The Extension of Social Security Coverage in Developing Countries*

Juergen Jung†
Towson University

Chung Tran‡
Australian National University

8th November 2011

Abstract

We study the dynamic general equilibrium effects of introducing a social pension program to elderly informal sector workers in developing countries who lack formal risk sharing mechanisms against income and longevity risk. To this end, we formulate a stochastic dynamic general equilibrium model that incorporates defining features of developing countries: a large informal sector, private transfers as an informal safety net, and a non-universal social security system. We find that the extension of retirement benefits to informal sector workers results in efficiency losses due to adverse effects on capital accumulation and the allocation of resources across formal and informal sectors. Despite these losses recipients of social pensions experience welfare gains as the positive insurance effects attributed to the extension of a social insurance system dominate. The welfare gains crucially depend on the skill distribution, private intra-family transfers and the specific tax used to finance the expansion.

JEL Classification: E6, E21, E26, H30, H53, H55, I38, O17

Keywords: Informal Sector, Family Social Safety Nets, Social Pension, General Equilibrium, and Welfare.

*We would like to thank Gerhard Glomm, Kim Huynh, Selahatting Imrohoroglu, Michael Kaganovich, John Piggott, Alan Woodland, and Willard Witte for many helpful comments. In addition, we would like to thank participants of the Jordan River Conference, the Midwest Macro Meetings, the PET conference, seminars at the Australian National University, the University of Sydney, Indiana University, and two anonymous referees for helpful comments. All remaining errors are ours.

†Department of Economics, Towson University, Maryland 21252, U.S.A., *E-mail:* jjung@towson.edu

‡Research School of Economics, The Australian National University Canberra, ACT 0200, Australia, Tel.: 61 2 6125 5638, *E-mail:* chung.tran@anu.edu.au

1 Introduction

Individuals in developing countries are confronted with a shortage of risk-sharing mechanisms which prevents them from being able to effectively insure their income and longevity risk. Private financial markets are underdeveloped and do not provide viable insurance instruments for large parts of the population. Public social insurance systems, on the other hand, cover only a small fraction of the population working in the formal sector. According to Palacious and Pallares-Mirallets (2000) the coverage rates of social security systems are usually less than 10 percent in low income countries and rarely exceed 50 percent in middle income countries. Therefore the traditional family support system – briefly summarized as parents supporting their young children and becoming recipients of support from their children when old – appears to be the most important source of income for the elderly, especially elderly informal sector workers (e.g. World-Bank (1994), Cox and Jimenez (2006), and Jung and Tran (2008)). However, the family transfer system cannot pool risk well across families so that an argument for increased government intervention can be made (compare Summers (1989), ILO (2002), Chetty and Looney (2006), and Palacious and Sluchynsky (2006)). A number of developing countries including Brazil, South Africa, India, and China have recently started government transfer programs for the uncovered elderly. Palacious and Sluchynsky (2006) use the term social pension for such transfers.

In this paper we conduct a quantitative analysis of the general equilibrium effects of extending social security coverage to workers in the informal sector in the context of developing countries. We formulate a two-sector, dynamic general equilibrium, dynastic overlapping generations model with incomplete markets and heterogenous agents that incorporates important features of developing countries. First, we model the existence of an informal production sector using the approach in De Soto (1989). Second, we model the presence of an informal safety net working through inter-generational private transfers. We follow the approach in Laitner (1992) and Fuster (1999) and assume that agents are two-sided altruistic, so that parents and children pool their resources and decide on transfers between households within a dynasty. Third, we capture the basic structure of social security systems in developing countries and introduce a non-universal and relatively small pension program for formal sector workers only. We then calibrate the model to match key characteristics of the Brazilian economy, a middle-income developing country that introduced a large-scale social pension program in early 1990. This initial calibration constitutes our benchmark economy. Finally, we introduce a social pension program for informal sector workers financed by either a consumption, labor or capital tax into the benchmark economy.

The extension of the pension program to informal sector workers has two roles. First, it is an intergenerational redistribution mechanism that transfers income to the poor elderly in the informal sector. Second, it is an important source of insurance against income and longevity risk, which allows people to smooth their consumption over the life cycle. It subsequently provides avenues for more efficient risk sharing across households and generations, which potentially decreases inequality and improves welfare (i.e. *positive insurance effects*). On the

other hand, as social pensions become a non-trivial source of income, they will crowd out the traditional family insurance system and create distortions in goods and labor markets that decrease aggregate output (i.e. *negative efficiency effects*).

In our model we find that a social pension program with a 50 percent replacement rate of average active wages decreases aggregate physical capital by up to 4 percent and human capital by up to 2.5 percent. In addition, some physical and human capital is shifted into the less productive informal sector. As a result, output decreases by 4 percent but recipients of social pensions still experience welfare gains.

The driving mechanism behind this positive welfare result is the trade-off between positive insurance effects and negative efficiency effects. The modelled social pension program is targeted to the elderly in the informal sector which provides social insurance against both income and longevity risk. In our model private insurance markets are absent and informal safety nets (i.e. intergenerational family transfers) are used for insurance. However, they fail to pool risk across dynasties. Moreover, segmentations in labor markets and production sectors expose informal sector workers (poor and low ability types) to even more risk. In this context, the insurance role of the social pension programs tends to become more pronounced.

On the other hand, the social pension program creates adverse incentives for precautionary savings and the various decisions associated with the labor market. This can lead to crowding-out effects (i.e. social insurance instead of intra family transfers) and allocative distortions (i.e. early retirement, changes in sector choices, etc.). The former primarily leads to decreases in capital accumulation and aggregate labor supply, while the latter distorts the allocation of physical and human capital towards the low productivity (informal) sector. However, since the social pension program targets only the relatively small group of older informal sector workers, the adverse effects tend to be small. In addition, intended bequests through family networks mitigate some of the crowding-out effects. Overall, we find that in an environment that lacks formal risk-sharing mechanisms, welfare gains due to insurance and redistribution effects dominate welfare losses from distortions and crowding out effects.

We provide a series of incremental experiments where we analyze the contribution of the various features of the model towards generating the observed welfare gains for recipient households. It turns out that skill heterogeneity and intentional bequests are two of the most important features that contribute to the welfare gains for recipient households. Other features like endogenous sector choice, technology differences between formal and informal sectors, or general equilibrium effects do change our results quantitatively but not qualitatively.

Finally, we analyze the important question of how to finance this reform. We use three separate tax regimes: a consumption tax, a labor tax on formal sector workers only, and a capital income tax. The economic distortions and the degree of social insurance provided through the tax-transfer system as a whole depends on the progressiveness of the tax in use. When a labor tax is used to finance the expansion, the positive insurance and redistribution effects of the social pension program outweigh the negative crowding-out and resource allocation effects. This creates welfare gains for recipient households. However, this is not generally true

when a capital tax finances the expansion. In this case the distortions become very large and most recipient households also experience welfare losses.

Literature. Our work is related to several branches of the social security literature. First, the studies evaluating the effects of public policy in developing countries have mainly focused on empirical microeconomic analysis using partial equilibrium models (e.g. see Cox and Jimenez (1992), Cox and Jimenez (1995), Gruber (1995), Schmidt-Hebbel (1999), Edwards and Cox-Edwards (2000), Packard (2002), Jensen (2003), Rofman and Carranza (2005), Valdes-Prieto (2008), and Jung and Tran (2008)). This approach abstracts from dynamic general equilibrium aspects which our current study provides.

More recently, Acemoglu (2010) argues that general equilibrium and political economy aspects are important for the external validity of econometric estimates. Papers advancing general equilibrium analysis of public policy in developing countries include Corsetti (1994), Loayza (1996), Fortin, Marceau and Savard (1997), Schmidt-Hebbel (1997), and Levy (2008). We contribute to this literature by focusing on the redistributional effects created by social pension systems in multi sector economies. To our knowledge, the literature on general equilibrium effects of social pensions in developing countries is sparse and none of the studies mentioned above has focused on exploring the insurance and redistributional effects of social pensions simultaneously in a qualitative and quantitative way.

The body of literature analyzing the effects of social security systems in developed countries is very large. Since the seminal contribution by Diamond (1965) the adverse effects of unfunded social security have been well documented in general equilibrium life cycle models (e.g. see Auerbach and Kotlikoff (1987), Hubbard and Judd (1987) and Imrohoroglu, Imrohoroglu and Jones (1995)).[1] This literature emphasizes the importance of accounting for general equilibrium effects and concludes that the expansion of social security systems usually leads to welfare losses because the adverse effects on capital accumulation and labor supply tend to dominate the positive insurance effects. We extend this approach by incorporating some of the defining features of developing countries and find that in contrast to previous studies calibrated to developed countries, welfare gains for the recipients of social pension benefits can be realized. These results depend on crucial features in the model: (*i*) skill heterogeneity coupled with segmented formal and informal labor markets and production sectors is essential to generate the degree of wealth disparity that amplifies the positive insurance effects of the reform, (*ii*) the social pension targets a relatively small group of informal sector retirees which keeps the program and therefore the distortions triggered by it small; and (*iii*) bequest motives alleviate the savings distortions caused by the social pension program and therefore trigger the welfare gains.

The paper is structured as follows. In the next section we set up the model and define equilibrium. Section 3 describes the calibration. Section 4 contains the discussion of policy reforms and results. Section 5 is devoted to sensitivity analysis. We conclude in section 6. The

[1] For an excellent literature survey of the literature on unfunded social security see Imrohoroglu, Imrohoroglu and Jones (1999).

appendix contains all tables and figures. A technical appendix is available upon request and presents the solution method, the solution algorithm, the construction of efficiency profiles, and the tables from the sensitivity analysis.[2]

2 Model

2.1 Demographics

Every period a new generation of individuals becomes economically active. Individuals face age and skill specific mortality $sp_j(\theta)$, where j denotes age and $\theta = \{\theta^L, \theta^H\}$ denotes the skill type: low skill and high skill respectively. Individuals live at most $2J$ periods so that $j = \{1, ..., 2J\}$. We assume that the survival probability depends on the working sector which captures the effect of sector specific working conditions on longevity. The population grows exogenously at rate n. The demographic structure of the population is assumed to be stationary so that the population share of the age cohorts is time invariant. The population consists of $2J$ overlapping generations and is normalized to 1 at any point in time. After detrending with the population growth rate, the population share of generation j in skill type θ is recursively defined as

$$\mu_j(\theta) = \frac{sp_j(\theta)}{(1+n)}\mu_{j-1}(\theta),$$

where $\sum_{\theta=\{\theta^L,\theta^H\}}\sum_{j=1}^{2J}\mu_j(\theta) = 1$. Similarly, the cohort size of agents dying each period (conditional on survival up to the previous period) can be defined recursively as

$$v_j(\theta) = \frac{1 - sp_j(\theta)}{(1+n)}\mu_{j-1}(\theta).$$

2.2 Altruism, living arrangements, and household dynasty

Family formation and living arrangements are complex in developing countries (e.g. Rosenzweig (1988*b*)). In this paper we follow the approach in Laitner (1992) and Fuster (1999) to model the main features of living arrangements in developing countries. We assume that individuals are altruistic towards their children and their parents (two-sided altruism). Since parents are altruistic towards their children, they transfer wealth to them while they are alive (inter vivos transfers). Additional transfers are made via accidental bequests if parents die before age $2J$ and intended bequests which they leave at age $2J$. On the other hand, children are altruistic towards their parents and derive utility not only from their own consumption and leisure but also from the utility of their parents.

We model two stages of the living arrangement of an individual. In the first stage agents are economically active *children.* In the second stage they become *parents*. That is, individuals

[2] This technical appendix is also available on the authors' website at: http://site.google.com/site/chung.q.tran/research/sscApp.pdf

are economically active young agents (i.e. children) from period 1 to J and become old agents (i.e. parents) when they are $J+1$ periods old. At that age their parents have died and their own children become economically active. Thus, individuals overlap with their parents in the first J periods and with their own children in the last J periods of their life. In each period the surviving and economically active members of a family form a decision unit called *household*. A sequence of households of parents, children, grandchildren etc. in a family line defines a dynasty. Each individual of a generation in a dynasty participates in two consecutive decision making units (or households) one with their parents and one with their children.

In our model, each individual has a random but finite lifetime overlapping with her parents and her children. Altruistic private transfers and skill inheritance generate inter-generational ties that link individuals together into a household and households into a dynasty. These features essentially transform a finitely-lived agent model into an infinitely-lived dynasty model. Skill shocks generate heterogeneity among individuals, households and dynasties. The demographic shock, which can break family lines with a certain probability, introduces another source of heterogeneity. [3] Hence, our model combines features of both the life-cycle and the infinite horizon framework with heterogenous agents.

2.3 Skill inheritance

Skill is one of the sources of agent heterogeneity in our model. We think of education as one of the principal avenues through which skill is passed down from parents to children. Children of highly educated parents tend to have more education – and therefore better skills – than their counterparts with poorly educated parents. This intergenerational persistence in educational attainment is an important driver of overall skill inequality and limits intergenerational income mobility (see also Corak (2004) and d'Addio (2007)). In the context of developing countries, parents' investment in children's education could be an important part of the family safety net as argued Chetty and Looney (2006). For simplicity we, however, abstract from modeling inter-generational links through education. We assume an exogenous skill inheritance process that transmits skills from one generation to the next within a dynasty.[4]

We capture the persistence in skill inequality using a simple two-state Markov process across generations. When agents become economically active they are endowed with a specific type of skill θ, which is either low θ^L or high θ^H. The probability to be endowed with a certain type of skill depends on the current skill of the parents according to the following transition probability matrix:

$$\Pi\left(\theta^p, \theta^k\right) = \begin{bmatrix} \pi_{L,L} & \pi_{L,H} \\ \pi_{H,L} & \pi_{H,H} \end{bmatrix}, \tag{1}$$

[3] There are other social and economic factors i.e. immigration that would influence living arrangements and family structures in developing countries. In this paper since we focus only on longevity risk and implications for social insurance in the context of developing countries we abstract from the role of other factors.

[4] The presence of a social pension would reduce such education investment incentives as the older parents do not have to rely as heavily on their children's income support anymore. On the other hand, it allows the credit constrained households to invest more in their children's education. The net effect on education is not conclusive and would also depend on agent heterogeneity and the design of the public education system.

where π_{θ^p,θ^k} is the probability that the children are endowed with skill type θ^k conditional on the parents' skill θ^p. This creates four types of households by skill level of parents and children: (H,H), (H,L), (L,H), and (L,L). The first letter denotes the skill type of the parent and the second denotes the skill type of their children.

Individuals cannot change their skill type during their lifetime. However, the efficiency unit associated with each specific skill changes over the life-cycle and captures the age profiles of income of the various skill groups. The efficiency unit that enters the production function as labor equivalent depends on an agent's age and skill type $e_j^i(\theta)$ where $\theta = \left\{\theta^L, \theta^H\right\}$. Individuals aged j are endowed with efficiency unit $e_j^i(\theta)$ and one unit of time in each period.

2.4 Occupational choice and labor markets

According to De Soto (1989), an informal sector arises when a government charges high taxes but lacks the appropriate enforcement mechanisms to collect these taxes. Escaping taxes by working in a "shadow economy" is not costless as informal sector workers are subject to penalties in the form of fines and asset confiscation as well as access restrictions to formal credit markets.

We incorporate that concept of informality in our model to model segmentations in the labor markets and production sectors. That is, we assume that workers in the informal sector receive lower wages but do not pay labor income taxes. They are not covered by the government social security system and also face informality costs including fines and capital confiscation. On other hand, workers in the formal sector receive higher wages but have to pay labor income and social security taxes. In addition, they will receive pension benefits upon retirement.

It is documented that young individuals are not free to choose an occupation or working sector in developing countries. Parental skills, occupation as well as parental networks play an important role in determining whether their children can find work in the formal sector. Children of formal sector employees in developing countries have typically better education than children of informal sector workers (Marcouiller, de Castilla and Woodruff (1997)) which will make it easier to secure work in the formal sector (Thomas (1992) and Maloney (1999)). We reflect these frictions in labor markets in developing countries in our model by assuming that only a fraction of newborn agents is offered a position in the formal sector. The probability that determines whether an agent receives a formal sector job offer depends on the characteristics of the parents. The agents who receive a job offer in the formal sector then choose whether they want to work in the formal or informal sector weighing the costs vs. the benefits. Agents who are not offered formal sector jobs are forced to work in the informal sector.

In the model individuals with high skilled parents have a larger probability of being high skilled themselves which increases the probability of formal sector job offers. We also assume that once an agent has chosen her working sector, she cannot change it anymore for the rest of her life. Depending on their working sector individuals allocate their time to leisure $l_j(\theta)$ and work $1 - l_j(\theta)$. The effective labor supply, or human capital is defined as $h_j(\theta) = e_j(\theta)(1 - l_j(\theta))$. Note that there is no restriction on how long individuals can stay in the labor force. The retirement age is chosen by the individual. However, there is a mandatory

age for retirement benefits for formal sector workers.

2.5 Informal social safety net

The traditional family support system has become the predominant source of income of older individuals, especially elderly informal sector workers. The importance of the family transfer system in developing countries is well documented in the literature (e.g. World-Bank (1994), and Cox and Jimenez (2006)). Family arrangements in developing countries provide an alternative risk sharing mechanism against income and longevity risk as private transfers act as substitutes for formal insurance contracts and credit markets (e.g. Rosenzweig (1988*a*) and Rosenzweig and Wolpin (1993)).

In our model we use persistence in the skill endowment process and two-sided altruism to link the generations. The stochastic nature of skill inheritance is a source of income uncertainty and household heterogeneity. Current households cannot change the skill set of its members, but the skill decomposition of the members that form next period's household can change as skill inheritance is stochastic. This random skill transmission introduces permanent shocks to the households' human capital and creates persistent intergenerational income inequality. In the model this intergenerational risk cannot be diversified away via market arrangements.

Intergenerational transfers due to two-sided altruism work as an informal social safety net within a household dynasty. That is, private transfers flow from high to low income members in a household within a period but also from rich to poor households of a dynasty across periods. Private transfers from parents to children help lessen liquidity constraints of young agents. However, this mechanism only provides partial insurance against income and longevity risk as households can only share risk within but not across dynasties. Households are therefore vulnerable to demographic shocks that can end a dynasty.

2.6 Production sectors

The economy consists of two distinct production sectors which differ with respect to their legal status and compliance with government imposed taxes and regulations. Sector one, the formal sector, is populated by regulated firms. Sector two, the informal sector, is populated by unregulated firms (De Soto (1989)).

In our model, both formal and informal sector firms produce a common final consumption good. The aggregate output in period t is therefore the sum of formal and informal sector production:

$$Y_t = Y_t^I + Y_t^F.$$

The formal production sector consists of a large number of perfectly competitive firms, which is equivalent to one aggregate representative firm that maximizes profits. The production technology of this firm is given by a constant returns to scale production function $Y^F = A^F \left(K^F\right)^{\alpha^F} \left(H^F\right)^{1-\alpha^F}$, where K^F is the input of capital, H^F is the input of effective labor services (human capital), A^F is the total factor productivity assumed to be growing at a

constant rate g, and α^F is the capital share in production. Capital depreciates at rate δ^F. We assume that there is no barrier for formal sector firms to access to the capital and labor markets.

The informal production sector consists of a large number of untaxed and unregulated firms. The development literature documents that informal firms tend to be less efficient, more labor intensive, and hire more low skilled labor. This could be due to market segmentation. However, empirically this has not been established (see Magnac (1991), Maloney (1999), and Pratap and Quintin (2006)). However, more recently Amaral and Quintin (2006) showed that a competitive model is also able to account for the concentration of low-skilled labor in the informal sector. We abstract from modeling these kind of frictions and simply assume that the informal production sector also behaves like an aggregate firm using the following technology $Y^I = A^I \left(K^I\right)^{\alpha^I} \left(H^I\right)^{1-\alpha^I}$, where K^I is the input of capital, H^I is the input of effective labor services, A^I is the total factor productivity growing at a constant rate g, and α^I is the capital share in the informal sector . Capital depreciates at rate δ^I.

Escaping taxes and regulations is not costless as informal activities are subject to shadow costs including limited access to government provided services (e.g. public goods like the enforcement of property rights etc.) and capital markets (De Soto (1989) and Loayza (1996)). To capture these costs we impose $A^I < A^F$. Moreover, informal sector firms face higher borrowing costs and tighter borrowing constraints. This subsequently induces informal sector firms to substitute low skilled labor for capital as argued in Amaral and Quintin (2006). Following this approach we assume that the informal sector production technology is less capital intensive, $\alpha^I < \alpha^F$.

2.7 Government

Social security system. The government runs a social security system including a contributory public pension program and a non-contributory social pension program. The public pension program is not universal in the benchmark model economy. Only workers in the formal sector who pay a social security tax when young are entitled to receive pensions when old. Informal sector workers who do not pay social security taxes when they are young do not receive pension benefits. The level of pension payments is a function of current wage rates in the formal sector w^F, average effective labor $\bar{h}^F$ over the working periods of the formal sector worker, and a replacement rate Ψ^F so that

$$Pen = \Psi^F w^F \bar{h}^F,$$

where the replacement rate Ψ^F is a measure of the generosity of the pension program.

In our policy experiment we allow the government to introduce a social pension program targeted to elderly workers in the informal sector who are not covered by the public pension program. The individual social pension benefit is calculated as

$$T = \Psi^I w^I \bar{h}^I,$$

where Ψ^I, w^I and $\bar{h}^I$ denote the replacement rate, the wage rate and average effective labor in the informal sector, respectively. The social pension program plays two important roles. First, it is an important source of insurance against income and longevity risk. Second, it redistributes income to the poor elderly in the informal sector. Note that the social pension program does not exist in the benchmark model and is introduced in our policy experiments. [5] Since it is evident that social security systems in developing countries are not self-financed and governments usually have to finance deficits in the social security system, we assume that social security is not independent of the government budget.[6]

Government purchases and debt. The government is assumed to spend a constant fraction Δ_G of final output Y on unproductive government consumption

$$G = \Delta_G Y.$$

Government debt B is also assumed to be a constant fraction Δ_B of final output, or

$$B = \Delta_B Y.$$

Government budget. The government collects a labor income tax τ_L, a social security tax τ_{SS}, a capital income tax τ_K, and a consumption tax τ_C to finance pensions Pen of formal sector retirees, lump-sum transfers T to informal sector workers, the debt service $R \times B$, and general government consumption G. The government budget clears in every period and can be

[5] In our set up, we abstract from transitory shocks like labor productivity shocks or health shocks. We only allow for permanent income shocks for members of a household that are generated by the skill inheritance process. In this sense we understate the importance of the insurance and redistribution function of the social pension program.

[6] For a description of financing social security in developing countries see Puffert (1988) and Ginneken (2003), for example.

written as

$$\overbrace{R\Delta_B Y}^{\text{debt payment}} + \overbrace{\Delta_G Y}^{\text{government consumption}} + \tag{2}$$

$$\overbrace{\sum_{j=J_w+1}^{J}\sum_{se^p=F,\xi^p,\xi^k}\int_a \mu_j\left(a_j,\Phi_j\right)Pen_j}^{\text{pension payment}} + \overbrace{\sum_{j=J_w+1}^{J}\sum_{se^p=I,\xi^p,\xi^k}\int_a \mu_j\left(a_j,\Phi_j\right)T_j}^{\text{transfer payment}}$$

$$= \overbrace{\sum_{j,\xi^p,\xi^k}\int_a \mu_j^i\left(a_j,\Phi_j\right)w^F\left(1-l_j\right)e_j^F\tau_L^F}^{\text{formal sector labor income tax revenue}} + \overbrace{\sum_{j,a,\xi^p,\xi^k}\int_a \mu_j^i\left(a_j,\Phi_j\right)w^F\left(1-l_j\right)e_j^F\tau_{SS}}^{\text{formal sector social security tax revenue}} +$$

$$\overbrace{\sum_{j,se^p,se^k,\xi^p,\xi^k}\int_a \mu_j\left(a_j,\Phi_j\right)a_j\left(a_j,\Phi_j\right)\tau_K}^{\text{capital income tax revenue}} + \overbrace{\sum_{j,se^p,se^k,\xi^p,\xi^k}\int_a \mu_j\left(a_j,\Phi_j\right)c_j\left(a_j,\Phi_j\right)\tau_C}^{\text{consumption tax revenue}} +$$

$$\overbrace{\sum_{j,se^p,se^k,\xi^p=\xi^k=0}\int_a \upsilon_j a_j\left(a_j,\Phi_j\right)}^{\text{accidental bequest revenue}} + \overbrace{\left(1+n\right)\left(1+g\right)\Delta_B Y}^{\text{borrowing}},$$

where g is an exogenous output growth rate.

2.8 Household problem

2.8.1 Household composition

Since individuals face mortality shocks, the demographic structure of a household can change every period. Households are therefore classified into one of three groups: Group 1− households are made up of parents and children, Group 2 − households consist of parents only, and Group 3− households consist of economically active children only.

Let g_j denote the demographic state of a household at age j so that $g_j = \{1,\ 2,\ \text{or } 3\}$. Let $\Omega\left(g_j, g_{j+1}\right)$ be a matrix of transition probabilities between the demographic states of households aged j to age $j+1$

$$\Omega\left(g_j, g_{j+1}\right) = \begin{bmatrix} sp_{J+j}^p sp_j^k & sp_{J+j}^p\left(1-sp_j^k\right) & (1-sp_{J+j}^p)sp_j^k \\ 0 & sp_{J+j}^p & 0 \\ 0 & 0 & sp_j^k \end{bmatrix},$$

where and sp_{J+j}^p and sp_j^k are survival probabilities of parents and children (i.e. kids), respectively. A household of group 1 where both parents and children are alive can become a household of group 2 if all children die, which happens with probability $\Omega\left(g_j = 1, g_{j+1} = 2\right) = sp_{J+j}^p\left(1-sp_j^k\right)$. Similarly, a household of group 1 can become a household of group 3 if parents die. The corresponding transition probability is $\Omega\left(g_j = 1, g_{j+1} = 3\right) = \left(1-sp_{J+j}^p\right)sp_j^k$. The parent-only and child-only households of group 2 and 3 cannot change their type to group

1 but they can remain in group 2 and 3 if they survive into the next period. [7]

If parents and children survive, they pool resources and solve a joint utility maximization problem.[8] If children do not survive, parents run households of their own and the family line stops after the parents have died. If parents die early, children take over and become a child-only household. At age $J+1$, children themselves become new parents and start a new household with their own children. They again pool their resources and jointly solve a new household optimization problem.

2.8.2 Household budget

Individual members of the household have idiosyncratic incomes depending on their time spent at work, their age-dependent labor productivity and their employment sector. The income of economically active children at age j is defined as

$$y_j^k = \begin{cases} \left(1-\tau_L^F-\tau_{SS}\right)\left(1-l_j^k\right)e_j^k w_j^F & \text{if } se^k = F, \\ \\ \left(1-l_j^k\right)e_j^k w_j^I - \varrho_j\left(a_j\right) & \text{if } se^k = I. \end{cases}$$

Expression $(1-l^k)$ denotes labor supply, e_j^k is the age-dependent labor efficiency unit, and $h_j^k = \left(1-l_j^k\right)e_j^k$ is the effective labor or human capital of the child. Pretax labor earnings income at age j is given by $\left(1-l_j^k\right)e_j^k w_j^{se}$. If the children work in the formal sector they are required to pay labor taxes τ_L^F and social security taxes τ_{SS}. If they work in the informal sector they do not have to pay any labor income tax but face "shadow" costs $\varrho_j\left(a_j\right)$. We assume that these costs are a function of a household's asset holdings with $\varrho' > 0$ and $\varrho'' < 0$. We interpret ϱ_j as penalties for informal activities. It is documented that informal firms very often have to surrender a considerable part of their output and capital stock.[9]

[7] Note that we only rely on demographic shocks to generate household heterogeneity in terms of demographic structures. One could complicate the sources of shocks to include other economic and social factors i.e. immigration.

[8] This is the simplest way to incorporate two-sided altruism. If we assume that parents and children maximize different objective functions, a strategic game between parents and children will arise. Solving models that incorporate such games requires a more complicated solution technique. Nishiyama (2002) provides more details on this.

[9] De Soto (1989), for instance, reports that informal entrepreneurs pay between 10 to 15 percent of their gross income on bribes.

The income of parents y^p_{J+j} includes wage income and pensions and is defined as

$$y^p_{J+j} = \begin{cases} \begin{cases} \left(1-\tau^F_L-\tau_{SS}\right)\left(1-l^p_{J+j}\right)e^p_{J+j}w^F_j & \text{if } J+j \le J_w \\ \left(1-l^p_{J+j}\right)e^p_{J+j}w^I_j + Pen_{J+j} & \text{if } J+j > J_w \end{cases} & \text{if } se^p = F, \\ \begin{cases} \left(1-l^p_{J+j}\right)e^I_{J+j}w^I_j - \varrho_j\left(a_j\right) & \text{if } J+j \le J_w \\ \left(1-l^p_{J+j}\right)e^p_{J+j}w^I_j - \varrho_j\left(a_j\right) + T_{J+j} & \text{if } J+j > J_w \end{cases} & \text{if } se^p = I, \end{cases}$$

where $\left(1-\tau^F_L-\tau_{SS}\right)\left(1-l^p_{J+j}\right)e^p_{J+j}w^F_j$ is the after tax labor income if parents work in the formal sector. When parents reach their mandatory retirement age, they have to retire and become eligible to receive pensions Pen_{J+j}. After retirement they can choose to work in the informal sector. Hence, the labor and pension income of a formal sector retiree is given by $\left(1-l^p_{J+j}\right)e^p_{J+j}w^I_j + Pen_{J+j}$. Workers can decide to not participate in the labor market, in which cases $\left(1-l^p_{J+j}\right)=0$.

Informal sector workers can work as long as they are alive. Our policy experiment assumes that when informal sector workers are older than the mandatory minimum retirement age, they receive additional income from a social pension program T_{J+j} so that their total income becomes $\left(1-l^p_{J+j}\right)e^p_{J+j}w^I_j + T_{J+j}$.

Let ξ^k_j denote an index function that is equal to $m=(1+n)^J$ if children are alive and 0 otherwise[10] and let ξ^p_j denote an index function equal to 1 if parents are alive and 0 otherwise. Let a_j denote the household's asset holding at the beginning of age j and a_{j+1} is the asset holding in the next period. Let g denote the exogenous economic growth rate, which is the same for both sectors. The household income is then the sum of all household members' incomes and savings. The growth-adjusted household budget constraint is given by

$$\left(1+\tau_C\right)\left(\xi^k_j c^k_j + \xi^p_j c^p_{J+j}\right) + \left(1+g\right)a_{j+1} = Ra_j + \xi^p_j y^p_j + \xi^k_j y^k_{J+j}, \text{ for } j=1,...J. \tag{3}$$

We restrict leisure of parents and children to be between $0 < l^p_j, l^k_j \le 1$. When $l=1$, individuals choose not to work. In addition, we assume that households face a borrowing constraint so that $a_j \ge 0$.

2.8.3 Recursive formulation

The state vector of a household within a dynasty includes initial assets (i.e. bequests received from the previous household in the dynasty), skill endowments, the working sector of the parents, and the job offer status (i.e. whether formal sector work is available). The household

[10] We assume that all children of a family either survive or die. A more satisfactory assumption is to allow heterogenous survival probabilities. However, this requires a more complex computational technique.

then chooses the working sector of the children and sequences of consumption, leisure and savings to maximize utility each period. Let $V_1(a_1, \Phi_1)$ be the value function of the household at age 1 given assets a_1 and state vector $\Phi_1 = \left\{sk^p, sk^k, se^p, \xi_1^p, \xi_1^k, \varkappa\right\}$ where sk^p is the skill type of the parent, sk^k is the skill type of the child, se^p the parent's working sector, ξ_1^p and ξ_1^k are indicator variables that fix the demographic structure of the household, and $\varkappa = 1$ if the household receives a formal sector job offer and $\varkappa = 0$ otherwise.

We break the household decision problem into two parts. First, households who have received a job offer can choose the work sector for their children when they become economically active at age $j = 1$. Households without a formal sector job offer have to send their children to work in the informal sector. The occupational choice for the children in a household with a job offer is given by

$$V_1(a_1, \Phi_1) = \max_{\{se^k\}} \left\{ V_1^{se^k=I}\left(a_1, \Phi_1, se^k = I\right), V_1^{se^k=F}\left(a_1, \Phi_1, se^k = F\right)\right\}, \tag{4}$$

where $V_1^{se^k=F}\left(a_1, \Phi_1, se^k = F\right)$ is the first period value function of a household with children working in the formal sector and $V_1^{se^k=I}\left(a_1, \Phi_1, se^k = I\right)$ is the same value function when children decide to work in the informal sector.

In the second part, the household has to solve for consumption, labor and savings of its members contingent on the sector choice of their children denoted $se^k = \{F, I\}$ so that the value function of an age j household is $V_j\left(a_j, \Phi_j^{se^k}\right)$ where again $\Phi_j^{se^k} = \left\{sk^p, sk^k, se^p, se^k, \xi_j^p, \xi_j^k\right\}$. The household problem of this second part of the decision problem can be defined recursively in terms of a Bellman equation as

$$V_j\left(a_j, \Phi_j^{se^k}\right) = \max_{\left\{c_j^k, l_j^k, c_{J+j}^p, l_{J+j}^p, a_{j+1}\right\}} \left\{\xi^k u\left(c_j^k, l_j^k\right) + \xi^p u\left(c_{J+j}^p l_{J+j}^p\right) + \beta EV_{j+1}\left(a_{j+1}, \Phi_{j+1}^{se^k}\right)\right\} \tag{5}$$

subject to the budget constraint, expression (3). Households face shocks to their demographic structure in each period as expressed by the Markov switching matrix $\Omega(g_j, g_{j+1})$. The expected value function EV_{j+1} in expression (5) is therefore defined as

$$EV_{j+1}\left(a_{j+1}, \Phi_{j+1}^{se^k}\right) = \sum_{g_{j+1}=1}^{3} \Omega(g_j, g_{j+1}) V_{j+1}\left(a_{j+1}, \Phi_{j+1}^{se^k}\right) \quad \text{for } j = 2, .., J-1.$$

In the last period a household whose children are alive maximizes not only its utility of consumption and leisure of its current household members but values also the expected utilities of the next household in the dynasty. The household has therefore an incentive to leave bequests to surviving members. The expected value function EV_{J+1} depends on the realization of a skill shock, a shock to the demographic structure (parents or children may die), and the occupational choice of the future household. The skill shock only affects the newborn generation and determines the skill composition of the household that the newborn children form with their parents. The household skill composition is determined by a Markov switching matrix

$\Pi\left(sk^p, sk^k\right)$, where sk^p and sk^k indicate the skill type of the parent and the children respectively. The occupational choice of the newborn children has to be consistent with the expected occupational composition of the future household. This composition follows a stationary law of motion $\Pi\left(se^p, se^k\right)$ in equilibrium where se^p is the work sector of the parent and se^k is the work sector of the child. The expected value function EV_{J+1} is defined as

$$EV_{J+1}\left(a_1, \Phi_1\right) = \left\{ \sum_{se^k \in \{F,I\}} \Pi\left(se^p, se^k\right) \sum_{sk^k \in \{L,H\}} \Pi\left(sk^p, sk^k\right) \sum_{g_1=1}^{3} \Omega\left(g_J, g_1\right) \times \theta \times m \times V_1\left(a_1, \Phi_1\right), \right.$$

where θ is the degree of altruism and m is the number of children. If $\theta = 0$ then the current household does not care about the utility of the next household within a dynasty and the model becomes a pure life-cycle model. If $\theta > 0$, the current household does care about its surviving members and leaves (intended) bequests. The last period savings serve as the intended bequest, which is divided equally among the number of children so that the starting asset value of the next household in the dynasty is $a_1' = \frac{a_{J+1}}{m}$.

2.9 Firm problem

Firms in both sectors choose to rent physical and human capital to produce output. Given sectorial factor prices for labor w^{se} and capital q^{se}, where $se = \{F, I\}$, each firms' profit maximization problem becomes

$$\max_{\left(H^{se}, K^{se}\right)} \left\{ A^{se} \left(K^{se}\right)^{\alpha^{se}} \left(H^{se}\right)^{1-\alpha^{se}} - w^{se} H^{se} - q^{se} K^{se} \right\}.$$

2.10 Recursive competitive equilibrium

Definition 1 *Given realizations of initial assets, the parent's working sector se^p, skill inheritance probabilities Π, job offer technology $\varkappa$, demographic structure $\left\{\xi_j^p, \xi_j^k\right\}$, the family type transition probability matrix Ω, and government policies $\left\{\tau_C, \tau_L^F, \tau_{ss}, \tau_K, \Delta_G, \Delta_B, Pen, T\right\}$, a stationary recursive competitive equilibrium is a collection of value functions $\left\{V_j\left(a_j, \Phi_j\right)\right\}_{j=1}^{J}$ with $\Phi_j = \left\{sk^p, sk^k, se^p, \xi_j^p, \xi_j^k, \varkappa\right\}$, household decision rules $\left\{se^k, l_{J+j}^p, l_{J+j}^p, c_j^k, l_j^k, a_{j+1}\right\}_{j=1}^{J}$, a collection of sequences of time invariant distributions $\left\{\mu_j\left(a_j, \Phi_j\right)\right\}_{j=1}^{J}$, sequences of aggregate stocks of physical capital and human capital $\left\{K^{se}, H^{se}\right\}$, and sequences of prices $\left\{w^{se}, q^{se}, R\right\}$ with $se = \{F, I\}$ such that*

(*i*) *household decision rules $\left\{se^k, l_{J+j}^p, l_{J+j}^p, c_j^k, l_j^k, a_{j+1}\right\}_{j=1}^{J}$ solve the household maximization problem* (4) *and* (5),

(*ii*) *firms solve the profit maximization problem so that factor prices are determined by*

$$\begin{aligned} w^F &= \left(1-\alpha^F\right) A^F \left(\frac{K^F}{H^F}\right)^{\alpha^F}, \\ w^I &= \left(1-\alpha^I\right) A^I \left(\frac{K^I}{H^I}\right)^{\alpha^I}, \\ q^F &= \alpha^F A^F \left(\frac{K^F}{H^F}\right)^{\alpha^F-1}, \\ q^I &= \alpha^I A^I \left(\frac{K^I}{H^I}\right)^{\alpha^I-1}, \end{aligned}$$

and the after-tax interest rate is determined by

$$R = (1-\tau_K)\left(q^F-\delta^F\right)+1 = (1-\tau_K)\left(q^I-\delta^I\right)+1,$$

(*iii*) *aggregate stocks of wealth, physical capital, saving, consumption, and human capital are given by*

$$\begin{aligned} A &= \sum_{j,se^p,se^k,\xi^p,\xi^k} \int_a \mu_j\left(a_j,\Phi_j\right) a_j\left(a_j,\Phi_j\right) + \sum_{j,se^p,se^k,\xi^p=\xi^k=0} \int_a \upsilon_j\left(a_j,\Phi_j\right) a_j\left(a_j,\Phi_j\right), \\ K &= A-B, \\ S &= \sum_{j,se^p,se^k,\xi^p,\xi^k} \int_a \mu_j\left(a_j,\Phi_j\right) a_{j+1}\left(a_j,\Phi_j\right), \\ C &= \sum_{j,se^p,se^k,\xi^p,\xi^k} \int_a \mu_j\left(a_j,\Phi_j\right) c_j\left(a_j,\Phi_j\right), \\ H^I &= \sum_{j,se^p,se^k,\xi^p,\xi^k} \int_a \mu_j\left(a_j,\Phi_j\right)(1-l_j)e_j^I, \\ H^F &= \sum_{j,se^p,se^k,\xi^p,\xi^k} \int_a \mu_j\left(a_j,\Phi_j\right)(1-l_j)e_j^F, \end{aligned}$$

(*iv*) *commodity markets clear*

$$C+(1+g)S+\Delta_G Y = Y+\sum_{se\in\{I,F\}}\left(1-\delta^{se}\right)K^{se},$$

(*v*) *the government budget constraint* (2) *holds*

(*vi*) *and the time invariant distribution satisfies*

$$\mu_1(a_1,\Phi_1) = \sum_{se^{p\prime}=k=\{I,F\}}\sum_{\xi^{p\prime},\xi^{k\prime}}\int_a \Pi\left(se^{p\prime},se^{k\prime}\right)\Omega(g_1,g_J)\,\mu_J(a_J,\Phi_J),$$

$$\mu_{j+1}(a_{j+1},\Phi_{j+1}) = \sum_{\xi^p,\xi^k}\int_a \Omega(g_j,g_{j+1})\,\mu_j(a_j,\Phi_j), \quad for\ j=1,...,J-1.$$

3 Calibration

Solutions to the model as well as algorithms are presented in a technical appendix.[11] We use parameters reported in table 1 to calibrate the benchmark steady state economy to match data from Brazil in the late 1990*s*. We choose Brazil for two reasons. First, in Brazil the poverty rate among the elderly is high. About 27 percent of the population lives on two dollars or less. One third of them are individuals older than 65 according to Secretariat (2009). Second, Brazil has been implementing a social pension program for years; and third, Brazil is a middle income emerging economy with reasonably good availability of data. Model outcomes and data comparisons are reported in table 2. In the following we will discuss the parameter selection.

3.1 Production Technology

Estimates of α for developing countries are higher than in developed countries. Ferreira and do Nascimento (2005) use $\alpha = 0.4$ to match the Brazilian economy. We are not aware of estimates relating the capital shares used in the formal and informal sectors separately. However, the informal sector is generally documented as a more labor intensive sector so that the income share of capital is smaller than in the formal sector. We calibrate the income shares of capital in the formal and informal sectors as $\alpha^F = 0.4$ and $\alpha^I = 0.25$ in the benchmark economy. We then conduct sensitivity analysis on the capital income share of the informal sector. The depreciation rate is assumed to be 5 percent annually for both sectors which is similar to the one sector model in Feu (2004) or Ferreira and do Nascimento (2005).

To the best of our knowledge there is no estimate comparing the levels of total factor productivity (TFP) in the informal sector to TFP in the formal sector. Since it is widely documented that in developing countries "traditional" technology with lower productivity is commonly used in the informal sector while "modern" technology is used in the formal sector (Dessy and Pallage (2003)) we feel comfortable applying the restriction $A^I < A^F$. That is, the formal sector is more efficient. We then normalize A^F to 1 and calibrate A^I so that the share of informal sector output in GDP is 25%, which is close to the estimated range for Brazil in Friedman et al. (2000) who report a lower bound of 29%.

The annual growth rate in Brazil was around 8.6% in the 1970*s*, dropped down to around 1.6% in the 1980*s*, and then went up again to 2.65% in the 1990*s*.[12] In the model, we therefore

[11] The technical appendix is available on the authors' website.

[12] See the report on GDP, growth and employment at http://www.brazil.org.uk/economy/gdp.html

choose an exogenous real annual growth rate $g = 2.65\%$.

3.2 Demographics

We assume that individuals are born at age 20 and become immediately economically active. Since survival rates are relatively small after the age of 90, we assume that individuals die at age 90. To reduce the computational burden, we pick the model period to be 5 years. This restriction implies that individual lifetime is 14 periods, composed of 9 working periods (equivalent to 45 years) and 5 retirement periods (equivalent to 25 years). In other words, agents retire at age 65, which is close to Brazil's average retirement age of 63 reported in Queiroz (2005). In the model we completely abstract from early retirement issues of the young generation (i.e. children).[13]

Survival probabilities are taken from the life tables published by the World Health Organization.[14] We adjust annual rates to 5 year period rates in our model. We do not have separate survival probabilities for formal and informal sector workers in Brazil. As documented in the health economics literature, less educated or low skilled workers have lower survival probabilities than more educated or high skilled workers. We therefore adjust the life-table survival probabilities and lower the survival probabilities of low skilled workers by 2 percent and increase the survival probabilities of high skilled workers by 0.5 percent.[15]

In the model, we assume that the population grows at a constant rate which together with the survival probabilities results in a stable demographic structure. According to Ferreira (2005) the average annual population growth rate over the last 20 years from 1980 to 2000 is 1.79%. We therefore pick a growth rate $n = 0.018$ resulting in $m = 1.5631$ children per individual in the model.

3.3 Preferences

We assume additive preferences in consumption and leisure so that

$$u\left(c_j, l_j\right) = \begin{cases} \frac{c_j^{1-\sigma}}{1-\sigma} & \text{for } j = 1, ..., J \\ \frac{c_j^{1-\sigma}}{1-\sigma} + \kappa \log l_j & \text{for } j = J+1, ..., 2J. \end{cases}$$

In our benchmark model, we restrict the utility of consumption to be of log form ($\sigma = 1$) in order to fulfil the condition for balanced growth as suggested in King, Plosser and Rebelo (2001).[16] We do not know any estimate for the parameter governing the intertemporal elasticity

[13] Generous pensions and early retirement are highly correlated in Brazil, especially in the public sector. See Glomm, Jung and Tran (2009) for more details on this issue.

[14] Visit http://www.who.int/whosis/database/life/life_tables/life_tables_process.cfm?country=bra&language=en

[15] We also conducted a sensitivity analysis with different assumptions on survival probabilities and find that our results are robust to these changes.

[16] Estimates of the parameter of intertemporal elasticity of substitution σ for Brazil vary from 1 to 5 (see Issler and Piqueira (2000) and Soriano and Nakane (2003)). Fuster, Imrohoroglu and Imrohoroglu (2007) use $\sigma = 4$ in a similar model with altruism. In our sensitivity analysis, we choose $\sigma = \{2 \text{ and } 4\}$ while assuming inelastic labor supply $\kappa = 0$.

of leisure in Brazil. Following previous studies, we therefore choose the log utility function.

Since we are interested in modelling the labor supply of the elderly in developing countries, we abstract from labor supply issues of the young and assume that children supply labor inelastically. This assumption implies that the weight of leisure of young household members is $\kappa = 0$ for $j = 1, ..., J$. We calibrate the exogenous labor supply of young agents to match average weekly working hours. On the other hand, we assume that parents supply labor elastically so that working hours and retirement age are endogenously determined. We calibrate parameter κ to match the average labor supply of the elderly and average retirement age.

Discount factor β and altruism factor θ are free parameters. One may calibrate either β or θ, or both to match the capital-output ratio. Fuster, Imrohoroglu and Imrohoroglu (2003) choose $\theta = 1$ and calibrate $\beta = 0.97$ (annual discount factor) to match the capital-output ratio. Nishiyama (2002) calibrates both β and θ. We follow the first approach and fix $\theta = 1$. We then adjust β to match the capital-output ratio.

3.4 Skill inheritance, sector mobility, and informality cost

Filho and Scorzafave (2009) report that around 47 percent of the Brazilian labor force in 2001 have high school education or higher. Bourguignon, Ferreira and Menendez (2007) find a strong correlation between parental schooling years and child schooling years in Brazil. We therefore assume that the probabilities for skill inheritance are $\pi_{L,L} = 0.8$, $\pi_{L,H} = 0.2$, $\pi_{H,L} = 0.2$, and $\pi_{H,H} = 0.8$ in expression (1) . This results in 50 percent of the work force being high skilled and 50 percent being low skilled. In addition we assume that 80 percent of the new born agents that inherit high skills from their parents get a job offer from the formal sector, while only 20 percent of low skilled types receive such an offer. Only these agents will be able to choose their working sector. This is consistent with Telles (1992) who reports that less educated individuals tend to work in the informal sector in Brazil.

We assume the informality cost function is $\varrho_j = \delta_1 a_j^{\delta_2} - \delta_0 a_j$. The size of the informal sector in terms of employment and relative size of GDP varies across countries. According to Giambiagi and Mello (2006) the coverage of social security in Brazil is around 50 percent in 2005. In our benchmark calibration, we let agents endogenously decide on their occupation and therefore calibrate parameters $\{\delta_0 = .045,\ \delta_1 = .014,\ \delta_2 = 2.2\}$ so that 50 percent of the labor force decides to work in the informal sector.

3.5 Lifetime efficiency units and labor earnings profiles

Turra and Queiroz (2005) report labor income of household heads by age and level of education in Brazil. Ferreira, Lanjouw and Neri (2003) report the distribution of the labor force by educational levels. We combine their estimates to construct labor income profiles for formal and informal sector workers.

We calibrate the labor efficiency profile so that we match the labor earnings profiles as well as the average income ratio between informal and formal sector workers in Brazil. In our model

the average labor income ratio between informal and formal sector workers is around 56 percent, which is in the range reported in Gindling and Terrell (2004) and Marcouiller, de Castilla and Woodruff (1997). We graph the income-age profiles of informal and formal sector workers in figure 1.[17]

3.6 Government and fiscal policy

In Brazil, total tax revenue is about 30 percent of GDP in 1998, with social security tax revenue contributing almost 5 percent (see Ferreira (2005)). We calibrate tax rates to match this size of government. In the model, the government taxes labor income of formal sector workers. The labor tax in the formal sector is $\tau_L^F = 20$ percent. According to Palacious and Pallares-Mirallets (2000), effective payroll taxes for pensions are between 7 to 12 percent of total labor cost in developing countries. In our calibration, the social security tax applies to labor income of formal sector employees and is set to 11 percent to match the share of social security tax revenue in terms of GDP. The capital income tax rate is set to 21 percent. The proportional consumption tax rate is around 15 percent which is close to the one reported in Immervoll et al. (2006). In the model, either consumption tax, formal sector labor income tax, or capital income tax adjust to balance the government budget every period.

In the benchmark economy there is no social pension available to the elderly in the informal sector. Note that the size of formal sector employment coincides with the fraction of social security coverage in our model. The social security trust fund is not independent from the government budget. As reported in Palacious and Pallares-Mirallets (2000), the average pension as a share of average wage ranges from 35 percent to 60 percent. Since Brazil has a very generous pension program, we choose the replacement rate for pension payments Ψ^F to match social security payments as a fraction of GDP. Our hypothetical replacement rate Ψ^F is 60 percent of the average labor income of pre-retirement employment and results in the social security program to be around 4.4 percent of GDP. Ferreira (2005) reports that social security spending made up 5.06 percent of GDP.

We assume that government borrows a fixed fraction of GDP each period. This assumption isolates our results from debt-financing effects. We calibrate the ratio of government borrowing to GDP to be 5 percent which is close to the average in the data between 1995 and 2000. Residual government consumption is 25 percent of GDP which matches the data. Government consumption plays no further role in the model as it is unproductive.

4 Results

In this section, we first present the calibration result of the benchmark model without the reform and discuss how our model matches the data. Next, we specify and discuss a variety of implementations of the social pension program for informal sector retirees on market aggregates and welfare in the context of developing countries. In addition, we isolate the effects of (i)

[17] The technical appendix contains the efficiency profiles that were used as a basis for the income profiles.

partial vs. general equilibrium models, (*ii*) the role of occupational choice between formal and informal sector employment, (*iii*) alternative tax revenue sources to finance the reform, (*iv*) the role of technology differences in formal and informal sectors, (*v*) the role of low skilled labor in the informal sector, and finally (*vi*) the role of bequests within a dynasty. We will point out important differences to the existing literature on pension reform as we discuss our results in detail.

4.1 Benchmark economy

Our pre-reform benchmark model economy is able to match key features of the Brazilian economy. We summarize our calibration results in table 2.

4.2 Introducing a social pension program

We start the benchmark economy without a social pension program for informal sector workers and calibrate this version to the economy of Brazil. We then assume that the government introduces a social pension program to all informal sector workers who are 65 and older. The generosity of the social pension program is reflected in the magnitude of the replacement rate Ψ^I. In our first policy experiment we assume that the government can finance the social pension program using revenue from consumption taxes.

Previous studies concentrate on developed countries and usually assume that the governments use a payroll tax or a labor income tax to finance social security payments (e.g. Imrohoroglu, Imrohoroglu and Joines (1995)). In developing countries, however, financing social security is quite different (see Puffert (1988) and Ginneken (2003)). First, social security funds are usually not independent of the general government budget. In developing countries many governments use surplus from social security funds to finance government budget deficits whereas other countries need to heavily subsidize social security programs from general tax revenue. Second, governments in developing countries have very limited capacity to raise labor income taxes to finance an expansion of social security systems. Consumption taxes including tariffs are therefore a major source of government revenue.

We consider three alternative policy reforms: Reform A with replacement rate $\Psi^I = 0.25$, Reform B with replacement rate $\Psi^I = 0.5$, and Reform C with replacement rate $\Psi^I = 0.75$. We report the effects on key aggregate variables and welfare in tables 3 and 5.[18]

4.2.1 Occupational choice and labor supply

In our model agents with formal sector job offers can choose between formal or informal sector work by weighing the costs and benefits of "informality". The introduction of a social pension program makes informal sector jobs more attractive which induces more high skilled agents to choose informal sector employment. Row 7 in table 3 shows that a social pension program with

[18] Note that we normalize the results of the pre-reform benchmark economy to 100 which allows for easy comparison with results from the post-reform steady states.

a 0.25 replacement rate increases the number of informal sector workers from 50 to 52 percent of the entire workforce. A more generous social pension with a replacement rate of 0.5 or 0.75 increases the workforce in the informal sector from 50 to 54 percent or 56 percent, respectively.

The introduction of the social pension program also affects the labor market behavior of informal sector workers. The average labor supply of informal sector workers N_1 drops by more than 1 percent when increasing the replacement rate to 0.75 (compare row 9 in table 3). The top panel of figure 2 reports changes in the labor force participation rate of informal sector workers. After the introduction of the social pension program the participation rate of informal sector workers drops significantly. Without the reform some informal sector workers stay in the labor force until age 90. The social pension program on the other hand ensures that no worker works beyond age 80. This is consistent with the finding by Filho (2008) that access to old-age benefits is a strong determinant of retirement of rural workers in Brazil after the social pension reform 1991. The bottom panel in figure 2 shows the change in the labor supply of informal sector workers. The intuition is straightforward. Without a social pension the elderly in the informal sector have to work more (intensive margin) and longer (extensive margin) to support their consumption. After the reform they have additional income from government transfers and they supply less labor. The average labor supply of formal sector workers also decreases slightly. Overall, the aggregate labor supply N declines by half a percent after the introduction of a social pension with a 50 percent replacement rate (compare row 8 in table 3).

4.2.2 Savings and capital accumulation

It is well documented that social insurance crowds out precautionary savings. In our framework, the introduction of a social pension program discourages people to save for two reasons. First, the social pension program redistributes income from the young with high propensity to save to the poor elderly with low propensity to save. Second, taxes used to finance the program distort the consumption-savings behavior directly by changing the relative price of the two. Consequently, this leads to a lower level of capital stock. The decreases in aggregate capital stock K are reported in row four of table 3. The introduction of a social pension program with a 25 percent replacement rate (Reform A) reduces aggregate capital stock by over 2 percent in the long run. If the program pays out more generously (e.g. Reform C has a replacement rate of $\Psi^I = 0.75$) the distortions are larger and aggregate capital stock decreases by almost 6 percent in the long run.

The crowding-out effect on capital accumulation is relatively small in comparison to previous studies on social security reform (e.g. Auerbach and Kotlikoff (1987) and Imrohoroglu, Imrohoroglu and Jones (1995)) due to two reasons. First, the social pension program is targeted to a relatively small group of the elderly population so that its size is relatively small. This leads to smaller distortions in the economy than in studies that analyzed a general expansion of social security to all elderly individuals. Second, as established in Fuster (1999) and Fuster, Imrohoroglu and Imrohoroglu (2003), the bequest motive mitigates the decrease in savings as the savings incentives are generally stronger in models with intentional bequests. Our results

from a model with intentional bequests reflect this whereas other studies on social security reform have abstracted from intentional bequests.

4.2.3 The role of the informal sector

The introduction of a social pension program results in two adverse efficiency effects. First, *crowding out effects* lower the stocks of physical capital and human capital. Second, *allocative effects* are responsible for the transfer of production factors from the formal sector with high TFP to the informal sector with low TFP. Crowding out effects are extensively analyzed in the literature on general equilibrium analysis of social security in developed countries. Auerbach and Kotlikoff (1987) is a seminal contribution in quantifying this type of efficiency loss. The analysis of allocative effects is relatively new and can only be tracked in a two sector model with endogenous sector choice. Loayza (1996) is an example of a model that incorporates an informal sector in a Barro style growth model and finds that the optimal tax rate is much lower when allocative effects are at work since they tend to amplify tax distortions.

This is also the case in our model environment where the presence of a sizeable informal sector amplifies the distortions caused by the social security program. Since the introduction of a social pension program to informal sector workers makes working in the informal sector more attractive, it distorts the allocation of resources across the two sectors. First, the social pension program affects the allocation of skills and time between the two production sectors. As a consequence, more human capital is concentrated in the informal sector after the reform. When the government increases the replacement rate of the social pension to 0.5 (Reform B), human capital in the informal sector H_1 increases by 6.5 percent while human capital in the formal sector H_2 decreases by over 8 percent (row twelve and thirteen in table 3). Overall, aggregate human capital H declines by almost 3 percent as a result of the reduced labor supply of the elderly (allocative effects). Second, changes in the allocation of human capital across sectors affect the marginal product of physical capital, which in return distorts its allocation across the two sectors. Higher concentration of human capital in the informal sector leads to a higher marginal product of physical capital which increases the flow of physical capital into the less productive informal sector. When the government increases the replacement rate for the social pension payment to 0.5, capital stock in the informal sector K_1 increases by 7 percent while capital stock in the formal sector K_2 decreases by over 8 percent; and overall capital stock K decreases by almost 4 percent (crowding out effect).

As a consequence the share of output contributed by the informal sector Y_1 increases while the share of output contributed by the formal sector Y_2 declines. Overall, the efficiency loss is sizable. With a 0.5 replacement rate the social pension program reduces steady state output by around 4 percent. If the program is more generous as in Reform C (i.e. a 75 percent replacement rate) then output drops by almost 6 percent (row one in table 3).

4.2.4 Social insurance and family transfers

There are two types of private intergenerational transfers in our model: (i) inter-vivos transfers within a household from parents to children and vice versa and (ii) bequests from household to household within a dynasty. These transfers act as informal credit and insurance markets that allow agents to smooth consumption over the life cycle. Inter-vivos transfers lessen the borrowing constraint of young agents so that individuals are able to consume more when young. Intentional bequests insure the consumption of parents and children against income and longevity shocks so that intergenerational transfers work as informal safety net (see also Chetty and Looney (2006) for a discussion of social safety nets in low-income economies).

The extension of a formal insurance system to the informal sector will crowd out existing intra family transfers. To quantify these effects we calculate changes in bequests by household type in table 4 and observe both, negative crowding-out effects and positive crowding-in effects on intergenerational bequests.

Bequests increase for households of type $G1 : I, I$ – where both parents and children are informal sector workers (first row in table 4). The introduction of a social pension program has a direct effect on the income of old parents in the informal sector. Holding other variables constant, the income of old parents increases and so does the overall income of the household. As a consequence, parents leave more bequests to their children (positive effect). On the other hand, the program raises the future income of children because current "informal sector" children will become recipients of a social pension when they themselves turn old. This results in a disincentive to leave bequests (negative effect) as current parents' account for these future gains of their children when optimizing the bequest decision. Whenever the positive effect is dominant, current households will increase their bequests. Row one in table 4 shows that bequests increase by 2 percent when the replacement rate is 0.25, by almost 6 percent when the replacement rate is 0.5 and by over 10 percent when the replacement rate is 0.75. In all three cases a consumption tax is used to finance the program.

For households $G1 : I, F$ – parents work in the informal sector, children work in the formal sector – bequests also increase (row 2 in table 4). That is, the current household with older members (i.e. a parent) receiving a social pension has an incentive to increase bequests to offset the negative effect on younger members (children) who will not receive the additional social pension when they are old but have to pay a higher consumption tax in the future (positive effect). On the other hand, since the social pension crowds out the labor supply of old parents, their labor earnings decline. Moreover, efficiency losses due to declines in aggregate capital stock and labor supply lower individual income which decreases bequests (negative effect). Adding positive and negative effects our results show that bequests for this family type can increase by 20 percent when a 75 percent replacement rate is in place (Reform C).

For households $G1 : F, I$ – parents work in the formal sector, children work in the informal sector – bequests decrease. The "formal sector" parents, who do not benefit from the social pension program but who have to pay for it, cut bequests to their "informal sector" children who will benefit from the program in the future. The introduction of a social pension with 0.75

replacement rate decreases bequests by a sizeable amount (4 percent). For households $G1 : F, F$ – parents and children work in the formal sector – bequests increase when the social pension program is small (see Reform A in row 4 of table 4). However, when the program becomes more generous (Reform C) then distortions become stronger and the household reduces bequests by almost 1 percent compared to the benchmark level.

At the aggregate level, bequests increase when the government finances the social pension program with consumption taxes (crowding in effect). This implies that private intergenerational transfers respond to changes in public social insurance. These bequest adjustments mitigate some of the adverse effects of social pension programs on savings and capital accumulation and partially explain why the distortions in our model are smaller than in models without bequests.

4.2.5 Welfare

Improvements in risk sharing increases welfare but negative efficiency effects (i.e. tax distortions and factor misallocations etc.) decrease income and therefore welfare. The welfare benefits of social insurance financed by progressive taxes has been analyzed in the literature early on (e.g. Varian (1980)). In an incomplete market model of risk sharing, there will be positive demand for social insurance. However, how much social insurance should be provided through the progressive tax system depends on uncertainty, individual risk aversion and the available private insurance market structure as discussed in Low and Maldoom (2004) and Krueger and Perri (2011). The optimal progressive tax-transfer system efficiently trades off the benefits from redistribution and risk-sharing with the costs from market distortions. In the context of a developing country it is likely that the existing tax-transfer system is far from such an optimal system. The introduction of social pension programs makes the tax-transfer system more progressive, i.e. the social pension program redistributes income from high skilled formal sector workers to low skilled informal sector workers. This can potentially result in welfare gains if negative efficiency distortions do not get out of hand.

We summarize the welfare effects across the various household types in table 5. Note that we use the value functions of newly established households, i.e. the expected utility of household at age 1 as a measure of welfare similar to Fuster, Imrohoroglu and Imrohoroglu (2003). Households are classified by their demographic structure and the composition of the working sectors of the household members. The population share of the various household types in the benchmark economy model are reported in parentheses in the first column of table 5. We normalize the welfare measure of every group in the benchmark model to 100. Household welfare under alternative policies are also normalized with respect to the welfare result of the benchmark regime. This allows for easy comparison.

We identify the following opposing forces driving the welfare effects. On the negative side, the social pension program distorts savings, occupational choice, labor supply, and the allocation of resources, which all result in efficiency loss that reduce welfare. On the positive side, the introduction of a social pension program provides an important instrument to insure

against longevity and income shocks across households and generations. When individuals are risk averse the insurance function of the social pension program increases welfare.

Furthermore, the additional redistribution of wealth via the social pension program directly improves the welfare of its recipients. The magnitude of these effects depends on the progressiveness of the financing instrument. Finally, the social pension program makes retirement more affordable to the very old whose marginal utility of leisure is very high. The welfare effects vary across household types and change significantly with increasing generosity of the social pension program. Depending on the demographic structure and the working sector/skill composition, a household can experience welfare gains or losses. In general we find that the welfare effects are monotone over the range of policy parameter Ψ^I for all household types. In the following we discuss the welfare effects of reform B (a 50 percent replacement rate) over benchmark.

The welfare of parent-child households $G1 : I, I$ – parents are recipients of social pensions, as are children once they retire – increases with the generosity of the social pension program (compare row 1 in table 5). We find increases of up to 2.7 percent over benchmark.[19]

The welfare of parent-child households $G1 : I, F$ – parents are recipients of the social pension, but their children are not – increases after the reform is implemented. Cash transfers to parents in the informal sector increase household wealth, consumption and leisure (welfare increasing). On the other hand, higher taxes and distortions of savings and labor supply lower household income, especially the income of children working in the formal sector (welfare decreasing). The positive effects are dominant and become even stronger as the generosity of the social pension program increases so that welfare increases by up to 1.69 percent over benchmark.

The welfare of households $G1 : F, I$ – formal sector parents do not receive a social pension, informal sector children do receive a pension when they are old – decreases after the reform is implemented. Inter-generational links via operative bequests spread the income effects over the generations in the dynasty. An additional increase in transfer income of the future household creates a positive effect on the current household's welfare. However, this positive future effect needs to be time discounted and as parents in the current household suffer from paying a higher tax, this type of household experiences a welfare loss of up to 3.0 percent (see row 3 in table 5). For households $G1 : F, F$, where both parents and children work in the formal sector the negative welfare effects dominate as these households pay for the social pension program but do not receive any additional transfers from it.

For households $G2 : I$ – parents working in the informal sector having no more children – the welfare effect is remarkably strong. These households do not have family support from their children nor will they receive public pension payments in the benchmark economy. They rely entirely on their own savings to support their consumption when old and to insure them-

[19] In order to give the reader an impression about the magnitude of these possible welfare effects we also calculate compensating consumption as percent of all future income streams of a household and find that we could remove 1.2 percent of all future consumption streams from households in the new regime (with a 50 percent replacement rate) in order to make them indifferent to identical households in the benchmark economy without the social pension for informal sector retirees.

selves against longevity risk. The introduction of a social pension program gives them a great opportunity to smooth their consumption. The expected utility of this household increases by 41 percent in the economy with a 50 percent replacement rate compared to the economy without a social pension program.

For all other household types, $G2:F$ (parent only households working in the formal sector), $G3:I$ (child only household working in the informal sector), and $G3:F$ (child only household working in the formal sector) we report welfare losses. This is mainly due to the distortions created by the social pension program which lower household income. The introduction of a social pension program does not result in any additional benefits for households $G2:F$ and $G3:F$. On the other hand, the program creates a number of distortions such as lower wage rates, higher taxes, and higher consumption prices that lower income and welfare. For instance, households $G2:F$ will not receive benefits from the public pension program but have to live in a less efficient economy with higher taxes. The situation is similar for households of type $G3:I$. Although the household eventually receives the newly established transfers upon retirement, these future benefits are not large enough to compensate for the lower current income.

4.2.6 General vs. partial equilibrium analysis

There are many empirical and microeconomic studies in development economics evaluating the impacts of public transfer programs that do not account for general equilibrium (price adjustment) effects (e.g. Cox and Jimenez (1992), Cox and Jimenez (1995), and Jensen (2003)). In order to demonstrate the importance of general equilibrium effects we conduct a partial equilibrium analysis of an otherwise identical policy reform. We again start the benchmark economy without a social pension program for informal sector workers. We then fix wages, interest rates and tax rates at their initial steady state levels and introduce a social pension program to informal sector workers who are 65 and older with replacement rates of $\Psi^I = 0.25$, $\Psi^I = 0.50$ and $\Psi^I = 0.75$.

We report the welfare effects of these experiments in table 6 right next to the general equilibrium results that we have already discussed in the previous section. This comparison reveals the magnitude of price adjustment effects.

We find that the pattern of the welfare effects is qualitatively and quantitatively different across all household types. In a partial equilibrium environment where prices do not adjust, the magnitudes of the positive welfare effects are substantially larger than in the general equilibrium setup from the previous section. In addition, tax distortions are not fully realized as prices are held constant. As a consequence, the positive welfare effects of the reform are magnified so that all household types experience welfare gains in the partial equilibrium setup.

This result illustrates how important it is to account for general equilibrium effects as we saw earlier that some household types do in effect experience welfare losses mainly caused by negative efficiency effects from tax distortions. However, these effects are not picked up by the partial equilibrium analysis with fixed prices or by empirical studies that collect data a short time after policy reform have been implemented, which might result in misleading outcomes

and policy recommendation (see Acemoglu (2010) for a further discussion).

4.3 Alternative tax financing instruments

In the previous experiments we used a consumption tax to finance the expansion of the social insurance system. We next analyze the effects of alternatively using labor income or capital taxes to finance the reform. The changes in aggregate variables and welfare by family type are reported in tables 7 and 8.

We want to emphasize two points. First, we would like to analyze which financing instrument results in the lowest efficiency cost. Second, there is a large literature emphasizing the welfare benefits of progressive tax systems (e.g. Varian (1980)). Understanding how the choice of tax financing instrument affects the progressiveness of the entire tax system is important to understand the trade off between positive insurance and negative efficiency effects on welfare.

Efficiency. Using labor income or capital income taxes to finance the reform introduces much larger efficiency losses compared to using a consumption tax. The adverse effects vary substantially between the financing alternatives. As shown in row 4 of table 7 capital stock drops by roughly 4, 15, and 25 percent using a consumption tax, a labor income tax, or a capital income tax respectively to finance the social pension with a 50 percent replacement rate (Reform B) . Similarly output decreases by 4, 15, and 16 percent respectively (compare row 1 in table 7). Labor supply drops by a large amount if a labor tax is used to finance the reform. This is not surprising as labor taxes directly affect the labor leisure choice (see also Fiorito and Padrini (2000)). The overall distortionary effects, however, are the largest when a capital income tax is used to finance the extension and the smallest when consumption taxes are used. This is not surprising as a capital tax has a direct adverse effect on the rate of capital accumulation which decreases output. Consumption taxes are spread over a larger population and have much smaller distortive effects in general.

Welfare. We still find welfare gains for households receiving the social pension benefits and welfare losses for households not receiving any social pension benefits when a labor income tax finances the reform. As discussed before, the efficiency loss is larger than in the benchmark consumption tax case. However, the labor income tax makes the tax-transfer system more progressive. That is, it taxes high income workers in the formal sector to pay the social benefits for low income workers in the informal sector. This strengthens the insurance- and redistribution function of the social pension program. The large welfare gains indicate that the insurance effects dominate the distortionary effects in this environment that lacks a formal risk sharing mechanism and exhibits high income inequality. Therefore the welfare gains of the "winners" of the reform are amplified, whereas the welfare losses of the "losers" are augmented as well.

This result is reversed when the most distortionary financing instrument (capital income tax) comes into play. The introduction of the social pension program with capital income tax as financing instrument results in welfare losses for all households except for $G2 : I$ as the

negative income effects (caused by distortions in capital accumulation) dominate all positive insurance effects.

4.4 The role of occupational choice, skill heterogeneity and bequests

4.4.1 Occupational choice

As discussed before, the presence of an unregulated and untaxed sector results in a number of new channels through which the social insurance program distorts the economy. First, the program affects the working sector choice of young agents and thus shifts the allocation of skills to the low productivity sector. This in turn distorts the allocation of physical capital across sectors as well. Second, the reform amplifies the tax distortions since the tax base in the two sector model is smaller than in models without an informal sector. This has been pointed out by Loayza (1996) who extends the Barro-growth model to include an informal sector. He finds that changes in government policy that promote an increase in the relative size of the informal economy tend to lower economic growth and that the optimal tax rate is lower when the informal sector is present. Very few studies have discussed this type of distortion in the social security literature. Corsetti (1994) examines the implications for economic growth in a representative agent model of a developing economy. Following this approach we extend our analysis to examine the role of sector choice and welfare implications with heterogenous households.

In order to estimate the extent to which the misallocation of resources to the informal sector magnifies the adverse effects of the social pension program we consider a model in which agents are not allowed to choose their working sector. In the following we impose that low skilled workers are restricted to work in the informal sector only. High skill workers, on the other hand, are restricted to work in the formal sector. Since individuals in the model are not able to change their skill type, workers are also not able to switch their employment sector. This restriction eliminates all allocative effects from our analysis. We then repeat the previous policy experiment and introduce a social pension for informal sector retirees into this new environment using again a consumption tax as financing instrument. We report the results in tables 9 and 10.

Comparing table 9, we find that the adverse effects of the social pension program are much smaller when the allocation effects are turned off. In the economy with no occupational choice output decreases by less than 1 percent when introducing a social pension program with 50 percent replacement rate (Reform B) as opposed to the 4 percent decrease with occupational choice turned on. The difference in changes of output between the two models with/without occupational choice is around 3 percent. This is an approximation of the size of the economic distortion caused purely by allocative effects.

As a direct consequence, we find that the welfare effects are more pronounced in the economy with exogenous sector allocation (compare table 9). The intuition for these results is that without sector choice the introduction of the social insurance program does not result in

additional misallocations of human capital into the low productivity (informal) sector. As a consequence the negative efficiency effects are smaller (compare the relatively small decreases in aggregate capital K and effective labor H in table 9) and do not decrease household income as much as in the case with endogenous sector choice.

4.4.2 Skill inequality

Stochastic skill inheritance is a source of income uncertainty and inequality across households and generations in our framework. This risk cannot be diversified fully via market arrangements and informal safety nets, which makes the potentially beneficial role of a social pension program as alternative insurance and redistribution mechanism possible.

We next consider a case with no difference in skill sets across agents. That is, everyone is endowed with high skills and agents are exogenously assigned to either work in the formal or informal sector. Agents working in the formal sector have to pay labor income taxes, a social security payroll tax and will receive pensions upon retirement. Agents working in the informal sector do not pay labor or payroll taxes.

In this setup, the introduction of a social pension program to informal sector retirees plays a rather small role in terms of redistributing income across different household groups. Note that demographic shocks are still in play so that we still have three different household types, i.e. both parents and children alive, parent only, and child only households. The social pension program does not produce any more welfare gains for any of the household types except for $G2:I$. Note that $G2:I$ is a household consisting of parents only who still work in or have already retired from the informal sector. This type receives the new social pension benefits paying no contribution when the program is financed by a labor tax rate and only paying a small contribution when the program is financed by consumption or capital taxes.

This welfare loss indicates that without skill heterogeneity the model does not generate sufficient levels of inequality so that the positive redistributional effects of the social pension program overpower the negative efficiency effects (except for group $G2:I$ of course). Without significant gaps in earnings and wealth across households the reform does not generate sufficient welfare gains to justify the inevitable distortions that lower output and therefore income for all households. This is another reason why studies calibrated to developed countries with a more homogenous income distribution are less likely to find welfare gains for recipient households.

4.4.3 Intentional bequests

Intentional bequests present an additional savings motive. In our model, the presence of intentional bequests in the model therefore alleviates some the crowding out effects of the social pension program on savings. As seen in table 4, there are crowding out and crowding in effects for different groups of households. However, bequests on average increase when the government finances the social pension program with consumption taxes as the crowding in effect is dominant. This implies that private intergenerational transfers responds to changes in public social insurance. These adjustments in the informal safety net mitigate some of the adverse

effects of the expansion in the formal insurance system on savings and capital accumulation. This partially explains why the distortions in a model with bequest motives are smaller than in models without bequests.

Early Auerbach and Kotlikoff (1987) type studies of social security reform that did not incorporate intentional bequests have therefore often found welfare losses for all groups. Fuster (1999) demonstrates that when individuals have bequest and inter-vivos transfer motives (two-sided altruism), social security is less detrimental to the capital stock in a heterogenous agents model economy. Yet, intentional bequests are an important ingredient for the generation of welfare gains for households that receive transfers from the social pension program as they crucially dampen the decrease in the savings rate. If we turn off intentional bequest all households except for $G2:I$ – parent only households working in the informal sector – experience welfare losses from the reform. This shows that the bequest motive and inter-generational transfers are instrumental in mitigating the distortions caused by the social pension program as described above.

5 Sensitivity analysis

Preferences. We first analyze changes in parameters σ and κ in the utility function and shut down the labor/leisure choice of the elderly by setting $\kappa = 0$ and keeping the parameter of risk aversion unchanged at $\sigma = 1$.[20] In our policy experiments, welfare gains are still obtained for household types $G1:I,I$ and $G2:I$. Household type $G1:I,F$ exhibits a non-monotonic pattern but the positive welfare effect starts at lower replacement rates than in the benchmark experiment. Second, since the magnitude of the risk-sharing effect is sensitive to the parameter of risk-aversion, we consider two cases with more risk averse agents. That is, we set $\kappa = 0$ but increase the level of risk aversion to $\sigma = 2$ and 4. We then find that welfare gains for all of the recipient households are magnified because the insurance function of the social pension program becomes more important with increasing risk aversion. Third, since the welfare effect varies with the preference of leisure of the elderly, we consider an economy in which the elderly value leisure more than in the benchmark economy, that is $\kappa = 2$. In this scenario, our results on the welfare effects become even more pronounced.

Technology. We next conduct our analysis in an economy with alternative capital income shares in the informal sector: $\alpha^I = 0.2$ and $\alpha^I = 0.3$. We find that our results form the benchmark experiment are robust with respect to these changes. We then consider the more extreme case with identical production technologies in both sectors. We again find that all our earlier results hold qualitatively. Also, since the formal and informal production sectors are now equally productive, the welfare gains from the reform are slightly larger as the distortions from allocation of human capital into the informal sector results in lower output losses.

The size of the informal sector. In the benchmark economy we assumed that 50 percent of workers work in the informal sector. In order to verify whether our results are robust with

[20] The tables for these experiments are available in the technical appendix.

respect to this assumption, we calibrate the model to an economy with 25 percent of workers working in the informal sector as well as to an economy with 75 percent of workers working in the informal sector. We then introduce a social pension into these two economies just like before and find that even though the magnitudes of the policy effects on aggregate variables change, the general results of the policy experiment do not change qualitatively.

More skill inequality. Finally, we consider a case in which there is more inequality in skill inheritance. We therefore calibrate efficiency profiles for formal and informal sector workers using a smaller ratio of informal to formal sector average lifetime income. That is, low skilled workers receive relatively less life time income than high skilled workers. We find that the positive welfare effect for group $G1 : I, F$– parents in the informal sector, children in the formal sector– becomes more pronounced. Therefore, group $G1 : I, F$ experiences a welfare gain. In this case the insurance function and the redistribution function of the social pension program dominate the negative effects from the distortions. This is true for all tax regimes. This also implies that for developing countries with a large income gap between formal and informal sector workers we are more likely to observe a positive welfare effect from a social pension program.

Alternative fiscal settings. We next analyze a smaller social pension program and target only households where both, parents and children are informal sector workers. In all of these experiments our main result, that group $G1 : I, I$, $G1 : I, F$, and $G2 : I$ experience welfare gains, still holds.

In our benchmark model we assume that governments are capable to adjust their consumption and borrowing in the long run so that government consumption and debt are held constant as a fraction of GDP. To check if our results are robust to this assumption we consider a case with revenue neutrality and keep the level of government consumption and debt at benchmark (pre reform) levels. Since the economy experiences more efficiency loss under this assumption the social pension program introduces more distortions into the economy because the government has to increase taxes even more to collect enough revenue. We find that welfare effects for low income households ($G1 : I, I$ and $G2 : I$) are still positive. However, household $G1 : I, F$ is no longer a beneficiary from the introduction of a social assistance program. Having one group (the children) in the formal sector is enough for the entire household to lose in terms of welfare.

6 Conclusion

Individuals in developing countries face a shortage of formal risk-sharing instruments and therefore rely largely on informal cash transfers from family members for insurance purposes. In this paper we study the trade off between the insurance effects and incentive effects resulting from the introduction of a social pension program for informal sector workers in developing countries. We construct an incomplete market, dynamic general equilibrium model with heterogeneous agents that includes a large informal sector, an informal safety net operated by households through intergenerational transfers, and a public pension program for formal sector

workers.

The introduction of a social pension program for informal sector workers results in significant economic distortions on capital accumulation and resource allocation between the formal and informal sectors. However, we find positive welfare effects for households receiving the social pension benefits. The realization of these welfare gains depends on the following crucial features of the model: (*i*) skill heterogeneity and segmentation between formal and informal sectors are essential to generate the degree of wealth disparities that amplify the positive insurance effects of the reform; (*ii*) the social pension targets a relatively small group of informal sector retirees which keeps the program and therefore the distortions triggered by it small; and (*iii*) bequest motives alleviate the savings distortions caused by the social pension program and therefore trigger the welfare gains. Finally, the direction and magnitude of the effects in terms of market aggregates and welfare depends on how the expansion is financed. A consumption tax with its broad tax base is the least distortive and generates the largest welfare gains for recipient households. Capital taxes, with their strong direct distortion of capital accumulation, generate the worst welfare and efficiency outcomes.

Our results carry several important implications. First, the study provides a macroeconomic analysis of social security policy in developing countries that provides an estimate of the efficiency loss resulting from running a social pension program. Second, it sheds some light on how to best finance public social safety nets in developing countries. Third, our results emphasize the importance of accounting for the defining characteristics of developing countries when studying fiscal policy reforms in a development context. More specifically, this work highlights the important role of public insurance in an environment that lacks formal private and public insurance mechanisms to insure against demographic and lifetime income shocks.

Extensions of our model can be used to study a wider range of questions concerning the general equilibrium effects of public pension and tax policy reforms in developing countries. Current limitations include the following. First, we ignore any transitory shocks like labor productivity shocks or health shocks. The stochastic skill inheritance process is the only source of income shock in the model. In this sense we understate the role of the insurance function and the redistribution function of the social pension program. A model that incorporates such transitory shocks would amplify the insurance and redistribution role of the social pension program and produce larger welfare gains. Second, we limit our analysis to steady states and are therefore not able to analyze the short-run implications of the introduction of the social pension program. Third, the transmission of skills is exogenous so that the skill of children is not a function of parental investment. In this sense, we abstract from the effects of social pensions on parental investments into education. Education investments are another component of the informal family safety net in developing countries that can potentially be crowded out by social pensions. We leave these issues for future research.

References

Acemoglu, Daron. 2010. "Theory, General Equilibrium and Political Economy in Development Economics." *Journal of Economic Perspectives* 24(3):17–32.

Amaral, Pedro S. and Erwan Quintin. 2006. "A Competitive Model of the Informal Sector." *Journal of Moneta* 53:1541–1553.

Auerbach, J. Alan and Laurence J. Kotlikoff. 1987. *Dynamic Fiscal Policy*. Cambridge University Press.

Bourguignon, Francois, Francisco H. G. Ferreira and Marta Menendez. 2007. "Inequality of Opportunities in Brazil." *Review of Income and Wealth* 53(4):585–618.

Bresser-Pereira, C. Luiz. 1990. The Perverse Macroeconomics of Debt, Deficit and Inflation in Brazil. In *Perspectives on the Pacific Basin Economy: A Comparison of Asia and Latin-America*, ed. Fukuchi T. and M. Kagami. Toquio: Institute of Developing Economies.

Chetty, Raj and Adam Looney. 2006. "Consumption Smoothing and the Welfare Consequences of Social Insurance inDeveloping Countries." *Journal of Public Economics* 90:2351–2356.

Corak, Miles. 2004. *Generational Income Mobility in North America and Europe*. Cambridge University Press.

Corsetti, Giancarlo. 1994. "An Endogenous Growth Model of Social Security and the Size of the Informal Sector." *Revista de Analisis Economico* 9(1):57–76.

Cox, Donald, Emanuela Galasso and Emmuanuel Jimenez. 2006. "Private Transfers in a Cross Section of Developing Countries." Working Paper 2006-2, Center for Retirement Research.

Cox, Donald and Emmanuel Jimenez. 1992. "Social Security and Private Transfers in Developing Countries: The Caseof Peru." *World Bank Economic Review* 6(1):155–169.

Cox, Donald and Emmanuel Jimenez. 1995. Private Transfers and the Effectiveness of Public Income Redistributionin the Philippines. In *Public Spending and the Poor: Theory and Evidence*, ed. Dominique van de Walle and Kimberly Nead. Baltimore: Johns Hopkins University.

d'Addio, Anna Cristina. 2007. "Intergenerational Transmission of Di Mobility or Immobility across Generation Disadvantage: Mobility or Immobility across Generations? A Review of the Evidence for OECD Countries." OECD Working Paper.

De Soto, Hernando. 1989. *The Other Path: The Invisible Revolution in the Third World*. Harpercollins.

Dessy, Sylvain and Stephane Pallage. 2003. "Taxes, Inequality and the Size of the Informal Sector." *Journal of Development Economics* 70:225–233.

Diamond, Peter A. 1965. "National Debt in a Neoclassical Growth Model." *American Economic Review* 60:1126–1150.

Edwards, Sabastian and Alejandra Cox-Edwards. 2000. "Economic Reforms and Labor Markets: Policy Issues and Lessons from Chile." NBER Working Paper, No. 7646.

Ferreira, Francisco H., Peter Lanjouw and Macelo Neri. 2003. "A Robust Poverty Profile for Brazil Using Multiple Data Sources." *Revista Brasileira De Economia* 57(1):59–92.

Ferreira, Pedro Cavalcanti and Leandro Goncalves do Nascimento. 2005. "Welfare and Growth Effects of Alternative Fiscal Rules for InfrastructureInvestmentin Brazil." Manuscript, EPGE - FGV(604).

Ferreira, Sergio G. 2005. "Pension Reform in Brazil: Transitional Issues in a Model with EndogenousLabor Supply." IBMEC Economics Discussion Paper 2005-02.

Feu, Aumara. 2004. "Evaluation of Capital Productivity in Brazil in the XX Century." *Economy & Energy* April-May, ISSN 1518-2932(43).
URL: *http://ecen.com/eee43/eee43e/cap$_p$rd$_X$X$_e$.htm*

Filho, Irineu Evangelista. 2008. "Old-age Benefits and Retirement Decisions of Rural Elderly in Brazil." *Journal of Development Economics* 86(1):129–146.

Filho, Naercio Menezes and Luiz Scorzafave. 2009. "Employment and Inequality Outcomes in Brazil." Working Paper.

Fiorito, Riccardo and Flavio Padrini. 2000. "Economic Reforms and Labor Markets: Policy Issues and Lessons from Chile." NBER Working Paper, No. 7646.

Fortin, Bernard, Nicolas Marceau and Luc Savard. 1997. "Taxation, wage controls and the informal sector." *Journal of Public Economics* 66:293312.

Friedman, Eric, Simon Johnson, Daniel Kaufmann and Pablo Zoido-Lobaton. 2000. "Dodging the Grabbing Hand: The Determinants of Unofficial Activity in 69Countries." *Journal of Public Economics* 76:459–493.

Fuster, Luisa. 1999. "Is Altruism Important for Understanding the Long-Run Effects of Social Securit." *Review of Economic Dynamics* 2:616–637.

Fuster, Luisa, Ayse Imrohoroglu and Selahattin Imrohoroglu. 2003. "A Welfare Analysis of Social Security in a Dynastic Framework." *Internaltional Economic Review* 44(4):1247–1274.

Fuster, Luisa, Ayse Imrohoroglu and Selahattin Imrohoroglu. 2007. "Elimination of Social Security in a Dynastic Framework." *Review of Economic Studies* 74 (1):113–145.

Garcia, Marcio G.P. 2003. "Brazil in the 21st Century: How to Escape the High Real Interest Trap?".
URL: *http://ideas.repec.org/p/rio/texdis/466.html*

Giambiagi, Fabio and Luiz Mello. 2006. "Social Security Reform in Brazil: Achievement and Remaining Challenges." OECD Working Papers No. 534.

Gindling, T.H. and Katherine Terrell. 2004. "Legal Minimum Wages and the Wages of Formal and Informal SEctor Workersin Costa Rica." IZA Discussion Paper No. 1018.

Ginneken, Wounter van. 2003. "Extending Social Security: Policies for Developing Countries." ESS Paper N0 13, International Labor Office.

Glomm, Gerhard, Juergen Jung and Chung Tran. 2009. "Macroeconomic Implications of Early Retirement in the Public Sector: TheCase of Brazil." *Journal of Economic Dynamics and Control* 33:777–797.

Gruber, Jonathan. 1995. "The Incidence of Payroll Taxation: Evidence from Chile." *NBER Working Paper 5053* .

Hubbard, R. Glenn and Kenneth Judd. 1987. "Social Security and Individual Welfare." *American Economic Review* 77(4):630–646.

ILO. 2002. *Social Security: a New Concensus*. International Labor Organization.

Immervoll, Herwig, Horacio Levy, Jose Ricardo Nogueira and CathalO'DonoghueandRozane Bezerra de Siqueira. 2006. "The Impact of Brazil's Tax-Benefit System on Inequality and Poverty." IZA Discuassion Paper No. 2114.

Imrohoroglu, Ayse, Selahattin Imrohoroglu and Douglas H. Jones. 1995. "A Life Cycle Analysis of Social Security." *Economic Theory* 6(1):83–114.

Imrohoroglu, Ayse, Selahattin Imrohoroglu and Douglas H. Jones. 1999. "Computational Models of Socal Security: A Survey." mimeo.

Imrohoroglu, Ayse, Selahattin Imrohoroglu and Douglas Joines. 1995. "A Life Cycle Analysis of Social Security." *Economic Theory* 6:83–114.

Issler, João V. and Natalia S. Piqueira. 2000. "Estimating Relative Risk Aversion, the Discount Rate, and the IntertemporalElasticity of Substitution in Consumption for Brazil Using Three Typesof Utility Functions." *Brazilian Review of Econometrics* 20:201–239.

Jensen, Robert .T. 2003. "Do Private Transfers 'Displace' The Benefits of Public Transfers? Evidencefrom South Africa." *Journal of Public Economics* 88:89–112.

Jung, Juergen and Chung Tran. 2008. "Transfers and Labor Market Behavior of the Elderly in Developing Countries: Theory and Evidence from Vietnam." Working Paper.

King, Robert G., Charles I. Plosser and Sergio T. Rebelo. 2001. "Production, Growth and Bussiness Cycles: Technical Appendix.".

Krueger, Dirk and Fabrizio Perri. 2011. "Public versus private risk sharing." *Journal of Economic Theory* 146(3):920–956.

Laitner, John. 1992. "Random Earning Differences, Lifetime Liquidity Constraints, and AltruisticIntergenerational Transfers." *Journal of Economic Theory* 58:135–170.

Levy, Santiago. 2008. *Good Intentions, Bad Outcomes, Social Policy, Informality, and Economic Growth in Mexico*. Brookings Institution Press.

Loayza, Norman V. 1996. "The Economics of the Informal Sector: a Simple Model and some Empirical Evidence from Latin America." *Carnegie-Rochester Conference Series on Public Policy* 45:129–162.

Low, Hamish and Daniel Maldoom. 2004. "Optimal Taxation, Prudence and Risk-sharing." *Journal of Public Economics* 88(3-4):443–464.

Magnac, Th. 1991. "Segmented or Competitive Labor Markets." *Econometrica* 59(1):165–187.

Maloney, W.F. 1999. "Does Informality imply Segmentation in Urban Labor Market> Evidence from Sectoral Transitions in Mexico." *The World Bank Economic Review* 13:275–302.

Marcouiller, Douglas, Veronica Ruiz de Castilla and Christopher Woodruff. 1997. "Formal Measures of the Informal-Sector Wage Gap in Mexico, El Salvador,and Peru." *Economic Development and Cultural Change* 45:367–392.

Nishiyama, Shinichi. 2002. "Simulating Social Security Reform in a Stochastic OLG Economy with HeterogenousAgents." Working Paper, Congessional Budget Office.

Packard, Trumand G. 2002. "Are there positive incentives from privatizing social security? A panel analysis of pension reform in Latin America." *Journal of Pension Economics and Finance* 1:89–109.

Palacious, Robert and Montserrat Pallares-Mirallets. 2000. "International Pattern of Pension Provision." *Social Protection Discussion Paper Series* No. 0009, World Bank.

Palacious, Robert and Oleksiy Sluchynsky. 2006. "Social Pensions Part I: Their Role in the Overall Pension System." *Social Protection Discussion Paper* No. 0601, World Bank.

Pratap, Sangeeta and Erwan Quintin. 2006. "Are Labor Markets Segmented in Developing Countries? A Semiparametric Approach." *European Economic Review* 50(7):1817–1841.

Puffert, Douglas J. 1988. "Social Security Finance In Developing Countries." WPS 36, World Bank.

Queiroz, Bernardo. 2005. Labor Force Participation, Social Security and Retirement in Brazil PhD thesis PhD Dissertation, Department of Demography, University of California atBerkeley.

Rofman, Rafael and Eliana Carranza. 2005. "Social Security Coverage in Latin America." *Social Protection Discussion Paper Series* No. 5023.

Rosenzweig, Mark R. 1988*a*. "Risk, Implicit Contracts and the Family in Rural Areas of Low-Income Countries." *The Economic Journal* 98:1148–1170.

Rosenzweig, Mark R. 1988*b*. "Risk, Private Information, and the Family." *The American Economic Review (Papers and Proceedings)* 78(2):245–250.

Rosenzweig, Mark R. and Kenneth I. Wolpin. 1993. "Credit Market Constraints, Consumption Smoothing, and the Accumulation of Durable Production Assets in Low-Income Countries: Investments in Bullocks in India." *Journal of Political Economy* 101(2):223–244.

Schmidt-Hebbel, Klaus. 1997. "Pension Reform, Informal Markets and Long-Term Income and Welfare." Central Bank of Chile Working Paper No. 04.

Schmidt-Hebbel, Klaus. 1999. "Latin America's Penion Revolution: A Review of Approaches and Experience." Unpublised, Central Bank of Chile.

Secretariat, OECD. 2009. "Growth, Employement and Inequality in Brazil, China, India and South Africa: an Overview." OECD Working Paper.

Soriano, Leonardo and Márcio I. Nakane. 2003. "Real Balance in the Utility Function: Evidence from Brazil." Working Paper Series 68, Banco Central do Brasil.

Souza-Sobrinho, Nelson F. 2004. "Structural Reforms and Economic Performance: Brazil in the 1990s." UCLA.

Summers, Lawrence H. 1989. "What Can Economics Contribute to Social Policy? Some Simple Economics of Mandated Benefits." *AER Papers and Proceedings* 79(2):177–183.

Telles, Edward. 1992. "Who Gets Formal Sector Jobs?: Determinants of Formal-Informal Participationin Brazilian Metropolitan Areas." *Work and Occupation* 19.

Thomas, J.J. 1992. "Informal Economic Activity." *Harvester Wheatsheaf* .

Turra, Cassio and Benardo Queiroz. 2005. "Intergenerational Transfers and Socioeconomic Inequality in Brazil: A FirstLook." Working Paper.

Valdes-Prieto, Salvador. 2008. "A Theory of Noncontributory Pension Design." PONTIFICIA UNIVERSIDAD CATOLICA DE CHILE, Department of Economics, Working Paper N. 335.

Varian, Hal R. 1980. "Redistributive Taxation as Social Insurance." *Journal of Public Economics* 14:49–68.

World-Bank. 1994. *Averting the Old Age Crisis: Policies to Protect the Old and Promote Growth*. Vol. World Bank Policy Research Report Oxford University Press.

7 Appendix

7.1 Tables and Graphs

	Parameters	Value	Observation/Comment/Source
Preferences			
	Discount factor	$\beta = 0.97$	to match $\frac{K}{Y} = 2.6$
	Weight on leisure	$\kappa = 1$	to match labor supply
	Altruism parameter	$\theta = 1$	Fuster et al. (2003)
Technology			
	Annual growth rate	$g = 2.65\%$	http://www.brazil.org.uk
	TFP	$A^I = 1$, $A^F = 1.3$,	to match $\frac{Y^I}{Y^F}$
	Informality costs ϱ	$\delta_0 = .045$, $\delta_1 = .014$, $\delta_2 = 2.2$,	to match informal sector labor force
	Share of capital income	$\alpha^I = 0.25$, $\alpha^F = 0.40$,	Ferreira and do Nascimento (2005) report 0.4 for Brazil
	Annual depreciation rate	$\delta^I = 5\%$, $\delta^F = 5\%$,	Feu (2004) and Ferreira and do Nascimento (2005)
Demography			
	Maximum lifetime	$2J = 14$	equivalent to 70 years
	Max working periods	$J_w = 9$	equivalent to 45 years
	Max retirement periods	$J_r = 5$	equivalent to 25 years
	Max household lifetime	$J = 7$	
	Annual population growth	$n = 1.8\%$	Ferreira (2005)
Sector	Sector Transitions	$\pi_{I,I} = 0.8$ $\pi_{F,F} = 0.8$	to match 50% of employment in the informal labor market
Government			
	Labor income taxes	$\tau_L^I = 5\%$ and $\tau_L^F = 15\%$	
	Capital tax	$\tau_K = 22.38\%$	
	Social security tax	$\tau_{SS} = 11\%$	to match social security tax revenue
	Consumption tax	$\tau^C = 23\%$	Immervoll et al. (2006)
	Replacement rates	$\Psi^I = 0,\ \Psi^F = 0.6$	
	Government borrowing as fraction of GDP	$\Delta_B = 0.05$	to match debt level of 36% of GDP reported in Ferreira (2005)
	Government consumption	$\Delta_G = 0.25$	to match government size

Table 1: Preference and Policy Parameters

	Variables: $\Psi^I = 0$	Model	Data	Observation/Comment/Source
$\frac{K}{Y}$	Capital output ratio	2.5	2.5	Bresser-Pereira (1990) and Souza-Sobrinho (2004)
R	Interest rate	6.6%	10%	Garcia (2003)
$\frac{Y^I}{Y}$	Informal sector size (in % of GDP)	24.2%	29%	Friedman et al. (2000)
	Informal sector size (in % of employment)	50%	50%	Giambiagi and Mello (2006)
	High skilled labor (in % of employment)	50%	47%	Filho and Scorzafave (2009)
$\frac{w^I H^I}{w^F H^F}$	Average income ratio informal to formal sector	55.5%	$30 - 80\%$	Gindling and Terrell (2004) and Marcouiller, de Castilla and Woodruff (1997)
$\frac{Debt}{Y}$	Debt-Output ratio	36.1%	36%	Ferreira (2005)
	Tax revenue	29.5%	30.6%	Ferreira (2005)
	Consumption tax revenue (in % of GDP)	10.5%	9.31%	Ferreira (2005)
	Social security tax revenue (in % of GDP)	5.04%	5.06%	Ferreira (2005)

Table 2: Model Outcomes that Match Data

	Benchmark	Reform A	Reform B	Reform C
Output Y	100.00	97.97	96.06	94.29
Output share - informal Y1/Y %	28.24%	29.87%	31.37%	32.84%
Output share - formal Y2/Y %	71.76%	70.13%	68.63%	67.16%
Captial K	100.00	97.87	95.92	94.13
Capital - informal K1	100.00	103.73	107.00	110.11
Capital - formal K2	100.00	95.86	92.11	88.62
Informal worker %	50%	52%	54%	56%
Labor N	100.00	99.74	99.50	99.28
Labor - informal N1	100.00	99.53	99.15	98.84
Labor - formal N2	100.00	99.99	99.96	99.93
Effective labor H	100.00	98.60	97.23	95.96
Effective labor - informal H1	100.00	103.54	106.57	109.40
Effective labor - formal H2	100.00	95.68	91.71	88.00
Wage rate - informal	100.00	100.06	100.14	100.23
Wage rate - formal	100.00	100.08	100.17	100.28
Informal/formal labor earning %	43%	46%	50%	53%
Interest rate %	6.39%	6.38%	6.37%	6.35%
Consumption tax τ_C %	15.02%	16.63%	18.36%	20.25%
Labor tax τ_L^F %	20.00%	20.00%	20.00%	20.00%
Capital Tax τ_K %	21.65%	21.65%	21.65%	21.65%
Tax revenue/GDP %	30.91%	31.73%	32.67%	33.72%
Social security/GDP %	5.96%	5.81%	5.67%	5.53%
Soical pension/GDP %	0.00	0.98%	2.07%	3.27%

Table 3: Aggregate effects of social pension program financed by a consumption tax. Reform A: social pension replacement rate $\Psi^I = 0.25$. Reform B: $\Psi^I = 0.5$. Reform C: $\Psi^I = 0.75$. Note that our benchmark model is featured with following elements : (i) general equilibrium, (ii) occupational choice, (iii) intended bequests, (iv) skill heterogeneity, and (v) differential production technology in formal vs. informal sector. The values of aggregate variables in the benchark model are normalized to 100.

	Reform A	Reform B	Reform C
Informal parent - Informal child G1:I,I	102.00	105.97	110.80
Informal parent - formal child G1:I,F	104.59	111.78	119.99
Formal parent - informal child G1:F,I	99.10	97.67	96.02
Formal parent - formal child G1:F,F	100.70	100.27	99.16
Average	101.14	102.60	104.12

Table 4: The effect of the social pension program financed by a consumption tax on intended bequests. The values of intended bequests in the benchark model are normalized to 100. Reform A: social pension replacement rate $\Psi^I = 0.25$. Reform B: $\Psi^I = 0.5$. Reform C: $\Psi^I = 0.75$.

	Reform A	Reform B	Reform C
Informal parent - Informal child G1:I,I (26.48%)	101.52	102.70	103.54
Informal parent - formal child G1:I,F (6.62%)	100.90	101.69	102.34
Formal parent - informal child G1:F,I (6.62%)	98.58	97.11	95.59
Formal parent - formal child G1:F,F (26.48%)	98.29	96.47	94.50
Informal parent only G2:I (1.05%)	121.27	141.27	159.28
Formal parent only G2:F (1.05%)	98.55	96.76	94.74
Informal child only G3:I (15.86%)	98.48	97.08	95.67
Formal child only G3:F (15.86%)	98.28	96.56	94.78

Table 5: Welfare effects of the social pension program financed by a consumption tax. The expected utilities in the benchark model are normalized to 100. The percentage numbers in brackets report the sizes of the various household types as fractions of the total population. Reform A: social pension replacement rate $\Psi^I = 0.25$. Reform B: $\Psi^I = 0.5$. Reform C: $\Psi^I = 0.75$.

	Reform A		Reform B		Reform C	
	PE	GE	PE	GE	PE	GE
Informal parent - Informal child G1:I,I	103.51	101.52	106.46	102.70	109.11	103.54
Informal parent - formal child G1:I,F	103.02	100.90	105.57	101.69	107.89	102.34
Formal parent - informal child G1:F,I	100.26	98.58	100.50	97.11	100.72	95.59
Formal parent - formal child G1:F,F	100.01	98.29	100.03	96.47	100.04	94.50
Informal parent only G2:I	124.73	121.27	147.17	141.27	167.52	159.28
Formal parent only G2:F	100.00	98.55	100.00	96.76	100.00	94.74
Informal child only G3:I	100.00	98.48	100.00	97.08	100.00	95.67
Formal child only G3:F	100.00	98.28	100.00	96.56	100.00	94.78

Table 6: Welfare Effects: partial equilibrium model (PE) vs. general equilibrium model (GE). Note that in the partial equilibrium model wage and interest rates are held constant at the levels of the benchmark economy without the reform.

	Reform A			Reform B		
	Cons. tax	Lab. tax	Cap. tax	Cons. tax	Lab. tax	Cap. tax
Output Y	-2.03%	-4.98%	-4.82%	-3.94%	-15.56%	-16.58%
Output share-informal (Y1/Y)	1.63%	1.38%	3.08%	3.13%	0.33%	12.89%
Capital	-2.13%	-4.83%	-8.26%	-4.08%	-15.80%	-24.68%
Capital K1	3.73%	-0.00%	2.14%	7.00%	-14.79%	11.57%
Capital K2	-4.14%	-6.49%	-11.84%	-7.89%	-16.15%	-37.17%
Informal worker	2%	6%	2%	4%	7%	5%
Effective labor H	-1.40%	-4.60%	-1.55%	-2.77%	-15.31%	-7.18%
Effective labor H1	3.54%	-0.52%	7.44%	6.57%	-14.47%	27.23%
Effective labor H2	-4.32%	-7.01%	-6.88%	-8.29%	-15.80%	-27.56%
Informal wage	0.06%	0.18%	-1.76%	0.14%	-0.13%	-4.49%
Formal wage	0.08%	0.23%	-2.17%	0.17%	-0.16%	-5.53%
Relative labor earning	3%	3%	7%	7%	1%	6%
Interest rate 1+r	-0.00	-0.00	-0.00	0.00	-0.00	-0.00
Consumption tax τ_C	1.61%	-0.02%	-0.02%	3.35%	-0.02%	-0.02%
Labor tax τ_L^F	0.00	1.76%	0.00	0.00	1.89%	0.00
Capital tax τ_K	0.00	0.00	2.86%	0.00	0.00	7.02%
Social pension/GDP	0.98%	1.08%	0.99%	2.07%	2.47%	2.31%

Table 7: Aggregate Effects: alternative taxes. Note that we report percentage deviations from the values in the benchmark economy without the reform. Reform A: social pension replacement rate $\Psi^I = 0.25$. Reform B: $\Psi^I = 0.5$.

	Reform A			Reform B		
	Cons. tax	Lab. tax	Cap. tax	Cons. tax	Lab. tax	Cap. tax
G1:I,I	101.52	102.80	100.35	102.70	105.96	98.60
G1:I,F	100.90	103.57	99.95	101.69	105.83	99.22
G1:F,I	98.58	97.30	96.02	97.11	96.54	90.45
G1:F,F	98.29	98.42	96.02	96.47	96.67	91.25
G2:I	121.27	124.22	115.61	141.27	143.17	127.25
G2:F	98.55	97.93	93.95	96.76	92.84	86.28
G3:I	98.48	98.33	98.16	97.08	99.65	94.92
G3:F	98.28	98.53	96.93	96.56	97.80	93.58

Table 8: Welfare Effects: alternative taxes.
Note that expected utilities in the benchark model are normalized to 100. G1:I,I Informal parent - Informal child; G1:I,F Informal parent - formal child; G1:F,I Formal parent - Informal child; G1:F,F Formal parent - formal child; G2:I Informal parent only; G2:F Formal parent only; G3:I Informal child only; G3:F Formal child only. Reform A: social pension replacement rate $\Psi^I = 0.25$. Reform B: $\Psi^I = 0.5$.

	Reform A		Reform B	
	no choice	choice	no choice	choice
Outpyt Y	99.83	97.97	99.72	96.06
Output share - informal Y1/Y	28.06	29.87	28.01	31.37
Output share - formal Y2/Y	71.94	70.13	71.99	68.63
Capital K	99.79	97.87	99.68	95.92
Capital - informal K1	99.57	103.73	99.26	107.00
Capital - formal K2	99.86	95.86	99.82	92.11
Effective labor H	99.84	98.60	99.70	97.23
Effective labor - informal H1	99.65	103.54	99.34	106.57
Effective labor - formal	99.95	95.68	99.91	91.71
Informal workers %	50%	52%	50%	54%

Table 9: Aggregate Effects: model without occupational choice (no choice) vs. model with occupational choice (choice) between formal and informal sector.
Note that consumption tax is the financing instrument. Reform A: social pension program with replacement rate $\Psi^I = 0.25$. Reform B: $\Psi_1 = 0.5$.

	Reform A		Reform B	
	no choice	choice	no choice	choice
Informal parent - Informal child G1:I,I	101.68	101.52	103.19	102.70
Informal parent - formal child G1:I,F	101.37	100.90	102.68	101.69
Formal parent - Informal child G1:F,I	98.75	98.58	97.59	97.11
Formal parent - formal child G1:F,F	98.77	98.29	97.50	96.47
Informal parent only G2:I	121.96	121.27	142.70	141.27
Formal parent only G2:F	99.47	98.55	98.63	96.76
Informal child only G3:I	98.67	98.48	97.58	97.08
Formal child only G3:F	98.94	98.28	97.91	96.56

Table 10: Welfare Effects: model without occupational choice (no choice) vs. model with occupational choice (choice) between formal and informal sector. Reform A: social pension program with replacement rate $\Psi^I = 0.25$. Reform B: $\Psi^I = 0.5$.

	Reform A		Reform B		Reform C	
	no hete.	hete.	no hete.	hete.	no hete.	hete.
Informal parent - Informal child G1:I,I	99.73	101.52	99.13	102.70	98.60	103.54
Informal parent - formal child G1:I,F	99.89	100.90	99.74	101.69	99.45	102.34
Formal parent - informal child G1:F,I	98.39	98.58	96.61	97.11	94.83	95.59
Formal parent - formal child G1:F,F	95.41	98.29	90.68	96.47	86.22	94.50
Informal parent only G2:I	173.09	121.27	229.45	141.27	274.58	159.28
Formal parent only G2:F	95.58	98.55	91.18	96.76	87.10	94.74
Informal child only G3:I	96.11	98.48	92.08	97.08	88.26	95.67
Formal child only G3:F	95.92	98.28	91.72	96.56	87.75	94.78

Table 11: Welfare Effects: model with no skill heterogeneity (no hete.) vs. model with skill heterogeneity (hete.). Reform A: replacement rate $\Psi_1 = 0.25$. Reform B: $\Psi^I = 0.5$. Reform C: $\Psi^I = 0.75$.

	Reform A		Reform B		Reform C	
	no beq.	beq.	no beq.	beq.	no beq.	beq.
Informal parent - Informal child G1:I,I	99.71	101.52	99.39	102.70	99.04	103.54
Informal parent - formal child G1:I,F	99.77	100.90	99.52	101.69	99.24	102.34
Formal parent - informal child G1:F,I	98.36	98.58	96.74	97.11	95.15	95.59
Formal parent - formal child G1:F,F	98.82	98.29	97.64	96.47	96.46	94.50
Informal parent only G2:I	101.37	121.27	102.63	141.27	103.79	159.28
Formal parent only G2:F	99.20	98.55	98.40	96.76	97.60	94.74
Informal child only G3:I	98.74	98.48	97.49	97.08	96.25	95.67
Formal child only G3:F	99.06	98.28	98.13	96.56	97.18	94.78

Table 12: Welfare Effects: model without bequests (no beq.) vs. model with intended bequests (beq.). Reform A: replacement rate $\Psi^I = 0.25$. Reform B: $\Psi^I = 0.5$. Reform C: $\Psi^I = 0.75$.

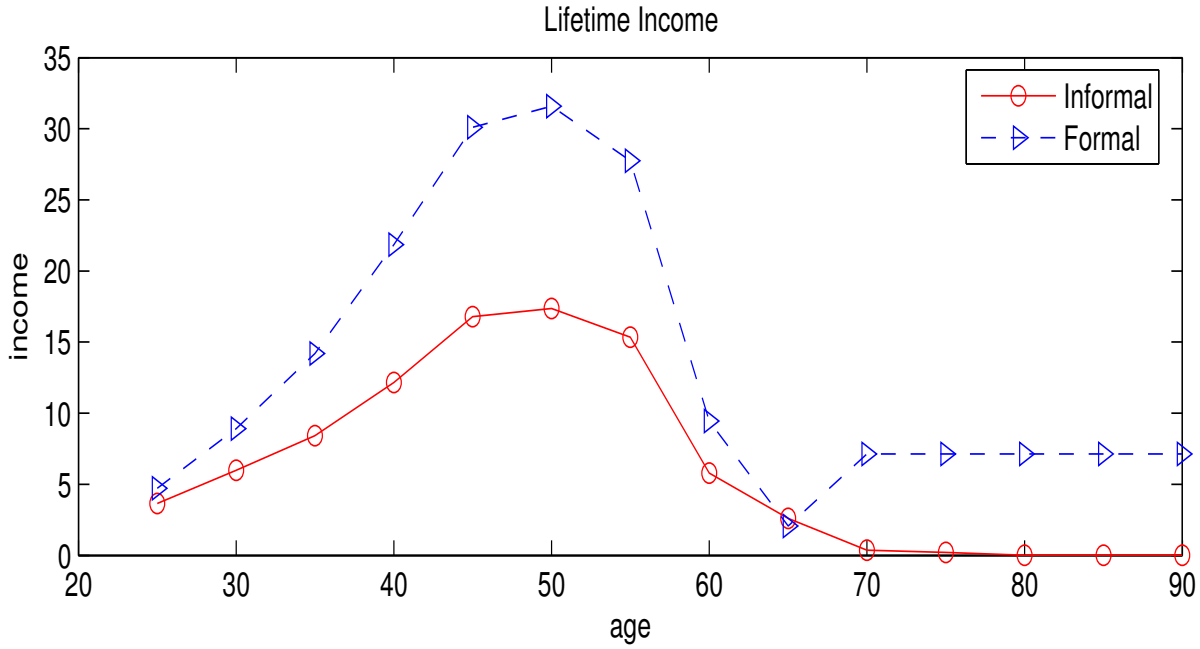

Figure 1: Labor Supply and Income Profile by Sectors

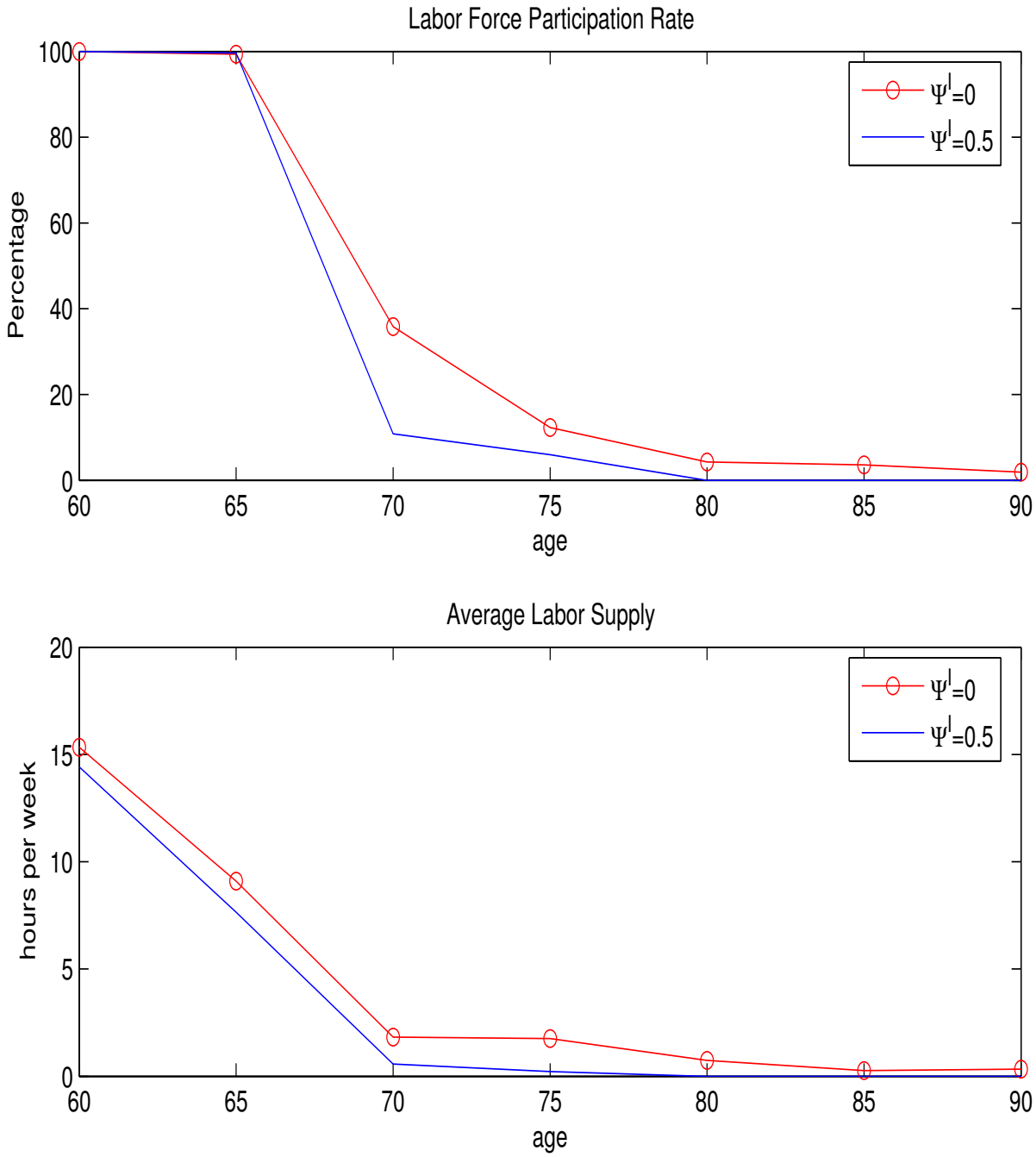

Figure 2: Labor Force Participation Rate and Lifetime Labor Supply of Informal Sector Workers