A COMPUTATIONAL INVESTIGATION OF OPTIMAL PARAMETERS IN PENSION REFORM

A Ph.D. Dissertation

by
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To

Unchanging

Universal Laws

A COMPUTATIONAL INVESTIGATION OF OPTIMAL PARAMETERS IN PENSION REFORM

The Institute of Economics and Social Sciences

of

Bilkent University

by

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ABSTRACT

A COMPUTATIONAL INVESTIGATION OF OPTIMAL PARAMETERS IN PENSION REFORM

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July 2000

The purpose of this dissertation is to develop a computational framework to identify a set of parametric reform options to rehabilitate publicly run, pay-as-you-go-based pension systems under alternative strategies for reform involving once-and-for-all as well as gradual changes in pension parameters. The techniques developed are applied to the Turkish pension system, which is particularly interesting as it already faces a severe financial crisis despite a relatively young population. The results confirm the need for urgent reform.

Keywords: Computational Methods, Search Algorithms, Pension Reform, Pay-as-you-go-based Pension System

ÖZET

EMEKLİLİK REFORMUNDA OPTİMAL PARAMETRELERİN HESAPLAMALI İNCELENMESİ

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Bu tezin amacı, dağıtım esasına göre hizmet eden emeklilik sistemlerine bir anlık ya da kademeli değişim süreci gibi farklı stratejilerde parametrik reform seçeneklerinin tespiti için gerekli hesaplamalı altyapıyı geliştirmektir. Geliştirilen teknikler genç nüfusuna rağmen mali çıkmaza girmiş ve devlet tarafından işletilmekte olan Türk Emeklilik Sistemine uygulanmıştır. Çalışma acil bir reform ihtiyacını doğrulamakta ve kabul edilmiş emeklilik reformu üzerinde yorum yapabilmek ve alternatifler sunmak için gereken analitik altyapıyı sağlamaktadır.

Anahtar Kelimeler: Hesaplamalı Metodlar, Arama Algoritmaları, Emeklilik Reformu, Dağıtım Esasıyla Çalışan Sigorta Sistemleri

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CHAPTER I

INTRODUCTION

This dissertation is intended to be a collection of individually independent essays, ordered according to evolution of the ideas on the use and development of computational search techniques for an investigation of parametric policy reform alternatives facing the financially troubled pension systems that are publicly managed on the basis of pay-as-you-go (PAYG) schemes.

Four essays making up the dissertation will introduce new numerical techniques to the pension reform literature applicable to any country data. In addition, they will consider the case of the Turkish pension system and tackle various aspects of the problem of identification of pension policy parameters, which would eliminate (or curb the growth in) the intertemporal pension deficits over a prespecified period of time. Pension policy parameters under consideration here are statutory entitlement ages (or minimum retirement ages), contribution and replacement rates.

Each essay will seek an answer to a different question on the basis of the results obtained through the solution of a complicated intertemporal optimization problem in an overlapping-generations set-up. As to be described in greater detail later, the questions taken up in these essays aim at either providing policy guidance, or explaining the behavior of the policy-makers/pension system managers with respect to the choice of different retirement age and contribution/replacement rate configurations.

Motivation for the study comes from the fact that publicly managed pension systems providing old-age or pension insurance coverage face financial difficulties in many countries across the world. Most of these systems are run on the basis of pay-as-you-go (PAYG) schemes, requiring pension payments to current retirees to be financed out of contributions collected from currently active workers and their employers. The primary reason causing financial difficulties these systems face is the increasing ratio of retirees to workers (the dependency ratio), most typically caused by the natural aging of population over the course of demographic transition. Following from increasing life expectancies and declining fertility rates over time, population aging is essentially a demographic phenomenon and cannot directly be controlled by pension authorities or policy makers. Pension balances would continuously deteriorate eventually causing sizable deficits, unless the resulting increase in dependency ratios could somehow be checked. High dependency ratios have already begun to challenge the financial sustainability of publicly run pension schemes in many countries (particularly, members of the OECD) forcing policy makers to take measures to curb the growth in pension deficits (Kohl and O'Brien, 1998). Avoiding such deficits requires controlling dependency ratios through changes in statutory entitlement ages (or minimum retirement ages), and/or adjustments in the values of contribution and replacement rates[1].

The purpose of this dissertation is to develop a computational framework to identify a set of parametric reform options to rehabilitate the publicly run, PAYG-based pension systems under alternative strategies for reform involving once-and-for-all as well as gradual changes in pension parameters. The Turkish example is particularly interesting as the state operated pension system in Turkey already faces a severe financial crisis despite a relatively young population/ workforce. Unlike other countries where similar pension systems face financial difficulties largely because of population aging over the course of their demographic transition, a major reason behind the crisis of the Turkish system was the retirement ages that were exceptionally low by international standards. The evident need to increase minimum contribution periods/retirement ages distinguished pension reform efforts in Turkey from the experience of other countries where policy makers had relatively little room to adjust in the retirement ages along with other two parameters. The numerical results reported in the dissertation make it possible to compare the magnitude of required increase in the retirement ages under each reform strategy considered.

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[1] Contribution rates are payroll tax rates by which contributions (or old-age insurance premiums) are collected, and replacement rates are those that tie pension payments to wages/salaries earned prior to retirement.

As pension reform increasingly becomes a priority issue in the policy agendas of many countries, a growing number of studies use numerical techniques to investigate parametric reform options for PAYG-based pension systems. The discussion in this section links up well with this literature as briefly surveyed by Chand and Jaeger (1996) and generational accounting studies. Especially relevant studies could be found in Halter and Hemming (1987), Van den Noord and Herd (1994), and Boll et al. (1994) and ILO (1996). The results here are also likely to provide useful inputs and experiment scenarios for dynamic overlapping generations general equilibrium analyses of social security reform, which are continuously added to an already sizeable literature.

The second chapter starts with a simple search for a pension reform through a once-and-for-all change in policy parameters. This part describes a very simple algorithm developed to identify all possible configurations compatible with this goal and illustrates its use with reference to the pension reform debate in Turkey, a country whose PAYG-based pension system already faces a severe financial crisis despite a relatively young workforce/population. The results indicate that for contribution and replacement rates to remain around their current values, the minimum retirement age must be increased substantially.

The third chapter is the extension of the previous study to the pension reform through detailed and more realistic assumptions and modifications in the data set. This chapter contains the explanation of the basic algorithm, which is developed and also used in the following parts of the dissertation. The aim of the introduced algorithm is to enable to make similar calculations for everybody in search of this kind of parameters with the illustration of this technique for the data of Turkey.

The fourth chapter is the combination of the previous two chapters. This part makes the discussion of identification of parametric reform options to prevent losses generated by a publicly managed, PAYG-based pension system with the use of the improved basic algorithm for this purpose. The computational framework developed in this chapter is used in the article "Identification of parametric policy options for rehabilitating a pay-as-you-go based pension system: An optimization analysis for Turkey," forthcoming in Applied Economics Letters with Serdar Sayan.

The fifth chapter is concentrated on the extension of the study to the pension reform through gradually increasing retirement ages with the extended algorithm for this purpose. This part discusses the identification of parametric reform options to control losses generated by a publicly managed, PAYG-based pension system under alternative deficit reduction (reform) strategies including one time jumps, as well as gradual changes in contribution and replacement rates and statutory retirement ages, i.e., the parameters characterizing a pension system. For this purpose, three different problems, each corresponding to a different pension reform strategy is considered using search algorithms and dynamic programming techniques. The computational framework developed in this chapter is used in the article "Parametric Pension Reform with Higher Retirement Ages: A Computational Investigation of Alternatives for a Pay-As-You-Go Based Pension System," forthcoming in Journal of Economic Dynamics and Control with Serdar Sayan.

CHAPTER II

A SIMPLE OPTIMIZATION ANALYSIS FOR A PUBLICLY MANAGED PENSION SYSTEM

II.1 INTRODUCTION

Publicly managed pension systems face financial difficulties worldwide. Most of the existing systems are financed by payroll taxes under pay-as-you-go (PAYG) schemes that use contributions collected from current workers' payrolls to finance pension benefits to current retirees. Under PAYG schemes, the contributions an individual worker makes prior to when he begins to collect his own retirement benefits are typically used to finance benefits paid to other retirees. While these contributions are essentially savings out of the incomes of current workers, they are not readily available for various financing needs of workers. Instead, the contributions made through payroll taxes entitle them to benefits to be collected in the future at a predetermined rate[2].

A trouble with this system is that it is often difficult to maintain *politically acceptable* configurations of key policy parameters that are also compatible with the predetermined *social and economic goals* of the social security institutions and the requirements for a *fiscally sound* management of the system. The three key policy parameters in this context are contribution (payroll tax) rates, replacement rates that tie the levels of pension benefits to wages earned prior to retirement, and minimum retirement ages.

Increasing the difficulty that lies in the way of policy makers/system managers who need to decide on such configurations of policy parameters is the need to operate under various exogenous constraints. These exogenous constraints include such demographic factors as average life expectancies and age composition of the workforce, and legal and structural factors such as the nature and enforceability of social security regulations. In many cases, exogenous changes such as a variation in the age composition of population or a shift in the tendency to underreport earnings occur suddenly or over time, causing actuarial balances of the pension funds to get disturbed. In such cases, holding on to the original configuration of policy

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[2] This is the reason why PAYG systems are considered to be based on "defined benefit" (as opposed to "defined contribution") schemes where the benefit rates are specified in advance, even though the cost to the social security administration of providing those benefits is uncertain.

parameters for extended periods of time would typically lead to a deterioration of fiscal balances sometimes causing growth in pension deficits to go unmanageable.

It may be argued, therefore, that in countries where pension funds are publicly managed on a PAYG basis, sustainability of the system depends critically on the ability of policy makers to make timely adjustments in policy parameters in response to changes in exogenous factors, demographic and structural alike. In a country where the pension system is set up when the population is relatively young, for example, small contributions from a large number of workers enable the system to pay generous benefits to a relatively small group of retirees. However, when the population begins to age due to baby booms of previous periods, reductions in birth rates and/or increasing life expectancies over the course of the country's demographic transition, dependency ratios may increase and maintaining the initial configuration of policy parameters may become increasingly difficult. This is, in fact, what is presently observed in many countries across the world and it largely explains the reason behind financial difficulties that the social security administrations of these countries face: When population ageing sets in, the retiree population begins to grow, increasing the burden of pension payments. If deterioration in fiscal balances is to be avoided, a new configuration of policy parameters must be introduced. This can be achieved either by changing one parameter at a time, or changing all three parameters at once. It can be shown that there are infinitely many combinations of contribution and replacement rates, and minimum retirement ages that are compatible with the goal of maintaining actuarial balances at their initial levels following an exogenous shock. Obviously, each choice between alternative combinations would imply a different intergenerational distribution of the costs and benefits of the social security system. From a policy making point of view, therefore, some configurations would be more desirable than others whereas some would not be politically acceptable at all because of the resistance from pensioners' associations or trade unions etc. In any case, for policy makers to make informed decisions, all available alternatives should be presented to them.

The purpose of this chapter is to present results concerning possible policy parameter configurations that are compatible with the maintenance over time of a selected balance between amounts of contributions (premiums) collected from workers and pensions paid to the retirees in Turkey, a country whose PAYG-based pension system already faces a severe financial crisis despite a relatively young workforce/population. For this purpose, a numerical optimization algorithm is developed to identify various combinations of PAYG policy parameters that may be chosen to stop the growth of the social security deficit in Turkey. The case of Turkish social security system is especially interesting for several reasons. Firstly, the financial crisis has hit the Turkish social security institutions earlier than it would otherwise be expected mainly because of the populist moves of the policy makers who short-sightedly reduced the legal level of minimum retirement age below the levels in almost every other country in the world (James, 1995)[3]. Under these

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[3] Presently, it is possible in Turkey to retire as early as 38 years of age.

circumstances, increasing the minimum retirement age through modifications to the existing law is a more important policy tool in Turkey than in many other countries. Secondly, the existence of certain structural barriers causes actual premia collection in Turkey to stay consistently lower than the potential levels, as commonly observed in many other countries where the volumes of unrecorded transactions reach significant levels. Despite the availability since the early 1940s of quite comprehensive laws regulating social security in the country, the lack of enforceability leads to substantial leakages from the system, particularly in the form of un(der)reported payments to labor by employers or their failure to comply with the legal requirements concerning timely transfer of contributions collected to social security institutions (ILO, 1996). Finally, the market for private pension funds in Turkey is still thin (Ergenekon, 1998), and even if steps are to be taken towards a more comprehensive reform involving privatization of social security, the existing public institutions need to be rehabilitated in such a way as to stop at least the growth in the social security deficit. Currently, choosing a new configuration of policy parameters and reducing the leakage rates can only achieve this goal. The consequences of these policies are investigated in this chapter, and despite the focus of the discussion on the Turkish case, the technique described here could be used for other countries as well.

The approach used in this chapter fits well into the branch of the growing social security literature that is concerned with pension system reform through an investigation of parametric alternatives as briefly surveyed by Chand and Jaeger (1996). Particularly relevant examples of this literature could be found in Halter and

Hemming (1987), Van den Noord and Herd (1994), and Boll, Raffelhüschen, Walliser (1994) among others. Despite certain similarities in frameworks of investigation, the one employed in the present essay has at least two salient features. First, it parametrically introduces leakages reducing potential revenues of social security institutions in Turkey, pointing to the magnitude of the contribution that structural constraints make to current deficits. Secondly, the numerical solution technique employed makes it possible to simultaneously consider the entire set of alternative policy parameter configurations designed to reduce/stabilize deficits. This represents a substantial improvement over the techniques employed in other studies that consider the effects on fiscal/actuarial balances of social security by changing any one of the three parameters at a time, which is explained in the next section. Section 3 presents some information on the relevant characteristics of the social security system in Turkey and briefly describes the database employed. Finally, Section 4 discusses the numerical results and concludes the chapter with a general discussion of policy alternatives.

II.2 THE NUMERICAL OPTIMISATION FRAMEWORK

Total losses generated by each of the three publicly managed social security institutions currently correspond to one of the major components of public sector deficits funded directly by the Treasury in Turkey. Furthermore, the losses tend to increase very rapidly both in absolute value and in their proportion to the GDP. Even now, the existing system absorbs most of the direct subsidies and transfers by the government and if the current parameter configurations are to be maintained, the total deficit of the pension system is projected to increase from 1.8% to 10.1% of GDP by the year 2050. Perhaps an even more striking figure is that the accumulated deficit is expected to reach to 31.6 per cent of the GDP until 2050 under present parameters (ILO, 1996). In the light of these alarming numbers, the goal of the numerical optimization exercise below was chosen as the complete elimination (over time) of pension deficit between 1995 to 2060, and parameter configurations calculated were required to be compatible with *zero* difference between the sums of future (expected) pension payments and total contribution collection in real present value terms[4]. Given this goal, the problem at hand could formally be defined as the minimization of

$$\Delta \equiv (1-\bar{\ell})\sum_{t=t_0}^{T}\frac{1}{(1+\delta)^{t'}}\bar{\chi}.CR_t.rw_t\left(\sum_{a=a_0}^{A-1}p_{a,t}\right)-\sum_{t=t_0}^{T}\frac{1}{(1+\delta)^{t'}}RR_t\left(\sum_{a=A}^{75'}rw_{a,t}p_{a,t}\right) \qquad \textbf{(1)}$$

subject to the *exogenously* given (projected) values of

rw_t : Average real wage earned by workers at time t,

$rw_{a,t}$: Average real wage earned by the retirees who are aged a at time t just prior to their retirement,

$p_{a,t}$: Population at the age of a at time t,

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[4] Obviously, the alternative configurations could have been found also by requiring this difference to take a positive value (rather than zero) to reflect social policy goals of governments who are willing to make positive transfers to the retirees out of Treasury sources.

where

a : Age index running from the beginning of working-life, a_0=20, to the end of life at 75+;

t : Time index running from t_0 =1995 to the end of time horizon, T=2060,

and $t' = t - t_0$.

Identification of alternative policy parameter configurations that are compatible with zero deficit requires finding the set of 3x65 policy vectors that will minimize the difference in (1) for any given values of parametric constants of the problem: the leakage rate, $\bar{\ell}$, the discount factor, δ, and the wage ceiling that puts an upper limit to the contributions collectable from wages, $\bar{\chi}$. The elements of each vector (*CR*, *RR*, A) for 65 years are defined as

CR_t : Average contribution (payroll tax) rate at year t,

RR_t : Average replacement rate used to tie pension benefits to wages earned by workers at year t, and

A : Legally allowed minimum of the retirement age.

With this notation in mind, the problem is to find endogenously determined values of all policy parameter triplets (CR_t, RR_t, A) at any given time, for given parametric values of the leakage rate, the discount factor, and the wage ceiling, on the one hand, and given projected values of real wages and age composition of population, so as to minimize the difference, Δ, between the total present value of real contributions (i.e., the first term on the right hand side of identity sign) to be collected, and total present value of pension payments to be made to the retiree population over a time horizon from 1995 to 2060.

It must be noted that the resulting *CR, RR* and A vector configurations would only be compatible with the previously explained goals concerning the balance between contribution receipts and pension expenditures and the exercise would not take into consideration survivors' benefits, health care payments, or old-age benefits to the needy. Subject to the availability of data, these aspects of social security could be incorporated into the analysis in a rather straightforward fashion. However, since the main area of concern for the applied part of this study is pension deficits in Turkey, unnecessary complications to the analysis and notation are avoided by leaving them out of the optimization exercise here. Likewise, the use of relevant averages for real wages and various parameters including the CR and RR aim to limit the scope of analysis to essential details only.

Within this set-up, the optimal value vectors of *CR*, *RR* and A were found through the numerical algorithm developed for this purpose. The algorithm was run in Gauss to produce (*CR, RR,* Λ) triplet vectors minimizing Δ for given values of $\bar{\ell}$,

δ, and $\bar{\chi}$. Computationally, the algorithm requires that the following ratio be less than 0.0001 for each configuration of parameters[5]:

$$\frac{\left|(1-\bar{\ell})\sum_{t=1995}^{2060}\frac{1}{(1+\delta)^{t'}}\bar{\chi}\,CR_t rw_t\left(\sum_{a=20}^{A-1}p_{a,t}\right)-\sum_{t=1995}^{2060}\frac{1}{(1+\delta)^{t'}}RR_t\left(\sum_{a=A}^{75^+}rw_{a,t}p_{a,t}\right)\right|}{(1-\bar{\ell})\sum_{t=1995}^{2060}\frac{1}{(1+\delta)^{t'}}\bar{\chi}\,CR_t rw_t\left(\sum_{a=a_0}^{A-1}p_{a,t}\right)+\sum_{t=1995}^{2060}\frac{1}{(1+\delta)^{t'}}RR_t.\left(\sum_{a=A}^{75^+}rw_{a,t}p_{a,t}\right)} \qquad (2)$$

In searching for the optimal values, the following procedure was used. First, keeping in mind that relevant values for real wages, *rw*, and population figures, *p*, come from projection data, the total present value of real pension payments was calculated by changing the replacement rates with increment of 0.05 within the interval [0, 1] for the assumed value of δ, and for each possible value of the retirement age, A. After storing the results from this stage, a search routine was employed to find *CR*s that will be compatible with the ratio in (2) being smaller than 0.0001 for each previously stored value of *RR* and the associated value of A. Finally, optimal (*CR*, *RR*, A) configurations are plotted in three dimensions as shown in the next section where a discussion of the results follows a brief description of the important characteristics of the Turkish pension system.

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[5] It can be shown that this amounts to minimizing the difference between the contributions collected and the pension payments as defined in (1) to the desired degree of precision for Δ. Requiring that the ratio in (2) be strictly smaller than 0.0001, yields a precision level with 4 digits after the point, but using 0.00001 instead would increase precision to 5 digits after the point etc.

II.3 A BRIEF DESCRIPTION OF THE DATA SET

The Turkish Social Security System is made up of three different and distinct branches each operating on a PAYG basis: *SSK*, *Bağ-Kur* (hereafter, *BK*) and *Emekli Sandığı* (hereafter, *ES*). Of these, *SSK* (Social Security Institution) provides coverage to blue-collar workers employed in the public sector and blue-collar and white-collar workers in the private sector; *BK* covers farmers, artisans and other self-employed people, and the *ES* is the pension fund administration for white-collar workers employed by local and central governments. The losses generated by these three institutions together currently correspond to one of the major components of public sector deficits funded directly by the Treasury. Furthermore, the losses tend to increase very rapidly both in absolute value and in proportion to the GDP. Projections for the period between 1995 and 2050 indicate that the GDP shares of individual deficits by these institutions will rise from 1.21% to 7.48% for *SSK*, from 0.53% to 1.83% for *ES*, and from 0.07% to 0.75% for *BK* if the current policies are maintained (ILO, 1996).

The primary reason causing this situation is the early ages of retirement coupled with the natural ageing of population. Despite differences across social security institutions, the retirement age is very low by international standards. As compared to nearly 65 years of age which is typical of OECD countries, the median retirement age is about 53 for people covered by *SSK* and *ES*, and slightly higher than 60 for *BK* (Gillion and Cichon, 1996). Consequently, there arises a trend of rapidly increasing ratios of pensioners to contributors from one year to another. In a recent parametric reform study carried out by the ILO (1996), the contribution and replacement rates required to curb the growth of pension deficits in Turkey were calculated by assuming an average retirement age of 55 for men and 53 for women first, and then the effects of increasing the retirement age on fiscal balances of Turkish pension system were investigated through simulation exercises. Since a salient feature of the algorithm employed here is its ability to find values of A compatible with optimal *CR* and *RR* values without relying on parametrically changed levels of retirement ages, no prior information about the average age at which people choose to retire is needed. Instead, all possible values of minimum retirement age are considered in the present analysis.

The projection data needed came from different sources and new series were generated under appropriate assumptions whenever necessary[6]. For population projections, the same data produced by the Turkish State Institute of Statistics (SIS) were used as the ILO (1996) study. Since SIS population projections were reported only for the beginning year of each decade until the year 2060, yearly population projections were obtained by assuming exponential growth between the beginning years of any two decades. Then, to obtain data on working population, 1994 workforce participation rates (i.e., the ratios of workforce to population) and information on the composition during the same year of the workforce by gender and age were used as reported by SIS (1994). By aggregating female and male workers, a

[6] A detailed and expanded explanation how the data is generated can be found in Chapter III section 2

single workforce participation rate independent of the gender of workers was found for each age group for 1994. Finally, working population projections obtained by using projected population figures under the assumption that the participation rates would remain constant at their 1994 values for each age group were fed into (1) as $p_{a,t}$'s for $20 \leq a \leq A-1$. As for the retiree population, the tables in SIS (1994) showing the stocks of female and male retirees covered by each of *SSK*, *BK* and *ES* in 1995 were used. While the tables reported the number of male and female workers who retired for different reasons (ageing, health and disabilities) separately, only those who retired due to ageing were considered here. So, after aggregating over sexes and excluding those who were forced to retire because of poor health or disability reasons, the numbers of people who have chosen to become pensioners at different ages were summed up across three institutions and the ratio of the number of retirees to total population was found for year 1995. Then, the projections concerning annual stocks of pensioners were generated under the assumption that this ratio would stay constant until 2060, the year marking the end of model horizon, and the resulting values were fed into (1) as $p_{a,t}$'s for $A \leq a$.

The other important set of data for the solution of optimization exercise was the real wage series. For this purpose, the real wage series in Bulutay (1992) was used for the period between 1965 and 1989[7]. In order to project the real wage series

[7] Although this real wage series went as far back as 1950, only the real wages after 1965 were taken into consideration as relevant since the retiree stock at the beginning of the time horizon included people who had been retired for as long as 30 years prior to 1995.

into 2060, the real wages until 1989 were extended by using assumed rates of productivity growth and expected inflation[8]. Finally, the wage ceiling, $\bar{\chi}$, was taken to be equal 0.4 (40%) as in Gillion and Cichon (1996) and the discount factor, δ, was set equal to 0.05 as in ILO (1996).

II.4 RESULTS AND CONCLUSIONS

The following figure shows all possible configurations of *CR*, *RR* and A that are compatible with zero difference between total present values of pension expenditures and contribution receipts (both in real terms) over the 1995-2060 period.

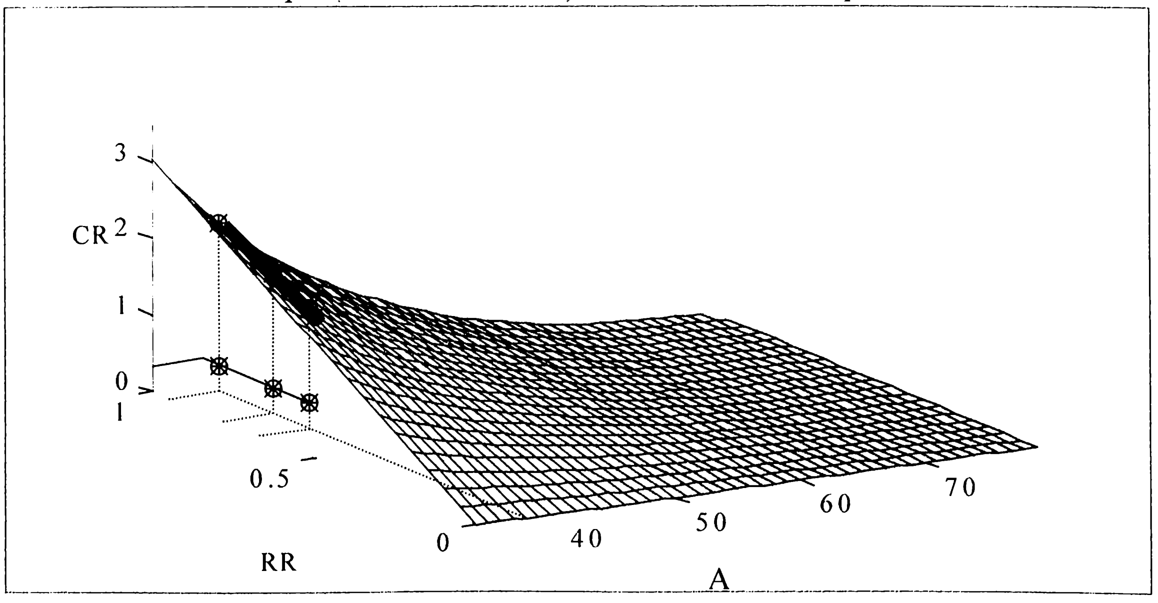

Figure 1

[8] It was assumed that the rate of labor productivity growth would be maintained at its long-term (1950-1989) value of 2.73 % calculated from Bulutay (1992). Expected inflation rates were assumed to be equal to previous year's rate until 1998 and to be the following thereafter: 50% for 1998-2000; 20% between 2000-2005; 10% between 2005-2010, 5% between 2010-2020, and 3% between 2020-2060.

The current situation is marked in the figure with the existing average constant contribution rate of 20% for *SSK* (TUSIAD, 1997), the largest of all three, and a minimum allowable retirement age of 38. The marked three stars show applicable replacement rates for people covered by each of the three social security institutions, i.e., 95% for *SSK*, 78% for *BK* and 67% for *ES* (Güzel, Okur and Şakar, 1990).

The bold black line in figure 1 shows the required (as opposed to actual) contribution rates for these replacement rates to be maintained by allowing people to retire as early as 38 years of age, and without allowing for a growth in pension deficits. The required contribution rates that correspond to *RR*s of 0.67 (*ES*), 0.78 (*BK*) and 0.95 (*SSK*) are 1.55, 1.83 and 2.17, respectively. Given the wage ceiling of 40%, a *CR* of 1.55 (155%) implies that 62% of the wages earned have to be contributed to the system by white-collar workers covered by *ES*. This is perhaps the most feasible of all, because for higher *RR*s applicable to the pensioners of other two institutions, the required *CR*s point to visibly higher levels of contributions that are as high as 87% of the wages earned by *SSK* workers.

As far as the policy options are concerned, the following figure 2 summarizes the possibilities for retirement age for a (currently realistic) leakage rate of 20%. All possible combinations of the *CR*, *RR* and A for balancing the pension deficit over time are shown on the left for the assumed leakage rate. The cross-section on the right shows retirement ages associated with constant *CR*=20% and *RR*= 0.67, 0.78 and 0.95. By these plots, current replacement rates of *ES*, *BK* and *SSK* require minimum retirement ages varying between 61 and 63 (all significantly higher than the currently allowed minimum retirement age of 38), if the average *CR* were to set at the reasonably high level of 20%.

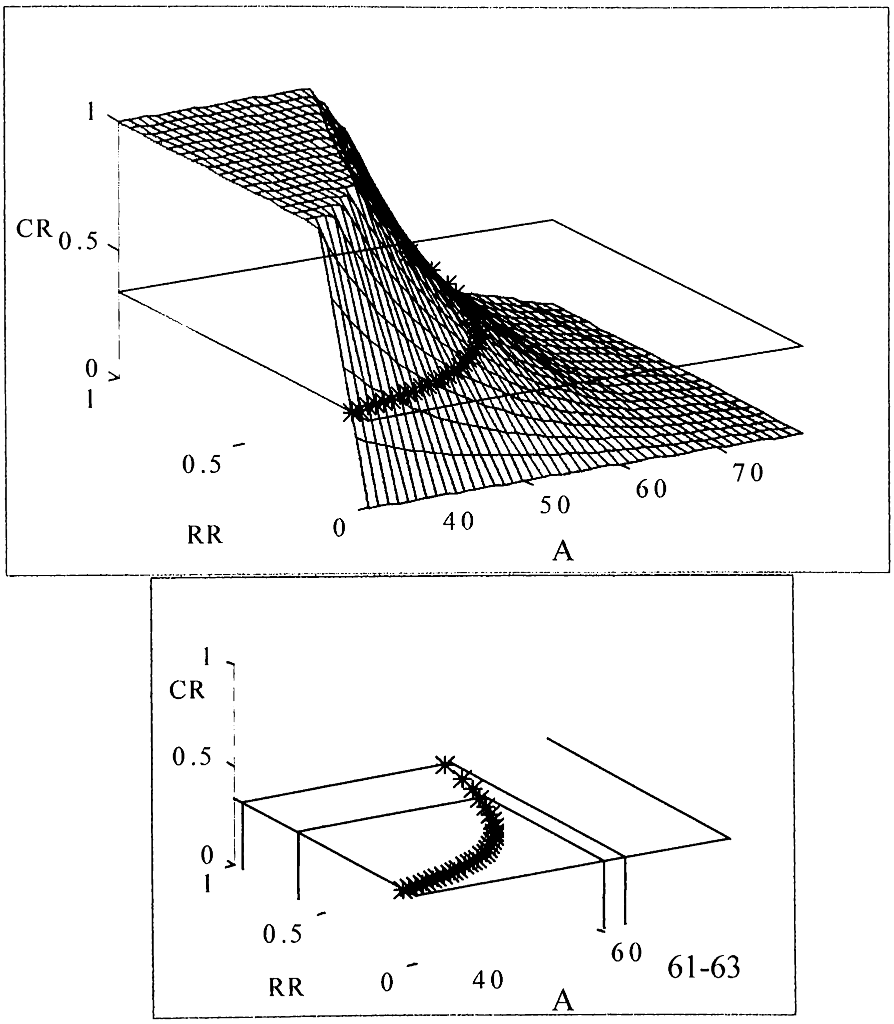

Figure 2

Similar cross-section plots could be generated for other politically acceptable values of *CR*s if the replacement rates are to be maintained at current values. Since each different configuration implies a different intergenerational distribution of pension system resources, the policy makers may be inclined not to retain replacement rates as well. In general, once a consensus on the need to curb the growth of pension deficits is reached, the particular parameter vector picked would depend on the relative political powers of parties involved, e.g., retirees' associations, trade unions etc.

Alternative plots for alternative leakage rates could also be produced by using the method developed here. In order to give a better idea about the flexibility of the results produced by the algorithm, a wider set of policy choices associated with different leakage rates is presented in the following table 1, which shows the retirement ages that are compatible with actual replacement rates of *ES*, *BK* and *SSK* for a given contribution rate of 20% and alternative leakage rates.

Table 1

Leakage Rates (%)	*CR*=20%
0	62-63
10	62-64
20	63-64
30	64-65
40	65-66
50	66-67

It is obvious from the numbers in the table that for *CR*s and *RR*s to remain around their current values, the minimum retirement age must be increased substantially. It appears not to be feasible to maintain retirement ages below 40 along with the current replacement rates, since this would require *CR* values exceeding 100% even if policy makers are willing to increase contribution rates. These conclusions hold for all conceivable leakage rates including the case of zero leakages. Yet, the consideration given to positive leakage rates here indicates that the set of policy tools to fight pension deficits is larger for policy makers in countries like Turkey, where certain structural factors make the collection of contributions difficult. Therefore, coupled with the ability to eliminate structural impediments lowering contribution receipts, the existence of a political determination to close pension deficits in these countries may result in a need for smaller adjustments in conventional parameter combinations as compared to other countries where leakages have been non-existent. In any case, for the policy makers to pick one of the possible configurations (with or without leakages), the entire set of choices must be made available to them so that they are aware of the results of their actions. Only then it would be up to them to decide which configuration to choose.

CHAPTER III

THE ALGORITHM

III.1 INTRODUCTION

Starting in Germany and completing its development in England and Holland, the Social Security System has become an important part of today's economies. It is important because it is a concern for about 90% of the population in the countries where the institution is well developed and in the countries on the way to industrialization[9]. This system provides security for the working population during work life and benefit during retirement. In addition, the security system provides a

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[9] In 1995 83.6 was the ratio of the insured population and 67.1 was the ratio of population covered by heath services in Turkey. (State planning Organization Economic And Social Indicators 1950-1998).

compulsory saving mechanism, which increases total savings in the economy and aims to decrease the poverty among the old and disabled people.

All social security systems work according to the fund management system. Inflows of this fund are the contributions made by working people and outflows of this fund are the pensions paid to the retirees, or to the people who already contributed for a specified period of time. So the longer one contributor works the more benefit to the system and the longer a retiree lives the more cost to the system.

A publicly managed pension institution, which is based on the pay-as-you-go (PAYG) system with a relatively high percentage of young population[10], would have been an ideal time period for the working and retired population, because a low contribution would suffice to finance the relatively low number of retired people[11]. However, populist movements of frequent changing[12] governments trying to gain votes by shifting the burden to the future generations or governments by allowing retirement at an age below 45 and even lower change this fact. If that happens to be, then the system causes an ever-increasing burden to the society, where none of the contributors and retirees are happy.

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[10] In Turkey 73.5 of the population and 64.1 of the workforce is below 40 years of age. (Statistical yearbook of Turkey 1994)

[11] Active to passive insured member ratio is the ratio of the number of people paying premium to people receiving retirement payments. If the number is large then little contribution of active payers is enough to finance passive retirees.

[12] Between the years 1950 to 1997 37 and between the years 1969 to 1998 24 government changes took place in Turkey. (Turkish National Assembly Library)

It is a fact that key policy variables, which are the parametric variables replacement rate (*RR*) and contribution rate (*CR*), and the structural variable the minimum retirement age, needs only some slight adjustment in case of demographic changes if the system is operating in some optimum configuration. In case of a temporary increase in the birth rate, the changes in the parametric variables might correspond to a few percent increase in *CR* or decrease in *RR*, which might also be tolerated without a change in these parameters. A structural change, however, is needed in case of a permanent change in demographic figures, so that if the birth rate slows or if the life expectancy increases, the percentage of the old people is going to increase so that the retirement age has to be increased. The population increase has slowed down in big cities in Turkey, where most of the people who benefit from the social security institution live. In addition, except for the immigrations, the native population of the big cities, where most of them are insured, does not grow[13].

There are three publicly managed social security institutions[14] in Turkey, where total losses generated by each of the three currently correspond to one of the major components of public sector deficits funded directly by the Treasury in Turkey. The losses are due to the deficit between the income received and payments made in the security system such that according to the ILO report the total deficit of

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[13] In Turkey there is immigration from east, where the population is not insured to west where most of the insured people live.

[14] The Turkish social security system is made up of three different and distinct branches each operating on a PAYG basis: *SSK*, *Bağ-Kur* and *Emekli Sandığı*.

the pension systems has increased from 1.8% to 10.1% of GDP in 50 years and the reports of ILO warns that the accumulated deficits will be three times larger than the expected GNP of the year 2050 (ILO, 1996).

One of the two main reasons for this large deficit is the fact that the real premium paying contributors have to finance an unsustainable number of pensioners. The retirement age should have stayed at 55 for male and 50 for female workers, however, with the populist policies of political parties, it is allowed to retire after 5000 premium-paying days, which corresponds to 13 year and 10 days (Güzel, Okur and Şakar, 1990). In addition, with the law issued in 1976 the payment duration was set to 25 years for male and to 20 years for female workers, which in turn enabled retirement at age 43 for male and 38 for female workers when they started working with the age of 18. There is no situation like this in any country in the world (James, 1995), where the young retirees become a big burden for the system and for the society. The second reason is that there is also a problem in the collection of the contributions[15], which increases the deficit so that the total contributions stay lower than the total pension of the system. Therefore, in spite of the young population there is a problem in the Turkish Social Security System, and on any other security institution that allows a retirement with the age of 38.

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[15] As an example, in *Bağ-Kur*, which is made up of about 3 million members from which 27% never paid their premiums and only 2.8 percent has no dept to pay to the institution (*Bağ-Kur* database 1999).

Turkey will not be the only country facing the pension problem because most of the industrial countries also started facing that problem due to the aging of their populations. For most of these countries the retirement age is set to an age between 55 to 60 years, but if technological advances continue to increase the average age of the population then this will require again an increase in the retirement age[16]. In this case the similar situation as in Turkey will emerge if not by medical costs, optimistically, just by the insufficient premium collection.

Since the early 1980s, the prospects of an aging population have widely been recognized and discussed as a key fiscal and macroeconomic problem, as detailed in studies by Heller, Hemming, and Kohnert (1986), OECD (1988b), Hageman and Nicoletti (1989), Cutler and others (1990), Van den Noord and Herd (1993,1994), World Bank (1994), Leibfritz and others (1995), and Masson and Mussa (1995). To analyze the need for pension reform in the major industrial countries, OECD studies by Van den Noord and Herd (1993 and 1994) and Leibfritz and others (1995) report estimates of unfunded public pension liabilities under the present pension arrangements and discuss the effectiveness of selected parametric reforms.

In addition, the Turkish Security System has to be adjusted so that it should be prepared for the aging of the young population and the western countries should be

[16] Such a demographic transition will naturally have various economic and fiscal impacts. The expected economic effects of transition include reductions in labor supply, increases in the share of consumption relative to output and hence, a lower saving rate and a slow-down in capital formation. As for fiscal effects, population ageing is expected to place serious pressures on public pension systems and, more generally, on societies' intergenerational transfer burdens.

prepared for the super old generations. Alternative ideas[17] were developed to get the system out of the crisis with no computational justifications, which requires try and fail methods to find the optimum configurations which can end up in years of experiments. Using expected future data, however, it is possible to develop an algorithm for computers that can increase the speed of adjustment and avoid possible experiments with the system that can result in loss of patience and trust to the institution. Such an algorithm should suggest all possible combinations of policy variables leaving the decision to the policy-maker who make the arrangements considering the other variables, which affect the social life.

This chapter follows the path of Chand and Jaeger (1996), who investigated the parametric alternatives for pension reforms. Other interesting cases of this literature could be found in Halter and Hemming (1987), Van den Noord and Herd (1994), and Boll, Raffelhüschen, Walliser (1994) among others. The difference of this investigation from the proceeding ones is that in some cases leakages from the system had to be considered. These reduce the potential revenues of social security institutions in Turkey, pointing to the importance of the magnitude of the contribution that structural constraints make to current deficits. In addition, the numerical solution technique employed makes it possible to simultaneously consider the entire set of alternative policy parameter configurations designed to reduce deficits. This

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[17] The market for private pension funds in Turkey is still thin (Ergenekon, 1998), and even if steps are to be taken towards a more comprehensive reform involving privatization of social security, existing public institutions need to be rehabilitated in such a way as to stop at least the growth in the social security deficit.

represents a substantial improvement over the techniques employed in other studies that consider the effects on fiscal/actuarial balances of social security by changing any one of the three parameters at a time. This numerical solution technique and data for estimations and real behavior of the population is explained in the next section in order to make the results as realistic as possible. Different pension indexation options are discussed by Hemming and Kay (1982) and Hills (1993). The 1992 Reform Act in Germany is discussed in a very detailed manner by Boll, Raffelhüschen and Walliser (1994) by using the generational accounting principle suggested by Auerbach, Gokhale and Kotlikoff (1991, 1992).

The aim in this dissertation is to design a system for policy makers such that they are endowed with many key political variables as possible. In order to make the alternatives acceptable, it was firstly required to show that it is impossible to continue this way and then to show alternative solution policies in order to make the system survive. The explanation of the data used in this part is in section 2 and in the following section the calculations are explained with examples if possible. After the calculations in the model section 3, the expected results are obtained and illustrated in the results section 4. The details are left to the appendix part with appropriate footnote references.

III.2 THE DATA

In order to make estimation for a smooth change in the parametric and structural variables in the social security system and also to make the system work as a self-financing institution, future predicted data by ILO reports (March 1996) and real data issued by SIS (State Institute of Statistics-DIE 1970-1997) are used. ILO future estimates for the female and male populations, participation rates out of population, unemployment rates for male and female out of workforce and death rates for male and female populations for the years 1995-2060 have been utilized. Data issued by SIS contained the change in the population behavior after the changes in the retirement age, unemployment rates and sickness rates for the time period 1970-1990 for male and female populations.

The data's published from both of the institutions were not enough to obtain yearly and age group data, therefore estimations of the required data had to be regenerated. The numbers of the ILO were published for each decade after year 2000, which needed to be recalculated so that yearly estimates, could be used with the help of the following formulas:

$$Pop_{t+k} = (1+g)^k * Pop_t \Rightarrow \log(\frac{Pop_{t+k}}{Pop_t}) = k * \log(1+g)$$

or

$$g = e^{\log(\frac{Pop_{t+k}}{Pop_t}) * \frac{1}{k}} - 1$$

where the following variables represent

Pop_{t+k} : the population at time t+k

g : the growth rate of the population between t and t+k, which is assumed to have stayed constant during the corresponding decade.

III.2.1. Workforce Calculation

Using these population estimates the workforce is calculated. The workforce participation ratios prepared by SIS in 1994 were taken as base and were used to calculate the workforce for the future years in the following way:

$$Workforce\ Participation\ Ratio(s,a) = \frac{Workforce(s,a)}{Population(s,a)}$$

where s∈{male, female} and for age group a∈{1, 2, …, 75+} in the year 1994. It is assumed that this workforce participation ratio does not change also in the future years, giving the workforce at any time after 1994 in the following way:

$$Workforce(s,a,t) = Workforce\ Participation\ Ratio(s,a) * Population(s,a,t)$$

where year t∈{1995,1996,…,2060}, s∈{male, female} and age group a∈{1, 2,…, 75+}.

These give the total workforce then as follows:

$$Total\ Workforce(t) = W(t) = \sum_{a=0}^{75+} \sum_{s=female}^{male} Workforce(s,a,t)$$

III.2.2. Age Group Estimation

In the original data the population estimates were the sum of 5-year age totals, i.e., the population estimates were given as for the ages 0-4, 5-9, ..., 70-74, 75+. In order to obtain the population and workforce estimates for each age, they were divided into a linear and continuous fashion so that the total sum of the 5-year age gave the same number as in the corresponding 5-year age group.

Considering this with an example, for the age group 0-4. The starting point is 0 and workforce starts without any workers. Afterwards the workforce increases linearly in such a way that till the age 4 the amounts in the ages 1, 2, 3 increased according to the formulas $y_1=a*1+b$, $y_2=a*2+b$, $y_3=a*3+b$ and $y_4=a*4+b$. At the end the sum $y_1+y_2+y_3+y_4$ is equal to the workforce for the ages 0-4.

III.2.3. Calculation of the Total Number of Retirees

In order to find a result that covers the whole nation, the retired people of all the three social security institutions, which are *SSK*, *Emekli Sandığı* (*ES*) and *Bağ-Kur* (*BK*), were added together. The following formulas summarize the procedure:

$$Total\ Retirees\ at\ time\ t = \sum_{a=0}^{75+} \sum_{s=female}^{male} Retirees(s,a,t) =$$

$$\sum_{a=0}^{75+} \sum_{s=female}^{male} (SSK(s,a,t) + BK(s,a,t) + ES(s,a,t))$$

To find the number of retirees at time t, the following ratio is assumed to be constant for all age groups and all sexes as it was the case for the workforce participation ratio where the 1995 retiree population data has been taken as constant in the following way:

$$Retirees\ Ratio(s,a) = \frac{Retirees(s,a,1995)}{Population(s,a,1995)} = \frac{Retirees(s,a,t)}{Population(s,a)}$$

where year t∈{1995,1996,...,2060}, s∈{male, female} and age group a∈{1,2,...,75+}.

Then the total number of retirees for each year t becomes:

$$Total\ Retirees\ at\ time\ t = \sum_{a=0}^{75+} \sum_{s=female}^{male} Retirees\ Ratio(s,a,t) * Population(s,a,t) =$$

$$\sum_{a=0}^{75+} \sum_{s=female}^{male} \frac{Retirees(s,a,t)}{Population(s,a)} * Population(s,a,t) =$$

$$\sum_{a=0}^{75+} \sum_{s=female}^{male} \frac{Retirees(s,a,1995)}{Population(s,a,1995)} = *Population(s,a,t)$$

The specialty of the developed algorithm is that it considers the people for each age group and each time period that are going to quit the workforce and start to get their retirement benefit separately. Though it is difficult to find the people that are going to retire each year now and in the future without a statistical survey the following trick was used to estimate the yearly and by age group retirees.

III.2.4. Calculation of the Yearly Number of Retirees

The trick for the yearly retiree calculation is based on the change in the participation and unemployment rates. In a population where nobody looses his/her job and nobody retires, the participation rates do not change in the consequent years. For example, for the year 2009 the estimated man population at the age 64 is 180634 and one year later the survived people from this generation, i.e., in year 2010 with age 65 are 176448. The participation in the year 2009 and age 64 was 74.4, which implies that 134391 of the man were in the workforce, however, in the year 2010 if people would not quit working and the same participation rate would be applicable, this would imply that at the year 2010 131277 people would be working. However, the participation rate at the age 65 is 35.9, which implies that actually 63344 men are still working. So the expected workforce was 131277, but it happens to be 63344, what happened to the 67933 people?

The reason for the participation rate change for the age groups is the fact that people quit working. This happens because people either die, loose their jobs or they start to get their retirement benefit. If it is assumed that the death rate is uniformly affecting all the man/woman population without distinguishing if the man/woman works or not, then the surviving population will still have the same participation rate.

Therefore, people either retire or loose their jobs. In addition, the change in the unemployment is usually too small to be considered for age groups, so it cannot explain the large changes in the participation rates. As a result, 67933 people are the men/women who retire at this age in 2010. For each year and age group the same calculation is made separately during the whole analysis and the whole paragraph can be summarized in the following figure 3:

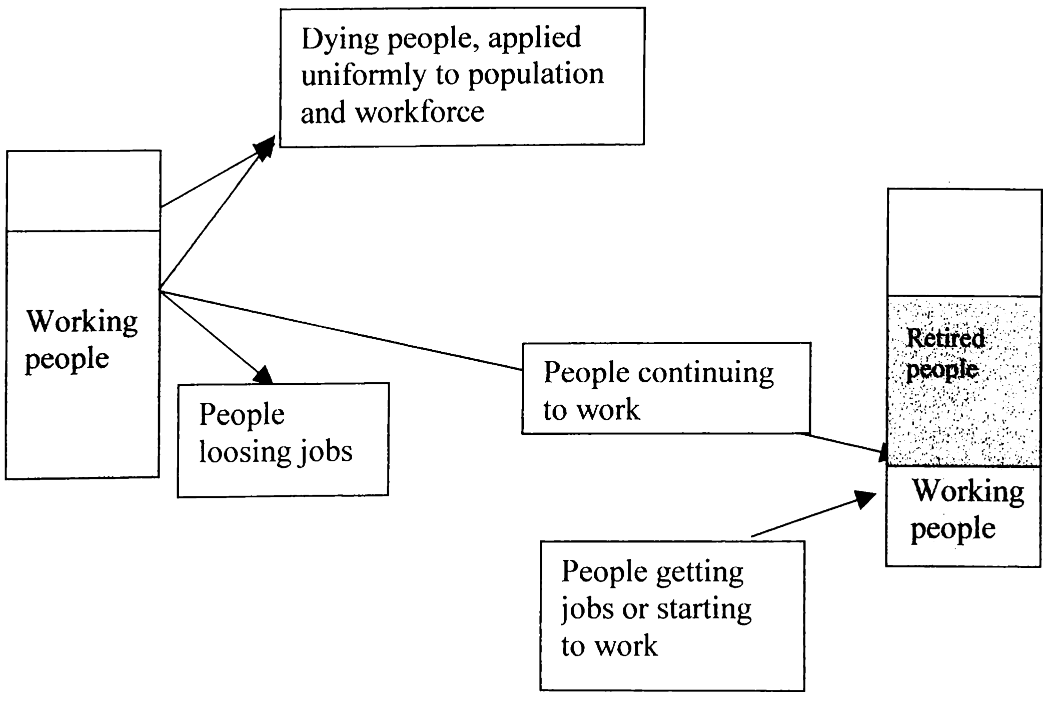

Figure 3

This way the algorithm was successful in explaining 50% of the male retiree number and 90% successful in explaining the female retiree data. The deviation comes from the fact that the data's are estimations instead of exact survey and, in addition; death rates are not equal in the working population and the rest of the population. In the following years unemployed people may also be managing somehow to get retired by paying their premium and start to receive payments without working, which is also another discrepancy. However, the unexplained data is also used in calculations so that they are responsible from the lower and upper bound for retirement ages, which is explained in the following section.

In the experimental process explained in the following part there is a minimum requirement age restriction so that all the calculated number of new entrants cannot retire prior the minimum retirement age, and only people due health or accidental reasons are allowed to retire. The people are assumed to postpone their retirement until the legal retirement age is reached.

III.2.5. Real Wage Series

The other important set of data for the solution of optimization exercise was the real wage series. For this purpose, the real wage series in Bulutay (1992) was used for the period between 1965 to 1989. Although this real wage series went as far back as 1950, only the real wages after 1965 were taken into consideration as relevant since the retiree stock at the beginning of the time horizon included people who had been retired for as long as 30 years prior to 1995. In order to project the real wage series into 2060, the real wages until 1989 were extended by using assumed rates of productivity growth and expected inflation[18]. Actually, from the structure of the problem the real wage was acting like a constant in the optimization problem and because of the long horizon, the same real wage appeared in the benefit and cost functions so that the real wage could be collected as coefficients reducing its effect in the problem. Finally, the wage ceiling, Wc, was taken to be equal 0.4 (40%) as in Gillion and Cichon (1996) and the discount factor, δ had intermediate values between 0 to 0.01.

III.3 THE MODEL

The problem of the Turkish System or any system, which allows early retirement is that there are an excess number of retirees that could have been working and contributing to the social security system. However, it is difficult to force people to postpone their retirement if they were allowed to retire earlier today. Therefore, in the first years of the adjustment process the designed model allows the country to continue facing deficits at a decreasing rate but at the end of the model horizon there is no debt caused by the structural change. In addition, after the end of the plan the pay-as-you-go model can continue working with the new parameters without any problem.

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[18] It was assumed that the rate of labor productivity growth would be maintained at its long-term (1950-1989) value of 2.73 % calculated from Bulutay (1992). Expected inflation rates were assumed to be equal to previous year's rate until 1998 and to be the following thereafter: 50% for 1998-2000; 20% between 2000-2005; 10% between 2005-2010, 5% between 2010-2020, and 3% between 2020-2060.

The developed algorithm here gives the administration lots of key policy variables and a policy time path, which can be chosen according to the political view. The policy variables are A (retirement age), RR_t (replacement rate) and CR_t (contribution rate). The policy path is the time dimension of these key policy variables, which allows them to be low today and high tomorrow. The plan for Turkey is to have a balanced system at the end of 2060, i.e., the collected premium should be able to finance the retiree fees starting from 1995 and ending at 2060. This huge sum can be summarized in the following equation:

$$(1-l)\sum_{t=1995}^{2060}\frac{1}{(1+\delta)^t}Wc\,CR_t\,Rw_t\sum_{a=15}^{75^+}wf_{a,t,\tau}=\sum_{t=1995}^{2060}\frac{1}{(1+\delta)^t}RR_t\,(\sum_{a=15}^{75^+}Rw_{t,s,rp_{a,t,\tau}}rp_{a,t,\tau})$$

III.3.1. Explanation of the Variables

The developed and on a computer implemented algorithm obtained solutions for the key policy variables A (retirement age), RR_t (replacement rate) and CR_t (contribution rate) satisfying the previous equality using the calculated *wf* (total workforce), *rp* (total retiree number) for each age group and each year. The last mentioned numbers or densities were changing of course if the minimum retirement age is allowed to change. In addition, the expected real wage increase Rw_t and the *Wc* (wage ceiling) were used as exogenous variables by the system. For the fair intergenerational division of the burden the *CR* and *RR* are assumed to be constants, but this does not rule out the possibility that they can be changing through time. The algorithm is easily modifiable to perform this task too.

III.3.2. Numerical Optimization Framework

In this part a general solution method is explained and the simplified form of it is used. The first one refers to a dynamic policy optimization where CR_t is time dependent and the second one is used if it is counted as a constant.

The first optimization framework can be summarized to minimize the difference

$$\Delta \equiv (1-l)\sum_{t=1995}^{2060} \frac{1}{(1+\delta)^t} Wc\, Cr_t\, Rw_t \sum_{a=15}^{75^+} wf_{a,t,\tau} - \sum_{t=1995}^{2060} \frac{1}{(1+\delta)^t} Rr_t \left(\sum_{a=15}^{75^+} Rw_{t,s,rp_{a,t,\tau}}\, rp_{a,t,\tau}\right)$$

subject to the exogenously given (projected) values of

t : time index for years 1995 to 2060,

a : age group index for ages 15 to 75^+,

A : legally allowed minimum of the retirement age,

Rw_t : average real wage earned at time t, which is applied to the workforce uniformly,

$Rw_{t,s,rp_{a,t,\tau}}$: average real wage earned by the retirees $rp_{a,t,\tau}$, who retired at the age a at time t, just prior to their retirement,

$rp_{a,t,\tau}$: retired people at age group a at year t and at the minimum retirement age A,

$wf_{a,t,\tau}$: workforce at age group a at year t and at the minimum retirement age A,

CR : average contribution (payroll tax) rate,

RR : the replacement ratio to finance the retired social security members,

δ : discount factor,

l : the uncollected part of benefits,

Wc : wage ceiling,

Both of these sums are in the order of 10^{16}, which makes the reduction the difference Δ to a number near zero very difficult. In addition, even a reduction to such a small difference was not important because a precision of 20 digits after the comma for the calculated variable was not required. So the objective for minimization was changed to the following formula, after which the results satisfy the required precision that is correct up to four digits after comma. The modified objective as follows:

$$\frac{\left|(1-l)\sum_{t=1995}^{2060}\frac{1}{(1+\delta)^t}Wc\,CR_t Rw_t\sum_{a=15}^{75^+}wf_{a,t,\tau} - \sum_{t=1995}^{2060}\frac{1}{(1+\delta)^t}RR_t\left(\sum_{a=15}^{75^+}Rw_{t,s,rp_{a,t,\tau}}rp_{a,t,\tau}\right)\right|}{(1-l)\sum_{t=1995}^{2060}\frac{1}{(1+\delta)^t}Wc\,CR_t Rw_t\sum_{a=15}^{75^+}wf_{a,t,\tau} + \sum_{t=1995}^{2060}\frac{1}{(1+\delta)^t}RR_t\left(\sum_{a=15}^{75^+}Rw_{t,s,rp_{a,t,\tau}}rp_{a,t,\tau}\right)}$$

subject to the mentioned constraints. The number of constraints may be larger and they might also be time dependent functions, which make the problems difficult to solve[19]. However, with increased computational cost, the first optimization problem will still work.

In the second optimization framework where the CR_t is a constant, the calculation reduces to an easy formula in the following way:

$$Cr = \frac{RR\sum_{t=1995}^{2060} \frac{1}{(1+\delta)^t} \left(\sum_{a=15}^{75^+} Rw_{t,s,rp_{a,t,r}} rp_{a,t,r}\right)}{(1-l)\sum_{t=1995}^{2060} \frac{1}{(1+\delta)^t} WcRw_t \sum_{a=15}^{75^+} wf_{a,t,r}}$$

As mentioned, the data published by ILO and SIS was not detailed and did not allow the calculation of the yearly retiring people for each year exactly. The calculated retirees were explaining 70% of the data and the unexplained rest of retired people data was used to calculate upper and lower bounds in the following way:

Firstly, the retirees calculated by the algorithm were eliminated from the estimated yearly retirement data. The rest is assigned the minimum retirement fee as lower bound and highest fee as upper bound, which will allow an error correction possibility. The lower bound will give an age where below that age the system will not be working definitely and the upper bound will give a retirement age above

[19] This complex solution process is designed for Genetic Algorithms.

which the system will work for certain. The intermediate region is an uncertain region, which can be summarized with the following formulas:

The lower bound is

$$Ben_{min} = \sum_{t=1995}^{2060} \frac{1}{(1+\delta)^t} RR \sum_{a=15}^{75^+} Rw_{\min, rp_{a,t,r}} rp_{a,t,r}$$ yielding A_{max} and

the upper bound is

$$Ben_{max} = \sum_{t=1995}^{2060} \frac{1}{(1+\delta)^t} RR \sum_{a=15}^{75^+} Rw_{\max, rp_{a,t,r}} rp_{a,t,r}$$ yielding A_{min}

where $Rw_{\min}$ and $Rw_{\max}$ are minimum and maximum wages earned by the retirees living in that year in the retired population.

The average benefit is $Ben_{av} = \sum_{t=1995}^{2060} \frac{1}{(1+\delta)^t} RR \sum_{a=15}^{75^+} Rw_{av, rp_{a,t,r}} rp_{a,t,r}$ where Rw_{av} is the average real wage earned by all retirees in that year.

With these real wages the following inequality and approximations are satisfied

$$Ben_{min} \leq \sum_{t=1995}^{2060} \frac{1}{(1+\delta)^t} RR \left(\sum_{a=15}^{75^+} Rw_{t,s,rp_{a,t,r}} rp_{a,t,r}\right) \leq Ben_{max}$$

$$\sum_{t=1995}^{2060} \frac{1}{(1+\delta)^t} RR \left(\sum_{a=15}^{75^+} Rw_{t,s,rp_{a,t,r}} rp_{a,t,r}\right) \approx Ben_{av}$$

giving the following inequalities and approximations $A_{min} \leq A \leq A_{max}$ and $A \approx A_{av}$ for retirement age by the algorithm explained in the next section. If it were possible to find all of the peoples retirement years then $Ben_{min}= Ben_{max}$ would be satisfied, lower and upper bounds would not be needed.

III.4 EXPLANATION OF THE ALGORITHM

The algorithm is in the appendix part and its optimization idea is outlined here. The algorithm may be unique because of its data handling capability and complex calculations.

As it is explained in the data section the data have to be converted to yearly base from decade-wise data and from the 5-year age group data to yearly age group data. In addition, except for the real wage, which came out to be a scaling factor in optimization, all data published in the ILO report were used so that the obtained results are the reflection of the ILO estimations.

After the initialization of the variables the yearly retiree calculation is performed and it gives the new retiring people, which is explaining about 70% of the estimated retiree number. Here the new retirees are followed closely and the lifetime sum of pension payments is individually calculated for each age group starting from the retirement year. For the unexplained 30%, however, it was impossible to identify when they were retired or how long they have been paid a retiree benefit. So this gives the system an uncertainty to deal with which is solved with upper and lower bounds for the retirement age[20].

In the next step the system is performing its calculations after incrementing the minimum retirement age A and adjusting the densities accordingly[21]. The *CR* and *RR* ratios are calculated with this new A to have the system in equilibrium. After incrementing the minimum retirement age it is obvious that people that were able to retire with the previous retirement age are not going to be able to retire at the incremented retirement age. So they have to wait until the new minimum retirement age comes and all the ones who have postponed their retirement have to postpone it for a further year.

The increase in the minimum retirement age does not rule out that there are people that are going to retire prior to that age due disability, but these will retire due sickness or accidents. According to this idea the workforce and retiree population where their distributions and sizes depend on the legal retirement age are adjusted so that yearly retiree people stay in the workforce till they retire, which increases contributions to the institution[22].

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[20] In the algorithm this corresponds to boxes A-D

[21] In the algorithm this corresponds to box E

[22] In the algorithm this corresponds to box E

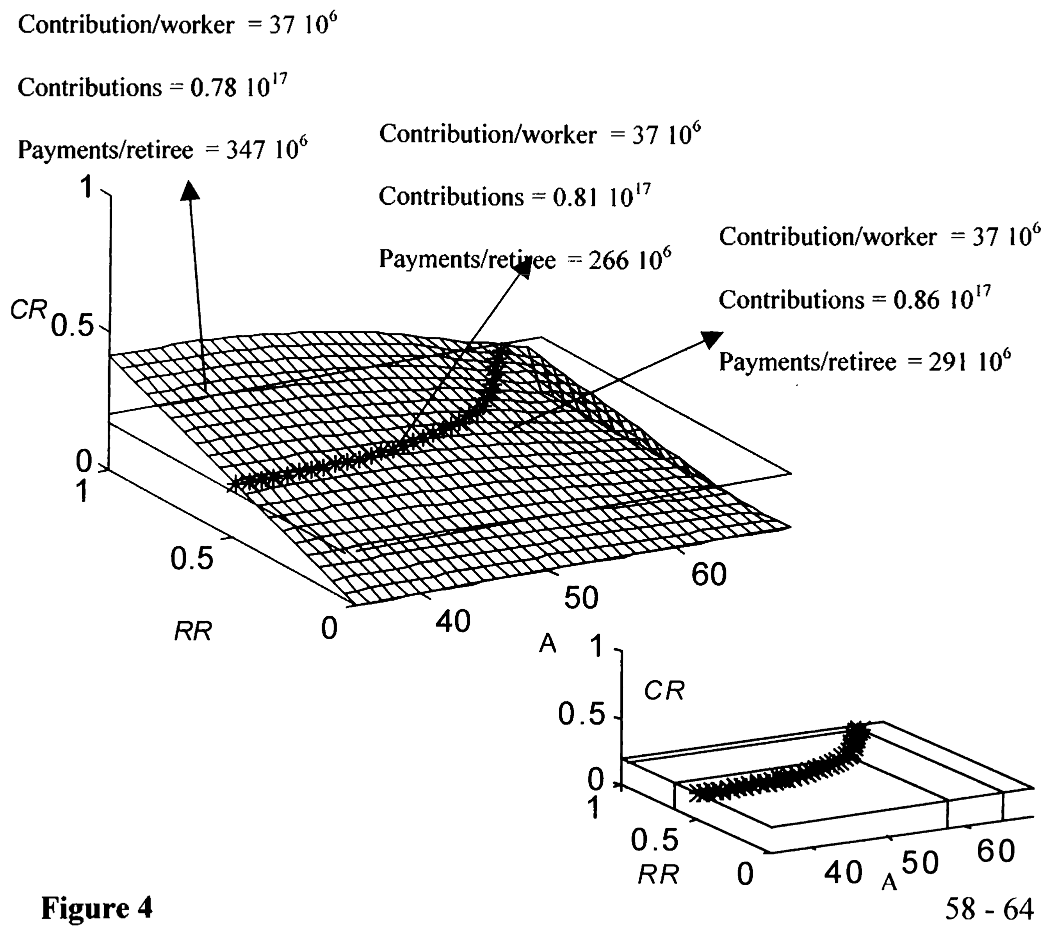

Figure 4

After the change in the retirement age and adjustment in the workforce and retiree densities, the calculation of the *CR* and *RR* are performed such that they equate Δ to 0. For this goal, one *RR* is chosen starting from 0 and ending at 1 and is incremented by 0.05 to calculate the only left key policy variable, namely the *CR*[23]. Given all the other exogenous variables, then the triple (*CR*, *RR*, A) is graphed in figure 4 for the possible configurations and results of sums

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[23] In the algorithm this corresponds to boxes F-H

The figure on the left gives all the triple combinations (*CR*, *RR*, A) where the system is in equilibrium. In the performed experiments a 20% of contribution rate is used[24] which give the stars on both figures. On the right figure the isoquant gives the desired results that can easily be read for 20% *CR*. It comes out to be that for *RR, which* equals to 65% the optimum retirement age is 58 and for *RR* of 95% the optimum retirement age is 63. Any intermediary *RR* will give an age between 58 to 63 according to figure drawn.

The figure on the right constitutes the last section of the algorithm, namely the calculation of the isoquant[25]. In this part the *CR* is held fixed at 20% and all the *RR* ratios equating the system for a minimum retirement age are calculated, yielding the isoquant on the right figure made up of stars. The same experiments are repeated for a leakage of 20%, which is the case for Turkey today[26] and this may also continue after the reform. All the results are calculated in the programming language called Gauss and used to write a graphing program in Matlab[27].

As seen in all the previous figures, it is impossible to continue this way, because if only parametric changes are preferred, a cut of at least 50 percent out of the wages of

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[24] 20% contribuiton rate is used because only that percentage corresponds to retirement.

[25] In the algorithm this corresponds to boxes K and L

[26] As an example, in *Bağ-Kur*, which has about 3 million members form which 27 % did never pay their premiums and only 2.8 percent has no dept to pay to the institution, but benefited form its services (*Bağ-Kur* database 1999).

[27] In the algorithm this corresponds to box N

workers is required, which would end up in a workforce that won't be insured surely. Employers also would prefer to pay higher wages in order not contribute the 55% of these payment, which is also nowadays observed.

III.5 RESULTS AND CONCLUSIONS

For the optimistic possible case where there is no leakage in the system the results say that the system requires a retirement age above 55 years, which is the case for most industrialized countries[28]. However, it should not frighten the retirees to get a replacement rate of 65% rather than their previous 95%. It is for sure that the inflation adjusted 65% is going to be more profitable than a nominally paid 95%, because in a country where the inflation is around 100%(1998) and the adjustments are made on a yearly basis the nominal wages depreciate quickly.

If we summarize our finding in a table we obtain the following results:

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[28] In a recent parametric reform study carried out by the ILO (1996), contribution and replacement rates required to curb the growth of pension deficits in Turkey were calculated by assuming an average retirement age of 55 for men and 53 for women first, and then the effects of increasing the retirement age on fiscal balances of Turkish pension system were investigated through simulation exercises

Table 2

Retirement age balancing the system for the given *CR*s and leakages

	δ=0%					
	Rw_{min}		Rw_{av}		Rw_{max}	
CR=20%	A_{min}	A_{min}	A_{av}	A_{av}	A_{max}	A_{max}
Leakage	*RR*=65%	*RR*=95%	*RR*=65%	*RR*=95%	*RR*=65%	*RR*=95%
0%	56	63	59	65	62	69
5%	58	64	60	66	63	69
10%	59	65	61	67	65	69
15%	60	65	62	68	66	69
20%	61	66	63	69	67	70
	δ=10%					
0%	64	69	66	69	68	69
5%	65	69	67	69	69	70
10%	66	69	67	69	70	70
15%	67	69	68	70	70	70
20%	67	70	69	70	70	70

Note: The variations of the A 's

Today a leakage rate of 20% is estimated and in the first stage of near future this might be reduced to 5%. The retirement ages for 5% leakage will give an age ranging between 58 to 64 in case of 65% *RR*. As explained in the previous parts the A_{max} will correspond to an age, where including that and the range above that age the system will work for certain, which is the age 63. Accepting a reform with retirement age 65 is then reasonable for many reasons but might not be supported by many worker unions, which claim that this would be *"retirement in the grave"*. The following table 3, however, does not support this idea.

Table 3

Expected Average Survival Duration of the General Population According to the				
	MALE		FEMALE	
Age Groups	Expected Survival Duration	Total Life Duration	Expected Survival Duration	Total Life Duration
At birth	60,6	60,6	65,5	65,5
5+	63,4	68,4	67,2	72,2
10+	58,7	68,7	62,5	72,5
15+	53,9	68,9	57,7	72,7
20+	49,3	69,3	53,0	73,0
25+	44,8	69,8	48,3	73,3
30+	40,3	70,3	43,7	73,7
35+	35,8	70,8	39,0	74,0
40+	31,3	71,3	34,5	74,5
45+	27,0	72,0	30,0	75,0
50+	22,8	72,8	25,6	75,6
55+	19,0	74,0	21,4	76,4
60+	15,5	75,5	17,4	77,4
65+	12,2	77,2	13,7	78,7
70+	9,4	79,4	10,4	80,4
75+	7,0	82,0	7,7	82,7
80+	5,1	85,1	5,6	85,6
Source:Social Insurance Organization (Damşoğlu, 1987 pg.23)				

Table 3 shows that someone who retires at the age of 65 can live additional 12,2 to 13,7 years. However, if the calculations are made according to the expectations for a newborn child, only the women live for five years in the retirement and the men are already dead. The reason for that discrepancy is the high death rate for children in Turkey, which is summarized in the table with the life expectancy for a newborn child of 60 years. However, the correct scientific figure to be evaluated is the life expectancy at the age 65, which gives a decade to live and which may be increased with the new technologies. So "*Retirement in the grave*" is an invalid argument.

Additionally, it is also possible to calculate the contribution per worker and payment per retiree from 1995 to 2060 when the retirement is 60 years with the mentioned configuration as graphed in figure 5.

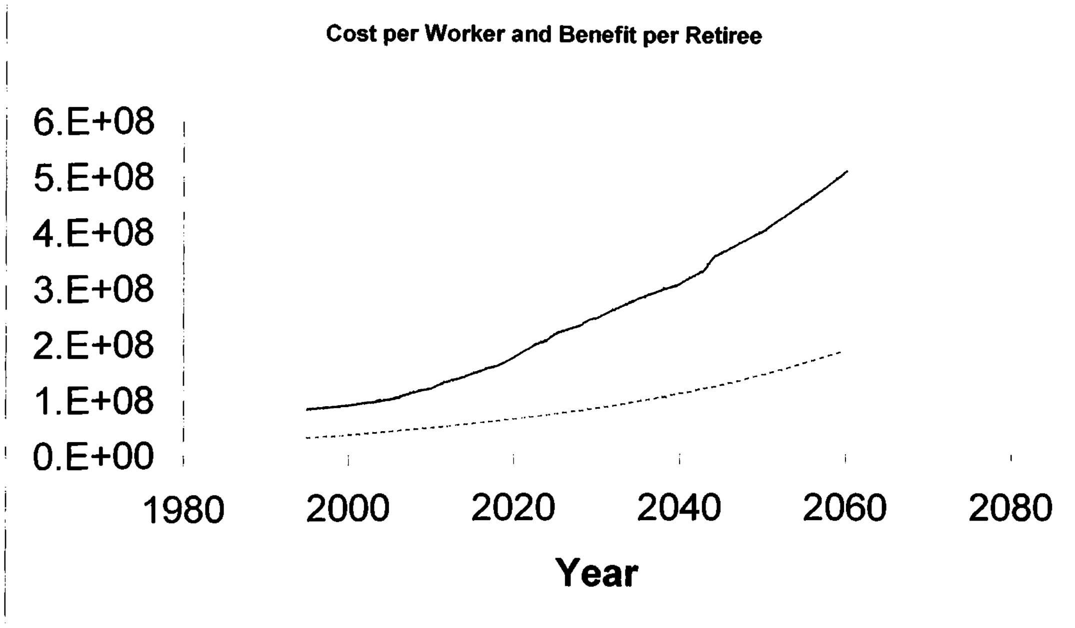

Figure 5

The dotted line represents the pension payment per worker, which is lower than the benefit per retiree because of the high number of workers. The exponential increase is due to the increase in the real wage but it is higher in contributions per retiree because of the aging of the population. From the figure we can conclude that the retirees are going to be satisfied with their earnings, because there is no drop in the pension payments they receive.

As a summary, in this chapter the data generation process of the dissertation is explained in detail with the general algorithm to be used in the social security literature is introduced. This algorithm allows the simultaneous calculation of the three social security parameters for various leakage rates. With the use of this algorithm it can be concluded that the minimum retirement age has to be increased substantially.

CHAPTER IV

IDENTIFICATION OF PARAMETRIC POLICY OPTIONS FOR REHABILITATING A PAY-AS-YOU-GO BASED PENSION SYSTEM: AN OPTIMIZATION ANALYSIS FOR TURKEY

IV.1 INTRODUCTION[29]

Publicly managed pension systems based on pay-as-you-go (PAYG) schemes face financial difficulties worldwide. These systems use contributions collected from currently active workers to pay pension benefits to eligible retirees who have previously contributed to the system. The contributions for each worker are determined by multiplying the wage/salary income with the applicable payroll tax rates, whereas the retirement incomes are calculated by using replacement rates that tie pension payments to wages/salaries earned prior to retirement. Since wages/

[29] Joint paper with Serdar Sayan forthcoming in 2000 in Applied Economics Letters

salaries are determined in the labor market, the pre-retirement incomes out of which contributions are collected and by which levels of pension payments are determined are exogenous to the pension system. While the relevant rates can be adjusted to control the amounts of contribution receipts and pension payments per individual, total revenues and expenditures of the entire system depend on the numbers of active workers and retirees covered. But these numbers themselves are largely determined by demographics; implying that in a country where coverage is compulsory, a publicly managed system can keep these under control only by setting minimum contribution periods. Pension authorities and policy makers of such a country, therefore, have essentially three parameters to adjust, whenever exogenous changes occurring over time seriously disturb the revenue-expenditure balances of the PAYG-based system: contribution and replacement rates, and minimum contribution periods (retirement ages).

When a growing pension deficit signals the need for parametric pension reform as it is sometimes called (Chand and Jaeger, 1996), existing values of pension parameters must be changed within politically acceptable limits so as to eliminate (or curb the growth in) pension deficits. Theoretically, however, there are infinite configurations of these three parameters that are compatible with the maintenance over time of a selected balance between contribution receipts and pension expenditures, and informing policy makers of the choices available to them requires identification of these possible configurations.

The present chapter considers this identification issue in an intertemporal setting as in generational accounting studies (Auerbach *et al.*, 1991). For this purpose, a simple optimization model is developed and applied to the case of parametric reform options before Turkey, a country whose publicly managed, PAYG-based pension system already faces a severe financial crisis despite a relatively young population/ workforce. Unlike other countries where similar pension systems face financial difficulties largely because of population ageing over the course of their demographic transition, a major reason behind the crisis of Turkish system is the retirement ages that are exceptionally low[30] by international standards. The evident need to increase minimum contribution periods/retirement ages distinguishes pension reform efforts in Turkey from the experience of other countries where policy makers had little room to adjust for retirement ages along with two other parameters. So, the numerical optimization algorithm used here has been developed to solve for optimal values of all three policy parameters simultaneously.

The optimization approach and its implementation are described in the next two sections. The results are presented in section 4 where the implications of results are briefly discussed.

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[30] Presently, it is possible in Turkey to retire as early as 38 years of age (James, 1995).

IV.2 THE NUMERICAL OPTIMISATION FRAMEWORK

The approach outlined in this section links up well with the growing pension reform literature as briefly surveyed by Chand and Jaeger (1996). Particularly relevant examples of this literature can be found in Halter and Hemming (1987), Van den Noord and Herd (1994), and Boll *et al.* (1994) for other countries, and in ILO (1996) for Turkey.

Alternative policy parameter configurations that will stop the growth of pension deficits over a specified period of time could be identified by solving the following minimization problem, subject to the values that exogenous variables are projected to take over time and non-negativity constraints:

$$\underset{CR,RR,A}{Min} D \equiv \sum_{t=t_0}^{\tau} \frac{\chi}{(1+\delta)^{t'}} (RR.\sum_{a=A}^{\ell} rw_{a,t-(a-A)-1}.r_{a,t} - CR.\sum_{a=a_0}^{A-1} rw_{a,t} w_{a,t}) \quad (1)$$

where

CR : Average rate for employee and employer contributions combined,

RR : Average replacement rate tying pension benefits to wages earned by workers,

A : Minimum retirement age,

δ : Discount rate,

χ : The fraction of wages on the basis of which contributions and pension payments are calculated (wage ceiling),

$rw_{a,t}$: Average real wage earned by workers at the age of a at time t,

$w_{a\,t}$: Number of workers at the age of a at time t,

$r_{a,t}$: Number of retirees at the age of a at time t,

a Age index running from the beginning of working-life, a_0 , to ℓ, life expectancy in years,

t : Time index running from initial period, t_0, to τ, the end of model horizon, and

$t' = t - t_0$.

Given this notation, total pension payments at t are calculated by multiplying the number of retirees in each age group a with the applicable pension for that group, and summing over a. The applicable pensions are calculated through a simple indexation scheme requiring each retiree to be paid a certain proportion, $\chi.RR$, of the last real wage earned prior to retirement. Since a retiree aged $a \geq$A at time t must have been collecting pensions for the past a-A years, the last pay check (s)he picked as a worker must be given in real terms by $rw_{a,\, t-(a-A)-1}$, implying that (s)he is entitled to collect RR% of this amount in pension payments. Each active worker aged a<A at time t, on the other hand, is paid $rw_{a,t}$, and contributions are collected at the rate of

CR out of χ% of this income. *D* in (1) therefore shows the difference between the sums of future (expected) pension payments and total contribution receipts in real present value terms. So, the problem can more precisely be formulated as finding the endogenously determined values of all 3x1 policy vectors (*CR RR* A) so as to minimize *D*, for given values of δ and χ, and exogenous projection data on working and retiree populations and real wages.[31]

IV.3 IMPLEMENTATION

In implementing the algorithm developed for this purpose, the goal for the Turkish pension system was set to have *D*=0 over the 1995-2060 period. Obviously, the alternative configurations could have been found also by requiring *D*>0, allowing the government to provide subsidies to pension institutions as a social policy. Even now, however, the existing system in Turkey absorbs most of the direct subsidies and transfers by the government as indicated in table 4. Moreover, the total deficit of social security system is projected to increase to 16.8% of GNP by the year 2050 if the current pension parameters are to be retained. Even considering pension losses alone, the projections indicate that by 2010, the GNP share of pension deficits is likely to exceed 5% (Ayas, 1998).

[31] As such, the exercise focuses on pension balances alone and overlooks survivors' benefits, health care payments, or old-age benefits to the needy and other similar aspects of social security.

Table 4

Growth of Social Security Deficit in Turkey		
Years	Share of Soc. Sec. Deficit in Total Budget Deficit (%)	Share of Total Transfers to Soc. Sec. Institutions in GNP (%)
1993	17	1.20
1994	20	1.13
1995	36	1.44
1996	26	2.16
1997	34	2.55
1998	35	2.85

SOURCE: Ayas (1998), pp. 48-49.

Getting *D* as close to 0 as possible is equivalent to the maintenance of the real deficit of the entire pension system in Turkey at its 1995 level. As the Turkish economy would continue to grow, this must be expected to lower the real GDP share of pension deficit to a negligible level by the year 2060.

Within this set-up, projection data were fed into the computational algorithm developed for this purpose and the optimal (*CR RR* A) triplets were found[32]. The projection data needed came from different sources and whenever necessary, new series were generated under appropriate assumptions. For population projections, the same data as the ILO (1996) study were used. Working population series was generated using these population projections under the assumption that workforce participation rates by gender and age in 1994 would remain the same as reported by SIS (1995). As for the retiree population, the ratio of the number of retirees to total population in 1995 was found using the numbers of voluntary retirees at each age group as reported in ILO (1996). Then, the projections concerning annual stocks of pensioners were generated under the assumption that this ratio would stay constant by the end of the model horizon. The real wage projections were obtained by extending the series in Bulutay (1992) to 2060 using assumed rates of productivity growth and expected inflation. Finally, χ was taken to be 40% as in Gillion and Cichon (1996) and δ was set equal to 0.05 as in ILO (1996).

The algorithm run in Gauss requires that the following inequality be satisfied for each configuration of parameters:[33]

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[32] In order to limit the scope of analysis to essential details only, the *CR* and *RR* values in the optimal configurations are taken here as average rates that would commonly apply to all three institutions.

[33] It can be shown that this amounts to minimizing *D* in (1) to the desired degree of precision. Requiring that the ratio in (2) be strictly smaller than 0.00001 rather than 0.0001, for example, would increase the precision.

$$\frac{\left|\sum_{t=1995}^{2060}\frac{CR}{(1+\delta)^{t'}}\left(\sum_{a=15}^{A-1} rw_{a,t}.w_{a,t}\right)-\sum_{t=1995}^{2060}\frac{RR}{(1+\delta)^{t'}}\left(\sum_{a=A}^{75'} rw_{t-(a-A)-1,t}.r_{a,t}\right)\right|}{\sum_{t=1995}^{2060}\frac{CR}{(1+\delta)^{t'}}\left(\sum_{a=15}^{A-1} rw_{a,t}.w_{a,t}\right)+\sum_{t=1995}^{2060}\frac{RR}{(1+\delta)^{t'}}\left(\sum_{a=A}^{75'} rw_{t-(a-A)-1,t}.r_{a,t}\right)}<0.0001 \quad (2)$$

In searching for the optimal values, the following procedure was used; For each alternative value of A considered, the exact $r_{a,t}$ series[34] in the initial projection data was regenerated by transferring the retirees younger than A to the working population. Then, the total present value of real pension payments was calculated by changing the *RR* with increments of 0.05 within the interval [0,1] for this new value of A. After storing the results from this stage, a search routine was employed to find *CR*s that will be compatible with the ratio in (2) being smaller than 0.0001 for each previously stored value of *RR* and the associated value of A. Finally, optimal configurations are plotted in three dimensions as shown in the next section.

IV.4 RESULTS AND CONCLUSIONS

The following figure 6 shows all (*CR RR* A) configurations that are compatible with *D*=0 over the 1995-2060 period. The current situation is marked in the figure with the existing average *CR* of 20%.

[34] The main innovation in this chapter is to use the exact number of retirees

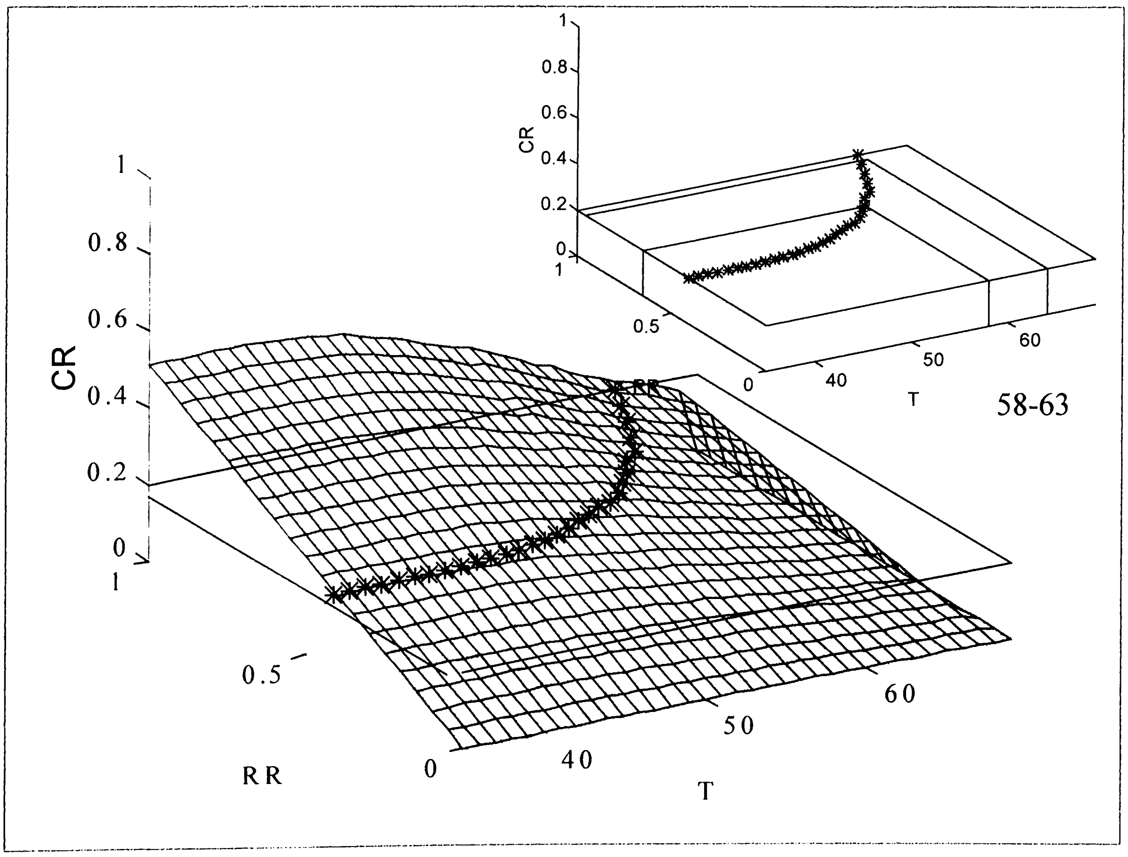

Figure 6

The cross-section in figure 6 shows the locus of possible (A, *RR*) combinations associated with *CR*=20%. The replacement rates of 0.67 and 0.95 marked in the figure indicate that current *RR*s of *ES* and *SSK* would require minimum retirement ages varying between 58 and 63, if the average *CR* of 20% is to be retained[35].

Similar cross-section plots could be generated for other politically acceptable values of *CR*s if the *RR*s are to be maintained at current values. Since each different

35 It must be noted that these results do not consider the possible leakage from the system.

configuration implies a different intergenerational distribution of pension system resources, the policy makers may opt to reduce *RR*s as well. In general, once a consensus on the need to curb the growth of pension deficits is reached, the particular parameter vector picked would depend on the relative political powers of parties involved, e.g., retirees' associations, trade unions etc. It is obvious from the results, however, that for *CR*s and *RR*s to remain around their current values, the minimum retirement age must be increased significantly.

CHAPTER V

PARAMETRIC PENSION REFORM WITH HIGHER RETIREMENT AGES: A COMPUTATIONAL INVESTIGATION OF ALTERNATIVES FOR A PAY-AS-YOU-GO BASED PENSION SYSTEM

V.1 INTRODUCTION[36]

Publicly managed pension systems providing old age or pension insurance coverage face financial difficulties in many countries across the world. Most of these systems are run as pay-as-you-go (PAYG) schemes requiring pension payments to current retirees to be financed out of contributions collected from currently active workers and their employers. The primary reason why these systems face financial difficulties is the increasing ratio of retirees to workers (the dependency ratio), most

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[36] Joint paper with Serdar Sayan forthcoming in 2000 in Journal of Economic Dynamics and Control

typically caused by the natural aging of the population. Followed by increasing life expectancies and declining fertility rates over time, population aging is essentially a demographic phenomenon and cannot be controlled by pension authorities or policy makers. Unless the resulting increases in dependency ratios can somehow be checked, pension balances will continue to deteriorate, eventually causing sizable deficits. High dependency ratios have already begun to challenge the financial sustainability of publicly run pension schemes in many countries (particularly, members of the OECD) forcing policy makers to take measures to curb the growth in pension deficits (Kohl and O'Brien, 1998). Avoiding such deficits requires controlling dependency ratios through changes in statutory entitlement ages (or minimum retirement ages) and/or adjustments in the values of contribution and replacement rates[37].

A parametric pension policy reform, as it is sometimes called (Chand and Jaeger, 1996), involves changing the existing values of pension program parameters within politically and demographically acceptable limits so as to prevent the size of pension deficit from exceeding tolerable levels determined by governments. Such a reform may involve once-and-for-all as well as gradual changes in the values of minimum retirement age contribution and replacement rates. However, the statutory retirement age is typically increased gradually through a predetermined time path. Regardless of

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[37] Contribution rates are payroll tax rates by which contributions (or old-age insurance premiums) are collected, and replacement rates are those that tie pension payments to wages/salaries earned prior to retirement.

the way they are introduced, new parameter values are expected to be compatible with the targeted level of deficit and to allow for demographically realistic contribution and retirement periods. Because of the fact that the policy makers pick the new parameters, the political feasibility of reform would also require avoiding configurations which might radically undermine the living standards of working and retiree populations. The availability of configurations might further be restricted by additional constraints and different priorities assigned to various outcomes of reform. Within this context, the timing of reform relative to election cycles and the implied distribution of the burden between the working young and retired elderly may be important considerations for policy makers in deciding whether or not a proposed configuration should be legislated. This issue has been considered in a previous essay, which is also presented at the Fifth International Conference of the Society for Computational Economics in Boston (June 24-26, 1999), which used an optimization framework with the objective function defined in such a way to allow policy makers to assign different weights to alternative policy goals and is available upon request from the author. Yet another consideration in picking the parameter configuration to be introduced may be given to the intergenerational aspects of the distribution of reform's burden on presently living and future generations (see, for example, Boll et.al., 1994; Sayan and Kiraci, 1999). So, for policy makers to make informed choices, alternative configurations meeting these restrictions must be identified.

The purpose of this essay is to identify a set of parametric reform options to rehabilitate the publicly run, PAYG pension system in Turkey under alternative strategies involving once-and-for-all, and gradual changes in pension parameters. The Turkish example is particularly interesting because the state pension system in Turkey already faces a severe financial crisis despite a relatively young population/ workforce. Unlike other countries where similar pension systems face financial difficulties largely due to population aging, the crisis of the Turkish system stems from the retirement ages that are exceptionally low by international standards. Presently, it is possible for women/men to retire as early as 38/43 years of age in Turkey but by the major pension reform proposal, which is currently awaiting the final approval of the President to become law, the minimum retirement age for women/men would be 58/60. Under intensive pressure from trade unions and other groups, the government modified the proposal to extend the transition period for gradual increases in the minimum retirement age to 10 years. The evident need to increase minimum contribution periods/retirement ages distinguishes pension reform efforts in Turkey from the experience of other countries, where policy makers had relatively little room to adjust for retirement ages along with other two parameters (Sayan and Kiraci, 2000). The numerical results reported in the essay makes it possible to compare the magnitude of required increases in the retirement ages under each reform strategy considered.

The essay is organized in such a way that the explanation of each strategy is followed by a description of the relevant algorithm used to generate numerical results based on Turkish data. The next section describes the numerical optimization exercises carried out to identify parametric reform options for Turkish pension system under the different reform strategies and discusses the implementation of algorithms employed and reports the results. Section 3 concludes the essay by summarizing policy implications and lessons that can be drawn from the computational analysis.

V.2 COMPUTATIONAL ANALYSIS OF REFORM OPTIONS

As pension reform becomes a higher priority in the policy agendas of many countries, a growing number of studies use numerical techniques to investigate parametric reform options for PAYG pension systems. The discussion in this section links up well with this literature, which is briefly surveyed by Chand and Jaeger (1996). Especially relevant studies include Halter and Hemming (1987), Van den Noord and Herd (1994), and Boll *et.al.* (1994), ILO (1996) and Sayan and Kiraci (2000). The results here are also likely to provide useful inputs and experiment scenarios for dynamic overlapping generations general equilibrium analyses of social security reform, adding to an already sizable literature (see Imrohoroglu, et.al, 1998 for a survey). Particularly good examples of overlapping generations general equilibrium analyses of parametric pension reform similar to that discussed here can be found in Miles (1999). Huang, Imrohoroglu and Sargent (1997) consider the general equilibrium impact transition from a PAYG to a fully funded system.

The rest of this section discusses the computational framework developed for this essay. The discussion begins by considering a once-and-for-all change in minimum retirement age and other pension parameters, proceeding thereafter to the issues arising with the constrained optimization problem.

V.2.1. Pension Reform Through a Once-And-For-All Change in System Parameters

Even though a sudden and steep increase in minimum retirement age would likely be politically infeasible, consideration of such policies serves as a good starting point for our search for new pension parameters that balance the expenditures and revenues of a PAYG pension system.

When D represents the difference between total pension payments to the retirees and total contribution receipts over the specified period of time running from, say, t_0 to τ, we can write

$$D=\sum_{t=t_0}^{\tau}\frac{1}{(1+\delta)^{t'}}\left(RR\sum_{a=A}^{le}\sum_{ra=A}^{a}\overline{rw}_{ra,a,t-(a-ra)-1}r_{ra,a,t}-CR\sum_{a=a_0}^{mwa}rw_{a,t}w_{a,t}\right)\quad\textbf{(1)}$$

where

CR : Average rate for employee and employer contributions combined ($0<CR<1$),

RR : Average replacement rate tying pension benefits to wages earned prior to retirement ($0<RR<1$), A : Minimum retirement age ($A < \bar{A} \leq mwa$, where *mwa* is maximum working age),

δ : Discount rate,

$w_{a,t}$: Number of workers at the age of a at time t,

$rw_{a,t}$: Average real wage earned by active workers at the age of a at time t –adjusted for the earnings cap or wage ceiling that determines the maximum amount out of which contributions are collected,

$r_{ra,a,t}$: Number of pensioners who retired at the age of ra, but are aged a at time t

$\overline{rw}_{ra,a,t-(a-ra)-1}$: Average work time earnings of pensioners who retired at the age of ra, but are aged a at time t

a : Age index running from the beginning of working-life, a_0 , to *le*, life expectancy in years (*le*>*mwa*),

ra : Actual retirement age index running from A to *mwa,*

t : Time index running from initial period, t_0, to τ, the end of model horizon, and $t' = t - t_0$, with all variables and indices other than A, *CR* and *RR* taking their values beyond the control of pension authorities.

Given this notation, total pension payments to be made at any year t are calculated by multiplying the number of retirees, distinguished by their current ages and the ages of retirement, with the applicable pension for the corresponding age group. The applicable pensions at time t are calculated through an indexation scheme requiring each retiree to be paid a certain proportion, RR, of the 10-year average of real wages earned prior to retirement. Since a retiree who retired at age ra and is currently aged a must have been collecting pensions for the past a-ra years, the average, wage ceiling-adjusted real wage she earned during the last 10 years of her career as a worker could be denoted by $\overline{rw}_{ra,a,t-(a-ra)-1}$,[38] implying that (s)he is entitled to collect RR % of this amount in pension payments. Each active worker aged a at time t, on the other hand, is paid $rw_{a,t}$ and contributions are collected at the rate of CR% of this income adjusted for the wage ceiling (i.e., the maximum level of wages or salaries by which contributions and pension payments are calculated). D in (1) therefore shows the difference between the sums of future (expected) pension payments and total contribution receipts in real present value terms over the time horizon considered. The time horizon for the computational exercises is chosen to be the period between 1995 and 2060. 1995 marks the period when Turkish pension deficits began to reach alarming magnitudes. The time horizon ends in 2060 since the Turkish population is projected to remain stable beyond this year, implying that a

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[38] To be more precise, $\overline{rw}_{ra,a,t-(a-ra)-1} \equiv \sum_{j=1}^{n} \frac{rw_{ra,a,t-(a-ra)-j}}{n}$ where n is the number of years in averaging period (taken to be equal to be 10 here).

parametric pension reform introduced to avoid deficits over this horizon would not need to be reversed afterwards.

Equation (1) is taken as the objective function in a constrained optimization problem requiring the minimization of D with respect to A, CR and RR, subject to the exogenously given, projected values of real wages, retiree and active worker populations and other relevant constraints. Given that publicly managed pension systems do not typically seek surpluses (with $D < 0$), however, a more realistic and relevant problem to consider would be to identify A, CR and RR values which would be compatible with a certain nonnegative value for D over the period under consideration. Since expenditures exceed receipts when $D > 0$, choice of a positive target value for D implies that the pension system is allowed to run a deficit. Because many governments view pension systems as a channel to make income transfers to working and/or retiree populations, they would often be willing, in fact, to allow public pension systems to run "reasonable" deficits –with the definition of reasonable varying across governments and macroeconomic conditions.

When considering this more realistic version of the pension reform problem in Turkey, the target level of pension deficit over the 1995-2060 period was set equal to zero since the losses generated by the public pension schemes (and by the social security system at large) in this country have already reached alarming proportions

(Sayan and Kiraci, 1999; Topal, 1999; Sayan and Kiraci, 2000). Given this target, the problem for the relevant time horizon would be[39]

$$\underset{A,CR,RR}{Minimize}\ |D| = \left| \sum_{t=1995}^{2060} \frac{1}{(1+\delta)^{t'}} \left(RR \sum_{a=A}^{le} \sum_{ra=A}^{a} \overline{rw}_{ra,a,t-(a-ra)-1} r_{ra,a,t} - CR \sum_{a=a_0}^{mwa} rw_{a,t} w_{a,t} \right) \right|$$

$$\begin{aligned} &subject\ to\ \sum_{ra=A}^{a} r_{ra,a,t} + w_{a,t} = p'_{a,t} \quad for\ \forall a \leq \mathrm{A}, \forall t \\ &0 < CR < 1;\ 0 < RR < 1;\ \mathrm{A} \leq mwa \end{aligned} \tag{2}$$

where. $p'_{a,t}$ represents the year t population of age group a minus the number of unemployed adults who are at the age of a in time t. Hence, the equality constraint in (2) states that anyone who is older than the minimum retirement age A and not unemployed at time t must either be a worker or a retiree who has been collecting pensions for the past *a-ra* years. Since the minimum retirement age marks the lower limit for summation in the first constraint, any increase in A introduced as part of a pension reform would increase the size of working population at the expense of the retiree population. So, each counterfactual increase in A considered requires regenerating projections on the working population by age groups and retiree population by (current as well as the actual retirement) ages in such a way to satisfy the equality constraint, and recalculating applicable incomes for retirees and

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[39] With the absolute value operator, the global minimum for $|D|$ would be zero ruling out the possibility of pension system running a surplus over 1995-2060.

workers[40]. This is, in fact, what raises the complexity of identifying the (*CR RR* A) triplets minimizing $|D|$, preventing the use of standard nonlinear programming solvers that come with commercially available software packages such as GAMS. To overcome the computational difficulty posed by this, a grid-search algorithm with a large data handling capacity was written in Gauss and used as described below.

Projected real wages and active worker/retiree populations by ages (aggregated over genders) were exogenously fed into the algorithm first. To make full use of the demographic projections available by age groups (ILO, 1996), the real wage series was projected into the year 2060 by taking into account the likely growth in economy wide labor productivities as well as productivity differentials due to seniority so as to allow for real wage differences across different age groups. The original ILO (1996) projections on working and retiree populations by age assumed that current pension regulations would be maintained over the 1995-2060 period, and hence, the current level of minimum retirement age would remain at its currently low level. Thus, each one-year increase counterfactually introduced to the minimum retirement age during the search for optimal configurations of A, *CR* and *RR* required that population projections be manipulated in such a way to transfer retirees younger than the value of A under consideration to working population[41]. So, after every incremental

[40] It must be noted that because of the multiplicative $\overline{rw}_{ra,a,t-(a-ra)-1}$ term in the objective function, this constraint cannot directly be incorporated into the objective function.

[41] Since we took into account the possibilities of death, unemployment and early retirement due to disabilities over the entire model horizon, the actual process for regenerating projection data after

increase in A, the algorithm calculated the left-hand side of equality constraint in (2) and calculated the appropriate real income terms to find the associated value of intertemporal pension balance, $|D|$. $|D|$ was then recalculated by incrementing *RR* over (0, 1) interval by 0.05 each time and computing the corresponding value of CR. As in the previous parts the results show that if the contribution rate is to be maintained at its current average of 20%, current replacement rates used by three pension institutions would require minimum retirement ages varying between 58 and 63 for the system to have a zero balance over the 1995-2060 period[42].

V.2.2. Pension Reform Through Gradual Increases in the Retirement Age

This implies that if pension parameters are changed once-and-for-all, the minimum retirement age must be at least 58. But if this rise in A is made effective for everyone immediately, thousands of workers who made their retirement plans under the pre-reform configuration of parameters would have to stay at work for several more years than they originally intended to. Because convincing workers to postpone retirement without notifying them well in advance would be very difficult (if not impossible), such an increase in the retirement age is not politically feasible.

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every increase in A is much more complicated than is described here. A detailed description can be found in the flow chart included in the appendix.

[42] Obviously, the exact timing of reform would affect the magnitude of changes that need to be introduced to statutory retirement ages and contribution/replacement rates. Since delays in legislating parametric reform would increase the initial level of deficit to be dealt with, such delays would drive statutory retirement ages and contribution rates higher and/or replacement rates lower.

However, there is the possibility that the reform with a *RR* of 0.65 in real terms, might encourage to stay in workforce and hence changing retirement plans of the workers because the nominal indexation of today yields a real *RR* of 0.4 and lower. But there is no clue about how many people will be willing to change their lives. If only the retirement age of junior workers is increased, on the other hand, it would be impossible to balance the pension deficit until 2060. To avoid this, the problem can be formulated to allow the retirement age to be increased gradually over time, thereby leaving enough time for current workers to plan ahead.

In this alternative formulation, the objective is to minimize the difference between contribution revenues and pension payments over a path that the minimum retirement age will follow between 1995 and 2060, subject to a given value for *CR* and a given range for *RR*. Since the working and retiree populations at any given period t are functions of the retirement age as discussed in Section 2.1,[43] the problem can now be expressed as:

[43] Since the relationship between working or retiree populations and the minimum retirement age is too complicated to be represented through a well-known functional form, the series were generated through an iterative process.

$$\underset{\alpha}{Min}\ \tilde{D} = \left| \sum_{t=1995}^{2060} \frac{1}{(1+\delta)^{t'}} (CR \textstyle\sum_{a=15}^{75+} rw_{a,t} w(A_t)_{a,t} - RR \sum_{a_t}^{75+} \sum_{ra_t = A_t}^{a_t} \overline{rw}_{ra,a,t-(a-ra)-1} r(A_t)_{ra,a,t} \right|$$

$$subject\ to\ \ A_{t+1} = A_t + \overline{A}(\alpha) e^{-\alpha(t-1995)}$$

$$\begin{aligned} &\alpha > 0 \\ &0.65 \le RR \le 0.95 \\ &CR = 0.2 \\ &A_t \le 65 \end{aligned} \qquad \textbf{(3)}$$

In this problem, a dynamic path was chosen for the retirement age by finding the value of α, a parameter capturing the rate of change of the retirement age over time. Another search algorithm was used to find the values of α minimizing the objective function for different RR values lying in the given interval. For each value of α considered, the corresponding minimum retirement age was calculated from the difference equation in the constraint[44]. Then, the resulting age was used to generate the yearly workforce, $w(A_t)$, and retiree population, $r(A_t)$, series which, in turn, were plugged into (3) to have the corresponding value of $\tilde{D}$ calculated. If $\tilde{D} > 0$ ($\tilde{D} < 0$), the same steps are repeated by considering a smaller (bigger) value for α. The iterations continued until the value of α specified to the sixth digit after the point

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[44] To solve the difference equation in the constraint for $\overline{A}$, we let $A_{1995} = 43$ and $\lim_{t\to\infty} A_t = 65$ where 43 is the minimum retirement age that is currently in effect for male workers and 65 is a reasonably high upper limit for retirement age increases in Turkey (that is, we take mwa=65). Starting with a guessed solution of the form $A_t = \beta_0 + \beta_1 e^{-\alpha(t-1995)}$, further manipulations would yield $\overline{A} = -22[e^{-\alpha} - 1]$ enabling us to write the constraint as $A_{t+1} = A_t - 22[e^{-\alpha} - 1]e^{-\alpha(t-1995)}$.

could not be changed any longer. (This optimization exercise was repeated for replacement rates varying between 0.65 and 0.95.)

Since minimum retirement ages could only take integer values, it was impossible to get $\tilde{D}$ strictly equal to zero. But the search routine was highly successful as the optimal value of α satisfied the following inequality:

$$\frac{\left| \sum_{t=1995}^{2060} \frac{1}{(1+\delta)^{t'}} [0.2 \sum_{a=15}^{75+} rw_{a,t} w(A_t^*)_{a,t} - RR \sum_{a_t}^{75+} \sum_{ra_t=A_t^*}^{a_t} \overline{rw}_{ra,a,t-(a-ra)-1} r(A_t^*)_{ra,a,t}] \right|}{\sum_{t=1995}^{2060} \frac{1}{(1+\delta)^{t'}} [0.2 \sum_{a=15}^{75+} rw_{a,t} w(A_t^*)_{a,t} + RR \sum_{a_t}^{75+} \sum_{ra_t=A_t^*}^{a_t} \overline{rw}_{ra,a,t-(a-ra)-1} r(A_t^*)_{ra,a,t}]} < .00025 \quad \textbf{(4)}$$

where the numerator on the left hand side is $\tilde{D}*$, the optimal value of $\tilde{D}$, and the denominator is the sum of the components of the difference in $\tilde{D}*$. So, this gives a performance indicator independent of currency units in which $\tilde{D}*$ is measured[45]. The behavior of the ratio in (4) with respect to changes in α is plotted in figure 7 with the obtained $\alpha*$, the optimal value of α, is approximately equal to 1/30 (0.033062 to be more precise).

[45] Had it been possible to get $\tilde{D}* = 0$ the left hand side of the inequality in (4) would have been strictly equal to zero as well.

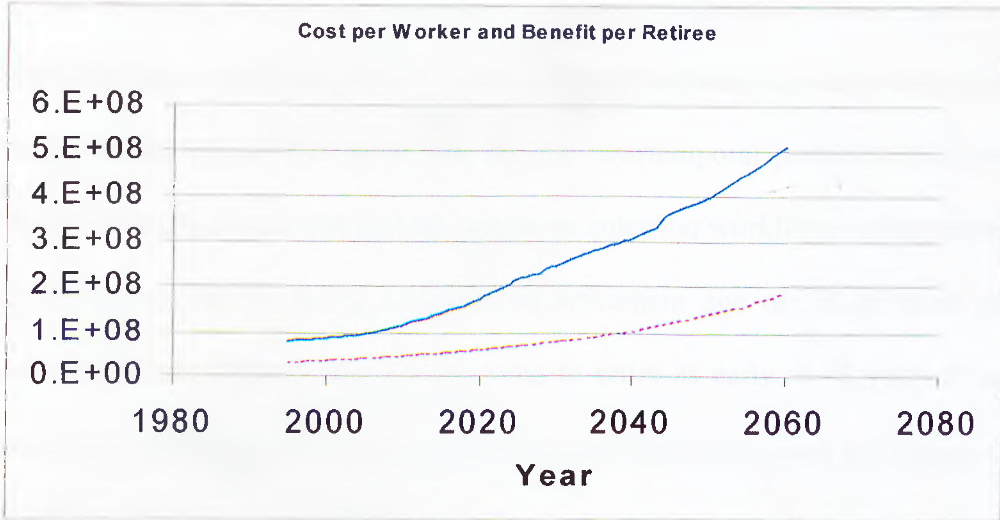

Figure 7: Behavior of Pension Deficit with Respect to Changes in α

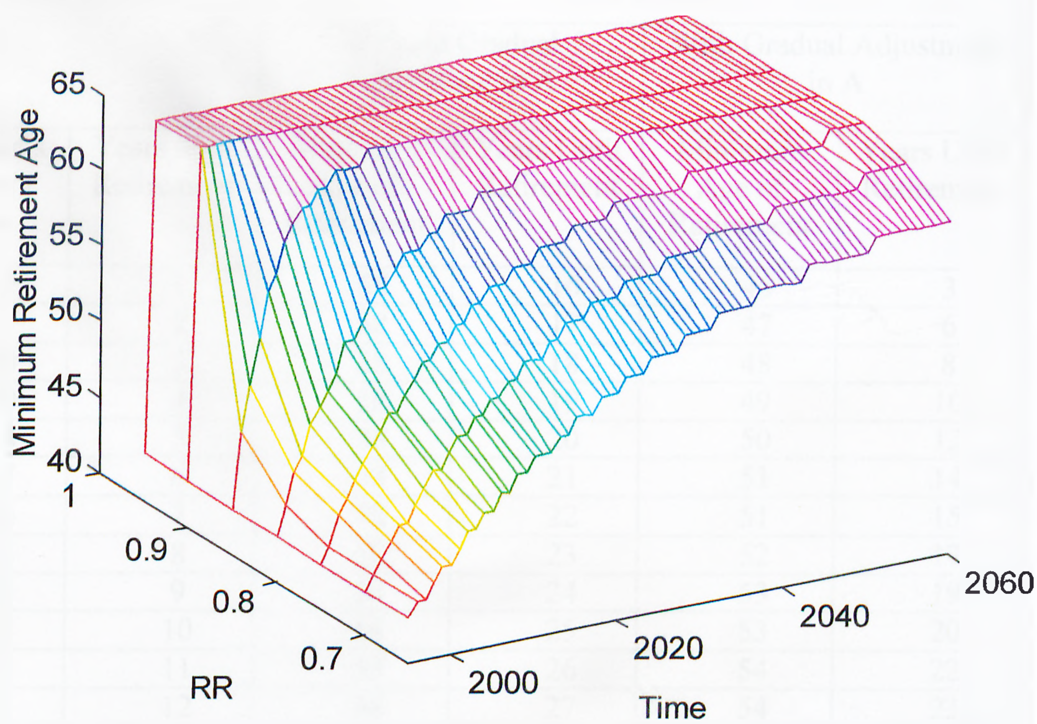

Figure 8: Behavior of Minimum Retirement Age over Time for Different Replacement Rates

The three-dimensional plot in figure 8 shows the dynamic paths of the minimum retirement age resulting under α^* across different replacement rates considered. The results behind figure 8 indicate that for the intertemporal pension deficit over the 1995-2060 period to be eliminated, people to enter the workforce in the aftermath of the reform would be facing a minimum retirement age of 58 or more, whereas currently active workers who are planning to retire as early as 43 years of age will have to postpone retirement by a number of years depending upon their current age.

Table 5: Minimum Retirement Age for Currently Active Workers Before and After Pension Reform

Before Reform		After Reform			
		Without Gradual Adjustment in A		With Gradual Adjustment in A	
Worker's Current Age	Years until Retirement	Minimum Age of Retirement	Years Until Retirement	Minimum Age of Retirement	Years Until Retirement
42	1	58	16	45	3
41	2	58	17	47	6
40	3	58	18	48	8
39	4	58	19	49	10
38	5	58	20	50	12
37	6	58	21	51	14
36	7	58	22	51	15
35	8	58	23	52	17
34	9	58	24	53	19
33	10	58	25	53	20
32	11	58	26	54	22
31	12	58	27	54	23
30	13	58	28	55	25
29	14	58	29	56	27
28	15	58	30	56	28
27	16	58	31	56	29
26	17	58	32	57	31
25	18	58	33	57	32

Table 5 reports the number of years remaining for retirement for workers at different ages in 1995 under both reform scenarios considered. Table 6 presents the same results for workers in different age groups in 2040 (i.e., people who were yet to be born in 1995). (To assure comparability of results across scenarios, all results reported in the tables were obtained by assuming a replacement rate of 0.65 and a contribution rate of 0.20.)

Table 6: Minimum Retirement Age for Currently Active Workers Before and After Pension Reform at 2040

Before Reform		After Reform			
		Without Gradual Adjustment in A		With Gradual Adjustment in A	
Worker's Current Age	Years until Retirement	Minimum Age of Retirement	Years Until Retirement	Minimum Age of Retirement	Years Until Retirement
42	1	58	16	60	18
41	2	58	17	60	19
40	3	58	18	60	20
39	4	58	19	61	22
38	5	58	20	61	23
37	6	58	21	61	24
36	7	58	22	61	25
35	8	58	23	61	26
34	9	58	24	61	27
33	10	58	25	61	28
32	11	58	26	61	29
31	12	58	27	62	31
30	13	58	28	62	32
29	14	58	29	62	33
28	15	58	30	62	34
27	16	58	31	62	35
26	17	58	32	62	36
25	18	58	33	62	37

Under the scenario in Section 2.1, when CR=0.20 and RR=0.65, the minimum retirement age would have to be increased to 58 for everyone regardless of whether they are currently in or yet to enter the work force. But since forcing workers who are at the age of 42 (41, 40 etc.) at time t and planning to retire at $t+1$ ($t+2$, $t+3$, etc.) to postpone retirement plans for 16 (or more) years would not be fair (if not infeasible), the present scenario gradually increasing the retirement age over time would be more sensible. This is, in fact, the reform strategy that has recently been put into use in several OECD countries (Kohl and O'Brien, 1998; SSA 1997), even though gradual increases in retirement age are determined in a less sophisticated fashion[46].

V.2.3. Sensitivity of Results

Since the results reported are expected to change under alternative discount and productivity growth rate assumptions, the sensitivity of results with respect to these parameters is considered in this section[47].

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[46] The retirement age for people covered by the OASI program in the U.S. to be eligible for full benefits, for example, will be increased by 2 months per year until 2022 (SSA, 1997).

[47] While alternative assumptions about the nature of demographic transition and workforce participation behavior are also likely to affect results, the absence of alternative population and workforce projections prevented us from carrying out sensitivity tests for changes in projected population and workforce series here. This, however, is one of the directions the research is planned to take in near future.

The results are robust to changes in the projected real wage series due to small deviations from assumed productivity growth rates since real wage changes affect the revenues and expenditures of the pension system in the same direction. Similarly, the sensitivity of results to changes in the assumed value of discount rate, δ, remains sufficiently low not to raise serious concerns about the usefulness of the previous discussion. Keeping the definition of pension balances in (1) in mind and starting from (*CR*, *RR*, A) triplets satisfying $|D|=0$, a *ceteris paribus* reduction in the discount rate will increase the value of $|D|$ above zero. To return this value back to zero, one or more of these pension parameters (statutory retirement age, A; contribution rate, *CR*, and replacement rate, *RR*) must adjust. The direction of change in each parameter required by a reduction in the discount rate, δ, can intuitively be analyzed, by keeping the other two parameters constant. For optimal values of *CR* and *RR* satisfying $|D|=0$, for example, statutory retirement age must be increased to counter the effect of a reduction in the discount rate on the desired pension balance. (By increasing the number of contributing workers and reducing the number of retirees drawing benefits, this will restore the desired balance at $|D|=0$.) This implies that for given values of contribution and replacement rates, the optimal value of statutory retirement age is negatively related to changes in the discount rate. This intuitive reasoning is supported by sensitivity results reported in table 7, which presents the optimal value of the statutory retirement age for alternative values of replacement rates and a contribution rate of 0.20, under each of the scenarios considered.

Table 7

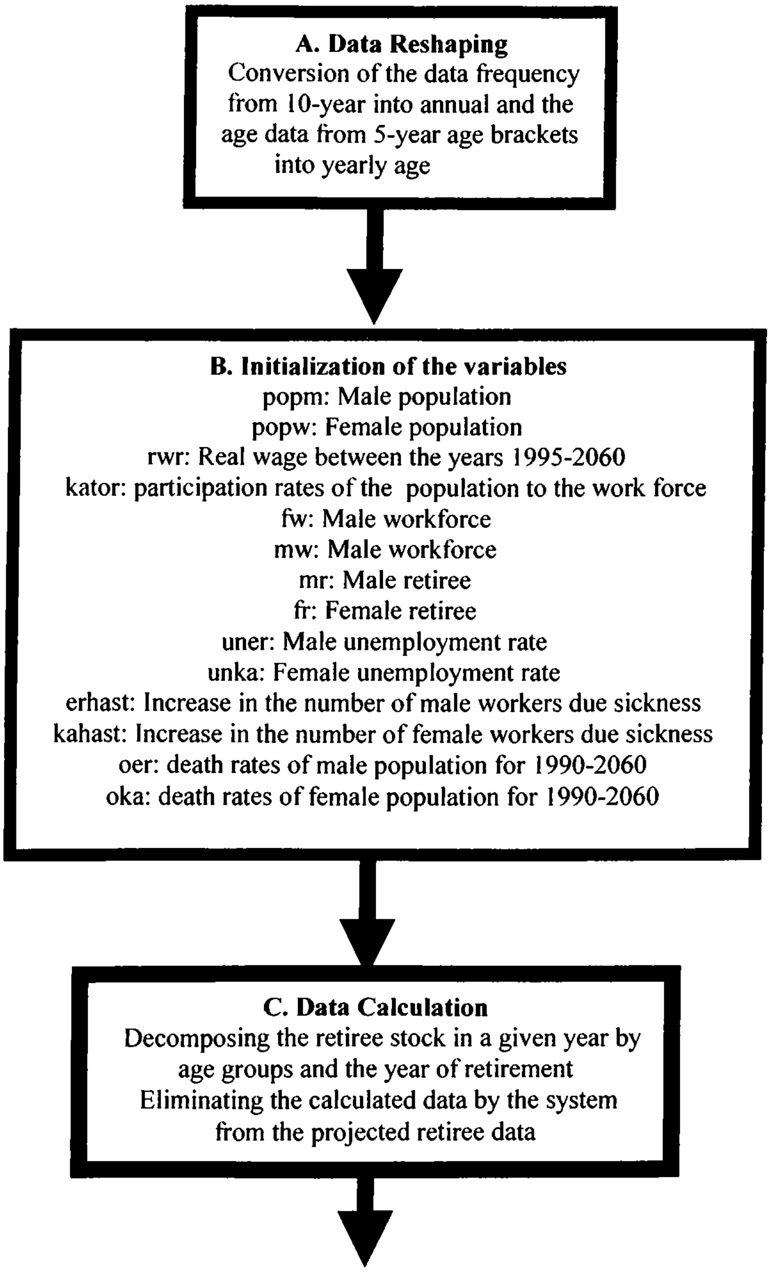
		RR													
		0.65		0.7		0.75		0.8		0.85		0.9		0.95	
δ	0	62	64	63	65	65	65	65	65	65	65	65	65	65	65
	0.01	61	64	63	65	64	65	65	65	65	65	65	65	65	65
	0.02	60	64	62	64	64	65	65	65	65	65	65	65	65	65
	0.03	60	63	61	64	63	65	64	65	65	65	65	65	65	65
	0.04	59	63	60	64	62	65	63	65	65	65	65	65	65	65
	0.05	58	62	60	64	61	65	63	65	64	65	65	65	65	65
	0.06	57	62	59	64	60	64	62	65	63	65	64	65	65	65
	0.07	56	61	58	63	59	64	61	65	62	65	64	65	65	65
	0.08	54	61	57	63	59	64	60	65	62	65	63	65	64	65
	0.09	53	60	57	63	58	64	60	65	61	65	63	65	64	65
	0.1	52	59	55	63	57	64	59	65	61	65	62	65	64	65

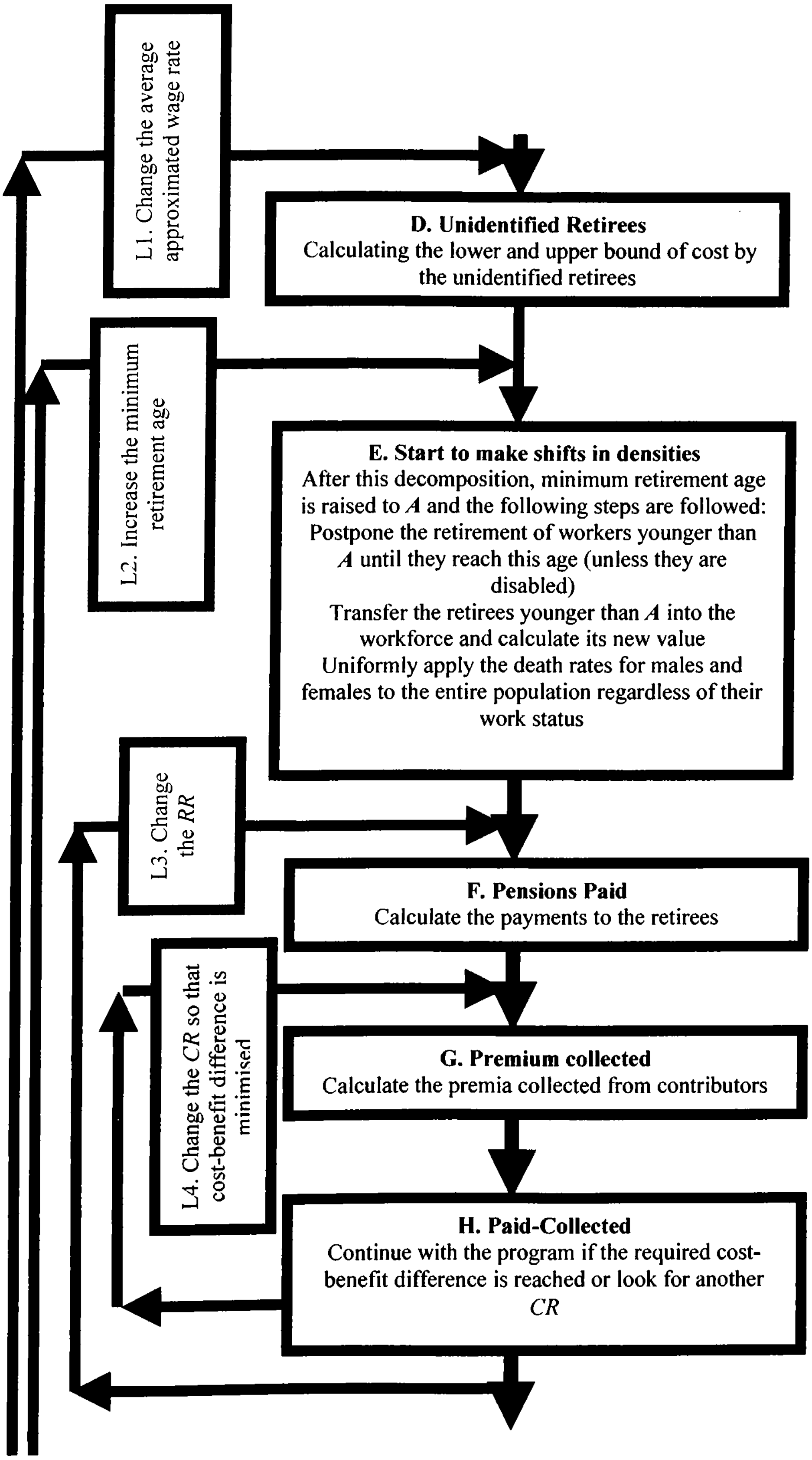
V.3 CONCLUSIONS

This chapter discussed the identification of parametric reform options to control losses generated by a publicly managed, PAYG pension system under alternative deficit reduction (reform) strategies including one time jumps, as well as gradual changes in contribution/replacement rates and statutory retirement ages. For this purpose, two different problems each corresponding to a different pension reform strategy, were analyzed using different computational techniques applied to the Turkish pension system. The first problem involved identification of alternative pension parameters compatible with a given target for revenue-expenditure balances of a pension system. The solution of the problem, obtained through a numerical search algorithm was shown to be non-unique unless additional constraints are not imposed to reflect the priorities of policy makers. It was argued that replacing the existing pension parameters at once rather than gradually over time could be particularly problematic if the new configuration calls for higher retirement ages for everyone including workers who plan to retire soon. Given the difficulties in convincing such workers to postpone their retirement plans, an alternative reform strategy involving gradual increases in retirement age was considered by solving a constrained optimization problem in which the pension deficit is minimized subject to a dynamic retirement age path and a one time change in replacement rates.

The results indicated that retaining current values of replacement and contribution rates while trying to eliminate the Turkish pension deficit over 1995-2060 period would require a substantial one-time increase in the minimum retirement age. If a gradual increase in the minimum retirement age is chosen instead, on the other hand, some generations will be allowed to retire at a lower age than the minimum age implied by the one-time jump scenario, but later generations will be required to stay in the workforce beyond this age.

APPENDIX


A. Data Reshaping
Conversion of the data frequency from 10-year into annual and the age data from 5-year age brackets into yearly age
B. Initialization of the variables
popm: Male population
popw: Female population
rwr: Real wage between the years 1995-2060
kator: participation rates of the population to the work force
fw: Male workforce
mw: Male workforce
mr: Male retiree
fr: Female retiree
uner: Male unemployment rate
unka: Female unemployment rate
erhast: Increase in the number of male workers due sickness
kahast: Increase in the number of female workers due sickness
oer: death rates of male population for 1990-2060
oka: death rates of female population for 1990-2060
C. Data Calculation
Decomposing the retiree stock in a given year by age groups and the year of retirement
Eliminating the calculated data by the system from the projected retiree data


L1. Change the average approximated wage rate
D. Unidentified Retirees
Calculating the lower and upper bound of cost by the unidentified retirees
L2. Increase the minimum retirement age
E. Start to make shifts in densities
After this decomposition, minimum retirement age is raised to A and the following steps are followed:
Postpone the retirement of workers younger than A until they reach this age (unless they are disabled)
Transfer the retirees younger than A into the workforce and calculate its new value
Uniformly apply the death rates for males and females to the entire population regardless of their work status
L3. Change the RR
F. Pensions Paid
Calculate the payments to the retirees
L4. Change the CR so that cost-benefit difference is minimised
G. Premium collected
Calculate the premia collected from contributors
H. Paid-Collected
Continue with the program if the required cost-benefit difference is reached or look for another CR

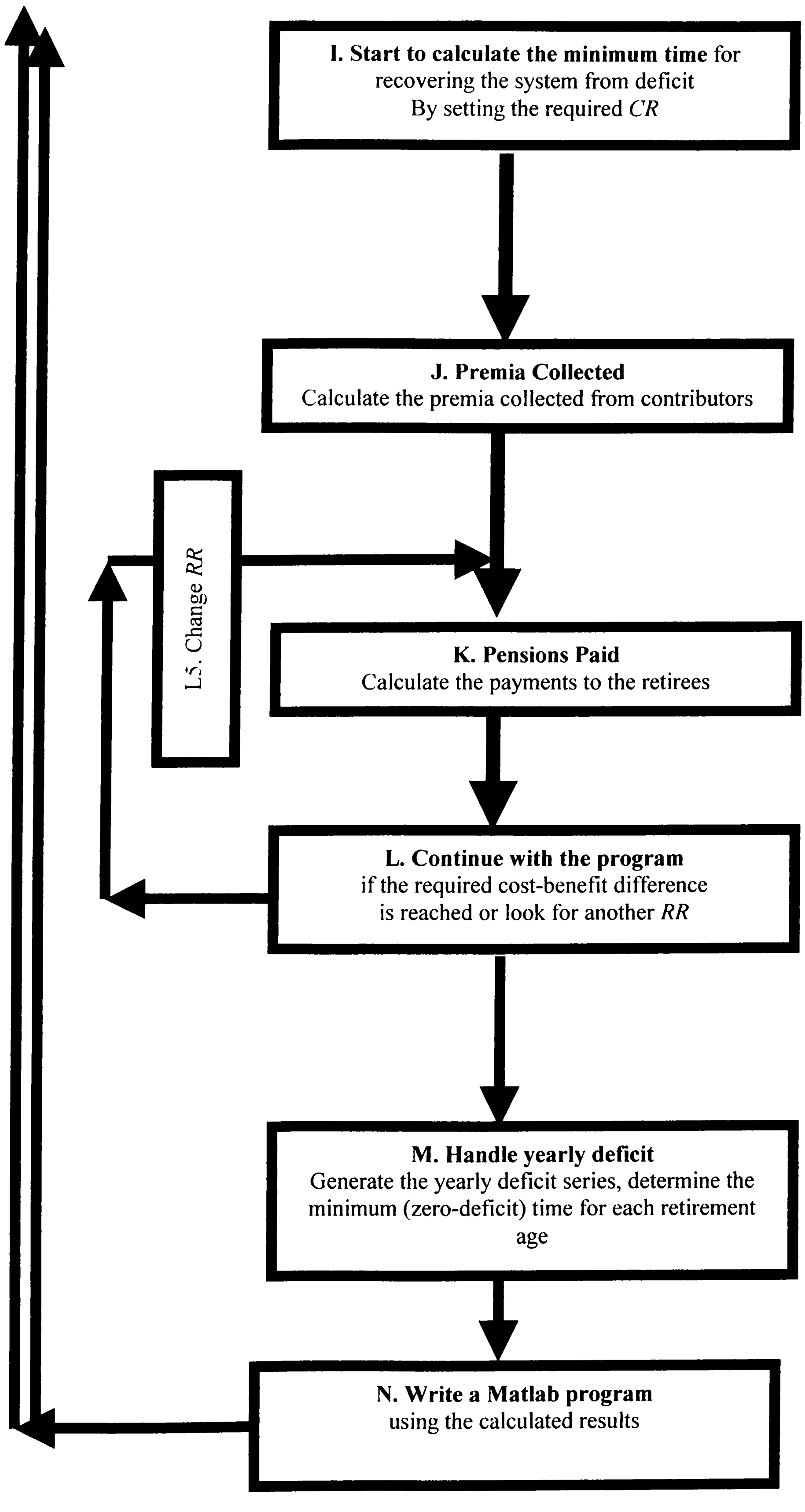

I. Start to calculate the minimum time for recovering the system from deficit By setting the required CR
J. Premia Collected Calculate the premia collected from contributors
L5. Change RR
K. Pensions Paid Calculate the payments to the retirees
L. Continue with the program if the required cost-benefit difference is reached or look for another RR
M. Handle yearly deficit Generate the yearly deficit series, determine the minimum (zero-deficit) time for each retirement age
N. Write a Matlab program using the calculated results

Table 8

Crude Birth and Death Rates for Selected Countries (per 1,000 population)

	Birth rate						Death rate					
Country	1998	1994	1990	1985	1980	1975	1998	1994	1990	1985	1980	1975
Australia	13.47	14.5	15.4	15.7	15.3	16.9	6.89	7.1	7.0	7.5	7.4	7.9
Austria	9.89	11.5	11.6	11.6	12.0	12.5	10.05	10.0	10.6	11.9	12.2	12.8
Belgium	10.21	11.6	12.6	11.5	12.7	12.2	10.41	10.4	10.6	11.2	11.6	12.2
Czech R[1]	8.96	10.3	13.4	14.5	16.4	19.6	10.92	11.3	11.7	11.8	12.1	11.5
Denmark	12.18	13.4	12.4	10.6	11.2	14.2	11.08	11.8	11.9	11.4	10.9	10.1
Finland	11.24	12.9	13.2	12.8	13.1	13.9	9.65	9.4	10.0	9.8	9.3	9.3
France	11.68	12.3	13.5	13.9	14.8	14.1	9.12	9.0	9.3	10.1	10.2	10.6
Germany[2]	8.84	9.5	11.4	9.6	10.0	9.7	10.77	10.9	11.2	11.5	11.6	12.1
Greece	9.65	9.9	10.2	11.7	15.4	15.7	9.37	9.4	9.3	9.4	9.1	8.9
Hungary	10.69	11.3	12.1	12.2	13.9	18.4	13.46	14.3	14.1	13.9	13.6	12.4
Ireland	13.49	13.4	15.1	17.6	21.9	21.5	8.51	8.6	9.1	9.4	9.7	10.6
Israel	19.99	21.2	22.2	23.5	24.1	28.2	6.19	6.3	6.2	6.6	6.7	7.1
Italy	9.13	9.2	9.8	10.1	11.2	14.8	10.18	9.6	9.4	9.5	9.7	9.9
Japan	10.26	9.9	9.9	11.9	13.7	17.2	7.94	7.0	6.7	6.2	6.2	6.4
Luxembourg	11.12	13.6	13.3	11.2	11.5	11.2	9.29	9.5	10.1	11.0	11.5	12.2
Mauritius	18.64	19.6	21.0	18.8	27.0	25.1	6.69	6.7	6.5	6.8	7.2	8.1
Netherlands	11.62	12.7	13.3	12.3	12.8	13.0	8.69	8.7	8.6	8.5	8.1	8.3
N Zealand	14.89	16.3	18.0	15.6	n.a.	18.4	7.60	7.8	7.9	8.4	n.a.	8.1
Norway	12.90	13.6	14.3	12.3	12.5	14.1	10.17	10.1	10.7	10.7	10.1	9.9
Panama	21.99	21.7	23.9	26.6	26.8	32.3	5.14	n.a.	n.a.	n.a.	n.a.	n.a.
Poland	9.79	12.5	14.3	18.2	19.5	18.9	9.76	10.1	10.2	10.3	9.8	8.7
Portugal	10.63	10.7	11.8	12.8	16.4	19.1	10.26	9.9	10.4	9.6	9.9	10.4
Romania	9.33	11.0	13.6	15.8	n.a.	n.a.	11.62	11.6	10.6	10.9	n.a.	n.a.
Singapore	13.79	16.9	17.0	16.6	17.3	17.8	4.68	5.1	n.a.	5.2	5.2	5.1
Sweden	11.70	12.8	14.5	11.8	11.7	12.6	10.78	10.3	11.0	11.3	11.0	10.8
Switzerland	10.81	11.9	12.5	11.6	11.3	12.3	9.03	8.9	9.5	9.2	9.2	8.7
Tunisia	20.07	22.7	25.8	31.3	35.2	36.6	5.06	n.a.	n.a.	n.a.	n.a.	n.a.
U Kingdom	12.01	12.9	13.9	13.3	13.5	12.5	10.72	10.7	11.2	11.8	11.8	11.9

U States	14.40	15.2	16.7	15.7	16.2	14.0	8.80	8.8	8.6	8.7	8.9	8.9
Yugoslavia[3]	n.a.	13.2	14.0	15.9	17.0	18.2	n.a.	10.1	9.0	9.1	9.0	8.7

1. Data prior to 1994 pertain to the former Czechoslovakia. 2. All data pertaining to Germany prior to 1990 are for West Germany. 3. Beginning January 1992, data refer to the Federal Republic of Yugoslavia. Prior to that date, data refer to the Socialist Federal Republic of Yugoslavia. NOTE: n.a. = not available. *Source:* United Nations, *Monthly Bulletin of Statistics, June 1997.* Data for 1998 from the U.S. Bureau of the Census, International Database.

Table 9

Infant Mortality Rates and Life Expectancy at Birth, by Sex, for Selected Countries, 1999						
	Infant deaths per 1,000 live births	Infant deaths per 1,000 live birthsMale	Infant deaths per 1,000 live birthsFemale	Life expectancy at birth (years)	Life expectancy at birth (years) Male	Life expectancy at birth (years) Female
North						
Canada	5.47	5.94	4.98	79.37	76.12	82.79
Mexico	24.62	27.79	21.29	72.00	68.98	75.17
United States	6.33	7.30	5.31	76.23	72.95	79.67
S. America						
Brazil	35.37	39.15	31.40	64.06	59.35	69.01
Chile	10.02	10.66	9.34	75.46	72.33	78.75
Costa Rica	12.89	13.59	12.15	76.04	73.60	78.61
Ecuador	30.69	34.99	26.17	72.16	69.54	74.90
Guatemala	46.15	49.91	42.20	66.45	63.78	69.24
Panama	23.35	25.67	20.95	74.66	71.91	77.51
Peru	38.97	43.79	33.93	70.38	68.08	72.78
Trinidad and	18.56	21.20	15.84	70.66	68.19	73.19
Uruguay	13.49	14.92	11.99	75.83	72.69	79.15
Venezuela	26.51	29.95	22.81	72.95	69.97	76.16
Europe						
Albania	42.90	45.41	40.19	69.00	65.92	72.33
Austria	5.10	5.57	4.60	77.48	74.31	80.82
Belgium	6.17	6.82	5.49	77.53	74.31	80.90
Cyprus	7.68	9.51	5.76	77.10	74.91	79.39
Czech	6.67	7.68	5.61	74.35	71.01	77.88
Denmark	5.11	5.73	4.45	76.51	73.83	79.33
Finland	3.80	4.15	3.44	77.32	73.81	80.98
France	5.62	6.36	4.84	78.63	74.76	82.71
Germany	5.14	5.69	4.56	77.17	74.01	80.50
Greece	7.13	7.54	6.70	78.43	75.87	81.18
Hungary	9.46	10.64	8.22	71.18	66.85	75.74
Ireland	5.94	6.36	5.49	76.39	73.64	79.32
Italy	6.30	6.82	5.74	78.51	75.40	81.82

Netherlands	5.11	5.81	4.37	78.15	75.28	81.17
Norway	4.96	5.49	4.40	78.36	75.55	81.35
Poland	12.76	14.11	11.33	73.06	68.93	77.41
Portugal	6.73	7.45	5.97	75.88	72.51	79.46
Russia	23.00	24.79	21.11	65.12	58.83	71.72
Slovakia	9.48	10.61	8.30	73.46	69.71	77.40
Spain	6.41	7.21	5.56	77.71	73.97	81.71
Sweden	3.91	4.43	3.36	79.29	76.61	82.11
Switzerland	4.87	5.42	4.30	78.99	75.83	82.32
United Kingdom	5.78	6.41	5.11	77.37	74.73	80.15
Asia						
Bangladesh	69.68	71.04	68.24	60.60	60.73	60.46
China	43.31	35.38	52.42	69.92	68.57	71.48
India	60.81	62.14	59.41	63.40	62.54	64.29
Iran	29.73	31.38	27.99	69.76	68.43	71.16
Israel	7.78	8.37	7.16	78.61	76.71	80.61
Japan	4.07	4.50	3.62	80.11	77.02	83.35
Pakistan	91.86	93.44	90.19	59.38	58.49	60.30
South Korea	7.57	7.86	7.24	74.30	70.75	78.32
Sri Lanka	16.12	17.88	14.28	72.67	69.89	75.59
Syria	36.42	37.51	35.29	68.09	66.75	69.48
Africa						
Egypt	67.46	69.32	65.51	62.39	60.39	64.49
Kenya	59.07	61.81	56.25	47.02	46.56	47.49
South Africa	51.99	56.46	47.39	54.76	52.68	56.90
Oceania						
Australia	5.11	5.64	4.56	80.14	77.22	83.23
New Zealand	6.22	7.28	5.10	77.82	74.55	81.27

Source: U.S. Census Bureau, International Data Base.

Table 10

Percentage of Population aged 65 and Over								
	1980	1990	2000	2010	2020	2030	2040	2050
Canada	9.51	11.37	12.84	14.61	18.59	22.39	22.47	21.34
Belgium	14.37	14.15	14.70	15.90	17.74	20.78	21.89	20.79
Denmark	14.41	15.32	14.87	16.67	20.11	22.56	24.70	23.17
France	13.96	13.79	15.28	16.26	19.45	21.76	22.72	22.33
Germany	15.51	15.51	17.12	20.35	21.74	25.82	27.60	24.48
Ireland	10.72	11.29	11.12	11.08	12.57	14.74	16.92	18.86
Italy	13.45	13.77	15.31	17.28	19.37	21.92	24.15	22.61
Luxembourg	13.52	14.64	16.74	18.12	20.15	22.38	22.03	20.28
Netherlands	11.51	12.69	13.46	15.13	18.89	22.96	24.77	22.61
UK	14.87	15.13	14.48	14.61	16.27	19.24	20.43	18.74
Japan	9.10	11.41	15.20	18.62	20.92	19.97	22.66	22.30
Turkey		4.00	5.50	6.10	7.70	9.00		
USA	11.29	12.23	12.15	12.79	16.16	19.49	19.80	19.31

Source: OECD Ageing Population

Table 11

Demographic Rates for Turkey							
	Population	Urbanization	Crude	Crude	Infant	Total	Life
65-70	2.52	6.03	30.0	13.5	158.00	5.31	54.91
70-75	2.50	5.62	34.5	11.6	140.40	4.46	57.88
75-80	2.06	4.40	32.2	10.0	110.79	4.33	61.20
80-85	2.49	4.91	30.8	9.0	82.96	4.05	63.00
85-90	2.17	4.99	29.9	7.8	65.22	3.76	65.58
90-95	1.85	4.40	23.5	6.7	50.56	2.80	67.28
95-00	1.62	4.67	21.4	6.5	39.02	2.45	68.55

Source: SIS, SPO, (1) Estimates by SIS and SPO

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