB as follows:

1. A rate of 6 % p.a. on all the funds accumulated before 1/7/1989, (except for those arising from contributions paid on variable wages where the rate was 8%);
2. A rate of 8 % p.a. on the new funds over 1989-90;
3. A rate of 9 % p.a. on the new funds over 1990-91;
4. A rate of 11 % p.a. on the new funds over 1991-92;
5. A rate of 13 % p.a. on the new funds over 1992-97;
6. A rate of 11 % p.a. on all the funds from 1/7/1997.

However, as a significant part of the funds accumulated before 1989, the average rate of return on the invested assets until 1994 did not exceed 8% as shown in Figure 2.7.

Figure 2.7. Comparison between the rate of return on the invested funds, the interest rates on bank deposits and the inflation rate



In 1996, the average rate of return reached more than 9% p.a. This was a reasonable rate compared with that generally obtained in the market and the inflation rate, around 4% p.a. in 1996-97. This means that the NIB started to provide a positive real rate of return on the invested funds after 1995. However, the overall rate of return on invested assets is still below the prevailing interest rates on deposits in commercial

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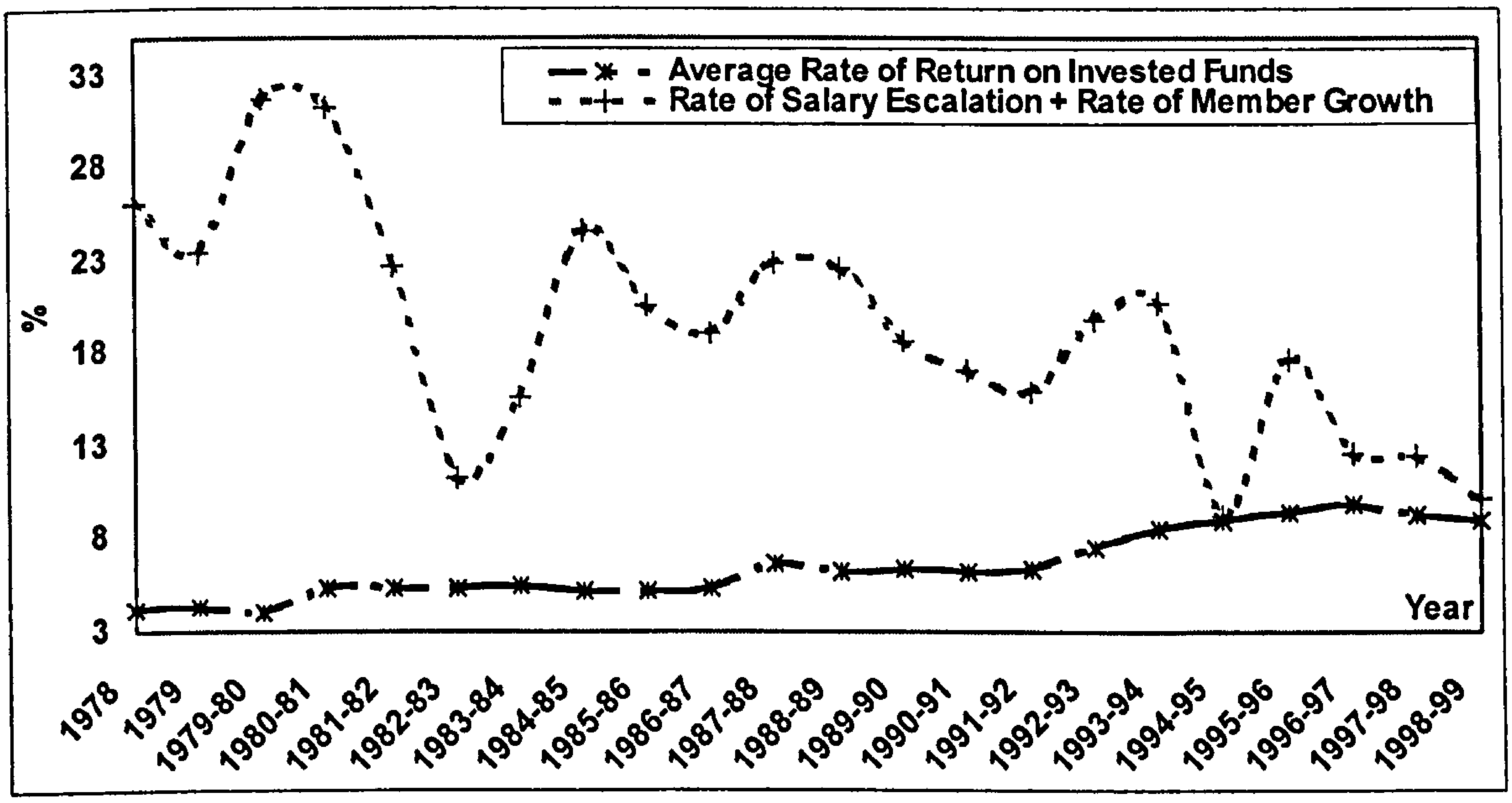
[27] It reached a peak rate of 21% in 1991 and since has been declining as the inflation rate declines and it was around 10% p. a. in 2002.

banks and, particularly, the average rate of return which can be achieved on the stock market (14% p.a. over 1994-97, IMF, 1999[28]). One of the main reasons for this is that the rate of interest on the loans to the Treasury is still very low at 5% p.a. and the Treasury is reluctant to increase it. Figure 2.7 also indicates that there have been large lost returns as a result of the current investment strategy.

The problem of low rate of return on the assets can also be illustrated by comparing it with the sum of the salary escalation and the growth of members rates, assuming the system has a stable population[29], as shown in Figure 2.8. In the long run, when the scheme reaches demographic and financial maturity, the rate of return on the assets of a funded scheme should exceed the sum of the growth of the insured population and the salary escalation rates, which has an economic interpretation (Iyer, S., 1999). This is necessary for a funded scheme to be more efficient than a PAYG scheme. Figure 2.8 shows that the average rate of return has been much lower than the sum of the two rates. From the second half of the 1990s, the gap between them started to narrow. This is a reasonable explanation for the high contribution rates required from the employees and employers of the ESIPS.

Figure 2.8. Rate of return compared with the salary escalation plus the rate of growth of members over 1978-99



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[28] This was calculated according to the Prime Index for Initial Public Offerings (PIPO) index. The index comprises 47 of the 48 privatised companies listed in the stock exchange. These companies accounted for 51% of total trading and 34% of market capitalisation in 1997.

[29] This is when the size of the population changes over time at a constant rate that is independent of time and its relative age distribution is constant.

The actuarial valuation of the GSF was repeated in 1987 using 7% p.a. as the future rate of return instead of the 6% p.a. This action reduced the actuarial deficit from more than LE 1.0 billion to LE 170.2 million (Ibrahim F., *et al.* 1994). A special committee was set up in 1990 to investigate how to reduce the actuarial deficit of the two Funds. One of the important recommendations was to allow private sector investment of the funds in order to improve the rate of return on invested assets.

2.8. Past Actuarial Valuation Results of the GSF and PPSF

A full actuarial valuation is normally carried out every 5 years and a brief statement by the actuary, referring to the latest valuation results has to be submitted to the MISAs. The Objectives of the actuarial valuation of the two Funds are as follow:

1. Determine the level of surplus/deficit, the reasons for having deficit and the means of remedy;
2. Determine the amount of finance required from the Treasury, to cover the Government liabilities for any additional or increase in benefits granted by political decisions, and to eliminate or reduce the deficit level;
3. Determine the required interest rate to amortise any deficits and to keep the ratio of funded liabilities at 100%[30] for the two Funds;
4. Determine whether the current contribution rates are sufficient for new entrants;
5. Determine any significant variations in experience from the assumptions made at the previous valuation and the reasons for that.

Actuarial deficit can be amortised by a loan from the Treasury over the 5-year interval period before the next actuarial valuation, which has to be paid off when there is an actuarial surplus. If the valuation reveals an existence of a surplus, it has to be kept in a special account, and can not be disposed of without the approval of the Fund's board of directors and only in one, or all, of the following:

1. To pay off any previous deficit financed by the Treasury;
2. To set up a special or general reserve for different purposes; and
3. To increase the level of pensions to match the level of prices increases.

The results disclosed at each actuarial valuation have confirmed that the current contribution rates are sufficient to meet the liabilities of new entrants, although it has

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[30] The regulation of the ESSPS proscribes underfunding to ensure the security of the system and larger contributions from employees or employers are not possible practical solutions to be recommended.

been argued that they are very high. But all the actuarial valuation reports have recommended higher interest rates on the funds loaned to the NIB and the Treasury to match those in the market and to amortise the actuarial deficit of the two Funds. The Treasury was providing finance to amortise the previous actuarial deficits but the interest rate used in all these valuation was between 4-6%. Table 2.2, showing the actuarial valuation results from 1959 until 1997, indicates that the deficit was increasing over time. The deficit reached its peak in 1987 and has since started to decline significantly as a result of changing the assumed future rate of return on the invested assets[31] from 6% to 7%. This was a result of the increase in interest rates given by the NIB, which contributed to both declines of the deficit as well as paying off of some of the debts to the Treasury.

Table 2.2: The Actuarial Valuation Surplus/(Deficit) of the ESSPS over 1959-97

Year	1959	1963	1968	1972	1977	1982	1987*	1987**	1992	1997
GSF	(47.9)	(131.4)	(166.2)	(307.1)	(984.1)	(551.6)	(1000+)	(170.2)	NA	NA
PPSF	-	7.4	(8.1)	(174.6)	(860.9)	(1022.4)	(1874)	(114.0)	12.0	NA
ESSPS	(47.9)	(124.0)	(174.3)	(481.7)	(1845)	(1574.0)	(2874+)	(284.2)	NA	NA

* This valuation was carried out using 6% as an average rate of return on the invested funds.
** This was carried out using 7% as an average rate of return on the invested funds.
Source: Actuarial Valuation Reports 1959-92

In most of the actuarial valuation reports, the deficit was attributed to one or more of the following reasons:

1. Low interest rates averaging between 4-6% per annum;
2. Unfunded benefit increases, such as changing the accrual rate from 1/50 to 1/45 and increasing the minimum pension in the case of death or disability in service to 65% of pensionable salary instead of 40%;
3. Unamortised deficits carried forward with interest;
4. Non-payment of funds promised by the Treasury;
5. Increase in the number of early retirements cases;
6. Increase in administration expenditure to cope with modernisation and computerisation of the system;
7. Contribution evasion on the part of employers and their workers,
8. The difference between the actual and assumed rate of interest on Treasury Bills;
9. The introduction of the lump sum payment of the end of service remuneration.

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[31] The rate of interest on the government loans was 4.5% and on assets invested in the NIB was 6% over 1982/87, which resulted in a lost return of more than one thousand million pound.

The actuarial economic and demographic parameters are usually determined using a deterministic approach, using time-invariant best estimates. The actuary can refer to both experienced values over past periods and his own perspective for future developments. Therefore, assumption regarding the future average rate of return on the invested funds over the projection period, can be assumed to range between 5.0-10.0%, matching that obtained to date by the NIB. Using this range of interest rates, the actuarial valuation will be repeated to test the sensitivity of the actuarial outcomes to expected rate of return on the funds.

2.9. Membership Coverage Rates and Stability

Pension schemes can be classified as young[32], mature[33] or declining schemes in the light of their long-term history[34]. The young and mature schemes are characterised by the property that the active members' age structure is relatively stable as the scheme continues. Young schemes are assumed to have stable membership that progresses by consistent application of a constant exponential rate of increase in new entrants (i.e. at each age is growing exponentially in a fixed rate over time). Mature schemes, in general, have stationary membership[35] characterised by a number at each age, which is independent of time, and the net increase in the total number of members equal zero. The declining scheme is when the number of members is decreasing exponentially[36] at a fixed rate over time (Sung, 1997). Therefore, it is important to explore the pattern of growth in the membership (contributors and beneficiaries) which is carried out in the following sections over 1975-99 and also over 1984-99[37].

2.9.1. The ESSPS

The number of members covered by the system increased quickly in the 1990s[38]. The number of contributors increased from 3.8m in 1975 to 17.5m in 1998-99. The ratio of contributors to the population aged 15-59 increased from 20% in 1975 to 51.2% in 1993-94 and decreased to 48.3% in 1998-99. The proportion of total beneficiaries to

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[32] When the scheme has a growing past service at different ages and a growing pensioner population.

[33] When the scheme has stable distribution of past service by age and stable distribution of pensioners and active members.

[34] These three stages of a defined benefit scheme may simply be called the scheme life-cycle.

[35] Mature scheme can also have a growing population.

[36] This is might be also the case for a closed scheme.

[37] Choosing this later second period was because of the surrounding economic and social circumstances, which bear strong relations to the present time.

[38] The analysis showed significant differences between over 1977-99 and over 1984-99 as a result of the introduction of new schemes. For that reason a comparison is carried out for both periods.

contributors increased from 21.4% in 1975 to 39.2% in 1998-99, which is relatively high. The increases in the proportions of pensioners and dependants cannot be traced totally to demographic changes, as the pension system still shows a young population structure. It may be due to the following reasons:

1. The extension of coverage to new population categories (particularly the CSIS);
2. The inclusion of more dependants into the survivors' category because the Law expands the definition of dependants and gives more rights to a larger chain of relatives over time, as mentioned in Chapter 1;
3. The increase in the frequency of early retirement, (a policy adopted by the government in the 1990s which is discussed later);
4. High rates of unemployment in the 1990s; and
5. The maturity of the schemes and particularly the employees' scheme.

2.9.2. The GSF

The GSF has only one category of members, civil servants, covered by Law 79 of 1975. The annual growth of new entrants in this fund is affected mainly by the Government strategy on civil service employment. The number of contributors of the GSF increased from 1.8m in 1975 to 4m in 1998-99, with a relatively stable annual growth of 3.7% over 1975-99 (3.5% over 1984-85) as shown in Table 2.3.

Table 2.3. Members of the GSF over 1973-1998 (thousands)

Members of the GSF	1975	1979	1983-84	1988-89	1993-94	1998-99
Contributors (CON)	1750	2101	2403	3025	3621	4000
Pensioners (PENS)	168	259	240	316	384	482
Beneficiaries (BEN)	630	931	915	1129	1398	1727
PENS/CON (%)	9.6	12.3	10.0	10.5	10.6	12.1
BEN/CON (%)	36.0	44.3	38.1	37.3	38.6	43.2

Source: MISAs, the annual reports; 1958-1998

The contributors of the GSF represented 22.9% of the system's members in 1998-99 (45.6% in 1975) and has been around 22-23% since 1980-81. The proportion of beneficiaries to contributors has increased from 36% in 1975 to 43.2% in 1998-99[39]. This Fund has experienced little fluctuation in its demographic structure except over the second half of the 1990s, as a result of the economic transition of the country. It is expected that the number of active members of this Fund may increase over the

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[39] The two years, which were exceptionally high for this proportion were 1979 and 1998-99 for one common reason: the increase in the early retirement rates as a result of changing Government policy.

coming years. This is because the Government has adopted a strategy of easing the pressure of high unemployment by increasing its own employees, as a political and social solution. It has also stopped any further employment after the age of 60, under any circumstances, and gives more incentives for taking early retirement at age 55.

2.9.3. The PPSF

This Fund comprises members of all other schemes and categories (except civil servants) and thus the annual growth of new entrants in this Fund is affected, mainly, by the overall economic conditions. The number of contributors to the PPSF was 13.5m in 1998-99, which represented 77.1% of the system's members in 1998-99. The proportion of pensioners to contributors in this fund increased from 2.6% in 1977 to 10.1% in 1998-99, and the proportion of beneficiaries to contributors has increased from 9.23% in 1975 to 38.1% in 1998-99.

2.10. Membership of Different Schemes

As mentioned earlier, different population categories were covered by the system under different laws (or schemes). Table 2.4 shows the number of covered active members to each scheme of the ESSPS over 1977-99 at five-year intervals.

Table 2.4: Number of covered active members according to their schemes over 1977-99 (m)

	Employees govn./ public/private	Employers and self-employed	Egyptians working abroad	The Comprehensive Social Insurance	Total
Year	Law 79/1975	Law 108/1976	Law 50/1978	Law 112/1980	Total
1977	4.262	0.380	0.003	2.013	6.66
1982	6.023	0.626	0.012	4.007	10.67
1987	7.158	1.080	0.029	4.265	12.53
1992	8.533	1.382	0.041	5.043	15.00
1995	8.702	1.576	0.068	5.537	15.88
1999	9.692	1.820	0.023	5.918	17.45

Source: MISA, the annual year reports; 1977-1999

2.10.1. LAW No. 79/1975 (Employees Scheme)

There are three main economic categories covered by this scheme: civil servants, public sector and private sector employees. The number of contributors covered by this scheme represents the total official work force in Egypt, as the state system is the main provider of pensions in the country. This scheme represents the most important part of the ESSPS from the financing point of view. It provides the main sources of finance through contributions and accumulated funds available for investment. In 1998-99 the contributors covered by this scheme represented more than 55% of the total ESSPS active members (including the CSIS) and 84% of the total ESIS contributors (excluding the CSIS).

There has been a steady reduction in the number of contributors from the public sector and an increase in the number of contributors from the private sector, particularly since 1978 and more significantly from 1990 when the government began the privatisation process. In general, there has been an overall steady decrease in the percentage of insured employees in this scheme, relative to the whole system, although it still represents the most significant scheme in the system. This decline has occurred for the following reasons:

1. The Government has implemented an economic reform policy based on privatising the public sector;
2. It is encouraging employees to leave work and receive early retirement benefits;
3. It is ending temporary contracts in public sector and civil services;
4. The increase in the unemployment rate over the last decade; and
5. An emerging trend of contribution evasion among private sector employees and employers.

This was reflected in the demographic dependency ratios of the three member categories, which were 11.3%, 28.0% and 8.0% in 1998-99 for civil servants, public and private sectors respectively (10.7% for public and private sector employees together). These can be compared with ratios of 9.7% for civil servants in 1986-87 (7.1% in 1975) and 5.9% for the public and private sector employees together in 1986-87. These increases in the demographic dependency ratios were due to the above mentioned economic factors as well as demographic changes and the low compliance rate among private sector employees, particularly non-regular workers. In general, changes in economic circumstances have slowed the growth in the numbers of contributors and pensioners of this scheme in the 1990s.

2.10.2. Law 108 of 1976 (Self-Employed Persons)

In 1998-99, this scheme coverage represented about 10.5% of total contributors to the system, compared with 5.7% in 1997. This may be as a result of the current trend of employees leaving the public sector and government employment and joining private and self-employment. This implies an annual growth rate of 9.5% over 1976-99, growing faster in the 1990s than over 1976-89[40]. The demographic dependency ratio of this category was 10.8% in 1998-99 compared with 3.7% in 1986-87.

A considerable migration of employees and workers between different schemes is expected over the coming years, particularly from public and private sectors to employers and self-employed sectors, with the latter gaining more importance as a result of economic reform and privatisation. It would be a realistic assumption to assume that the current trend of moving from the public sector to the private sector and self-employed will stay at the current level until 2010, and slow down thereafter.

2.10.3 Law 50 of 1978 (Egyptians Working Abroad)

The number of contributors covered by this scheme is not stable over time. This scheme covered 23,000 member in 1998-99, which represented less than 0.13% of the ESSPS (68,000 were covered by this scheme in 1996-97 but only 18% were contributing to the scheme). The dependency ratio of this category was 26.8% in 1998-99 compared with 5% in 1986-87 and it is expected to increase more in the coming years. This is because the number of contributors of this category is expected to decrease significantly over the coming years as opportunities for working abroad decline. The rate of compliance in this scheme is very low, particularly when we appreciate that this category is not supposed to be in financial difficulties. This might be due to the voluntary nature of the scheme, which motivated the legislator to make it compulsory from the financial year 2002-03.

2.10.4. Law 112 of 1980 (The CSIS)

In 1989-99, the proportion covered by this scheme was 33.9% of the system's total active members (compared with 35.23% in 1984)[41]. The number of active members grew by a stable annual rate of 2.9% over 1984-99. The system is trying to restrict the number of new entrants joining the scheme because of it is heavy and increasing

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[40] The proportion of active employees in the self-employed scheme to the whole system has been increasing over time at an average rate of 1.7 % p.a. over 1984-99. It is assumed that this increase will start to slow and then stabilise over the projection period.

[41] This proportion may decrease further in the future for the following reasons:

1. The expected shift in the structure of the population (particularly those aged 65+ which is expected to increase);
2. The expected decrease in the share of this scheme to the total ESSPS as the Government desires to restrict the number who joins this scheme in favour of the funded scheme in order to limit its liabilities towards the system.

financial cost on the Government budget. It was found that only 13% of those covered by the definition of insurability under this law contributed to the scheme in 1997. The dependency ratio was 8.7%, but when the rate of compliance was taken into account it was estimated at 82% in1997. The main conclusion from this analysis is that the Egyptian population and the ESSPS have a young demographic structure and thus the ESSPS has an increasing membership of active members and pensioners.

2.11. Projecting Future Growth of Membership of ESSPS

With such a large national system, it is realistic to assume that the growth in the number of active members during the period $(t, t+1)$ is measured in terms of a dynamic growth function $(Act(t))$ satisfying a time-varying homogeneous recurrence function. In accordance with the concept of a stable increasing membership, the assumption can be made that the new entrants occur at a fixed entry age and are increasing exponentially at a fixed force of growth ρ. In a demographic sense, the membership resulting from the special case when ρ is constant for all t is called a stable membership. The scheme will have ultimately a stable exponentially growing membership with $\rho > 0$ and the number of members in each age increasing at the same rate ρ over time t.

Therefore, (since $Act(t)$ is dependent on the time of entry into the scheme) we have:

$$Act(t+1) = (1+Z(t+1)) \times Act(t), \tag{2.1}$$

where, $Z(t+1)$ denotes the annual growth rate during the period $(t, t+1)$.

Considering a stable increasing membership (i.e. a stable geometric growth in membership), we have $Z(t+1) = Z(t) =$ constant for all t. This indicates that the size of the total covered membership grows geometrically over time t and $Z(t) > 0$ for all t. Also the distribution of age structure of every scheme remains unchanged over time t. So the equivalent force of growth of active members over (t, t+1) is given by

$$1+Z(t+1) = exp(\rho(t+1)) \qquad \text{for all t.} \tag{2.2}$$

So, we obtain the number of active members at time (t+n) from:

$$Act(t+n) = exp((\rho(t+1) + \rho(t+2) + ... + \rho(t+n)) \times Act(t), \qquad \textit{for all } t \geq 1 \tag{2.3}$$

Then, over the period (t, t+n) and under the assumption of an increasing membership, we can use the following formula to estimate the force of growth of the active members over the period (t, t+n) as:

$$\rho = ln(\sqrt[n]{(1 + (Z(t + 1))(1 + Z(t + 2))............(1 + Z(t + n))}) \tag{2.4}$$

Iyer S., (1999) shows that when the retired population consists only of surviving new entrants, the active and retired population would grow at an instantaneous rate (ρ) and the force of growth of the total insured population would become identical to the force of growth of new entrants and

$$R(t+dt)\,/\,R(t) = Act(t+dt)\,/Act(t) = 1 + \rho.dt^{42} \qquad (2.5)$$

where: $Act(t)$ is the active population function, and

$R(t)$ is the retired population function.

This assumes that the system operates without any fundamental changes, such as a significant modification of the benefit provisions or an appreciable expansion of its scope of coverage, except for the steady flow of new entrants at a force of growth ρ. In the following sections, the force of growth of active members of each individual scheme are examined using the above methods.

2.11.1. Assumptions of Membership Growth over 1997-2025

The above methods were applied over 1975-99 assuming that the age structure of every individual scheme is stable. This can be considered as a realistic assumption taking into account the large population size and its demographic structure. The previous indicators and analysis show that, in general, there was a relative stable increasing membership particularly in the GSF. This conclusion was quite clear from the analysis of membership over 1984-99.

The annual force of growth of active members, pensioners, survivors[43] and beneficiaries of the whole ESIPS (excluding the CSIS) were 3.1%, 3.4%[44], 1.8% and 2.4% respectively over 1984-99. There were relatively steady annual increases for contributors (except for public sector employees and Egyptians working abroad), pensioners, survivors and beneficiaries respectively. These results indicated that the average annual increases for the members of the whole system was varying around 3% p.a. over 1984-99. This result is important in demonstrating the stability of the system over a long period of time as shown in Figure 2.9. This result is also important in connection with the rate of the population growth of the country over long term, as long as the system remains compulsory and without any significant change.

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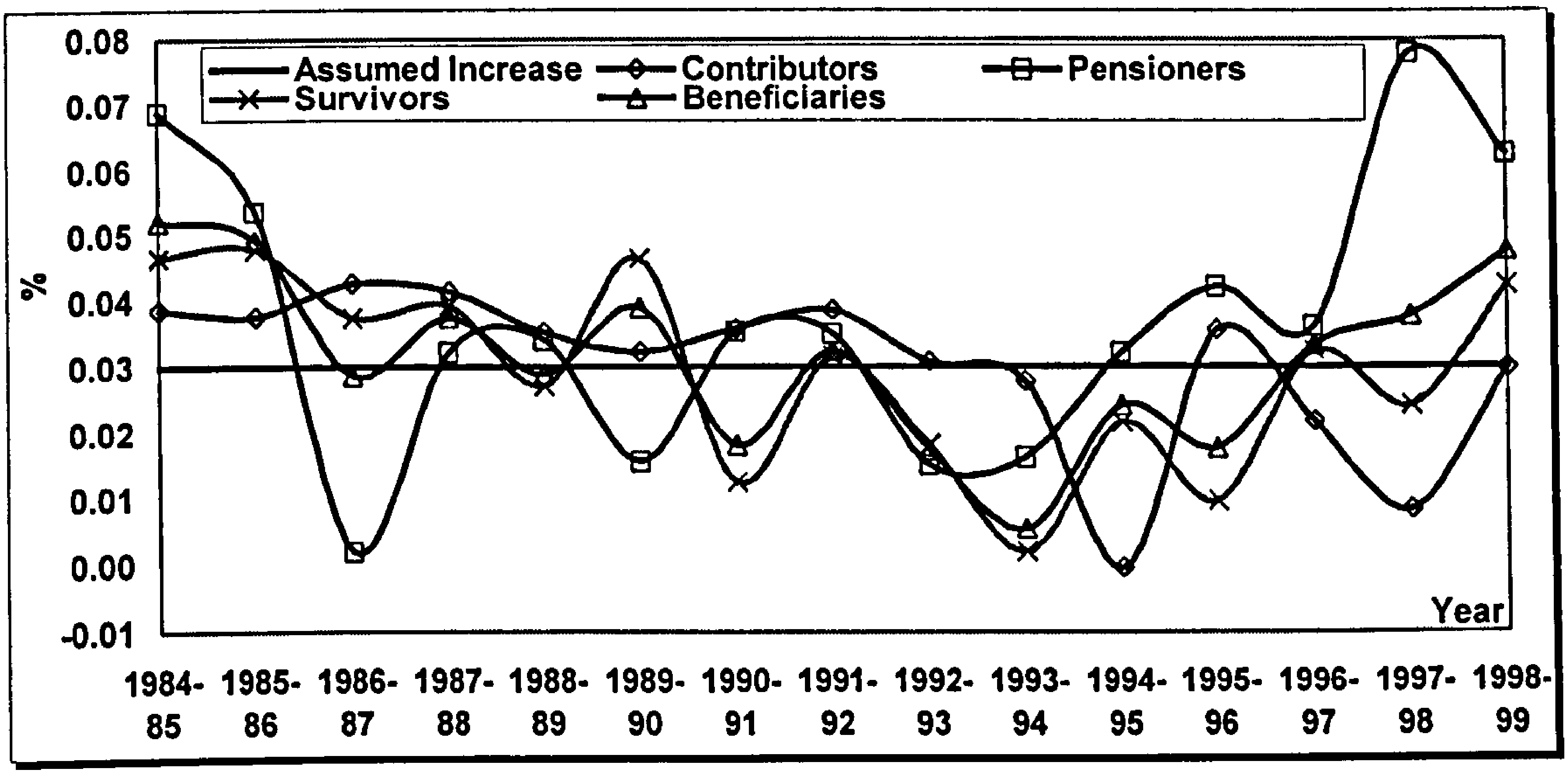
[42] Both functions are assumed to be continuous and differentiable functions.

[43] Survivors only and total beneficiaries were growing at 1.8% and 2.4% respectively.

[44] 1998 was excluded, as increases in this year were high at 8%.

Figure 2.9: The average annual increase in the number of contributors, pensioners, survivors, beneficiaries and the assumed annual increase over 1984-99



The forces of growth of active members of the three economic categories of the employee's scheme (civil servants, public sector and private sector employees) were 3.53%, 0.12%, and 7.87% respectively over 1975-98, as shown in Table 2.5.

Table 2.5. Force of increase of contributors, pensioners and survivors over 1975-1999

Period	Gov. Employees	Public Sector Employees	Private Sector Employees	Law 79	Law 108	Law 50[45]	Law 112	Total ESIPS	Total ESSPS
Contributors*									
1975-99	3.6	-0.14	7.74	4.3	9.1	11.1	8.0	4.78	6.58
1984-99	3.4	-3.53	5.16	2.8	4.7	1.27	2.8	3.08	2.99
Pensioners									
1975-99	5.6	NA		NA	NA	NA	NA	NA	8.6
1984-99	4.9	6.94		5.80	7.30	15.81	2.61	3.35	3.16
Survivors									
1975-99	5.0	NA		NA	NA	NA	NA	NA	8.50
1984-99	4.1	4.88		4.39	6.64	10.3	4.45	1.79	2.88

* The force of increase of new entrants of the public and private sector contributors together over 1975-1998 was 4.94% and 2.5% over 1984-99.

Source: Derived by Author

Using the analysis of the historic data, the arguments explained before, and our judgement, we can set up the following assumptions about the future force of growth in active members:- $e^p=1.037$ for civil servants, $e^p=1.03$ for public and private, $e^p=1.035$ for Law 79/1975 active members, $e^p=1.05$ for self-employed person scheme, and $e^p=1.03$ for casual workers scheme.

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[45] The data for this scheme are not significant as a result of the voluntary nature of the scheme, the very small number of members, and because the scheme has been in force for a short period.

The assumption for civil servants results in a lower accumulated growth in membership than the actual growth over 1975-96 and slightly exceeds the actual growth thereafter. This is consistent with reality, as a lower rate of employment in the government sectors was witnessed over 1975-96. However, the Government has recently adopted a new strategy of creating more new jobs within the government sectors to reduce the level of unemployment over the coming years. We estimated one rate for the public and private sector employees together, as eventual situation after the end of the privatisation process. For the other schemes, we used the mentioned criteria and arguments in setting these assumptions.

Although it is known that the demographic and economic assumptions vary over time, it is assumed that these growth rates will progress uniformly over the projection period. The demographic projections established on the basis of the assumed forces of growth, in fact, represent average or expected values of Act(t) which are used as stable and longstanding trends. This is the classical actuarial approach based on expected values –called the "deterministic" approach – which is used in this thesis.

2.12. Salary Increases

It is important to take into account the salary progress in projecting future benefit outgo for the purpose of funding calculations, particularly when the level of insured salary forms the base for calculating both the contributions and benefits. The salary increases have to allow for merit, seniority, long-term effects of inflation and increases in productivity. The increases in salary of every individual member normally include two elements: general salary escalation levels and salary promotion due to age/seniority. In a stable workforce and large scheme, the average salary profile should give a good indication of how much of the increase was due to escalation of general pay levels and how much was due to the salary scale, (Wilson, 1992). In the following sections these two elements of salary increase are discussed and applied to every individual scheme of the ESIPS.

2.12.1. General Salary Escalation

General salary escalation is an important factor in determining the future liabilities of a pension scheme, particularly in the case of defined benefit final salary schemes. General salary escalation refers to the average pay increases experienced by the working population as a whole, rather than increases linked to career advancement of particular individuals (Khorasanee, 1998). The general salary escalation, which is on top of the progression of individual salaries, should be measured by reference to increases in national average earnings[46].

The past and future service liabilities for active members depend on changes in future pay levels over these periods, so the salary increases used must be projected through to retirement. The valuation bases have to take into account both the effects of future inflation and general increases in pay levels at a rate different from the increase in prices. Therefore, barring exceptional circumstances (for example, during a major economic transition), the rate of salary escalation should be assumed to exceed the rate of inflation, the difference representing the gain in productivity (Iyer S., 1999).

It is supposed that GDP in real terms grows as a result of increased productivity, which is shared between labour and capital. This suggests that pension systems are supposed to be particularly sensitive to the competing demands of profits and wages as the increases of the latter represent a critical factor in the future liabilities of the pension scheme. In the long term, it is expected that wages will increase in line with the increase in GDP (Wilson, 1992). The average annual growth rate in GDP and the general average level of earnings (salary escalation) are affected by many economic factors, which are not discussed in this thesis. Table 2.6 shows that the average basic salary in the GSF is escalating more rapidly than the variable salaries for males and females and female average salaries have improved better than males over 1992-97[47].

Table 2.6. Average monthly basic and variable salaries in the GSF over 1992-1997 (LE).

Year	Average Monthly Basic Salary			Average Monthly Variable Salary		
	Males	Females	Total	Males	Females	Total
1997	145.1	141.1	143.8	145.2	139.9	143.4
1992	91.1	85.5	89.4	97.9	85.6	94.1
% Increase	59.3	65.1	60.8	48.3	63.5	52.4

Source: MISAs report 1992-1997

2.12.1.1. Estimating Salary Escalation from Insured Salaries

The insured salary function $S(t)$[48] (along with the expenditure function) characterises the financial development of a pension scheme. It is assumed that the eventual trend of the average amount of benefit expenditure grows at a force at which the general

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[46] They represent changes in the general levels of earnings on account of continuing inflation.

[47] Lower results were obtained for the PPSF over the same period.

[48] It is assumed to be continuous and differentiable and the projected value represents the expected value of this function.

level of pensionable salaries is growing (γ), benefits being based on final salary due to the replacement effect (Iyer S., 1999). This means that the growth in the insured salary plays a crucial rule in estimating the future liabilities of these pension schemes.

Assume that the annual growth in the average earnings in year $(t, t+1)$ is an estimate of the growth in the annual insured salaries of the covered population in the same year. If it is assumed that the insured salary in the interval $(0, dt)$ is dt, then the insured salary in the interval $(t, t + dt)$ would be $e^{\gamma t}dt$ (as γ represents the force of growth in the insured salaries). The total insured payroll in the interval $(t, t+dt)$ is given by $S(t)$ dt[49]. Therefore, the growth function, $S(t)$, of the total insured salaries over $(t, t+1)$ is given by following time-varying homogeneous recurrence equation and is independent of the age of individuals in the scheme,

$$S(t+1) = (1+rs_{t+1}) . S(t) \qquad (2.6)$$

where, rs_{t+1} denotes the annual growth of the total insured salaries over $(t, t+1)$ which is defined as the growth in $S(t)$ during the period $(t, t+1)$.

This indicates that the size of the total insured salary grows geometrically if $rs > 0$. Considering a stable increase in the general escalation of insured salaries (i.e. a geometric growth), we have $(1+rs_{t+1}) = (1+rs_t)$ for all t and thus we can assume that there exists γ_{t+1} satisfying

$$(1+ rs_{t+1}) = exp(\gamma_{t+1}) \quad for\ all\ t \qquad (2.7)$$

Then the insured salaries at time (t+n) is given by

$$S(t+n) = exp((\gamma_t + \gamma_{t+1} + ... + \gamma_{t+n}) . S(t) \qquad for\ all\ t \geq 1 \qquad (2.8)$$

However, the previous arguments did not take into account inflation in estimating the growth in the insured salaries. So, taking the annual growth in the consumer price index in the t^th^ year as (j_t) gives the following formula.

$$Rs_{t+1} = ((1 + rs_{t+1}) / (1 + j_{t+1})) - 1,\ and \qquad (2.9)$$

where Rs_i denotes the growth in the total insured salaries in the t^th^ year net of inflation there exists θ_{t+1} satisfying

$$(1+ j_{t+1}) = exp(\theta_{t+1}) \qquad for\ all\ t \geq 1 \qquad (2.10)$$

The geometric mean of the increases in the total insured salaries over $(t, t+n)$ net of inflation can be given by the following formula:

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[49] The assumption made here is that the general level of insured salaries is growing geometrically over each discrete time interval and this geometric growth is convertible to exponential growth, similar to the approach used for the force of growth of active members.

$$Rs_{t+n} = \left(\prod_{i=1}^{n} \left(\frac{(1 + rs_i)}{(1 + j_i)} \right) \right)^{\frac{1}{n}} \qquad (2.11)$$

This formula was applied to the data for the insured salaries covered by Law 79/1979, which represents the majority of the contributors over 1975-99 for basic, variable and total insured salaries. The assumption is that the distribution of salary by age in this scheme is stable so it is useful to study the experience of this scheme. Table 2.7 shows the growth in basic, variable and total insured salaries over 1975-99.

Table 2.7. The increase in average pensionable salaries over 1976-99[50]

Period	%	Basic (%)		Variable (%)		Total (%)	
	CPI	Increase	After Inflation	Increase	After Inflation	Increase	After Inflation
1976-79	7.9	18.4	6.3	NA	NA	18.4	6.3
1979-89	18.7	13.7	- 4.2	30.0	5.5	20.5	1.5
1989-99	10.1	10.7	0.6	15.5	5.0	13.1	2.7
1994-99	6.1	11.2	4.9	10.4	4.1	10.8	4.4
1976-99	12.1	13.0	-0.8	19.5	5.1	16.9	2.7

Source: Derived by Author

Table 2.7 shows that the net escalation in the basic insured salaries was negative in the 1980s and over the whole period 1976-99. It was only in the second half of the 1990s when it became positive. Some of the reasons for this trend were as follow:

1. There were no significant increases in basic salaries over 1975-95, and the annual increments, which started in 1987, were included in the variable salaries for economic and financial reasons;
2. The Government did not want to increase the salary level of the whole country by increasing the basic salary but only to give social increments to some categories of the working population to enable them to cope with the increasing cost of living[51];
3. The high levels of inflation over 1975-95; and
4. In 1995, the Government started to include some of the previous salary increments into the basic salary after inflation was brought under control.

The escalation of the insured variable salary net of inflation was always positive over 1984-99 for some of the following reasons:

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[50] Based on the increase in the general insured salaries covered by Law 79/1975

[51] A large proportion of variable salaries depends on the amount of the basic salary, so increasing basic salaries would have also resulted in increases in variable salaries. These increases have a critical significance because of their effect on the overall cost of production and the level of inflation, which are important factors in attracting foreign investors to invest in Egypt.

1. Variable salaries represent a major proportion of the individual's total monthly income, which normally exceeds 100% of the basic salary[52];
2. The inflation rate started to decline significantly from 1992[53];
3. All the salary increments since 1987 were included first in the variable salaries.

However, using general escalation of insured salaries to estimate the force of general salary escalation needs special considerations. This is because some of the growth in the insured salaries are related to the growth in the active members, and not to escalation in salaries. This is explained in the following section and a special formula for estimating the force of salary escalation is derived.

2.12.1.2. Estimating Real Salary Escalation from Insured Salaries

Part of the growth in insured salaries is due to the growth in the number of contributors. It is recognised that when the scheme reaches what may be termed "financial maturity", there is a certain relationship between the total insured salaries over consecutive years, given by (Iyer S., 1999):

$$\frac{S(t+1)}{S(t)} = \rho + \gamma, \qquad for\ all\ t \geq 1 \qquad (2.12)$$

where $S(t)$ is the total insured salaries function in year t;

ρ is the force of growth in new entrants; and

γ is the force of escalation in the total insured salaries.

Assuming that the employees' scheme has reached "financial maturity" the following formula can be used to estimate the real growth in general salary escalation taking into account both the growth in contributors and inflation:

$$(1+S_{t+1}) = exp(\gamma_{t+1} - \rho_{t+1} - \theta_{t+1}) \qquad for\ all\ t \geq 1 \qquad (2.13)$$

where s_{t+1} = rate of real general salary escalation over $(t, t+1)$

This formula was applied to the data of the employees' scheme (the general scheme) over 1975-99 for basic, variable and total insured salaries under the assumption that the distribution of the salary by age of employee was stable. Table 2.8 shows that the real escalation in the average insured salaries were not stable over 1975-99. It was Negative for most of the period for the basic salary, with an overall average of -5.0%,

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[52] Over the 1990s, this proportion was between 100-130% of basic insured salaries.

[53] The Financial Times on 9th of May 2001 estimated the inflation rate in Egypt over 2001-03 to be between 3.9-4.2% per annum.

except for the second half of the 1990s, which was positive as a result of including some of the earlier salary increments within the basic salary.

Table 2.8. Average force of real escalation in insured salaries over the period 1976-99.

Period	Basic Insured Salary	Variable Insured Salary	Total Insured Salary
1976-79	-2.2	NA	-1.5
1979-89	-9.0	1.5	-2.9
1989-99	-1.6	2.6	0.6
1994-99	3.3	2.5	2.8
1976-99	- 5.0	2.3	-1.2

Source: Derived by Author

The expected future trend is to have positive real escalation in the basic salary but not as much as that experienced over the second half of the 1990s. This is because the Government has committed itself to include more increments in the basic salary over the coming years. The trend has been positive for the variable insured salary since it was introduced in 1984-85, as all the annual salary increments were initially included in the variable salary. Also employers find it more convenient to give rises in variable salaries as they can cancel them at any time. The average real escalation in the variable salary was between 2.0-2.5%. The overall trend experienced in the 1990s is expected to continue over the coming years.

When the results from formula 2.13 were compared with the real escalation of the average insured salaries, which was calculated as:

$$(1+iv_{t+1}) = \frac{S(t+1)/(1+j_{t+1})}{Act(t+1)} \qquad \text{for all } t \geq 1 \qquad (2.14)$$

where iv_{t+1} = the real average annual rate of salary escalation

The real average annual salary escalation of the insured salaries over 1975-99 were similar to those obtained using formula 2.13 (-4.8% for the basic and 2.75% for the variable). From 1984-85, there was no difference between the two results. This analysis indicates that the general salary escalation is not stable in general, with the basic salary varying much more than the variable salary.

2.12.2. Experience of Salary Increments and Pensionable Salaries

There is no index which reflects the average level of salary inflation in Egypt, and salaries have been increasing annually on budget day since 1987 by political decree. These increases have been between 10-20% (10% since 1993) of the basic salary. The maximum and minimum insurable salaries are up-rated at the start of each budget year (on the 1st of July) by these increments. These increases apply only to civil servants and public sector employees and are not obligatory for any other categories of workers. However, these increases affect the minimum and general salary levels in the market, particularly for regular private sector employees, as workers and employees unions usually ask for similar increments. The maximum insured part of basic salary was LE550 per month and the minimum was LE 45 per month in 1999/2000. The ceiling of the insured part of the variable salary was LE 6000 per year (LE 500 a month) in 1999/2000. The maximum total insurable salary in 1999/2000 was LE 12,600.

Using the previous analysis and arguments, it can be assumed that the reasonable range for real salary escalation (before any allowance for salary scale) will be 1.0-2.0% p.a. for the real basic salary escalation and 2.0%-3.0% p.a. for the real variable salary escalation. The analysis in Chapter 1 of past inflation rates over 1977-98, indicates that the reasonable inflation rate to be assumed is 5% p.a. Therefore, the rates of nominal general salary escalation rates (the rates above the assumed inflation rate) will be a range of 6-7% for the basic salary and 7-8% for the variable salary. These ranges are consistent with past experience and are prudent enough to be used in the actuarial projection and valuation of the employees' scheme (Law 79/1975).

In 1987, the Actuary conducted an investigation on insured salaries of private sector employees, and it was found that they were roughly constant among different ages. It was also found that the level of insured salary changes only with time (Nagib.S., 1994). This was strongly confirmed in 1998-99, when it was found that 64% of the regular private sector employees' insured salaries were between L.E.45-100 per month. It was also found that the total average insured salary (basic + variable) of private sector employees was L.E.195, which was very much less than the general level of earnings for civil servants and public sector employees in this year (L.E.392 and L.E.350 respectively). This casts a huge doubt that the private sector is using their employees' actual earnings for their pensionable salaries. The problem is supposed to be more severe for non-regular private sector employees.

2.12.3. General Salary Escalation of the other Schemes

Although the self-employed and Egyptians Working Abroad schemes may be regarded as not relevant in this matter as they have the right to choose the level of their pensionable salary (basic only), they can apply salary increases by moving to a higher pensionable salary every number of years. In 1998-99, it was found that 68% of the members of the self-employed (compared with 83.3% in 1994-95) and 55% of the members of the Egyptians working abroad schemes were using the minimum level of L.E. 50 as the pensionable salary. The system has been trying to find a solution to this problem by convincing the members of these schemes to choose a level of pensionable salary which best matches their actual incomes and the system has increased the minimum level to LE 100 from 2001[54].

A similar analysis to the above was carried out on the insured salaries for these two categories of insured members. The analysis gives much lower results for the escalation of the basic salary than in the employees' scheme and therefore, a lower range of rates will be applied to these two categories.

So, we conclude these sections by stating the following assumptions regarding the real general salary escalation:

1. For civil servants and public sector employees the real growth rate is 1-2% p.a. for basic salaries and 2-3% per annum for variable salaries.
2. For private sector employees the real growth rate is 0% p.a. (only the assumed inflation rate) for basic and variable salaries.
3. For self-employed and Egyptians working abroad a real growth rate of -2% p.a. for insured pensionable salaries.

2.12.4. Salary Scale

Salary scale represents the rate at which earnings are expected to increase by promotion rather than by general wage inflation. The salary scale will provide a basis for the projection of future earnings whatever types of earnings are involved. Obviously, the extent of such increases will depend on the particular employee, but it is reasonable to assume that those who have worked longer will, on average, receive a higher salary[55]. The approach normally taken is to assume that the average salary at

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[54] Since 1993/4, the PPSF has been undertaking intensive inspection on its members and, as a result, the percentage of private sector workers who contribute at the minimum wage level has been significantly reduced from 52% in 1993-94 to 16% in 1996-97.

[55] In some countries such as UK it is found that the average salary peaks in the mid-40s age group, and then declines for older members.

each age varies according to a promotional scheme. The type of function almost invariably used in practice for this purpose is a relative scale, that is a scale representing the ratio of average annual earnings in each future year to present average annual earnings.

For the majority of the employed population in Egypt, pay generally increases with experience and age, and the standard of living is much better for the older employed than for younger employed. This is indicated in the basic structure of the annual periodical increments for civil servants and public enterprise employees as shown in **Table 1.1 of Appendix 1.** A typical salary scale, based on data from the ESSPS statistics for members covered by Law 79 of 1979, shows the estimated average salary at different ages, measured relative to the lowest average salary at the youngest age shown in **Table 2.4.A of Appendix 2.**

However, the ongoing changes in the economic and social environment due to economic reforms and privatisation of the public sector enterprises may have some effects on the salary structure. In 1982, the Actuary of the ESSPS recommended that actuarial valuations should distinguish between the salaries of public workers, private, employers and the self-employed, and Egyptians working abroad. In the private sector, the level of such increases depends on individual employees in different companies although, in general, the assumption that those who have worked for longer will, on average, receive a higher salary is still exist.

The approach taken by the Actuary in conducting the actuarial valuation of the two Funds in 1987 was to assume that the average salary at each age varies according to a promotional scale, where a starting salary of LE 100 and an entry age at 20 were assumed. The following two linear formulae were applied for the salary scale for employees covered by Law 79/1975.

For civil servants and public sector employees the formula used was:

$$SAL(M, x, B) = 100 + 15\,(x - 20), \tag{2.15}$$

For private sector employees the formula used was:

$$SAL(M, x, B) = 100 + 12\,(x - 20) \tag{2.16}$$

Following the actuarial valuation conducted in 1992 it was decided to use a promotional salary scale of 5% compound, for both public and private sector employees according to the following formula.

$SAL(M, x, B) = 100 \times (1 + \varphi(M, B))^{x-20}$[56], $b \leq x < r$ and $0 \leq t \leq 28$ (2.17)

where, $SAL(M, b, B)$[57] $= 100$

However, it was found that the salary structure of private sector employees is different from that of public sector employees. Therefore, for the promotional salary scale of the basic salary, after investigating the available data over 1992-96 we will assume the following:

1. For civil servants, public sector employees and private sector employees, Formula 2.17 is applied with $\phi = 5\%$, 4.5% and 4% respectively;
2. For private sector employees Formula 2.17 will be used but with $SAL_{20} = 80$;
3. For other categories, there are no assumed changes in earnings with age.

Both the promotional scale according to function 2.17 and the general salary escalation assumptions (γ) are used to project forward the basic insured salary of the scheme's active members. For variable pensionable salary, it is only the general salary escalation (γ) is used to project forward the variable pensionable salary of active members covered by Law 79/1975.

2.13. Rates of Compliance

It is observed that one of the critical factors effecting the ESSPS is the rate of compliance. This problem is faced only in the PPSF, which had a very low rate of compliance in the 1980s and the 1990s[58]. The levels of compliance for casual workers, Egyptian working abroad, non-regular private sector workers, regular private sector workers, self-employed persons and civil servants and public sector employees were estimated at 13%, 18%, 25%, 62%, 69% and 100% respectively in 1997[59]. These rates are used in the projection and valuation of contribution income and benefit outgo of these schemes

The casual workers' scheme creates incentives for non-compliance until late ages (50+) by not having a strong linkage between contributions and benefits. In the

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[56] This function is usually assumed to be a step-shaped function with a constant level throughout any given year of age. This assumes that rises were granted on a fixed date each year. This is consistent with the actual situation in Egypt as salaries increase at the beginning of each financial year. However, for the self-employed and the Egyptians working abroad schemes, the pensionable salary level is allowed to be increased at the middle of the financial year (on 1st of January of every year).

[57] It is assumed in the actuarial valuation that the earliest age for joining the system is 16 and the relative salary scale will be 0.95, 0.91, 0.86, and 0.82 for ages 19, 18, 17 and 16 respectively.

[58] There is a decline in social security receipts from private employers because of the non-compliance.

[59] It is measured as the percentage of active members paying contributions in a specific year.

private sector, generally, there is significant evasion in respect of workers who are engaged without a labour contract because neither the employer nor the worker wishes to accept the related obligations as explained. Egyptians working abroad scheme's low levels of compliance presumably influenced by the voluntary nature of the scheme. Self-employed compliance rate may reflect the use of a narrow definition of 'self-employment', which transfers the problem to the casual workers scheme.

2.14. Dependants

The pension of a deceased member is divided among survivors according to a legal schedule (with various maximum allocations of pension), which includes many dependants as explained in Chapter 1. Religious and cultural considerations have been understandably taken into account and the provisions apparently correspond to the Shariaa Law[60]. The process of establishing and verifying entitlement is very complex and time consuming. In designing provisions for surviving dependants, it is often difficult to strike the right balance between responding to the large variety of family relationships and simplifying the scheme. It is also difficult to ensure that all the relevant facts have been obtained and that there is no significant change in the circumstances of dependants.

By examining the data of the whole system (both Funds) on 30/6/1999, it was found that the total number of death pension cases in force on that date, were 2.024 million. This number of death cases created a total number of survivors of 5.012 millions who claimed benefits on the same date as shown in Table 2.9. Death benefits represent a significant share of the total benefit expenditure of the whole system as survivors represent 73% of the total beneficiaries.

Table 2.9. Number of pensioners and survivors of different schemes in 1998-99 (thousands)

Type of insured persons	Pensioners	Survivors	Total
Employees; (79/1975).	1089	2418	3507
Self-employed persons (108/1976)	135	400	535
Egyptians working abroad; (50/1978)	4	2	6
The CSIS (112/1980)	567	1535	2102
SPP	39	657	696
Total	1834	5012	6846

Source: MISA, the annual year report; 1998-99.

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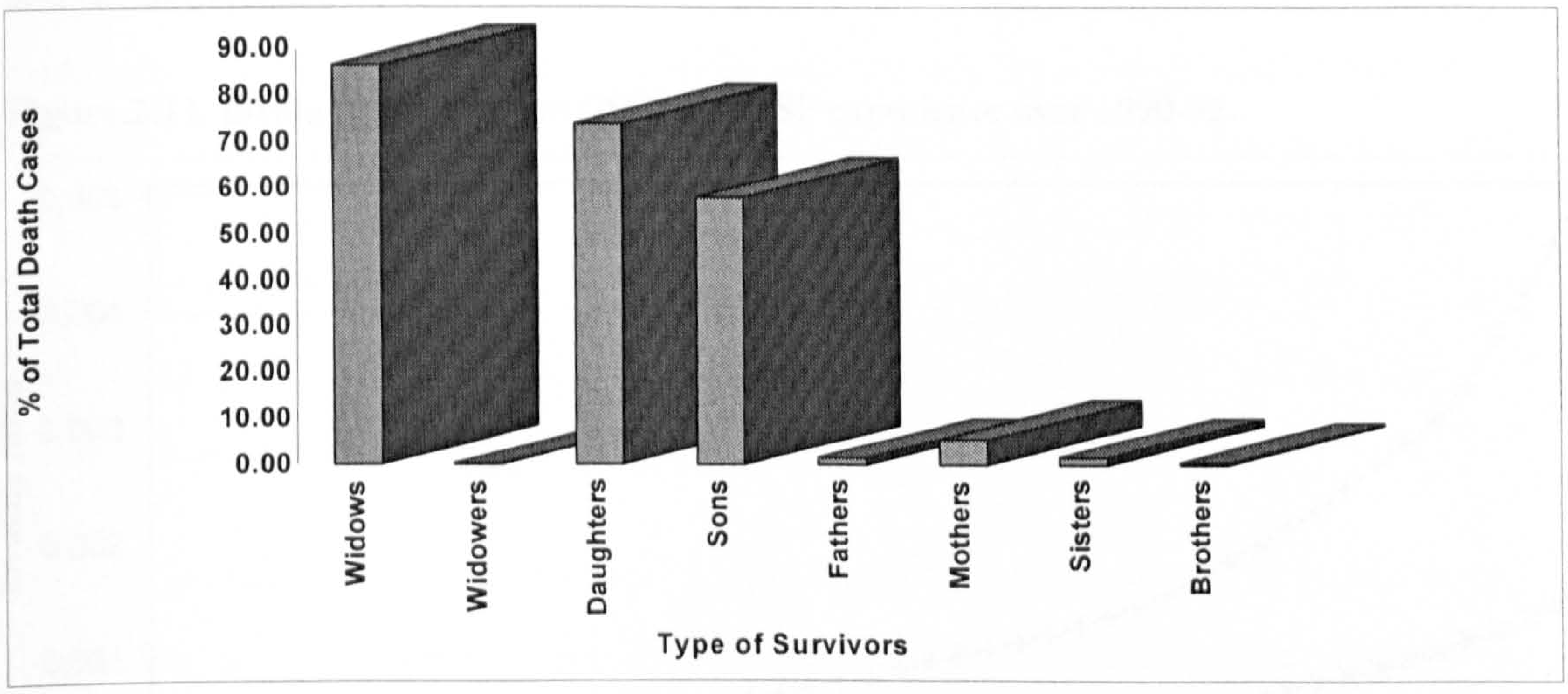
[60] It is taken from Koran, the Muslim holy book.

The most significant two categories of survivors in the system are widows and orphans as shown in Figure 2.10. This makes modelling the scheme and the cost of its benefits very hard. Therefore, it is assumed in the valuation and projection model that 100% of the pension value is divided between a widow (50%) and two orphans (25% for male orphan and 25% for female orphan). In the case of the death of a female member, it is assumed in the valuation and projection model that two-thirds of the pension value is divided between two orphans[61] (one-third for male orphan and one-third for female orphan).

Figure 2.10. Proportion of each category of Survivors to the total death pension cases of the whole system on 30/6/1997.



The other beneficiaries such as parents and siblings are assumed ineligible according to this analysis. This assumption is consistent with reality and it is prudent as it assumes that the survivors inherit the full pension value. The survivors take from each other and replace each other in the pension entitlement according to very complex rules. It is noticed that high mortality groups, which receive smaller retirement benefits, also receive larger survivors' benefits. Combining these effects, we find that the old age and survivors benefits have an active role in distributing income among social groups, particularly women and large families who benefit the most.

2.15. Mortality and Invalidity Decrements Experiences

The active population is subject to two continuous decrements over the year of age: mortality and invalidity. A third decrement is assumed to take place at exact integral ages, i.e. just before each birthday: early retirement. The retired population is subject

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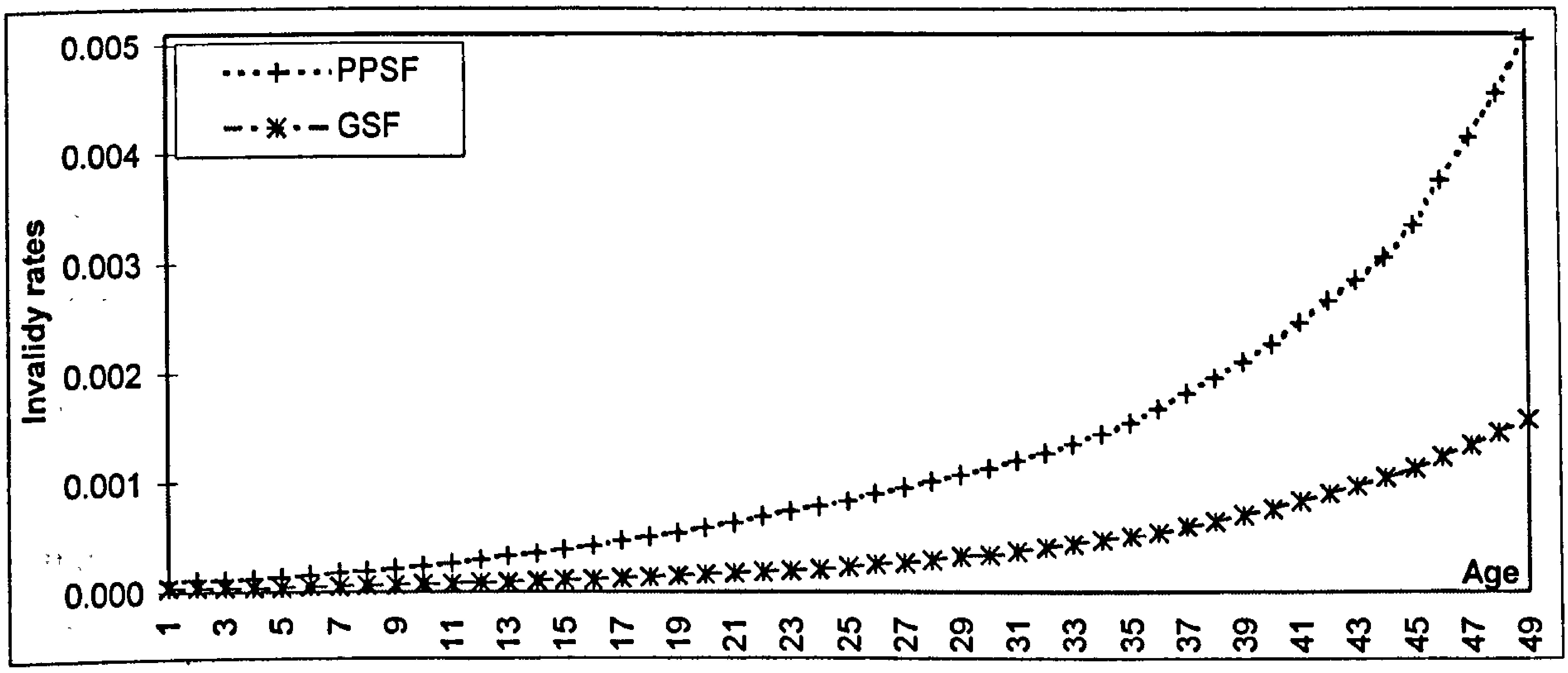
[61] This is the rule in the case of no widower and if there are only orphans.

to the mortality decrement only. The force of each decrement is gender and age specific. The effect on the actuarial costs of assuming specific levels of mortality and invalidity are very significant. An increase in the force of invalidity has the same effect as a similar increase in the force of mortality at the same age[62] in relation to the cost of normal retirement benefits.

However, in the Egyptian case, where 100% of the pension is inherited in the case of death or paid as an invalidity pension, this would not have a significant affect on the total actuarial cost. This produces a mutually compensating effect in a comprehensive social security pension scheme covering all three risks of age retirement, invalidity and death (Thullen, 1973).

Figure 2.11. Invalidity rates in the GSF and PPSF experience over 1990-92.



Mortality rates for death in service, after old age retirement and after invalidity retirement, are derived in Chapter 4 according to the national mortality experience of Egypt over 1994-96 and in comparison with the English mortality tables employed in the valuation of the ESSPS. Detailed data about invalidity cases by age and sex were not available. However, invalidity rates for both funds were provided by the system as shown in Figure 2.11 and in **Table 2.4.B of Appendix 2.**

2.16. Early Retirement Experience

Early retirement option is a very important measure, as its effect on the actuarial soundness of the ESSPS needs careful consideration. The most important

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[62] This is equivalent to the increase in the rate of interest in the calculation of the actuarial cost of retirement benefits only and thus, a decrease in the actuarial cost of such benefits.

determinants of early retirement are length of pensionable service and state of health rather than level of pay. In Egypt, of more significance than the pension age, is the facility for early retirement and for the receipt of retirement pension considerably earlier than age 60, which is a very important factor in determining the pension cost. There are too many pensions being paid to people who are young and healthy enough to be in the labour force, but the system allows (and may be said encourages) the receipt of retirement pension earlier than the NRA.

An insured person can claim an early retirement pension after 20 contributory years (except casual workers) with a reduction in the pension calculated at NRA varying between 15% and 5%[63] for retirement between ages 40-55. Given that this reduction rate is not actuarially adequate or fair for the system, and there is no reduction for retirement from age 55, early retirement results in an increase in the pension costs. This is because pensioners are receiving pension for significantly longer than was envisaged in the legislation. This facility played a very significant role in increasing the overall benefits cost[64] of the system in the 1990s, as a consequence of privatisation and public sector retrenchment.

The Government is encouraging many civil servants and public sector employees to take early retirement benefits to achieve two goals. First, to reduce the effect of the high unemployment and easing the pressure on the labour market[65], as it is thought that this measure would stabilise the labour market and free new vacancies for young entrants[66]. Second, facilitating the process of privatising the public sector companies and accelerating economic reform.

An increasing trend of early retirement over 1989-99, was reflected in a steady increase in the percentage of early retirement pensioners to the total number of pensioners during this period. In 1998, this percentage represented 12.43% compared

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[63] The rate of reduction is set at a level lower than equitable rates. It is estimated on an actuarial basis that the rate of reduction should be in the order of 5% p.a. which is applied to the variable salary.

[64] The actuarial reports indicate that these increases in the early retirement rates contribute to the deficit of the system (Ibrahim et. al. 1994).

[65] Early retirement is often seen as a "painless way to cut unemployment by enabling the long-term employed to retire and alleviating youth unemployment.

[66] This has not materialised, as labour force participation among the young continued to decrease in the 1990s. Also, many of early retirement pensioners are receiving the benefits when they are still working in some other sectors. Although pension entitlement is subject to suspension on return to work, there are considerable opportunities for informal employment outside the scope of insurable employment under the social security scheme.

with 4.04% in 1979. Early retirement benefits represented 11.5% of the total benefits paid in 1998 compared with 9.8% in 1992 and 5.8% in 1981[67]. Most newly awarded early retirement pensions in the 1990s are in the public sector and concentrated around age 50.

An analysis of pensioners of 1998-99 reveals that early retirement is slightly more prevalent in the public sector: 26.5% of all public sector pensioners are in receipt of an early pension against 23% of all private sector pensioners. It is found that the rates of early retirement for females represented more than three times those of males for the age range 45-59 over 1992-98[68] as shown in **Table 2.4.C of Appendix 2**. Early retirement results also in workers having a lower level of social protection as the cumulative structure of the pension formula, combined with the penalty for early retirement, has an effect of producing a relatively low retirement pension[69].

Thus, early retirement provision is used to provide a response to the problem of unemployment. It is undesirable for this labour market problem to be tackled by generous early retirement provisions which place a burden on the ESSPS. Special programmes to facilitate public sector downsizing and unemployment should be designed rather than permitting all insured persons to make early retirement choices which may be against their own interests and certainly the interests of the system.

2.17. Administration Costs

Pension projection models also incorporate forecasts of administration costs, which are usually quite simple technically. In long-term projections at least, administration costs are estimated as a share of total expenditures, contributions, pensionable salaries or assumed to follow the price or earnings index. According to the experience of the two Funds over 1977-99, the total administrative cost, as a share of total expenditure, was around 2.0-2.5% in the GSF and decreased from 6.2% in 1977 to 2.63% in 1998-99 in the PPSF. As a share of total contribution income it was 1.35% in the GSF and

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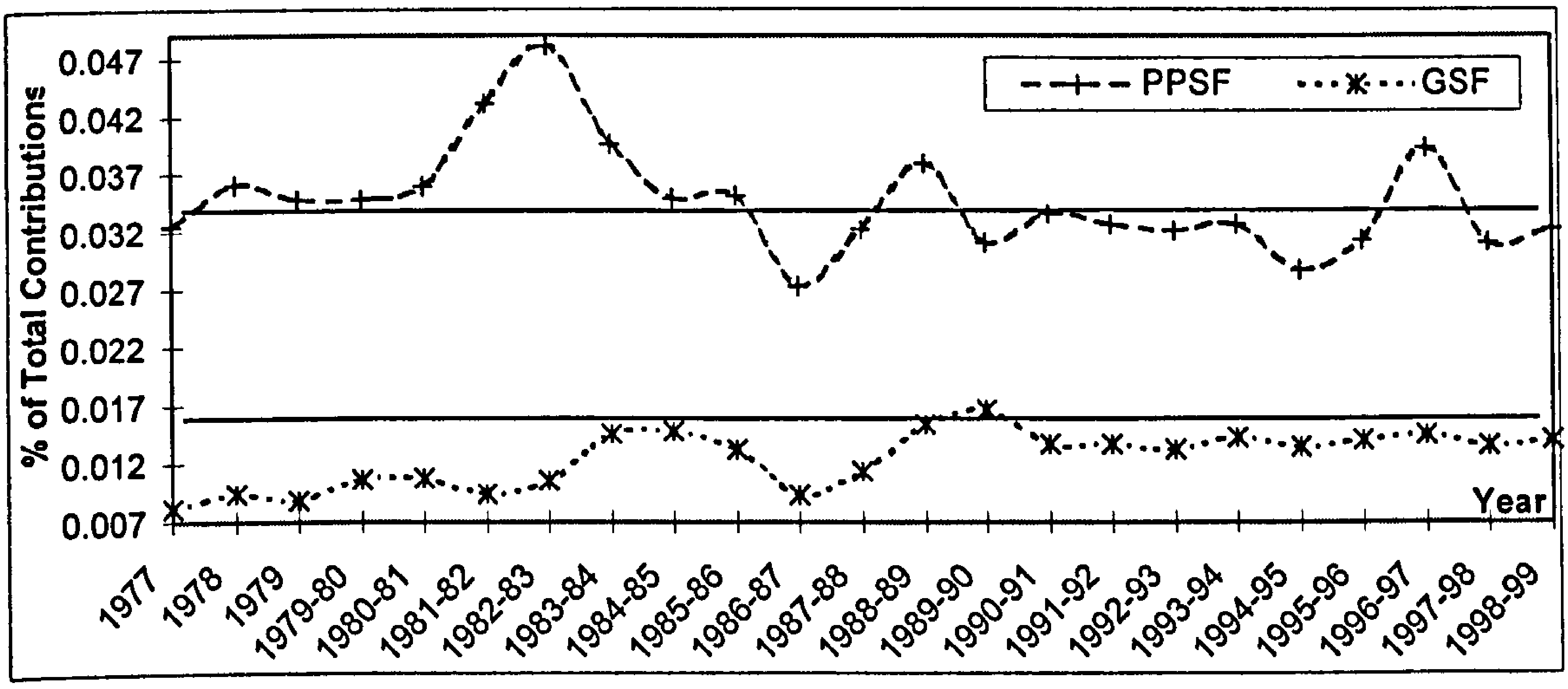
[67] It is expected that the number and cost of early retirements may increase over the next few years for the purpose of releasing more jobs for young unemployed people.

[68] Early retirement rates were obtained from the experience recorded in both Funds over 1992-98.

[69] For example, retirement at age 49 results in a pension reduction of 11/45 plus the 10% penalty (a total of 34 %). The average new pension award for public sector workers in 1998 at age 60 was LE 433 whereas the average new early retirement award was LE 125 (this could also have an adverse effect on survivors' benefits). This is also due to the fact that the special annual increments were not applicable for early retirement pensioners until recently when some early retirement pensioners managed to get a rule from the constitutional court to receive these increments.

3.3% in the PPFS as shown in Figure 2.12. These are roughly equivalent to 0.45% and 1% of the total pensionable salaries in the GSF and PPSF respectively. Therefore, in the projection and valuation of the two Funds, these two proportions of pensionable salary are assumed to be the administration costs of the two Funds.

Figure 2.12. The proportion of administration costs to total contribution income over 1977-99



2.18. Unemployment Insurance Experience

The scope of coverage against the consequences of unemployment is very limited as take-up rates for unemployment benefit seem low, they are of short duration and very little is available to members in terms of amount paid and job protection. Unemployment benefits are not significant[70] and are only applied to public and regular private sector employees [71] as explained in Chapter 1. It is found that the annual paid unemployment benefits is less than 1% of the annual unemployment contributions (paid to less than 1% of the covered contributors) over 1972-98.

Unemployment benefits do not play a major role because the vast majority of "open" unemployment represents new entrants to the labour force who do not qualify for unemployment benefits[72]. Therefore, for unemployment benefits to be effective they have to be made available to the vast majority of the unemployed. It is the responsibility of the state to create job opportunities, particularly for those young job-seekers without a record of insurable employment. The Treasury can finance any deficit in the unemployment provision if there are not enough resources. As data

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[70] Its annual liabilities represents less than 0.001% of the total annual expenditure of the PPSF.

[71] This is may be inconsistent with policies aimed at introducing greater flexibility in the labour market and a shift from public to private sector employment.

[72] Some 94% of the unemployed are in the age group 15-29.

about unemployment insurance in the PPSF is not available and the insurance does not represent a significant part of the system's cost, the projection will have to be an approximation as explained in Chapte3.

2.19. Conclusion

The ESSPS is giving indications that it may experience financial difficulties, both in the short and long term. This is because of increasing unfunded benefit promises, an inability to collect all the revenues due to it and to invest its assets wisely. It is feared that the funding position will worsen in future years, placing an increasing burden on the Government to put more funds into the system in order to reduce its cash flow deficit. This will affect the actuarial soundness of the system.

The current investment strategy set by the government has resulted in rates of interest, which depend on the discretion of the NIB and the Government. The Government has used the assets of the pension system to finance its development plans by investing nearly all the funds in government vehicles, in return for a low interest rate. This policy has resulted in low, or even negative, real returns and effectively transfers resources back to the state. It can also be regarded as a significant factor for the deficit of the system.

The increasing incidence of early retirement is having an impact on the financial structure of the ESSPS. This may result in the system becoming expensive to maintain, and requiring increases in financing or increases in the system's deficit. In general, the ESSPS, practically, can not be regarded as a full funded system and it may be looked at as a different model of PAYG national insurance systems.

Chapter 3

Projection and Valuation of the ESSPS

3.1. Introduction

The financing of national pension schemes is threatened by possible disruptions arising from various types of demographic, economic and political crises. Therefore, a key objective for national pension insurance is to ensure its financial sustainability. Decision-makers need analyses of the outcomes of pension policy decisions–both those that strengthen and those likely to weaken the schemes. The projection results may affect the government budget to a large extent. If the share of GDP allocated to social insurance pension expenditure is expected to increase, this may exert pressure on the government budget and cause either the tax burden or the budget deficit to rise.

The models applied to analyse questions related to social insurance systems have tended to be either actuarial models with few economic linkages or economic models with little detail on the mathematics of pension systems (Mackellar, L., et al., 2000). However, there are models take account of the linkages between social insurance systems and the economy containing both economic behaviour and structural detail of the social pension systems. In this thesis we model the structural detail of the ESSPS, the future evolving of the distribution of the population of the country and the ESSPS and the level of unemployment.

Actuarial projections and valuation models play a key role in this task as they can help in understanding the financial stability of the system and how to protect it from adverse deviations. They are the tools which can provide long-term estimates of future expenditure and income. They provide estimate of the actuarial long-term soundness of the system and financial management on the basis of sound actuarial assumptions. Periodical actuarial projections and valuations are means of providing the quantitative basis for information about the likely future development of pension schemes and policy-making decisions about such schemes. Whatever the pension scheme, one requirement common to all pension projections is that they must be able to produce reliable information on income and expenditure, i.e. the financial balance of the schemes. In complex financial systems, such as national insurance pension systems, projection and valuation require an integrated and comprehensive set of interconnected models, which fit the available data.

In Chapters 1 & 2, the main features and experiences of the ESSPS were discussed. In this Chapter, a projection and valuation model for the ESSPS is constructed. The model deals with two main objectives. The first is to project the annual cash-flow surplus/deficit[1] of the two Funds under different demographic and economic scenarios over the projection period. The second is about how to keep the two Funds in actuarial equilibrium according to the concept of fully funded liabilities.

3.2 Factors Influencing the Design of Projection and Valuation Models

In each country, pension schemes are a product of their unique historical development, therefore, differences between them can be significant. However, projection and valuation methods have plenty of features in common, regardless of the fact that such models are usually custom-made to fit the requirements of each scheme. This is because the role of projections and valuations and the mechanisms affecting the development of pension insurance are similar.

Various factors affecting the scheme impose certain requirements on the choice and development of actuarial projection and valuation models which predict expected future inflows and outflows. Such factors include:

1. The level of coverage in the scheme (whole population/certain categories);
2. Financing (contributory, general revenues);
3. Type of funding (funded, partially funded, PAYG);
4. Benefits (flat rate, earnings related);
5. Type of scheme (public, private);
6. The rules operating the scheme;
7. Potential outlook of the demographic and economic characteristics of the population covered by the scheme;
8. The regulations and policy guidelines governing the funding and investment strategies of the scheme.

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[1] This includes the initial surplus/deficit (defined as difference between contribution income and expenditure) and the net surplus which includes the investment return and the Treasury subsidy to the system.

The choice of projection method and model is influenced by whether the projections are made for the short, medium or long term[2]. The time span of the projection sets certain requirements on the model's structure. In short-term models, devised primarily to serve the needs of short-term liquidity management, different factors are emphasised than is the case with long-term models extending several decades into the future. In long-term models, demographic factors play an important role. In some countries, long-term projections must be made every 3 or 5 year. Therefore, the projection methods and basic assumptions used and the general results obtained, differ from one country to another. However, the ESSPS does not conduct any projections for any term. Therefore, it is very important to conduct a medium term projection.

A projection and valuation model of the ESSPS must allow for future membership of the system, project future annual cash-flow surplus/deficit and enable actuarial valuation of the system. These projections require modelling of the demographic structure of the system, to estimate the number of contributors and beneficiaries, and of the financial factors in order to estimate the future income and expenditure.

There are two actuarial approaches for the analysis of a pension scheme, the projection technique and the present value technique. In the case of a state scheme, both techniques can be used in quantitative financial analysis to determine the future long-term financial soundness of the scheme under certain national economic and demographic circumstances. In the following sections, both techniques are explored and used to design a model for the projection and valuation of the ESSPS.

3.3 Actuarial Projection Technique

The actuarial projection technique is appropriate in the case of partially funded and PAYG social security pension schemes. Projection models can be quite complex and may incorporate a wide variety of calculatory rules. Pension projection models can consist of a number of modules, which are usually combined in order to discover the scheme's financial balance. They may have linkages e.g. to outside econometric models. Among the modules are ones dedicated to demographics, financing and investment, and income and expenditure. Separate modules are often devised for

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[2] The financial status of the system can be evaluated on the basis of estimates made over three time periods: short range (5-10 years), medium range (25 years), and long range (75 years). It has to be borne in mind that the projections become increasingly uncertain the further one looks into the future.

different pension categories (old-age, disability, survivor pensions etc.). Contributions by employers and the insured may also be modelled separately. In addition, funded schemes have separate models for forecasting funding levels, returns on investment and liquidity. An overlapping generations model has also been devised in the form of a dynamic equilibrium model, as in the German pension scheme.

The projection method most commonly used in a pension projection scheme is deterministic simulation (normally based on aggregate data), but also extrapolation, stochastic models[3] and sample-based methods have been used. This means that, given the underlying parameters, the outcome in terms of the actuarial functions is taken as uniquely determined. Deterministic simulations operate by modifying an observed starting position via various parameters. It is especially common in forecasts of pension expenditures and to some extent also in contribution income projections. How accurate a projection technique is used depends on issues such as the nature of the scheme and the availability of data.

The primary objective of scheme-specific actuarial projection models is to produce estimates on future income, expenditure and financial balance of the pension schemes. It is also to give a picture of trends in the existing scheme and the impact of possible changes, and to simulate the future development of the scheme under different national demographic and economic scenarios. Pension insurance schemes need also other types of projection data, including the number of pension recipients, the active population etc. Projections can also anticipate the accumulation of funds, support investment activities and determine the funding level in the case of a funded social insurance scheme. Therefore, many countries have imposed statutory requirements on pension institutions to perform projections.

Income forecasts for contributory schemes are designed to use, as demographic and economic variables, labour force participation rate, increases in the earnings level and possibly various income distribution parameters. In universal schemes and in schemes financed out of general revenues, the projections of income are often made by using general macroeconomic variables. Pension expenditures forecasts complement demographic projections by projecting benefit levels that are peculiar to each scheme.

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[3] The resulting value of an actuarial function under the stochastic approach is the expected value of the outcome. The actual outcome has a probability distribution, hence its precise value is uncertain.

The basic elements of the projection approach are the expenditure function *B*(t) and the insured salary function *S(t)*. Projection models dealing with expenditure and income are based on the age and sex structure of the insured population and expected changes. A common way to design such models is to analyse the baseline position at the level of one-year age cohorts and to make year-by-year forecasts based on various transition scenarios. The results of projections are presented at nominal and constant prices. Long-term projections are usually made at constant prices, which provide the advantage that the real value of money can be more easily compared with present-day figures. In practice, projection models distinguish between a real component and a price component.

3.4. Sensitivity Analysis of the Projection Results

Since it is not possible to precisely forecast economic and demographic factors which may change repeatedly, even over the course of a single year[4], a degree of uncertainty necessarily attaches to these quantities and consequently to the projections. Therefore, it often makes sense to assess the impact of uncertain future experience by providing a variety of scenarios, especially where long-term projections are concerned, based on different sets of assumptions, labelled "alternatives". Long-term projections cannot predict the outcome, but they can illustrate the sensitivity of the result by considering possible, and plausible, future changes in the parameter values and give early warning of a situation where the results may be considered unfavourable[5].

The sets of alternatives are derived on the basis of consistency with historical experience, expected changes in the economy and population, and other assumptions. The alternatives achieve different projections in two manners. The first is in the timing of changes and the second is in the level of the rates of change. Clearly the number of alternative projections which might be shown is infinite. However, projections are normally prepared under a range of assumptions, including low cost (alternative I (optimistic assumption)), intermediate cost (alternative II, (the principle assumption)), and high cost (alternative III, or the pessimistic assumption). This set of

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[4] The most difficult problem faced by actuaries in the social security field is the development of reasonable and appropriate economic assumptions to be used in the cost estimates, both short-range and long-range (Robert J. Myers, 1983).

[5] Such analysis does not add a great deal to the traditional actuarial philosophy of using 'prudent' assumptions.

assumptions is generally regarded as suitable for actuarial projections. A simple form of sensitivity analysis is required for all cash flow income and outgo projections.

In this thesis, examination of the financial status of the ESSPS over the projection period under different future scenarios concentrates on particular combinations of assumptions. Sensitivity analysis illustrations for the projection results are carried out using three cost alternatives (explained in details in Chapter 6[6]) with two different sets of pension and salary increase ranges. This determines the level of surplus of the two Funds under these three alternatives. Another sensitivity analysis of the valuation results is carried out using a range of assumptions for earned interest rates on the invested funds (as explained in details in Chapter 2[7]). This will illustrate the valuation results of the estimated level of funding in connection with future investment returns and salary increases. This sensitivity analysis is undertaken in Chapter 7.

3.5. Designing the Projection Model of the ESSPS

There is considerable uncertainty about future cash flows for two the Funds of the ESSPS. Each future year of the scheme's operations will involve the receipt of contributions from members and employers, investment income, the Treasury's subsidies to the system, and expenditure upon benefits of various types. A projection of expected annual revenue and expenditure over a long period could thus be constructed. These series of cash flows depend on many factors such as the cost of benefits payable, contribution rates, level of Treasury subsidies, future interest rates given by the NIB, future fertility, future longevity, economic growth and unemployment. The model has to project and simulate income and expenditure and evaluate the surplus/deficit for the two Funds over the projection period.

Therefore, the actuarial projection model of the ESSPS' **main objectives are:**

1- Project the system's annual cash flows and funds (through year-by-year simulations over the projection period) under the three mentioned alternatives;

2- Project the initial and net surplus/deficit of the two Funds (and the system as a whole) under the three mentioned alternatives;

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[6] These alternative projections represent combinations of lower and higher fertility, mortality improvement, labour force participation and unemployment than assumed in the principal projection.

[7] The Government Actuary Department of the UK uses sensitivity analysis in the quinquennial review of the UK national insurance scheme. In determining the contribution rates required to sustain the PAYG state pension, projections are made by varying key variables, such as mortality, fertility and growth in average earnings (Khorasanee, 1999).

3- Project the annual Treasury subsidies[8] to the system under the three mentioned alternatives.

The results from that model will include projections of other various amounts critical to the system, including total insured salaries, the number of active members[9], the number of benefit receipts, and benefit increases. The financial assessment and projection of different amounts of income and expenditure are carried out by reference to each scheme of the system, as they are currently structured.

3.5.1 Modelling Future Active Members of Different Schemes

Whether the elderly are supported by a State pension scheme on a pay-as-you-go basis or by funded pension schemes, the effective burden of supporting them falls on the economically active population, unless wealth can be transferred over time by investment outside of the economies affected (Young, A., et al, 1987). Therefore, the projection of the number of active members of the scheme in year (t, t+1) will be critical in determining the annual cost of the system.

The proportion of active employees in a scheme to those in the whole system may increase or decrease over time at a specific average rate per annum. This has to be taken into account for the projection of future active members[10]. In assuming how such changes will occur, the most common approach is to assume that they increase or decrease for a specific period until the rate starts to slow and then stabilise over the remaining projection period. Therefore, the model has to project the future membership of each scheme as was discussed in Chapter 2. It is also assumed that the increases or decreases will only affect active members over specific ages (e.g. between the youngest age at entry and an assumed older age) as the mobility of active members occurs at specific ages[11].

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[8] These represent, mainly, annual increments, most of the cost of the CSIS and other benefits which the state has committed itself to finance.

[9] The development of the active and retired populations will be projected under various assumptions regarding mortality, fertility, labour force participation and unemployment.

[10] As a result of economic reforms and the privatisation process, it is expected that, in the near future, the system may experience a considerable migration of workers between different schemes, particularly from public and private sectors to self-employed sectors, with the latter gaining more importance. It would be a realistic assumption to assume that the current trend of moving from the public sector to the private sector and self-employed will stay at the current level over 1997-2010 and slow thereafter.

[11] After investigating the available data it was assumed that these ages are 39 for $M = V$ and P, 44 for $M = E$, 39 for $M = W$ and 49 for $M = C$.

The construction of membership of different schemes in year t can be derived from the following formulae[12]:

For $x_1 < x \leq x_2$

$$Z(M, x, t, s) = (1 + g)^t \qquad (3.1)$$

where x_1 = the youngest age at entry and x_2 = the assumed oldest age for entry

For $x > x_2$

$$Z(M, x, t, s) = 1 \quad when \quad x_2 - x > t \quad and \qquad (3.2)$$

$$Z(M, x, t, s) = (1 + g)^t \quad when \quad t \geq x_2 - x \qquad (3.3)$$

$$Act(M, x, t, s) = 1.05 \times PC(M, x, t, s) \times Z(M, x, t, s) \times EM(x, t, s)^{13} \qquad (3.4)$$

In general, the methodological core of demographic projections is the iterative "moving forward" of a matrix (consisting of the scheme's members, active contributors, inactive registered members and beneficiaries) on a year-to-year basis. This means that on the basis of a demographic matrix for year *t*, a matrix for year *(t + 1)* of the same structure is produced. The transition from t to *t + 1* is governed by a set of transition rules which are established on the basis of past experience or expected future conditions (Cichon M. *et al*, 2000).

3.5.2.Effect of the Density Factor

The density factor is the proportion of potential time that members in the active age range are effectively contributing to the scheme. Assuming that the density factor uniformly affects all individuals of a given age, the total contributory service of a new entrant at age b on reaching retirement age r would be:

$$PS\,(M, x) = \int_b^r \lambda(M, x)\, dx \qquad (3.5)$$

$\lambda(x)$ over the age range (b, r) is approximated using the following function:

$$= \frac{\int_b^r dc(M, x)\, dx}{r - b} \qquad (3.6)$$

Function *3.5* can be approximated by:

$$PS\,(M, x + t, t, s) = PS(M, x, 0, s) + dc(M) \times t^{14} \qquad (3.7)$$

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[12] It is assumed that $Z(M, x, t, s) \geq 1$ for some schemes and < 1 for some other schemes as a result of negative growth in new members. This is may be interpreted as signifying that there are decreases in new entrants in some schemes which resulted in increases in other schemes within the ESSPS.

[13] The coverage rate is projected to stabilise at about 105% of the total employed members.

[14] It is assumed that the contribution density *(dc(M, x, t))* equals the average compliance rate *P(M)* which equals the benefit density *(db(M, x, t))* (which is the proportion of the potential period of service

where $dc(M)$ is assumed to follow the following function:

$$dc(M, x, t, s) = dc(M) = db(M, x, t, s) = db(M) = P(M) \qquad (3.8)$$

As the approach taken in this thesis is deterministic, the densities were assumed to be uniform at the compliance rates[15] at all ages. Service credit during non-contributory periods is ignored here.

3.5.3 Modelling Annual Contribution Income

There are two main different methods that can be used in modelling future insured salaries, (Iyer, S. 1999). The first method, the classical method, models the age- and time- related insured salaries using an age-related salary scale and an assumption for general salary escalation over time. However, this method does not allow for variation in the age-wise salary structure and also does not allow for the salary distribution at each age. The second method[16], which is more accurate but more complicated, models the salary distribution by age. It models changes in age-related average salary structure over time. However, the first method is adopted in this thesis, as it is the more common and simpler method, which is used in actuarial valuations.

When contributions and benefits are defined as a percentage of the salary (final or career average), it is necessary to project future salaries in order to evaluate contributions and benefits. The total annual contribution income of active members of the scheme depends, mainly, on the following factors[17]:

1. The growth in the membership of the scheme (ρ);
2. The average annual contribution density $(dc(M, x, t, s))$ which is taken as the average compliance rate $(P(M))$, representing the proportion of members who pay contributions in year $(t, t+1)$ under the assumption that the $dc(M, x, t, s)$ is unity for this proportion;
3. The general salary escalation in the scheme (γ)[18];
4. The contribution rate for basic and variable salary $C(M, B/V)$;
5. The salary scale is taken into account only for the employees scheme and ignored for the other schemes where the insured income level is not a function of age.

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in the age interval $(x, x+1)$ which is effectively taken into account for the pension purpose). This function assumes that the average past service increases linearly over time.

[15] The rates of compliance are taken as assumed in Chapter 2.

[16] This method is based on the ILO-DIST Models, *1997*.

[17] Details of the assumptions underlying the projections are given in Chapters 1, 2, 4, 5 & 6.

[18] In models analysing future pension expenditures for earnings-related pensions (such as the ESSPS), a link between past work history and the resulting pensions is required.

3.5.3.1. Employees and Public and Private Workers Scheme

3.5.3.1.1 Basic Salary

The age-dependent salary scale is given by formula 2.17. So, starting from the given initial values at $t = 0$ (the start of the projection period), the average basic pensionable salary of active members aged x last birthday at discrete time points t, $(t = 1, 2, \dots, 28)$, can be modelled by the function $S(M, x, t)$[19], which represents the average total salary of all the insured members aged x last birthday at time t and is given by:

$$S(M, x, t, B) = e^{\gamma t} \times SAL(M, x, B) \qquad 0 \leq t \leq 28 \qquad (3.9)$$

The maximum annual insured basic salary covered by this scheme in year t is determined using the following function:

$$S(M, x, t, B) \leq ((550 + 250 \times e^{\gamma t}) \times 12) \quad for \quad 0 \leq t \leq 28 \qquad (3.10)$$

Hence the sum of all the basic pensionable salaries ($TS(M, t, B)$) in year $(t, t+1)$ of this scheme is given by:

$$TS(M, t, B) = \sum_{s} \sum_{x=b}^{r-1} Act(M, x, t, s) \times S(M, x, t, B) \qquad (3.11)$$

Subsequently the total contribution income can be calculated as:

$$TC(M, t, B) = dc(M, t) \times C(M, B) \times TS(M, t, B) \qquad (3.12)$$

$For\ M = C\ \&\ P$

3.5.3.1.2 Variable Salary

The variable salary is not linked to the salary scale and only changes because of salary escalation. So, the average variable pensionable salary of active members aged x last birthday at discrete time points t, $(t = 1, 2, \dots, 28)$, can be modelled by the function $S(M, x, t, V)$, which represents the average total variable salary of all the insured members aged x last birthday at time t, and is given by:

$$S(M, x, t, V) = e^{\gamma t} \times S(M, x, 0, V) \qquad (3.13)$$

The maximum annual insured variable salary maximum covered by this scheme in year t is determined using the following function:

$$\mathrm{S(M, x, t, B)} \leq ((500 \times e^{\gamma t}) \times 12) \qquad \text{for} \quad 0 \leq \mathrm{t} \leq 28 \qquad (3.14)$$

Hence the sum of all the variable pensionable salaries (TS(M, t, V)) in year (t, t+1) of this scheme is given by:

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[19] This represents per capita amounts of insured salary relevant to the social security scheme, summed for the active members in year t. It is a weighted average of the salary cohort surviving from t and that of new entrant cohort entering in the year (t, t+1), assumed to enter at age x last birthday.

$$TS(M, t, V) = \sum_{s} \sum_{x=b}^{r-1} Act(M, x, t, s) \times S(M, x, t, V) \qquad (3.15)$$

Subsequently the total contribution income can be calculated as:

$$TC(M, t, V) = dc(M, t) \times C(M, V) \times TS(M, t, V) \qquad for\ M = C \,\&\, P \qquad (3.16)$$

3.5.3.2. Self-Employed and Egyptians Working Abroad Schemes

In these two schemes there is only one pensionable salary which is regarded as the basic one, which is determined as follows.

S(M, x, t) represents the average total salary of all the insured members aged x last birthday at time t and is given by:

$$S(M, x, t) = e^{\gamma t} \times S(M, x, 0) \text{ for } 0 \leq t \leq 28 \qquad (3.17)$$

The sum of the pensionable salaries (TS) in year (t, t+1) of this scheme is given by:

$$TS(M, t, B) = \sum_{s} \sum_{x=b}^{r-1} Act(M, x, t, B) \times S(M, x, t, B) \quad 0 \leq t \leq 28 \qquad (3.18)$$

Subsequently the total contribution income can be calculated as:

$$TC(M, t, B) = dc(M, t) \times C(M, B) \times TS(M, t, B) \qquad for\ M = E \,\&\, W \qquad (3.19)$$

3.5.3.3. Casual Workers Scheme (CSIS)

No contributions are projected for this scheme. The proportion of contribution income from active members and non-government sources to the total expenditure of the CSIS (including the SPP) is not significant (around 5%) and has been declining over time, also the Treasury finances most of the benefits. It is predicted that within a few years the Treasury will finance all the liabilities of this scheme[20]. Therefore, modelling of the CSIS concentrates on projecting future liabilities.

In the following sections, general formulae for modelling the projection of annual benefits expenditure of the schemes (except the CSIS) are derived, and the differences between schemes are indicated where applicable. Separate formulae are derived in later sections for the CSIS.

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[20] This assumes that the annual expenditure is covered totally by the Treasury and if there is any income from any sources, it will only reduce the Treasury liabilities. Over the projection period it is assumed that the Treasury will cover 95% of the annual expenditure.

3.6. Modelling Annual Benefit Outgo[21]

The benefits are mainly payable on old age (including early) retirement, ill-health retirement and the death of the member. We shall focus on the benefits of a group of members all aged x last birthday. Projections will have to determine when benefit payments are to be made (demographic projection) and the level of benefits to be paid (economic projection). The actuarial formulae used in the model are constructed from the following main elements:

1. Multiple decrement tables for employee members ('service tables');
2. Scales for estimating members' future earnings;
3. Mortality tables for pensioners;
4. Mortality tables for widows and orphans of deceased members and pensioners;
5. Proportions married amongst active members and pensioners dying at each age;
6. Age differences of husbands and wives and orphans and other family statistics;
7. Compound interest functions;
8. The rules of the scheme for benefits provided on old age retirement, ill-health retirement and death.

The main benefits which subject to actuarial calculations are as follows:

(a) Pension payable for life from the attainment of the retirement age.

(b) Pension payable to widows and dependants on the death of members, both when they die whilst actively employed and when they have retired;

(c) Pension payable on total disability or lump sum payable on partial disability;

(d) Additional benefits such as end of service remuneration, death and disability compensations, death and funeral grants and orphan female's marriage grant.

The number of beneficiaries is given by the following formula:

$$TNF(M, x, t, s) = \sum_{G} G(M, x, t, s) \text{ where } G = R, N, E, I, W, D \text{ and } U \qquad (3.20)$$

The total annual benefit expenditure of the scheme M over *(t, t+1)* is estimated as the sum of the costs of providing benefits under the covered contingencies, as given by the following formula:

$$TB(M, t) = \sum_{G} TGB(M, t) \quad \text{where } G = R, N, E, I, W, D \text{ and } U \qquad (3.21)$$

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[21] The modelling of the CSIS is not included in this section as it has different characteristics of the other schemes and it is included in the later sections of projection in this Chapter.

Decrements are assumed, in general, to spread evenly across each year except for retirements, which are assumed to occur only at exact ages. Therefore, it is assumed that the service (multiple decrement) table for the active members of the ESSPS allows for two decrements, death and invalidity. The basic and variable amounts of pension are constant once the pension has been awarded. However, the total amount of pension for every individual pensioner in year *(t, t+1)* is the sum of these two amounts plus the total annual increments, which are proportion of the basic pension.

Therefore, the total amount of pension benefits is affected by three factors:

1- The annual pension increment for surviving beneficiaries;
2- The decrement of beneficiaries as a result of death and other cessation's;
3- The increment of new pensioners as a result of retirement.

Hence, the total annual benefit outgo of pensioners of the scheme in year *(t, t+1)* is given by the following formula:

$$\text{Benefit outgo} = \text{Pensions of surviving beneficiaries} + \text{Pensions of new beneficiaries} + \text{Lump sum benefits} \qquad (3.22)$$

3.6.1. Normal Retirement Benefits

The total annual benefit outgo for old-age pensions in year *(t, t+1)* is determined using the following formula.

$$TNB(M, t+1) = \left(\sum_{s} \sum_{x=r}^{\omega} TNP(M, x, t+1, s)\right) + \left(\sum_{s} TNLS(M, r, t+1, s)\right) \qquad (3.23)$$

Total normal old-age annual pension outgo in year *(t, t+1)* starting from the total annual pension outgo a year earlier, is

$$TNP(M, x+1, t+1, s) \qquad (3.24)$$

$$= \begin{cases} TNP(M, x, t, s) \times (1 - q_x^d) + TNP(M, x, t, s, B) \times (1 - q_x^d) \times \beta_t & x > r \text{ [22]} \\ NP(M, r, t+1, s, (B+V)) \times Act(M, r-1, t, s) \times (1 - {}^{*}q_{r-1}^{d} - {}^{*}q_{r-1}^{i}) & x = r \end{cases}$$

for t = 0, 1, 2,...., 28, where

---

[22] The second term of the formula gives the amount of pension increment over the year *(t, t+1)* which will be added to the pension increments in payment at the start of the year. It is a proportion of the total basic pension at time t. This total pension increment in year *(t, t+1)* is reduced by mortality over the year *(t, t+1)*. New pensioners do not get a pension increment until the beginning of the next financial year following their retirement.

$$TNP(M, x, t, s) = \left(\begin{array}{ll} TNP(M,x-1,t-1,s)\times(1-q^{d}_{x-1}) & x>r \\ NP(M,r,t,s,(B+V))\times Act(M,r-1,t,s)\times(1-{}^{*}q^{d}_{r-1}-{}^{*}q^{i}_{r-1}) & x=r \end{array}\right) \quad (3.25)$$

for $r = 60$ *for* $M = C \& P \& W$ *and* $r = 65$ *for* $M = E$, $t = 0, 1, 2, \ldots, 28$ *and*

$NP(M, r, t, s, B)$ *and* $RP(M, r, t, s, V)$ are determined as follows:

$$NP(M, r, t, s, B) = \left\{\begin{array}{ll} max\left(max(\frac{(min(36,\ PS(M,r,t,s,B))}{45},0.5)\times AS(M,r,t,s,B),55\right) & PS > 9 \\ 0 & PS \leq 9 \end{array}\right. \quad ^{23}\ (3.26)$$

for $t = 0, 1, 2, \ldots, 28$, *and* $9 < PS(M, r, s, B) \leq 36$[24]

$$NP(M, r, t, s, V) = \left(\begin{array}{ll} \frac{AS(M,r,t,s,V)\times(min(36,(max(PS(M,r,t,s,V),22.5)}{45}\times & \\ (1+0.02\times PS(M,r,t,s,V)) & PS > 9 \\ 0 & PS \leq 9 \end{array}\right) \quad (3.27)$$

for $t = 0, 1, 2, \ldots, 28$, *and* $22.5 < PS(M, r, s, V) \leq 36$[25]

Final basic pensionable earning is taken as the average earnings over the last two years immediately before retirement as follows.

$$AS(M, r, t, B) = FS(M, r, t, B) = \frac{S(M, r-1, t-1, B) + S(M, r, t, B)}{2} \quad (3.28)$$

for $M = C \& P$ *and* $L = B$

However, for variable salary it is taken as the career average salary as follows:

$$AS(M, r, t, V) = CAS(M, r, t, V) = \frac{\sum_{x=b}^{r-1} S(M,x,t,V)}{b-r} \quad (3.29)$$

---

[23] $AS(M, x, t, s, B)$ is the career average pensionable salary in the case of self-employed and Egyptian working abroad schemes and FS is the final salary in the case of other schemes. The minimum pension for the self-employed and Egyptians working abroad is LE 35 and not LE 55.

[24] In the calculations, it is assumed that all active members who attain the *NRA (r)* will be eligible for old-age pension as they will satisfy the condition of 9 years + 1 month. The reasons are:

a- The rules of the scheme permit members of the scheme to continue paying contributions until they satisfy the condition or pay the remaining contributions in lump sum;

b- It is more prudent to assume that all the active members who attain the *NRA (r)* will be eligible for old-age pension.

[25] Even if the past service of the variable salary at the NRA is less than 22.5 years (but > 9), it is taken as 22.5 years in the calculations to give a variable pension of 50-80% of the CAS, as variable salary pension provision started on 1/4/1984. This concept of variable salary does not exist for the self-employed and Egyptians working abroad schemes.

For M = E & W and L = B   *and also*   *For M = C & P and L = V*

$$TNLS(M, r, t, s) \tag{3.30}$$

= Lump sum for the end of service remuneration + Lump sum compensation for either contributory years above 36 or if the insured person does not qualify for a pension

$$\begin{aligned} TNLS(M,r,t,s) = {} & FS(M,r,t,s,B) \times max(PS(M,r,t,s,B),10) \times \\ & Act(M,r-1,t,s) \times (1 - {}^{\bullet}q^{d}_{r-1} - {}^{\bullet}q^{i}_{r-1}) \qquad for\ G = R \\ & + \begin{pmatrix} AS(M,r,t,s,B) \times max((PS(M,r,t,s,B) - 36),0) & \\ \times 1.8 \times Act(M,r-1,t,s) \times (1 - {}^{\bullet}q^{d}_{r-1} - {}^{\bullet}q^{i}_{r-1}) & if\ \ PS > 36 \\ & \\ AS(M,r,t,s,B) \times PS(M,r,t,s,B) \times 1.8 & \\ \times Act(M,r-1,t,s) \times (1 - {}^{\bullet}q^{d}_{r-1} - {}^{\bullet}q^{i}_{r-1}) & \\ + & \\ AS(M,r,t,s,V) \times (1 + 0.02 \times PS(M,r,t,s,V)) \times 1.8 & \\ \times Act(M,r-1,t,s) \times (1 - {}^{\bullet}q^{d}_{r-1} - {}^{\bullet}q^{i}_{r-1}) & if\ \ PS \leq 9 \end{pmatrix} \end{aligned} \tag{3.31}$$

[26]

for t = 0, 1, 2,…., 28,   *and*   *for G = R if PS < 10 it is taken as 10 and M ≠ H*

3.6.2. Early Retirement Benefits

The total annual benefit outgo for early retirement pensioners in year *(t, t+1)* is determined using the following formula[27]:

$$\begin{aligned} & TEB(M, t + 1) \\ & = \left(\sum_{s} \sum_{x=b+1}^{\omega} TEP(M, x, t + 1, s)\right) + \left(\sum_{s} \sum_{x=b+1}^{x=r-1} TELS(M, x, t + 1, s)\right) \end{aligned} \tag{3.32}$$

The total annual pension outgo in year *(t, t+1)* starting from the total annual pension outgo a year earlier is determined as follows:

$$\begin{aligned} & TEP(M, x + 1, t + 1, s) \\ & = \begin{pmatrix} TEP(M, x, t, s) \times (1 - q^{d}_{x}) + TEP(M, x, t, s, B) \times (1 - q^{d}_{x}) \times \beta_{t} \\ + EP(M, x, t, s, (B + V)) \times Act(M, x, t, s) \times (1 - {}^{\bullet}q^{d}_{x} - {}^{\bullet}q^{i}_{x}) \times q^{e}_{x+1} \end{pmatrix} \end{aligned} \tag{3.33}$$

[28]

for $x \geq b+20$ *for* $L = B$ & $x \geq 50$ *for* $L = V$[29], $t = 0, 1, 2,.., 28$

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[26] The end of service remuneration is payable for any cause of retirement with a minimum of 10 month of the monthly average final basic salary as it was introduced on 1/4/1984. In the case of $x > 36$, the lump sum compensation is paid only in respect of the basic salary however, in the case of $x \leq 9$ it is paid in respect of both basic and variable salaries.

[27] Early retirement is assumed to take place at exact integral ages, just before each birthday.

[28] The second term of the formula gives the amount of pension increment over the year (t, t+1) which will be added to the pension increments in payment at the start of the year. It is a proportion of the total basic pension amount at time t. This total in the case of x ≥ b+20, consists of the basic pension at (t – 1) reduced by q_{x-1} plus the new basic pension amount arise from the new early retirees over (t – 1, t). New pensioners do not get pension increment until the beginning of the following financial year. This pension increment in year (t, t+1) is reduced by the mortality over that year.

[29] Variable pension only exists for M = C & P.

$$TEP(M,x,t,s) = \begin{pmatrix} TEP(M,x-1,t-1,s)\times(1-q_x^d)+EP(M,x,t,s,(B+V)) \\ \times Act(M,x-1,t-1,s)\times(1-{}^{*}q_{x-1}^{d}-{}^{*}q_{x-1}^{i})\times q_x^e \end{pmatrix} \tag{3.34}$$

$x \geq b+20$ for (for $L = B$), $x \geq 50$ (for $L = V$), $M = C$ & P and $t = 0, 1, 2, .., 28$

$$EP(M,x,t,s,B) = \begin{pmatrix} \frac{PS(M,x,t,s,B)}{45} \times AS(M,x,t,s,B) \times (1 - RF(M,x,B)) & PS \geq 20 \\ 0 & PS < 20 \end{pmatrix} \tag{3.35}$$

$$EP(M,x,t,s,V)^{30} = \begin{pmatrix} \frac{\min(\max(PS(M,x,t,s,V),22.5),36)}{45} \times AS(M,x,t,s,V) \times (1 - RF(M,x,V)) & & \\ \times (1 + 0.02 \times PS(M,x,t,s,V)) \qquad x \geq 50 & \& & PS \geq 20 \\ 0 \qquad x < 50 & \text{or} & PS < 20 \end{pmatrix} \tag{3.36}$$

$$AS(M,x+z,t,B) = FS(M,x+z,t,B) = \frac{S(M,x+z-1,t-1,B)+S(M,x+z,t,B)}{2} \tag{3.37}$$

$$AS(M,x,t,V) = CAS(M,x,t,V) = \frac{\sum_{z=b+1}^{x} S(z,t-x+z,s,B/V)}{x-b} \tag{3.38}$$

$PS(M,x,t,B/V) \geq 20$, $b+20 \leq x < r$, $t = 0, 1, 2, ...,28$ and $M \neq H$

$$RF(M,x,V) = [(r-x) \times 0.05] \tag{3.39}$$

$$RF(M,x,B) = \begin{bmatrix} 0 & 55 \leq x \leq 60 \\ [\frac{r-x}{45} + 0.05] & 50 \leq x \leq 54 \\ [\frac{r-x}{45} + 0.10] & 45 \leq x \leq 49 \\ [\frac{r-x}{45} + 0.15] & x \leq 44 \end{bmatrix} \tag{3.40}$$

$TELS(M, x+1, t+1, s)$ (3.41)

= Lump sum for the end of service remuneration + Lump sum compensation for either contributory years above 36 or if the insured person does not qualify for a pension

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[30] The variable pension in the case of early retirement (only for M= C & P) is not payable if the age at retirement is less than 50 even if the contributory years at early retirement is more than 19 years.

$$\begin{aligned}\mathrm{TELS}(\mathrm{M}, \mathrm{x}+1, \mathrm{t}+1, \mathrm{s}) &= FS(M,x,t,s,B) \times max(PS(M,x,t,s,B),10) \\ &\quad \times Act(M,x,t,s) \times (1 - {}^{*}q_x^d - {}^{*}q_x^i) \times q_{x+1}^e \quad for \;\; G=R \qquad (3.42) \\ &+ \begin{pmatrix} AS(M,x,t,s,B) \times max((PS(M,x,t,s,B)-36),0) & \\ \times 1.8 \times Act(M,x,t,s) \times (1 - {}^{*}q_x^d - {}^{*}q_x^i) \times q_{x+1}^e & if \quad PS > 36 \\ & \\ AS(M,x,t,s,(B/V)) \times PS(M,x,t,s,(B/V)) \times 1.8 & \\ \times Act(M,x,t,s) \times (1 - {}^{*}q_x^d - {}^{*}q_x^i) \times q_{x+1}^e \quad if \;\; PS < 20 \;\; and/or \; x < 50 \; for \, V & \end{pmatrix}\end{aligned}$$

$b \leq x \leq r\text{-}1,\ and\ t = 0,\ 1,\ 2, \ldots ., \ 28\ and\ M \neq H$

3.6.3. Invalidity Benefits

The total annual benefit outgo for invalidity retirement pensioners in year *(t, t+1)* is determined using the following formula:

$$TIB(M, t+1) = \left(\sum_s \sum_{x=b}^{\omega} TIP(M, x, t+1, s)\right) + \left(\sum_s \sum_{x=b}^{x=r-1} TILS(M, x, t+1, s)\right) \qquad (3.43)$$

The total annual pension outgo in year (t, t+1) starting from the total annual pension outgo a year earlier is determined as follows:

$$TIP(M, x+1, t+1, s) = \begin{pmatrix} TIP(M, x, t, s) \times (1 - q_x^{id}) + TIP(M, x, t, s, B) \times (1 - q_x^{id}) \times \beta_t \\ + IP(M, x, t, s, (B+V)) \times Act(M, x, t, s) \times (1 - 0.5\ {}^{*}q_x^d) \times {}^{*}q_x^i \end{pmatrix} \qquad (3.44)$$

$for\ b \leq x \geq r\text{-}1,\ \ t = 0,\ 1,\ 2, \ldots .,\ 28,\ and\ M \neq H$

where

$$TIP(M,x,t,s) = \begin{pmatrix} TIP(M, x-1, t-1, s) \times (1 - q_{x-1}^{id}) + IP(M,x,t,s,(B+V)) \times \\ Act(M, x-1, t-1, s) \times (1 - 0.5\ {}^{*}q_x^d) \times {}^{*}q_x^i + \\ WP(M,x,t,s,B/V) \times Act(M, x-1, t-1, s) \times (1 - 0.5\ {}^{*}q_x^d) \times {}^{*}q_x^w \end{pmatrix} \qquad (3.45)$$

$$IP(M, x, t, s, B) = \qquad (3.46)$$

$$max\left(max\left[\frac{min(PS(M, x, t, s, B) + min(3, (r - x)), 36)}{45}, 0.65 \right] \times AS(M, x, t, s, B), 40 \right)$$

$for\ b \leq x \geq r\text{-}1,\ \ t = 0,\ 1,\ 2, \ldots .,\ 28,\ and\ M \neq H$

$$IP(M, x, t, s, V) = \qquad (3.47)$$

$$\left(min \left\{ \begin{matrix} \dfrac{min(max(PS(M, x, t, s, V) + min((r - x), 3), 22.5), , 36)}{45} \\ \times\ AS(M, x, t, s, V)) \times (1 + 0.02 \times PS(M, x, t, s, V)) \end{matrix} \right\}, 40 \right)$$

The pension for invalidity retirement pensioners arising from work or illness injuries is determined as follow:

$$WP(M, x, t, s, B/V) = \left(max\left(AS(M, x, t, s, (B + V)) \times 0.80,\ 35\right)\right) \tag{3.48}$$

$b \leq x \geq r\text{-}1,\ t = 0, 1, 2, \ldots.., 28 \text{ and } M \neq H$

$$AS(M, x+z, t, B) = S(M, x+z, t, B) \tag{3.49}$$

$AS(M, x, t, s, V)$ is determined as in formula *3.38.*

$$TILS(M, x+1, t+1, s) \tag{3.50}$$

= Lump sum for the end of service remuneration

+ Lump sum compensation for contributory years above 36

+ Lump sum compensation for the invalidity or work injuries contingencies

$$TILS(M, x + 1, t + 1, s)$$
$$= \left(\begin{array}{ll} FS(M, x, t, s, B) \times max(PS(M, x, t, s, B), 10) & \\ \times\ Act(M, x, t, s) \times (1 - 0.5\ {}^{*}q_x^d) \times {}^{*}q_x^i & \text{for } G = R \\ + & \\ AS(M, x, t, s, B) \times max((PS(M, x, t, s, B) - 36), 0) & \\ \times\ 1.8 \times Act(M, x, t, s) \times (1 - 0.5\ {}^{*}q_x^d) \times {}^{*}q_x^i & PS > 36 \\ + & \\ AS(M, x, t, s, B/V) \times Pr(x) & \\ \times\ Act(M, x, t, s) \times (1 - 0.5\ {}^{*}q_x^d) \times {}^{*}q_x^i & \\ & \\ AS(M, x, t, s, B/V) \times Pr(x) \times 1.5 & \\ \times\ Act(M, x, t, s) \times (1 - 0.5\ {}^{*}q_x^d) \times {}^{*}q_x^w & \end{array} \right) \tag{3.51}$$

$b \leq x \leq r\text{-}1$, and $t = 0, 1, 2, \ldots.., 28$ and $M \neq H$

3.6.4. Death Benefits

Social security pension schemes almost invariably cover the risk of death and provide pensions to survivors (generally, widows/widowers and orphans[31]) of those who die during active service or when in receipt of a retirement or invalidity pension. The ESSPS provide survivors' benefits as explained in Chapters 1 & 2. Survivors' benefits form a significant part of the liabilities of the ESSPS, as the system's rules make the likelihood of distributing the full pension between the survivors of the deceased member approximately certain.

By examining the data over 1990-99, it was found that the number and amount of benefit for siblings, parents and widowers[32] were not significant in proportion to

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[31] Also siblings and parents in the ESSPS; however they are ignored in our model as a simplification and it is assumed that the 100% of the pension is divided between the widow and two orphans.

[32] The recorded number of widower pension cases over 1990-99 represented less than 1% of the total death cases and the likelihood that this situation will change in the future is not significant. However, the expected increase in female labour force participation may represent an increasing share in the future expenditure for widowers' pension

widows and orphans. Therefore, it was decided to ignore them in modelling future survivors' benefits of the system[33]. Therefore, the assumption is that every deceased male will leave behind a widow, son and daughter and they will share the 100%[34] of the pension amount of the deceased member in the proportions 50%, 25% and 25% respectively, as explained in Chapter 2. In respect of the death of a female member, it is assumed that there will be son and daughter survivors and only 2/3 of the pension amount is inherited (50% for each of the 2/3 of the pension of the deceased member). Daughters will act as a proxy for sisters and mothers and sons will act as a proxy for brothers and fathers. This assumption takes a prudent view and reduces the tedious levels of assumptions and calculations of survivors' benefits.

The inclusion of survivors' pensions requires the derivation of actuarial formulae for death benefits provided to adult dependants and dependent children. This includes the use of proportions for married members and for average age differences of members and dependants. The total annual death benefit outgo for the beneficiaries of the system over a year *(t, t+1)* can be determined using the following formula:

$$\text{Death benefit outgo} = \text{Death in service benefits} + \text{Death after retirement benefits} + \text{Funeral and death grants' costs} \qquad (3.52)$$

$$\text{Survivors Benefits} = \text{Widow Benefits} + \text{Orphans Benefits} \qquad (3.53)$$

The total annual benefit outgo for death benefits in year *(t, t+1)* is determined using the following formula:

$$TDB(M,t+1) = \left(\sum_{y_x=x-d_z}^{\omega} \sum_{z=0} TDP(M,(y_x \,\&\, z),t+1) \right) + \left(\sum_{x=b}^{\omega} \sum_{z=16} TDLS(M,(x \,\&\, z),t+1) \right) \qquad (3.54)$$

where

$$TDP(M,(y_x \,\&\, z),t+1) = \left(\sum_{y_x=x-d_x}^{\omega} TDP(M,y_x+1,t+1) \right) + \left(\sum_{Z_f=0}^{\omega} TDP(M,Z_f+1,t+1) \right) + \left(\sum_{Z_m=2}^{\omega} TDP(M,Z_m+1,t+1) \right) \qquad (3.55)$$

---

[33] The available data on the 1/7/1997 of brothers, fathers and widowers were integrated with sons and of sisters and mothers were integrated with daughters.

[34] This assumption is supported by the following arguments:

1. The system is generous in giving benefits to survivors as it gives benefits to a large chain of relatives of the deceased member, a phenomenon which puts a heavy liabilities on the system;
2. The system's experience shows that a significant share of the expenditures goes to the survivors;
3. The actuaries of the system usually make the same assumptions.

Similar formulae to that developed for old age and invalidity retirement are used here with the introduction of 'proportions married' into the factors[35]. Widows' pensions are usually valued by formulae of the same general type as those developed for members' pensions, but including extra functions, when required. The total annual pension outgo for widows in year *(t, t+1)* starting from the total annual pension outgo a year earlier is determined as follows:

$$TDP(M, y + 1, t + 1)$$

$$= \begin{pmatrix} TDP(M, y, t) \times (1 - {}^{*}q_y^{d_{rm}} - {}^{*}q_y^{rm_d}) + TDP(M, y, t, B) \\ \times (1 - {}^{*}q_y^{d_{rm}} - {}^{*}q_y^{rm_d}) \times \beta_t + 0.5 \times NDP(M, y_x, t) \end{pmatrix}^{36} \tag{3.56}$$

for $(x\text{-}d_x) \leq y \leq \omega$ *for* $t = 0, 1, 2,.., 28$

The annual pension outgo for orphans (females and males respectively) in year (t, t+1) starting from the total annual pension outgo a year earlier is determined as follows:

$$TDP(M, Z_f + 1, t + 1)$$

$$= \begin{pmatrix} TDP(M, Z_f, t) \times (1 - {}^{*}q_{Z_f}^{d_m} - {}^{*}q_{Z_f}^{m_d}) + TDP(M, Z_f, t, B) \\ \times (1 - {}^{*}q_{Z_f}^{d_m} - {}^{*}q_{Z_f}^{m_d}) \times \beta_t + 0.25 \times NDP(M, (z_{f,x}), t) \end{pmatrix} \tag{3.57}$$

for $0 \leq Z_f \geq \omega$ *for* $t = 0, 1, 2,.., 28$ *and*

$$TDP(M, Z_m + 1, t + 1)$$

$$= \begin{pmatrix} TDP(M, Z_m, t) \times (1 - {}^{*}q_{Z_m}^{d}) + TDP(M, y, t, B) \\ \times (1 - q_{Z_m}^{d}) \times \beta_t + 0.25 \times NDP(M, (z_{m,x}), t) \end{pmatrix} \tag{3.58}$$

for $2 \leq Z_m \geq Z^{*}$[37] *for* $t = 0, 1, 2,.., 28$

$$NDP(M, x, t) = \sum_{K = Act \& G} D_K P(M, x, t)$$

$$= \begin{bmatrix} (TNP(M, x, t, s) + TEP(M, x, t, s)) \times q_x^d \times h_x + TIP(M, x, t, s) \times q_x^{id} \\ \times h_x + DP(M, x, t, (B + V)) \times Act(M, x, t) \times (1 - 0.5\, {}^{*}q_x^i) \times {}^{*}q_x^d \times h_x \end{bmatrix} \tag{3.59}$$

for $b \leq x \geq \omega$ *for* $t = 0, 1, 2,.., 28$

DP(M, x, t, B/V) is found by using the formula *3.46* & 3.47 and *AS(M, x, t, s, B)* and *AS(M, x, t, s, V)* are found from formulae *3.49* and *3.38*.

---

[35] This is known as the 'collective' method of valuation (Lee, 1986).

[36] By examining the data for female marriage and remarriage, it is found that the probability of female remarriage is significantly lower than the probability of marriage for the first time.

[37] Invalid sons and brothers can continue receive their pension beyond the age of Z^{*}. By examining the data of the system, it was found that only 10% of the number of sons and brothers continue to receive pension after the age of Z^{*}.

3.6.4.1. Lump Sums and Additional Survivors Benefits

There are some other survivors' benefits, which are paid in the form of a lump sum as explained in Chapter 1. These include the following:

$$TDLS(M, x+1, t+1, s) \tag{3.60}$$

= Lump sum for the end of service remuneration

+ Lump sum compensation for the death contingency

+ Lump sum compensation for contributory years above 36

+ Death and funeral grants[38] + Marriage and student grants[39]

$$TDLS(M, x+1, t+1, s)$$

$$\left[\begin{array}{ll}
FS(M, x, t, s, B) \times max(PS(M, x, t, s, B), 10) & \\
\times\ Act(M, x, t, s) \times (1 - 0.5\,{}^{*}q_x^i) \times {}^{*}q_x^d & for\ G = R \\
+ & \\
AS(M, x, t, s, B/V) \times Pr(x) & \\
\times\ Act(M, x, t, s) \times (1 - 0.5\,{}^{*}q_x^d) \times {}^{*}q_x^i & \\
+ & \\
AS(M, x, t, s, B) \times max((PS(M, x, t, s, B) - 36), 0) & \\
\times\ 1.8 \times Act(M, x, t, s) \times (1 - 0.5\,{}^{*}q_x^i) \times {}^{*}q_x^d & PS > 36 \\
+ & \\
\left(\begin{array}{l} 5 \times ((TNP(M, x, t, s) + TEP(M, x, t, s)) \times q_x^d \\ + TIP(M, x, t, s) \times q_x^{id} + DP(M, x, t, (B + V)) \\ \times\ Act(M, x, t) \times (1 - 0.5\,{}^{*}q_x^i) \times {}^{*}q_x^d) \end{array}\right) & \\
+ & \\
\left(\begin{array}{l} max(12 \times (TDP(M, Z_f, t) + TDP(M, y, t, B) \times \beta_t) \\ \qquad \times (1 - {}^{*}q_{Z_f}^{d_m}) \times ({}^{*}q_{Z_f}^{m_d}), 100) \end{array}\right) & Z_f \geq 15
\end{array}\right] \tag{3.61}$$

$b \leq x \leq r\text{-}1,\ t = 0, 1, 2, \ldots., 28\ and\ M \neq H$

Similar formulae to *3.52-3.59*, without the term for widow's pension, the inclusion of the proportion of 2/3 in the formula *3.47* and the proportion of married females (h_y) are applied in the case of the death benefits for deceased female members.

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[38] The death grant is 3 month of the total monthly pension amount and the funeral grant is 2 month of the total monthly pension amount with a minimum of LE 200.

[39] A "marriage grant" equal to the maximum of one-year's daughter pension and LE 200 is given to the daughters of the deceased member when they marry or remarry but it is payable only once. The pension itself ceases on the marriage of the female orphan of the deceased member. A "student grant" is given to the orphan male student when he finishes study and stops receiving pension. However, because there is no available data to project the cost of the "student grant", only a small loading would be added to the additional cost of survivors' benefits. The loading for the "student grant" benefit would be in keeping with the past experience of the scheme.

3.6.5. Unemployment Benefits

Such benefits are often allowed for in projection and valuation by loading the value of benefits by a percentage, or by setting up a contingency reserve as appropriate, in the light of the general experience. For modelling the annual unemployment benefits expenditure, we will be prudent and assume that the full benefit as explained in Chapters 1 & 2, is paid for each claim. The annual amount of unemployment benefits can be projected in year *(t, t+1)* using the following formula:

$$TUB(P, x, t, s)$$

$$= AS(M, x, t, s, B/V) \times 0.6 \times 7 \times \mathrm{Act}(M, x, t, s) \times (1 - {}^{\bullet}q_x^d - {}^{\bullet}q_x^i) \times q_{x+1}^u \qquad (3.62)$$

3.7. Projection of Benefits outgo of the CSIS

This scheme has to be modelled separately. It is not insurance-based like the other schemes and is mainly intended to provide social assistance benefits rather than social insurance-based benefits. Therefore, the aim is to estimate the amount of money that would have to be set aside annually to cover the emerging pension obligations of the scheme. The total annual expenditure on benefits to pensioners and survivors of this scheme will be mostly financed by the treasury (assumed to be 95% in this model). No reserves of any kind are held for this scheme.

The benefit expenditure is split between the original CSIS and the SPP (the CSIS' pension amount is always greater than that of the SPP[40]) as explained in Chapter 1. However, the number of SPP members has been decreasing significantly[41], as it has been closed to new members since the second half of the 1980s[42] and the majority of its members were already above the age of 65. Therefore, the SPP is no longer a significant scheme. It is assumed that there is only one category of beneficiaries belonging to the main CSIS and the total cost of providing benefits is calculated under this assumption. This reduces the tedious level of calculations of benefits and takes the prudent side, which is the normal approach in actuarial projections and valuations.

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[40] Examination of the data indicates that the scheme should not have any pension cases from the SPP by year 2010.

[41] Only people aged 65 and over and without any type of pension were allowed to join this scheme, particularly widows and divorced women.

[42] The proportion of the SPP pension cases to the total pension cases under the CSIS has been decreasing significantly over time.

The modelling of future benefit expenditure will depend on the future structure of the beneficiaries of this scheme which is determined by the following formula[43]:

$$TNF(M, x, t, s) = \sum_{G} G(H, x, t, s) \text{ where } G = N, I, \text{ and } D \qquad (3.63)$$

Hence, the total annual benefit expenditure of the scheme over *(t, t+1)* is estimated as the sum of the costs of providing benefits under the covered contingencies, as given by the following formula:

$$TB(M, t) = \sum_{G} TGB(M, t) \quad \text{where } G = N, I, \text{ and } D \qquad (3.64)$$

The basic pension plus the total annual increments is a flat amount to all pensioners in year *(t, t+1)* (of course different for the survivors of the deceased member). Therefore, the total amount of pension benefits is affected by the three factors mentioned in section 3.6. Hence, the total annual benefit outgo of pensioners of the scheme in year *(t, t+1)* is determined according to the formula 3.20.

3.7.1. Normal Retirement Benefits

The total annual benefit outgo for old-age pensions in year *(t, t+1)* is determined using the following formula[44].

$$TNB(H, t+1) = \left(\sum_{s} \sum_{x=r}^{\omega} TNP(H, x, t+1, s) \right) \qquad (3.65)$$

Total normal old-age annual pension outgo in year *(t, t+1)* starting from the total annual pension outgo a year earlier, is

$$TNP(H, x+1, t+1, s)$$

$$= \begin{cases} TNP(H, x, t, s) \times (1 - q_x^d) + TNP(H, x, t, s, B) \times (1 - q_x^d) \times \beta_t & x > r \text{ [45]} \\ AM(H, t) \times Act(H, r-1, t, s) \times (1 - {}^{*}q_{r-1}^{d} - {}^{*}q_{r-1}^{i}) & x = r \end{cases} \qquad (3.66)$$

for $b \leq x \leq r$, $b = 21$, $r = 65$, $t = 0, 1, 2, \dots, 28$,

where

TNP(H, x, t, s, B)

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[43] Retirement is assumed to occur only at exact age 65. Therefore, it is assumed that the service table for the active members of the CSIS allows for two decrements, death and invalidity with the assumption that they spread evenly across each year of age.

[44] The assumption here is that all active members who attain age 65 will be eligible for old-age pension as explained earlier.

[45] The second term of the formula gives the amount of pension increment over the year *(t, t+1)* which will be added to the pension increments in payment at the start of the year. It is a proportion of the total basic pension amount at time t. This total pension increments in year *(t, t+1)* is reduced by the rate of mortality over the year *(t, t+1)*. It has to be noted that new pensioners do not get pension increment until the beginning of the next financial year following their retirement.

$$= \begin{pmatrix} TNP(H, x-1, t-1, s, B) \times (1 - q^{d}_{x-1}) & x > r \\ AM(H, t) \times Act(H, r-1, t, s) \times (1 - {}^{*}q^{d}_{r-1} - {}^{*}q^{i}_{r-1}) & x = r \end{pmatrix} \qquad (3.67)$$

for $b \leq x \leq r$, $b = 21$, $r = 65$, $t = 0, 1, 2, \ldots., 28$

3.7. 2. Invalidity Benefits

The total annual benefit outgo for invalidity retirement pensioners in year *(t, t+1)* is determined using the following formula:

$$TIB(H, t+1) = \left(\sum_{s} \sum_{x=b}^{\omega} TIP(H, x, t+1, s)\right) + \left(\sum_{s} \sum_{x=b}^{x=r-1} TILS(H, x, t+1, s)\right) \qquad (3.68)$$

The total annual pension outgo in year *(t, t+1)* starting from the total annual pension outgo a year earlier is determined as follows:

$$TIP(H, x+1, t+1, s) = \begin{pmatrix} TIP(H, x, t, s) \times (1 - q^{id}_{x}) + TIP(H, x, t, s, B) \times (1 - q^{id}_{x}) \times \beta_{t} \\ + AM(H, t) \times Act(H, x, t, s) \times (1 - 0.5\ {}^{*}q^{d_i}_{x}) \times {}^{*}q^{i_d}_{x} \end{pmatrix} \qquad (3.69)$$

for $b \leq x \leq r-1$, $b = 21$, $r = 65$, $t = 0, 1, 2, \ldots., 28$, *and*

$$TIP(H, x, t, s, B) = \begin{pmatrix} TIP(H, x-1, t-1, s, B) \times (1 - q^{id}_{x-1}) + AM(H, t) \\ \times Act(H, x-1, t-1, s) \times (1 - 0.5\ {}^{*}q^{d_i}_{x}) \times {}^{*}q^{i_d}_{x} \end{pmatrix} \qquad (3.70)$$

$TILS(M, x+1, t+1, s)$=Lump sum compensation for the invalidity contingency *(3.71)*

$$TILS(M, x+1, t+1, s) = \left(AM(H, t) \times Pr(x) \times \mathrm{Act}(M, x, t, s) \times (1 - 0.5\ {}^{*}q^{d_i}_{x}) \times {}^{*}q^{i_d}_{x}\right) \qquad (3.72)$$

$b \leq x \leq r-1$, $t = 0, 1, 2, \ldots., 28$

3.7.3. Death Benefits

The CSIS provide survivors' pension, in addition to retirement and invalidity pensions, in the same manner as other schemes, as explained in Chapter 1. The arguments mentioned in section 3.6.4. apply to the death benefits of the CSIS. The total death benefit of the scheme is determined using the formula 3.50. The total annual benefit outgo for death benefits in year *(t, t+1)* is determined using the formulae 3.52-356. However, the total death pension amount of a new deceased member is determined using the following formula:

$$DPT(H, x, t) = \sum_{K = Act \& G} D_K P(H, x, t)$$

$$= \begin{bmatrix} (TNP(H, x, t, s) \times q_x^d \times h_x + TIP(M, x, t, s) \times q_x^{id} \times h_x \\ + AM(H, t) \times Act(M, x, t) \times (1 - 0.5\ {}^{*}q_x^i) \times {}^{*}q_x^d \times h_x \end{bmatrix} \tag{3.73}$$

$for\ b \leq x \leq r\text{-}1,\ t = 0, 1, 2, \ldots, 28,$

3.7.3.1. Lump Sums and Additional Survivors Benefits

There are some other survivors' benefits, which are paid in the form of a lump sum as explained in Chapter 1. These include the following:

= Lump sum compensation for the death contingency + Funeral grant[46] (3.74)

$TDLS(M, x+1, t+1, s)$

$$\begin{bmatrix} AS(M, x, t, s, B/V) \times Pr(x) \\ \times \mathrm{Act(M, x, t, s)} \times (1 - 0.5\ {}^{*}\mathrm{q}_x^d) \times {}^{*}\mathrm{q}_x^i \\ + \\ max\left(2 \times \begin{pmatrix} 2TNP(H, x, t, s) \times q_x^d + TIP(M, x, t, s) \times q_x^{id} \\ + AM(H, t) \times Act(M, x, t, s) \times (1 - 0.5\ {}^{*}q_x^i) \times {}^{*}q_x^d \end{pmatrix}, 200\right) \end{bmatrix} \tag{3.75}$$

$b \leq x \leq r\text{-}1, t = 0, 1, 2, \ldots, 28$

3.8. Projecting Future Treasury Subsidy

The Treasury subsidies to different schemes are also considered as part of the projections of the income and outgo of the annual cash flow using the following formula:

$TTS\ (ESSPS, t)$ (3.76)

$$= 1\% \times \sum_{M = V,P,T} TS(M, t, B / V) + \sum_{\forall M} TGP(M, x, t, s, I) + 95\% \times \sum TB(H, x, t, s, B)$$

3.9. Total Income, Expenditure and Surplus of the System

In projecting future income and expenditure of the ESSPS the following formulae were also employed:

$$TI(M, t) = TC(M, t) + TIR(M, t) + TS(M, t) \qquad for\ all\ M \tag{3.77}$$

$$F(M, t + 1) = \left[F(M, t) \times e^{\delta_t} + \left((TI(M, t + 1) - TE(M, t)) \times e^{\frac{1}{2}\delta}\right)\right] \tag{3.78}$$

$for\ M = GSF\ \&\ PPSF$

$$TS(GSF, t) = 1.0\% \times TS(C, t) + + TB(C, t, I) \tag{3.79}$$

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[46] The funeral grant is 2 months of the flat monthly pension amount with a minimum of LE 200.

$$TS(PPSF, t, I) = 0.95\% \times TB(H, t) + 1.0\% \times TS(P, t) + TB(M, t, I) \tag{3.80}$$

$$for\ M = P, E, W$$

$$TB(GSF, t) = TG(C, t) = TGP(C, x, t, s) + TGLS(C, x, t, s) \tag{3.81}$$

$$TB(PPSF, t) = TGP(M, x, t, s) + TGLS(M, x, t, s)\ for\ M{=}P, E, W\ and\ H \tag{3.82}$$

$$TAC(GSF, t) = 0.45\% \times TS(C, t) \tag{3.83}$$

$$TAC(PPSF, t) = 1.0\% \times TS(PPSF, t) \tag{3.84}$$

$$TE(M, t) = TB(M, t) + TAC(M, t) \qquad for\ M = GSF\ \&\ PPSF\ \&\ ESSPS \tag{3.85}$$

$$NI(M, t)^{47} = TI(M, t) - TE(M, t) \qquad for\ M = GSF\ \&\ PPSF\ \&\ ESSPS \tag{3.86}$$

$$FI(M, t) = NI(M, t) \qquad for\ M = GSF\ \&\ PPSF\ \&\ ESSPS \tag{3.87}$$

$$F(M, t{+}1) = F(M, t) + NI(M, t{+}1) \quad for\ M = GSF\ \&\ PPSF\ \&\ ESSPS \tag{3.88}$$

$$TTS(ESSPS, t) = TS(GSF, t) + TS(PPSF, t) \tag{3.89}$$

3.10. Actuarial Present Value Valuation Technique

The present value valuation technique provides additional financial insight and is therefore a useful adjunct to the projection technique. This technique considers one cohort of insured persons at a time and computes the probable present values of future insured salaries, on the one hand, and of the benefits payable to the members of the cohort and their survivors, on the other. This technique is naturally suited to the valuation of schemes which are generally fully funded. The actuarial valuation determines whether the scheme can be expected to remain in balance over a longer period and it will also determine the actuarial cost and the level of funding.

The actuarial balance is measured as the difference between the present value of assets and the present value of liabilities over the period of the valuation, taking into account the fund balance at the valuation date. This balance (surplus/deficit) at the valuation indicates the actuarial funding level of the scheme which will depend not only on the assumptions used in preparing the estimates of the financial status of the scheme but also on the method of financing and/or the actuarial cost method used.

A number of pension schemes are either fully or partially funded and buffer funds may also exist in many PAYG schemes[48]. The PAYG and partially funded pension

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[47] This is the 'total cash-flow balance', which is defined as the contribution income plus the state subsidy less expenditure although recent experience has shown that there is a risk that the Treasury may fail to pay the full amount.

[48] The unfunded social security schemes valuation is carried out on forward projections of expenditures and insured-salaries with no standard contribution rate, no standard fund and therefore no asset/liability ratio established at each valuation based on service to date. The portion of the cost which is to be met each year is generally expressed as a percentage of annual pensionable salary.

schemes involve inter-generational transfers, which are acceptable in a social security scheme but are not intended for an occupational scheme[49]. The principles used in the valuation of occupational pension schemes can also apply to funded public sector schemes, although in practice the basis for an occupational pension scheme may differ from that for a social security pension scheme (Iyer, S., 1999). Occupational pension schemes are considerably more pre-funded than social security pension schemes and as a consequence, such schemes generally accumulate large funds. The funding methods applied to occupational pension schemes are essentially an extension of financing methods applied to social security pension schemes (Iyer, S., 1999).

The ESIPS has characteristics which are not very different from that of occupational pension schemes[50]. The ESIPS applies the accruals accounting principle, which suggests that the cost of an employee's pension should be charged over the period of his/her employment. The benefits are based on a formula which is strictly proportional to the period of contributory service and to the terminal salary (at retirement) of the member. The ESIPS generally aims to achieve financial equilibrium on a "closed fund" basis, meaning that only the existing membership is brought into the equation, thereby excluding future entrants. In this manner, equilibrium is established independently of the new entrants. However, provided future entrants are also, as a group, in financial equilibrium, the scheme will also be in actuarial balance on an "open fund" basis (Iyer, S., 1999).

3.11. Main Actuarial Funding Methods[51]

In a funded defined benefit scheme the aim is to build up assets, which will be sufficient to cover future liabilities of the members. Therefore, the scheme actuary has to determine the required contribution rate to achieve this goal following every actuarial valuation. Actuaries have devised a number of different actuarial funding methods for defined benefit schemes. These methods refer to the way of determining

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[49] However, the French complementary occupational pension schemes are effectively PAYG and most of the German occupational pension schemes are operated by establishing book reserves within the account of the employers to recognise the accrued pension liabilities. But in 1985, PAYG and Book-reserving occupational pension schemes were outlawed in Belgium because of concerns about the security of members' benefits in the event of the employer's bankruptcy (Daykin, 1999).

[50] It can be argued that the State in Egypt works as the employer sponsoring the system and therefore, has to cover any actuarial deficit at any valuation.

[51] When the PAYG system of financing pension schemes is excluded, the word "funding" is used and the funding methods are referred as the actuarial cost methods.

the amount and timing of contributions made to meet the cost of providing retirement benefits and also define the "target fund" that should be held at a particular point in time. Each method gives a general formula for calculating the contribution to the scheme, which applies whether or not the scheme is mature or has a stationary population of members. The calculations are always based on the details of the current population of the scheme, but in projecting the benefit payments to be made population development is also projected.

There are certain requirements which should be met by all actuarial funding methods. Firstly, all funding methods should aim to accumulate a fund over the service life of each active member sufficient to pay for the benefits of that member. Secondly, the method has to establish the Standard Contribution rate required by each active member and also the Standard Fund, which is the target fund for each member (including pensioners). Any particular actuarial cost method could be judged on certain criteria. This includes, in particular, the relative stability of the cost, expressed as percentage of salaries and the resilience of the contribution rate to a closure of the scheme to new entrants and security[52] (Lee, 1986). The actuarial cost methods can be divided into two groups: individual methods and aggregate methods.

3.11.1. Individual Cost Methods

Individual cost methods which are closed group methods address the adjustments required for achieving the closed-fund financial equilibrium of the initial population. In such methods the actuarial functions are applied to yield the standard contribution rate and the standard fund for each participant which are then summed for individual members. The most common actuarial valuation methods currently used for pension schemes are; Entry age method, Attained age method, Projected unit (and Projected accrued) method and Current unit method.

Only the entry age method is mentioned in the following section as it has an important connection with the ESIPS. The adequacy of the level of payable contribution is measured in comparison with the entry age actuarial cost. The aggregate method is the actuarial cost method employed in the actuarial valuation of the ESIPS, and therefore, we concentrate on the aggregate cost method of funding retirement liabilities.

3.11.1.1. Entry Age Actuarial Cost Methods

The Entry Age Method (EAM) seeks to establish a level contribution rate required to fund the future benefits of a new entrant at the assumed entry age. The rationale of the method is that the prospective retirement benefits of an employee should be funded at a uniform percentage of compensation or in uniform annual increment over the entire working lifetime. Taking retirement pension as an example, the contributions paid over a new entrant generation's active lifetime should, by retirement age, accumulate capital value sufficient to finance the benefits being provided. The standard contribution rate is determined as "the required rate to fund the benefits of a member entering the scheme at a fixed "entry age[53] (Khorasanee, 2000). This rate, as a percentage of earnings, is found by solving the following equation:

Present value of future contributions at entry = Present value of future benefits at entry

(3.90)

The "normal cost", as a function of time, refers to the total contributions then payable by the active members, based on the age at entry related contribution rate function. This cost would be unaffected if the age distribution of the active population shifted upwards or the scheme is closed to new entrants. The Standard Fund is found to be the difference between the present value of total future benefits for all members, and the present value of future contributions of active members of the scheme.

Normal Entry Age Method (EANM)[54]: This method assumes, for simplicity, that all new cohorts will enter at the same age b and retire at a single age r. The standard contribution rate is derived by reference to an active member entering at this "normal" entry age which is then applied to the whole of the active membership. So, the contribution rate will be the average premium for all new entrants and will be the same at all values of x assuming that the experience coincides with the initial assumptions. A stable contribution rate will be achieved only if new entrants have on average an entry age equal to the "normal" entry age used in the method[55].

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[52] May be described in terms of the required amount of the standard fund to be held at any one time in relation to the liabilities.

[53] The rate is normally determined by reference to an active member entering at the "normal" entry age and will then applied to the whole of the active membership.

[54] The "Entry Age" method = the "Entry Age Normal" method as defined in the UK and it is occasionally used for pension funds in the UK and Spain and it is also used in Germany for book reserved pension plans.

[55] The "normal" entry age is either estimated by the actuary by reference to the experience of the actual membership, or calculated from the decrement table employed.

3.11.2. Aggregate Cost methods[56]

In aggregate or group actuarial cost methods (ACM) contributions are determined on a collective basis and not as a sum of contributions for individual participants. The standard fund and standard contribution rate are not defined. The aim is to establish for the active members of the scheme a level contribution rate such that the existing fund plus the future contributions will be sufficient to finance all future benefits. If the pension scheme is closed to new entrants, then the contribution rate calculated using this method should be stable (Haberman, S. et al., 1999). In this method, the time-related contribution is that level rate which would ensure the closed fund financial equilibrium of the scheme at that time, taking into account the accumulated fund. Such methods define a contribution rate that depends on the level of funding.

The method used to be, in general, the most common approach to funding defined benefit schemes and in particular pension schemes where benefits are dependent upon the salary of the employees concerned. It is still used for many schemes, especially those which are closed to new entrants or have a small number of active members. If applied to a scheme with a stationary population of members, the contribution will tend asymptotically to entry age method's standard contribution and the fund will tend asymptotically to entry age method's standard fund (Khorasanee, 1997). The equation of equilibrium in this method is defined as[57]:

$$\textit{Existing fund} + \textit{Present value of future contribution} = \textit{Present value of future benefits} \tag{3.91}$$

The method calculates the value of the projected benefits for the members, based on both past and future service together. It then deducts the value of whatever assets have been accumulated in the fund and works out the level percentage contribution rate needed for existing members over their future service in order to provide the balance. Theoretically, the contribution rate will remain constant if all actuarial assumptions are borne out in practice and the group remains closed. In practice, of course, the assumptions will not be realised precisely and the group will have both increments and decrements. Hence, except for coincidence, the contribution rate will change following every valuation.

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[56] They are used occasionally for pension funds in the UK, Ireland and Portugal and for insured pension schemes in Belgium.

[57] The calculation will normally be made by reference to projected benefits.

3.12. Actuarial Valuation of the ESIPS

The valuation of the ESIPS aims to specify the surplus/deficit of the system using the actuarial aggregate cost method. The surplus/deficit is calculated as the present value of the assets, plus the present value of contributions of the active members, (assuming a closed fund)[58] less the present value of future liabilities toward the existing members, (active, pensioners and dependants) on the valuation date.

This means that to have a 100% funding level (defined as the actuarial equilibrium of the system), the present value of liabilities, less the present value of contributions, has to be matched by the available assets on the valuation date. If there are not enough assets to match the liabilities, the balance has to be amortised by higher interest rates on the invested assets[59] as well as a transfer from the Treasury. The Government is also committed to discharge any unfunded liability, and the cost of raising pensions, through a transfer from the Treasury. Therefore such increases or any additional benefits are not taken into account in the valuation of the system.

3.12.1. Objectives of the Actuarial Valuation

The actuarial viability of the ESIPS is assessed in accordance with the following actuarial objectives:

1- To have a funding ratio (FR) of 100%;

2- To amortise any deficit before the following actuarial valuation;

3- To confirm whether or not the current contribution rates are sufficient to meet future liabilities for new entrants under an assumed interest rate and different entry ages.

In analysing the system's funding level[60], there are specific questions raised, such as:

1. What is the required interest rate[61] on the invested funds to keep the surplus/deficit at zero over specific period (e.g. the actuarial valuation intervals);
2. How the FR of the system would change as a result of changing the interest rate and the salary escalation rate (γ)?

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[58] The assets and liabilities of the system are determined at the valuation date, which is taken as $30/6/(1997 + t)$ with $0 \leq t \leq 28$. The assets are taken at the book value.

[59] For any unfunded liabilities in the ESIPS the actuary first look at the given interest rate on the invested funds by the NIB and second at the Treasury debts.

[60] A funding level (FR) of 100% of the liabilities is defined as the 'equilibrium position'.

[61] The valuation interest rate is the assumed rate of investment return on the scheme's fund. Both the valuation interest rate and the actual rates of investment return are measured in the same terms, nominal or real. The real return represents the rate of investment return in excess of the general price inflation.

3. The adequacy of the contribution rates to meet the expected future liabilities of a new entrant under different expected rates of interest.

In assessing the present value of liabilities for comparison with the value of the assets held, we will use the assumed range of interest rates mentioned in Chapter 2 to discount future liabilities[62] and contributions and also the assumed range of rates of salary escalation. In this thesis, the objectives of the actuarial valuation are as follows:

(I) **Objective 1:** To determine whether the assets of the two Funds are sufficient to meet the liabilities on a closed fund basis (determine surplus/deficit level);

(II) **Objective 2:** To determine whether the current contribution rates are adequate for new entrants[63];

(III) **Objective 3:** To study the relationship between the assumed salary growth rates, the interest rates and the *FR* of the two funds. Under this objective we are interested in the interest rate required to stabilise the *FR* of the two Funds at 100% of liabilities at different levels of salary escalation *(γ)* over the whole simulation period.

We are interested in keeping the Funds sufficient to match future liabilities (payable according to the current regulations) over the actuarial valuation interval period by changing the interest rate required to keep the deficit at 0%[64]. To keep the *FR* at 100% of the liabilities constant, the required interest rate on the assets will depend on:

$$Surplus/Deficit\,(M, t) = PVF(M,t) + C(M) \times PVS(M,t) - PVB(M,t) \qquad (3.92)$$

In calculating the present value of contributions, we will assume that the contribution rates will stay at the current level. We will assume that after the valuation of 30/6/1997, it is required to keep the level of surplus at 0%. Therefore, the interest rate at equilibrium will be determined as equivalent rate to a δ_{eq} which keeps the *FR* =100% of liabilities and determined by the following formula;

$$FR(M, t) = \frac{F(M,t) + PVC(M,t) @ \delta_{eq} \;\&\; \gamma}{PVB(M,t) @ \delta_{eq} \;\&\; \gamma} = 1 \quad for\ M = GSF \& \ PPSF \qquad (3.93)$$

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[62] Since the liabilities of the schemes extend for a long period into the future, it is necessary to select a valuation interest rate which is the average rate likely to apply over very many years in the future.

[63] Objectives 2 & 3 can be restated as the interest rates and contribution rates have to be consistent with long-term equilibrium of the system.

[64] The present value of future liabilities less any funds already accumulated and the present value of future contributions is divided by the present value of future liabilities.

Multiple solutions are possible: the surplus/deficit can be fixed at 0% of the liabilities by varying the following parameters:

1. Higher interest rate and lower salary escalation;
2. Lower interest rate and higher salary escalation;
3. The same interest rate and salary escalation.

3.13. Present Value of Contributions

The same discrete-time interval that was used in the cash-flow projections is used in the valuation of the ESIPS. The actuarial present value of future contributions in respect of members currently being paid a monthly income of $S(x,\ t)$ is determined by the following function:

$$PVC(M, t, B/V) = \tag{3.94}$$

$$C(M, B/V) \times dc(M,t) \sum_{x=b}^{r} \sum_{z=0}^{r-x} e^{-(\delta-\gamma)z} \times SAL(M, x+z, t, B/V) \times Act(x,t) \times {}_{z}(ap)_{x}$$

$b \le x < r$ and $x \le z < r$

$$PVC\ (GSF, t) = PVC(C, t) \qquad for\ M = C \tag{3.95}$$

$$PVC\ (PPSF, t) = \sum_{M} \mathrm{PVC(M, t)} \quad for\ M = P, E, and\ W \tag{3.96}$$

In the self employed and the Egyptians working abroad schemes, the salary scale is ignored and only the salary escalation is taken into account, however in the other schemes both the salary scale and the salary escalation are taken into account.

3.14. Present Value of Liabilities

The valuation of liabilities is based on the aggregate funding method (i.e. based on both past and future service together). This determines the present value of benefits payable to current beneficiaries (pensioners + survivors) and the present value of the future benefits due to current active members on a closed fund basis. The present value of liabilities is then determined using the following function:

$$PVB(M, t)$$

$$= PVNB(M, t) + PVEB(M, t) + PVIB(M, t) + PVDB(M, t) + PVAC(M, t) \tag{3.97}$$

3.14.1 Normal Retirement Benefits[65]

$$PVNB(M, t) = PVNP(M, t) + PVNA(M, t) \tag{3.98}$$

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[65] There is no distinction between past and future service as the aggregate cost method is based on the value of the total projected benefits of the existing members.

3.14.1.1. Pensioners

$$PVNP(M,t) = \sum_{s} \sum_{x=r}^{\omega} TNP(M,x,s,t,(B+V)) \times \bar{a}_x^r \qquad r \leq x \leq \omega \tag{3.99}$$

3.14.1.2. Active Members

$$PVNA(M,t) = PVNAP(M,t) + PVNAL(M,t) \tag{3.100}$$

$$PVNAP(M,t) = \tag{3.101}$$

$$\sum_{s} \sum_{x=b}^{x=r-1} NP(M,\ r, t+r-x, s, B/V) \times Act(M,\ x, t, s) \times {}_{r-x}(ap)_x \times \bar{a}_r^r \times v^{r-x}$$

$$NP(M,\ r,\ t+r-x,\ s,\ B) \tag{3.102}$$

$$= \begin{cases} max\begin{pmatrix} max(\dfrac{(min(36,\ PS(M,r,t+r-x,s,B))}{45},0.5) \\ \times\ AS(M,r,t+r-x,s,B),55 \end{pmatrix} & PS > 9\,[66] \\ 0 & PS \leq 9 \end{cases}$$

where $9 < PS(M,\ r,\ s,\ B) \leq 36$

$$NP(M,\ r,\ t+r-x,\ s,\ V) = \tag{3.103}$$

$$\frac{1}{45} \times \begin{pmatrix} AS(M,r,t+r-x,s,V) \times (min(36,(max(PS(M,r,t+r-x,s,V),22.5) \\ \times (1+0.02 \times PS(M,r,t+r-x,s,V)) \end{pmatrix}$$

for $x \geq r$, and $9 < PS(M,\ r,\ s,\ V) \leq 36$[67], where

$$AS(M,x) = CAS(M,x) = \frac{\sum_{y=b}^{y=r-1} S(y)\, e^{\gamma(y-x)}}{r-b} \tag{3.104}$$

$$AS(M,x) = FS(M,x) = \frac{\sum_{y=r-2}^{y=r-1} S(y)\, e^{\gamma(y-x)}}{2} \tag{3.105}$$

$$PS\,(M,\ r,\ t,\ B/V) = PS(M,\ x,\ t,\ B/V) + db(M,\ t,\ B/V) \times (r-x) \tag{3.106}$$

$$PVNAL(M,t) \tag{3.107}$$

= Lump sum end of service remuneration (basic only)

+ Lump sum compensation for contributory years above 36 (basic only)

$PVNAL(M,t)$

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[66] It is assumed in the valuation, as in the projection, that active members who attain NRA (r) will satisfy the condition of 9 years + 1 month to be eligible for pension for the same reasons stated in the projection. Therefore, the present value of the lump sum benefits for such a case is ignored here.

[67] Even if the past service at the NRA is less than 22.5 years (but > 9), it is taken as 22.5 years in the calculations to give a variable pension of 50-80% of the CAS as the variable salary pension provision started on *1/4/1984*. This concept of variable salary does not exist in the case of the self-employed and Egyptians working abroad schemes.

$$=\sum_{s}\sum_{x=b}^{x=r-1} Act(M,\ x,\ t,\ s) \times {}_{r-x}(ap)_{x} \times v^{r-x} \times \begin{bmatrix} NR(M,\ r, t+r\ \ x, s,\ B)\ + \\ NL(M,\ r, t+r\ \ x, s,\ B) \end{bmatrix} \quad (3.108)$$

$NR(M, r, t+r-x, s, B)$

$$= FS(M, r, t + r - x, s, B) \times max(PS(M, r, t, s, B),10) \qquad (3.109)$$

$NL(M, r, t+r-x, s, B)$

$$= FS(M, r, t + r - x, s, B) \times 1.8 \times max(0, PS - 36) \qquad PS > 36 \qquad (3.110)$$

3.14.2. Early Retirement Benefits

$$PVEB(M, t) = PVEP(M, t) + PVEA(M, t) \qquad (3.111)$$

3.14.2.1. Pensioners

$$PVEP(M, t) = \sum_{s}\sum_{x=b+20}^{\omega} TEP(M, x, t, s, (B + V)) \times \bar{a}_x^r \qquad (3.112)$$

3.14.2.2. Active Members

$$PVEA(M, t) = PVEAP(M, t) + PVEAL(M, t) \qquad (3.113)$$

$$PVEAP(M, t) \qquad (3.114)$$

$$= \sum_{s}\sum_{x=b+20}^{r-1}\sum_{z=0}^{z=r-1-x}\begin{pmatrix} EP(M, x+z, t+z, s, B\ /\ V) \times Act(M, x, t, s) \\ \times_z (ap)_x \times v^z \times q^e_{x+z} \times \bar{a}^r_{x+z} \end{pmatrix}$$

$EP(M, x+z, t+z, s, B)$

$$= \frac{1}{45} \times \begin{pmatrix} AS(M, x+z, t+z, s, B) \times PS(M, x+z, t+z, B) \\ \times (1 - RF(x+z, B)) \end{pmatrix} \qquad (3.115)$$

where $b + 20 \leq x < r$ & $PS(M, x+z, t+z, s, B) \geq 20$

$EP(M, x+z, t+z, s, V)$[68]

$$= \begin{pmatrix} \dfrac{min(max(PS(M, x+z, t+z, s, V),22.5),36)}{45} \times AS(M, x+z, t+z, s, V) \\ \times (1 - RF(M, x, V)) \times (1 + 0.02 \times PS(M, x, t, s, V)) \end{pmatrix} \qquad (3.116)$$

for $50 \leq x < r$, & $PS(M, x+z, t+z, s, B) \geq 20$ and $M = C$ & P

$$AS(M, x+z, B/V) = CAS(M, x+z, B/V) = \frac{\sum_{x=b}^{x+z} S(y)\, e^{\gamma(y-x)}}{x + z - b} \qquad (3.117)$$

$$AS(M, x+z, B/V) = FS(M, x+z, B/V) = \frac{\sum_{x+z-1}^{x+z} S(y)\, e^{\gamma(y-x)}}{2} \qquad (3.118)$$

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[68] The variable pension in the case of early retirement is not eligible if the contributory years is not more than 19 years and if it is more than 19 years is not payable until the attainment of age 50.

$$PS(M, x+z, t, B/V) = PS(M, x, B/V) + db(M, t, B/V) \times z \tag{3.119}$$

$$PVEAL(M, t) \tag{3.120}$$

= Lump sum end of service remuneration (basic only)

+ Lump sum compensation for contributory years above 36 (basic only)

+ Lump sum if the insured person does not qualify for a pension (basic & variable)

$$PVEAL(M, t) = \tag{3.121}$$

$$\sum_{s} \sum_{x=b+20}^{r-1} \sum_{z=0}^{z=r-1-x} \left(\begin{pmatrix} ER(M, x+z, t+z, s, B) + \\ EL(M, x+z, t+z, s, B/V) \end{pmatrix} \times Act(M, x, t, s) \times v^{z} \times {}_{z}(ap)_{x} \times q^{e}_{x+z} \right)$$

$ER(M, x+z, t+z, s, B)$

$$= FS(M, x+z, t+z, s, B) \times max(PS(M, x+z, t+z, s, B), 10) \tag{3.122}$$

$EL(M, x+z, t+z, s, B/V)$

$$= \begin{pmatrix} FS(M, x+z, t+z, s, B) \times & \\ max((PS(M, x+z, t+z, s, B) - 36), 0) \times 1.8 & PS > 36 \\ + & \\ AS(M, x+z, t+z, s, B/V) \times & \\ PS(M, x+z, t+z, s, B/V) \times 1.8 & PS < 20 \end{pmatrix} \tag{3.123}$$

$b \leq x \leq r-1$

3.14.3. Invalidity Benefits

$$PVIB(M, t) = PVIP(M, t) + PVIA(M, t) \tag{3.124}$$

3.14.3.1. Pensioners

$$PVIP(M, t) = \sum_{s} \sum_{x=b}^{\omega} TIP(M, x, t, s(B+V)) \times \bar{a}^{i}_{x} \tag{3.125}$$

3.14.3.2. Active Members

$$PVIA(M, t) = PVIAP(M, t) + PVWA(M, t) + PVIAL(M, t) \tag{3.126}$$

$$PVIAP(M, t) = \tag{3.127}$$

$$\sum_{s} \sum_{x=b}^{r-1} \sum_{z=0}^{z=r-1-x} IP(M, x+z, t+z, s, B/V) \times Act(M, x, t, s) \times v^{z} \times {}_{z}(ap)_{x} \times {}^{*}q^{i}_{x+z} \times \bar{a}^{i}_{x+z}$$

$$\text{where } IP(M, x+z, t+z, s, B) = \tag{3.128}$$

$$max\left(min\left\{ \begin{matrix} max\left[\dfrac{min(PS(M, x+z, t+z, s, B) + min(3, (r-x-z)), 36)}{45}, 0.65 \right] \\ \times AS(M, x+z, t+z, s, B), 550 \end{matrix} \right\}, 40 \right)$$

for $b < x < r-1$

$$IP(M, x+z, t+z, s, V) = \tag{3.129}$$

$$max\left(min\left\{ \begin{matrix} max\left[\frac{min(PS(M, x+z, t+z, s, V) + min(3, (r-x-z)), 36)}{45}, 0.65 \right] \\ \times AS(M, x+z, t+z, s, B/V) \times (1 + 0.02 \times PS(M, x+z, t+z, s, V)), 550 \end{matrix} \right\}, 40 \right)$$

$$\text{where } AS(M, x+z, B) = FS(M, x+z, B) = \frac{\int_{x+z-1}^{x+z} S(y)\, e^{\gamma(y-x)} dy}{2} \tag{3.130}$$

$$AS(M, x+z, V) = CAS(M, x+z, B/V) = \frac{\int_{b}^{x+z} S(y)\, e^{\gamma(y-x)} dy}{x+z-b} \tag{3.131}$$

$$PS\,(M, x+z, t, B/V) = PS(M, x, B/V) + db(M, t, B/V) \times z \tag{3.132}$$

Invalidity retirement liabilities arising from work injuries or occupational illness have been increasing over time as the ESSPS gives generously on such a contingency. However, there is no available data to derive these rates. Therefore, it was decided to estimate the cost of this contingency as 0.5%[69] of the present value of the pensionable salaries of the active members which is determined as follow:

$$PVWA(M, t, s, B/V) \tag{3.133}$$

$$= 0.005 \times \sum_{s} \sum_{x=b}^{r-1} \sum_{z=0}^{r-x-1} e^{-(\delta-\gamma)z} \times SAL(M, x+z, t, B/V) \times Act(M, x, t, s) \times {}_{z}(ap)_{x}$$

$$PVIAL(M, t) \tag{3.134}$$

= Lump sum end of service remuneration

+ Lump sum compensation for the invalidity or work injuries contingencies

+ Lump sum compensation for contributory years above 36

$$PVIAL(M, t) = \tag{3.135}$$

$$\sum_{s} \sum_{x=b}^{r-1} \sum_{z=0}^{z=r-1-x} \begin{pmatrix} IR(M, x+z, t+z, s, B) + \\ IL(M, x+z, t+z, s, B/V) \end{pmatrix} \times Act(M, x, t, s) \times v^{z} \times {}_{z}(ap)_{x} \times {}^{*}q^{I}_{x+z}$$

$$IR(M, x+z, t+z, s, B) \tag{3.136}$$

$$= FS(M, x+z, t+z, s, B) \times max(PS(M, x+z, t+z, s, B), 10)$$

$$IL(M, x+z, t+z, s, B/V)$$

$$= \begin{pmatrix} FS(M, x+z, t+z, s, B) \times & \\ max((PS(M, x+z, t+z, s, B) - 36), 0) \times 1.8 & PS > 36 \\ + & \\ AS(M, x+z, t+z, s, B/V) \times Pr(x+z, t+z) & \\ PS(M, x+z, t+z, s, B/V) & \end{pmatrix} \tag{3.137}$$

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[69] This is the contribution rate for the work injury risk.

$b \leq x \leq r\text{-}1$

$$AS(M, x+z, t, B) = FS(M, x+z, t, B) = S(M, x+z, t, B)) \tag{3.138}$$

$AS(M, x, t, s, V)$ is determined as in formula 3.38.

3.14.4. Death Benefits

The total present value of death benefits can be determined according to the following formula:

$$PVDB(M, t) = PVDP(M, t) + PVDS(M, t) + PVDA(M, t) \tag{3.139}$$

3.14.4.1. Pensioners' Death Benefits

$$PVDP(M, t)$$

$$= PVDPN(M, t) + PVDPE(M, t) + PVDPI(M, t) + PVDPLS(M, t) \tag{3.140}$$

$$PVDP(M, t)$$

$$= \sum_{s} \sum_{x=b}^{\omega} \sum_{j=0}^{\omega} \begin{pmatrix} \begin{pmatrix} (TNP(M,\ x, t, s, (B+V)) + TEP(M,\ x, t, s, (B+V))) \\ \times\, q_{x+j}^{d} + TIP(M,\ x, t, s,\ (B+V)) \times q_{x+j}^{id} \end{pmatrix} \\ \times\, v^{j} \times h_{x+j} \times SurV(M, x+j, t+j) \end{pmatrix} \tag{3.141}$$

$SurV(M, x, t)$ is determined according to the formula *(11)*

$$PVDPLS(M, t) = \textit{Death Grant} + \textit{Funeral Grant} = \tag{3.142}$$

$$\sum_{s} \sum_{x=b}^{\omega} \sum_{j=0}^{\omega} max \begin{pmatrix} \left(\dfrac{5}{12} \times \begin{pmatrix} (TNP(M, x, t, s, (B+V)) + TEP(M, x, t, s, (B+V))) \\ \times\, q_{x+j}^{d} + TIP(M, x, t, s,\ (B+V)) \times q_{x+j}^{id} \end{pmatrix} \times_{j} (ap)_{x} \times v^{j} \right), \\ \left(\begin{pmatrix} \dfrac{3}{12} \times \begin{pmatrix} TNP(M, x, t, s, (B+V)) + TEP(M, x, t, s, (B+V))) \\ \times\, q_{x+j}^{d} + TIP(M, x, t, s,\ (B+V)) \times q_{x+j}^{id} \end{pmatrix} \\ +\, 200 \begin{pmatrix} N(M, x, t, s, (B+V)) + E(M, x, t, s, (B+V))) \\ \times\, q_{x+j}^{d} + I(M, x, t, s,\ (B+V)) \times q_{x+j}^{id} \end{pmatrix} \end{pmatrix} \times_{j} (ap)_{x} \times v^{j} \right) \end{pmatrix}$$

3.14.4.2. Survivors' Death Benefits

$$PVDS(M, t) = PVDW(M, t) + PVDO(M, t) + PVDLS(M, t) \tag{3.143}$$

$PVDW(M, t) = \sum_{y=b-d_l}^{\omega} TDP(M, y, t, (B+V)) \times \bar{a}_{y}^{W}$[70] (3.144)

$$PVDO(M, t) \tag{3.145}$$

$$= \sum_{z=0}^{\omega} TDP(M, z_{f_x}, t, (B+V)) \times \bar{a}_{y}^{D} + \sum_{z_m=2}^{\omega} TDP(M, z_{m_x}, t, (B+V)) \times \bar{a}_{y}^{S} \tag{3.146}$$

$PVDLS(M, t) = \textit{Marriage Grant}$[71]

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[70] Although calculations in respect of benefits to widowers of female members involve no new principles, they are ignored in our model on the ground of their non-significance. Also the formulae for the other non-important parts of death liabilities, such as that in respect of future parents and siblings of members are complicated and the small liability involved hardly ever justifies their use.

[71] This assumes that the maximum possible age for daughter's marriage is 49.

$$= \sum_{z_f=0}^{z_f=49} \sum_{j=15}^{j=49-z_f} TDP(M, z_{f_x} + j, t + j, (B + V)) \times v^j \times {}_j(ap)_{z_f} \times q^m_{z_f+j} \qquad (3.147)$$

3.14.4.3. Death Benefits of Active Members

We now deal with the widows' and children's benefits on death in service or after retirement. In valuating the present value of future death benefits, it is assumed that 100% of the pension will be paid using the same arguments stated for the projections. These liabilities can be determined according to the following formula.

$$PVDA(M, t, B/V) = PVDAS(M, t, B/V) + PVDAN(M, t, B/V) + PVDAE(M, t, B/V)$$
$$+ PVDAI(M, t, B/V) \qquad (3.148)$$

3.14.4.3.1. Death in Service

The present value of future death in service benefits is estimated using the following formula.

$$PVDAS(M, t) = PVDASP(M, t) + PVDASL(M, t) \qquad (3.149)$$

$$PVDASP(M,t) = \sum_{s} \sum_{x=b}^{r-1} \sum_{z=0}^{z=r-1-x} \begin{pmatrix} DP(M, x+z, t+z, s, B/V) \times Act(M, x, t, s) \times \\ v^z \times {}_z(ap)_x \times {}^*q^d_{x+z} \times h_{x+z} \times SurV(M, x+z, t+z) \end{pmatrix} \qquad (3.150)$$

DP(M, x+z, t+z, s, B) and DP(M, x+z, t+z, s, V) are determined according to the formulae *(3.127) to (3.128)*

$$PVDASL(M, t) \qquad (3.151)$$

= Formula 3.135 + Death and Funeral Grants

$$PVDASL(M, t) = \sum_{s} \sum_{x=b}^{r-1} \sum_{z=0}^{z=r-1-x} \begin{pmatrix} \begin{pmatrix} DR(M, x+z, t+z, s, B) + \\ DSL(M, x+z, t+z, s, B/V) \end{pmatrix} \times \\ Act(M, x, t, s) \times {}_z(ap)_x \times v^z \times q^d_{x+z} \end{pmatrix} \qquad (3.152)$$

DR(M, x+z, t + z, s, B) calculated as in the formula (3.135) and

$$DSL(M, x + z, t + z, s, B / V)$$

$$= \left(\begin{array}{ll} FS(M, x+z, t+z, s, B) \times & \\ max((PS(M, x+z, t+z, s, B) - 36), 0) \times 1.8 & PS > 36 \\ + & \\ AS(M, x+z, t+z, s, B/V) \times Pr(x+z, t+z) & \\ PS(M, x+z, t+z, s, B/V) & \\ + & \\ max(2 \times AS(M, x+z, t+z, s, (B+V)), 200) & \\ +(3 \times AS(M, x+z, t+z, s, (B+V)) & \end{array} \right) \qquad (3.153)$$

$b \leq x \leq r\text{-}1$

AS(M, x+z, t, B) and AS(M, x, t, s, V) are *determined as in the formulae 3.130 and* 3.131 respectively.

3.14.4.3.2. Death after Normal Retirement

The functions for the valuation of a pension payable to dependants on the death of the member after retirement at age r, or earlier retirement or on grounds of ill-health, are determined as in the following functions being based on the service tables and life tables. The liability for benefits on death after retirement has to be allowed for in the annuity of the dependants brought into the pension formulae. For the valuation of widows' and children' pensions payable on death after normal retirement we follow the following formulae.

$$PVDAN(M,t) = PVDANP(M,t) + PVDANL(M,t) \tag{3.154}$$

$$PVDANP(M,t)$$

$$= \sum_{s} \sum_{x=b}^{\omega} \sum_{z=0}^{\omega} \begin{pmatrix} NP(M,r,t+r-x,s,B/V) \times Act(M,x,t,s) \times {}_{r-x+z}(ap)_x \times \\ q^d_{r+z} \times h_{r+z} \times v^{r-x+z} \times SurV(M,r+z,t+r-x+z) \end{pmatrix} \tag{3.155}$$

$PVDANL(M, t)$ = Death and Funeral Grants

$$PVDANL(M,t) = \sum_{s} \sum_{x=b}^{r-1} \sum_{z=0}^{z=r-1-x} \begin{pmatrix} (DNL(M,r,t+r-x,s,B/V)) \times \\ Act(M,x,t,s) \times_{r-x+z} (ap)_x \times v^{r-x+z} \times q^d_{r+z} \end{pmatrix} \tag{3.156}$$

$$DNL(M,r,t+r-x,s,B/V)$$

$$= \begin{pmatrix} max(2 \times NP(M,r,t+r-x,s,(B+V)),200) \\ +(3 \times NP(M,r,t+r-x,s,(B+V)) \end{pmatrix} \tag{3.157}$$

$NP(M, r, t+r-x, s, B/V)$ are determined according to the formulae *(3.102) and (3.103)*

3.14.4.3.3. Death after Early Retirement

$$PVDAE(M,t) = PVDAEP(M,t) + PVDAEL(M,t) \tag{3.158}$$

$$PVDAE(M,t) = \tag{3.159}$$

$$\sum_{x=b+20}^{r-1} \sum_{z=0}^{z=r-1-x} \sum_{j=0}^{\omega} \begin{pmatrix} EP(M,x+z,t+z,s,B/V) \times Act(M,x,t,s) \times {}_{z+j}(ap)_x \times \\ v^{z+j} \times q^e_{x+z} \times q^d_{x+z+j} \times h_{x+z+j} \times SurV(M,x+z+j,t+z+j) \end{pmatrix}$$

$EP(M, x+z, t+z, s, B)$ *and* $EP(M, x+z, t+z, s, V)$ are determined according to the formulae *(3.115), (3.116)*

$PVDAEL(M, t)$ = Death and Funeral Grants *(3.160)*

$$= \sum_{x=b+20}^{r-1} \sum_{z=0}^{z=r-1-x} \sum_{j=0}^{\omega} \begin{pmatrix} DEL(M,x+z,t+z,s,B/V) \times Act(M,x,t,s) \\ \times {}_{z+j}(ap)_x \times q^e_{x+z} \times q^d_{x+z+j} \times v^{z+j} \end{pmatrix}$$

$$DEL(M,x+z,t+z,s,B/V)$$

$$= \begin{pmatrix} max(2 \times EP(M,x+z,t+z,s,(B+V)),200) \\ +(3 \times EP(M,x+z,t+z,s,(B+V)) \end{pmatrix} \tag{3.161}$$

$b \leq x \leq r\text{-}1$

3.14.4.3.4. Death after Invalidity Retirement

$$PVDAI(M,t) = PVDAIP(M,t) + PVDAIL(M,t) \tag{3.162}$$

$$PVDAI(M,t) = \tag{3.163}$$

$$\sum_{x=b+20}^{r-1} \sum_{z=0}^{z=r-1-x} \sum_{j=0}^{\omega} \begin{pmatrix} IP(M, x+z, t+z, s, B/V) \times Act(M, x, t, s) \times {}_{z+j}(ap)_x \times \\ v^{z+j} \times q^{i}_{x+z} \times q^{id}_{x+z+j} \times h_{x+z+j} \times SurV(M, x+z+j, t+z+j) \end{pmatrix}$$

$$PVDAIL(M,t)$$

$$= \sum_{x=b+20}^{r-1} \sum_{z=0}^{z=r-1-x} \sum_{j=0}^{\omega} \begin{pmatrix} DIL(M, x+z, t+z, s, B/V) \times Act(M, x, t, s) \\ \times v^{z+j} \times {}_{z+j}(ap)_x \times q^{i}_{x+z} \times q^{id}_{x+z+j} \end{pmatrix} \tag{3.164}$$

$$DIL(M, x+z, t+z, s, B/V)$$

$$= \begin{pmatrix} max(2 \times IP(M, x+z, t+z, s, (B+V)), 200) \\ +(3 \times IP(M, x+z, t+z, s, (B+V)) \end{pmatrix} \tag{3.165}$$

IP(M, x+z, t+z, s, B) and IP(M, x+z, t+z, s, V) are determined according to the formulae *(3.128), (3.129)*

3.14.5. Administrative Costs

The present value of future administrative cost is determined using the following function:

$$PVAC(M,t) = ACR(M) \times \sum_{x=b}^{r} Act(x,t) \sum_{z=0}^{r-x} e^{-(\delta-\gamma)z} S(M, x+z, t, B/V)\ {}_{z}(ap)_x$$

$$x < r \quad and \quad x \le z < r,\ M = GSF\ \&\ PPSF \tag{3.166}$$

3.15 Conclusion

In modelling the projection and valuation of the ESSPS two techniques were employed. The projection technique which deals with aggregate cash-flow and the present value technique which deals with cohorts of members. Due to the complexity of the ESSPS and to be able to study and analyse it, many simplifications in deriving the model are required. However, the model contains all the main characteristics of the scheme. The ESIPS is a relatively complex system and the models used to prepare actuarial projection and valuation estimates are complex as a result of the efforts to improve accuracy and utility of the estimates.

Chapter 4

Construction of an Egyptian Life Table Based on 1994-96 Population Mortality Experience

4.1. Introduction

Mortality, migration and future fertility rates form the required components in projecting the future population of any country[1]. A starting point in the population projection using the component method is to have a life table, which reflects the true underlying mortality rates of the population in the base year. The concept of life tables is well known in many fields of science. They traditionally contain a set of mortality rates which progress smoothly with age, calculated as accurately as possible from death registration data and population numbers. Demographers and actuaries use these tables as a tool reflecting the true underlying mortality rates in population projections and other actuarial work.

There are no existing Egyptian life tables which can be used for the purpose of population projections and other actuarial work. The standard mortality rates that have been used for the ESSPS valuation were those of the A24/29 Table[2] until 1992 and the mortality rates of the A49/52 Table with some modifications thereafter. Accordingly, it is considered very important to construct an Egyptian life table which is extracted from Egyptian population data. This table is to be used, among other purposes, in the projection of the future population within the ESSPS area. The projected population is then used to project the system's future income and expenditure. This chapter sets out the construction of an Egyptian life table through the graduation of crude central mortality rates derived from the Egyptian population data over 1994-96.

4.2. Data Used in the Construction of the Life Table

The Egyptian mortality experience is investigated over the most recent three-year period, 1994-96 for males and females separately, as a three-year period is normally

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[1] Migration is ignored in projecting the Egyptian population, as it is considered not significant as described in Chapter 5.

[2] Produced by the Continuous Mortality Investigation Bureau (CMIB) of the Institute of Actuaries in the UK, which is different from the English Life Tables produced every 10 years by GAD in the UK.

seen of sufficient length to smooth out most of the effect of variable mortality experience (Chris Daykin, 1996).

The data required for constructing life tables are the numbers of deaths and exposed to risk. The Central Agency for Public Mobilisation and Statistics (CAPMAS) provided the required data in the following age-related form[3] (see **Table 3.1 of Appendix 3**):

1. Central exposed to risk, in the form of mid-year population estimates of 1994 and 1995; and the 1996 census split by sex and age groups;
2. Numbers of deaths[4], split by sex and age groups for each of these calendar years.
3. Data are provided for the first year of life, the subsequent 4 years of life, and then in quinquennial age groups until the last available age group for lives aged 75+.
4. Both the exposed to risk and deaths are classified according to the age definition "age last birthday".

Therefore, this investigation uses the population data for ages 0-74 only in quinquennial age groups as there is no available data for individual ages, and data for ages 75+ is ignored because they are contained together in one group[5]. The non-existence of individual age data is largely due to the difficulty of obtaining accurate information from ordinary people, and particularly elderly people, as some of them do not even have an official date of birth. It is also because of errors present in the data as neither the population censuses are perfectly accurate or complete nor are the mid-year estimates of the population. Death registrations, however, are believed to be relatively more accurate in reporting age at death, although the problem of dealing with the elderly still applies. However, although the reliability of the Egyptian data is questionable, Egypt is regarded as one of the countries supplying reliable data to the UN (BAJ, Volume 4, Part I, 1998).

4.3. Crude Central Mortality Rates, 1994-96

The total central exposed to risk at each quinquennial age group were taken as the sum of the population numbers over 1994-96 and the same applies to the total numbers of death as shown in Appendix 4.1. Let $A_{k,x}$ represents the number of deaths of a particular sex in calendar year 1994+k at attained age x, with $k = 0, 1 \text{ and } 2$. Let

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[3] They are the same as those published by the UN and they are grouped according to the classifications and definitions used by the UN.

[4] These include all deaths registered in Egypt including deaths abroad of residents of Egypt.

[5] Males and females deaths at ages 75+ represent 19.4% and 28.8% of the total number of deaths respectively.

$P_{k,x}$, represents the mid-year population estimates of a particular sex aged x last birthday on 30 June of year *1994 + k – ½, for k = 0.5, 1.5, 2.5,* and denoted by $P_{\frac{1}{2},x}\ P_{1\frac{1}{2},x}\ P_{2\frac{1}{2},x}$ respectively. The central exposed to risk, R_x^c is defined assuming that $P_{k,x}$ varies linearly with k as follows:

$$R_x^c = \int_0^3 P_{k,x}dk = (P_{\frac{1}{2},x} + P_{1\frac{1}{2},x} + P_{2\frac{1}{2},x}) \qquad (4.1)$$

As the available data is the central exposed to risk and deaths, we estimate μ-type (m_x) mortality rates. The crude central mortality rates, $\overset{\circ}{m}_x$, for the age groups *0, 1-4, 5-9, 10-14, ..., 70-74* over 1994-96 were then derived by formula (*4.2*) below and are shown in Table 4.1:

$$\overset{\bullet}{m}_x = \frac{A_{0,x} + A_{1,x} + A_{2,x}}{R_x^c} = \frac{A_{0,x} + A_{1,x} + A_{2.x}}{P_{\frac{1}{2},x} + P_{1\frac{1}{2},x} + P_{2\frac{1}{2},x}} \qquad (4.2)$$

Given that the number of deaths has a Poisson distribution:

$A_x \sim \text{Poisson}(R_x^c \cdot m_x)$ and because, $\overset{\circ}{m}_x = \frac{A_x}{R_x^c}$, then

$$E(\overset{\circ}{m}_x) = m_x \text{ and} \qquad (4.3)$$

$$Var(\overset{\circ}{m}_x) = \frac{m_x}{R_x^c} \qquad (4.4)$$

Table 4.1. Crude Central Mortality Rates of Males and Females ate each age group, 1994-96.

Age	Males Crude Mortality Rates	Females Crude Mortality Rates
0-<1	0.02750	0.02761
1-4	0.00277	0.00293
5-9	0.00098	0.00082
10-14	0.00086	0.00068
15-19	0.00112	0.00085
20-24	0.00123	0.00084
25-29	0.00146	0.00109
30-34	0.00203	0.00131
35-39	0.00286	0.00198
40-44	0.00465	0.00255
45-49	0.00721	0.00426
50-54	0.01071	0.00701
55-59	0.01752	0.01057
60-64	0.03117	0.02014
65-69	0.04836	0.03311
70-74	0.07665	0.05861

Source: Derived by Author

The main features of the mortality trends of the Egyptian population can be extracted by visual inspection of the two curves of the crude central mortality rates (1994-96 experience) for males and females as shown in Figure 4.1.

Figure 4.1. Crude Central Mortality Rates of Males and Females Experience over 1994-96 versus age on a log scale.

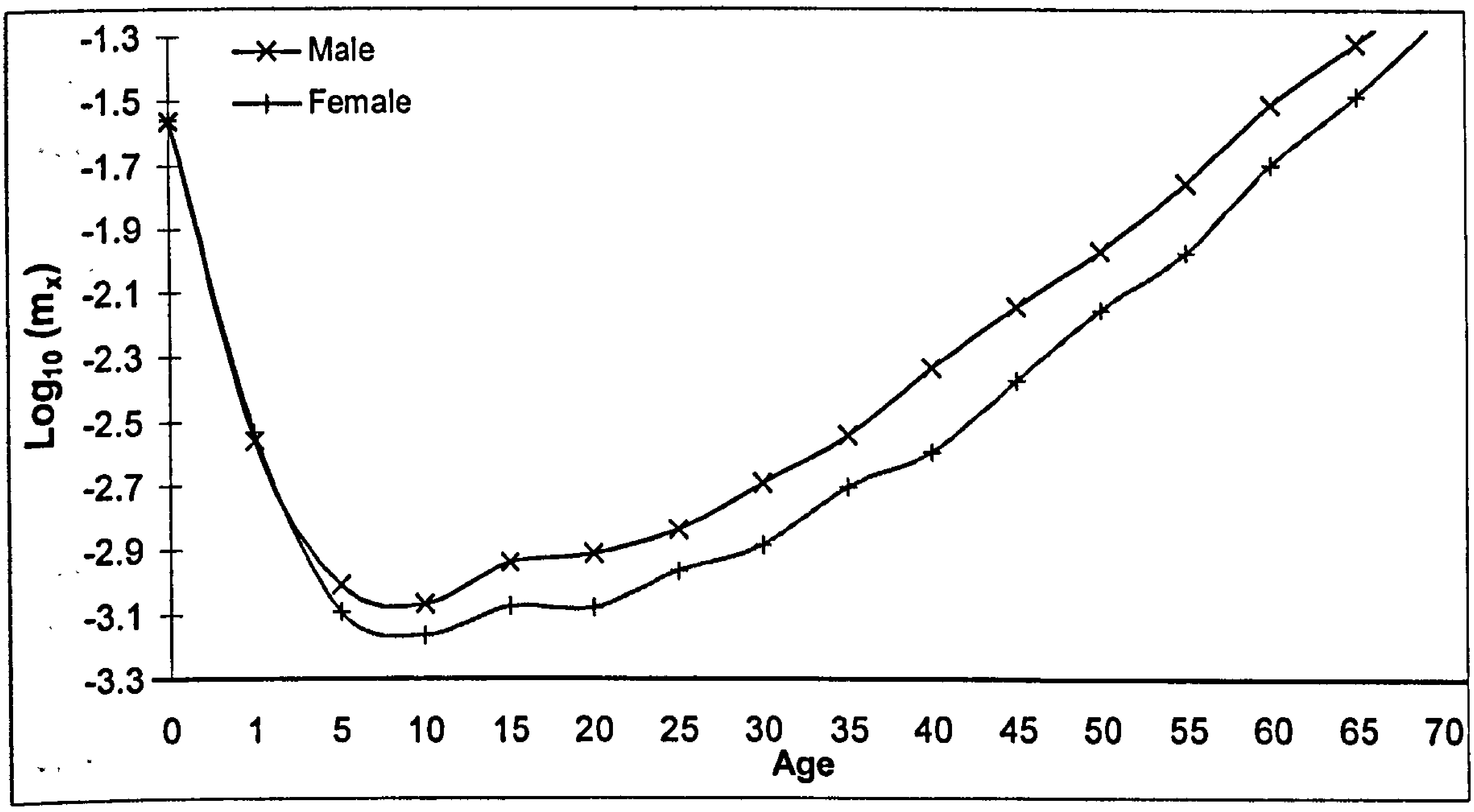

Figure 4.1 shows the following features:

1. Allowing for errors in the census data, death registration and age classification, the observed crude rates of mortality for the quinary age-groups show fairly regular progression, even before graduation;
2. Figure 4.1 and Table 4.1 show that the crude central mortality rates for males and females exhibit, in general, the same features of most standard normal mortality curves;
3. There is no evidence of an accident hump at ages under 20 although there is a very small hump around age 15 for both males and females;
4. Male mortality is higher than female mortality at most ages and female mortality is higher only at the very young age group 0-4.

It is clear that the crude mortality rates may not represent the true underlying mortality rates as these rates are subject to random errors. This is because of the need to extract mortality data over a limited period of time and/or using random samples, which cause random fluctuations. Therefore, these rates have to be adjusted or smoothed in order to represent the true ones, by removing or reducing random fluctuations through "Graduation". Therefore, the second stage of constructing a life table is the graduation of the crude rates, which is explained in the following sections.

4.4. Graduation

Benjamin and Pollard (1980) defined the graduation process as follows: "graduation is the art of smoothing the separate maximum likelihood values to obtain the best possible estimates of the underlying population values". This definition of graduation presents two main concepts, "smoothness" and "best estimates (adherence to data)".

4.4.1. Fidelity (Adherence) to Data

Adherence to data is achieved if the graduated rates are close enough to the crude ones. It should be noted that in most cases the closer the adherence to data, the worse the smoothness would be, and vice versa. Hence, it is usually important to find an acceptable balance between them. There are many statistical tests for adherence to data, which are mentioned later in this chapter and briefly described in **Appendix 3**.

4.4.2. Smoothness

The main assumption the graduation process is based on is that the true underlying mortality rates should progress reasonably smoothly, as the age X_l increases for biological reasons. The criterion of smoothness is equivalent, in the mortality context, to the third order differences being small (Bizley, 1958). This criterion is used to test the smoothness of the curve of graduated mortality rates. We can rewrite that smoothness criterion in mathematical form as follows:

$$\sum_{x=x_1}^{x_r-3} \left|\Delta^3\mu_x\right| \rightarrow 0 \qquad (4.5)$$

where

$$\Delta^r f(x) = \Delta^{r-1} f(x+1) - \Delta^{r-1} f(x),$$

$$\Delta^0 f(x) = f(x)$$

4.5. Methods of Graduation

Graduation methods are mainly classified into two groups, parametric and non-parametric. In the following two subsections, these two main groups of graduation methods will be briefly explained.

4.5.1. Parametric Methods

A classic solution to the graduation problem is the parametric regression model, where a pre-chosen function (usually based on a polynomial) fits the data and whose coefficients are estimated by a least squares method or the maximum likelihood method. This method is based on fitting a mathematical formula, which represents the true underlying mortality rates, to the data over the whole age range. However, in many cases it is difficult to find such a formula. Parametric methods include linear models, generalised linear and non-linear models and many other methods that have been suggested throughout the history of graduation theory.

The greatest advantage of the graduation by fitting a mathematical formula is that the obtained mortality rates are automatically smooth, especially when the used formula is a polynomial of low degree, so there is no need to test for smoothness in this case. However, the greater the degree of the polynomial the less the smoothness of the fitted curve as the number of parameters used governs the trade-off between goodness of fit and smoothness. There are also many data sets where it might be inappropriate to use a parametric model. The problem is that the data determines only the coefficients of the pre-chosen function to be fitted, through the least squares method, while a smoothing approach allows the data to determine the whole function, as shown in the following sections.

4.5.2. Non-Parametric Methods

A central problem of mathematical statistics is to summarise the behaviour of a dependent variable *Y* (e.g. mortality rates), which is a function of a set of independent variables X_I (ages, predictors). A tool for summarising the behaviour of a response variable *Y*, as a function of the predictor X_i, is called a smoother, which is a function of both the response variable and the independent variable and given by the function[6]:

$$\hat{f} = S(y|x) \tag{4.6}$$

In this case the crude mortality rates (Y_i) are a function of a set of ages (X_i), which will be subject to random errors. It is assumed that the realised values of the dependent variable Y are $y = (y_1, y_2, ..., y_n)$, and the corresponding realised values of the

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[6] Note that $\hat{f}(x_i)$ could be a parametric model as well.

independent variable X, are $x = (x_1, x_2, .., x_n)$. The domain of $\hat{f}$ consists of the realised values of the predictor variable, so if x_i is a realised value of the independent variable X, then $\hat{f}(x_i)$ will be the function: $S(y/x)$ evaluated at x_i (i.e. the fitted value at x_i).

The aim is to fit the function $\hat{f}(x_i)$ to the data in order to obtain a new set of mortality rates (graduated) and this function will be an unspecified one in the case of non-parametric methods. The unspecified function $\hat{f}(x_i)$ can be estimated using one of the common scatterplot smoothers and there is a wide range of methods (smoothers) for obtaining $\hat{f}(x_i)$. The important property of scatter-plot smoothers is their non-parametric regression nature, which means that when using a smoother we do not assume a rigid form of dependence between the response variable and the predictor. So, the produced estimate of the mortality rates (that is the smooth curve) is less variable than Y itself, a feature which justifies the name "smoother". Because of their flexible nature, curve estimates can be produced, which usually meet the criteria of goodness of fit and smoothness in a satisfactory way.

Non-parametric methods include Bin smoothers, moving-weighted averages, Kernel graduation, Whittaker graduation, local-polynomial graduation[7] and cubic splines. In the following sections, two of the non-parametric graduation methods, cubic splines smoothing and Whittaker graduation, which are used in the graduation of the Egyptian data, are described within the context of the Generalised Additive Models (GAMs).

4.6. Generalised Additive Models (GAMs)

Additive regression models are similar to the classical linear models, but used in the case of non-parametric graduation. An additive regression model can provide a sensible compromise between the inappropriate assumption of the linear regression models and the lack of structure of a general surface smoother, which is non-parametric regression tools but only for small dimensions. The additive regression model takes the general form:

$$Y = \alpha + \sum_{i=1}^{p} f_i(x_i) + e \quad ^{8} \qquad (4.7)$$

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[7] It is called Loess in the S-Plus statistical computing language.

[8] $\alpha + \sum_{i=1}^{p} f_i(X_i)$ is called the additive predictor of the model

where Y is the response with mean $E(Y) = m$;

X_i, $(i = 1, 2, \ldots, p)$, are the predictors (independent) variables;

α is a constant, e is the error in observing Y.

It is assumed that the errors are independently normally distributed with:

mean $E(e_i) = 0$, and variance $Var(e_i) = \sigma^2$ where σ^2 is a constant.

$f_i(x_i)$ is usually -but not necessarily- a univariate unspecified function of the covariate x_i, with one for each predictor, so they are the analogues of the coefficients in the linear regression model. The function f_i will be individually estimated by using the scatterplot smoother corresponding to the X_i variable. The main drawback of fitting an additive model to a set of data is that it is always an approximation to the true regression surface, possibly masking real effects of interaction between explanatory variables which, given sufficient data, could be modelled explicitly.

The additive model, if it finally fits a given set of data, is easy to apply, but in some cases it is not appropriate. The reasons for this are:

a) If Y takes values within a certain limited range, then the model:

$$m = E(Y \mid X_1, X_2, \ldots, X_p) = \alpha + \sum_{j=1}^{p} f_j(X_j) \qquad (4.8)$$

for the mean of Y, that is m, will not inherit this restriction.

b) For many data sets, it is not always a realistic assumption to assume that the variance of Y is a constant independent of the mean.

GAMs are defined as a generalisation of the additive models, which enable the use of the exact distribution of the number of deaths instead of the normal approximation, and hence the distribution of the error does not need to be normal. GAMs have a clear non-parametric nature, which allows the data to determine the function itself, rather than its parameters. Also the predictor might be a function of the response's mean rather than the mean itself (Mohamed W., 1997). GAMs provide solutions to the previously stated problems of the additive models by using the following two functions:

a) The link function[9], $g(\cdot)$, which describes the dependence of the mean of Y itself on the predictors, so that:

$$g(m) = g(E(Y)) = \alpha + \sum_{i=1}^{p} f_i(X_i) \qquad (4.9)$$

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[9] Some link functions (canonical link functions), used in the context of different GAMs, together with the corresponding variance function, are summarised in **Appendix 3**.

b) The variance function, $V(\cdot)$, which describes the dependence of the variance of Y, upon the mean of Y, so that:

$$Var(Y) = \phi \cdot V(m) \qquad \text{where } \phi \text{ is a constant} \qquad (4.10)$$

Link functions are monotone increasing and hence, by definition, invertible and represent link between the response and the predictor (also called systematic component) expressed as a function of the response's mean. If the inverse link function g^{-1} is denoted by h, and function f_i is an equivalent and usually a more convenient function for relating m to the predictors then:

$$m = h(\alpha + \sum_{i=1}^{p} f_i(X_i)) \quad \Leftrightarrow \quad g(m) = \alpha + \sum_{i=1}^{p} f_i(X_i) \qquad (4.11)$$

It is customary to denote the additive predictor by η, that is:

$$\eta = g(m) = \alpha + \sum_{i=1}^{p} f_i(X_i) \quad \text{then} \qquad (4.12)$$

$$log(m_x) = log(E(\overset{o}{m}_x)) = \eta_x = \alpha + f(x) \qquad (4.13)$$

The link function g is the main characteristic of the GAMs as seen in *4.12*. The additive predictor produces an estimated value for g(m). Like the additive models, both the coefficient α, and the functions f_i, $i = 1, 2,..., p$, (of the generalised additive predictor), are calculated using scatterplot smoothers iteratively, using appropriate algorithms. The estimated functions will result and each of the calculated functions will be a smooth one. This means that the smoothness of the fitted (graduated) values is guaranteed when the GAMs are used. The appropriate algorithm is a Newton-Raphson iteration and is a form of an IRLS method (Iteratively Reweighted Least Square Method, also known as Fisher scoring).

4.7. Cubic Splines Smoother

Splines are used to form a continuous curve that fits the data exactly, rather than modelling a trend from data subject to random variation. The smoothed curve consists of a series of cubic curves, selected so that one cubic curve runs smoothly into the next with knots taken for each year of age. The method explicitly considers the two conflicting goals of graduation: (a) obtaining a good fit to the observed data and (b) obtaining a curve that is smooth. This smoother is not constructed explicitly but it can be shown to be the unique solution of the following optimisation problem.

Given a set of n values of the independent variable X, $(x_1, x_2, \ldots, x_n)$ and the corresponding set of values of the dependent variable Y, $(y_1, y_2, \ldots, y_n)$, we are looking for a unique function $\hat{f}(x_i)$ with two continuous derivatives, to fit the given data and to minimise the quantity:

$$\sum_{i=1}^{n} \{y_i - f(x_i)\}^2 + \lambda \cdot \int_a^b \{f''(t)\}^2 dt \qquad (4.14)$$

λ is a fixed constant and it is called the smoothing parameter

The quantity *(4.14)* is called: the penalised residual sum of squares and it is a natural cubic spline with knots at the unique values of x_i, where

$$a \le x_1 \le x_2 \le \ldots \le x_n \le b$$

The first term in *(4.14)* is a decreasing measure of the goodness of fit, while the second term is a decreasing measure of the smoothness. The two terms in *(4.14)* correspond to the conflicting criteria of goodness of fit and smoothness and these have been combined together as a weighted average. The aim is to fit a function to the given data by minimising the formula *(4.14)* and to emphasis the trade-off between goodness of fit and smoothness through the coefficient parameter, λ, which governs this trade-off.

Large values of λ produce smoother curves while small values of it produce more jagged curves but closer to the data. At the extremest case where $\lambda \rightarrow \infty$ then $f''(x) \rightarrow 0, \forall x$, and as a result the solution tends to the least squares line. On the other hand when $\lambda \rightarrow 0$, then the second term of *(4.14)* tends to zero and the solution tends to an interpolation of the data and ceases to provide a smooth trend. In practice, a compromise curve can be selected by choosing an intermediate value of λ. The degrees of freedom of the smoothed splines play the role of the smoothness parameter.

This method of graduation is flexible and easy to apply and it was applied in the construction of the English Life Tables No.15 and used for the construction of interim or abridged life tables and for graduating fertility data (Haberman S., 1996). However, the cubic splines smoother may produce unreliable estimates, since data below the first knot and above the last knot, become, by construction, a straight line[10]. Cubic splines are not therefore well suited for producing estimates rates outside the range of the data.

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[10] This feature was proved when the model applied to the Egyptian data.

4.8. Whittaker Graduation

Although it is argued that Whittaker graduation has a very close connection with parametric curve fitting techniques, it is usually viewed as non-parametric method (Verrall R., 1995). In this method, the estimate of the function $\hat{f}(x_i)$ is obtained by minimising the quantity:

$$\sum_{x=x_1}^{x_n}(\dot{\mu}_x - f(x))^2 + \lambda\int_a^b(\nabla^2 f(t))^2 dt \qquad (4.15)$$

where, $a \leq x_1 \leq x_2 \leq \cdots\cdots \leq x_n \leq b$

$\nabla^2 f(x)$ indicates the second difference in the estimates. The value given by the formula *(4.15)* is called the penalised residual sum of squares. It is clear from formula *(4.15)* that the first term is a measure of goodness of fit and the second is a measure of smoothness. It can be shown that the value *(4.15)* has a unique minimiser, which is a natural cubic spline with knots at each value of X (Verrall R. J., 1996).

The parameter λ controls the trade-off between goodness of fit and smoothness and it can be chosen subjectively or by a mathematical method such as the cross validation method. The greater the value of λ the smoother the fitted curve and vice versa. So, if $\lambda = \infty$, we get a very smooth curve and the solution will be the least squares solution, but if $\lambda = 0$, a very wiggly curve is produced and the solution will tend to an interpolating twice differentiable function. It is observed that increasing the model degrees of freedom produces a graduation, which is less smooth[11].

4.9. Tests of graduation

The hypothesis to be tested in this mortality investigation is that the true mortality rates of the population are those graduated rates. A wide selection of graduation tests for goodness of fit and smoothness are available which include the χ^2 test, individual standardised deviations test, the signs test, cumulative deviations test, grouping test, serial correlation test and smoothness. These tests are briefly mentioned in **Appendix 3**. Smoothness is not tested since GAMs ensure a smooth progression of the fitted (graduated) rates.

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[11] Full details about GAMs and smoothers can be found in: Hastie and Tibshirani, 1990, Chambers and Hastie, 1993, 1994, W.N. Venables and B.D. Ripley, 1998, and Verrall R. J., 1993, 1995 & 1996.

4.10. Estimating Individual age Data

As mentioned earlier, data are available only in 5-year age groups (except for age groups 0, 1-4) and the data for ages 75+ is in one group, which is not usable or reliable, so that mortality rates for these ages need to be extrapolated. These features have to be addressed in the process of graduation as they affect the selection of the appropriate model to graduate the crude mortality rates. The first problem is dealt with in the following section. The second problem, about estimating mortality rates at high ages through extrapolation, is dealt with at the end of this chapter.

4.10.1. Grouped Data

Carrying out mortality or actuarial investigations based on data grouped into age ranges rather than individual years of age is not a new phenomenon, and was often encountered during the early years of actuarial practice. Data from some early censuses and from many countries, including Egypt, are available for age groups (usually quinary ones) both for exposed to risk and deaths. Even when data become available for individual ages, maintaining data in age groups is seen useful. This is because subdividing data into quinary groups was thought to be necessary in order to offset the systematic errors in the statement of age (Benjamin and Haycocks, 1972).

The systematic errors occur because of many people's preference for certain terminal digits of their age, particularly those who are actually unsure of their exact ages amongst old people, and also in the case of countries where there is high level of illiteracy. Under such conditions, quinary age groups were considered to minimise the distortion caused by such errors, since it might be preferable to deal with the imprecision of a set of grouped data rather than a corresponding set of individual ages' data which might be doubtful. However, having to graduate a set of grouped data, there are some disadvantages such as:

1. There is a relatively small number of data points in the graduation process;
2. The average crude rate of each group together with the equivalent average age of each group is used to represent the whole group of ages, which may be a misrepresentative of the actual mortality rates of the individual ages of this group;
3. Some important but relatively small-scale features of the true rates might not be detected as the representative data points may not give a clear view regarding the progression of the true rates;
4. Grouping higher ages in one-group results in losing all the details about these ages.

Improving the reliability and accuracy of the results of a graduation process of a set of grouped data might be achieved if the number of data points is increased. This can happen by either estimating exposures and death counts or mortality rates for each year of age from group totals. Theses data points (estimates of the individual age) can then be graduated and in this case the graduation process will have been based on a wider range of data points and not only on the representative ones of each group. Therefore, it is considered necessary to estimate the individual ages' data from the grouped ones, in the process of the construction of the Egyptian Life Table.

4.10.2. Methods of Estimating Individual age Data Points

There are many demographic and actuarial methods for estimating individual age data points given a set of grouped data points[12]. In this section, two of the actuarial techniques are mentioned and the second one is applied to the numbers of both exposed to risk and deaths of the Egyptian data. The first is the King's/Osculatory method and the second is an alternative (iterative) method. Tzeis (1996) applied these two methods on the exposed to risk of the Greek pension scheme and also on the data of the ELT No 13 in order to validate the alternative method against King's/Osculatory method. In the next sections, the King's/Osculatory method is mentioned and the alternative method is described in more details as it is applied to the quinary Egyptian data.

4.10.2.1. King's/Osculatory Method

A traditional way for improving the graduation process of grouped data, as described by George King, estimates the intermediate data points of each group, the "pivotal values", u_{x+r}. The grouped totals may be denoted in the following way:

$$\left.\begin{array}{l} W_{-1} = \sum_{r=-2n-1}^{=1} u_{x+r} \\ W_0 = \sum_{r=0}^{2n} u_{x+r} \\ W_1 = \sum_{r=2n+1}^{4n+1} u_{x+r} \\ \quad \ldots \end{array}\right\} \qquad (4.16)$$

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[12] For details about the demographic methods readers can be referred to the Manual X of the Indirect Techniques for Demographic Estimation of the United Nations, 1983.

where u_{x+r} represents the data at each individual age, *x+r*, and is a third-degree function of *r* which could represent any chosen variable derived from the data, such as exposures (R_{x+r}), deaths (A_{x+r}) or crude rates ($\overset{\bullet}{m}_{x+r}$). It is desired to obtain the numeric value of u_{x+r} (the pivotal value), from the grouped totals of W_{x+r}, where every group extends over 2n+1 values of *r*. King's pivotal value formula for quinary groupings is:

$$u_{x+2}=0.2\times W_0-0.008\times \Delta^2 W_{-1}+\cdots \tag{4.17}$$

And the formula can be extended for the pivotal value of every group as follows:

$$\left.\begin{array}{l} u_{x+2}\approx 0.2\times W_0-0.008\times \Delta^2 W_{-1} \\ u_{x+7}\approx 0.2\times W_1-0.008\times \Delta^2 W_0 \\ u_{x+12}\approx 0.2\times W_2-0.008\times \Delta^2 W_1 \\ \quad\cdots \end{array}\right\} \tag{4.18}$$

The method then applies osculatory interpolation in order to obtain data estimates at each individual age for the entire age range. Assume that we want to interpolate the values of u_x, between u_x and u_1, given a set of 4 pivotal values: u_{-1} , u_0 , u_1 and u_2. The symmetrical third degree osculatory interpolation formula, correct to the second differences and appropriate for the age interval *[0, 1]* is called Lidstone's formula:

$$u_x=u_0+x\times \Delta u_{-1}+\frac{x(x+1)}{2}\times \Delta^2 u_{-1}+\frac{x^2(x-1)}{2}\times \Delta^3 u_{-1} \tag{4.19}$$

Lidstone's interpolation formula ensures the continuity of the first derivative of the overlapping interpolation curves at the relevant pivotal ages so that these curves join smoothly.

This method was applied to national census data and used in the construction of the English Life Tables numbers *7-10* as data were available in quinary age groups. However, given a set of n pivotal values: $u_1, u_2, \ldots, u_{n-1}, u_n$, the only estimates that can be generated by King's/Osculatory method lie within the interval $[u_2, u_{n-1}]$. This means that the individual ages' estimates extend only between the second and the *n-1* pivotal values and this weakness makes the method inappropriate for the Egyptian data, which is already insufficient[13].

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[13] More details about the King/Osculatory method can be found in (Benjamin and Haycocks, 1972).

4.10.2.2. The Alternative (Iterative) Method

Tzeis (1996) demonstrates that the alternative (iterative) method produces almost identical results to those of the King/Osculatory method, given a good amount of data. He proved that the alternative method approximates the King/Osculatory method to a very satisfactory degree. But it has an advantage over the King/Osculatory method of producing individual data estimates covering the whole age range of the initial grouped values, which is a critical point for the limited age range of the Egyptian data.

This method assumes that there are *n* quinary age groups of data, which means that there is $5 \times n$ individual age data points to be estimated. These ($5 \times n$) individual age data points form a vector of length of $5 \times n$, whose i^{th} element equals the average of the data of the age group to which the individual age x_i belongs. The newly formed vector is called "level vector", and has a piecewise constant form. This vector is to be smoothed subject to the constraint that the total of the new smoothed estimates of each group equals the initial quinary age group.

Then, if the absolute value of the difference between the original i^{th} element and the predicted value of the i^{th} element is less than a certain numerical limit[14] for every one of the n groups, then these predicted values represent the required estimated individual ages' data. However, if this objective was not met, another step called correction is carried out. In the correction step, a vector of length $5 \times n$ whose i^{th} element equals:

i^{th} *element of the initial exposures -* i^{th} *element of the predicted exposures/5* *(4.20)*

is created. This correction vector is then added to the predicted vector. Then the smoothing and correction steps are to be repeated until the above mentioned criterion is satisfied, which is examined after each smoothing.

The smoothing process is carried out by fitting cubic spline with knots at each age from 1 to 74. Cubic spline fitting acts as an alternative to Lidstone's osculatory method as it is the smoother that approximates the features of osculatory interpolation. Cubic spline fitting ensures the continuity of the first derivatives on the pivotal values, which is a property of the Lidstone's formula, because, by definition,

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[14] The numerical limits for the method to converge were set as a proportion equal to the **0.000001** of the aggregate actual central exposures and **0.00001** of the aggregate actual deaths for each group, which were used in order to terminate the iterations.

their first and second derivatives are continuous over their whole domain. The above described method was applied using modules written using the statistical package S-Plus developed for this purpose.

4.10.2.3. Applying the Alternative Method

It was observed that the inclusion of age 0-1 into the iterative method distorts the progression of the predicted values and therefore that age group was not included. The grouped data, x = 2, 7,....., 72 are taken as applying to the mid-points of the age groups (BAJ, Volume 4, Part I, 1998). The iterative method produced satisfactory estimates of individual age exposures and deaths for both males and females over the age range 1-74 (**see Table 3.2 of Appendix 3**). Figures 4.2 and 4.3 demonstrate the graphical results of the alternative method as a comparison between the estimated exposures and deaths against the average exposure and deaths of each group respectively.

Figure 4.2. Individual's ages Exposure by the iterative method and the Initial Grouped Ones

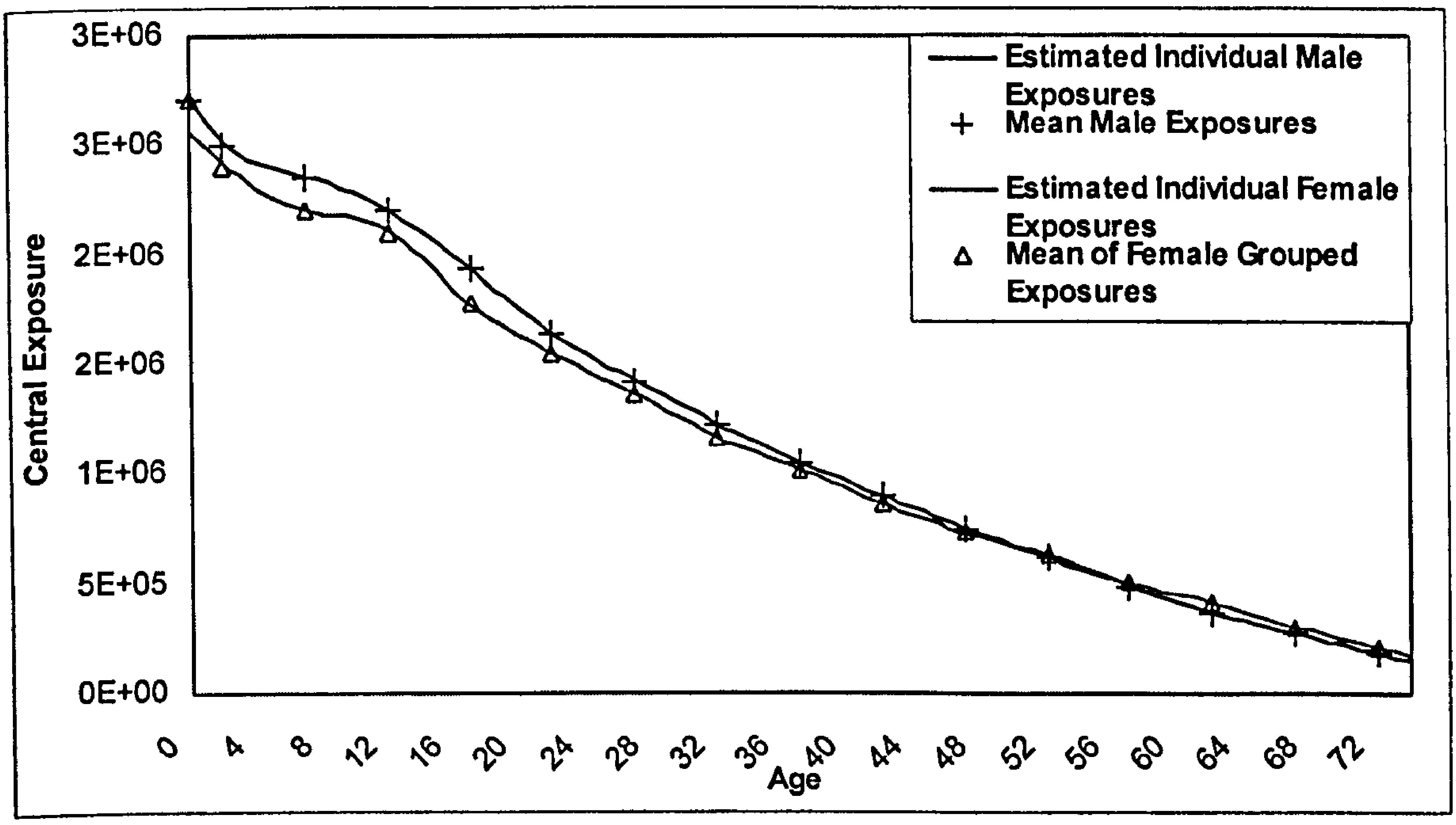
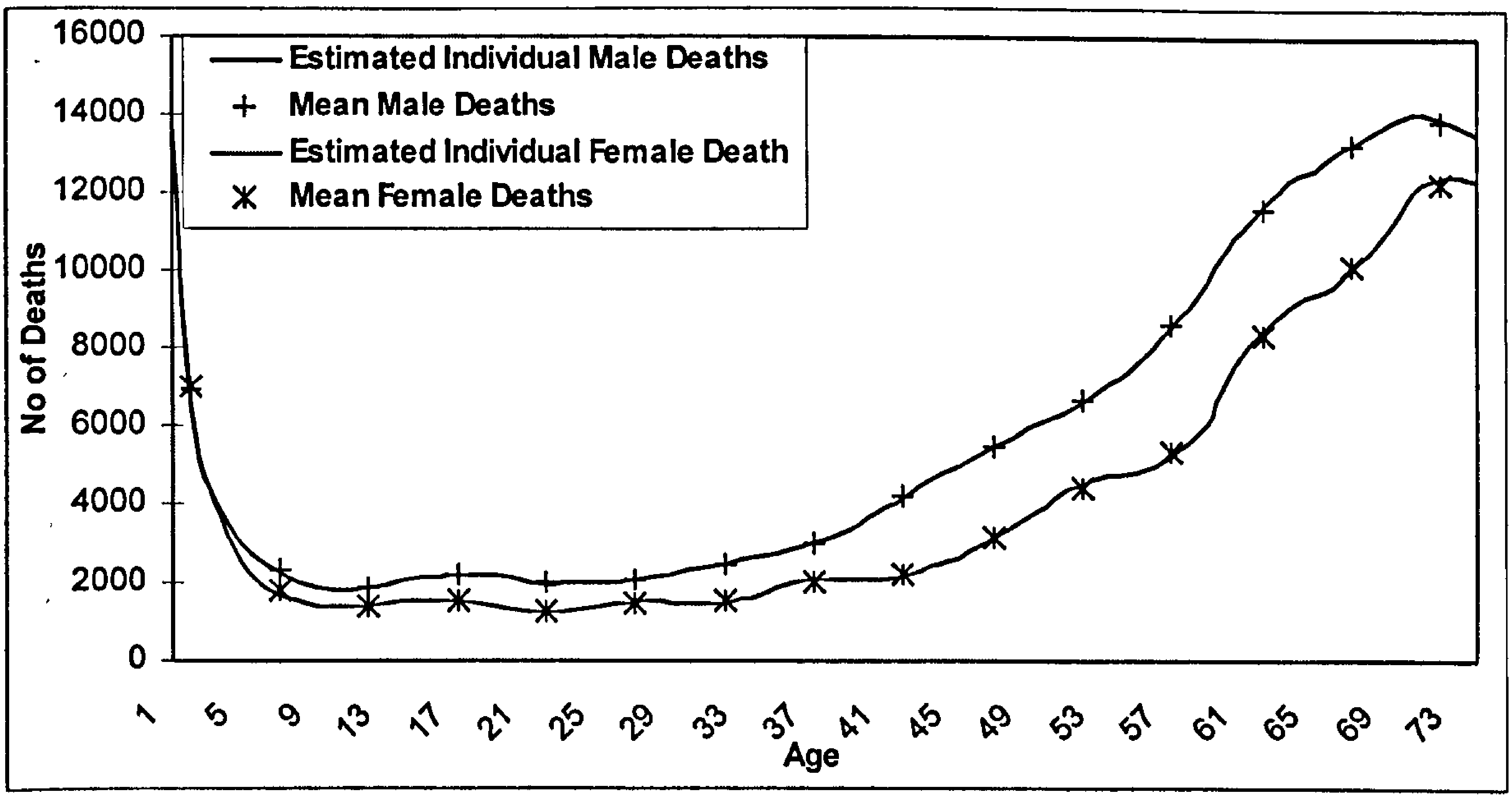


Figure 4.3. Individual age deaths by the iterative method and the Initial grouped ones



The two figures show that both curves behave in a proper manner and that the fitted curves lie within the means of the actual grouped data, which implies a satisfactory fitting. There were no significant fluctuations in the overall progression of the exposures, although there were little humps at age group 10-15. However, the females' death curve shows fluctuations at most of the ages, and particularly at ages 15+, as a result of inconsistent increases in the total number of deaths with the increase in age. The crude central mortality rates for males and females were then calculated for individual ages using central exposures and deaths estimated by the iterative method, and are compared with the grouped ones on the log scale as shown in Figure 4.4 and **Table 3.2 of Appendix 3.**

Figure 4.4. Individual's ages Central Crude Mortality Rates and the Initial Grouped

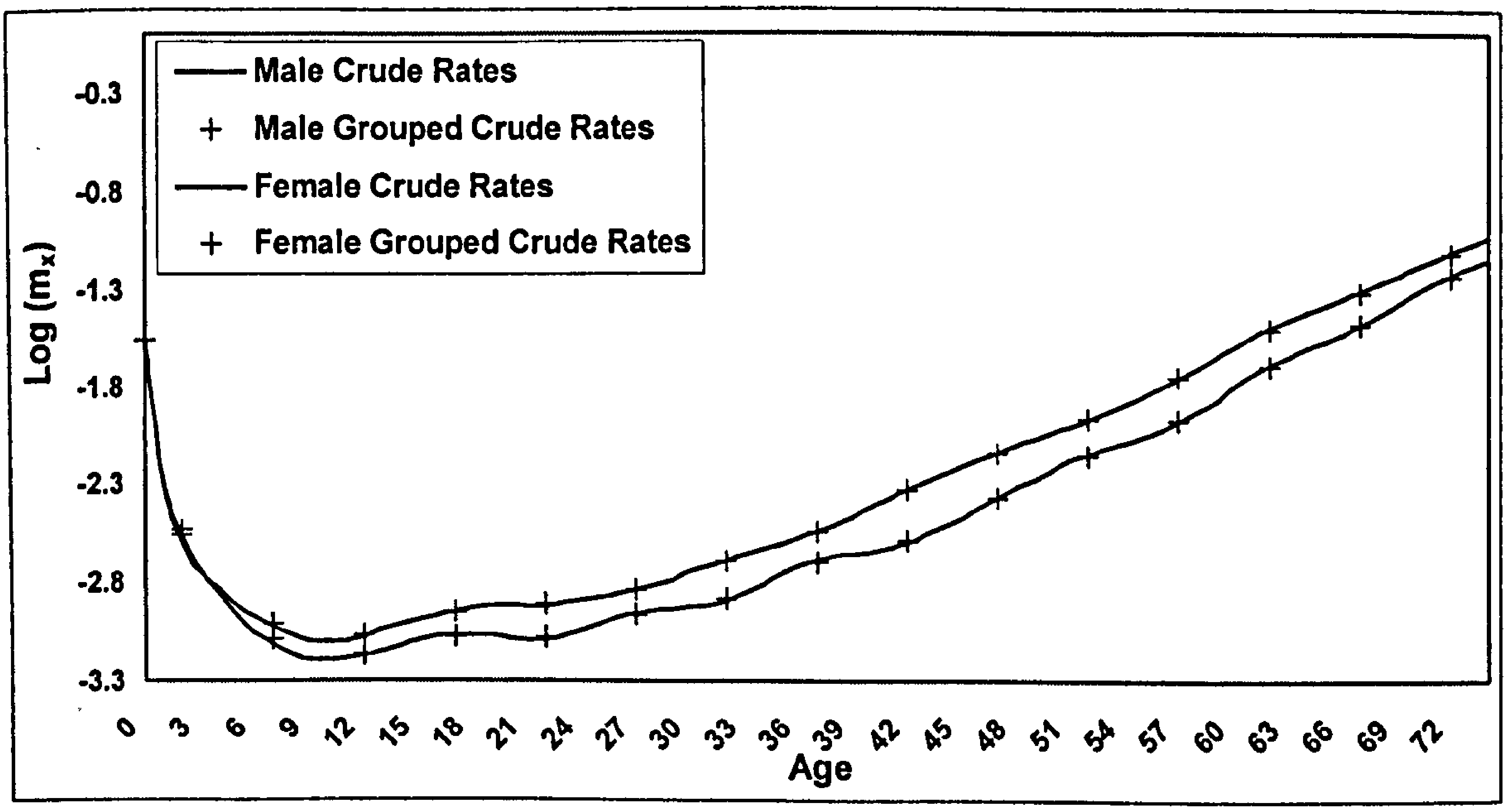


Figure 4.4 shows that individual age crude mortality rates fluctuate more than the grouped ones, particularly within the females' rates. This was expected because the grouped ones were just representatives of their groups, as explained before. It is also because the accuracy of the female data is relatively less than male data, particularly for females who live in the rural areas of Egypt.

These crude rates have to be graduated to reduce the random fluctuations and progress smoothly over the whole age range, while still preserving the general shape of the true mortality experience of the 1994-96 investigation as far as possible. In the following sections, the results of the graduation of the individual crude mortality rates are presented.

4.11. Graduating Individual Ages' Mortality Rates

The model used is a GAM based on a Poisson family using a natural (default) link function for this distribution, that is a log-link, and R_x^c as prior weights assigned to each observation $\overset{\circ}{m}_x$. Therefore, with m_x as the response variable and the age as the predictor, a GAM is fitted using the function 4.12.

Some of the earlier mentioned non-parametric models[15] were applied within the context of the GAMs, to the individual age crude central mortality rates for ages *1-74* of males and females. It was decided to utilise the crude value at age 0 without modification and not to include it in the fitting procedure as it places a heavy constraint on the fitting procedure as a result of the severe curvature of mortality.

Graduation tests were applied to the fitted models to select the one which best fits the data. It was found that the Whittaker and Cubic Splines give a satisfactory fit as both models pass most of the statistical tests. However, a problem was encountered with estimating mortality rates at high ages. Cubic Spline produces biased estimates at the end of the available age and unreliable estimates are observed, since above the last knot the fitted curve becomes a straight line. Therefore, it was decided not to use such model.

Whittaker graduation produced a good fit for the available age range 1-74 as well as satisfactory estimates at high ages. Accordingly, it was decided to employ a variant of

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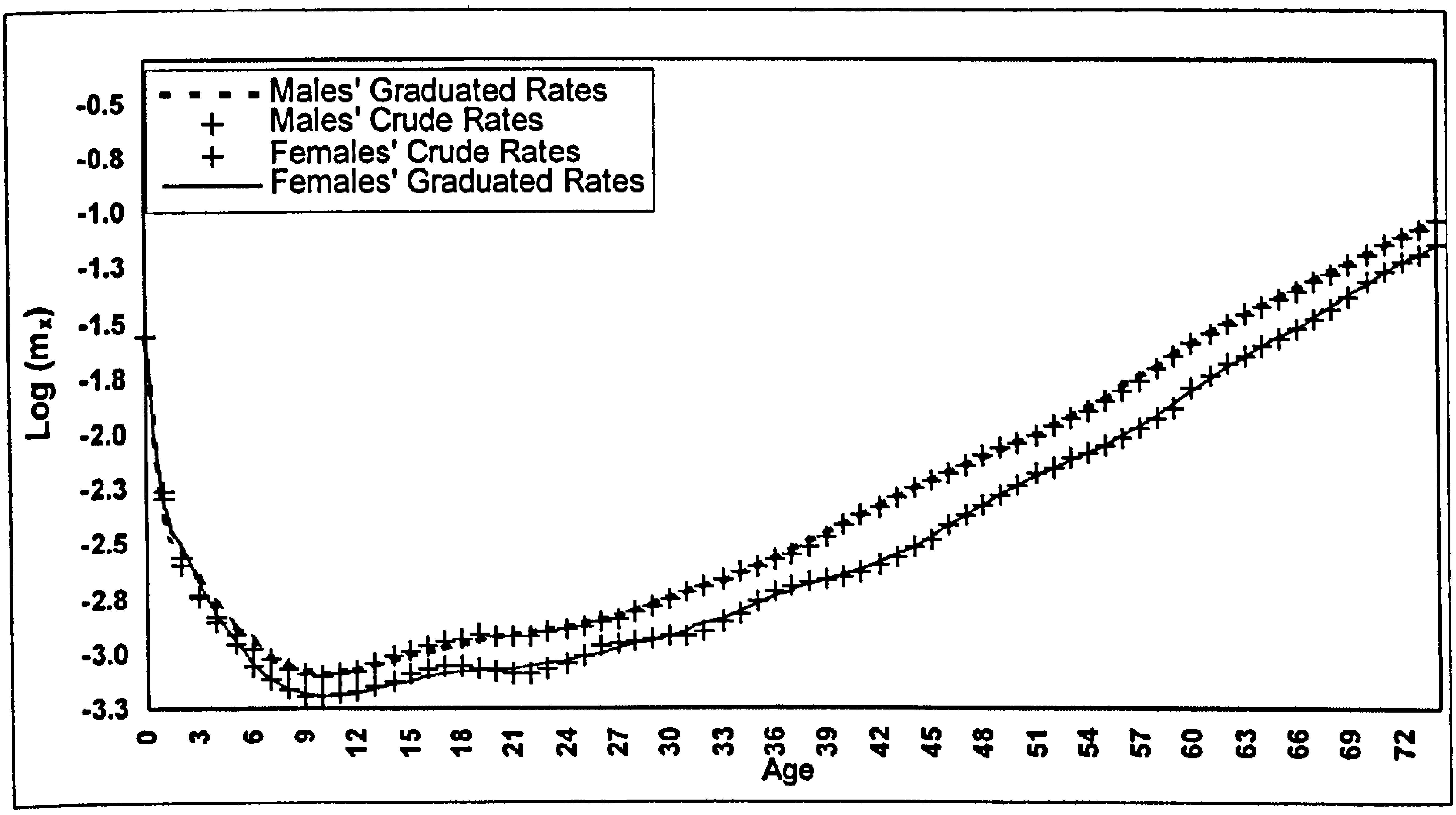
[15] It was very hard and beyond the scope of this thesis to find a parametric model to fit the whole mortality curve.

the Whittaker fitting method to smooth the curve for ages 1-74 for both males and females. Whittaker models with parameter *df*[16] = 12 for males and *df* = 13 for females provided the best fit according to the graduation tests carried out.

Plots of the fitted (graduated) and crude central mortality rates are displayed on a log-scale against age for males and females shown in Figure 4.5. A visual inspection of Figure 4.5 (as well as the statistical tests) shows that the graduation seems to provide satisfactory fit to the data, though not perfect. The results of fitting the model and the results of the statistical tests applied to the graduated rates are in **Tables 3.2 Appendix 3.**

Figure 4.5. Individual Age's Crude and Graduated Mortality Rates of the Egyptian Male and Female Population, 1994-96



It was also important to make a visual inspection of the graduated individual age mortality rates against the grouped ones on the log scale for both males and females as shown in Figure *4.6*. It is clear from figure *4.6* that the grouped crude mortality rates lay within the fitted curve, which implies a satisfactory fitting. The graduation is satisfactory and hence the model is considered to be adequate as the results prove to be quite supportive of the fitted model. The overall conclusion is that the Whittaker model provides a satisfactory graduation.

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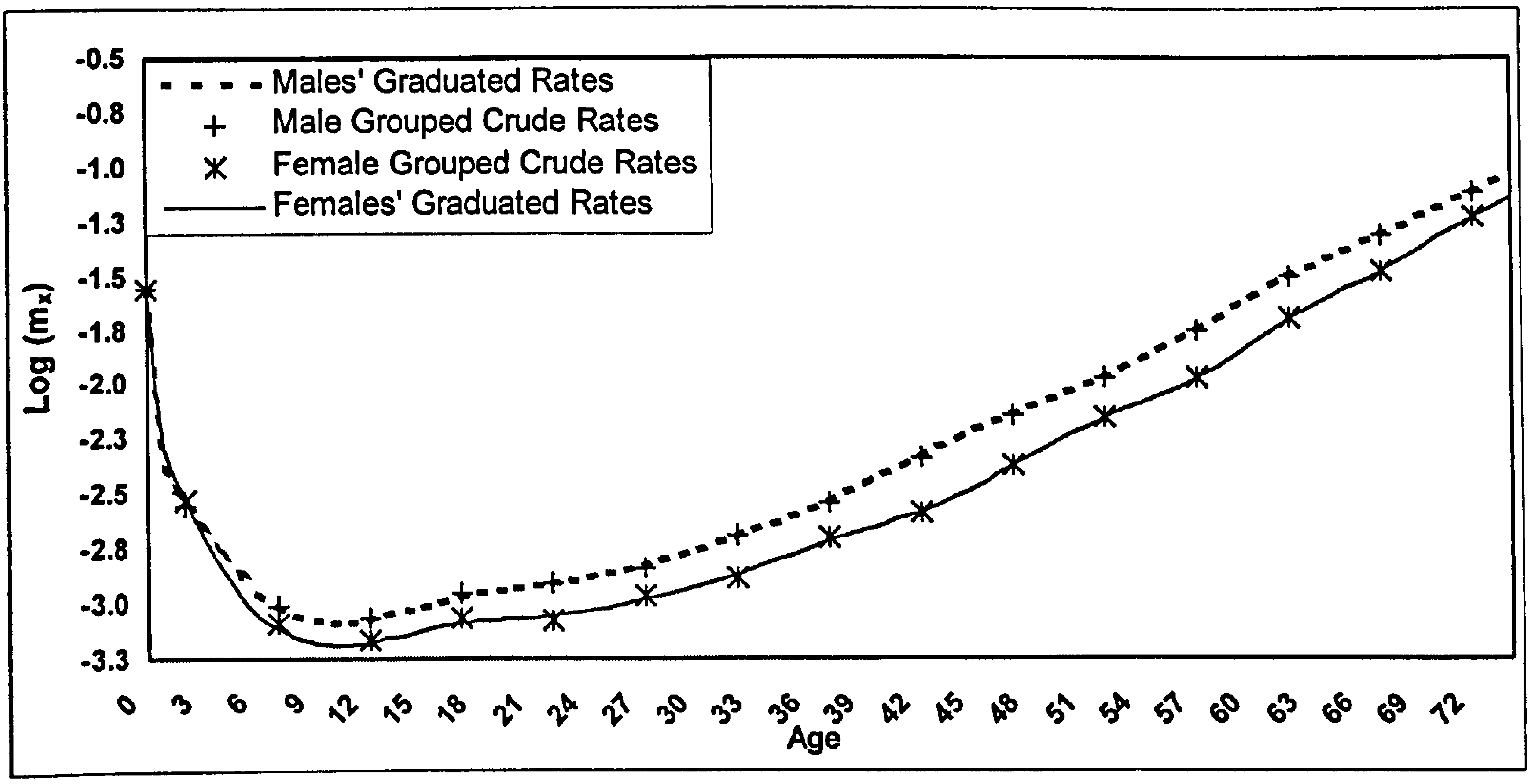
[16] The number of degrees of freedom is a measurement of the smoothness demanded and it is inversely proportional to the smoothing parameter, and the number lost in the fit is decided by the parameter *df.*

Figure 4.6. Individual Age's Graduated and Grouped Crude of Log$_{10}$ (m_x) of Males and Females, 1994-96 experience.



4.12. Extrapolating Mortality Rates at ages 75+

The available data for exposed to risk and deaths enable the fitting of curves for individual ages up to age 74 only, for both sexes. However, it is necessary to complete the graduation by obtaining mortality rates at all ages until ω[17]. In Egypt, there is no recorded experience for mortality rates for ages 75+ other than the grouped data for ages 75+. Therefore, mortality rates for these ages must be estimated by extrapolating the fitted curve beyond the age range.

However, it was necessary to ensure that for the ages included there is a monotonic (upward) progression in the crude rates otherwise the graduated rates of mortality may turn downwards. Mohamed (1997) used a method taken from Renshaw and Haberman (1997) to test the goodness of the estimated rates of the Whittaker model and he concluded that the Whittaker model provides satisfactory estimates of mortality rates at high ages[18] beyond the age range. Therefore, the Whittaker model was used to estimate mortality rates for ages 75+ for both males and females and the model gives reasonable estimates beyond the age range. The model extrapolates the values of m_x[19] obtained for ages 75 to 103 for males and to 105 for females as shown in Figure 4.7[20].

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[17] Meaning last available age in the life table.

[18] He used data of lives assured of the largest three insurance companies in Egypt over 1986-1991 and the A49/52 Table as a standard table.

[19] The values estimated are the m_x (by default).

[20] The prediction procedure is carried out using the S-Plus.

Figure 4.7. Graduated, predicted and grouped crude of $\text{Log}_{10}(m_x)$ of males and females, 1994-96 experience

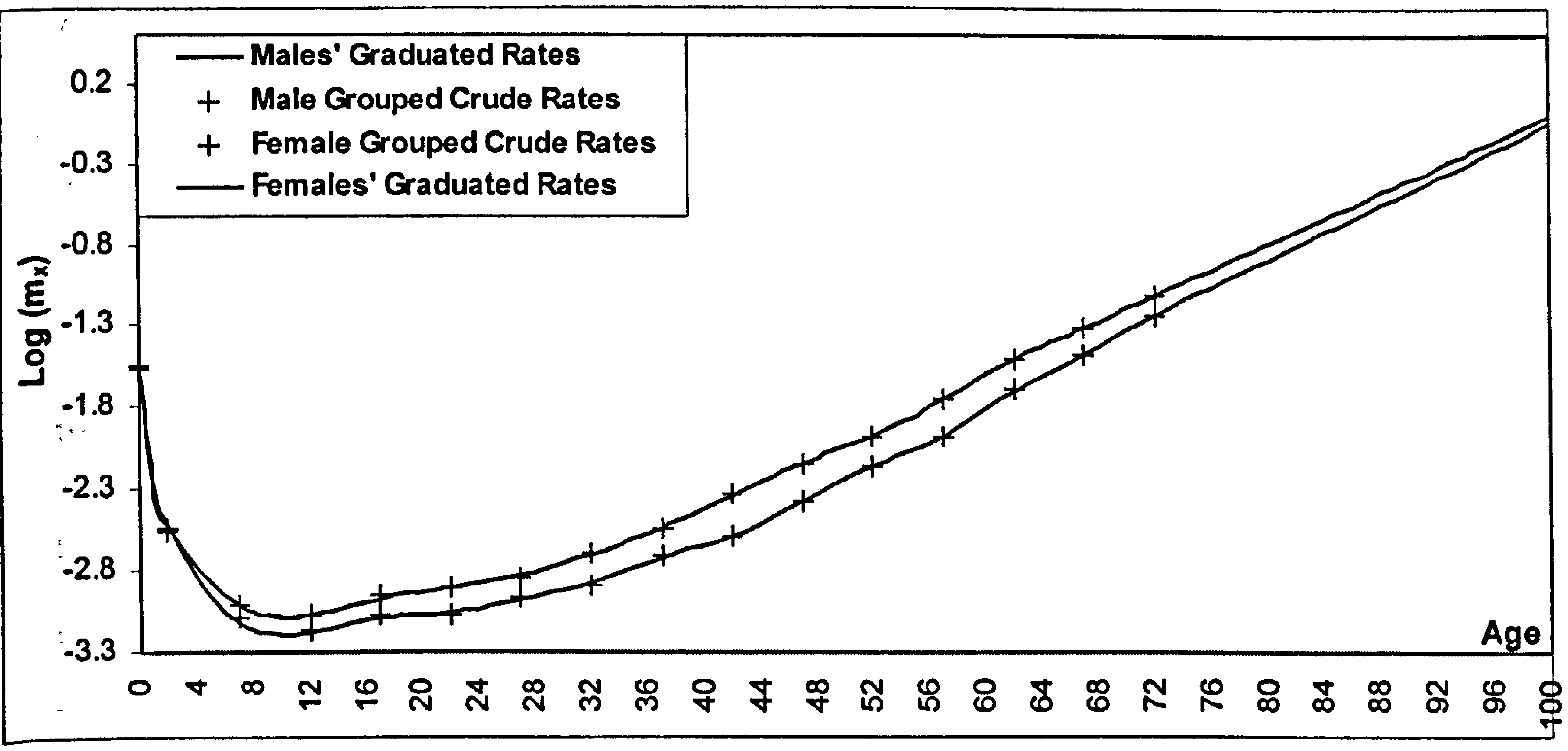

Figure 4.7 shows the whole curves of graduated and predicted central mortality rates alongside the grouped crude central mortality rates for both males and females at all ages including high ages on the log scale. A visual inspection of this figure shows that the Whittaker model provides satisfactory estimates of mortality throughout the available age range and provides good estimates for mortality rates at high ages (see **Table 3.2 of Appendix 3**).

4.13. Construction of the Full Life Table

4.13.1. Estimating Initial Mortality Rates (q_x)

In order to produce life tables for both males and females, it was necessary to calculate the other parameters of the table from the graduated central mortality rates, m_x such as the values of q_x (initial mortality rates). Graduated central mortality rates were converted into initial mortality rates, q_x which give the probability of a person aged exactly x dying before reaching age $(x + 1)$. The available information is

(i) Value of q_0 derived directly from the data at age 0 over 1994-96

(ii) Graduated central mortality rates m_x for x = 1,...., 74

(iii) Projected central mortality rates m_x for x = 75,......, ω[21] (for males and females).

(iv) φ_0 the average age at death for those dying in the first year of life, assumed to be 0.10 for males and 0.08 for females (CAPMAS, 1995).

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[21] q_x approaches, but never quite reaches, the value of 1 as age increases.

The mathematical procedure for determining the initial mortality rates is then:

$$m_0 = \frac{q_0}{1 - (1 - \varphi_0)q_0} \qquad (4.21)$$

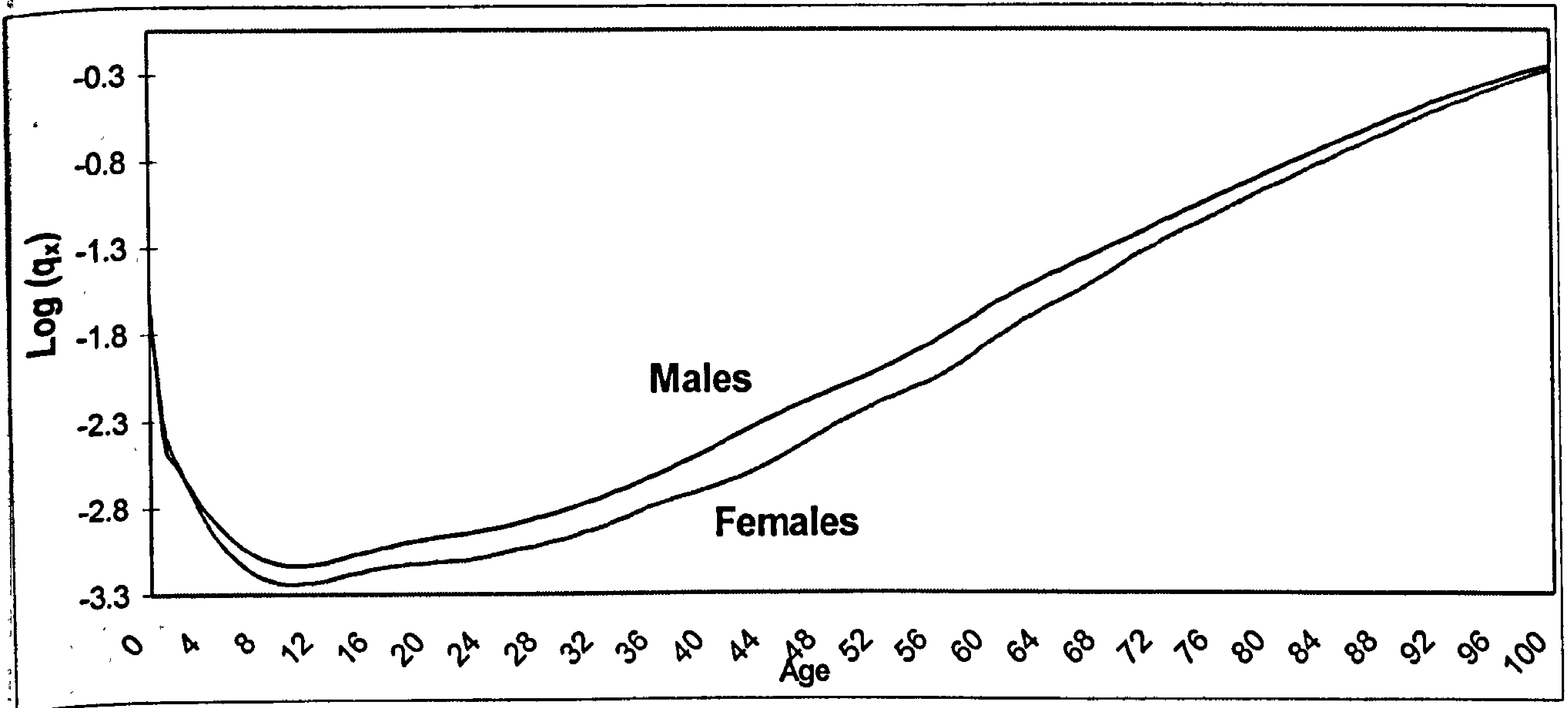
$$q_0 = m_1\left[\frac{1 + \frac{1}{2}m_2}{1 + \frac{1}{2}(7m_1 + 5m_2) + \frac{1}{3}m_1m_2}\right] \qquad (4.22)$$

$$q_x = m_x\left[\frac{1 - \frac{1}{2}m_{x-1}}{1 + \frac{5}{12}(m_x - m_{x-1}) - \frac{1}{6}m_xm_{x-1}}\right] \qquad (4.23)$$

for $x = 2, 3, \ldots\ldots, \omega - 1$ (for both males and females)

Having made these assumptions, the arrays (m_x) and (q_x) are completely determined for $x = 0, 1, \ldots\ldots\ldots, \omega - 1$ in **Table 3.2 of Appendix 3** and Figure *4.8* shows the (q_x) of males and females on the log scale.

Figure 4.8. The q_x of males and females Egyptian population on log scale, 1994-96 experience



4.13.2. Life Expectancy

This national life table has been constructed assuming that 100,000 persons born are divided in the ratio[22] 106:100 between females and males and that the resulting male and female populations develop in line with the respective single sex life tables. The ratio has been selected as being the average sex ratio of births over 1980s and 1990s. The values of l_x were found successively from the radix l_0 and the following

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[22] This ratio was estimated as the geometric mean over the period 1967-96. This ratio increased from 1.01 in 1948 to 1.29 in 1966 and since then has been decreasing to 1.05 in 1996.

relationship:

$$l_{x+1} = l_x(1 - q_x) \qquad (4.24)$$

The values for the complete expectation of life at each age, $\overset{\bullet}{e}_x$ were calculated as follows:

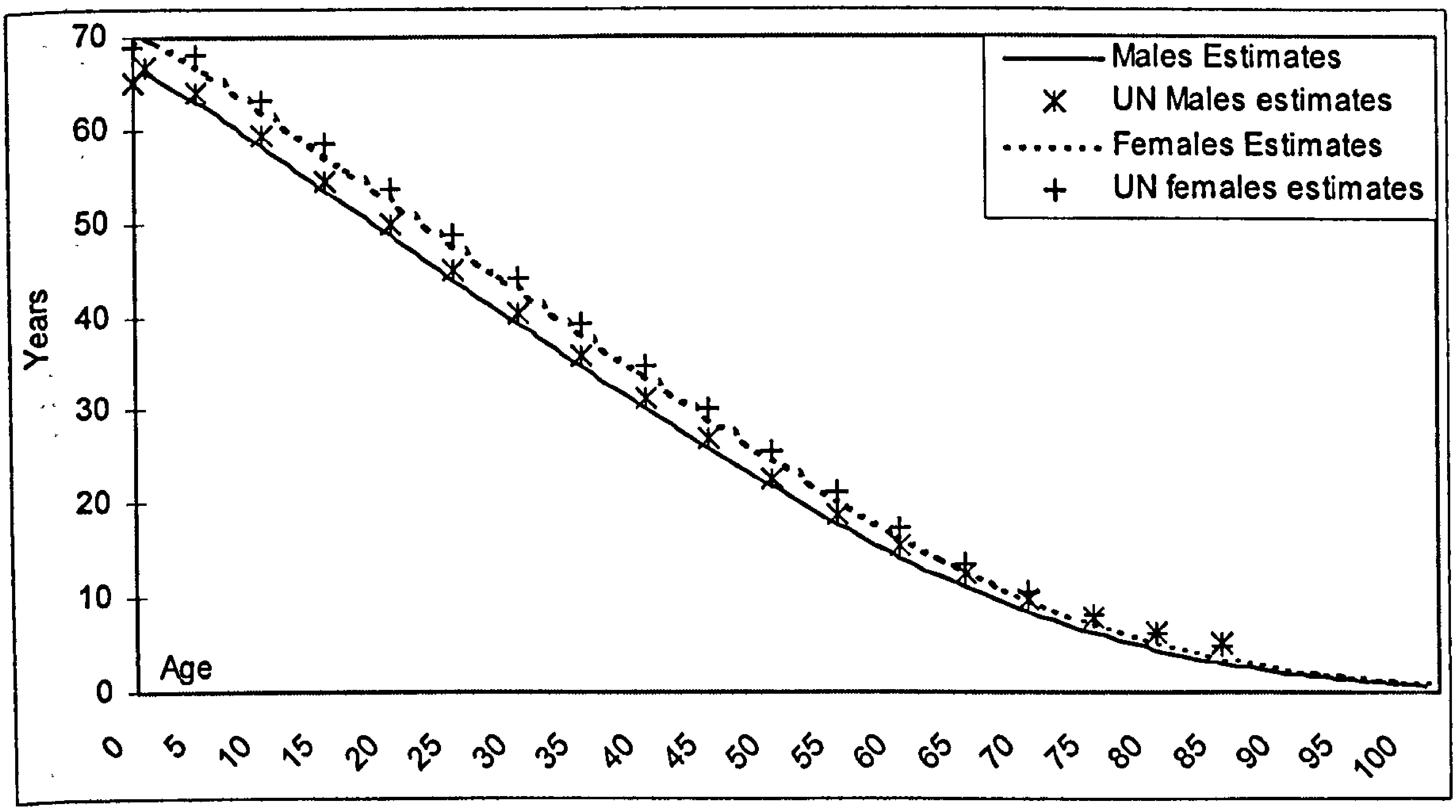
$$\overset{\bullet}{e}_x = \sum_{t=1}^{w-x-1} \frac{l_{x+t}}{l_x} + ½ - ½\,\mu_x \qquad (4.25)$$

The value of T_x, the number of years that survivors to age x will collectively survive thereafter is calculated as $l_x \overset{\bullet}{e}_x$. A comparison between the life expectancy of males and females of 1994-96 experience with the UN 1996-97 estimates shows that the later are slightly higher (except for age 0) as shown in Figure 4.9 and **Table 3.2** of **Appendix 3.**

These differences can be attributed to one or all of the following factors:

1. The difference in the investigation periods, which is roughly 2 years earlier in our investigation;
2. The use of different models in the estimation of future mortality rates;
3. The accuracy of the data used in both of the investigation.

Figure 4.9. Life Expectancy for males and females, 1994-96 experience compared with that estimated by the UN 1996-97



However, this comparison shows that the model produces very reasonable results, which indicate that the Whittaker model produced satisfactory results. An important indicator in this case is the expectation of life of a man and a woman at the current state pension age of 60 which are14.13 and 16.43 years respectively in our model and 14.85 and 15.47 in the UN estimates.

4.13.3. The Force of Mortality

The value of μ_x, the force of mortality at age *x*, is calculated as

$$(11l_x - 18l_{x+1} + 9l_{x+2} - 2l_{x+2}) / 6l_x \qquad \text{for } x = 1 \text{ or } 2, \text{ and} \qquad (4.26)$$

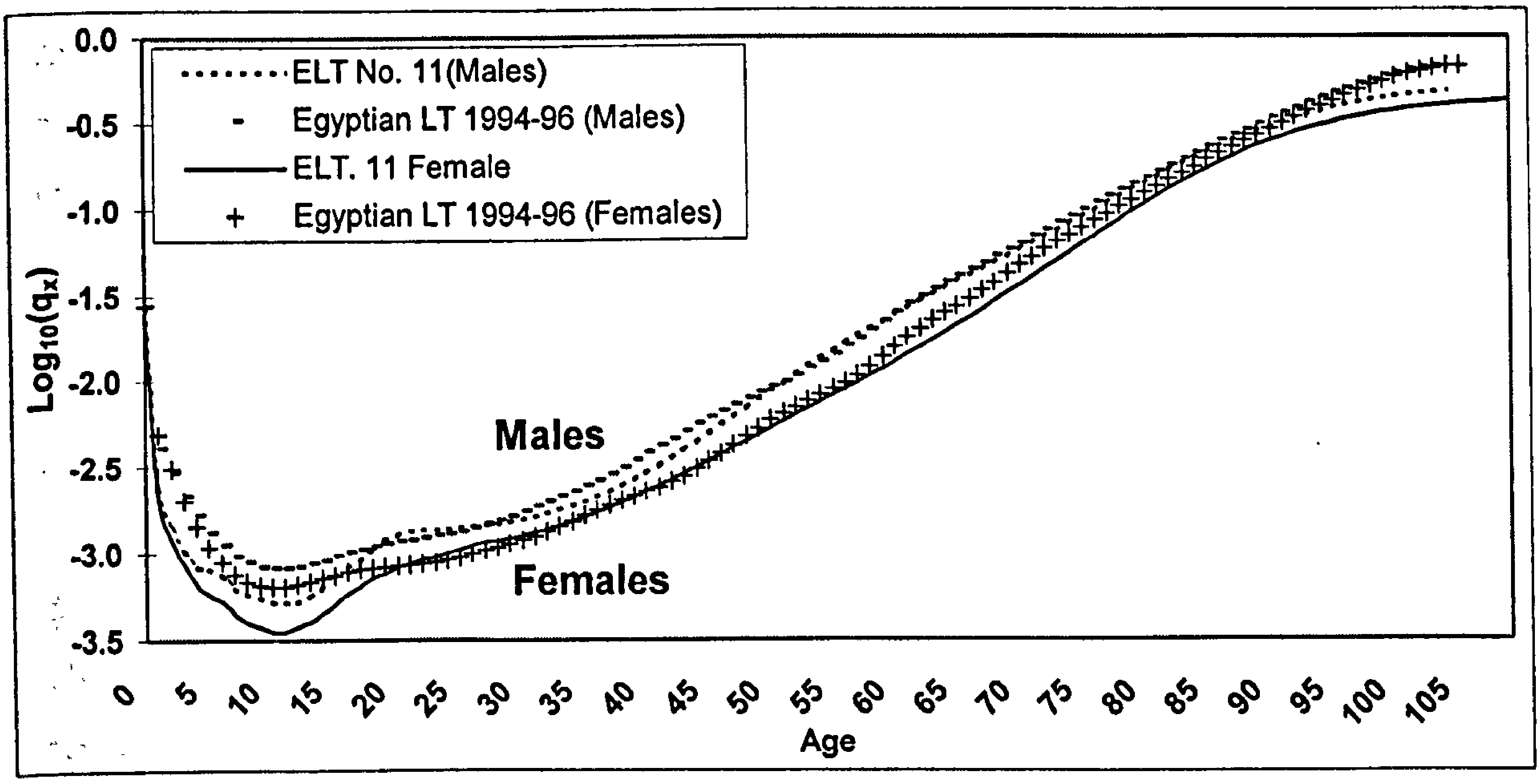
$$(-l_{x-2} + 8l_{x-1} - 8l_{x+1} + l_{x+2}) / 12l_x \qquad \text{otherwise} \qquad (4.27)$$

The full results of the construction of the Egyptian life table are in **Table 3.2 of Appendix 3.**

4.14. Comparison with the ELT No. 11

A comparison between the Egyptian mortality rates and the English Life Table No. 11 is carried out in order to indicate the level of the Egyptian mortality compared with a standard table such as ELT. Figure 4.10 shows the Egyptian rates of males and females versus the ELT No. 11 (1950-52 experience) of *males and females* on log scale (**see Table 3.2 of Appendix 4**).

Figure 4.10. The q_x of the Egyptian 1994-96 Experience compared with the ELT No. 11 (1950-52 Experience) of Males and Females on Log scale.



This graph shows that male mortality in Egypt is higher than that of ELT No. 11, except for ages *0-1, 19-26* and *53-58*. Egyptian female mortality is lower than that of the ELT No. 11 at ages *21-33* and *41-45* only. The largest differences between male mortality in Egypt and ELT No. 11 are at ages *1-17* and *60+*, and for females at ages *1-20* and *60+*. Therefore, the conclusion from this comparison is that the Egyptian mortality experience of 1994-96 is heavier that those of the ELT No. 11 at most of ages other than birth (age 0).

4.15. Mortality Experience of the Members of the ESSPS

Improving the quality of the valuation and projection of pension schemes requires the use of mortality rates that based on the most recent experience of the scheme's members to reflect the actual situation and give accurate information about the financial position of the scheme. This also requires the adoption of different mortality rates for death in service, death after old age retirement, death after invalidity retirement and death of survivors. This also requires using different mortality rates for different categories of members (or different schemes) of the system. It is clear that the homogeneity of members within each scheme will have specific effects on the mortality rates of these schemes and we should allow for this mortality differences between different schemes with the heaviest is supposed to be the casual workers.

However, there is no available data to investigate such mortality experiences of the members of the ESSPS as a whole or of different schemes. Therefore, prudent mortality rates are necessary required in such a case. Although national population mortality rates are supposed to be heavier than the mortality of the members of pension schemes, they represent the prudent assumption in such a case. Therefor, a comparison between the Egyptian Life Table 1994-96 experience, constructed in this Chapter, and the mortality tables adopted by the actuaries in the valuation of the ESSPS and occupational pension schemes in Egypt is carried out. And the effects of different members' schemes on mortality rates will be ignored and the same mortality rates are used for the different schemes unless stated otherwise.

4.15.1. Death in Service

The mortality tables for the active members that have been used in most of the actuarial valuations of the ESSPS over 1963-92[23] are the A24-29 and A1949/52 (Ultimate) Tables with some different modifications. In the 1992 actuarial valuation, the actuary of the GSF employed the A1949/52 (Ultimate) Table with an up rating of

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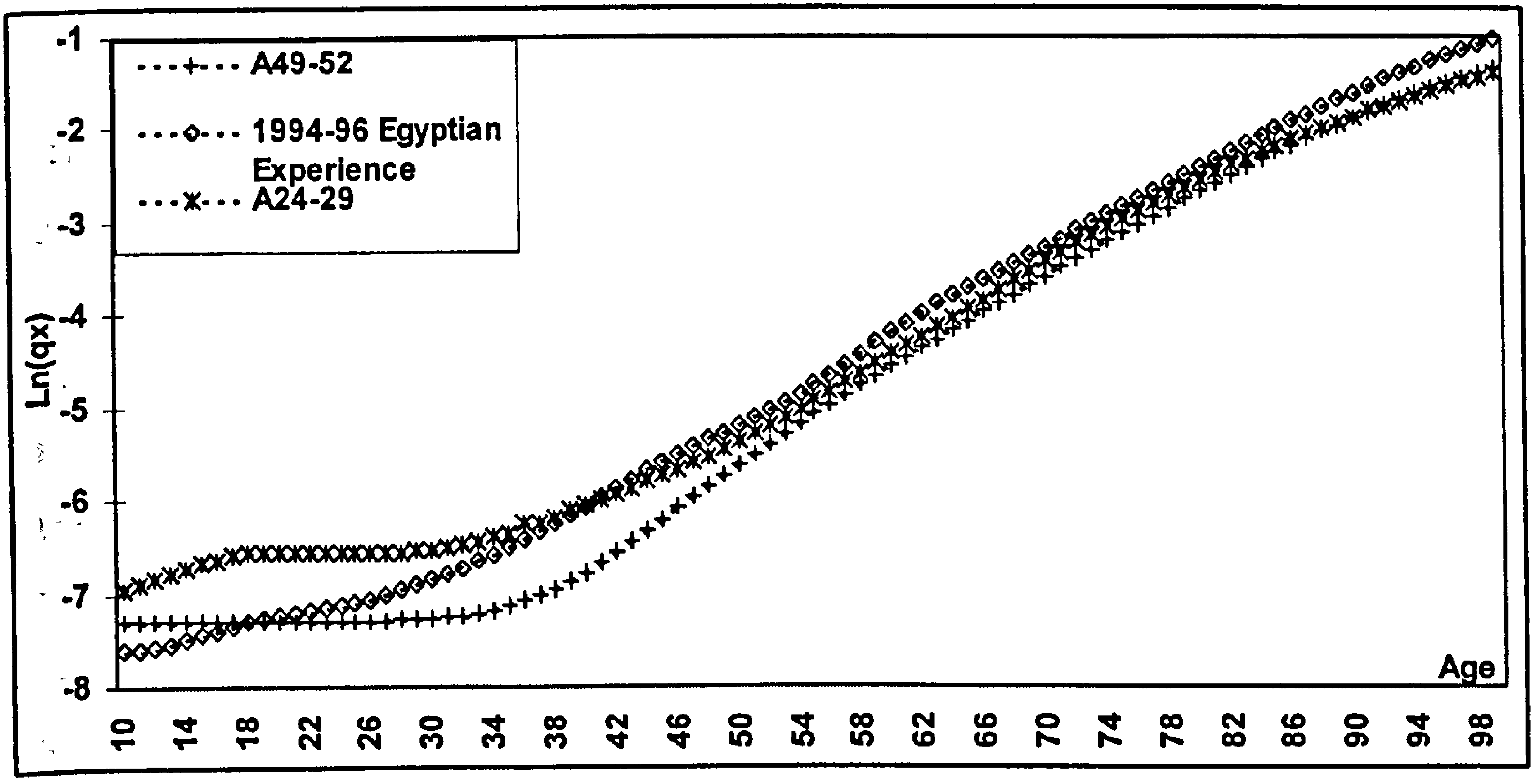
[23] These are the only available reports.

5 and 1 years for males and females respectively. In the PPSF the actuary continued to employee the A24-29 Table rated down 1 years for both males and females. The actuaries of the occupational pension schemes are required by law to adopt the A1949/52 (Ultimate) Table in dealing with death in service of active members. However, there are some evidences from the national population mortality experience of lighter mortality at the young ages and heavier at middle and old ages than those adopted of A24-29 and A1949-52 (Ultimate) Tables for males and females.

Figures 4.11 and 4.12 compare these English Life Tables with the Egyptian population mortality experience[24] of 1994-96 to judge the appropriateness of using any of them in the valuation of pension in Egypt. The two English Tables imply heavier mortality than the actual general population experience of Egypt at the young ages (particularly the A24/29) and lighter mortality than the actual experience of the middle and old ages for males (18 and over) and females (40 and over).

Figure 4.11. Male mortality experience of the Egyptian population over 1994-96 in comparison with the A1924-29 and A1949-52 (Ultimate) Tables



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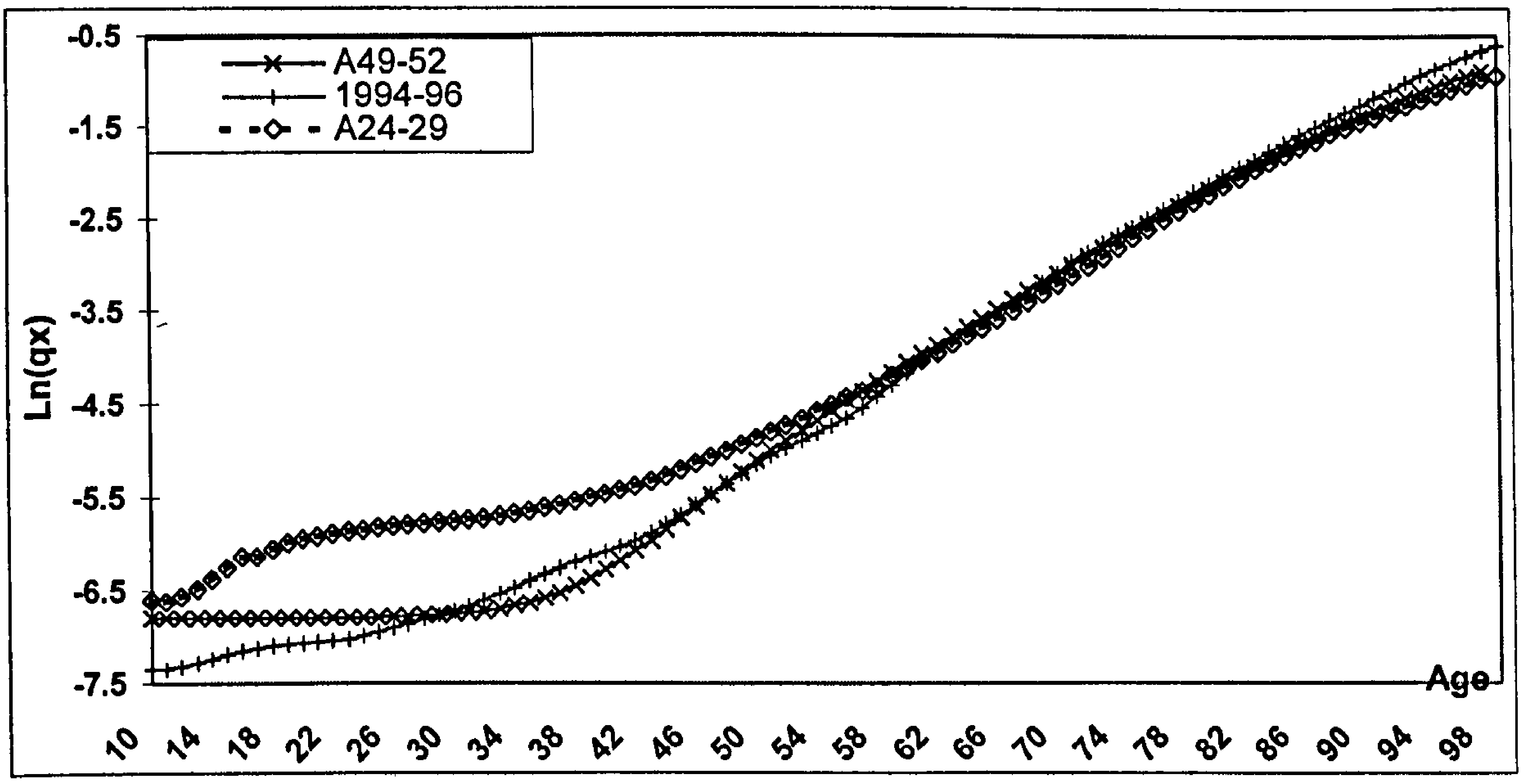
[24] It is supposed that lives-based pensioners' tables have a slightly higher life expectancy than of the corresponding general population. However, as the ESSPS covers nearly 40% of the Egyptian population it should be a good indicator for the most recent mortality trends.

Figure 4.12. Female mortality experience of the Egyptian population over 1994-96 in comparison with the A1924-29 and A1949-52 Ultimate Tables



It was found that the English Life Table A1949/52 (Ultimate) with an up rating of 4 years for males and non-for females can approximately match the actual experience of the Egyptian general population mortality of 1994-96 for death in service[25].

4.15.2. Death after Retirement

4.15.2.1. Old Age Pensioners

For mortality experience of old age pensioners over 1963-92, the actuaries of both Funds employed the English Life Table A24-29 with some different age ratings. In the 1992 actuarial valuation, the English Life Table a55 was employed for males (rated up 2 years) and for females (rated up 3 years), with the assumption that the probability of surviving after age 100 is zero. However, it was found that the a55 with an up rating of 5 years for males and 6 years for females can approximately match the actual experience of the general Egyptian population mortality of 1994-96 for ages 40+ as shown in Figure 4.13 for males with is exactly similar trend for females.

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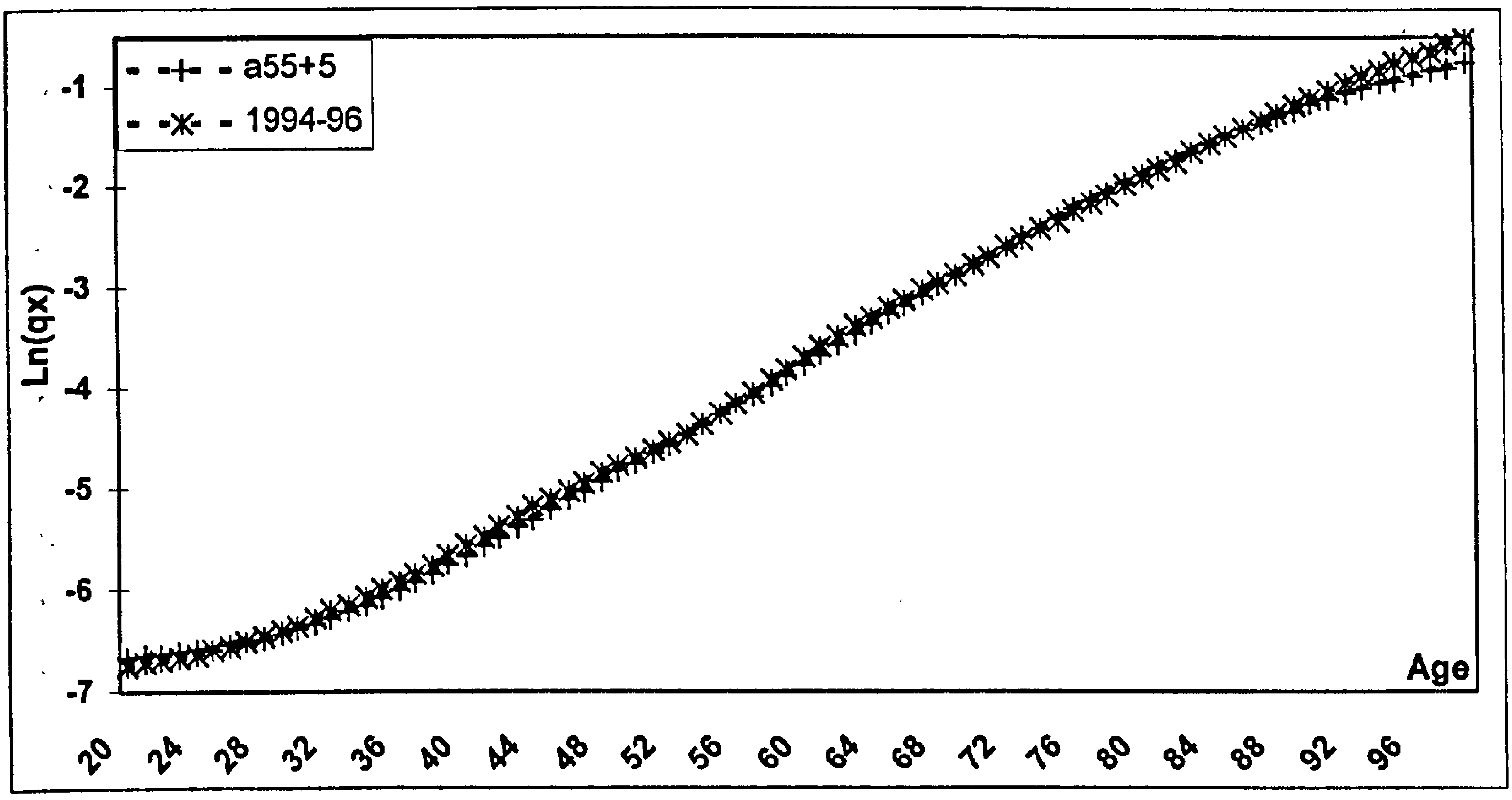
[25] This means that lives are assumed to experience the mortality of a life at a fixed number of years older. To estimate the age rating, different attempts were tested using the least squares estimator criterion which is $min \sum \left[q_x - \hat{q}_x\right]^2$ where q_x and $\hat{q}_x$ are the population and A49-52 mortality experiences respectively at age x. It was found that the best age rating is up rating of 4 years for males and nothing for females and this was adopted in the valuation of the liabilities of the ESSPS.

Figure 4.13. Male mortality experience of the general population of Egypt over 1994-96 in comparison with the a55+5 English Table



4.15.2.2. Invalidity Pensioners

The same problem of unavailability of data for estimating the mortality rates of invalidity and work injuries' pensioners is exist here as well. However, the actuaries of both Funds acknowledged that their experiences show that the mortality of invalidity pensioners could be approximated by using mortality rates higher than those of the old age retirement pensioners by nearly 2-3% at all ages (AbdElhamid, 1997). Therefore proportion increases of 2% and 3% were applied to the a55 with an up rating of 5 years for males and 6 years for females at all ages for the GSF and PPSF respectively as an estimation for the mortality of invalidity pensioners.

4.15.2.3. Mortality of Survivors

For the mortality of survivors and because the system covers nearly 40% of the Egyptian population it is a reasonable assumption to use the Egyptian Life Table 1994-96 to represent the mortality of the survivors; widows and orphans.

4.15.3. Mortality Improvements of the Members of the ESSPS

The improvement of death in service mortality rates will result in an increase in the cost of retirement benefits. However, although any increase in mortality rates of active members will lead to reducing the cost of the retirement benefits, it will lead to increase in the cost of survivors' benefits for deceased members. This means that improvement of mortality of the members will have double effects on the system's liabilities, and may cancel out the mortality differentials effect.

Thus it is clear that the differences between the actual and expected mortality rates may not have any significant financial effects on the overall cost of the system, unless there are other factors which have some effects (e.g. when there is a minimum death benefit such as 65% in the ESSPS). As a result of the unavailability of data to investigate such improvements, the assumptions adopted in determining the cost of survivors' benefits, and the significant number of members of the system (can minimise the mortality risks as a result of limiting statistical fluctuations), allowance for any future mortality improvement is not adopted in any of the projection or valuations of the ESSPS system in this thesis.

In order to complete the required components for the projection of future population, future fertility rates and mortality trends over the projection period need to be estimated. In Chapter 5, both fertility and mortality trends are projected and used alongside the mortality rates of the life table within the component method to project the future population of Egypt over 1997-2025.

4.16. Conclusion

The projection of future population, using the age-cohorts of the population, requires a life table which reflects the true underlying mortality rates in the base year of projection. Egypt has no life table and therefore it was essential to investigate and graduate the mortality experience of the Egyptian population of males and females over 1994-96. The non-parametric Whittaker model produced satisfactory results, not only for the graduation of the individual age crude mortality rates estimated by the alternative method over the available age range but also for the estimation of mortality rates at ages above the age range. These rates were used to construct a full Egyptian Life Table based on 1994-96 experience. A comparison with the ELT No. 11 (1950-52 experience) showed that Egyptian population mortality is behind English population mortality by an average of half a century for most ages.

Chapter 5
Projections of the Egyptian National Population, 1997-2025

5.1. Introduction

The national population projection is a critical matter when making long-term projections for national insurance funds. Future population structure and numbers will determine amounts of potential members, and estimates of income and expenditure, long-term financial status and the cost of state pensions. Population projections can be obtained from national statistics offices[1], however it is preferable for national insurance schemes to produce their own population projections allowing for alternative scenarios and to vary factors[2] such as fertility, mortality and migration. The projection presents a picture of what would happen if these factors were borne out in practice. In this chapter, population, mortality and fertility projection methodologies are discussed briefly and the methods applied in projecting the population of Egypt are considered in detail.

5.2. Methodologies of Population Projections

Throughout the history of population projections many methodologies have been suggested for projecting the future population of a given country, P_t, at time t years from the present. These methodologies can be classified into two approaches: the mathematical models and the component method. In the following sections, the first methodology is briefly mentioned and the second methodology is explained in detail as it is the one employed in projecting the population of Egypt.

5.2.1. Mathematical Models[3]

These models represent a demographic process in the form of a mathematical function or set of functions, by relating two or more measurable demographic variables. They represent the population at time t + 1 as simply a function of the population at time t

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[1] In Egypt, estimates of the national population are undertaken by several institutions, such as CAPMAS, the Cairo Demographic Centre, as well as the United Nations and the World Bank.

[2] This is the case in the US, Finland and the UK social security pension schemes. The Government Actuary's Department in the UK (GAD) produces a principal projection accompanied by variants assuming higher and lower fertility and mortality improvements.

[3] This is the most practical approach for population projections in countries where demographic information is scanty, which is the case in many developing countries (Scoot, 2000).

and this depends on the assumptions employed. One possible assumption is of linearity, using regression techniques to fit a line and extrapolate it into the future, which can be presented by the following formula:

$$P_t = \alpha + \beta t \qquad (t \geq 0) \tag{5.1}$$

Another simple assumption is of a constant rate of increase, so that the population at time t, P_t, can be estimated by assuming that it follows the differential equation:

$$\frac{dP_t}{dt} = K \times P_t \tag{5.2}$$

where K is the rate of increase[4]. This equation may easily be solved to give:

$$P_t = P_0 \times e^{Kt} \qquad \text{for } t \geq 0 \tag{5.3}$$

This function may be reasonable for a few years into the future, but the assumption of an indefinitely continuing constant rate of growth eventually produces misleading figures. Formula (5.2) can be modified to take into account the physical limit to the numbers capable of occupying a given space by applying a term tending to "drag the population down", thus:

$$\frac{dP_t}{dt} = K \times P_t - f(P_t) \qquad (t \geq 0) \tag{5.4}$$

The simplest form of $f(P_t)$ could be $C \times P_t$ where C is another positive constant[5], which leads to the logistic curve[6] (Renn, 1988):

$$\frac{1}{P_t} = P_0 \times e^{Kt} + \frac{C}{K}, \text{ (with an upper limit of } P_t = \frac{r}{C}\text{)} \quad (t \geq 0) \tag{5.5}$$

Scott (2000) suggests that one might postulate equation (5.4) thus (for example):

$$\frac{dP_t}{dt} = K \times P_t - K[P_t]^2 \quad (t \geq 0) \tag{5.6}$$

this logistic differential equation is of the Bernoulli type which may be solved by substitution.

Other mathematical formulae, which may also be used for estimating populations, for example ARIMA time series models, either based simply upon total population numbers or upon increasingly sophisticated breakdowns of the components of the

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[4] This indicates that the rate of growth of the population is directly proportional to its size.

[5] This also gives an exponential form as $\frac{dP_t}{dt} = (K - C)P_t$.

[6] Such logistic curves were fitted to long periods of past data in Europe and the US, but subsequent census results have usually shown figures below those predicted by these curves.

population such births, deaths and migration. However, such mathematical models are normally used to estimates the total population, P_t particularly when detailed demographic statistics are lacking (Scott, 2000). These methods do not usually use detailed information on the structure of the population and they cannot easily be used to produce breakdowns of the composition of the projected population. They also do not normally take into account the expected changes in the population components.

5.2.2. The Component Methodology of Population Projection

This is the most commonly used method in national population projections[7]. It is an appropriate method for estimating national population for many practical purposes which require estimates of the population broken down by age and sex for each successive year from the projection base year. It also covers the components in their entirety, although the projections may lose sight of possible "interactions" between the components of the projection[8] (Scott, 2000). The method is adopted to project the national population of Egypt.

It requires the calculation of the distribution of births, immigrants, deaths and emigrants[9]. The starting population plus net inward migrants less the number of deaths produces the number in the population one year older at the end of the year, and the survivors of those born during the year produce the number in their first year of life. The time horizon for projections can be anything from a few months to a century or more[10]. However, these rolled forward estimates are subject to increasing error as they move further away from the last census year.

The basic formula of the component method is:

$$P_{x,t,s} = P_{x-1,t-1,s} \times (1 - q_{x-\frac{1}{2},t-1,s}) \pm \left[\frac{M_{x,t} + M_{x-1,t}}{2}\right] \times \left(1 - \frac{1}{2} * q_{x,t-1}\right) \qquad (5.7)$$

for x =1, 2, 3, ... and t = 1, 2, 3, ...

where $P_{x,t,s}$ = Projected number of population of sex s aged x last birthday at mid-

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[7] The British official population projections employ this methodology and it is also employed in the projection of the national population within the social insurance area in the USA.

[8] In some countries when the fertility is low there might be a tendency for net inward migration to increase. Myers (1985) suggests an inverse relationship between fertility and immigration assumptions and states that this element serves as a proxy for fertility.

[9] There can be a need for retrospective population estimates, for example working backward from a current census to earlier dates to provide a base for the calculation of birth, death and migration rates.

[10] In the UK, projections are produced for a period of 40 years from the base year, however the focus of the results is on the first 25 years from the base year.

year *t* years from the present;

$M_{x,t,s}$ = Projected number of "net migrants" (= immigrants – emigrants) of sex s in the period of mid-year *t-1* to mid-year *t* who survived to mid-year *t* when they were aged x last birthday at the date of migration;

$q_{x-\frac{1}{2},t-1,s}$ = Probability of death within a year of those of sex s and aged x-1 last birthday at mid-year t-1.

At age 0 the formula used is:

$$P_{0,t,s} = \left\{ \begin{array}{l} \dfrac{1.06}{2.06} B_{t,m} \times (1 - {}_{\frac{1}{2}}q_{0,t-1,f}) \pm M_{0,t,f} \\ \dfrac{1}{2.06} B_{t,f} \times (1 - {}_{\frac{1}{2}}q_{0,t-1,m}) \pm M_{0,t,m} \end{array} \right\} [11] \tag{5.8}$$

where, $P_{0,t,s}$ = Projected number of children (male/female as appropriate) aged 0 to 1 of sex s in the period mid-year *t-1* to mid-year *t*;

$B_{t,s}$ = Projected number of live births of sex s in the period mid-year *t-1* to mid-year *t*;

$M_{0,t,s}$ = Projected number of net migrants of sex s in the same period that was 0 last birthday at mid-year t;

${}_{\frac{1}{2}}q_{0,t-1,s}$ = Probability that a live birth of sex s in the same period would die before mid-year t;

The number of births, B_t, is obtained using the following formula[12]:

$$B_t \cong \sum_{x=15}^{x=49} E^c_{x,t} \times FR_{x,t} \tag{5.9}$$

$$E^c_{x,t} \cong \frac{1}{2}\left[P_{x,t-1,f} + P_{x,t,f}\right] \tag{5.10}$$

where $E^c_{x,t}$ = The woman-years of exposure at age x last birthday;

$P_{x,t,f}$ = Number of women at mid-year n aged x last birthday, and

$FR_{x,t}$ = Fertility rate at age x last birthday for births in the period of mid-year *t-1* to mid-year *t* of women aged x last birthday at childbirth.

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[11] The ratio was estimated as the geometric mean over the period 1967-1996. This ratio increased from 1.01 in 1948 to 1.29 in 1966 and since then has been increasing to 1.05 in 1996.

[12] It means the number of live births per woman-year and the assumption here is that the distribution of the number of live births is approximately Poisson with mean $E^c_x \times FR_x$.

Population projections using this method require data and assumptions about the following components for every age and sex over the projection period:

1. Mid-year population for the base year of the projections[13], which are used as starting populations for the projection period;
2. Life tables for the base year reflecting mortality during the base period;
3. Allowance for mortality improvement (or worsening)[14];
4. Estimates of annual total period fertility rates (TPFRs); and
5. Estimates of annual net migration.

Thus, this method requires projections of the future mortality, fertility and migration[15] trends over the projection period. Assumptions regarding these components have to be based on the statistical evidence available from the analysis of the trends at the time of projection. In the following sections, investigations of the Egyptian national mortality and fertility experience are carried out. Following this investigation, the expected future national mortality and fertility trends for 1997-2025 are projected.

5.3. Variant Projections

The inherent uncertainty associated with the demographic components' behaviours results in projections which will inevitably be proved wrong to a greater or lesser extent. This is because the likely future path of the components is not known at the time the projection is carried out. This means that the accuracy of the population estimates can not be relied upon. Therefore, variant projections have to be carried out on plausible alternative assumptions of future demographic events to draw attention to the sensitivity of the projections to these assumptions. Theses assumptions do not represent upper and lower limits or reflect a particular level of confidence that the outcome will lie between the high and low variant projections.

There are various methods by which variants might be specified, depending on the underlying method used for projecting the demographic components, which are discussed with the methods of projecting of mortality and fertility. Probability levels

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[13] It should be taken as the official mid-year population estimates or census, which should be the most reliable for that year.

[14] It is usually thought that mortality rates are the most predictable of the three components.

[15] Egypt is a labour exporting country (with some 2.6 million Egyptians working abroad in 1996). Due to the unavailability of the migration statistics, and to the unpredictability of international migration, it has been assumed that there will be no net migration during the period of projection, as often this migration is temporary for work.

can be attached to variants using a methodology that is essentially subjective such as constructing confidence intervals based on the size of errors in past projections[16]. However, when parameters and variants are set subjectively, it is not possible to derive confidence intervals. Another method is to obtain the views of experts on likely ranges of future changes and construct variant assumptions based on them.

5.4. National Mortality Experience of Egypt, 1948-96

Incorporating a prudent projection for future mortality improvement (or worsening) is considered a significant factor in the population projection process. In Egypt, there is no official national mortality experience available[17] and therefore these rates have to be derived from other sources such as the United Nations' model life tables or an investigation of past data. In this thesis, assumptions about future mortality improvements are obtained from investigating trends in past data and selecting a methodology to project future trends. The national mortality experience of Egypt is investigated over 1948-96 and the main features over the last half-century are extracted by analysing the following points:

1. Basis of analysis of mortality trends,
2. Trends in male and female mortality,
3. Trends in infant, childhood, middle adult life and advanced ages mortality,
4. Life expectancy trends,
5. Reviewing the relevant methodologies and methods that can be adopted in projecting mortality rates for national population projections, and
6. Applying the selected methodology to project future mortality improvements of the national population of Egypt.

5.4.1. Basis of Mortality Analysis and Projection

The nature and features of the data can determine and dictate the appropriate method used for analysis. Mortality improvements can be analysed and projected on a period basis[18] or a cohort basis[19]. Analysis on the cohort basis takes into account the inherent

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[16] If the distribution of errors is known then confidence intervals can be produced for the projected values, which is only possible to make if the distribution of forecast errors remains stable over time.

[17] In the UK, the GAD produces two sets of annual life tables known as Interim Life Tables. The first is based on mortality data for a single calendar year and the second is based on mortality data for three consecutive calendar years combined (as for ELTs) and these tables are not graduated.

[18] The rates apply at each age in a given year and improvement rates are calendar-year specific.

[19] The rates apply at each age are to people born in a particular year (year of birth) and improvement rates are year-of-birth specific.

experience within the generations concerned on the assumption that cohort effects will persist. If this is the case, a method that incorporates this effect is likely to perform better than one that takes no account of it[20] However, if there is no significant evidence of cohort effects, mortality can be projected on a period basis.

Mortality rates can be also analysed in aggregate (that is, all-causes) or separately by cause of death for age and sex. Pollard (1989) suggestes that total mortality can be obtained by separately projecting mortality from certain groups of disease and then adding them together to get the total mortality[21]. However, it is a complex approach to apply and there are many potential problems associated with it, such as causes showing greatest past improvements becoming relatively less common in the future (Willets, 1999). Also, when causes of death are separated they may follow a much more irregular pattern than when all causes are taken together, making it difficult to establish a trend. It is not a recommended approach *in the UK (GAD, 2001).* Therefore, in the investigation of the national population mortality of Egypt, the analysis is carried out on a period basis.

5.4.2. Data

This investigation is confined to the available calendar years of national population mortality data over 1948-96, which relates to lives from different generations. The data comprises of midyear population estimates and the numbers of deaths[22], subdivided by age and sex, provided in the format mentioned in Chapter 4. The data considered is for ages 0-74 in quinquennial age groups as there is no available data for individual ages, which might reduce irregularities due to errors of age statement, etc. as discussed in Chapter 4. For ages 75 and over, data is contained in one group, which represents an average improvement for old ages. Trends for ages 75 and over cannot be analysed properly and have to be estimated according to a suitable methodology.

Crude central mortality rates for each age group (m_x)[23] and each calendar year are derived by the method explained in Chapter 4 (see **Table 4.1 of Appendix 4 for Male and Female Central Mortality Rates**). These rates are not graduated; however, as

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[20] GAD (2001) indicates that the poor performance of extrapolatory models in reproducing past UK mortality rates may be partly related to their inability to deal adequately with some cohorts.

[21] Japan latest projections used a method based on extrapolating standardised cause-specific mortality by sex in five-year age groups over 1975-95, for 13 cause-of-death groupings.

[22] Number of deaths are counted in the calendar year in which they are occurred (an occurrence basis).

[23] These mortality rates do not purport to show the likely experience of any particular generation.

data are derived from large national population numbers, this should lead to less variability in the rates, and these rates should progress fairly smoothly from age to age and year to year. This should make trends easier to discern, even without graduation, and give a true indication of the underlying mortality rates. However, examination of the Egyptian data reveals some irregularities, particularly the old ages as shown in Figures 5.1 & 5.2. This might indicate that the quality of the data provided is not considered high, especially for the older years. This may be attributed to the possibility of some misreported death data, estimated midyear population data or that the data were not grouped properly in quinary age groups.

5.4.3. Mortality Trends

Mortality rates by age, sex and year provide a valuable time series for monitoring the changing patterns in mortality over time and to have a view of likely changes in the future. In the following sections, mortality trends over 1948-96 are examined and some comments about current conditions are made. Trends over 1948-96, are obtained by comparing the crude central mortality rates (m_x) of the age groups for the calendar years 1948, 1976 and 1996. The rates are plotted on the log scale at 5-year age groups (except for ages 0, 1-4 and for ages 75 and over) for males and females as shown in Figures 5.1 & 5.2 which give a broad picture of the secular trends of mortality changes of the Egyptian population.

The Figures exhibit roughly similar features of mortality changes for males and females for most age groups over 1948-96. Trends in observed levels of mortality have shown an overall substantial improvement with a gradual fall at most ages for both males and females. The overall mortality rate per person in 1996 was 29.6% of that in 1948, the fall being greatest at the young and middle age groups with levels of improvement declining with increasing age.

5.4.3.1. Male Experience

Overall the mortality rate for males in 1996 was 29.1% of that in 1948. The greatest improvements[24] in male mortality were at the very young age groups (87.8% for age 0-1 & 94.2% for age group1-4). The second largest improvement was at the age group 5-34 (improved by 76.5-74.0%, declining with age) as shown in Figure 5.1.

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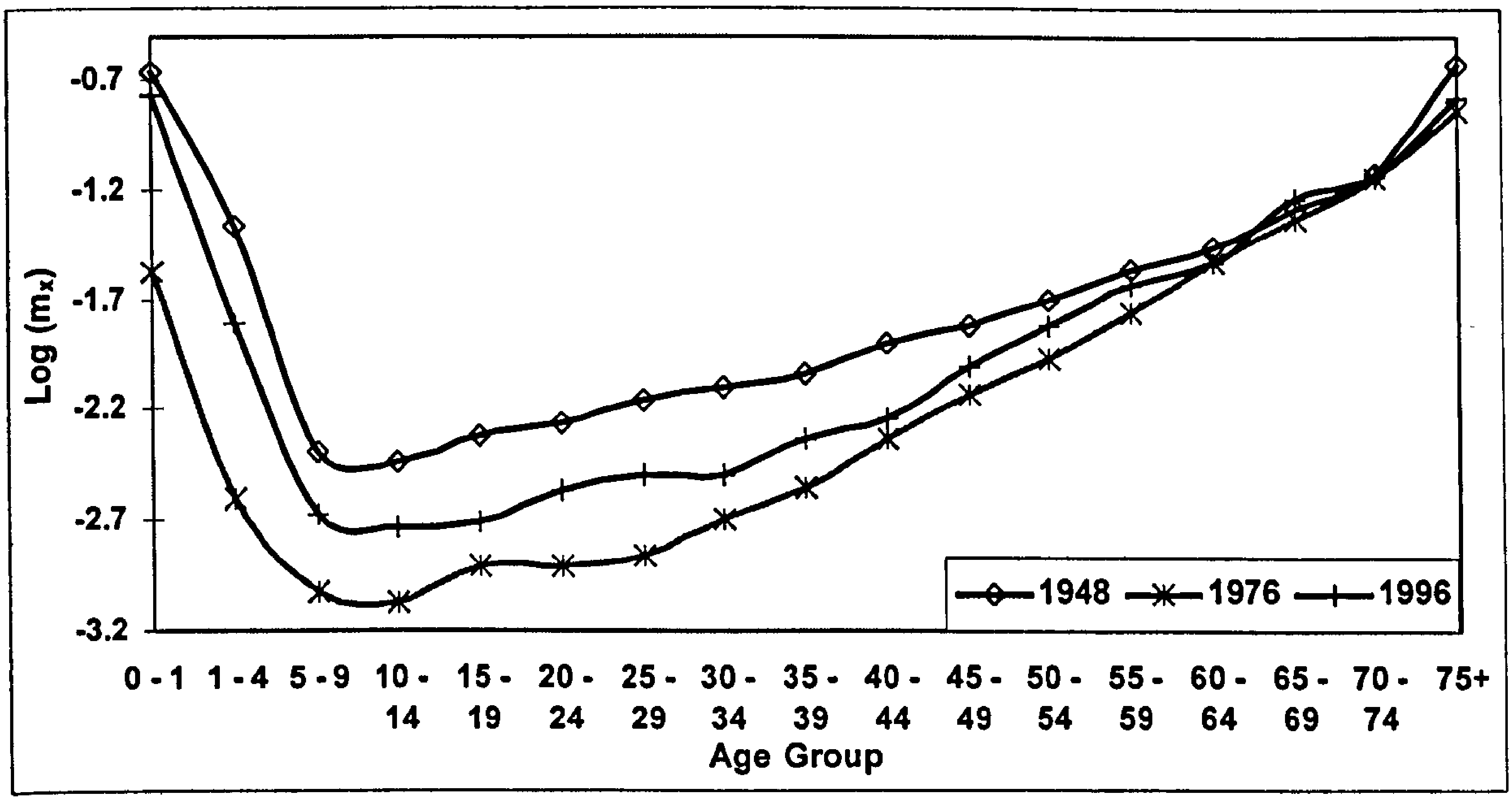
[24] The percentage change in mortality rates over 1948-96 is calculated by dividing the difference in central mortality rates between 1996 and 1948 by the central mortality rate in 1948.

Figure 5.1. Male mortality of the Egyptian population over 1948-96



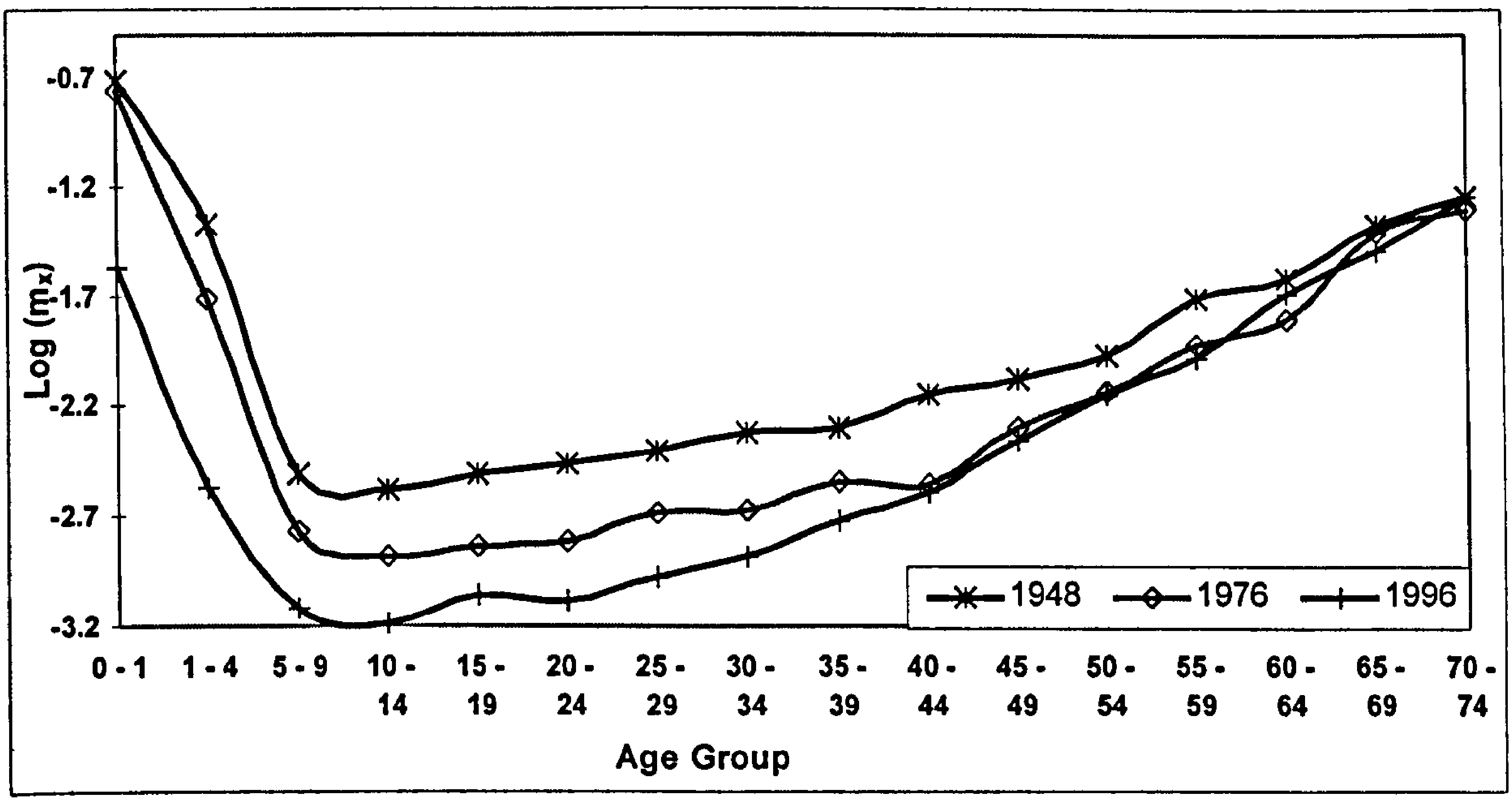
Middle age groups 34-59, improved by 64.7-41.8% (declining with age) and very modest improvements occurred at age 60 and over. Mortality for age 75 and over as one group was 60.9% in 1996 of that in 1948. In general, although male mortality improvement lessens with age, male mortality rates have reduced by at least 51% up to age 49 and by 38 % up to age 59.

5.4.3.2. Female Experience

Female mortality trends exhibit similar feature to male mortality over 1948-96 as shown in Figure 5.2. The overall mortality rate for females in 1996 was 29.1% of that in 1948, similar to that of males. There was improvement through all ages up to 69 when deterioration or no improvement occurred for some old age groups. Figure 5.2 shows that the greatest improvements in female mortality were at the very young ages, similar to males, (86.1% for age 0-1 and 93.7% for age group1-4).

The second largest improvement was 5-44 age group, (improved by 75.6-64.0%). Improvement also occurred in the age group 45-59 (improved by 48.0- 23.9%). There were very modest improvements at age group 60-69 (15.8% and 23.9% respectively) and deterioration of the age group 70-74. Mortality for age 75 and over, as one group, was 50% in 1996 of that in 1948. Although female mortality improvement lessens with age, mortality rates have reduced by at least 47% up to age 59.

Figure 5.2. Female crude central mortality rates over 1948-96



5.4.3.3. Differences Between Male and Female Mortality Improvements

Changes over 1948-97 are examined in more details in Figure 5.3, which shows the percentages improvement (or worsening) in mortality rates over 1948-96.

Figure 5.3. Percentage Improvement in Egyptian Mortality over 1948-96

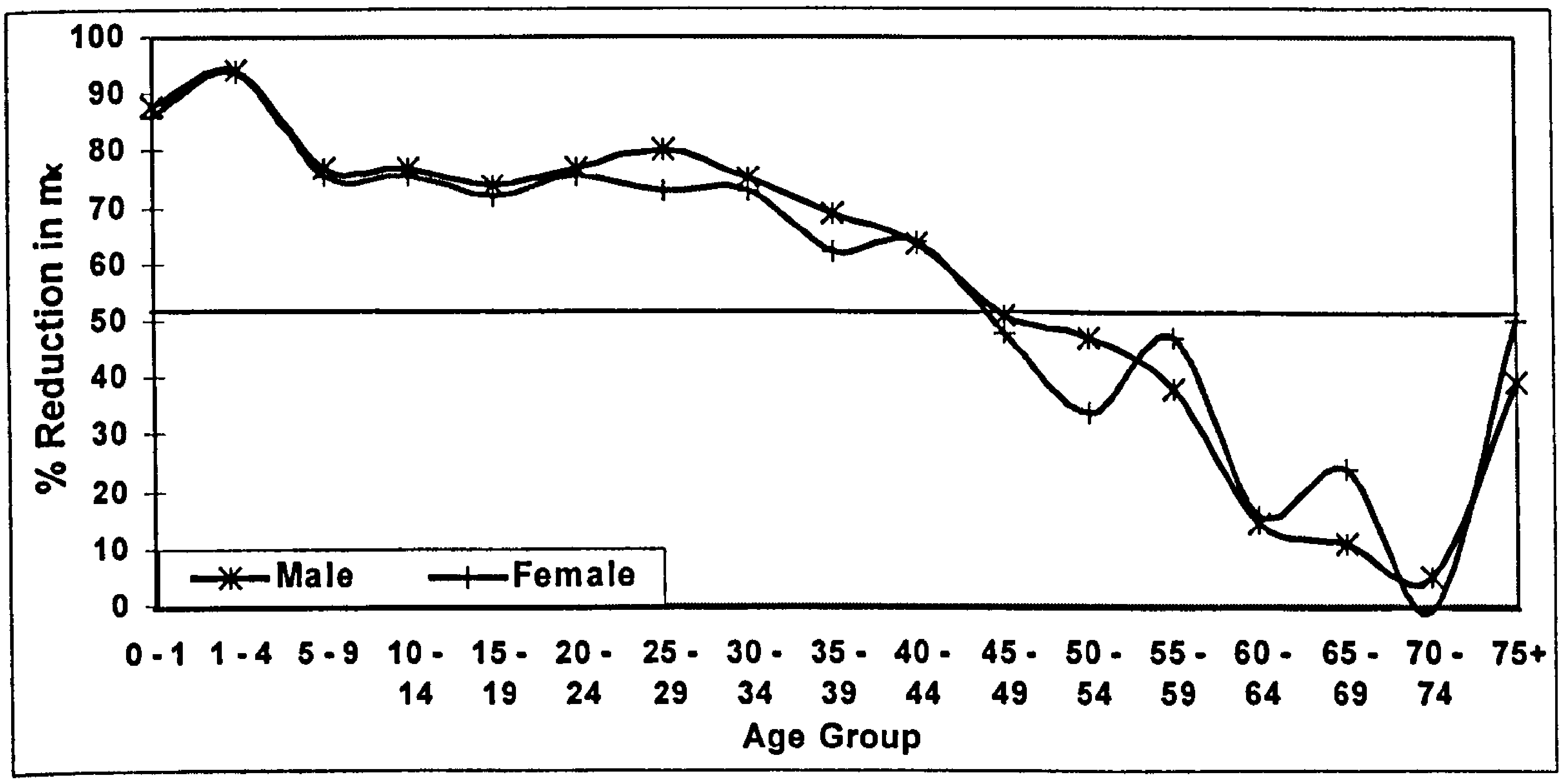


Table 5.1 shows the % reductions and the effective average annual rates of improvement in mortality for males and females over 1948-96. Figure 5.3 and Table 5.1 confirms the earlier findings of similar patterns of mortality changes for males and females for most of the age groups over 1948-96. They show that male mortality continues to improve at slightly higher average annual rates than that of females up to age group 50-54 (except for the age group 40-44). Female mortality improvements

were higher than of males for ages 55 and over (except for the age group 70-74, which deteriorated by about 0.72 %). The overall rate of improvement over 1977-96 was better than over 1948-76 for males and females. The overall female mortality fell more than for males over 1977-96 compared with 1948-76. Mortality improvement has been higher over 1948-76 than over 1976-96 at most age groups above age 15.

Table 5.1: Mortality reduction and the effective annual average rates of improvement in mortality over 1948-96

Age Group	**% Reduction**						**Effective Annual Reduction Rate**	
	Males			**Females**			**Males**	**Females**
	1948-76	**1977-96**	**1948-96**	**1948-76**	**1977-96**	**1948-96**		
0 - < 1	20.7	83.7	87.8	10.1	84.0	86.2	4.3	4.0
1- 4	63.9	84.6	94.2	54.7	86.2	93.7	5.8	5.6
5 - 9	48.0	57.9	76.9	45.0	61.2	75.8	3.0	2.9
10 - 14	48.9	57.1	76.9	50.5	54.7	75.6	3.0	2.9
15 - 19[25]	58.2	40.3	73.9	53.0	41.3	72.2	2.8	2.6
20 - 24	50.0	56.0	77.2	54.8	48.8	75.6	3.0	2.9
25 - 29	54.2	58.7	80.1	48.0	50.4	73.2	3.3	2.7
30 - 34	60.0	40.7	75.1	55.9	38.4	73.0	2.9	2.7
35 - 39	49.0	37.1	68.8	44.2	30.4	62.0	2.4	2.0
40 - 44	54.2	18.4	63.6	60.8	7.6	64.0	2.1	2.1
45 - 49	34.4	26.2	50.8	39.1	16.1	48.0	1.5	1.4
50 - 54	25.4	28.3	47.0	31.4	5.4	33.9	1.3	0.9
55 - 59	16.7	26.0	37.8	39.9	11.9	46.7	1.0	1.3
60 - 64	14.6	-5.1	14.3	34.8	-26.0	15.8	0.3	0.4
65 - 69	-10.7	18.7	10.9	8.1	16.6	23.9	0.2	0.6
70 - 74	3.5	-0.5	5.2	12.1	-13.6	-0.7	0.1	0.0
75+[26]	30.1	13.8	39.1	25.3	28.2	49.8	1.0	1.4
Overall	45.0	47.1	70.9	42.3	49.5	71.0	2.5	2.5

Source: Derived by Author

In general, male mortality improved better than females for young ages and female mortality improved better than males for old ages. Mortality at young ages improved better over 1977-96 than over 1948-76, whereas for old ages, most of the improvement occurred over 1948-76. This is might be interpreted as a result of the wars and diseases Egypt experienced over 1948-73[27]. The lower improvement in mortality of middle and higher age groups is a reflection of the lack of significant changes at these ages compared to the improvements at younger ages over 1948-96.

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[25] Improvement at this age group over 1977-96 is significantly less than over 1948-76 and different from the trend of the previous and the following age groups. This is might be an indication of an emerging of an accident hump similar to that one experienced by the UK as a result of increased risk due to accidental causes and violence at these ages.

[26] Figures for the age group 75 and over should be treated as just a general indicator.

[27] Egypt fought more than 4 wars and experienced many fatal diseases over 1948-76. The conquest of infectious disease, which generally killed early in life, has altered the age pattern of mortality.

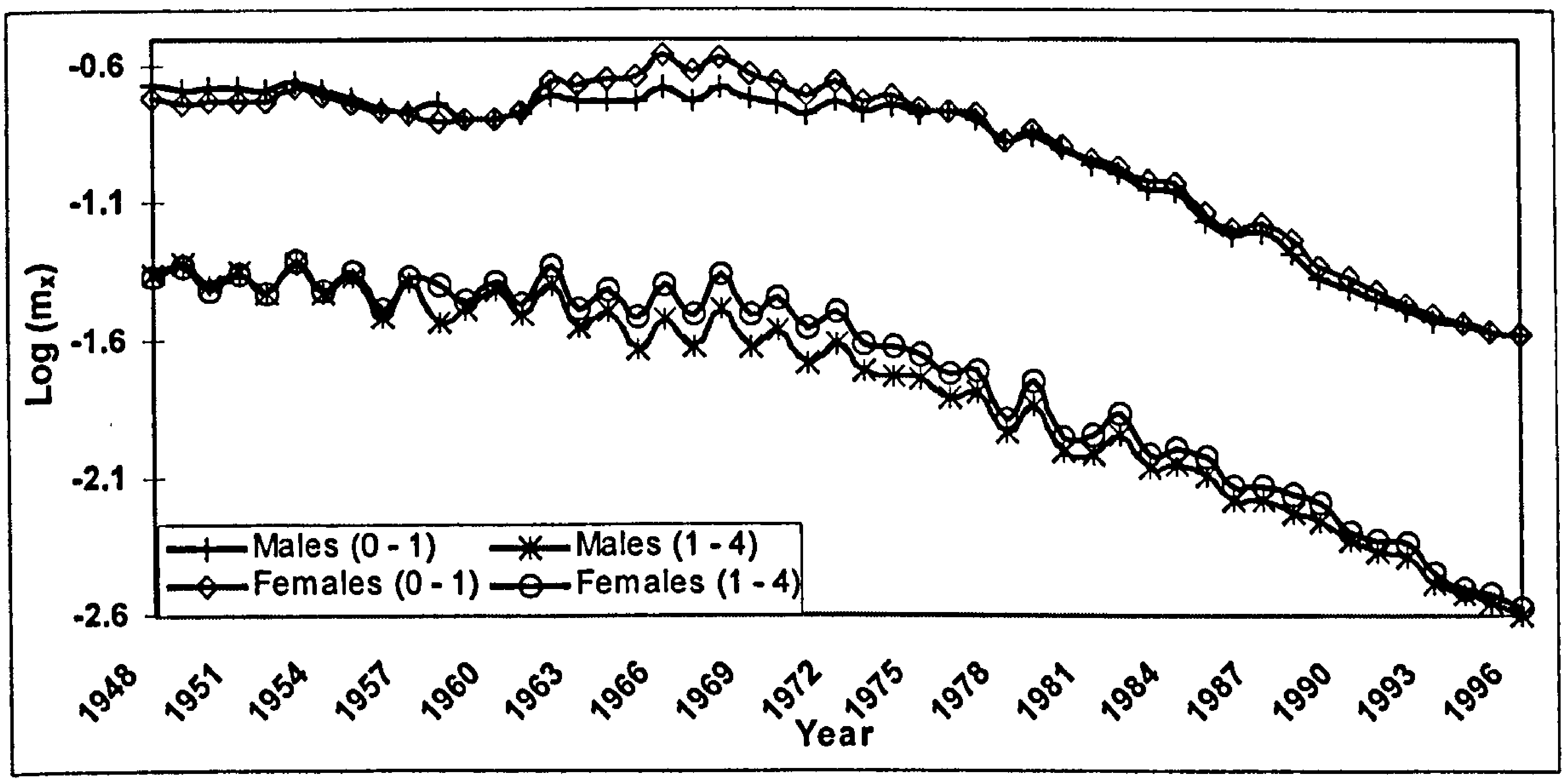
5.4.4. Mortality Improvement over the Life-Span

The causes of death in a population are many and tend to vary over the life-span. Improvements in health care and treatment of some diseases, safety, changes in life style, living standards and behaviour can all improve mortality experience. However, the momentum of mortality improvement cannot be sustained continuously by only such factors. Many fundamental problems, such as the emergence of new diseases like Aids, changes in economic circumstances (e.g. high unemployment), lack of social welfare and education remain to affect mortality. Mortality can improve only up to a point, as the human body does eventually wear out, so those who do survive to old ages are still faced with an undiminished risk of mental or physical deterioration.

5.4.4.1. Infancy, Childhood and Early Adult Life

Mortality at young ages has a significant effect on population numbers. Infants (under 1) and early childhood (1-4) experienced the largest mortality improvement over 1948-96 as shown in Figure 5.4.

Figure 5.4. Infant and childhood Mortality Improvement over 1948-96



It is clear that a large part of the mortality improvement since 1948 was due to reductions in infant and childhood mortality. Infant mortality has reduced to less than one-tenth of its level in 1948 with similar improvement for both sexes over 1948-96[28] particularly over 1977-96. Figure 5.5 shows male mortality improvement for the age

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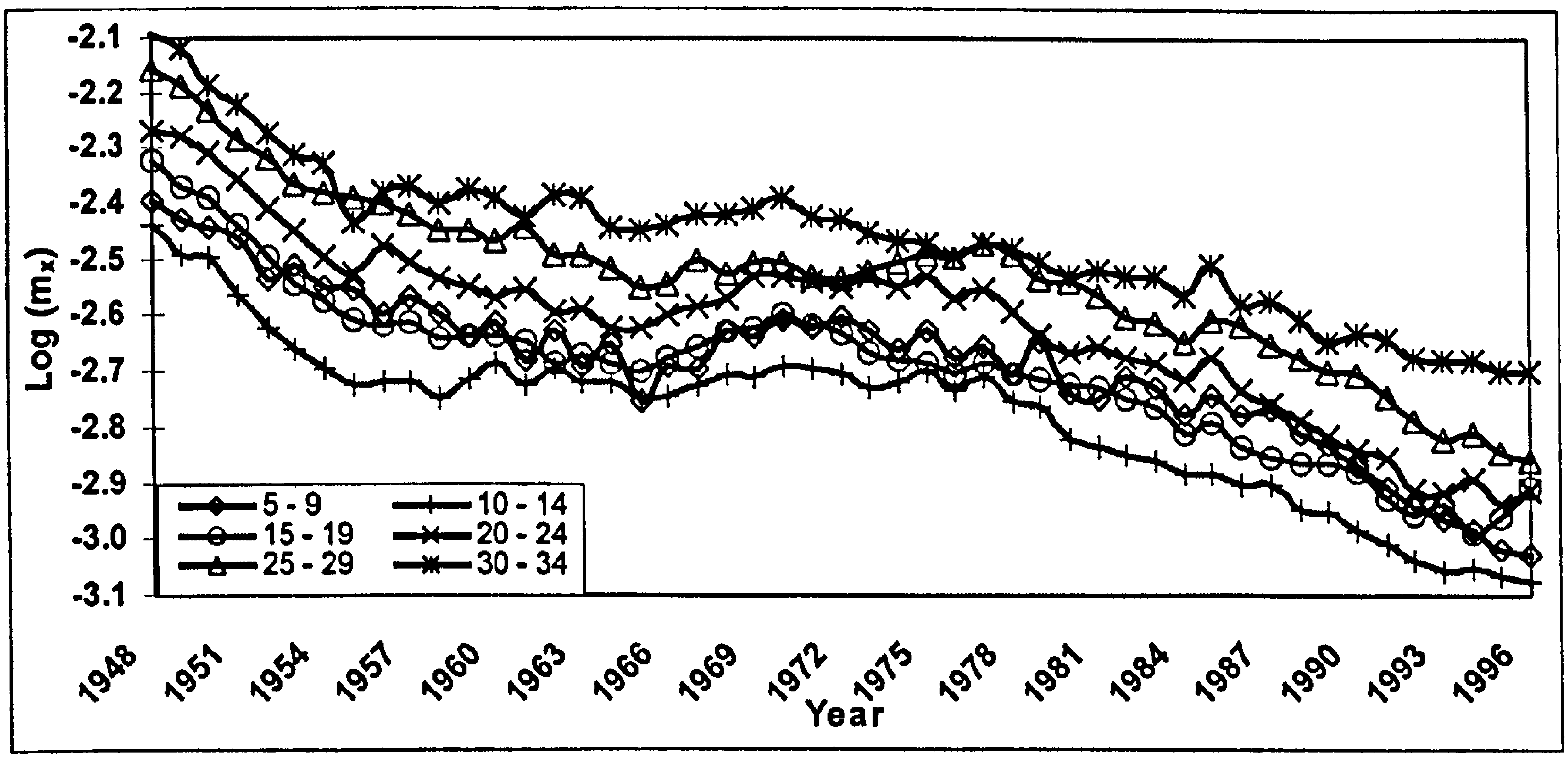
[28] Female mortality in Egypt at these ages are higher and achieved less improvement than males as they appear to be more susceptible to birth hazards, death by infection, accidental death, suggesting that female babies receive less care.

groups 5-34 over 1948-96, as female mortality trends for the same age groups exhibit exactly similar trends.

Figure 5.5. Male Mortality Trends for the age groups 5-34 over 1948-96

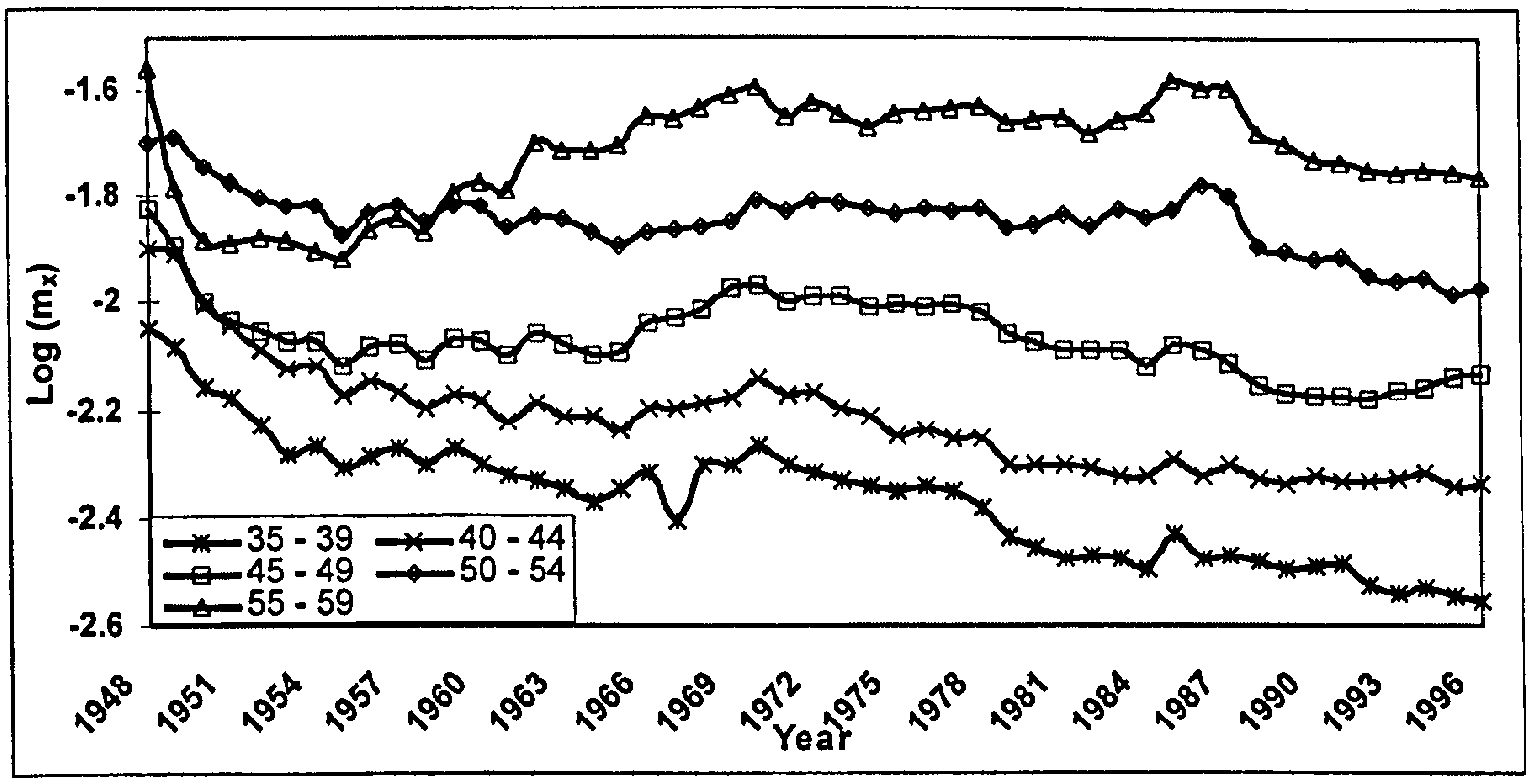


5.4.4.2. Middle Adult Life and Advanced Ages

The third largest improvement in mortality rates over 1948-96 was for the age groups 35-44 (improved by 69-64% for males and 64-62% for females) and at ages 45-59 the improvement was 51-38% for males and 48-47% for females as shown in Figure 5.6 for males' aged 35-59. Mortality rates at these ages have a significant potential impact on the ESSPS. Mortality improvement for the age group 60-74 has varied between very modest improvement and deterioration, as the average annual rates of improvement of these ages were the lowest over 1948-96 as shown in Table 5.1. At most of these ages, the levels of mortality improvement were significantly lower over 1977-96 than over 1948-76. For the age group 75 and over, the rate of improvement, as a general indicator, was 39.1% for males and 49.8% for females.

In general, there has been a considerable fall in mortality in infancy, childhood, early and middle adult life for both males and females over 1948-96. There has been some modest fall in mortality in late middle adult life and advanced ages for both males and females over 1948-96, but the percentage improvement was not significant, and even some deterioration has occurred at some advanced age groups, particularly for females. This means that the possibility for improvement at old ages is much less than for younger and middle ages.

Figure 5.6. Male Mortality Trends for the age groups 35-59 over 1948-96.



5.4.5. Period Expectations of Life

Another way of illustrating reductions in death rates is to show the increase in expectation of life at birth, as it summaries the overall effect of mortality in a single value. It can be calculated from the death rates in particular calendar years (period expectations of life) which show the overall effects of changes in mortality of people of different generations. It can be also calculated by taking the rates over time applicable to people born in a particular year (cohort expectations of life)[29]. This takes into account changes in mortality rates in years succeeding the year of birth, whereas the period calculation uses mortality rates applicable in the year under consideration.

Over 1937-96, the period expectation of life at birth[30] increased by nearly 29.5 years for a boy (from 35.7 in 1937 to 65.4 in 1996[31]) and by nearly 27.5 years for a girl. The period expectation of life at birth increased by about 4.9 years for males and 4.6 years for females in each decade. Male expectation of life has improved better than females at all ages. Reductions in mortality in infancy, childhood and early adult life have made the largest contribution to this improvement as shown in Figure 5.7. The expectation of life of a woman at the state pension age of 60 had reached 17.3 years

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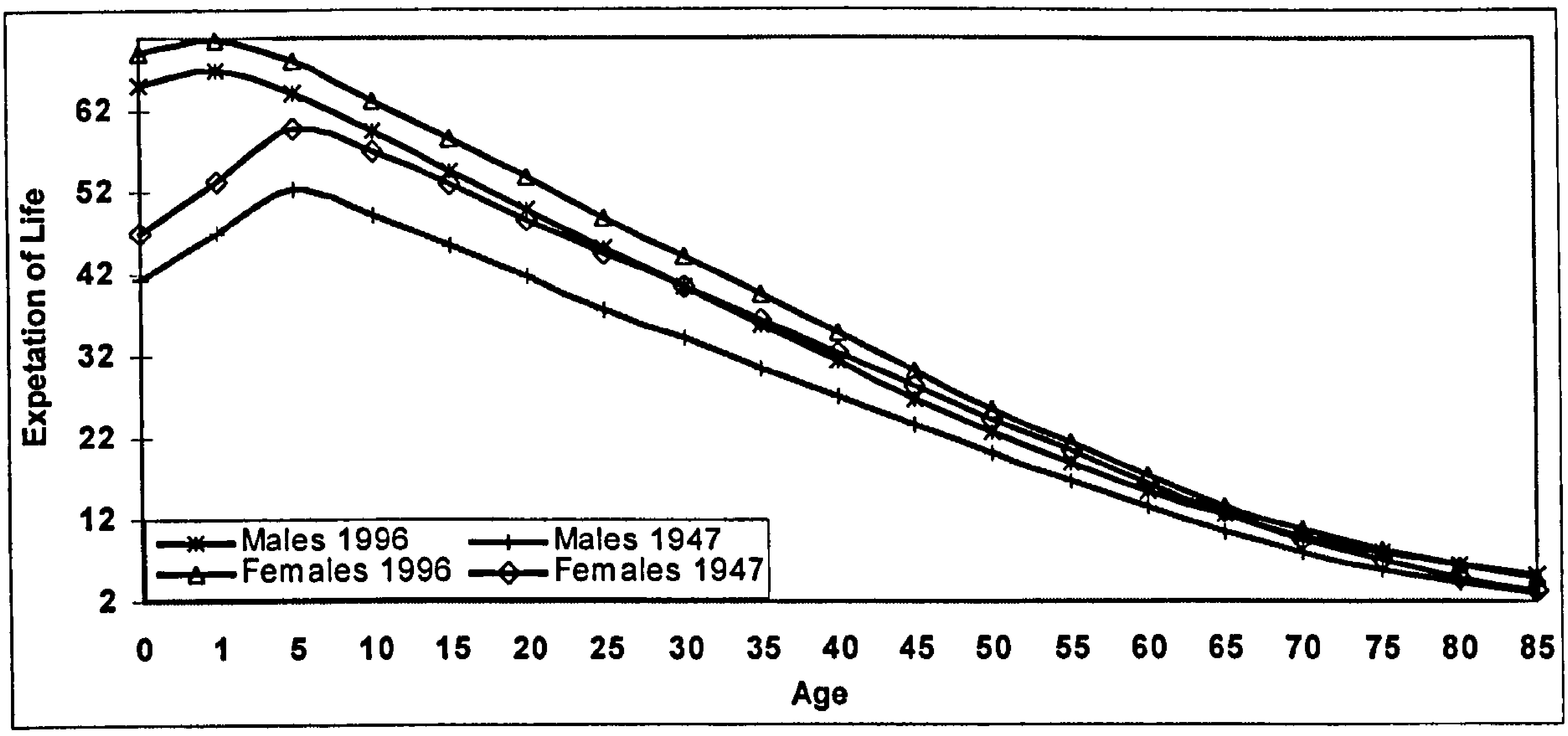
[29] This can be done for generations not yet extinct by making assumptions about future death rates.

[30] This represents the average number of years that a new-born baby could expect to live. These figures were available from the UN demographic yearbook for years back from 1937, however figures for the whole life table were only available for few years and the first available one was 1947.

[31] The values for 1947 are taken from the UN demographic yearbook and for 1996 they are taken from the results of the Egyptian Life tables constructed in Chapter 4.

whereas, for a man it had reached 15.5 years in 1996. The increase in the expectation of life at age 60 over 1947-96, is less than 2 years for males and 1 year for females.

Figure 5.7. Expectation of life for the age groups in 1947 & 1996.



After studying the trends in mortality revealed by this investigation, the methodology rates has to be selected. In the following sections, different methodologies for projecting mortality are briefly explored and the methodology adopted for the Egyptian data is then applied.

5.5. Methodologies of Projecting Mortality Trends[32]

There are a variety of methodologies for mortality projection. The scope of the topic is very extensive and it has to be restricted to general population measurements. The methods can be broadly classified as (GAD, 2001):

1. **Process-based methods:** such methods concentrate on factors that determine deaths and model mortality rates from a bio-medical perspective. These methods are only effective if the processes causing death are understood and can be modelled, but such methods are not usually used to make official projections[33].
2. **Explanatory-based methods:** such methods employ a causal forecasting approach, using econometric techniques to project mortality from the impact of

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[32] The core part of this literature review depends on the Benjamin et. el. (1993) (Mortality on the Move) and the GAD (2001), "National Population Projections: Review of Methodology for Projecting Mortality" which included methodologies used in some other developed countries and others sources.

[33] The USA Social Security Administration (SSA) latest population projections calculated death rates by age group, sex, and cause of death. Cause-specific death rates were calculated for ten cause-of-death groupings over 1968-94 for four age groupings – less than 15, 15 to 64, 65 to 84 and 85 and over. Annual reductions were then determined for 1968-94 by age group, sex and cause-of-death groupings.

various risk factors, such as income or socio-economic factors[34]. The methods require the aggregate mortality projections to be built up by analysing mortality into component parts, which would be difficult to predict. They also require projection of the prevalent risk factors. Such methods are rarely used in official projections.

3. **Extrapolative methods:** they based on projecting historical trends in mortality into the future. These include some element of subjective judgement and are only reliable to the extent that the conditions, which led to changing mortality in the past, will continue to have a similar impact in the future. Any significant change could invalidate the results of an extrapolative projection. In this investigation, extrapolative projection methodologies are explored.

Methods for estimating mortality improvement rates can be classified into targeting methods and trend methods. Targeting methods may involve a set of age-specific mortality rates which are assumed to hold at a certain future date, specified rates of mortality improvement, or a life table based on the experience of some other countries. Methods could also be either deterministic, meaning that one set of projected rates based on a predetermined set of parameters is produced, or stochastic, meaning that the projected rates contain a random element from an assumed probability distribution for the parameters.

Any methodology should satisfy some criteria to be a suitable one. Some of such criteria are: accuracy, simplicity, availability of data, subjectivity, suitability for creating variants, fitting into the process of population projections and providing a reasonable level of performance in terms of reliability and defensibility. Accurate projections may represent the highest priority in selecting a methodology, although this cannot be tested at the time of projection. Complex models may result in small marginal increases in accuracy, which does not justify using them. The methodology should allow some element of judgement in setting assumptions, informed by views on what changes are likely to occur in future, based on exogenous information.

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[34] In 1992-93, The World Bank projected life expectancy and infant mortality from national data using a logistic function for the rate of change in mortality over time, varying across countries and, for a given country, across time. The projection included socioeconomic variables in the countries.

Benjamin et el. (1993), grouped the methods of projecting mortality into[35]: the logarithmic method, the logit method, the use of mathematical curve over the whole range of ages, projection by the cause of death, projection of the parameters of the curve of deaths and the Continuous Mortality Investigation (CMI) methodology. GAD (2001) added: the Lee-Carter method and the methodology adopted by GAD. A brief description and commentary on these methods, and their suitability, or otherwise, for use in the case of Egypt, are explored very briefly in **Appendix 4.** In the following sections, a description and commentary on GAD methodology, which is employed for use in the case of Egypt, is explored. This adopted methodology is applied to the national population projection of Egypt and assumptions used for deriving variant mortality projections are determined.

5.5.1. GAD Current Methodology[36]

The GAD's current projection methodology focuses, particularly, on projecting and targeting rates of mortality improvement rather than mortality rates themselves or expectations of life (and a target year). The methodology is summarised as follow:

1. Estimate levels of mortality from the base year of the projections on the strength of past trends and assuming initial levels of improvements in mortality;
2. Levels of improvements are then projected forward for each future year to meet particular target rates of improvement at a particular year (after this point assumptions are often held constant or are assumed to change in a regular way);
3. Projected rates of improvement for each future year are then applied successively to theses base-year mortality rates to obtain future mortality rates;
4. Two mortality variants are produced, one projecting lower expectations of life and the other higher expectations of life than the principal projection and the method is adapted to allow for the cohort effects.

The methodology can be based on the use of the same target rates of mortality improvement and can change the target year in which the target rates will be achieved. Another way is to retain the same target year but altar the rate at which future improvements are assumed to converge to the target improvements. The

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[35] Pollard (1989) grouped the methodologies into: projection by extrapolation of mortality rates at selected ages, projection by reference to a "law of mortality", projection by reference to model life tables, projection by reference to another "more advanced" population; projection by cause of death; and combinations of these methods.

[36] It was used for the first time to project mortality for 1992-based national population projections.

method uses a combination of trend extrapolation and targeting methods. Trend extrapolation is used to project mortality rates and rates of improvement for the base year of the projection. The rates of improvement are obtained by interpolating between the improvement rates assumed in the first year and the target rates for a later year. Interpolates would be linear or geometric between current mortality rates and the set of target rates. Targeting overcomes some of the disadvantages of a purely extrapolative approach by taking account of any possible future significant changes.

Some of the weaknesses of this methodology are:

1. Choice of parameters may be perceived as somewhat arbitrary, for example, the ultimate target-improvement rates could be set for any number of years[37];
2. It may constrain the possibilities for choosing variants, in particular for the low life-expectancy variant, and does not allow statements of probability or confidence intervals to be attached to them;
3. Requires a large degree of subjectivity[38], which leads to a relative loss of transparency in how the parameters are chosen.

5.6. The Methodology and Assumptions Adopted for Projecting Mortality rates in Egypt over 1997- 2025

It is clear that there is no universally accepted method for projecting mortality rates and the methodologies adopted are changed from time to time, as has happened in the UK, and differ from country to country. The GAD's current methodology of employing target mortality improvements is considered as the most suitable methodology and is adopted in this thesis.

The methodology and the core main assumptions are as follow[39]:

1. Rates of annual improvement based on extrapolation of the rates of improvement experienced over 1977-96 by age and sex which allow for the fact that the

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[37] A shorter target period is preferred because of the high uncertainty over long-term mortality levels. The principal projection result in the UK is 25 years.

[38] Most objective extrapolation methods can reproduce historic UK data, but such methods would inevitably require a certain amount of subjective amendment to be used in projections.

[39] This is similar to the Canada Pension Plan methodology, which applies mortality improvement rates by age and sex successively to the base mortality rates to obtain future mortality rates. The initial improvement rates are determined by analysing trends by age and sex in the mortality of Canada over the previous ten years. The base-year mortality improvement rates are then graded using linear interpolation from their initial level to their ultimate level over a 20-year period varying by age, sex and calendar year. The ultimate rates of improvement are assumed to apply for every year thereafter.

mortality of young population has been improving more rapidly than of that in the middle and old ages;

2. Male and female mortality rates have been observed to change at roughly the same rates in the past and it was decided for simplicity to use the same methodology and their experienced mortality improvement rates.
3. There are limiting minimum mortality improvement rates by the end of the projection period;
4. Setting three variants (I, II, III) by altering targets and speeds by which rates of improvements decrease;
5. Constant exponential reductions in rates of mortality improvement (decreasing with age) are assumed in each future year of the projections for variants I and II. Thus the improvement rates decrease to their limiting values by exponential decay over the projection period.

Variant I (high mortality projection): It assumes that the future rate of mortality improvement fall exponentially towards a rate of 0% p.a. of that experienced over 1977-96 by the end of the projection period for males and females up to age 64[40]. A pessimistic view of mortality prospects for old ages, with no future improvement (mortality rates remain unaltered in future years) assumed for either sex for age 65 and over (which might be presented as an unlikely prospect).

Variant II (principle or central projection): It assumes a rapid slowing in the rates of annual improvement. It assumes that the future rate of improvement fall exponentially towards an annual improvement rate of 50% of that experienced over 1977-96 by the end of the projection period for males and females up to age 54. An assumed rate of mortality improvement of 1.5% p.a. for ages 55 and over, which also moves (exponentially) towards an annual improvement rate of 1% p.a. by year 2025.

Variant III (low mortality variant): This variant adopts more optimistic rates of improvement for most of ages. It covers the possibility of recent trends of mortality improvement experienced over 1977-96 being unchanged over the projection period for males and females up to age 39. It assumes a constant improvement rate of 2.5% p.a. for all ages 40 and over. At ages 40 and over it is assumed that there would be a

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[40] Most official projections assume that rates of improvement will fall in the future as improvements become more difficult to maintain and few, if any, assume a worsening of mortality, even in the most pessimistic scenarios.

better improvement than warranted by current trends, which is an optimistic view that might not presented as a realistic prospect.

The three variants represent scenarios which produce three sets of projected mortality rates varying by age, sex and calendar year. Clearly, the projection assumption is that rates for younger people will fall dramatically, whereas there will be limited improvements for old ages.

The following steps are carried out in projecting mortality rates for both sexes.

1. Standard mortality tables reflecting the observed mortality experience of the base period referred to as the "Base" tables (i.e. "current" mortality) to which future projected improvements were applied are generally taken as the average rates experienced over a recent three-year period. The standard mortality rates are taken as that of the 1994-96 experience which were constructed in Chapter 4.
2. Projections of expected future mortality rates allow for future improvements in mortality from the base tables. Projected future mortality rates are derived for each year by sex and age last birthday, at the middle of each future calendar year, for the projection period;

5.6.1. Results of the Projection

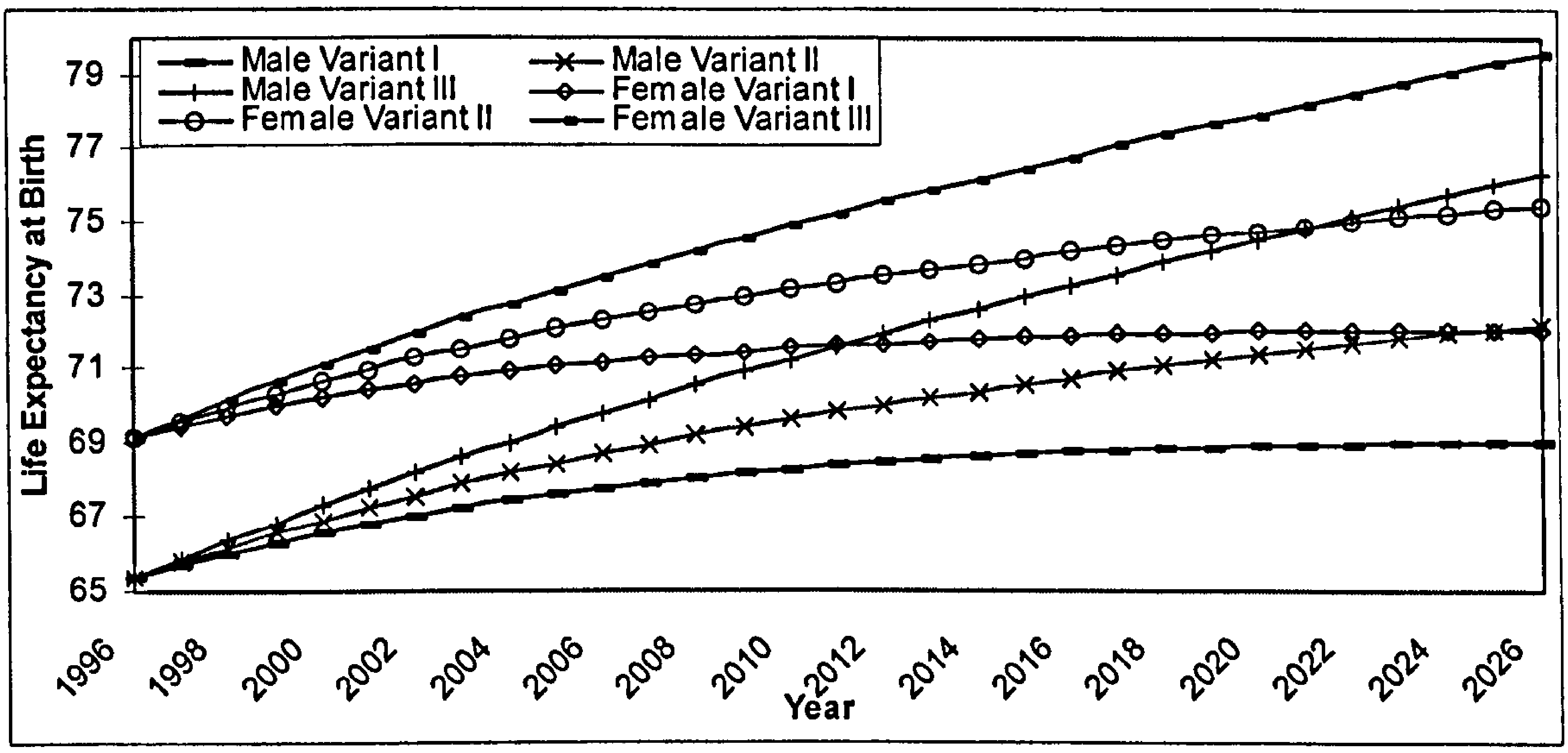
Based on mortality rates assumed in the principal projections (Variant II), life expectancies at birth are 72.1 and 75.4 years for males and females, respectively, in 2025 rising from 65.3 and 69.1 years for males and females respectively in 1996. This indicates a gradual narrowing of the gender disparity in life expectancy –from a difference of 3.8 years in 1996 to less than 3.3 years in 2025. The resulting projected mortality rates and life expectations under the three variants seem plausible and reasonable as shown in Figure 5.8 and **Table 4.2 of Appendix 4.**

Variant I led to projected life expectancies at birth of 69 and 72.1 years for males and females respectively in year 2025. Variant III led to projected life expectancies at birth of 76.0 and 79.3 in year 2025. The differences in life expectancy at birth between variants I and III are 7.0 and 7.3 years for males and females respectively by the end of the projection period.

The UN projects the life expectancy at birth in Egypt to be 72.2 and 76.0 years for males and females respectively and 74.1 for both sexes combined over the period

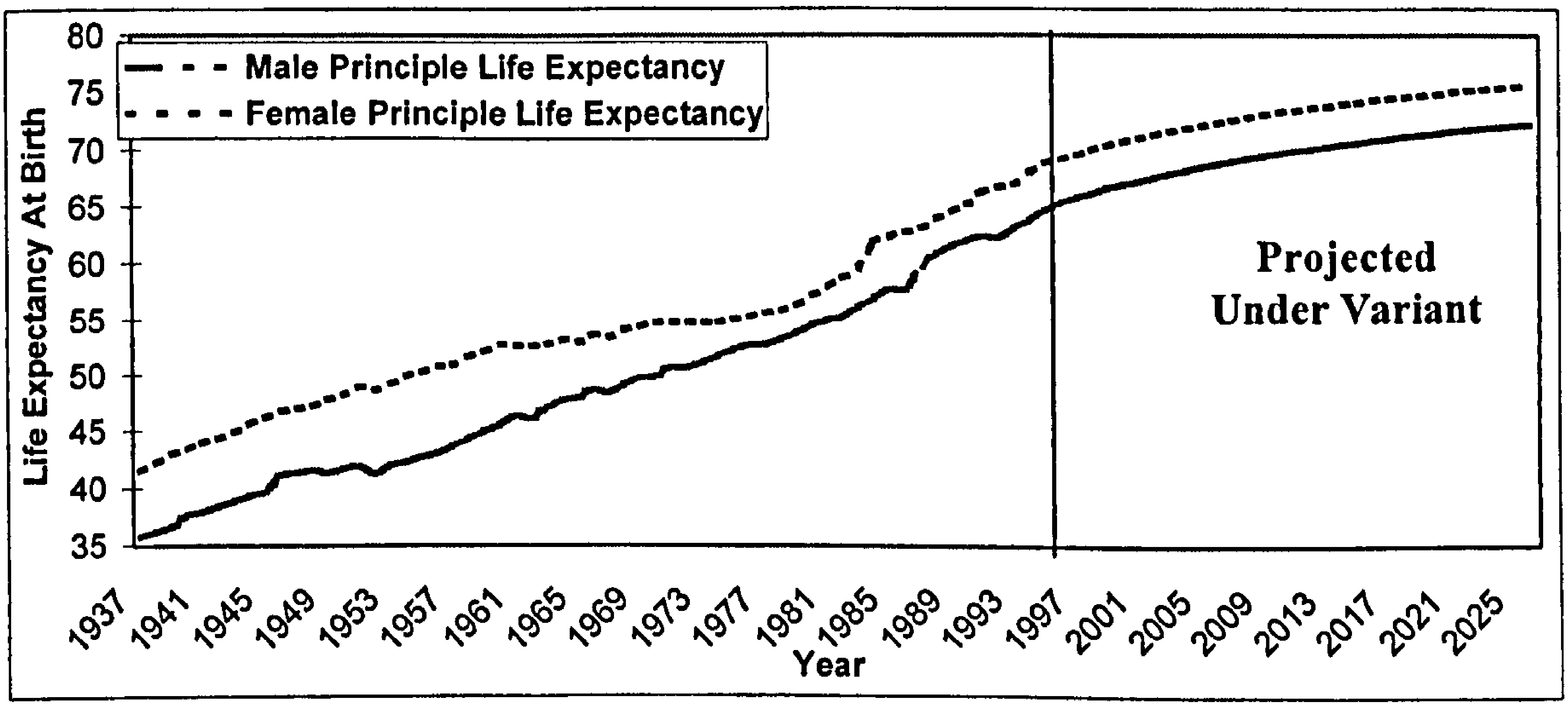
2020-2030 according to the medium-variant projection. The UN (1999) low mortality variant estimates that by year 2025 the life expectancy at birth in Egypt would increase to 75.5 years for males and to 80.5 years for females. The World Bank estimates that over the period of 2020-2030 the life expectancy at birth in the Middle East & North Africa for both sexes combined would be 72.7 and 74.3 years for males and females respectively compared with 80.7 to 81.2 years of the high income (OECD) countries.

Figure 5.8. Projected Life Expectancy at Birth of the Egyptian Population over 1997-2025



All these indicators indicate that the results driven from this methodology are reasonable and adequate to be used in the national population projection of Egypt over 1997-2025. **Table 4.2 of Appendix 4** gives details of projected expectations of life under the three variants and the actual and projected life expectancy at birth under variant II for males and females as shown in Figure 5.9.

Figure 5.9. Actual and projected expectation of life over 1937-2025



In the projections' output, mortality rates are provided in the form of probabilities of dying between one mid-calendar year to the next, by age last birthday at the beginning of that 12-month period ($q_{x+[t]}$).

5.7. Fertility Rates[41]

Analysis and monitoring of fertility levels are essential steps toward projecting the national population. In the medium and long-term, fertility is likely to be the largest source of uncertainty in projecting the size of the population (consequently the labour force and the beneficiary population), which is quite sensitive to this factor. Fertility is sensitive to social and economic changes affecting attitudes to family size, as the decision to have a child depends on many factors such as:

1- Influence of leading writers, religious, social and tradition factors;
2- General ethos (fashion or culture) and loss of leisure or gainful employment;
3- Economic and political outlook at the time of conception;
4- The prohibition of the employment of young children, causing them to become economic liabilities rather than assets and the rise in the costs of raising a child;
5- The decline in infant mortality leading to a major increase in the proportion of children who survive to adulthood, the general improvement of the health of mothers, babies and social conditions;
6- More widespread knowledge of contraceptive methods and the introduction of more efficient methods.

These factors have brought about a profound change of attitude towards, a smaller family size, which has been witnessed in many countries. This decline can be also explained in part by economic uncertainty created by business cycles which have led to periods of high unemployment and increased poverty. This decline is not likely to be reversed without positive motivation.

In countries where most births occur within marriage, the pattern of fertility could be analysed according to the mother's year and duration of marriage. A temporary slowing of the marriage rate would produce temporary decreases in age fertility rates. For this reason reproduction rates are sometimes marriage-standardised, although this raises the problem of projecting marriage rates. Marriage experience of a single year

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[41] See for example, G. H. Andrews et. el. (1987); Pressat, 1978; Colin Newell, Newell, 1988; Benjamin and J H Pollard, (1989); Orszag et. el., 2000).

may be a misleading guide: for example, economic conditions may later produce some temporary postponement of marriage or a general reduction in marriage prospects. In general, fertility rates decline with the advancing age of mothers and with the lengthening duration of marriage and these are very important in assessing fertility prospects for particular population.

Fertility can be analysed on a period basis, parity (birth order or number of children) and a cohort approach, examining family building both by age and duration of marriage. Births patterns according to the year of the mother's birth, for women now past childbearing, can be used to extrapolate the incomplete pattern of those still at a fertile age (15-49). It is preferable to analyse data according to year of birth, i.e. to calculate a replacement rate applicable to a single generation (those born in a particular calendar year). It is desired to use both ex-nuptial and nuptial fertility, so a general approach can be modified to produce the expected number of births. This follows a generation through childhood, marriage and productive life, subject to mortality, nuptiality and fertility recorded for that generation if it has reached the end of reproductive life, or projected if it has not.

Fertility and nuptiality are inherently more variable than mortality, this means that their models will, on average, fit the data less closely than mortality models. These models are more complex, less numerous and less widely used. In this thesis we restrict ourselves to TPFRs (calendar-year central rates) analysis, as the data was collected in this way in Egypt over 1946-96, and estimates of TPFRs over 1997-2025.

5.7.1. Total Period Fertility Rate (TPFR[42]) in Egypt over 1946-96

Fertility rates are usually related to females by age, both because there are fewer ages involved and also because data is commonly collected in this way. They can be represented as the total births produced by a woman during her reproductive lifetime if she experiences, throughout that period, the age-fertility rates of the particular year. It is a mixture of fertility rates of many generations (a secular rate) and for this reason it is called the period total fertility rate (TPFR).

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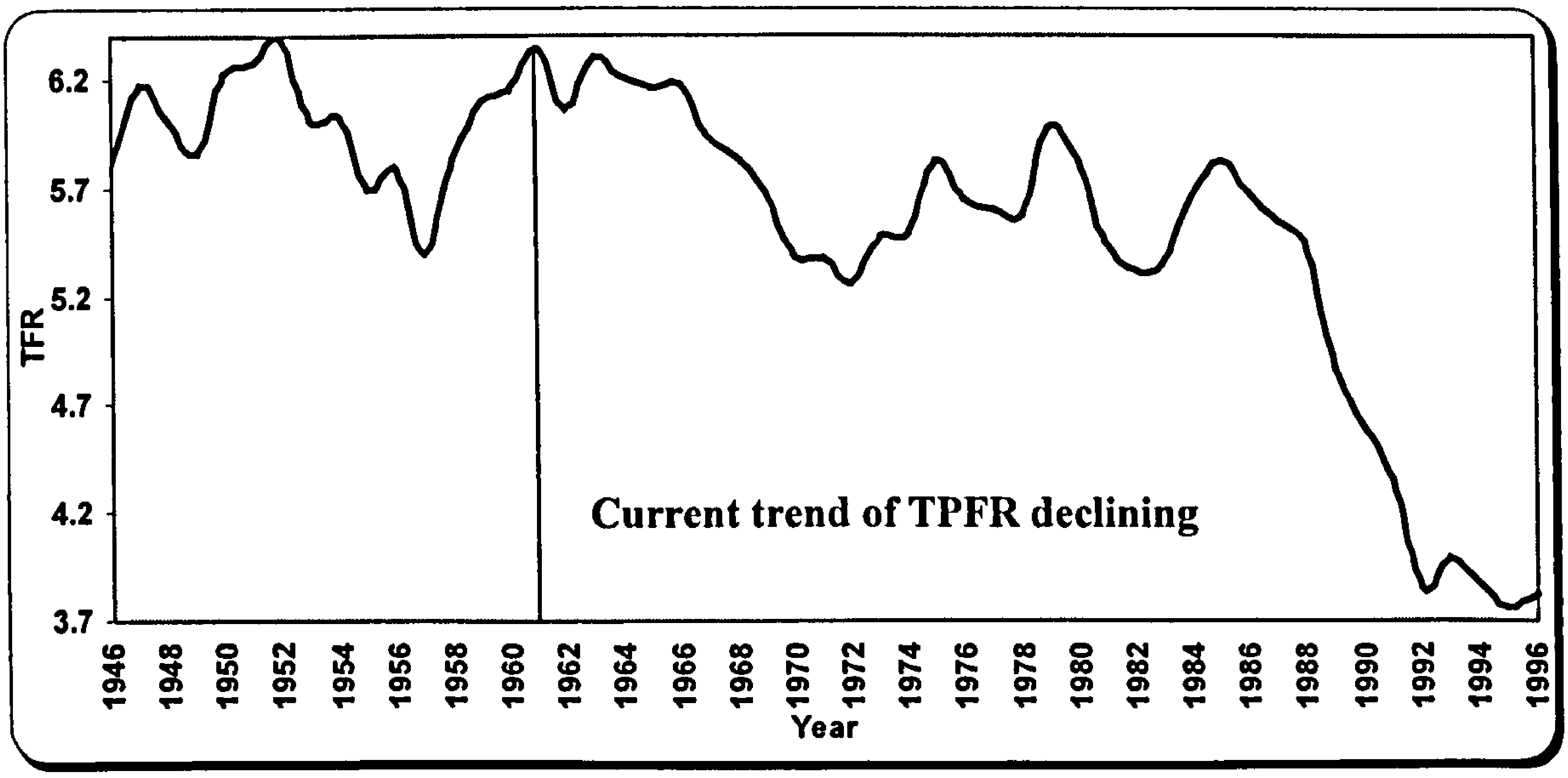
[42] It is the average number of children in a year who would be born to a woman in her lifetime if she were to survive her entire childbearing years and were to experience those age-specific birth rates throughout her childbearing years. It represents the expected number of children to whom a woman would give birth if she followed the natality experience of that year throughout her childbearing years. It is a simple sum of the age-specific fertility rates experience for a single year.

Examining trends in fertility is the first step in projecting fertility. Although fertility rates in Egypt have been traditionally high, Egypt has experienced many of the changes witnessed in many other countries during the past 20 years, which have contributed to reducing the number of children being born. These factors are an upward shift in the average age of first marriage, an increase in female participation in the labour force, continuing urbanisation, modernisation of education and health, changes in social attitudes, and changes in economic and political conditions. In Egypt, births must be within marriage to be recognised officially and therefore the extent to which people marry exercises a powerful influence on the subsequent flow of births. These changes have affected both marriage and fertility.

Analysis of the TPFR patterns over 1946-96 shows a considerable secular decline, ranging from a high of more than 6.38 in 1952 to a low of 3.76 in 1995 as shown in Figure 5.10. It has been declining since 1979 and has tended toward the lower end of the current range of around 3.8 in 1996. As Figure 5.10 shows, a significant shift has occurred from higher to lower fertility over 1946-96. This trend indicates that as time passes there is a substantial fall in TPFR.

Figure 5.10. TPFR over 1946-96

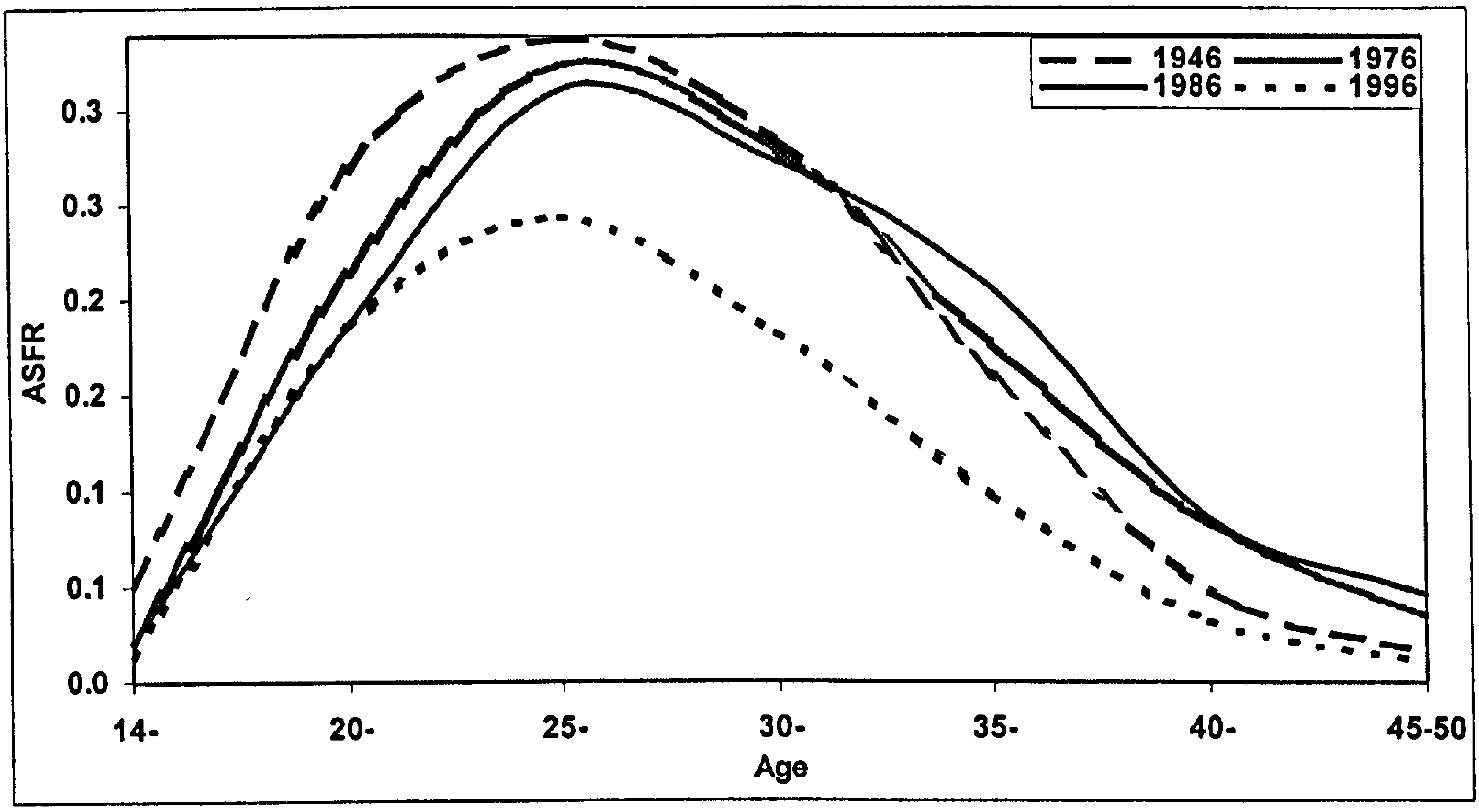


The crude birth rate also declined from 46.8 per 1000 in 1946 to around 27 per 1000 in 1996. The average number of children born per woman, which has been falling is reflected in reduction in the average family size from 4.9 persons in 1986 census to 4.6 in 1996 census. This family size is still high and above the natural replacement level, however, the three-child family has now become the popular family size in Egypt and this is likely to continue.

5.7.2. Age-Specific Fertility Rate (ASFR)[43]

Age specific fertility rates (ASFRs) of mothers are generally used in population projections. Differential fertility at different ages within the child-bearing group gives a clearer picture of possible variations, such as any arise from unusual features of the age structure of the population. The pattern of ASFRs fertility rates for women at ages 14-49 over 1946-96 in Egypt, for four selected calendar years is shown in Figure 5.11.

Figure 5.11. ASFRs over 1946-96



The curves have their peaks between ages 20-30 and a decrease in the TPFR over 1946-96, is largely due to the very significant decrease in birth rates among women in their middle 20s, 30s and 40s who put off having children when they are in the early 20s. Fertility rates for women aged 20 years and over were decreasing significantly over 1946-96, particularly over 1986-96 and it is expected to decrease further. A slight decline for women under 20 year is also noticed. The period of high fertility in the 1980s was followed by a period of a substantial decline in fertility rates in the 1990s. However, as a result of the current economic situation and high unemployment in Egypt, discussed in the next chapter, misleading indications of fertility can result in age specific fertility rates as a result of marriages postponed. This is opposed to what happened in the second half of the 1970s and the first half of the 1980s when marriages were accelerated.

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[43] It is defined as the total births during the year to mothers at the specific age divided by the midyear female population at that age.

5.7.3. Experience of other Countries

Selecting ultimate TPFRs for different projections can be assessed by examining the evolution of recent TPFRs in other nations, as fertility rates have been converging across countries (Orszag, et.el., 2000). Orszag, et.el. (2000) found that the percentage of the countries with a TPFR below 4 had increased from only 37% in 1987 to 61% of countries by 1998 and the mean fertility rate fell from 4.7 in 1978 to 3.5 in 1998.

In 1995, the average TPFR of the high income OECD, Eastern Europe and Russia, Latin American & Caribbean, Asia, Middle East & North Africa and Sub-Saharan Africa were 1.6, 1.6, 2.9, 3.2, 4.0 and 5.5 respectively. A comparison of TPFRs in 1996[44], for the U.S., Canada, and nineteen industrialised countries revealed a range from 2.1 in New Zealand to 1.3 in Italy. Many other European countries had a TPFR under 1.6. Therefore, it is possible that the TPFR could be as low as 1.6 children per woman on average over a long period of time. Orszag et. el. (2000) show that there is a substantial evidence that countries with high fertility rates experience larger and faster declines in fertility than countries with lower fertility rates, providing evidence that fertility rates are converging across countries, although fertility has not declined in Africa as rapidly as the rest of the world. In general, in the long run, TPFRs have fallen.

5.7.4. Variant Future TPFRs Assumptions in Egypt over 1997-2025

For the reasons already cited, it is not believed that the TPFR in Egypt will return to a level as high as that experienced over 1946-79 or even to remain close to recent levels, as no significant reversal of these changes is anticipated for any sustained period. Therefore, the TPFR can be assumed to remain constant at about current levels or to follow some trend (e.g. to continue decrease) in the future.

Various assumptions about the ultimate TPFR over the projection period are selected according to the assessment of the past data and future prospects. An ultimate TPFR of 2.5 children per woman in 2025 was selected as the intermediate variant assumption for the principal projection[45] after a gradual decline[46] from the preliminary value of 3.82 children per woman in 1996.

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[44] For the most recent calendar year published in the 1996 United Nations Demographic Yearbook.

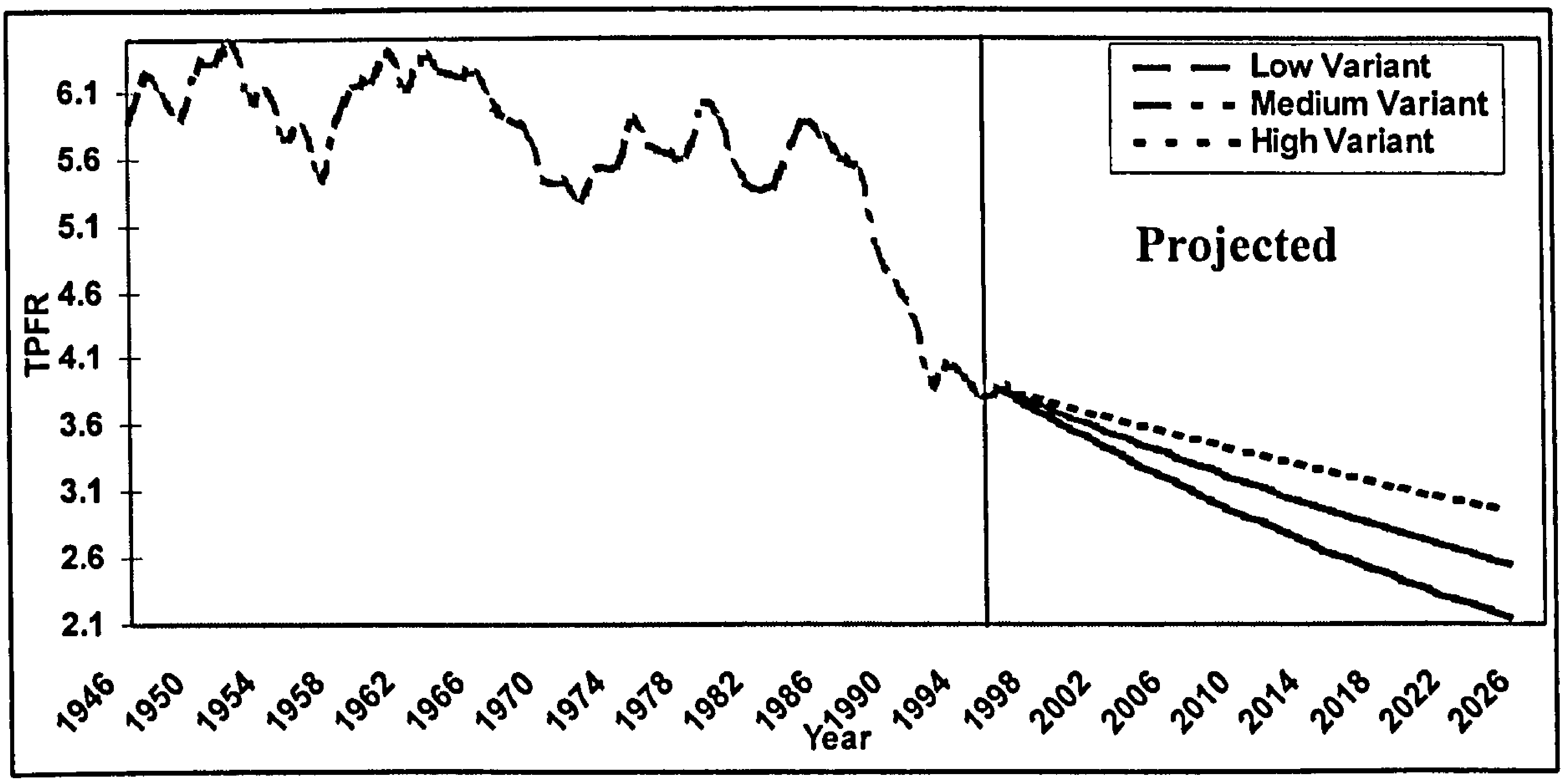
[45] Total cost paid by the Treasury is significantly affected by the number of members covered by the ESSPS and a higher fertility rate means a larger cost, which is opposite to the PAYG systems.

[46] The annual decline rate was estimated using a geometric mean over 1961-96.

An ultimate TPFR in 2025 of 2.1 children per woman[47] was selected as the low variant assumption (low cost variant for the ESSPS) as it represents the replacement level of the population (UN, 1999). Although low by historical standards in Egypt, it seems consistent with international organisations in their principal projections. The low variant assumes that the average family size of successive cohorts will continue to fall and that fertility rates will be lower at all ages as compared with the principal projection. This means a larger decline in rates at younger ages than in the principal projection and a levelling off in the upward trend in rates at ages over 30.

An ultimate TPFR of 2.9 children in 2025 per woman was selected as the high variant assumption (high cost variant). The higher variant would imply a slow decline of the recent downward trend in average family size. Figure 5.12 gives past and projected TPFRs for the three alternatives and shows that each of the overall levels assumed in the variants are consistent with the recent decline in the TPFRs. The methodologies for projecting ASFRs are described in the following sections.

Figure 5.12: Historical and Projected TPFR according different Variants



5.7.5. Models for Projecting Future ASFRs

ASFRs can be assumed to remain constant in the future or to follow some trend. How do we estimate the age-specific fertility rates in year t? Colin (1988) mentioned three models of projecting fertility. The first is the Coale –Trussell fertility model (Coale and Trussel, 1974), which is a combination of the Coale-McNeil nuptiality model and

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[47] The Egyptian Government target is to achieve this TPFR by year 2017, which seems very difficult.

a model of marital fertility. The second is the Gompertz relational fertility model of Brass (1981), which is similar in principle to the logit relational model life-table system. The third is the Brass Fertility Polynomial model. In the following section the first is mentioned briefly and the second is explained in detail as it is applied in projecting ASFRs. The third is ignored because it is not nearly as good as the two other models (Newell, 1988).

5.7.5.1. Coale –Trussell Fertility Model

This model can be expressed algebraically as:

$$f(x) = G(x).n(x).e^{m.v(x)} \qquad (5.11)$$

where f(x) is the age specific fertility rate at age x, m gives the extent of fertility control and G(x) is the proportion ever married at age x as determined from the a_0 (the age of onset of marriage) and k (the rate of marriage). n(x) and v(x) are fixed values expressing natural marital fertility and the typical departure from natural fertility respectively.

A model which can fit a set of observed ASFRs is needed. The nuptiality model, which the model incorporates, can only model well-behaved cohorts where nuptiality has not been changing rapidly. Also it is a three-parameter system, and these normally have to be found from six or seven ASFRs. The model is quite sensitive to small differences or errors in the data and such sensitivity is a disadvantage when working with data from developing countries, which are likely to contain errors and biases (Newell, 1988). These problems are to some extent overcome in the Gompertz relational model system.

5.7.5.2. Gompertz Relational Fertility Model

This system bears many similarities to the logit relational system of model life tables. The Gompertz model uses ASFRs expressed as proportions (i.e. divided by the TFR) and cumulated. A Gompertz transformation is used to linearise the data and is called 'Gompit'. The transformation is then:

$$\text{Gompit}(p) = -\text{Ln}(-\text{Ln } p) \qquad (5.12)$$

And its inverse (anti-Gompit) is:

$$P = \text{Exp}(-\text{Exp}(\text{Gompit})) \qquad (5.13)$$

where p is transforming proportions. The key to the model is that plotting the Gompits of one set of cumulative proportional ASFRs against another, such as a predefined standard, produces an approximately straight line. Expressing this algebraically, if the Gompit of the cumulative relative fertility at age x is called Y(x), and that of a standard fertility function is denoted by the subscript s, then:

$$Y(x) = \alpha + \beta\ Y_s(x) \qquad (5.14)$$

A standard fertility function can be used, such as the one generated by Booth (1984), and was designed to represent the typical pattern of fertility in high-fertility populations. The parameter α denotes the change of the age-location of the model and the parameters β may be interpreted as determining the spread, or degree of concentration, of the fertility function. It should be remembered that α and β only have meaning relative to the standard. If a different standard is used, then the values of α and β will change.

The advantages of the Gompertz fertility model over the Coale-Trussell fertility model are first that it uses two rather than three parameters which makes the model less sensitive to errors and biases in data. Second, the model is useful in the evaluation of data quality and its application is easy. Because it is based upon a relational principle it might well fit cross-sectional data rather better, especially where nuptiality is changing rapidly.

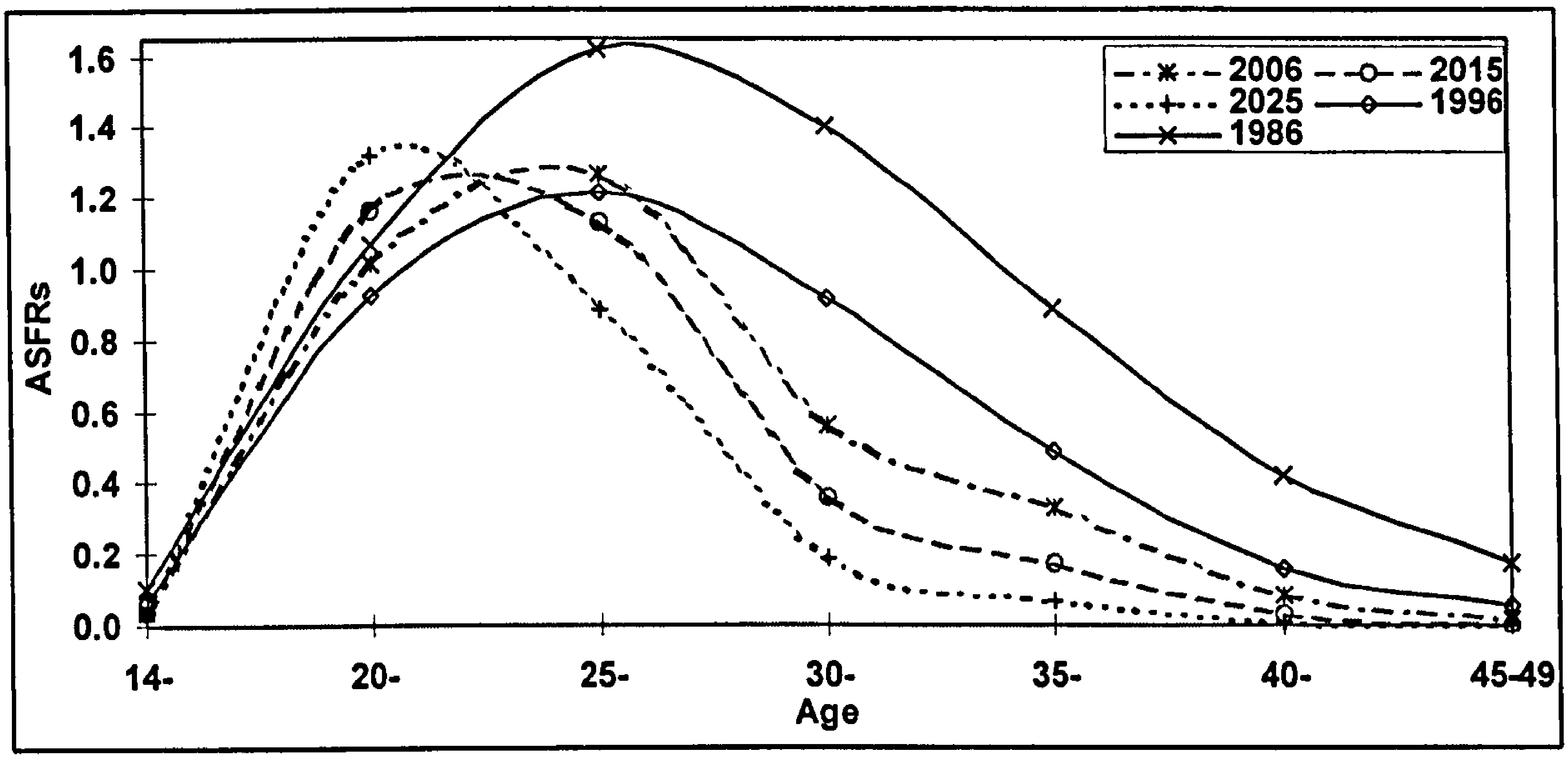
5.7.6. Projecting ASFRs in Egypt over 1997-2025

The Gompertz model is adopted for projecting future ASFRs with the following modifications:

1- For a given calendar year, the total ASFRs is restricted to TPFRs assumed under the three variants;
2- The standard schedule (the base year) is taken as 1947;
3- The linear trends in α and β are used to project future ASFRs.

This assumes that TPFR for a year is distributed over the assumed childbearing ages (14 through 49) in a pattern consistent with the ASFR trends experienced over 1948-96, a pattern which is assumed to persist throughout the projection process. Over 1997-2025, the ASFRs are projected to follow the same pattern (trend) experienced over 1946-96, which is reflected in the Gompertz model such that the completed fertility rate would gradually approach the assumed ultimate total fertility rate. The assumptions are based on the relative distribution of ASFR for the average historical age distribution. This methodological change serves to make the relative ASFRs distribution moves in trends similar to recent data. Figure 5.13 shows that the Gompertz model produces projected future ASFRs over the projected period 1997-2025, which takes into account the trends over 1947-96. The Figure indicates that future ASFR curves are moving towards a deep decline at ages 30 and over and more concentration at the age group 20-30. The projected fertility rates over 1997-2025 are shown in **Table 4.3 of Appendix 4.**

Figure 5.13. Historical and Projected ASFRs according Medium TPFR Variants



5.8. Results of the Egyptian Population Projections

A population projection over the period 1995-2025[48], using the component model, was prepared according to the following:

1. The population's census at the middle of the 1996 as the base year,
2. The Egyptian Life Table, which was constructed in Chapter 4, as the standard mortality table in the base year,
3. Allowance for mortality improvement over the projection period according to the three variants and the assumptions stated,
4. Assumptions about the future TPFRs and ASFRs according to the three variants modelled and assumed over the projection.

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[48] Projections become increasingly uncertain the further into the future they are carried. The period of time between the base year of the projection and the target year is an indication of the relative uncertainty of that component. Over the longer term, errors in population numbers can arise from the cumulative effects of a series of smaller errors at some ages being projected forward through the projection period. This type of error would be particularly significant to long-term projections.

The projected population figures and the results are presented in such a way that the inherent uncertainties and interactions involved in alternative mortality and fertility assumptions on the development of the Egyptian population and its structural composition are explored. Nine population projections for Egypt under different sets of assumptions were carried out, however, three main scenarios from the point of view of the ESSPS are considered.

Scenario I (low cost variant): this represents low fertility and high mortality variants;

Scenario II (medium cost variant): this represents the medium variants of mortality and fertility assumptions;

Scenario III (high cost variant): represents high fertility and low mortality variants.

Table 5.2: Egyptian population projection by sex, and age structure over 1997-2025

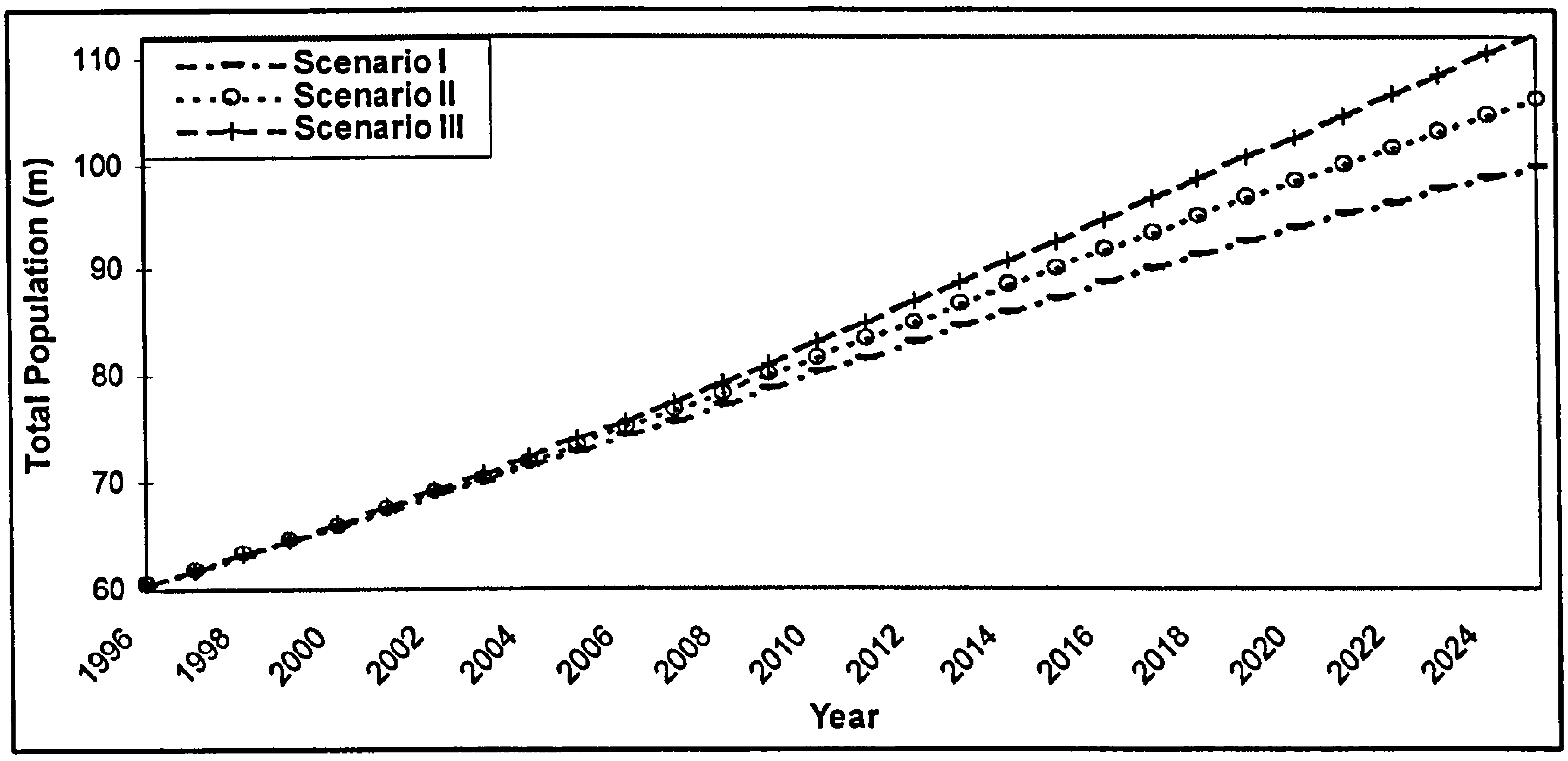
Year		**1997**	**2000**	**2005**	**2010**	**2015**	**2020**	**2025**
Total Population At mid-year	VI	61.89	65.90	72.91	80.24	87.41	93.98	99.65
	VII	61.90	66.03	73.51	81.72	90.14	98.38	106.20
	VIII	61.92	66.14	74.07	83.09	92.75	102.60	112.29
Male Population	VI	31.48	33.50	37.06	40.79	44.44	47.78	50.65
	VII	31.49	33.57	37.37	41.54	45.83	50.02	53.99
	VIII	31.49	33.63	37.65	42.24	47.17	52.19	57.13
Female Population	VI	30.41	32.39	35.85	39.45	42.97	46.20	49.00
	VII	30.42	32.46	36.15	40.18	44.32	48.36	52.21
	VIII	30.42	32.51	36.42	40.85	45.58	50.41	55.16
Age Structure								
0-14	VI	38.3	36.7	34.3	33.0	31.5	29.8	27.5
	VII	38.3	36.8	34.8	33.9	33.0	31.7	29.7
	VIII	38.3	36.8	35.4	34.6	34.2	33.2	31.4
15-59	VI	55.8	57.2	59.1	60.0	61.0	62.1	63.6
	VII	55.8	57.1	58.5	59.0	59.3	59.9	61.0
	VIII	55.8	57.0	57.9	58.1	57.9	58.1	58.9
60+	VI	5.9	6.1	6.6	7.0	7.5	8.1	8.9
	VII	6.0	6.2	6.7	7.2	7.7	8.4	9.3
	VIII	6.0	6.2	6.7	7.3	8.0	8.8	9.7
Dependency Ratio	VI	10.7	10.7	11.1	11.6	12.3	13.1	14.0
	VII	10.7	10.8	11.4	12.1	13.1	14.1	15.2
	VIII	10.7	10.8	11.6	12.5	13.8	15.1	16.5

Source: Derived by Author

Egypt's demographic transition which began in the second half of the 1980s when the population growth rate declined from about 2.8% p.a. over 1976-86 to around 2.1% over 1986-96, is expected to continue over the projection period. According to the three scenarios, the population growth rate is expected to decrease to 1.08% p.a., 1.47% p.a., and 1.74% p.a. respectively by year 2025.

The main features of the projection results are shown in Table 5.2 and the main results are summarised in **Table 4.4 of Appendix 4.** Table 5.2 shows that there is a shift in population structure in terms of classical demographic ratios. The overall Egyptian population is projected to increase gradually from 60.6 million in 1996 to reach 99.65, 106.2 or 112.29 million by 2025, according to the three scenario projections[49] as shown in Figure 5.14. By the end of the projection period in year 2025, the population under scenario I would be about 12.94 million smaller than under scenario III.

Figure 5.14. Projected total Egyptian population under the three scenarios over 1997-2025



Matters of particular interest include a projected gradual rise in the population and a marked increase in the population of pensionable age. The proportion of the population of pensionable age (60+) over 1948-97 was relatively stable, increasing from 5.85% in 1986 to 5.95% in 1996[50]. This proportion is projected to increase to 8.9-9.7% in 2025 according to the three scenarios. The main changes of the population structures over 1948-97 were in the age groups 0-14 and 15-59. The proportion of the population aged 0-14 decreased from 43.0% in 1960 to 39.0% in 1997, with annual decreases varying between 0.20-0.33%, which still reflects a young population structure[51]. This proportion is projected to fall to 27.5-31.4% by year 2025.

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[49] The Egyptian government official estimate of the population on 30/6/1999 is 64.33 million compared with the model projection of 64.62 million according to the principle projection (scenario II).

[50] UN (1997) projects that this age group will steadily increase annually by 0.1% which seems a reasonable estimate.

[51] High fertility rates in the 1970s and 1980s have resulted in a young population structure, which has resulted in high concentration of young persons in the labour force.

The proportion of people working age (ages 15-60 for men and women) has increased from 51.0% in 1949 to 55.3% in 1997 with annual increases varying between 0.19-0.26%[52]. This proportion is projected to rise to 58.9-63.6% by 2025. The average age of the population continues to increase, with the mean age projected to rise from 24.3 years in 1996 to 30.6-28.7 years by the end of the projection period according to the three scenarios. The median age is estimated to rise from 19 years in 1996 to about 27-25 years in 2025. Factors causing this include the fall in the expected number of children under 15, however, it still indicates a young population structure.

The demographic old-age dependency ratio[53] declined from 11.9% in 1948 to 11.6% in 1993, and has since increased to 10.7% in 1996. It is estimated to increase slowly to 17.0-13.5% in 2025 according to the three scenarios. The demographic youth dependency ratio[54] has fallen from 79.5% in 1948 to 67.3% in 1996 as a result of the increase in the proportion aged 15-60 and as the number of births continues to fall. The total demographic dependency ratio[55] has fallen from 86% in 1948 to 73.8% in 1996. These ratios indicate a gradual shift in the population structure of Egypt, which will affect not only its future labour force but also its future social protection system as a whole.

5.9. Conclusion

There is strong evidence that population mortality experience is improving faster at young ages and early adulthood than at late adulthood and old ages for males and females. Fertility is also declining significantly, particularly, from the second half of the 1980s, and it is expected to continue declining over the projection period. The overall population of Egypt is gradually increasing but at a declining rate of growth under the three scenarios. For Egypt, the key assumptions for the future according to the principle projection are: Life expectancy at birth, based on the mortality rates for that year, to rise from 64.6 years in 1996 to 72.1 years in 2025 for men, and from 69.1 years in 1996 to 75.4 years in 2025 for women; TPFRs to decline from 3.82 children

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[52] UN (1997) projects that the population aged 15-59 will increase annually by 0.4% and that the population aged 0-14 will decrease annually by 0.5% in the future. Both estimates seem to be high, compared with the past experience over 1948-97, and particularly when taking into account the social and religious factors affecting fertility in Egypt.

[53] The ratio of the population aged 60+ to the total population aged 15-60.

[54] The ratio of the population aged under 15 to the total population aged 15-60.

[55] This is the sum of the youth and old age demographic dependency ratios.

per woman in 1996 to 2.5 in 2025. The assumed declining fertility rates and extended life expectancy result in the changing profile of the population. The analysis reveals that the dominant impact arises from the fertility assumptions rather that the mortality assumptions.

The impact of fertility can be expected to be increasingly important impact over a longer projection period, beyond 2025. But the parameters used to determine forecast of fertility over a very long time horizon are likely to be subject to greater uncertainty than those used to predict mortality, because they are based on social and cultural attitudes.

The population as a whole is ageing, with particularly large increases in the very old. However, this ageing is moderate and significant effects will not materialise until well into the next century. These changes have to be taken into account when providing public resources for the ESSPS. In this context, a direct link was found between the projected population, the projected age structure of the contributors and the State liabilities towards the system. However, the analysis must focus not only on the number of persons contributing, and potentially receiving benefits, but also on the total liabilities that will be borne by the state towards them. The insured labour force is determined by the level and structure of the total population, and more precisely by the maximum number of potentially active persons.