The Extension of Social Security Coverage in Developing Countries

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Abstract

We investigate the effects of extending the coverage of social security to uncovered elderly individuals in the informal sector in developing countries. We use a stochastic overlapping generations framework and incorporate important characteristics of developing countries including family transfers and a sizeable informal sector. Our calibrated model predicts that the introduction of a moderately sized social assistance program decreases steady state output by up to 3.25% and labor supply by up to 2.5%. In contrast to literature focusing on developed countries, the model predicts that extending the coverage of the social security system results in welfare gains for low income households. This result indicates that the insurance function and the redistribution function of the social assistance program dominate the distortionary effects in an environment without adequate risk sharing mechanisms and high inequality.

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1 Introduction

A shortage of risk sharing mechanisms against longevity risk is an important issue in developing countries. According to Palacios and Pallares-Mirallets (2000) social security systems cover only a small part of the population. For example, the coverage rates of social security systems are less than 10% in low income countries in Sub-Saharan Africa and South Asia and rarely exceed half of the working population in middle income countries in Latin America.1 Meanwhile, financial markets are underdeveloped and do not provide reliable financial instruments to insure people at higher ages. It is therefore not surprising that in developing countries family transfer payments are the most important source of income for the elderly next to labor income (World-Bank (1994)).

The family transfer system – briefly summarized as parents supporting their young children and becoming recipients of support from their children when old – is widespread across developing countries. Frankenberg and Karoly (1995), Knodel and Debaulya (1997), Frankenberg and Kuhn (2004), and Cox and Jimenez (2006) provide evidence about the importance of the family transfer system in developing countries. Although the family transfer system has the advantage of eliminating source of the moral hazard and adverse selection associated standard insurance programs, the family transfer system fails to provide enough support for the old generation. A major weakness of the family transfer system is that it fails to pool risk efficiently over different families. Besides, the family transfer system has been weakened due to rapid changes in the social and economic environment in developing countries2. Moreover, as societies age, the family transfer system will come under pressure as parents have to be supported by their children for a longer period of time.

Being left without sufficient income, many elderly have to stay in the labor force until very high ages. The development literature introduced the term “ceaseless toil” to describe the fact that the elderly have to work as long as they are physically capable. Evidence of very high

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1 We define coverage as the fraction of the working population participating in a contributory social security program. This program then pays pensions to retired participating workers.

2 It is not unreasonable to assume that the erosion of family ties that has been observed in western societies can also advance to less developed countries. For a study on the evolution of attitudes towards the family in the United States compare Thornton and Young-DeMarco (2001).
rates of labor force participation of the elderly has been found in China (Benjamin, Brand and Fan (2003)), Indonesia (McKee (2006)), and Vietnam (Tran (2007)).

Since private markets and the family transfer system have failed to become adequate sources of insurance in developing countries, a natural question to ask is, whether the government should step in and insure the elderly. Some international development organizations have lobbied for an immediate public intervention to protect the elderly in developing countries (e.g. see ILO (2002)). Meanwhile, several developing countries like Brazil, India, and South Africa have already started their own social assistance/pension programs for uncovered old people. Currently, more and more developing countries consider instituting similar programs.3

The social assistance program is a component of the social security system. One of the major benefits of social security is that it provides avenues for risk sharing, which is welfare increasing. On the other hand, social security distorts savings and labor supply decisions, which results in welfare losses. The adverse effects of public transfer programs have been well documented. In pure life-cycle frameworks, Diamond (1965) establishes that pay-as-you-go social security lowers the steady state capital stock because social security redistributes away from young agents with higher marginal propensities to save to old agents with lower marginal propensities to save. More recent literature explores the magnitude of these effects. In large scale deterministic life-cycle models, Auerbach and Kotlikoff (1987) find that social security substantially decreases capital accumulation. Since there is no insurance role played by social security in a deterministic framework, the introduction of social security in the Auerbach-Kotlikoff model always results in welfare losses. The literature therefore extended the deterministic Auerbach-Kotlikoff setup by adding various sources of uncertainty. Hubbard and Judd (1987) introduce borrowing restrictions and random lifetime and find that in a full general equilibrium model, there is almost no welfare gain from social security programs. Imrohoroglu, Imrohoroglu and Jones (1995) add labor earnings uncertainty to the previous model and find that social security improves welfare. This result is due to eliminating the economy’s dynamic inefficiency. After Imrohoroglu, Imrohoroglu and Joines (1999) introduce land as a fixed factor of production

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3 See Palacios and Sluchynsky (2006) for an overview of social pension programs in developing countries.
which rules out dynamic inefficiency, they find no beneficial role of social security anymore.

The effects of social security have also been analyzed in models with altruism. In his seminal work, Barro (1974) shows that private transfers can neutralize the effect of public transfers and public debt when a bequest motive is operative (Ricardian equivalence). In a quantitative study, Fuster (1999) finds that an altruistic framework mitigates the crowding-out effect of social security on capital stock. Fuster, Imrohoroglu and Imrohoroglu (2003) develop a similar model with inelastic labor supply and show that the insurance role played by social security dominates the crowding-out effects on capital stock. Fuster, Imrohoroglu and Imrohoroglu (2007) extend their previous work to include labor/leisure choice and find that individuals prefer to be born into an economy without social security mainly due to efficiency gains from removing distortions on labor supply.4

In general, the literature does not support the expansion of social security systems because crowding-out effects tend to dominate the insurance role of social security. The introduction of a social assistance program in developing countries is therefore a controversial idea. However, in the context of developing countries social assistance programs play two important roles. First, social assistance programs are an important source of insurance. Second, social assistance programs provide an instrument to redistribute income to poor informal sector workers. Social assistance programs can therefore lead to significant welfare gains if the insurance function and the redistribution function dominate the crowding-out effects.

Although there is a substantial literature on social security systems in developed countries, less attention has been given to social security reforms in developing countries. So far the literature has focused on empirical and microeconomic analysis (e.g. see Cox and Jimenez (1992), Cox and Jimenez (1995), Jensen (2003), Filho (2004), McKee (2006) and Tran (2007)) rather than macroeconomic analysis. We believe that it is essential to evaluate such programs in a macroeconomic framework because a social assistance program makes up a significant share of the government budget and has impacts on significant parts of the population in developing countries. In addition, we believe that it is important to study the effects of social security pro-

4For an excellent literature survey of unfunded social security see Imrohoroglu, Imrohoroglu and Jones (1999).
grams in a model incorporating the main features of economic systems in developing countries such as a sizeable informal sector, incomplete financial markets, segmented labor markets, high income inequality, low coverage rates of public social security, and a large family transfer system. Incorporating these features will result in new economic insights and policy implications. The paper, therefore, is a first attempt in that research area. In particular, we focus on quantifying the crowding-out effects of introducing a social assistance program to informal sector workers, who are not covered by a contributory social security system and rely wholly on family transfers. We are particularly interested in studying the effects on family transfers, bequests, savings, labor supply, and the wealth distribution and in analyzing the welfare consequences. We are also interested in comparing the effects under alternative financing schemes.

We use a two-sector overlapping generations economy with two-sided altruism and competitive firms. The setup of the household sector is similar to Laitner (1992) and Fuster (1999). Parents and children form a decision unit called a household in which resources are pooled and decisions are made jointly. A sequence of households in a family line, which is linked together through skill transmission and a bequest motive, form a household dynasty. Households face demographic and occupational shocks which are uninsurable. Deviating from the previous studies we introduce two production sectors, a formal and an informal sector, and a double-standard social security system. The two production sectors differ with respect to technology and the quality of labor inputs. The social security system is only available to formal sector workers. The social security system is financed by the government. The government taxes consumption, labor income, and capital income to balance its budget each period. We calibrate the model to match certain characteristics of Brazil. In our policy experiment, we study the effects of varying the size of social assistance programs.

As predicted in previous literature, we find that the public social pension program crowds out capital stock and aggregate labor supply. The model shows that the introduction of a social assistance program with a 50% replacement rate decreases output by up to 3.25% and labor supply by up to 2.5%. The magnitude of the crowding-out effects depends substantially on the tax that is used to finance the expansion. In addition, the function that the social
assistance program is effective is completely determining labor force participation by very old (> 75) in the informal sector. Moreover, the model has an interesting implication on welfare. In our calibrated economy, it turns out that the insurance- and redistribution function of the social assistance program outweigh the crowding-out effects, so that we find welfare gains for recipients of social assistance benefits. This presents a contrast to the findings in Fuster, Imrohoroglu and Imrohoroglu (2007) who calibrate to the U.S. economy. Our results imply that incorporating crucial characteristics of developing countries is important, qualitatively as well as quantitatively, to evaluate the impacts of social security reforms in those countries.

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 Appendix contains all tables and figures. The Technical Appendix presents the solution method, the solution algorithm, the construction of efficiency profiles, and the tables from the sensitivity analysis.  

2 Model

2.1 Environment

Production Sectors. The economy consists of two distinct production sectors. Sector one, the informal sector, is populated by low productivity firms and sector two, the formal sector, is populated by high productivity firms. Both sectors produce a common final consumption good. The production technologies are Cobb-Douglas in both sectors

\[ Y_{t}^{se} = A^{se}(K_{t}^{se})^{\alpha^{se}}(H_{t}^{se})^{1-\alpha^{se}}, \]

where \( A^{se} > 0, \alpha^{se} \in (0,1) \) and \( se = \{F, I\} \) which denotes formal and informal sectors. Capital \( K^{se} \) depreciates at rate \( \delta^{se} \) each period and \( H^{se} \) is aggregate human capital in sector \( se \). We

\footnote{The Technical Appendix is available on the authors’ website at: http://mypage.iu.edu/~chtran/Research/sscApp.pdf}
impose $A_F > A_I$, so that the formal sector is more productive than the informal sector. Each sector is assumed to use a certain type of labor input. Physical capital, however, is assumed to move freely across sectors. The aggregate final consumption good is the sum of formal and informal sector production so that

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

The economy is assumed to grow exogenously at constant rate $g$.

**Population and Living Arrangements.** The population consists of $2 \times J$ overlapping generations and is normalized to 1 at any point in time. Variable $J$ denotes the number of periods that children overlap with their parents. The population grows exogenously at rate $n$ and the survival probability (conditional on surviving to age $j − 1$) is $sp_j$. The demographic structure of the population is assumed to be stationary so that the population share of the age cohorts is time invariant. After detrending with the growth rate of the population, the population share $\mu_j$ is recursively defined as

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

Individuals live at most $2J$ periods. Individuals experience two stages of living arrangements. In the first stage of life we call the agents *children* and in the second stage of life we call them *parents*. That is, individuals are children from period 1 to $J$ and become parents when they are $J+1$ periods old. At that age their parent has died and their own children become economically active. Thus, individuals overlap with their parents in the first $J$ periods and they overlap with their own children in the last $J$ periods of their life.

Individuals are assumed to be altruistic towards their children and their parents (two-sided altruism). Parents are altruistic towards their children in the sense that parents value the utility of their children. This is independent of whether the parent is alive or not. Therefore, parents transfer wealth to their children while they are alive (intervivos transfers). Additional transfers are made via accidental bequests if parents die early before they reach age $2J$ and intended bequests if they reach age $2J$. 


Children are also altruistic towards their parents and can transfer wealth to ensure the well-being of their parents. Hence, individuals derive utility not only from their own consumption and leisure but also from the well-being of their parents and children. In uncertain environments, two-sided altruism generates a risk sharing mechanism across generations, which is also called family insurance.

In each period the surviving and economically active members of a family form a decision unit called “household”. Depending on their demographic structure, households are classified into one of three groups. Group 1 households are made up of parents and children, group 2 households are parent only households, and group 3 households consist of children only. If parents and children survive, they pool resources and solve a joint utility maximization problem. This is the simplest way to incorporate two-sided altruism. If children do not survive, parents run households of their own and the family line stops after 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.

The households of group 1 last for $J$ periods until the parents die at age $2J$. During $J$ periods, a household from group 1 could change its state to either group 2 if their children die or to group 3 if parents die. Meanwhile, the parent-only of child-only households of group 2 and 3 cannot change their type within the next $J$ periods. The transition probability matrix that describes these movements between groups is given by

$$
\Omega(g_j, g_{j+1}) = \begin{bmatrix}
sp^p_{J+j}sp^k_j & sp^p_{J+j} \left(1 - sp^k_j\right) & (1 - sp^p_{J+j}) \left(1 - sp^k_j\right) \\
0 & sp^p_{J+j} & 0 \\
0 & 0 & sp^k_j
\end{bmatrix},
$$

where $g_j = 1, 2, \text{ or } 3$ and $sp^p_{J+j}$ and $sp^k_{j}$ are survival probabilities of a parent and children, respectively.

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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.
Household preferences are the sum of preferences of parents and $m$ children during the $J$ periods in which they overlap. These expected preferences are expressed as

$$W_h = E \sum_{j=1}^{J} \beta^{j-1} \left\{ \prod_{i=1}^{j} sp_{i,t}^k u \left( c_{j,t}^k, l_{j,t}^k \right) + m \prod_{i=1}^{J+j} sp_{i,t}^p u \left( c_{J+j,t}^p, l_{J+j,t}^p \right) \right\},$$

where superscripts $p$ denotes parents and $k$ denotes kids, $j$ is the child’s age, $t$ is calendar time, $J + j$ is the parent’s age, $\beta$ is the discount rate, $c$ denotes consumption, $l$ denotes leisure and the period consumption-leisure utility function $u(c,l)$ has the usual properties.

**Skill Endowment and Job Assignment.** When agents become economically active they are endowed with either low or high skills. If individuals have high skills, they will work in the formal sector, otherwise they will work in the informal sector. Formal sector workers have higher income and participate in a pay-as-you-go social security program. Informal sector workers have lower income and no access to social security. Individuals are not allowed to choose their working sectors and they cannot move between sectors. However, their children have the chance to be endowed with a different skill and therefore they are able to switch to a different working sector. The probability to be endowed with a job in either the formal or informal sector depends on the current working sector of the parents. That is, sector mobility is allowed across generations and follows a simple two-state Markov process with the transition probability matrix given by

$$\Pi \left( s e^p, s e^k \right) = \begin{bmatrix} \pi_{I,I} & \pi_{I,F} \\ \pi_{F,I} & \pi_{F,F} \end{bmatrix},$$

where $\pi_{se,se'}$ is the probability to get a job in sector $se'$ conditional on the parents’ working sector $se$. Household dynasties are heterogeneous in the composition of the respective working sectors of parents and children which results in four different household types, $(F,F)$, $(F,I)$, $(I,F)$, and $(I,I)$, where the first letter denotes the occupational sector of the parent and the second the occupational sector of their children.

\[7\] Since skill and working sector are interchangeable in our setup, we use either “sector” or “skill” from now on.
Individuals are endowed with one unit of time each period which is allocated to leisure or work. An individual’s effective labor supply in each period is given by \( h^i_j = e^i_j \left(1 - l^i_j\right) \), where \( h^i_j \) is the human capital (or effective labor) of individual \( i \) at age \( j \), \( e^i_j \) is the efficiency unit and \( l^i_j \) denotes the amount of leisure consumed.

There is a minimum mandatory retirement age of \( J_w \), equivalent to age 65, for formal sector workers. Upon reaching this age they can draw benefits from pension schemes. Formal sector retirees are allowed to continue working in the informal sector even when they receive pension or transfer payments. \( J_w \) is also the eligible age for informal sector workers to participate in a social assistance program that we introduce later in our policy experiment.

**Household Dynasty.** The sequence of households of parents, children, grandchildren etc. in a family line defines a household dynasty. Each individual of a generation in the dynasty participates in two consecutive decision making units (or households) one with their parents and one with their children. The expected utility of a dynasty given the household starts from generation 0 with a parent working in sector \( s e^p_0 \) and children working in sector \( s e^k_1 \) is given by

\[
\sum_{h=0}^{\infty} \Pi \left(s e^p_h, s e^k_{h+1}\right) \left[(\theta \beta)^{\frac{1}{2}}\right]^h W_h, \tag{2}
\]

where \( h \) is the generation age in the household dynasty and \( \theta \) is an altruism parameter that governs how much the current household values the utility of the next household. If parents die before reaching age \( 2J \), the surviving children still live in a household without parents until the age of \( J \) and then start a new household with their own children. If all children are dead, parents live alone until they die, then the family line breaks.

The model combines features of both the OLG and the infinite horizon framework. Skill transmission and two-sided altruism generate a household dynasty, that essentially introduces the infinite horizon framework. On the other hand, each individual has a random finite lifetime overlapping with her parents and her children and the demographic shock could break family lines with a certain probability which introduces the life-cycle framework. When the altruism

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\(^8^\)To save on notation we drop time subscript \( t \) but we do not restrict our setup to steady states only.
parameter \( \theta = 0 \), the model becomes a pure life-cycle model.

**Government and Social Security.** The government runs a social security system including a contributory public pension program and a non-contributory social assistance program. The public pension program is not universal. Only workers in the formal sector who pay a social security tax when young are entitled to draw pensions when old. Meanwhile, informal sector workers who do not pay social security taxes when they are young are prohibited from collecting pension benefits. Pension payments to the old pensioners are defined as 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 \( \Psi^F \). The functional form is

\[
Pen = \Psi^F w^F \bar{h}^F.
\]

As a policy experiment we model a social assistance program targeted to elderly workers in the informal sector, who are not covered by the public pension program. The individual lump-sum transfer/social pension is calculated based on the following formula

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

where \( \Psi^I \), \( w^I \) and \( \bar{h}^I \) denote the replacement rate, the wage rate and the average effective labor in the informal sector, respectively. The replacement rate \( \Psi^I \) is a measure of the generosity of the social assistance program. Government debt is assumed to be a constant fraction of final output

\[
B = \Delta_B Y.
\]

Residual government expenditure is given as a fraction of final output

\[
G = \Delta_G Y.
\]

The government collects a social security tax, a labor income tax, a capital income tax, and a
consumption tax to finance pensions for formal sector retirees, lump-sum transfers to informal sector workers, debt service, and general government consumption. The government budget constraint is assumed to be balanced each period.

2.2 Household Problem

Individual members of the household have different incomes depending on their working time, age-dependent labor productivity and employment sector. The income of economically active children $y_j^k$ at age $j$ is defined as

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

where $\tau_L^F$ and $\tau_L^I$ denote the labor tax rates in the formal and informal sectors, respectively and $\tau_{SS}$ is the social security tax, which is paid by formal sector workers only. Since it is much easier to evade taxes in the informal sector, the labor income tax rate in the formal sector is assumed to be higher than in the informal sector, $\tau_L^F > \tau_L^I$. Expression $(1 - l_j^k)$ denotes labor supply, $e_j^{se}$ is the labor efficiency unit of skill $se$ at age $j$, and $h_j^k = (1 - l_j^k) e_j^{se}$ is effective labor, so that $(1 - l_j^k) e_j^{se} w_j^{se}$ is gross labor earning income at age $j$.

The income of parents $y_{J+j}^p$, including wage income and pensions, is summarized as

$$y_{J+j}^p = \begin{cases} \left(1 - \tau_L^F - \tau_{SS}\right) \left(1 - l_{J+j}^p\right) e_{J+j}^F w_{J+j}^F & \text{if } J + j \leq J_w \text{ if } s e^p = F, \\ \left(1 - \tau_L^I\right) \left(1 - l_{J+j}^p\right) e_{J+j}^I w_{J+j}^I + \text{Pen}_{J+j} & \text{if } J + j > J_w \text{ if } s e^p = I, \end{cases}$$

where $\left(1 - \tau_L^F - \tau_{SS}\right) \left(1 - l_{J+j}^p\right) e_{J+j}^F w_{J+j}^F$ is the net labor income if parents work in the formal sector. When parents who work in the formal sector reach their mandatory retirement age, they have to retire and become eligible to receive pensions $\text{Pen}_{J+j}$. They can earn additional
income if they decide to work in the informal sector during retirement. Hence, the labor and pension income of a formal sector retiree is given by
\[ (1 - \tau_I) \left( 1 - l_{J+j}^p \right) e_{J+j}^I w_I^J + Pen_{J+j}. \]
If formal sector retirees choose not to participate in labor market, that is \( (1 - l_{J+j}^p) = 0 \), then there is no labor income. Informal sector workers can work as long as they are alive and want to work. When they are older than the mandatory minimum retirement age, informal sector workers receive additional income from a social assistance program \( T_{J+j} \) so that their total income is
\[ (1 - \tau_I) \left( 1 - l_{J+j}^p \right) e_{J+j}^I w_I^J + T_{J+j}. \]

Individuals are endowed with one unit of time each period so that leisure of parents and children lies in \( 0 < l_{J}^p, l_{J}^k \leq 1 \). When \( l = 1 \), individuals choose not to work.

The growth-adjusted household budget constraint is given by
\[
(1 + \tau_C) \left( \xi_j^k e_j^k + \xi_j^p e_{J+j}^p \right) + (1 + g) a_{j+1} = Ra_j + \xi_j^p y_j^p + \xi_j^k y_{J+j}^k, \quad \text{for} \quad j = 1, \ldots, J, \tag{3}
\]

where \( \xi_j^k \) is an index function that is equal to \( m = (1 + n)^J \) if children are alive and 0 otherwise \(^9\), while \( \xi_j^p \) is an index function equal to 1 if parents are alive and 0 otherwise. Variable \( a_j \) denotes the household’s asset holding at beginning of age \( j \) and \( a_{j+1} \) is the asset holding in next period.

Expression \( g \) is the exogenous economic growth rate, which is the same for both sectors. Finally, \( a_j \geq 0 \) is a borrowing constraint.

Let \( V_j(a_j, \Phi_j) \) be the indirect utility of a household at age \( j \) given state variables \( a_j \) and \( \Phi_j = \{ se^p, se^k, \xi_j^p, \xi_j^k \} \), including occupational composition and demographic structure of the household. A household in a dynasty starts with some initial assets in the form of bequests received from the previous household and then chooses consumption, leisure and savings to maximize its indirect utility given its state variables each period. During the last period a household with children alive maximizes not only its utility but also the expected utilities of the next households and therefore leaves bequests to the next household in the dynasty. The

\(^9\)We assume that children all either survive or die.
The household problem can be defined recursively in terms of a Bellman equation as

\[ V_j (a_j, \Phi_j) = \max_{\{c_j, l_j, e_{j+1}, e_{j+1}^{a_{j+1}}\}} \left\{ \xi_k u \left( c_j, l_j^p \right) + \xi_l u \left( e_{j+1}^{p_j}, e_{j+1}^{l_{j+1}} \right) + \beta EV_{j+1} (a_{j+1}, \Phi_{j+1}) \right\} \]  

(4)

subject to (3). The expected value function \( EV_{j+1} \) is defined as

\[
EV_{j+1} (a_{j+1}, \Phi_{j+1}) = \begin{cases} 
\sum_{g=1}^{3} \Omega (g_j, g_{j+1}) V_{j+1} (a_{j+1}, \Phi_{j+1}) & \text{for } j = 1, \ldots, J - 1, \\
\sum_{se^{e} \in \{F,I\}} \Pi \left( se^{e}, se^{k} \right) \sum_{g=1}^{3} \Omega (g_J, g_1) \theta m V_1 (a_1, \Phi_1) & \text{for } j = J.
\end{cases}
\]

Households face shocks to their demographic structure each period as expressed by the Markov switching matrix \( \Omega (g_j, g_{j+1}) \). Every \( J \) period when the new household is formed a shock to the occupational composition is realized via Markov switching matrix \( \Pi \left( se^{e}, se^{k} \right) \). This shock only affects the newborn generation and determines the type of household that this generation will form with their parents. The current household saving in the last period is the intended bequest, which is divided equally among \( m \) children and becomes the initial asset of the next households in the family line \( a_1' = \frac{a_{J+1}}{m} \).

2.3 Firm Problem

Firms in both sectors choose to rent physical capital and human capital to maximize profits. Thus, the firm’s problem is

\[
\max_{(H^{se}_t, K^{se}_t)} \left\{ A^{se} (K^{se})^{\alpha^{se}} (H^{se})^{1-\alpha^{se}} - w^{se} H^{se} - q^{se} K^{se} \right\},
\]

given factor prices \( w^{se} \) and \( q^{se} \), where \( se = \{I, F\} \).

2.4 Recursive Competitive Equilibrium

**Definition 1** Given realizations of initial assets, occupational composition \( \{ se^{p}, se^{k} \} \), exogenous sector transition probabilities \( \Pi \), survival probabilities, and government policies
A stationary recursive competitive equilibrium is a collection of value functions \( \{ V_j (a_j, \Phi_j) \}^J_{j=1} \) with \( \Phi_j = \{ s_e^j, s_k^j, \xi_p^j, \xi_k^j \} \), household decision rules \( \{ c_{J+1}^j, l_{J+1}^j, c_j^k, l_j^k, a_j + 1 \}^J_{j=1} \), a collection of sequences of time invariant distributions \( \{ \mu_j (a_j, \Phi_j) \}^J_{j=1} \), sequences of aggregate stocks of physical capital and human capital \( \{ K^s e, H^s e \} \), and sequences of prices \( \{ w^s e, q^s e, R \} \) with \( s e = \{ F, I \} \) such that

(i) household decision rules \( \{ c_{J+1}^j, l_{J+1}^j, c_j^k, l_j^k, a_j + 1 \}^J_{j=1} \) solve the household maximization problem (4),

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

\[
\begin{align*}
        w^F &= (1 - \alpha^F) A^F \left( K^F \over H^F \right)^{\alpha^F}, \\
        w^I &= (1 - \alpha^I) A^I \left( K^I \over H^I \right)^{\alpha^I}, \\
        q^F &= \alpha^F A^F \left( K^F \over H^F \right)^{\alpha^F - 1}, \\
        q^I &= \alpha^I A^I \left( K^I \over H^I \right)^{\alpha^I - 1},
\end{align*}
\]
and the after-tax interest rate is determined by

\[
R = (1 - \tau_K) q^F + 1 - \delta^F = (1 - \tau_K) q^I + 1 - \delta^I,
\]

(iii) aggregate stocks are given by

\[
\begin{align*}
        S &= \sum_{j, s_e^j, s_k^j, \xi_p^j, \xi_k^j} \int_a \mu_j (a_j, \Phi_j) a_j (a_j, \Phi_j), \\
        C &= \sum_{j, s_e^j, s_k^j, \xi_p^j, \xi_k^j} \int_a \mu_j (a_j, \Phi_j) c_j (a_j, \Phi_j), \\
        H^I &= \sum_{j, s_e^j, s_k^j, \xi_p^j, \xi_k^j} \int_a \mu_j (a_j, \Phi_j) (1 - l_j) e^I_j, \\
        H^F &= \sum_{j, s_e^j, s_k^j, \xi_p^j, \xi_k^j} \int_a \mu_j (a_j, \Phi_j) (1 - l_j) e^F_j,
\end{align*}
\]
(iv) commodity markets clear

\[ C + S + \Delta G \sum_{se \in \{I,F\}} Y^{se} = \sum_{se \in \{I,F\}} Y^{se} + \sum_{se \in \{I,F\}} (1 - \delta^{se}) K^{se}, \]

(v) the government budget constraint holds

\[ \text{debt payment} \quad \widehat{RB} + \Delta G Y + \text{pension payment} \quad \sum_{j=J_0+1}^{J} \sum_{se^{p}=F,\xi^{p},\xi^{k}} \int_{a}^{\mu_{j}(a_{j}, \Phi_{j})} Pen + \sum_{j=J_0+1}^{J} \sum_{se^{p}=I,\xi^{p},\xi^{k}} \int_{a}^{\mu_{j}(a_{j}, \Phi_{j})} T \]

\[ \text{labor income tax revenue} \quad \mu_{j}^{a}(a_{j}, \Phi_{j}) w^{se^{p}} (1 - l_{j}) e^{se^{p} - se} \tau_{L}^{se^{p}} + \sum_{j,\xi^{p},\xi^{k}} \int_{a}^{\mu_{j}^{i}(a_{j}, \Phi_{j})} w^{F} (1 - l_{j}) e^{F} \tau_{SS}^{F} + \]

\[ \text{capital income tax revenue} \quad \mu_{j}^{a}(a_{j}, \Phi_{j}) a_{j}(a_{j}, \Phi_{j}) \tau_{K} + \sum_{j,\xi^{p},\xi^{k}} \int_{a}^{\mu_{j}^{i}(a_{j}, \Phi_{j})} c_{j}(a_{j}, \Phi_{j}) \tau_{C} + \]

\[ \text{accidental bequest revenue} \quad \sum_{j,\xi^{p},\xi^{k}} \int_{a}^{[1 - \mu_{j}(a_{j}, \Phi_{j})]} a_{j}(a_{j}, \Phi_{j}) + (1 + n)(1 + g) B, \]

(vi) and the time invariant distribution satisfies

\[ \mu_{1}(a_{1}, \Phi_{1}) = \sum_{se^{p}=k=\{I,F\}}^{\xi^{p},\xi^{k}} \int_{a}^{\Pi(se^{p}, se^{k})} \Omega(g_{1}, g_{j}) \mu_{j}(a_{j}, \Phi_{j}), \]

\[ \mu_{j+1}(a_{j+1}, \Phi_{j+1}) = \sum_{\xi^{p},\xi^{k}} \int_{a}^{\Omega(g_{j}, g_{j+1})} \mu_{j}(a_{j}, \Phi_{j}), \quad \text{for } j = 1, \ldots, J - 1. \]

3 Calibration

We use parameters reported in table 1 to calibrate the benchmark steady state economy to match data from Brazil in the late 1990s. We choose Brazil for two reasons. First, Brazil has been implementing a social assistance program for years and second, Brazil is a middle income developing country 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. Solutions to the model as well as algorithms are presented in a Technical Appendix.\textsuperscript{10}

### 3.1 Technology

In standard one sector models the income share of capital $\alpha$ is in the range of 0.3 to 0.36. Estimates of $\alpha$ for developing countries tend to be higher. Ferreira and do Nascimento (2005) use $\alpha = 0.4$ to match the Brazilian economy. We are not aware of estimates relating the capital shares of formal and informal sectors separately. However, the informal sector is documented as a labor-intensive sector so the income share of capital is likely to be smaller than in the formal sector. We therefore calibrate the income shares of capital in the informal and formal sectors with $\alpha^I = 0.25$ and $\alpha^F = 0.4$ 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% annually for both sectors.

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. However, we feel comfortable applying the restriction $A^I < A^F$, so that the formal sector is more efficient. We then normalize $A^F$ to 1 and pick $A^I$ to restrict the share of informal sector output in GDP to be around 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 1970s, dropped down to around 1.6% in the 1980s, and then went up again to 2.65% in the 1990s.\textsuperscript{11} In the model, we therefore choose a real annual rate of growth $g = 2.65%$.

### 3.2 The Size of the Informal Labor Market and Sector Mobility

The size of the informal sector in terms of employment and relative size of GDP varies across countries. The size of formal sector employment coincide with the fraction of social security

\textsuperscript{10}The Technical Appendix is available on the authors’ website at: http://mypage.iu.edu/~chtran/Research/sscApp.pdf

\textsuperscript{11}See the report on GDP, growth and employment at http://www.brazil.org.uk/economy/gdp.html
coverage in our model. According to Giambiagi and Mello (2006) the coverage of social security in Brazil is around 50% in 2005.

It is evident that parents’ skills and occupation as well as parental networks will play an important role in determining their children’ probabilities to find work in the formal sector. These private networks are especially important in the context of developing countries and are a source of inter-generational dependence. Children of formal sector employees have typically better education than children of informal sector workers. Compare Marcouiller, de Castilla and Woodruff (1997) for evidence on respective higher education levels of formal sector workers in developing countries. Better education and existing private networks will make it easier to secure work in the formal sector. In other words, the probability to transition from the formal to the informal sector is smaller for children of formal sector parents. In our calibration, we use Markov transition probabilities of $\pi_{I,I} = 0.8$ and $\pi_{F,F} = 0.8$, which reflect the sector persistence and result in 50% of the labor force working in the informal sector.

### 3.3 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 the link between public pensions and early retirement in Brazil.\(^{12}\)

Survival probabilities are taken from the life tables of World Health Organization member countries.\(^{13}\) 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

\(^{12}\)Generous pensions and early retirement are highly correlated in Brazil, especially in the public sector. See Glomm, Jung and Tran (2006) for more details on this issue.

in the literature, the poor (informal sector workers) have lower survival probabilities than the rich (formal sector workers). We therefore adjust the life-table survival probabilities in the following way. We lower the survival probabilities of informal sector workers by 2% and we increase the survival probabilities of formal sector workers by 0.5%.

In the model, we assume that population grows at a constant rate so that there is a stationary demographic structure. Population growth has slowed during the last 20 years in Brazil. 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.

3.4 Preference and Altruism

In our model, we use additive preferences in consumption and leisure

$$u(c, l) = \frac{c^{1-\sigma}}{1-\sigma} + \kappa \frac{l^{1-\psi}}{1-\psi},$$

where we restrict the utility of consumption to be of log form ($\sigma = 1$) in order to fulfill the condition for balanced growth as suggested in King, Plosser and Rebelo (2001). Estimates of the parameter of intertemporal elasticity of substitution $\sigma$ 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. We do not know any estimate for the parameter governing the intertemporal elasticity of leisure $\psi$ in Brazil. Following previous studies, we choose $\psi = 1$.

In the similar model for the U.S. economy Fuster, Imrohoroglu and Imrohoroglu (2007) use elastic labor supply for workers and force the elderly to be fully retired. In this paper, since we want to concentrate on the labor supply of elderly people, we assume that young agents supply labor inelastically. This restriction implies that the weight of leisure of young household members is $\kappa = 0$. We calibrate the labor supply of young agents to match average weekly working hours. We calibrate parameter $\kappa$ for parents to match average labor supply at higher
Discount factor $\beta$ and altruism factor $\theta$ are free parameters. One may calibrate either $\beta$ or $\theta$, 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 $\beta$ and $\theta$. We set $\theta = 1$ and adjust $\beta$ to match the capital-output ratio.

3.5 Life-Time Efficiency Unit and Labor Earning Profile

Turra and Queiroz (2005) report labor incomes 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 informal and formal sector workers and the average labor income ratio between informal and formal sector workers. We assume that less educated people tend to work in the informal sector as reported in Telles (1992).

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 60%, 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.$^{14}$

3.6 Government

In Brazil, total tax revenue is about 30% of GDP in 1998, with social security tax revenue contributing almost 5% (see Ferreira (2005)). We calibrate tax rates to match this size of government.

In the model, the government taxes labor income of both informal and formal sector workers. The labor tax in the formal sector is $\tau^F_L = 20\%$. We assume that the labor income tax rate in

$^{14}$The Technical Appendix contains the efficiency profiles that were used as a basis for the income profiles. The Technical Appendix is available on the authors’ website at: http://mypage.iu.edu/~chtran/Research/sscApp.pdf
the informal sector $\tau^I_L$ is rather small at 3%, which reflects financial contributions of informal sector workers to the government budget. According to Palacios and Pallares-Mirallets (2000), effective pension taxes are between 7% to 12% 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 10%, which results in a 4.5% share of social security tax revenue in terms of GDP. The capital income tax rate is chosen at 20%. The proportional consumption tax rate is around 15% which is close to the one reported in Ferreira (2005). 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 assistance available to the elderly in the informal sector so that $\Psi^I = 0$. The government only has a social security program for retirees in the formal sector. The social security trust fund is not independent from the government budget. As reported in Palacios and Pallares-Mirallets (2000), the average pension as a share of average wage ranges from 35% to 60%. Since Brazil has a very generous pension program, we choose the replacement rate for pension payments $\Psi^F$ to match social security payments as a fraction of GDP. Our hypothetical replacement rate $\Psi^F = 60\%$ of the average labor income of pre-retirement employment results in the social security program to be around 4.5% of GDP. It is smaller than 5.06% of GDP reported in Ferreira (2005) because this number includes the social assistance program.

We assume that government borrows a fix fraction of GDP each period. We calibrate the ratio of government debt to GDP to be 35% which is close to the average in the data between 1995 and 2000. Residual government consumption is 25% of GDP and matches the size of the government budget in the data. Government consumption plays no further role in the model.

4 Policy Experiments and Results

We start the benchmark economy without a social assistance program for informal sector workers. We then assume that the government starts a social assistance program that is
available to all informal sector workers who are 65 and older. The generosity of the social assistance program is reflected in the magnitude of the replacement rate $\Psi^I$. In the benchmark economy the replacement rate equals zero, $\Psi^I = 0$. In our policy experiments we vary the generosity of the social assistance program and assume that the government can use either consumption tax, labor tax, or capital income tax to finance the program. We then report changes in key aggregate variables, family transfers, and welfare in tables 3, 4 and 5.15

**Capital accumulation.** The distortions on savings from introducing the social pension program are reported in the third column of table 3. The extension of social security discourages people to save for two reasons. First, the social assistance program redistributes from the young (high propensity to save) to the poor elderly (low propensity to save). Second, taxes used to finance the program distort the savings behavior. This is especially true for capital taxes.

The crowding-out effects vary substantially between different financing instruments. Crowding out effects are the largest when capital income tax is used to finance the extension and the smallest when consumption tax adjusts. When increasing the replacement rate from 0 to 0.5, capital stock drops by 1%, 2.7%, and 8% under consumption tax, labor income tax, and capital income tax financing schemes, respectively.

The crowding-out effect is relatively small in comparison to previous results in the literature on social security reform due to two reasons. First, the social assistance program is targeted to a subpart of the population so that its size is kept relatively small. This leads to smaller distortions in the economy. Second, as established in Fuster (1999), the bequest motive dampens the decrease in savings due to life cycle patterns.

**Labor supply.** The labor supply adjustments are reported in columns 4, 5 and 6 of table 3. The social assistance program generates different effects on average labor supply depending on skills and working sector. The average labor supply of informal sector workers drops by more than 3% when increasing the replacement rate to 0.5. The intuition is straightforward. Without social assistance the elderly in the informal sector have to work longer (extensive

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15 Note that we normalize the results of the benchmark economy to 100 which allows for easy comparison with the results of alternative policies.
margin) and harder (intensive margin) to support their consumption. After the reform they have additional income from government transfers to finance their consumption and therefore supply less labor. The top panel of figure 2 reports changes in the labor force participation rate of informal sector workers. We see that after the introduction of the social assistance program the participation rate of informal sector workers drops significantly. Before the social assistance program some informal sector workers stay in the labor force until age 90. The social assistance program ensures that no workers works beyond age 80. The bottom panel in figure 2 shows the change in labor supply of informal sector workers.

The average labor supply of formal sector workers also decreases slightly when the replacement rate is 0.5 and either consumption tax or labor tax adjusts. Surprisingly, the labor supply of formal sector workers increases slightly when capital tax is used as a financing instrument and the social assistance program is relatively large (Ψ^I > 0.7). As the crowding-out effects are more pronounced under this financing scheme, formal sector workers decide to work longer to compensate for the income loss. Note that formal sector workers finance the extension without getting much direct benefit from it.

Overall, the aggregate labor supply declines by almost 2% when introducing a social assistance program with a 0.5 replacement rate.

**Output.** The cost of introducing the social assistance program in terms of lost output is non-trivial. For a 0.5 replacement rate the social assistance program reduces steady state output between 0.6% and 3.25% depending on whether consumption tax or capital tax is used to finance the expansion. This result is a direct consequence of the crowding-out effects, which lower the stocks of physical capital and human capital.

**Bequests.** We report the effect of public transfers on bequests by household types in table 4. We observe both crowding-out and crowding-in effects on intended bequests across household types. The effects also are non-monotone within certain types of households.

For households G1 : I, I – whose parents and children are informal sector workers – bequests increase by 12% when the replacement rate is 0.5 and consumption tax is the financing instrument. The introduction of a social assistance program has a direct effect on the income
of old parents. Holding other thing constants, the income of old parents increase and so does the overall income of the household. As a consequence, parents want to leave more bequests to their children (positive effect). On the other hand, the introduction of a social assistance program raises the future income of children because current “informal sector” children will become recipients of a social pension when they are old. This results in a disincentive for leaving bequests (negative effect), since the 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 as can be seen in column 2 of table 4.

For households $G_1: I, F$ – whose parents are in the informal sector but whose children are in the formal sector – bequests increase. That is, the current household with older members (parent) receiving social assistance wants to increase bequests to offset the negative effect on younger members (children) who will not receive social assistance but have to pay a higher price for consumption in the future (positive effect). On the other hand, since social assistance crowds out the labor supply of old parents, their labor earnings decline. Moreover, efficiency loss due to declines in aggregate capital stock and labor supply lower individual income. which results in a decrease in bequests (negative effect). Our results show that bequests are consistently larger under all tax regimes. This implies that the positive effects dominate.

For households $G_1: F, I$ – whose parent is in the formal sector but whose children are in the informal sector – bequests decrease for all three tax regimes. The current “formal sector” parents, who are suffering from the social assistance program, cut bequests to their “informal sector” children, who will benefit from the program.

For households $G_1: F, F$ bequests change by a small amount (1%) when consumption tax is the financing instrument. However, when labor and capital income taxes are used to finance the expansion, bequests start dropping as the social assistance program becomes more generous (up to 5% for $\Psi^t = 0.5$).

At the aggregate level, bequests increase when the government finances the social assistance program with consumption tax or labor tax (crowding in effect). On the other hand bequests decrease when capital taxes finance the expansion. In other words, in this case public transfers
crowd out aggregate bequests.

**Within family transfers.** Family transfers have a credit and an insurance function. The former lessens the borrowing constraint so that individuals are able to consume more when young. The later insures the consumption of parents and children against income shocks. As reported in the top panels of figure 3, households whose parents work in the informal sector $G_1: I, I$ and $G_1: I, F$ transfer money from children to parents. From the bottom panels we see that children in households where parents are formal sector workers ($G_1: F, I$ and $G_1: F, F$), borrow from their parents early in their careers because their income is low. They later transfer income back to their parents when the parents have become old.

The effects of the public insurance program (when capital taxes adjust) on intervivos transfers from parents to their children differ across household types. Household types $G_1: I, F$ and $G_1: F, I$ tend to increase transfers from children to parents, whereas household type $G_1: I, I$ increases transfers to parents around age 70 and decrease transfers when parents are older than 75. This indicates that intervivos (private) transfers are only partially crowded out by public transfers.

**Wealth Inequality.** Perhaps surprisingly, the wealth inequality increases. The Gini coefficient becomes larger after increasing the replacement rate. The changes in the Gini coefficient are monotone over the range of the policy parameter. We identify two possible reasons. First, altruistic agents change the amount of bequests to compensate their parents or children who suffer from the new policy. Young formal sector workers who will not be recipients of social assistance receive more bequests from their parents as protection against high taxes in the future. Young informal sector workers who will receive social assistance tend to receive less bequests from their parent. Second, the effect of a social assistance program on labor supply are not identical across agents. The labor supply of informal sector workers drops much more than that of formal sector workers. Therefore, labor income of informal sector workers is much lower than that of formal sector workers. This also leads to higher concentration of wealth.

**Welfare.** We report welfare effects across household groups and types in table 5. Welfare is measured in terms of indirect utility of newly established households. We identify the following
important sources of welfare effects: (i) crowding-out effect due to distortions on savings and labor supply; (ii) redistribution effect resulting from the targeting of the social assistance program and its financing instruments; (iii) risk-sharing effect due to risk aversion and the resulting insurance function of the social assistance program. The welfare effects vary across household types and change significantly with increasing generosity of the social assistance program. Depending on the demographic structure and the working sector/skill composition, a household can experience welfare gains or losses.

The welfare on the parent-child households $G1 : I, I$ – who are recipients of social pensions – increases by 2.5% following an increase in the replacement rate from $\Psi^I = 0$ to $\Psi^I = 0.5$ (consumption tax case). The welfare gains are even more pronounced under labor income tax and capital income tax financing. The welfare effects are monotone over the range of policy parameter $\Psi^I$.

The welfare effects on the parent-child household $G1 : I, F$ – whose parents are recipients of social assistance – are not monotone due to two competing forces. On one hand, cash transfers to parents in the informal sector increase household consumption and leisure (positive effect). On the other hand, higher taxes and distortionary effects on savings and labor supply lower household income, especially the income of children working in the formal sector (negative effect). Consequently, the dominant effect will determine the direction of the welfare change. For small transfer programs the negative effect dominates, so that welfare drops. As the social assistance program grows in size, welfare increases approximately to its original level.

The welfare effect on household types $G1 : F, I$ – whose formal sector parents do not receive a social pension but whose informal sector children will when they are old enough – is negative. Intergenerational links through operative bequests spread the income effects over the generations in the dynasty, which in turn affects welfare. An additional increase in transfer income of the future household results in a positive effect on the current household’s welfare. However, the current household suffers from paying a higher tax. The welfare loss indicates that the negative effects are dominant.
For households $G2 : I$ – parents with no children work in the informal sector – the welfare effect is remarkably strong. They will have no family support nor will they receive public pension payments when old. They therefore rely on their own savings to support consumption when old. There is no other instrument to insure themselves against longevity risk. The introduction of a social assistance program, therefore, gives them a great opportunity to smooth their consumption.

Household type $G3 : I$ – children in the informal sector without parents – experience welfare losses when consumption tax and capital tax are financing the expansion of the social assistance program. In the labor tax regime this type experiences a welfare gain, due to the fact that this type does not pay the increased labor tax.

For all other household types, $G2 : F$ and $G3 : F$ we report welfare losses. This is mainly due to the distortion of the social assistance program which in the end lowers household incomes. The introduction of a social assistance program does not result in any additional benefit to these agents. On other hand, the program creates distortions such as lower wage rates, higher taxes, and higher consumption prices which then lower income and welfare. For instance, households $G2 : F$ – parents in the formal sector without children – will not receive benefits from the public pension program but have to live in a less efficient economy with higher tax rates.

5 Sensitivity Analysis

In this section we conduct sensitivity analysis on parameters $\sigma$ and $\kappa$ in the utility function.\(^\text{16}\) First, we shut down labor/leisure choice of the elderly by setting $\kappa = 0$ and keeping the parameter of risk aversion unchanged at $\sigma = 1$. In our policy experiments, welfare gains are still obtained for household types $G1 : I, I$ and $G2 : I$. Type $G1 : I, F$ still exhibits a non-monotonic pattern but the positive welfare effect starts already at low replacement rates.

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. In our policy experiments, welfare gains for all of these recipient households are magnified because the insurance function of the social assistance program becomes more important with increasing risk aversion.

Third, since the welfare effect varies with the preference for 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.

Fourth, we are interested in analyzing these effects in an economy with more income inequality. We calibrate efficiency profiles for formal and informal sector workers in such way that results a smaller ratio of average lifetime income between informal and formal sector workers becomes smaller (28%). 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 assistance 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 assistance program.

Fifth, we are also concerned that the size of the informal sector or the coverage rate of social security may be important for the magnitude of the distortion effects caused by the social assistance program. To verify whether our results would be different in an economy with either a smaller or a larger informal sector, we calibrate the model to an economy with coverage rates of social security of 25% and 75%, respectively. Our results indicate that even though the magnitudes of the policy effects on aggregate variables are changing, the general result of the policy experiment does not change.

Finally, we conduct our analysis in an economy with a capital income share of the informal sector $\alpha^I = 0.2$ and $\alpha^I = 0.3$. We also run a smaller social assistance program targeting only to 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, holds.

Hence, in contrast to the literature focusing on developed countries (e.g. Fuster, Imrohoroglu and Imrohoroglu (2003) and Fuster, Imrohoroglu and Imrohoroglu (2007)) our welfare effects are more persistent. First, since social assistance programs target only a small part of the population, the crowding-out effects are relatively small. Second, skill shocks in combination with the segmentation of the production sectors and labor markets, increase the importance of the insurance function of social assistance programs. Third, social assistance programs have a redistribution function because they target the uncovered elderly in the informal sector. Fourth, decreasing in labor supply of very old informal sector workers (> 75) results in welfare gain.

6 Conclusion

We examine the effects of extending social security on private transfers, savings, labor supply of elderly workers, the wealth distribution, and welfare. Our analysis emphasizes the context of developing countries and is different from previous literature in several dimensions. First, we model the segmentation of labor markets and production sectors in a two-sector model. Second, we explicitly model a “dual” social security system, a formal one operated by the government and covering only a part of the population and an informal one operated by households themselves via altruistic motives. Third, we model the environment in which there is a lack of insurance instruments against demographic and lifetime income shocks. Individual agents have uneven access to insurance services against those shocks. Informal sector workers rely exclusively on family insurance and face a severe shortage of insurance services when old.

Similar to results in previous literature, our model predicts the crowding-out effects of social security. Introducing a moderately-sized social assistance program lowers output by up to 3.25% and labor supply by up to 2.5%. The magnitude of the effects depends on how the expansion is financed. In contrast to previous literature on social security reform in developed countries, the model predicts that the introduction of a public social assistance program has positive effects on the welfare of recipients. This result suggests that the “positive” insurance function and the
redistribution function of the social assistance program dominate the “negative” crowding-out effects. In addition, the labor force participation rate of very old informal sector workers (> 75) can be reduced to zero. Our results show that accounting for the characteristics of developing countries is essential when studying social security reform in developing countries.

Our results carry policy implications. First, our findings provide a justification for extending the coverage of social security. Second, our results quantify the efficiency loss of a social assistance program. Third, the results indicate that consumption taxes minimize the efficiency loss. Finally, our results show that introducing a social assistance program will not lead to more equality in the long run.

Our analysis is limited in several dimensions. First, we have not yet solved for transitions. We are therefore not able to make a statement about the short-run implications. Second, the occupational/sector choice is not endogenized. In addition, there are several interesting questions which can be studied within this framework, for example, the relationship between fiscal policy and the size of the informal sector, allocation of skills across sectors, trade-offs between a social assistance program and other public programs such as education and health, the effects on private investment in education and human capital accumulation, and the effects of population aging in developing countries. We leave these issues for future research.
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URL: http://ideas.repec.org/p/rio/tecdis/466.html


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## 7 Appendix

### 7.1 Tables and Graphs

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Model</th>
<th>Observation/Comment/Source</th>
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Table 1: Preference and Policy Parameters
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Table 2: Model Outcomes that Match Data
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Table 3: Aggregate Effects with \(w^I H^I/w^F H^F = 0.6\) and \(\kappa = 1\)
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Table 4: Bequests to Next Households with \(w^I H^I / w^F H^F\) = 0.6 and \(\kappa = 1\)
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Table 5: Welfare of Household Age 1 with \(w^I H^I / w^F H^F = 0.6\) and \(\kappa = 1\)
Figure 1: Labor Supply and Income Profile by Sectors
Figure 2: Labor Force Participation Rate and Lifetime Labor Supply of Informal Sector Workers
Figure 3: Average Intervivos Transfers Before and After