

ESSAYS ON FISCAL AND PENSION POLICIES IN
DEVELOPING ECONOMIES

A Dissertation

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I would like to dedicate this dissertation to my beloved wife, Vivian Opoku and
adorable children: Nyamebohye, Nyameaye and Nyameanimpa . . .

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Abstract

This dissertation investigates two germane issues relating to a developing economy with a large informal sector: optimal income taxation and pension policies. First, we developed a two-sector general equilibrium overlapping generation model with endogenous formal-informal labor supply and human capital investment to characterize the optimal capital and labor income taxation in developing economy with large informal sector. For the quantitative analyses, Ghana is used as an example given its large size of informal sector employing about 88% of total workers. We found that in an economy with large informal sector, capital income should be taxed at a rate higher than that of labor income tax. This result comes from the fact that a labor income tax still distorts human capital investment and this necessitate a positive capital income tax to mitigate the negative impact of labor tax. In addition, even if informal sector can be taxed, optimal tax design still requires a non-zero capital income tax due to the presence of human capital investment which will be more elastic compared to financial savings. We thus find that neglecting informal sector in tax design would lead to understating optimal capital income tax and overstating labor income tax and the difference is quantitatively significant.

Second, we developed an applied partial equilibrium life cycle model that consists of overlapping generations of 60-period lived individuals facing mortality risk and individual income risk to investigate the role matching contributions and payments options in influencing participation and contribution to informal pension schemes in developing countries. The model was calibrated to data from Ghana for the quantitative

analyses. The simulation results suggest that matching contributions (pension saving subsidy) targeted to informal workers could be a potent instrument to encourage voluntary participation and contribution by informal workers pension schemes. The policy proposal would be welfare improvement resulting from the redistribution of income from the rich formal workers to the poor informal workers, insurance against risk of poverty from annuity, intra-generation redistribution through accidental bequest from mortality premium and reduction in self control costs. In addition, Our results indicate that targeted matching contributions (pension saving subsidy) to informal workers increase savings unlike redistribution for social pensions (or unconditional redistribution). The study also showed that mandatory annuitization of pension savings with 0% of matching rate would improve participation, contribution, savings and improve welfare of the society.

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Chapter 1

Introduction

This chapter first highlights the motivation and policy background of the studies in this dissertation. Second, our research objectives and the methodologies used in this dissertation are discussed and the choice of the representative country for the quantitative analysis. Finally, we briefly talk about the organization of this dissertation.

1.1 Motivation

Informal employment has persisted and become important part of employment in developing countries¹ contrary to expectation when it was first discussed in academic and policy papers to be temporary mode of employment of unskilled workers (Todaro, 1969). This dissertation therefore investigates two germane issues relating to a developing economy with a large informal sector: optimal income taxation and pension policies.

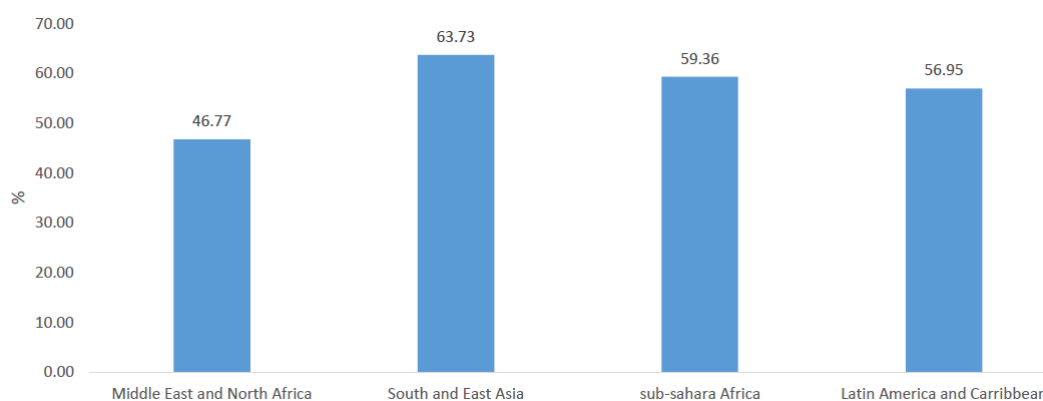
The presence of large informal sector constrains government ability to tax incomes for developmental spending. Figure 1.1 reports the share of informal employment to total employment in the non-agriculture sector for regions of developing economies from the International Labor Organization. These regions report informal employment that are well over 45% compared to developed countries with average of less than 15%.

¹See for example Hart (1973) and ILO (1973)

It is therefore not surprising that income tax structure and sources of tax revenues of developing countries are quite distinct from that of advanced countries as indicated in Figure 1.2. Tax revenues in developing countries are low (averaging 13% in lower middle income countries, compared to 24% percent in high income countries) under a tax system structure that favors indirect taxation (Penalosa and Turnovsky, 2005). Indirect taxes (VAT and consumption tax) constitute about 76% of tax revenue, or 10% of GDP, in developing countries.

The informal sector also disproportionately employs unskilled labor. For instance, while about half of youth with tertiary education have informal sector jobs in developing countries, around 87% of youth who do not have primary education earn their living from informal employment (see Shehu and Nilsson, 2014). Thus, a labor income tax which applies to the formal sector only may affect human capital investment negatively, since most formal sector workers are skilled and educated (see Amaral and Quintin, 2005).

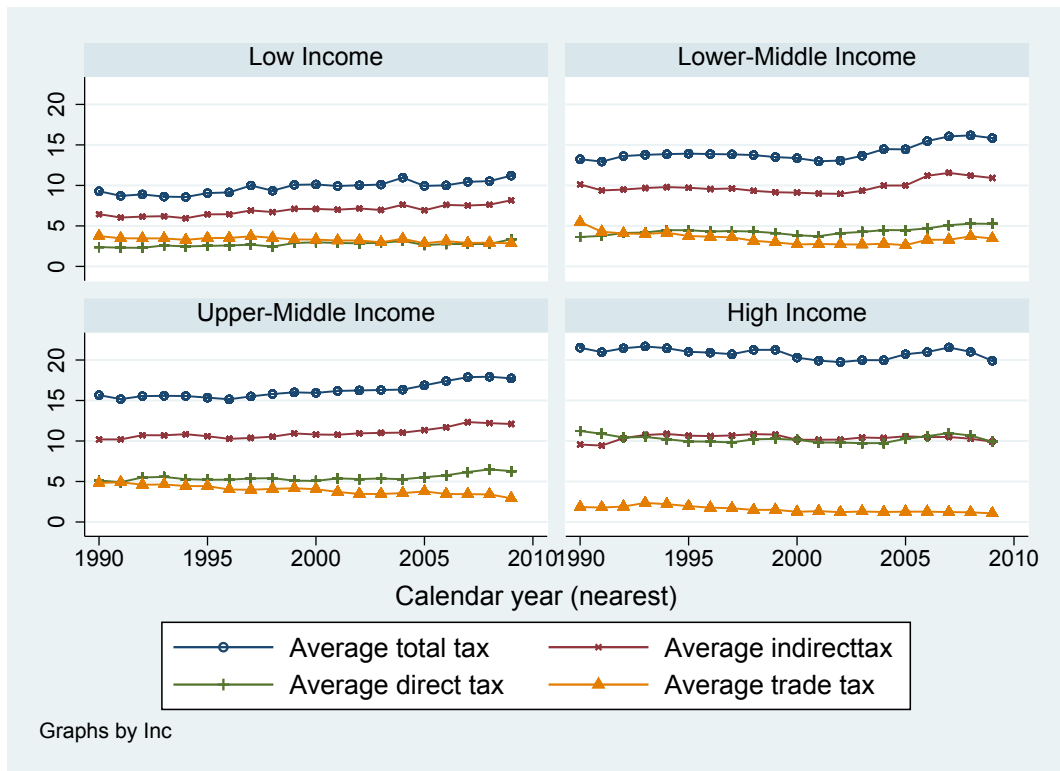
Fig. 1.1 Informal Employment Share (non-agriculture)



Source:authors' calculations based data from ILO (2013).

However, the implications of informality and human capital investment with heterogeneous agents in developing countries on optimal labor income and capital income

Fig. 1.2 Tax Revenue components as percentage of GDP



Source: authors' calculations based on UNU-WIDER data.

taxation has not been fully studied in the literature. More importantly, the optimal design of tax policy for developing countries has received very little attention.²

Informality also restricts government ability to mandate workers to contribute to social security and pension schemes in developing countries. Old age consumption is usually sustained by unstable labor income from employment in developing countries with large informal sector without comprehensive pension policies financed by taxes. Kidd and Whitehouse (2009) find that over 70% of men above age 60+ work outside home in low income countries compared with around 20% in developed economies. Figure 1.3 indicates that employment rates among 65+ is high with 50% as the lowest rate in the selected lower-middle income countries. The problem is expected to be dire as life expectancy in developing countries keep on rising. Already incidence of poverty is high among the elderly population in developing countries. According to Kakwani

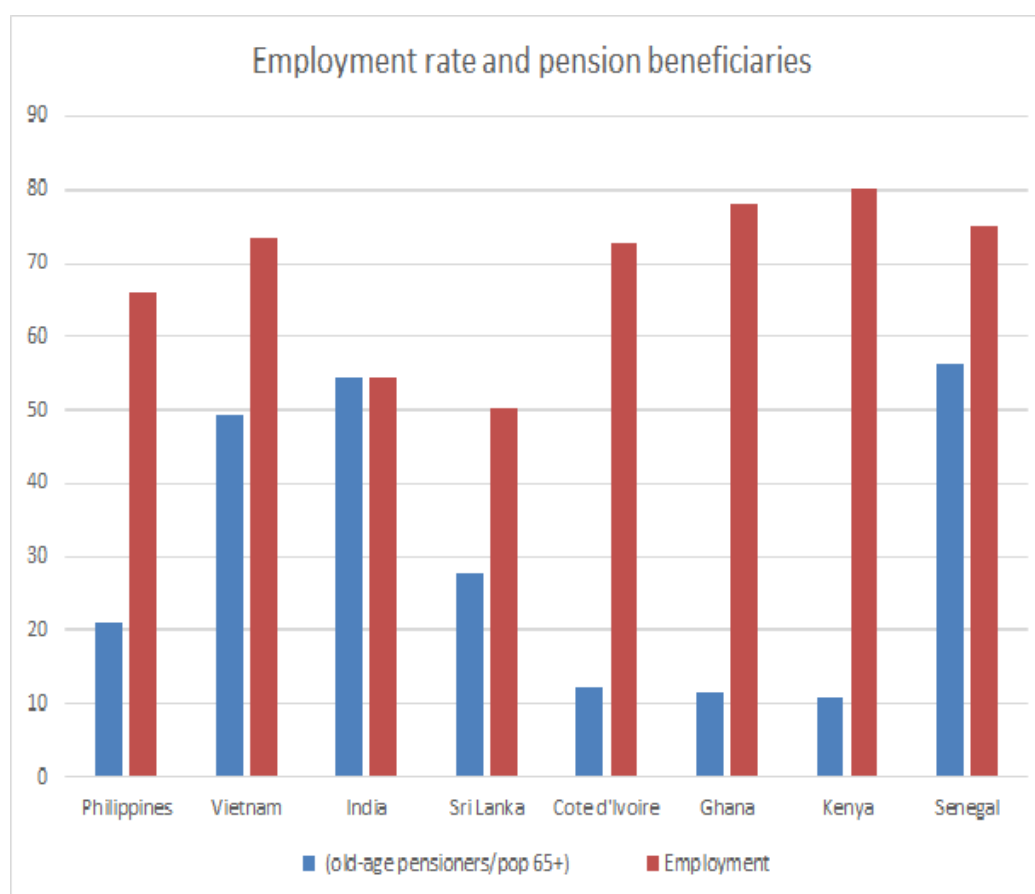
²Exceptions are the studies of Penalosa and Turnovsky (2005) and Kanbul et al (2015), which consider analytical and numerical optimal taxation in a framework with non-taxed informal workers.

and Subbarao (2005), households with old people are poor than the general population in some sub-Saharan African countries where there are no social pension. United Nations' population forecasts indicates that by 2050 the global elderly population (60+) will be doubled to 2 billion (about 25% of the population) in which developing countries will account for about 80% with majority of them without any form of pension. This phenomenon would also likely lead to high dependency ratio and worsen savings rate in developing countries. Already, savings rate in many developing countries are quite low partly due to lack of institutional savings arrangement that can be linked to the presence of large informal sector. Savings rate in low-income and lower-middle income economies are relatively low to support the needed growth and development. Figure 1.4 indicates that savings rates are low in developing countries compared with developed countries where informality is low. Thus, a policy that will enable the employees of informal sector to save for retirement will enhance capital accumulation and spur development.

Lack of fiscal capacity to support universal pension scheme has led to new arrangement where informal workers are allowed to voluntarily participate in pension scheme in many developing countries. The approach is to allow informal workers and self employed to contribute voluntarily to pension schemes when they are young and active in order to secure their future income and consumption when old and incapable of working (Palacios and Orszag, 2015). These schemes in addition to providing secure consumption at old age, is expected to increase national savings and provide necessary capital to support economic growth.

Despite these reforms, the pension scheme coverage for working adults is still low in many developing countries that have introduced voluntary pension scheme for informal workers (Holzmann, Hinz, and Tuesta, 2015). This has necessitated the introduction of financial incentives to induce pension participation and contributions for informal workers who do not adequately prepare old age due to liquidity constraints, myopic decision making or lack of foresight, and incomplete information (Love, 2007). Mat-

Fig. 1.3 Pension Beneficiaries and Employment rate of some selected Lower Middle Income Countries

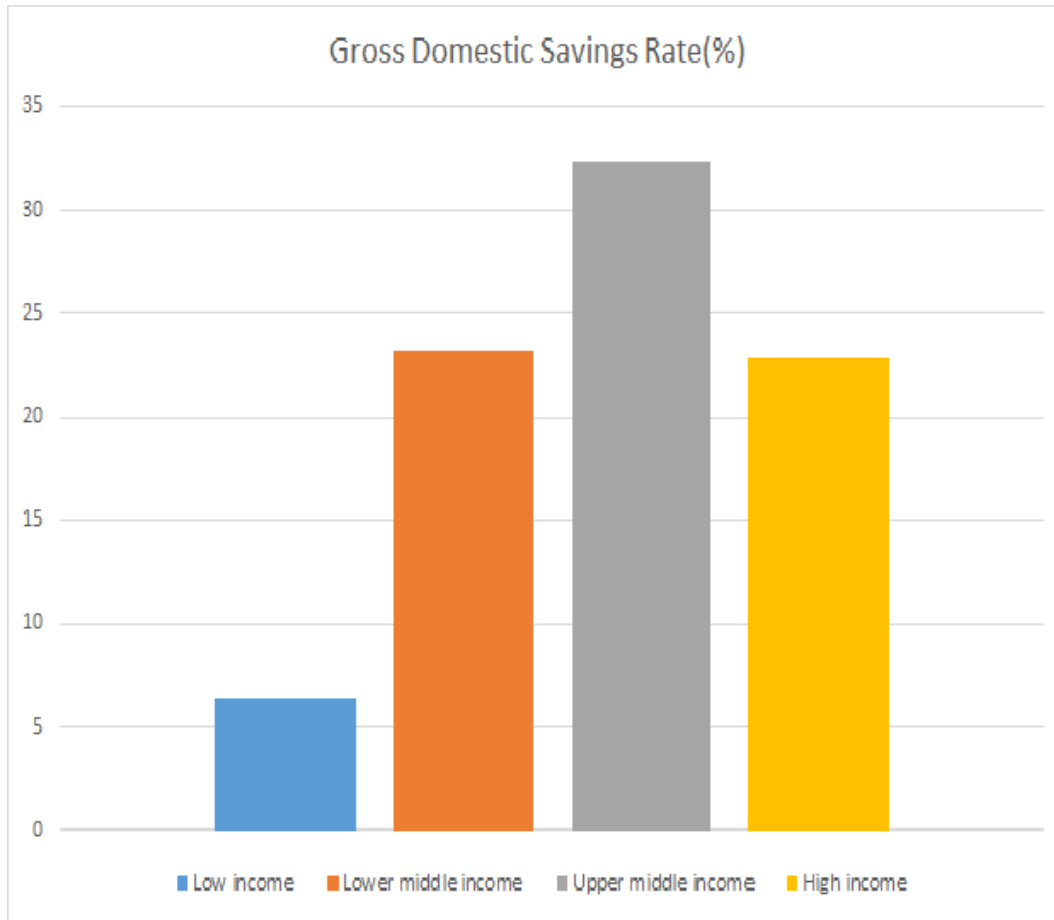


ching contributions³ are increasingly being employed to increase the pension coverage and contribution of workers in many countries and informal workers particularly in developing countries (Palacios and Robalino, 2009).⁴ Recommendations for including matching contributions in voluntary pensions scheme for informal sector has been proposed for other developing countries with low pension coverage (Dorfman, 2015). Matching contributions increase the net rate of return on retirement savings relative to ordinary savings and present consumption (Hubbard and Skinner, 1996).

³Traditionally, granting of preferential tax treatment has been employed in advanced economies to encourage private voluntary retirement saving (Whitehouse, 2015). However, the large size of labor force that do not pay tax (either earning is below taxable income or work in informal sector which is dominant in developing countries) will cannot be incentivized by tax incentives.

⁴Several low- and middle-income countries, including Colombia, Mexico, and Peru; China; and India are implementing variant forms of matching contributions to facilitate pension coverage expansion. Legislation and proposals for other countries have also been made (for example, Peru).

Fig. 1.4 Savings rate by Income Groups (1990-2015)



However, much is not known about the effectiveness of matching contributions on increasing participation and contributions towards pension scheme in developing countries giving the unique characteristics such as informal and self employment for old people coupled with relatively low income during the active period of life. In particular, the impact of matching contributions and benefit payment options on participation, contribution, savings, and welfare in developing countries are yet to be studied. Understanding the effect of matching contributions and payment options for informal workers on household saving behavior and welfare in developing countries is crucial for the design of pension policies for informal workers.

1.2 Policy Background

1.2.1 Optimal income Taxation

Raising adequate revenue for developmental spending on items such as infrastructure, education and redistribution is a major concern in developing countries. The already high consumption tax and concerns about regressivity of indirect taxation in general and VAT in particular implies that developing countries have to raise any additional revenues through income tax (Turnovsky and Basher, 2009).⁵ Moreover, the high and rising degree of income inequality in many developing countries⁶ suggests that a redistributive tax and transfer systems based on imposition of personal income tax would be beneficial for poverty reduction (Kanbul et al, 2015). Indeed, recommendations for tax reforms in developing countries have usually emphasized the need for increased use of direct taxation (see Ahmad and Stern, 1991).

However, in developing countries, raising tax revenues through personal income tax, especially labor tax, is impeded by the large informal sector.⁷ In addition, interest income/capital income is seldomly taxed in developing countries with tax rates below that of labor income tax (Penalosa and Turnovsky, 2005), perhaps motivated by the startling finding of Judd (1985) and Chamley (1985) on long run zero capital income tax. In Ghana, for instance interest income on savings and bonds are not taxed. A law promulgated in September 2015 imposing a personal interest income tax rate of 1% was abolished in February 2016 as it was perceived to create a disincentive to saving and therefore inefficient.

The presence of a large informal sector in developing economies not only has a limiting effect on government efforts to generate revenues but also optimal income tax

⁵Average VAT rates are: low-income countries 16%; lower-middle income countries 13%; upper middle income countries 15%; and high income countries 20% (IMF, 2011)

⁶Niño-Zarazúa, *et al* (2016) indicates that, sub-Sahara Africa, for examples, has the highest inequality in the world measured by Gini with an average Gini coefficient of 61.9% over the last 3 decades

⁷Typically, informal sector firms do not pay tax and are less productive than formal sector firms. The informal sector exists in every economy, although more substantially in developing countries, where it is a large and significant part of economic activity.

policy (see Fortin et al, 1997; Cuff, 2011). In addition, the informal sector increases the efficiency cost of taxes, especially avoidable income tax such as labor tax (Kanbul et al, 2015).⁸

1.2.2 Pension Coverage Expansion in Developing Countries: Incentive Scheme for Informal Workers

Pension coverage has been persistently low in developing countries due to high informality as pensions are usually linked to formal employment. Meanwhile, the population of old people in developing countries keeps on rising posing a difficult challenge for these countries with regard to finding resources to support these vulnerable group.

In recent times, many developing countries in responding to the persistent low coverage for formal sector pensions, and encouragement from international organizations⁹, have been exploring alternatives approaches of providing social security or stable income for informal sector workers who are usually plunged into poverty when they are old. One common approach is allowing informal workers and self employed to voluntary contribute to pension schemes when they are young in order to secure their future income and consumption when old and incapable of working (Palacios and Orszag, 2015). These schemes are expected to provide income security for old people, reduce old age poverty and improve welfare in developing countries. Moreover, it is expected to increase national savings to facilitate capital accumulation for economic development. The important role of institutions such as formal arrangement set up to encourage retirement savings by low income households has been discussed in the literature (see for eg Beverly and Sherraden, 1999).

⁸Developing countries with weak fiscal capacity face both economic and institutional constraints on revenue generation. While such economic incentive constraints limit the use of high income tax rates to raise more fiscal resources, since labor will move from formal to informal sector, the institutional constraints limit the broadening of the income tax base due to low fiscal capacity in monitoring and compliance, giving rise to a sizeable informal sector (Besley and Persson, 2013).

⁹see for example World Bank (1994) - "Averting the Old Age Crisis". Though the report emphasized increasing coverage for non-contributory pension to reduce old age poverty, the huge fiscal cost involved has led to the concentration on expansion of the coverage of contributory pension system.

The implementation of matching contributions to informal sector generates important questions regarding the effect of matching contributions on savings behavior/pension scheme participation of informal workers in developing countries and the role of benefits payment options. This is particularly important given that these targeted people are self employed and informal workers who do not necessarily retire but continue to work and depend on old age labor income (albeit insufficient). Yet the impact of matching rates¹⁰ and the appropriate form of benefit payment options¹¹ have not been analyzed in the literature. The participation and contribution effect of two main benefit payment options (annuity and lump sum payments) have been ignored in the literature. Annuity payments and lump sum payments could have different impact on contribution and old age poverty reduction or welfare. Mortality premium which is introduced by annuity and insurance against longevity risk would have impact on participation and contribution. Moreover, in the presence of self control problems à la Gul and Pesendorfer (2001), provision of annuity would be welfare enhancing. Lump sum payments, however, provides limited liquidity as savers get access to pension savings at retirement age. This would be important when conditional mortality rate at retirement age is high. On the other hand, the high welfare costs in terms of self control costs that would be incurred in smoothing consumption over the retirement period could affect outcomes.

¹⁰Agents contributions to the retirement account are matched by government to motivate agents to save and also serves as incentive to contribute towards retirement. The matching rate typically range from 25 percent to 100 percent and sometimes above 300 percent with some differences in modalities depending on the sponsor (government, employer or both)

¹¹Typical options include lump sums, phased withdrawals, and mandated annuitization (Palacios and Orszag, 2015). A Phased withdrawal is similar to annuity payments but does not pool longevity risk hence no insurance component.

1.3 Research Objective

Taxation and pension policies are very important topical issues in developing countries. This dissertation attempts to study the optimal income tax, and appropriate policies to increase coverage of pension and improve social welfare.

First, owing to the burden of informality on raising tax revenues in developing countries, we attempt to study a better way of distributing the burden of income tax on labor and capital taking into consideration the presence of large informal sector that do not pay labor income tax. Thus, the main goal of this study is to quantitatively characterize the optimal labor income tax and capital income tax combinations for a developing economy with a sizeable informal sector. We would also like to investigate the role of informal sector and human capital investment in determining the optimal income tax.

Second, we investigate the impact of matching contributions policy as an incentive scheme to expand the coverage of pension system in developing countries. The policy is intended to provide pension for old people in developing countries where there is widespread of informality and old age poverty. In this respect we would like to understand the impact of a costly government sponsored matching contributions in increasing pension participation and contribution. The form of benefit payment options (lump sum vs annuity) may be important for individual's response to savings incentives. We would like to investigate the option that would help to increase participation and contribution on one hand and improve welfare of old people on the other hand. In this regard, the optimal matching contributions rate is determined in the context of a developing economy with large share of informal workers in the labor force.

1.4 Methodology and Target

In characterizing optimal income taxation, we have adopted a structural approach and developed a two-sector general equilibrium overlapping generations model with endogenous education/human capital investment.

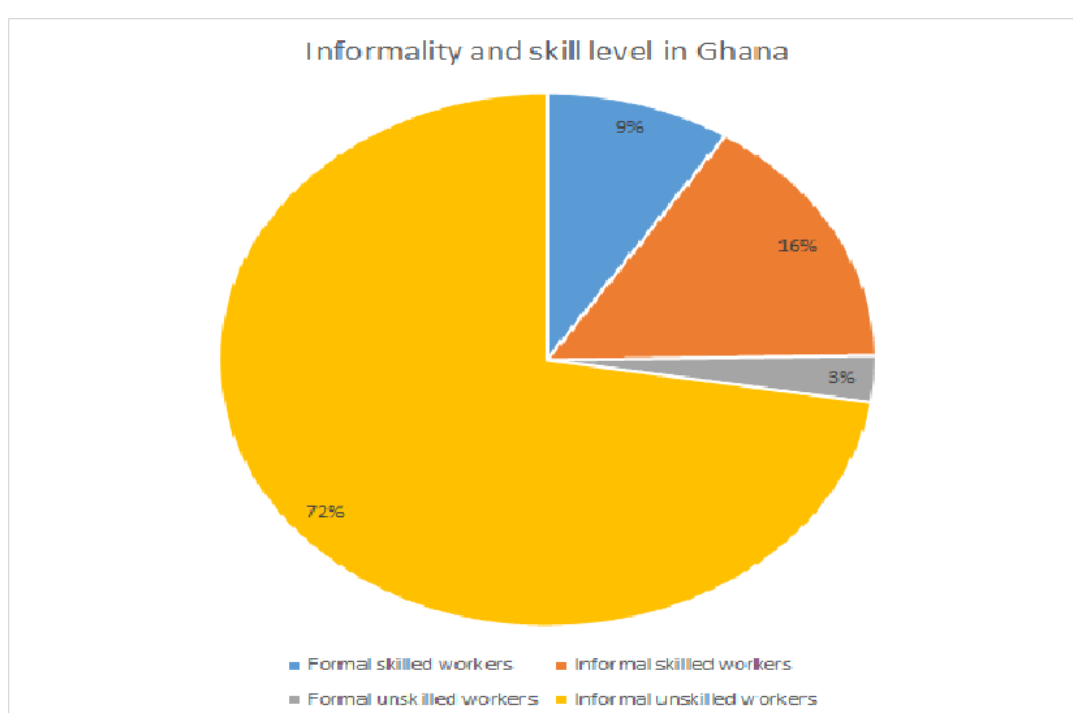
In the model, individuals choose to allocate labor between formal and informal sectors though formal sector work is constrained due to existence of formal-informal sector wage gap. The life cycle is characterized by three stages: child, young adult, and old adult. In the model, parents (young adults) care for children and decide quantity of education to provided for the children, formal-informal labor supply, and consumption/savings. Parents heterogeneity in terms of skill type and income are transmitted to their children through education investment and luck leading to income inequality that emerges endogenously.

In investigating the role of incentive scheme (matching contributions) and appropriate method of benefits payment, we developed a partial equilibrium life cycle model that consists of overlapping generations of 60-period lived individuals facing mortality risk and individual income risk emanating from employment and health status uncertainties. There is absence of private credit markets, including markets for private annuities. Individual preference includes temptation and self-control problems that is biased towards present consumption and generate welfare cost with high cash-on-hand. As argued by Engen et al.(1994), when data for empirical analysis is limited (which usually the case for this policy which has just been introduced or are yet to be implemented in many developing countries), a behavioral model would be important to analyze the impact of such a policy.

Qualitative and quantitative analyses are undertaking to provide insights about the above-mentioned issues in developing countries. Ghana is selected here as a representative country in order to set up a benchmark economy and perform quantitative exercises. Ghana was selected for the following reasons: first, Ghana has a large

informal sector, accounting for about 88% of total employment; second, human capital level in Ghana is very low (see Figure 1.5); third, through household surveys we are able to observe the labor income of individuals in both sectors; finally, interest income is tax exempt in Ghana (The Income Tax (Amendment) Act, 2016 (Act 907)). fourth, it has recently started a voluntary pension scheme with low participation and measures to improve coverage are being discussed.

Fig. 1.5 Informality and skilled proportion in Ghana



Source: authors' calculations based on GLSS 6.

1.5 Organization of the study

The remaining part of this dissertation organized as follows. In chapter 2, we briefly review the literature on optimal income taxation in general and optimal income taxation in economies with informal sector in particular as well as issues on pension in developing economies. The contribution of this dissertation is also provided in this same chapter. In chapter 3, we quantitatively characterized the optimal income tax in a developing

country with large informal sector. We also discuss important mechanism that influence the optimal income tax structure. In Chapter 4, we investigate appropriate benefits payments tools and matching contributions important for encouraging informal workers to participate and contribute to voluntary pension scheme. We also investigate the role of availability of informal employment for old people on their participation to pension scheme. The results from the dissertation and quantitative exercises are summarized with some policy implications in Chapter 5. Finally, we also state some potential directions for future research in areas of this study.

Chapter 2

Literature Review

This chapter will first briefly review the related literature on optimal income taxation in the presence of informality and human capital development. Second, we provide a concise and succinct review of the literature associated savings and welfare implications of matching contributions and pension schemes in developing economies with large informal sector. Finally, the contributions of each study in this dissertation are discussed.

2.1 Optimal Income Taxation in Developing Economies

There is extensive literature that identifies circumstances under which long run non-zero capital income tax is optimal.¹ A number of studies using overlapping generations model find that non-zero capital income tax is optimal for efficient savings and capital utilization (see for example Atkinson and Sadmo, 1980; Chamley, 1985). In general, the desirability of non-zero capital income taxation is the result of constrained choices over taxes and consumption plan by government and individuals respectively (Judd, 1999)².

¹The long run zero capital income tax seminal contribution proposition due to Judd (1985) and Chamley (1985) is one of the celebrated results in optimal taxation literature.

²For studies on household constraint choice and market imperfection on optimal capita income taxation, see also Aiyagari (1995), Imrohoruglu (1998), Conesa et al (2009) Hsu and Yang (2013). There is also a literature called “new dynamic public finance,” which builds on static non-linear optimal labor income taxation literature in the Mirrleesian framework, introduce capital income taxation in

Correia (1996) has shown that from the government constrained choice perspective³, capital income should be taxed when it is impossible to tax other factors of production optimally. In an overlapping generations model with altruistic agents set up, Cremer et al. (2003) showed that if inherited wealth is not perfectly observable and cannot be taxed, then non-zero capital income tax is optimal since it enables the indirect taxation of inherited wealth.

Our study is closely related to existing studies analyzing the circumstances where government is unable to tax human capital income and labor income separately (Jacobs and Bovenberg, 2009; Stantcheva, 2014, Davies et al, 2009; Peterman, 2016; Chen et al, 2011)⁴ and also unable to tax factors of production employed in a particular sector (specifically, informal sector labor inputs) (Penalosa and Turnovsky, 2005; Cerda and Saravia, 2013; Kanbur et al, 2015; Doligalski, 2016).⁵

The endogeneity of human capital investment has been shown to account for the desirability of non-zero capital income taxation (Jacobs and Bovenberg, 2009; Stantcheva, 2014; Davies et al. 2009; and Peterman, 2016).⁶ In a partial equilibrium framework, Jacobs and Bovenberg (2009) use a life cycle model with heterogeneous agents in terms of their ability to acquire human capital and showed that capital income tax is positive and significant. Since labor income tax distorts human capital accumulation, positive capital income is needed to alleviate labor income distortions. Applying a dynamic intergenerational model of human capital investment and bequests, Stantcheva

dynamic framework and focused on stochastic skills evolution and aggregate shocks with emphasis on the implications of information frictions for optimal taxes (see Golosov, Kocherlakota, and Tsyvinski, 2003; and Kocherlakota, 2005).

³See also: Erosa (2002) and Garriga (2003), who used an overlapping generations life-cycle model to show theoretically that if age-dependent taxes are not allowed, a non-zero capital income tax is optimal.

⁴In an infinitely lived agent model with human capital investment, Lucas (1990), Judd (1999), and Jones et al (1993, 1997) found both physical capital income and human capital income tax to be zero in finite time.

⁵In infinitely agent model with labor market search frictions, a non-zero capital income tax is needed to correct distortions in the labor market in order to encourage hiring and labor supply (Domeij, 2005).

⁶Browning and Burbidge (1990) showed that positive capital income with zero labor income tax (or a subsidy on labor supply, if the desired government revenue is small) is still optimal even if there is no redistribution, as long as liquidity constraint is present in the early stage of the life cycle in a single agent model of human capital investment.

(2014) finds that bequest taxes are generally non-zero. Here, the non-zero bequest taxes indirectly influence education investment and work decisions.

Davies et al. (2009) showed analytically that capital income should be taxed at a higher rate than labor income tax in order to create incentive to work. However, a subsidy on investment is required to mitigate the distortionary impact of capital income taxation so that income tax will still be optimal at steady state. Peterman (2016) quantitatively characterized optimal linear capital income taxation and non-linear labor taxation in a comprehensive general equilibrium model of overlapping generations with endogenous human capital accumulation and found that high capital income tax with flat but lower labor income tax is optimal for reduction of human capital distortions associated with non-linear labor income tax.⁷

All these studies⁸ except Peterman (2016), derived optimal labor income and capital income tax results analytically. On the other hand, this paper calibrates our model to data in order to quantitatively characterize optimal income taxation in a family dynastic model with overlapping generations where parents undertake human capital investment of their children. Furthermore, we focus on financial savings for old age that generates capital accumulation rather than financial savings for bequests purposes.

Informality and/or the informal sector have not been explicitly considered in studies of optimal tax design, especially for developing countries where the size informal sector is large, with the exception of Kanbur et al (2015), Cerda and Saravia (2013), Penalosa and Turnovsky (2005) and Doligalski (2016)⁹.

Penalosa and Turnovsky (2005) showed that impossibility of taxing a sector leads to optimality of non-zero capital income tax. They employed a two-sector model contain-

⁷In an infinitely lived agent model with labor market search frictions and endogenous human capital accumulation, Chen et al (2011) find that a higher capital income tax and reduced labor income tax are needed to cause a rise in wage discount and encourage more hiring and employment.

⁸Other related literature considers the effects of fiscal policy on education or human capital investment (see for example Heckman, 1976; Benabou, 2002; Erosa and Koreshkova, 2007)

⁹Our paper is also related to the literature that analyze fiscal implications of informality in developing countries (see for example Turnovsky and Basher, 2009; Busato, et al 2012; Fortin et al 1997; Prado, 2011)

ning both formal and non-taxable informal sectors. Both sectors employ homogeneous labor and capital as factors of production, with high capital-labor ratio in the formal sector and considered capital and labor income taxation. Those models have special relevance for developing countries as opposed to canonical optimal taxation analysis, where government is assumed to possess the fiscal capacity to tax income from every sector. Penalosa and Turnovsky (2005) find that the optimal capital income tax rate should be at least as large as the labor tax rate in an economy with nontaxable informal sector. Since in the model both capital income taxation and labor income taxation are distortionary as a result of shifting resources to the informal sector, higher taxation of capital income raises more revenue since the taxable formal sector is capital intensive.

Cerda and Saravia (2013), however, modeled formal and informal sector in monopolistic competition market with three tax instruments, labor tax, capital income tax and profit tax. Formal sector employed both capital and labor as factors of production, while informal sector employed only labor as production input. The study found negative capital and labor income tax and positive profit tax as optimal. Here the negative capital and labor income tax rates prevents distortions on savings or capital accumulations and misallocation of labor into low productivity informal sector, respectively. The present study, however, considers labor heterogeneity considering the difference type of labor inputs engaged in both formal and informal sectors. This papers considers labor income tax and capital income tax in perfect competitive market.

Amaral and Quintin (2006) considered two sector economy of formal and informal sectors with endogenous education and heterogeneous abilities in dynamic model to explain the key features of informal and formal sectors. He showed that the formal sector which is capital intensive due to its managers' ability and opportunity to expand through borrowing, employs more skilled workers relative to unskilled workers due to the complementarity between physical and human capital. Though the present paper and Amaral and Quintin (2006) framework are similar, we rather focus on the design of optimal capital and labor income taxation.

Kanbur et al. (2015) studied the effects of informality on optimal linear labor income tax and transfer system with exogenous earning capacities of agents. The study derived optimal tax formulas in a static model of welfare and poverty minimization that features efficiency cost of taxation and society's value for redistribution. They found that the presence of informal sector alleviate the burden of higher taxes on the poor but also increases the elasticity of the tax base implying high efficiency cost of higher taxes.

Doligalski (2016) also analyzed optimal non-linear labor income tax in formal-informal framework where workers are differentiated based on differences in formal and informal productivities in static environment. In this present paper, workers heterogeneity are treated as endogenous in a dynamic general equilibrium model to consider both linear labor income tax and capital income tax.

Moreover, these studies provide analytical and numerical findings of the effects of informality on optimal income taxation¹⁰. We use a calibrated data to quantitatively characterize optimal income taxation. This study considers optimal taxation policy in developing economies with large informal sector. We specifically, analyze the implications of large but low-productivity non-taxable informal sector and human capital investment on the design of optimal capital income and labor income taxes in dynastic human capital model.

2.2 Pension Coverage Expansion in Developing Countries: Incentive Scheme for Informal Workers

This study contributes to two main strands of literatures on matching contributions and voluntary pension schemes. The first is the literature on calibrated models that analyze response of retirement savings to savings incentives targeted to boost consumption

¹⁰Except Doligalski (2016) who calibrated the model to Columbian economy where about 58% of labor work in the informal sector but as noted earlier that model is static and do not deal with capital income tax.

after retirement with behavioral life cycle set up in partial equilibrium. The literature, that concentrates on advanced economies and United States in particular, have analyze implications of employer and government matching contributions in tax-favored Individual retirement accounts (IRAs). Closely related papers in this literature include Love (2007), Engen et al. (1994) and Laibson et al. (1998). Engen (1997) analyzed the effect of matching contributions on 401(k) plans and IRAs using a partial equilibrium life cycle model with income and mortality risks. The simulation results of their study indicates a short run substitution from liquid or conventional savings account to the IRAs but found a moderate increase in aggregate savings in the long run. Laibson et al. (1998) explicitly models savings impact for households with hyperbolic discount functions. They find that IRAs increase households savings and the impact is larger for hyperbolic households that benefits from commitments provided by IRAs. Love (1997) quantitatively characterized the impact of employer-matching and other features of 401(k) plans. The simulation results indicate that participation and contribution response to matching contributions are significant albeit for only middle age workers since young workers in their early working life facing rising life cycle income profile also face liquidity constraints.

Others including Fehr and Kindermann (2010a) and Imrohoroglu et al. (1998) have considered retirement savings in general equilibrium set up. Imrohoroglu et al. (1998) studied IRA in United in a general equilibrium framework and find that financial incentives provided by IRAs raises national savings rate and capital stock in a steady-state and that about 9 percent of IRA contributions are additional saving. Fehr and Kindermann (2010a) calibrated a general equilibrium model with sophisticated time inconsistency agents to Germany to examine the effect of moving from PAYG pension to voluntary personal retirement assets. They find that sophisticated hyperbolic consumers would voluntarily save optimally when committing accounts are available. They find that welfare losses of replacing pay-as-go- pension with IRA is less severe for hyperbolic consumers compared to rational consumers. IRAs are found to be more

attractive for hyperbolic than for rational consumers, due to the commitment device provided by restricted withdrawal during active years of life. They find that assets are higher in response to IRAs availability in an economy populated by hyperbolic individuals.

A closely related study with regard to a developing country context is Palacios and Rabalino (2009). It is the only study that analyze effectiveness of matching contributions on pension savings using life-cycle behavioral model in a developing country context. The model assumed the absence of precautionary motive savings in order to concentrate on the response of workers to matching contributions. The study which simulated life cycle decisions indicates that matching contributions can substantially raise the density of contributions to a pension system. Their result suggest that the level of matching relative to earnings is an important determinant of take up rates and amount of contributions. Our paper builds a more realistic life cycle behavioral model including precautionary savings and availability of employment for old people in the informal sector. A related paper on provision of pension for informal sector workers in developing economies is Jung and Tran (2012) who considers welfare and savings impact of social pension for informal sector workers in dynamic general equilibrium set up. Giving the fiscal challenges in provision of universal old age pensions, many developing countries are not considering *ex post* transfer as discussed by Jung and Tran (2012) but rather *ex ante* incentives to participate in contributory scheme. Our study therefore considers welfare and savings implications of these policies.

The second strand of relevant literature is on empirical estimation analyzing effect of financial incentives (tax incentives and matching contributions) on retirement savings mostly in developed economies, and United States, in particular. In United States, the matching rates variations in employer-sponsored marching contribution has been used as natural experiment to analyze its effect on individual savings. Most studies find support for theoretical prediction of positive effect of matching on participation rates (see for example Dworak-Fisher, 2008; Mitchell, Utkus, and Yang 2007; Papke and

Poterba 1995; and Huberman, Iyengar, and Jiang 2007).¹¹ The empirical evidence on impact of employer matching rates on contributions, is however, less conclusive (see Marian, 2015 and Adams et al. 2015 for review on literature in United States). In Korea, matching contributions is found to have had a moderate effect in increasing participation by farmers and fishermen who are entitled to the matching (Moon, 2015).

In developing countries, there is lack of literature on the evidence of matching effectiveness and implications on welfare due to data unavailability as programs are in their early stages of implementations. Early evidence from China and India indicates that matching contributions has the potential to increase participation and contribution to informal pension schemes in developing countries (Palacios and Sane, 2013). Given the lack of empirical evidence due to data unavailability, much can be learned from a well designed simulation exercise. We therefore use behavioral life cycle model to examine the effects of the proposed policies. For such an exercise to be able to provide a compelling results and policy evaluations, the model must reflect adequately the behavior of workers in developing countries than that of the simple model of Palacios and Rabalino (2009). The model in particular should represent consumption-savings choices and the key features of informal pension scheme in developing countries.

In our study, we consider how matching contributions will influence informal workers with low savings rate in a developing country context. Moreover, we also examine the influence of benefit payments methods including lump sum, partial and full annuity. This is particularly important since annuity payments, for example, could reduce over-consumption and provide income security for old people who may suffer from temptations and through its insurance effect. Hubbard and Judd (1987) found that

¹¹Few studies find evidence of less positive significant effect of matching on participation. Example include Engelhardt and Kumar (2007) and Duflo, et al (2006). Engelhardt and Kumar (2007) using naturally occurring variation in employer matching rates in United States and Duflo, et al (2006) using a field experiment on low income households find that though participation rates are positively affected matching rates, they are less responsive to changes in matching rates. Other studies such as Papke (1995) find no evidence of effect of matching rates on participation rates. Dworak-Fisher (2011) also finds employer-sponsored matching in United States have insignificant effect on participation of workers with lowest income workers.

annuitization of savings by providing longevity insurance increases welfare and reduces savings in a model with an uncertain lifespan. Thus, the study takes into consideration the implications of different payments options on participation and contribution and analyze their effect on savings and welfare of government sponsored matching contributions in developing economy with large informal workers.

2.3 Contribution of the Study

2.3.1 Optimal Income Taxation in Developing Economies

This study contributes to the existing literature on taxation policies in developing countries with large informal sector. First, the study extends the literature on optimal income taxation by incorporating informal sector, a key feature in developing economies, in a calibrated model to a typical developing country with large informal sector. Very few studies consider informal sector and developing economy in the literature on optimal taxation. (Penalosa and Turnovsky, 2005; Cerda and Saravia, 2013) provide analytical and numerical analysis of economy with relatively small size of informal sector as pertain in advanced economies. We use data to match a real economy with large informal sector to provide quantitative characterization of optimal income tax rates.

Second, The study contributes to the optimal capital and labor income taxation literature as the first to incorporate with human capital investment and informal sector in a two-sector model with formal and informal sectors. Among the studies that considers informal sector, this study is the first to incorporate human capital investment.

2.3.2 Pension Coverage Expansion in Developing Countries: Incentive Scheme for Informal Workers

This study contributes to the existing literature on pension policies in developing countries with sizable informality. Very few studies consider pension expansion in developing countries. Jung and Tran (2012) considers pay-as-you-go (PAYG) or unfunded pension to informal workers focusing on risk sharing role of social pension. This study focuses on funded pension in the presence of self-control problems which may lead to old age poverty resulting from suboptimal savings. These issues were not considered by Jung and Tran (2012).

The study also extends the literature on impacts of financial incentives on pension participation by allowing for endogenous elderly labor supply, a key feature in developing countries. Love (2007) assumed exogenous retirement which increases the necessity of retirement savings. The differential impacts of lump sum and annuity payments options which have not been considered in the literature are also explored as part of instrument to encourage pension participation and for welfare improvement.

While some studies analyze the savings and welfare impacts of matching contributions, there is no study that determines the optimal matching contribution rate, at least in the context of developing economy. Love (2007) examines contributions and participation response of 401(k) plans to employer matching rates in United States. Fehr and Kindermann (2010a, 2010b) and Imrohoroglu et al. (1998) have considered savings effect of tax-favored retirement accounts in general equilibrium set up. This study is the first to determine the optimal matching contributions rate with annuitization of pension assets as benefits payment option in the context of a developing economy.

Chapter 3

Optimal Income Taxation in Developing Economies

This chapter quantitatively characterizes the optimal income taxation in a developing economy with a sizeable informal sector. While many studies have examined the optimal income taxation, very few have considered key features in developing countries. Due to the widespread, importance and persistence of informalities in developing countries amidst low level of skilled manpower, it would be importance to explicitly consider informal sector and human capital investment in determining optimal tax design.

Many developing countries rely on indirect taxes to raise revenues for government spending. Indirect taxation constitutes about 76% of tax revenue (10% of GDP) in developing countries similar to that of advanced countries. This suggests that there may be few options in raising more revenue through indirect taxation. Moreover, there are concerns over regressivity of indirect taxation in general and VAT in particular. Thus, the increasing need for high spending for infrastructural and redistribution, suggest that additional revenues should be raised through income taxation. However, the presence of large informal sector restricts the use of labor income taxes as it pertains in many advanced countries. This study therefore examined how the burden of personal income

tax in developing countries should be shared among labor and capital as factors of production.

We first determine the optimal income taxation when government revenues are generated through income tax with fixed government expenditure, with and without redistribution. We then examine the sources of distortions and important factors that influence optimal income taxation in a developing country context. Our study find that capital income tax should be larger than labor income tax when informal and human capital investment are explicitly considered and that even if there is no allocative inefficiency associated with informal sector, capital income tax should still be positive due to human capital investment.

In this chapter, we develop a two-sector general equilibrium overlapping generations model with endogenous education or human capital investment. In the model, individuals choose to allocate labor between formal and informal sectors though formal sector work is constrained due to existence of formal-informal sector wage gap. The life cycle is characterized by three stages: child, young adult, and old adult. We further use Ghana as a representative for calibration and quantitative analysis. Ghana has large informal sector, taxes only formal labor income and no interest income taxation. Therefore, it is very important for Ghana to design taxation policies that take into consideration its large and persistence informal sector to help reduce tax distortions.

3.1 The Model

3.1.1 Demography

The economy is populated by a continuum of three-period lived heterogeneous agents. Individuals are described as child, young adult and old adult over the life cycle. In the first period, individuals are children who do not work, make no economic decisions but receive education investment in school as determined by their parents. Children

then become young adults and enter the beginning of their second period with children of their own. Young adults decide the education or human capital investment of their children, e_i , and how much to consume and save. Young adults retire and enter the third period as old adults, consume all their savings and die deterministically at the end of the third period. Young adults, who are in their second period, are categorized as skilled and unskilled agents based on the education decision of their parents and luck in accumulating human capital in the first period (as children).

3.1.2 Production Structure

There is a representative firm in each sector; all such firms produce an identical good that can either be consumed or saved for future consumption. All firms in all sectors are perfectly competitive in both goods and factors markets, albeit constrained in the formal sector, using a constant-return-to-scale technology. While capital is immobile and restricted to the formal sector, labor services are perfectly mobile across the two productive sectors. The total output in the economy is given by $Y = Y^f + Y^h$.

Formal Sector

There is a representative firm in the formal sector that employs physical capital and skilled labor as the only factors of production. The goods and capital markets in the formal sector are perfectly competitive, whereas labor market is not, due to existence of constraints on formal-informal wage gap. Factors employed in formal sector firms voluntarily pay taxes imposed by government. Formal sector production is given as

$$Y^f = A^f K^{\alpha_k} (L_s^f)^{\alpha_s} (L_u^f)^{\alpha_u}, \quad \alpha_k + \alpha_s + \alpha_u = 1$$

where physical capital share of income, skilled labor share of income, and unskilled labor share of income are given by α_k , α_s and α_u respectively. In terms of per worker,

the formal sector production function can be written as

$$y^f = A^f k^{\alpha_k} (l_s^f)^{\alpha_s} (l_u^f)^{\alpha_u} \quad (3.1)$$

We assume that prices of input factors are determined in perfect competitive markets subject to former sector constraint on formal-informal wage premium.¹ Profit maximization therefore necessitates that firms pay each production factor its marginal product at equilibrium.

Formal sector firm profit maximization problem is formally specified as follows:

$$\Pi = \underset{k, l_s^f, l_u^f}{Max} \{ A^f k^{\alpha_k} (l_s^f)^{\alpha_s} (l_u^f)^{\alpha_u} - rk - w_s^f l_s^f - w_u^f l_u^f \} \quad (3.2)$$

$$r = (\alpha_k) A^f (k)^{\alpha_k - 1} (l_s^f)^{\alpha_s} (l_u^f)^{\alpha_u} \quad (3.3)$$

$$w_s^f = (\alpha_s) A^f (k)^{\alpha_k} (l_s^f)^{\alpha_s - 1} (l_u^f)^{\alpha_u} \quad (3.4)$$

$$w_u^f = (\alpha_u) A^f (k)^{\alpha_k} (l_s^f)^{\alpha_s} (l_u^f)^{\alpha_u - 1} \quad (3.5)$$

Informal Sector

The representative firm that operates in the informal sector does not pay tax on the factors employed in its production, which leads to incompleteness in the tax system. Following the literature on informal sector that models informal sector firms as labor intensive relative to formal sector firms, we model informal sector firm using only

¹This is akin to the Rauch (1991) general equilibrium model where firms avoid payments of minimum wage by operating in a small scale informal sector. Instead of minimum wage, this paper uses minimum formal-informal wage premium/gap to generate informal sector employment and allow prices to be set competitively.

skilled and unskilled labor (see, for example, Turnovsky and Basher, 2009; Ihrig and Moe, 2004; and Cerda and Saravia, 2013)². Thus, the production function and prices of inputs (skilled and unskilled labor) are given by

$$Y^h = A^h (L_s^h)^\gamma (L_u^h)^{1-\gamma}, \quad \gamma < 1$$

with per worker output of the form

$$y^h = A^h (l_s^h)^\gamma (l_u^h)^{1-\gamma} \quad (3.6)$$

$$w_s^h = (\gamma) A^h (l_s^h)^{\gamma-1} (l_u^h)^{1-\gamma} \quad (3.7)$$

$$w_u = (1 - \gamma) A^h (l_s^h)^\gamma (l_u^h)^{-\gamma} \quad (3.8)$$

Labor Market Distortion

There exist a well-documented evidence that wages of formal sector are higher even after accounting for observable characteristics such as education (see for example Amaral and Quintin, 2006). This wage differential has been attributed to minimum wage, efficiency wage and trade unions by creating barriers to entry (Harris and Todaro, 1970). Heckman and Hotz (1986) for example provide evidence of differential earnings functions across sectors in Panama. Recently, Gunther and Launov (2012) provide evidence of involuntary informal employment in Cote d'Ivoire.

This feature of labor market in developing countries is incorporated in our model in a reduced form by assuming that there is labor market distortion/friction such that the supply of formal labor supply is constraint leading to a higher net wage in the formal

²In related literature, this formulation is similar to frameworks where capital is fixed in the informal sector and where capital is abstracted. Doekpe (2004), for instance, used this type of production function for the agricultural sector.

sector. In effect, there is job rationing in the formal sector due to formal-informal wage premium. Thus, we assume there exists a labor mobility constraint such that

$$(1 - \tau_l)w_i^f > w_i^h, \quad i = s, u \quad (3.9)$$

3.1.3 Government

Government taxes³ formal sector labor and capital incomes at rates τ_L and τ_K , respectively, to finance exogenous lump sum transfer and general government consumption. Government budget constraint in every period is given by

$$n_s \tau_L(l_s w_s^f) + (1 - n_s) \tau_L(l_u w_u^f) + \tau_K r k = T + g \quad (3.10)$$

where $k = K/N^y$ is capital per worker. On the right, the first term is transfer per worker to households and g is exogenous general government expenditure. n_s is the share of skill workers in the total work force.

3.1.4 Education and Skill Acquisition

We assume that skill type of a child is determined in the first period of life by education decisions by the parent⁴ and by random elements similar to the formulation of Caucutt,

³Our model set up implicitly incorporates tax evasion with regard to labor income tax as labor can work in both the formal and informal sectors. Thus, workers evade tax (theoretically) by supplying labor to informal sector in response to a higher labor income tax. Since the supply of labor and therefore labor income can be switched from formal sector to informal sector, tax evasion for labor income is theoretically endogenous in the model. However, we abstract from tax evasion concerning capital income tax by our assumption that capital is only employed in the formal sector but not the informal sector. We recognize that this assumption may be over simplification of production in the informal sector, but we used this approach to represent a convenient benchmark case for the labor intensive production of the informal sector (Turnosky and Basher, 2009).

⁴Household expenditure on education in sub-Sahara Africa accounts for about 25.5% of total expenditure on education. Primary (29%), lower secondary (49%), upper secondary (44%), tertiary level (22%). The high unit cost at tertiary level makes it burdensome for parents. Even in developed countries,

Imrohoroglu and Kumar (2003; 2006) and Cramer et al (2011)⁵. That randomness implies that parental investment in education does not necessarily transform a child into a skilled young adult but increases the probability of the child becoming skilled (Doepke and Zilibotti, 2005). Every young adult has one child and decides the number of hours the child spends in school (with the teacher) for education purposes and pays a formal skilled wage per unit of time spent in school by the child.⁶

We normalize school or teacher's time to 1 and therefore a parent has to choose $e_i \leq 1$ for his/her child's education. With positive time in school, the probability of a child of an i -type young adult becoming a skilled young adult in the second period is given by $\pi_i(e_i)$, with $1 - \pi_i(e_i)$ probability that child becomes unskilled. We assume that $\pi_i(e_i)$ is an increasing and strictly concave function with $\pi \in (0, 1)$ and $\pi(0) = 0$, implying that the probability of skill acquisition exhibits a diminishing return on educational time investment. Specifically, we assume human capital production function of the form:

$$\pi_i = b_i e_i^\eta \tag{3.11}$$

where $b_s \geq b_u$ to account for advantages that children of affluent parents have in completing school or becoming skilled workers, factors which are not modeled here. These advantages may be related to early childhood education or pre-school care and schooling advantages of affluent children (see Caucutt and Kumar, 2007).

education expenses is a major burden for families with children at almost all stages of education since the parents pay all costs associated with primary and secondary schooling (see Stantcheva, 2014). For children at college level, parents, relatives and friends covered about 48% of total college expenses in 2016 (Sallie Mae, 2016).

⁵However, Cramer et al (2011) added third component family background and parental genes.

⁶Since we focus on inequality in education investment and hence in skill level, we abstract from public investment in education.

Conditional on the parent choice of quantity of education,⁷ the intergenerational mobility probability matrix between the skilled and unskilled states is given by

$$\begin{pmatrix} & \text{skilled} & \text{unskilled} \\ \text{skilled} & \pi(e_s^*) & 1 - \pi(e_s^*) \\ \text{unskilled} & \pi(e_u^*) & 1 - \pi(e_u^*) \end{pmatrix} \quad (3.12)$$

We calibrate our model of these transition probabilities to the empirical estimates from data.

3.1.5 Household's Problem

In this model economy, only young adults make economic decisions. A young adult cares about present and future consumption as well as future welfare of her child. The Bellman equation for an young adult agent with skill-type i who decides on present and future consumption, savings (a_i), formal labor supply and child's human capital investment (e_i),⁸ to maximize her lifetime utility is:⁹

$$V_i = \underset{c_i^y, c_i^{o'}, a_i, e_i, l_i \leq \bar{l}_i}{\text{Max}} \left\{ u(C^y) + \beta u(C^{o'}) + \Psi \left(\pi_i(e_i) V_s' + (1 - \pi_i(e_i)) V_u' \right) \right\}, \quad i = s, u \quad (3.13)$$

subject to

$$C_i^y + a_i' + e_i w_s^f = (1 - \tau_L) l_i w_i^f + (1 - l_i) w_i^h + T \quad (3.14)$$

⁷In fact, the education time could also be interpreted as education quality bought by the parent

⁸We focus on education as the only that parents can transfer resources to their children in this model and thus abstract from bequest. Indeed, in developing countries the proportion of parents that plan to leave bequest as opposed to *intervivos* will be very small. Bequest recipients in the US account for only about 3.7% of the total population (Gale and Scholz, 1994)

⁹We abstract from labor-leisure choice by assuming that total labor supply is fixed. Indeed, leisure may be less valued and consumed in developing countries given the low level of consumption (see Turnosky and Basher (2011)). The informal sector may serve as a buffer where hours not spent on formal production are employed (see, for example, Todaro (1989)).

$$C_i^{o'} = [1 + (1 - \tau_K)r' - \delta] a_i' \quad (3.15)$$

$$l_i = \bar{l}_i(\kappa_i) \quad (3.16)$$

where β is the subjective discount factor with respect to own future utility from consumption and Ψ is the general level of altruism factor that discounts child's future welfare. $\kappa_i \geq 1$ is a measure of employment constraint/distortion in the formal sector labor market that prevents an agent from choosing the optimal formal sector labor supply.¹⁰ We model out-of-pocket household expenses on education and abstract from any government intervention or subsidy.¹¹ Equation (17) indicates that young adult consumption, savings, and child's education expenditure should be equal to working life labor income reflecting absence of credit market to finance education investment.¹²

The utility function, $u(C^y)$ is twice differentiable with $u_{C^y}(C^y) \geq 0$ and $u_{C^y C^y}(C^y) < 0$. We use the CRRA utility function for empirical analysis of the form $u = \frac{C^{1-\sigma}}{1-\sigma}$. τ_L and τ_K are labor income tax rate and capital income tax rate respectively.¹³

¹⁰Gunther and Launov (2012) find involuntary informal employment where it serves as employment of last resort after rationing out from formal job.

¹¹Thus $e_i w_s^f$ is household expenditure on education

¹²This is particularly relevant in the case of developing countries where higher education is usually sponsored by parents but children cannot be held liable to their parents who borrow to finance their education. See for example Benabou (2002) and Schoonbroodt and Tertilt (2014) for similar exposition where inability of parents to have leverage of children serves as a source of liquidity constraint. See also Picketty (2000).

¹³We concentrate on linear taxes as this study focuses on labor allocation efficiency between formal and informal sectors. We model the endogenous labor supply to both sectors but abstract from the tax progressivity. As long as the general tax level in the formal sector is higher than the informal sector, there will exist an incentive for individuals to reallocate some labor to the informal sector that affects the allocation efficiency. In the model we assume that income tax rate is zero in the informal sector that can be interpreted as that we normalize the effective tax rate in the informal sector to zero and the tax rate in the formal sector is the additional rate relative to the informal sector tax rate. In addition, as argued by Kanbur et al (2015), progressive income tax system reaches only small fraction of the population that work in the formal sector in developing countries.

3.2 Equilibrium Features of the Model and Welfare measure

3.2.1 Optimal Decisions

Formal-Informal Labor Decision

Young adults maximize labor income by allocating a fixed time unit between working in formal and informal sectors. Thus, young adult chooses formal labor supply l_i to maximize his life time utility. This is equivalent to maximizing the expected net wage/labor income by choosing formal labor supply, l_i . Thus, at optimum l_i

$$(1 - \tau_i)w_i^f = \kappa_i w_i^h \quad \text{if } \kappa_i > 1 \quad \text{and} \quad (3.17)$$

$$l_i = \bar{l}_i(\kappa_i) \quad (3.18)$$

where $\kappa_i > 1$ as noted above, is a measure distortion in the labor market that prevents after tax formal wage to equalized informal wage at equilibrium. We assume that this distortion is constant over time.

Saving Decisions

$$u_{c^y} = \beta (1 + (1 - \tau_k)r' - \delta) u_{c^{o'}} \quad (3.19)$$

where u_{c^y} and $u_{c^{o'}}$ are marginal utilities of present and future consumption respectively.

Parent Education Decision

Young adults maximizes life time utility by choosing child's education time e_i . Thus, at optimum e_i , marginal benefits from child's education must be equal to 'internalized'

marginal cost of child education. This is given as

$$\Psi \pi_{e_i}(e_i) \Omega = u_{c_i^y} w_s^f \quad (3.20)$$

where $\Omega = V_s' - V_u'$ and therefore $\Psi \pi_{e_i}(e_i) \Omega$ is the marginal benefit of offspring's human capital investment given by the value to being skilled, Ω' weighted by the altruism factor Ψ and the marginal productivity of the human capital investment $\pi_{e_i}(e_i)$. $u_{c_i^y} w_s^f$ is the marginal cost of child's human capital investment composed of per unit cost of education (formal sector skilled wage) w_s^f weighted by marginal utility of consumption $u_{c_i^y}$ that will be lost (Caucutt, Imrohoroglu and Kumar, 2003; 2006).

Thus, the optimal decisions of skilled and unskilled young adult leads to the following¹⁴:

For skilled young adult,

$$\Psi \pi_{e_s}(e_s) \Omega = u_{c_s^y} w_s^f$$

For unskilled young adult

$$\Psi \pi_{e_u}(e_u) \Omega = u_{c_u^y} w_s^f$$

We derive the maximum lifetime utilities, V_s and V_u , by evaluating the Bellman equation with optimal policy functions, including saving function $a_i^*(n_s)$, formal labor supply l_i^* and therefore maximized wage income and children education function e_i^* to get V_s and V_u . We subtract the value for unskilled from skilled worker to get the law of motion of the value of being skilled worker Ω ,

$$\Omega = CU_s - CU_u + \Psi (\pi_s(e_s^*) - \pi_u(e_u^*)) \Omega'$$

¹⁴Notice that the concavity of utility function and π as well as the fact that $w_s > w_u$ implies that $e_s > e_u$ since for a given human capital investment $e_s = e_u$, the marginal cost of human capital investment is higher for the unskilled young adult relative to the skilled young adult. This results from the higher utility cost of human capital investment for unskilled relative to that of skilled workers.

where CU_s is consumption utility of the skilled/rich and CU_u consumption is utility of the unskilled/poor.

As in Caucutt, Imrohorglu and Kumar (2003; 2006), the value to being skilled has two component comprising $CU_s - CU_u$, the present increase in consumption utility from being skilled worker and a higher probability of realizing the future of being skilled Ω' . Moreover, the endogenous altruism factor increases with the difference in investment in education between skilled and unskilled workers.

The law of motion for a fraction of skilled workers is given by

$$n'_s = n_s \pi(e_s^*) + (1 - n_s) \pi(e_u^*)$$

and the law of motion for physical capital per worker is given by

$$k' = n_s a'_s + (1 - n_s) a'_u$$

3.2.2 Definition of equilibrium

Definition 1. A competitive equilibrium of this economy is a collection of allocations $\{c, a'_i, l_i, e_i\}$, a sequence of prices $\{w_s^f, w_s^h, w_u^h, r\}$, a government policy $\{\tau_l, \tau_k, T\}$ such that Given prices w_s^f, w_s^h, w_u^h, r ; Ω ; and government policies τ_l, τ_k, T

1. Young adults choose c_i, a'_i, l_i , and e_i to solve their decision problem for each skill-type $i = s, u$
2. The representative firm in both formal and informal sectors chooses k^*, l_s^{f*} and l_u^{f*} respectively to maximize profits so that prices of capital, and both types of workers are paid their marginal products.
3. Capital market clears, i.e $k' = n_s a'_s + (1 - n_s) a'_u$

4. The formal sector labor market supply is $l_s^f = l_s n_s$ and $l_u^f = l_u(1 - n_s)$ and informal sector with $l_s^h = (1 - l_s)n_s$ and $l_u^h = (1 - l_u)(1 - n_s)$
5. The labor market clears. That is; $l_s = n_s$; and $l_u = 1 - n_s$ where $l_s = l_s^f + l_s^h$ and $l_u = l_u^f + l_u^h$ ¹⁵
6. Government balances its budget every period i.e

$$(1 - n_s)\tau_l l_u^f w_u^f + n_s \tau_l l_s^f w_s^f = T + g$$
7. The goods market clears, i.e.

$$c + \bar{e} + k' + g = y + (1 - \delta)k$$
 where $c = n_s(c_s^y + c_s^o) + (1 - n_s)(c_u^y + c_u^o)$
 and $k = K/N^y$ and $y = y^f + y^h$ and $\bar{e} = (n_s e_s + (1 - n_s)e_u)w_s^f$ and $g = (1 - n_s)\left(\tau_l l_u^f w_u^f\right) + n_s\left(\tau_l l_s^f w_s^f\right) - T$
8. $\Omega(n_s)$ is consistent with young parents education investment decisions of their children.
9. The n_s' function that individuals posit is consistent with decisions rules

3.2.3 Steady State Equilibrium

A steady state is a competitive equilibrium with $n_s = n_s^*$ and $k = k^*$ with $n_s'^* = n_s^*$ and $k'^* = k^*$

On a steady state, all variables including wages, output per worker, capital/savings per worker, fraction of skilled young adults, and the value of being skilled are time-invariant. Thus, $\Omega = \Omega'$, hence

$$\Omega(n_s) = \frac{CU_s - CU_u}{1 - \Psi(\pi_s(e_s^*) - \pi_u(e_u^*))}$$

¹⁵Notice that we did not account for teachers who form part of the skilled labor force for the sake of simplicity as the percentage of teachers in the working population is expected to be small. According to GSS (2013), education sector workers are about 2% of the workers in 2012 and therefore those teaching staff that would be involved in secondary and tertiary level will be fewer.

and $n'_s = n_s$

$$n_s = \frac{\pi(e_u^*)}{1 - (\pi(e_s^*) - \pi(e_u^*))}$$

and $k' = k$

$$k = n_s a_s^* + (1 - n_s) a_u^*$$

3.2.4 Welfare Measure

We measure social welfare by the average lifetime values of all agents who have entered the economy as young adults in steady state equilibrium. Following Caucutt, Imrohorglu and Kumar (2003)¹⁶ we use utilitarian welfare criterion given by

$$SW = \left(\frac{1}{(1 - \sigma)} \right) (n_s ((c_s^y)^{1-\sigma} + \beta (c_s^{o'})^{1-\sigma}) + (1 - n_s) ((c_u^y)^{1-\sigma} + \beta (c_u^{o'})^{1-\sigma})) \quad (3.21)$$

Government maximizes the aggregate social welfare by choosing capital income tax rate τ_k , and labor income tax rate τ_l .

To compare optimal tax welfare with benchmark model, we use the consumption-equivalent variation (CEV), measured as ω and defined as

$$\omega = \left(\frac{SW_{opt}}{SW} \right)^{\frac{1}{1-\sigma}} - 1$$

where SW_{opt} represents social welfare measure at the optimal taxation economy and SW being the baseline economy where the taxes imposed are not optimal.

3.3 Calibration

In our quantitative analysis, Ghana is used as a representative economy. Our strategy is to make the model economy consistent with the Ghanaian economy on important

¹⁶Also, as suggested by Hammond (1988; cited in Cremer et al, 2003), we do not include altruistic component in the social welfare function.

indicators such as capital output ratio, fraction of workers that have at least secondary education¹⁷, probability of intergeneration transmission of education status, and government revenue as a percentage of GDP. By doing so, we also ensure that the number of parameters jointly used to match the data are reduced. Our aim is to get a set of parameters in the calibrated model economy that will serve as our benchmark economy for further experiments or policy analyses.

The parameters used to calibrate our steady state benchmark economy are summarized in Table 3.1. There are two sets of the parameters: the first set are either estimated from the data without the model or taking from the existing literature and the second set consists of parameters that were used jointly to match key economic variables in the data.

Table 3.1 Parameters

Parameters	Interpretation	Value	Source/Target
Production			
γ	skilled labor share of informal output	0.204	w_s^h/w_u^h
α_k	capital share of formal output	0.4	IMF
α_s	skilled labor share of formal output	0.5255	w_s^f/w_u^f
A^f	formal sector productivity level	10	normalization
κ_s	Measure of formal skilled wage distortion	2.27	w_u^f/w_u^h
κ_u	Measure of formal unskilled wage distortion	1.34	w_s^f/w_s^h
Government Policy			
τ_L	Labor tax	0.1	Effective rate for median tax payer
τ_K	Capital tax	0.21	Nguyen-Thanh & Strupat (2012)
Calibrated Parameters			
A^h	Informal sector productivity level	4	Joint {
β	Subjective discount factor	0.875	
Ψ	altruism factor	0.7	
η	elasticity of human capital	0.2	
b_u	productivity measure of education (poor)	0.5	

The first set of the parameters are those which can be calibrated independently. For production parameters, we normalize formal sector productivity, $A_f = 10$. We set capital income share of output $\alpha = 0.4$ (IMF, 2007). For shares of skilled and unskilled

¹⁷Secondary school education is considered as the minimum level of education for a worker to be skilled. As argued by Caucut and Kumar (2003), return to secondary school education is substantially higher than the primary school which could be as low as 2% for some African countries (see Bigsten et al., 2000)

labor income, we use the employment share to match the skilled wage premium. From the data, we calculate the share of formal skilled workers and unskilled workers in total employment; these amounted to 9.3 per cent and 3 per cent respectively. We then match the share of formal skilled and unskilled workers shares to the skilled wage premium in the formal sector to derive skilled and unskilled labor share. Similarly, skilled and unskilled labor share in the informal sector is calculated by using the information in the informal sector. We choose the depreciation rate, $\delta = 1$ as we assume that one generation last for 30 years and thus the capital stock would have been completely depreciated.

For parameters related to fiscal policy, as stated above we assume that only the formal sector pay tax. Thus, we concentrate on labor income tax and capital (interest) income tax rates in the formal sector. Average total tax revenue from these two sources in Ghana average about 5.4% of GDP. Since government also faces borrowing constraint in the model, we use revenue of 5.4% of GDP to represent exogenous government expenditure g . Thus, we choose government spending g so that it account for 5.4 per cent of GDP in the initial steady state equilibrium. Lump sum transfer is taken as residue of tax revenue minus government expenditure.

Capital income tax rate in Ghana is estimated as 21% which is equivalent to the sum of effective average tax rate on both equity and debt, as measured by Nguyen-Thanh & Strupat (2012). Labor income tax is calculated as the individual income tax rates levied directly on an individual's income. The personal income tax system in Ghana is staggered according to the taxable income and ranges from 0% to a maximum 25%. We chose 10% to represent labor income tax in our calibration as the rate that correspond to average tax rate of mean income earner in the formal sector.

Joint Calibration

Since parameters in the human capital production functions are specific to our model, following Calcutt et al. (2003) we normalize the productivity parameter of the skilled human capital technology, $b_s = 1$. Our model includes both discount factor (β) and altruism factor (Ψ) which are usually proxied by only discount factor in infinitely lived agent models. Since there is no widely accepted empirical estimate of altruism factor (Leung and Chen, 2006), we jointly calibrate the remaining parameters in the human capital production functions along with the intergenerational altruism factor (Ψ) and the discount factor (β) so that the model outcomes match the data including capital-output ratio, fraction of skilled workers, intergenerational mobility matrices and government expenditure to GDP ratio.

Calibration properties

From Table 3.2, it can be confirmed that the targeted moments of the model replicate well moments from the data well. In fact, even for moments that were not targeted explicitly (skill premiums, share of sector employment by skilled type, share of capital and labor tax in GDP), calibration yields parameters that match well with the data. The size of informal sector of about 62% is not significantly different from the sub-Saharan Africa, which according to ILO (2014) estimates ranges from 36.2% to 60%.¹⁸ The model outcome of 2.32% of total household expenditure on education as a percentage on GDP is well within the sub-Saharan Africa range of 0.1% to 4.8% with an average of 1.5% (UNESCO Institute for Statistics, 2011).

¹⁸As also reported in Table 3.2, estimates for some sub-Saharan African economies.

Table 3.2 Comparison of Model Outcome

Model Quantity	Interpretation	Data	Model(Benchmark)
n_s	fraction of skilled workers	24.39	25
K/Y	capital-output ratio	2.0	2.2
$b_s(e_s)^{\eta_s}$	prob(skilled skilled)	54.39	50.01
$b_u(e_u)^{\eta_u}$	prob(skilled unskilled)	20.43	16.64
g/y	Personal income tax as a % of GDP	5.4	5.4
$p_f = w_s^f/w_u^f$	Formal skill wage premium	2.0	2.1
$p_h = w_s^h/w_u^h$	Informal skill wage premium	1.18	1.24
p	skill income premium	1.64	1.80
$\tau_l * L.W/GDP$	share of Labor tax in GDP	2.11	2.25
$\tau_k * r.K/GDP$	share of capital tax in GDP	3.48	3.15
l_s^f	Formal skilled workers(%)	9.7	9.28
l_u^f	Formal unskilled workers (%)	3.14	2.76
l_s^h	Informal skilled Workers (%)	14.61	15.72
l_u^h	Informal Unskilled workers (%)	72.41	72.22
Y^h/Y	size of Informal sector (%)	36.2 - 61.8	62
$(n_s * e_s + (1 - n_s)e_u)w_s^f/Y$	Household expenditure on education as a % of GDP	0.1-4.8	2.32

3.4 Optimal Taxation

In this section, we present quantitative results for optimal capital and income taxation at steady state. First, we find optimal tax rates when there is no redistribution, ie. government solves for optimal combination of capital and labor income tax rates to raise revenue for fixed government expenditure. Second, we introduce a lump sum transfer to households for redistributive reasons. In both sections, we also conduct experiments to diagnose the effect of each distortion on optimal income taxation.

3.4.1 Optimal taxation without redistribution

We find optimal labor income tax and capital income tax to be 3% and 29.64% respectively, as reported in Table 3.3. The optimal capital income tax rate is higher than the capital tax rate in the benchmark Ghanaian economy, while the labor income tax rate is lower. Moreover, the optimal capital income tax is relatively larger than optimal labor income tax. This suggests that the distortion resulting from labor income tax (including displacing workers to less productive informal sector and decreasing educational investment) is relatively large compared to the inter-temporal allocation of

consumption distortion created by capital income tax. Hence, the government optimizes social welfare by reducing distortion created by labor income tax (which discourages human capital investment) by setting a low labor income tax and a higher capital income tax, which discourages financial savings and increases human capital investment through substitution effect. The optimal capital income tax sacrifices efficiency at the level of financial and human capital investment for efficiency in composition of these investment (see Jacobs and Bovenberg, 2009).

This findings of positive capital income tax support Penalosa and Turnovsky (2005) conclusion that the optimal capital income tax rate should be at least as large as the labor tax rate in an economy with non-taxable informal sector. Aiyagari (1995) also finds non-zero capital income tax in an economy with borrowing constraints and incomplete markets lead to suboptimal capital due to high precautionary savings. Peterman (2016) also finds positive capital income tax in a life cycle model when there is human capital investment. The results, however, is contrary to Judd (1985) and Chamley (1985) proposition of the long run zero capital income tax. This study considered informal sector (where government is constrained to impose tax) and human capital investment in over lapping generation model which were not modeled by Judd (1985) and Chamley (1985). Cerda and Saravia (2013) modeled the existence of untaxed informal sector and found negative capital income tax and negative labor income tax but a positive tax of firms' profit. Since taxation would have both extensive margin distortion due to decision of firms to operate in less productive informal sector and intensive margin distortion due to factor mis-allocation, government subsidizes capital and labor to induce more firms into production in formal sector and raise revenues through profit tax. This study did not consider profit tax and extensive margin distortion.

Aggregate effects The third column of Table 3.3 reports differences in some relevant aggregate variables in the optimal tax system and benchmark economy. Capital-output ratio falls due to higher capital income taxes under the optimal tax system, which

Table 3.3 Optimal Tax vs Benchmark

Indicator	Benchmark	Optimal Tax	Change
Column	1	2	3
Capital income tax rate (%)	21.0	29.6	8.64
Labor income tax rate(%)	10.0	3.00	-7.00
Skilled Share (%)	25.0	25.6	0.55
K/Y	2.22	2.11	-4.95
Output per worker	3.35	3.38	0.90
Skill premium (Formal)	2.10	2.15	2.38
Skill premium (Informal)	1.24	1.26	1.61
Formal Labor supply-skilled	0.37	0.41	10.8
Formal Labor supply-unskilled	0.037	0.042	13.5
Social Welfare Change (CEV, %)	-	-	0.38
Welfare change -skilled (%)	-	-	-1.33
Welfare change -unskilled (%)	-	-	0.03

Note: Row 1-3 of column 3 are percentage points changes. Row 4 to 9 of column 3 are percentage changes.

lower savings and therefore aggregate capital accumulation. The higher capital income tax also leads to marginal increase in educational investment and skill share of the population through substitution effect. The output per worker also rises from 3.35 to 3.38, an increase of 0.90%, due to an increase in labor supply in the high productive formal sector when labor income tax rate is low. Compared to the benchmark model to the optimal tax economy, there is welfare improvement equivalent to a 0.38 per cent increase in lifetime consumption, as indicated by the social welfare measured in terms of consumption-equivalent variation (CEV). The result indicates that formal sector labor supply would increase as a result of lower labor tax. The formal-informal net wage premium increases due to a lower labor tax in the formal sector increasing net wage which labor response by raising hours work in the formal sector. The lower labor income tax would lead higher after tax wage rate in the formal sector which implies

that at the margin, workers would supply more hours to the formal sector firms. Thus, labor supply to the formal sector rises and that of informal sector shrinks.

Formal-informal labor supply, education and savings tax Distortions

In the model, labor income tax distorts formal-informal labor supply and human capital investment through its effect on future benefit of human capital. Capital income tax, on the other hand, distorts consumption-savings decisions directly and human capital investment indirectly. Capital income tax increases the relative present value of human capital investment to that of financial savings. Thus, due to the decline in after tax returns on savings as a result of higher capital income tax, individuals substitute human capital investment for financial savings.

Fixed sector labor supply We fix formal and informal labor supply for skilled and unskilled agents at the equilibrium level of the optimal-tax baseline economy. This is intended to shut down the tax distortion from informal-formal labor supply decision. Thus, in this counterfactual experiment, there would be no formal-informal labor supply effects of labor income tax. The column 2 of Table 3.4 indicates that by fixing sectorial labor supply and hence eliminating such distortion increases optimal labor income tax from 3% to 12% while reducing optimal capital income tax from 29.64% to 16.25%. Therefore, neglecting formal-informal labor decisions leads to overestimation of labor income tax and underestimation of capital income tax by 9 and 13.2 percentage points respectively. In other words, the presence of non-taxable informal sector limits the use of labor income tax to generate revenue for government expenditure. Thus, economies with large informal sector would be better off by imposing lower labor income tax.

It can also be argued that capital income tax is used to indirectly tax the unobserved informal sector labor income. Since financial savings will be proportional to after tax labor income, which includes formal sector wage income and informal sector wage income, capital income tax is a way of indirectly taxing informal sector income without

generating the formal-informal distortion that would be created by labor income taxation of the formal income.

Fixed Education Investment To shut down the tax distortion imposed on human capital investment decision, we fix education investment for skilled and unskilled agents at their equilibrium values of an optimal-tax baseline economy. In this way, labor income tax will not affect education decision and therefore will have no effect on the skill proportion of the population. In column 3 of Table 3.4 it can be seen that the optimal capital income tax falls from 29.64% to 23.43% while the labor income tax rises from 3% to 6% in the baseline economy. Thus, since there is no inter-temporal distortion of labor income tax, the government optimizes social welfare by reducing capital income tax and increasing labor income tax to raise enough revenue for the exogenous expenditure. This implies that neglecting human capital decisions leads to overestimated of labor income tax.

No Labor income Tax Distortion In column 4 of Table 3.4, we fix both formal labor supply and education hours to the equilibrium level of the baseline economy. In this way, income tax will not have any effect on labor supply and human capital investment. The results depict optimal capital income tax of 21.05% and optimal labor income tax of 8%, compared to the baseline rates of 29.64% and 3% for capital income tax and labor income tax. Thus, the government finds it efficient to reduce capital income tax and increase labor tax, which has no distorting effect on the economy. The implication is that without explicitly considering the taxation impacts of both informal sector and human capital investment, tax design, especially in developing countries, would be inefficient by overtaxing labor income and undertaxing capital income.

The high rate of capital income tax in the experiment with no labor distortion suggests the need for long run efficient capital income tax to increase capital accumulation as savings are for life cycle reasons (see Chameley, 1986; Atkinson and Sadmo, 1980).

Taxation of interest on savings is needed to ensure efficient allocation of consumption and accumulation of high capital formation. Thus, in spite of the fact that distortion of labor income tax has been effectively eliminated, it is still optimal to tax capital income.

Fixed asset level We fix the financial savings level to eliminate inter-temporal distortions arising from capital income tax. Column 5 of Table 3.4 reports the result of this counter-factual case, which indicates that optimal labor income tax should be zero with capital income tax rising from baseline optimal tax economy of 29.64% to 30.64%, as all government expenditure is financed by capital income taxation. The implication is that making savings for old age an exogenous will lead to an overestimation of capital income taxes and understatement of the need for labor income tax that maximizes social welfare.

Table 3.4 Experiments

Indicator	Baseline Experiment	Labor-Distortion			
		Fixed labor	Fixed education	Both	Fixed Savings
Column	1	2	3	4	5
Capital income tax rate (%)	29.6	16.3	23.4	21.05	30.6
Labor income tax rate(%)	3.00	12.0	6.00	8.00	0.00
Skilled Share (%)	25.6	25.70	25.57	25.57	27.9
K/Y	2.11	2.08	2.31	2.26	2.07
Output per worker	3.38	3.37	3.44	3.42	3.47
Skill premium	1.89	1.77	1.91	1.86	1.84
Formal Labor supply (skilled)	0.41	0.406	0.41	0.406	0.45
Formal Labor supply (unskilled)	0.042	0.042	0.043	0.042	0.05

3.4.2 Optimal taxation with redistribution

The presence of incomplete market (or non-borrowing constraints) and agents heterogeneity make a case for introduction of redistributive policies. We therefore determine optimal income tax for a redistributive government. In addition to raising revenues to finance government expenditure, more revenues are raised using the same tax instruments (capital income tax and labor income tax) for lump sum transfer. The result is shown in Table 3.5.

With the incentive of reducing inequality, a redistributive government taxes labor income and capital income at high rates to generate more revenue. We find that the optimal redistributive optimal capital and labor income tax rates are 40% and 10% respectively. The welfare improvement from benchmark model where there is no redistribution to the optimal redistributive tax economy is equivalent to 0.81 per cent increase in lifetime consumption as measured by consumption-equivalent variation (CEV).

The increase in labor income tax to finance lump sum transfer creates intra-temporal distortion by pushing workers into the informal sector. It also generates inter-temporal efficiency concern of reducing the benefit from education. Without capital income tax, agents increase their investment in financial savings and reduce investment in human capital. To alleviate this labor tax distortion, capital income tax must increase to mitigate the negative effect of labor tax on human capital investment. Jacobs and Bovenberg (2010) also find the need for capital income tax for mitigating purposes when labor income tax affect human capital investment.

Aggregate effects With redistribution, government generates higher revenues through labor income tax. This creates inter-temporal distortion of investment in human capital by discouraging parents from educational investment as net benefit from being skilled decreases. Parents save more for future consumption rather than investing in child education. The increase in savings leads to a higher capital output ratio and output per worker, which rise by 0.3222 and 0.0389 respectively when compared to the baseline without redistribution. To alleviate this distortion of human capital investment, tax rate on capital income is raised. Despite the ameliorating effect of capital income tax, skilled population decreases by 1.01 percentage point from the baseline optimal equilibrium without redistribution.

The results indicates that in economies with high inequalities and liquidity constrained agents, redistributing income from high to low and from old adults to young adults

Table 3.5 Optimal Redistribution Policy

Indicator	Benchmark	Baseline(No R)	Optimal R Tax	Change (Col3-Col2)
Column	1	2	3	4
Capital income tax rate (%)	21	29.6	40.0	10.4
Labor income tax rate(%)	10	3.00	10.0	7.00
Skilled Share (%)	25.0	25.6	24.5	-1.01
K/Y	2.22	2.11	2.44	15.6
Output per worker	3.35	3.38	3.42	1.8
Transfer per worker	-	-	11.4	-
Formal Labor supply (skilled)	0.37	0.41	0.39	-4.88
Formal Labor supply (unskilled)	0.037	0.042	0.040	-4.76
Social Welfare Change (CEV, %)	-	0.38	0.82	0.44
Welfare change -skilled (%)	-	-1.33	-1.42	-0.10
Welfare change -unskilled (%)	-	-0.03	-0.74	-0.01

Note: Row 4 to 8 of column 3 are percentage changes.

increases capital output ratio. However, redistribution exerts negative impact on human capital investment on the rich households thereby reducing the skilled labor force in the economy.

Formal-informal labor supply, education and savings tax Distortions

By introducing lump sum transfer that redistributes income from the rich to the poor, we conduct our experiment to determine the effect of distortions on optimal income taxation policy. As shown in Table 3.6, we fix formal labor supply, education investment and assets to the steady state equilibrium levels as found in the baseline policy.

Fixed sector labor supply As seen in the column 2 of Table 3.6, when labor supply is fixed, a redistributive government taxes labor income at a high rate of 60% compared to 46% capital income tax. Without formal-informal labor supply distortion, the government uses high labor income tax to raise adequate revenues for redistribution. Capital income tax was increased by 6 percentage points to mitigate the effect of labor income tax on educational investment (see Jacobs and Bovenberg, 2010; Peterman, 2016).

Table 3.6 Experiments-Redistribution

Indicator	Labor-Distortion				Fixed Assets
	Baseline	Fixed labor	Fixed education	Both	
Column	1	2	3	4	5
Capital income tax rate (%)	40.0	46.0	75.5	60.0	52.0
Labor income tax rate(%)	10.0	60.0	21.0	83.0	0.0
Skilled Share (%)	24.5	21.2	24.5	24.5	29.0
K/Y	2.44	3.73	5.12	3.98	2.31
Output per worker	3.42	3.59	4.32	3.78	3.64
Skill premium	1.91	1.66	2.59	1.10	1.92
Transfer per worker	0.11	0.64	0.84	1.07	0.17
Formal Labor supply (skilled)	0.39	0.39	0.51	0.39	0.49
Formal Labor supply (unskilled)	0.04	0.04	0.06	0.04	0.06

Fixed Education Investment Column 3 of Table 3.6 reports counterfactual case where the inter-temporal distortion of labor income is completely shut down, leaving only intra-temporal labor movement between formal and informal sectors and inter-temporal savings effect. It can be seen that both capital income tax and labor income tax increased from 40% and 10% to 75.5% and 21% respectively. Compared to results shown in column 2, it is clear that intra-temporal distortion resulting from labor income tax in the presence of informal sector is more profound than inter-temporal distortion of reducing education investment as it limits the use of labor income taxation for redistribution.

Fixed asset level Fixing asset level to baseline optimal savings level for both skilled and unskilled agents eliminates savings distortions of capital income tax. The result indicates an optimal capital income tax of 52% compared to 40% at baseline optimal equilibrium. The optimal labor tax is 0% as all government expenditure and redistribution are financed by capital income tax, as indicated in column 5 of Table 3.6.

Table 3.7 Taxation of Informal sector

Indicator	Non-Redistributive		Redistributive	
	Baseline	Taxing Informal	Baseline	Taxing Informal
Column	1	2	3	4
Capital income tax rate (%)	29.64	33.42	40.0	68.0
Labor income tax rate(%)	3.00	0.00	10.0	71.0
Skilled Share (%)	25.6	25.7	24.5	21.3
K/Y	2.11	2.08	2.44	4.45
Output per worker	3.38	3.39	3.42	4.04
Skill premium	1.89	1.93	1.91	3.42
Formal Labor supply (skilled)	0.41	0.42	0.39	0.55
Formal Labor supply (unskilled)	0.04	0.04	0.04	0.07

3.4.3 Role of the Informal Sector

The optimal tax mix is significantly affected by the presence of the non-taxable informal sector. As explained by Correira (1996), the inability to optimally tax a given factor has a long term effect on capital income tax (see also Judd, 1999). We therefore assume that the government has the capacity to tax income on factors that are employed in the informal sector as well as the formal sector in order to disentangle the effect of non-taxable informal sector on optimal tax design.

Non-redistributive As shown in column 2 of Table 3.7, we find that when the informal sector can be taxed and government expenditure is low, optimal income tax calls for zero labor tax and positive capital income tax. Specifically, if government eliminate tax inefficiency by developing capacity to tax the informal sector, zero labor income tax is optimal. Government therefore raises revenues from capital income tax amounting to 33.42%. This suggests that the inter-temporal distortion of the labor tax is significantly stronger than that of capital income tax, hence the need for zero labor income tax.¹⁹

Moreover, since financial savings are for life cycle purposes hence less elastic to tax rates compared to human capital, it is more efficient to tax capital than labor. In the pure

¹⁹Tax rates are restricted to be non-negative. In principle negative labor tax (labor subsidy) with high capital tax could be optimal (see Browning and Burbidge, 1990)

life cycle model, Browning and Burbidge (1990), finds that with low level of desired government revenue, capital income should be taxed, possibly with consumption (labor income) subsidy if households face liquidity constraint in the early cycle when human capital investment is undertaken.

Government capacity to tax informal sector means that at any tax rate, supply of labor in the formal sector will be larger than when it does not have the capacity. The increase in formal labor supply raises the marginal productivities of labor and capital. But the formal sector is more productive, hence it is efficient to push more workers into formal sector. With fixed revenue requirement, government chooses tax rates that minimize savings and human capital distortions. With the given revenue requirement of 5.4% of GDP government, government chooses 0% labor income tax and 33.42% capital income tax as optimal income tax rates as human capital distortions of labor tax is larger than distortion associated to capital income tax. However, an increase in revenue requirement leads to a positive labor tax as indicated in Table 3.8.

Redistributive It can be seen in Column 4 of Table 3.7 that, for a redistributive government, taxing the informal sector leads to optimal capital and labor income tax of 68 per cent and 71 per cent respectively. Since there is no constraint on tax collection from the informal sector, the redistributive government increases both tax rates in order to finance higher transfer and reduce consumption inequality.

3.5 Sensitivity Analysis

3.5.1 Role of the formal-informal wage premium

In this section, we investigate the effect of exogenous formal-informal wage premium on formal sector labor supply. First, we analyze a situation where at equilibrium, formal after tax wage is exactly equal with informal wage. Thus, workers allocate their labor

Table 3.8 The Role of government expenditure (in Taxation of Informal sector)

Indicator	Taxing Informal($g=0.81$)	Taxing Informal($g1=1.5*g$)
Column	1	2
Capital income tax rate (%)	33.4	31.0
Labor income tax rate(%)	0.00	3.84
Skilled Share (%)	25.7	25.6
K/Y	2.08	2.02
Output per worker	3.39	3.36
Formal Labor supply (skilled)	0.42	0.41
Formal Labor supply (unskilled)	0.045	0.043

resources between formal and informal sector until net wages are equal in the two sectors.

Table 3.9 Formal-Informal wage gap

Indicator	Non-Redistributive			Redistributive	
	Baseline(k_i^b)	No Formal constraint ($k_i = 1$)	$k_i = 1.5 * k_i^b$	Baseline	No Formal constraint
Column	1	2	3	4	5
Capital income tax rate (%)	29.6	8.06	43.4	40.0	60.0
Labor income tax rate(%)	3.00	12.0	0.00	10.0	41.0
Skilled Share (%)	25.6	30.8	22.2	24.5	24.4
K/Y	2.11	1.44	2.98	2.44	3.00
Output per worker	3.38	3.44	3.24	3.42	3.83
Skill premium	1.89	1.80	1.96	1.91	1.84
Formal Labor supply (skilled)	0.41	0.69	0.26	0.39	0.60
Formal Labor supply (unskilled)	0.04	0.08	0.02	0.04	0.07

Non-redistributive Column 2 of Table 3.9 reports optimal tax mix for government that raises tax revenues for exogenous government expenditure. Optimal capital income tax and labor income tax are 8.06% and 12% respectively compared to 29.64% and 3% in the baseline economy. By eliminating after tax wage gap between formal and informal sectors, labor resources will be more efficiently allocated. Thus, the government increases tax on labor income higher and reduces capital income tax in order to maximize social welfare.

As can be seen in columns 1, 2 and 3, when the formal-informal wage gap is high, capital income tax may be preferable to labor income tax. The implied employment in

the formal sector resulting from high formal-informal wage gap is relatively low and therefore labor income tax distortion created by pushing more workers into the informal sector is substantial. Hence optimal taxation requires high capital income tax which has no intra-temporal distortion and a lower or no labor income tax.

Redistributive The optimal redistributive tax is 41 per cent for labor income and 60 per cent for capital income. The elimination of constraint allows more labor resources to be employed in the more productive formal sector. This allows the government to increase labor income tax for the purpose of redistribution and a higher capital income tax to alleviate the burden of labor income tax on human capital investment.

3.5.2 Changes skilled Population

In the benchmark model, we matched the model to the existing skilled mobility matrix for Ghana. In this section, we conduct a sensitivity check to determine the optimal tax implications of a high proportion of skilled workers in the economy. We perform this task by using different values of the elasticity of human capital investment efficiency, measured by η . A lower η implies that education investment technology is efficient in producing skilled labor.

The results of the sensitivity check are reported in Table 3.10. It can be seen that capital and labor income tax should be 29.18% and 0.0% respectively. Thus, when education technology is very efficient in transforming children to skilled adults, only capital income should be used in order not to discourage investment in human capital. However, when η is increased from 0.2 to 0.25, both optimal labor income tax and capital income tax rise. η determines the welfare gains of capital taxes serving as a subsidy of human capital investment through the production of more skilled workers. Thus, when human capital technology is very efficient then the gain resulting from lower η outweighs the welfare cost of distorting the financial savings, hence higher capital income tax and lower labor tax (see Jacobs and Bovenberg, 2010).

Table 3.10 skilled Population

Indicator	$\eta = 0.15$	$\eta = 0.2$	$\eta = 0.25$
Capital income tax rate (%)	29.2	29.6	33.38
Labor income tax rate(%)	0.00	3.00	5.10
Skilled Share (%)	32.6	25.6	19.3
K/Y	1.79	2.11	2.52
Output per worker	3.48	3.38	3.22
Skill premium	1.54	1.89	2.39
Formal Labor supply (skilled)	0.47	0.41	0.35
Formal Labor supply (unskilled)	0.05	0.04	0.03

3.6 Conclusion

We developed a three-period life cycle model of overlapping generations with human capital investment, financial savings, and formal-informal labor supply, which are relevant for developing economies with large informal sector. Parents' heterogeneity in terms of skill type and income is transmitted to their children through education investment and luck, leading to income inequality that emerges endogenously.

The model is calibrated to Ghanaian economy to quantitatively characterize optimal capital and labor income tax. We find that optimal capital income tax is higher than that currently applied in Ghana with lower optimal labor income tax. We show that neglecting informal sector in tax design would lead to understating optimal capital income tax and overstating labor income tax, and the difference is quantitatively significant. The parental decision on educational or human capital investment of their offspring is also important for sharing the burden of income tax optimally. Non-consideration of education decision of parents leads to an underestimation of capital income tax and overestimation of labor income tax.

Since many developing countries have not been able to overcome the restraints on revenue generation efforts imposed by the presence of large informal sector, redirecting

taxation on capital income could generate higher revenues with less distortion than increasing labor income tax. Moreover, since part of income generated from the informal sector is ultimately put into savings, capital income tax could be used to indirectly tax the informal sector labor income. However, this design of tax system that shifts more tax burden to capital income would depend on the key assumption that capital income tax, unlike labor income tax, cannot be evaded. Thus, the result about the need for higher capital income tax would be affected when capital also move to the informal sector or if there is free movement of capital.

Chapter 4

Pension Coverage Expansion in Developing Countries: Incentive Scheme for Informal Workers

This chapter analyzes the implications of matching contributions on voluntary pension scheme participation, savings and welfare in a developing economy. The demographic transition in many developing countries suggests that in the next few decades support for old people would be a critical problem in countries, which have hitherto relied on family in supporting old people. It is against this background that many developing countries have introduced pension system that intend to expand the coverage to informal workers in Ghana and other developing countries.

However, the pension participation rates by informal workers in these countries including Ghana are low (Holzmann, Hinz, and Tuesta, 2015) suggesting a need for incentives to encourage participation and contributions in order to expand the coverage of pension system. Matching contributions is being proposed as one instrument to encourage participation and contribution. While various studies on empirical analysis of matching contributions on pension contribution and participation have been conducted in advanced economies, lack of data has limited such studies in developing countries

which have recently designed such policy to encourage pension contributions from informal workers.

First, we analyze the impact of matching contributions on pension participation and contributions. Second, we also analyze the role of benefit payment options (lump sum and annuity) for government sponsored matching contributions on savings, welfare and labor supply of elderly people. Third, we determine the optimal matching rate that would maximize social welfare. Finally, we perform sensitivity analysis to discuss the robustness of our results.

In this chapter, we develop a partial equilibrium life cycle model that consists of overlapping generations of 60-period lived individuals facing mortality risk and individual income risk to investigate the role of matching contributions and payment options in influencing participation and contribution to informal pension schemes in developing countries. We further use Ghana as a representative for calibration and quantitative analysis. Ghana has a large proportion of its labor force working in the informal sector. Pension reforms to expand the coverage to informal workers have been introduced. However, the take up rate or pension participation rate remains very low. Therefore, it is very important for Ghana to start considering policies that will encourage participation and contribution to pension system.

4.1 The model

We develop a model that is consistent with the literature on voluntary pension contribution (or retirement savings) with key feature in developing countries (the presence of large informal employment). The uncertainties in the model emanates from the sector of employment and health shocks resulting to labor income uncertainties. There is also uncertainty regarding the length of life. Agents in the model economy are heterogeneous in terms of education status, age, sector and status of employment, young or old, health status, retirement status and asset holdings.

4.1.1 Demographics

The economy is populated by *ex ante* heterogeneous individuals in terms of education of age $j = 1, 2, \dots, J$. We assume that an individual enters the economy with a permanent education status e , which can be low or high, $e \in \{l, h\}$. Agents are categorized into young and old along the life cycle: young agents are those with age $j < J^r$ (where J^r is the mandatory retirement age from formal work) and those with age $j \geq J^r$ are described as old agents. An individual with age j survives to the next period $j + 1$ with conditional probability ψ_j . All agents live a maximum of J periods.

4.1.2 Social Security System and Government

There are two forms of mandatory social security that all formal sector employees contribute to: tier 1 basic pension which pays annuity to pensioners after retirement and tier 2 fully funded pension that pays lump sum upon retirement. All these forms of pension systems are contributory. Contribution rates for tier 1 and tier 2 are given by τ_1 and τ_2 respectively.

We introduce retirement saving (or pension) scheme to the informal workers. Informal workers make voluntary contributions to retirement account which will only be available at ‘mandatory retirement’ age through lump sum payment. We also consider a mandatory annuity at retirement age J^r : in this case the government converts the value of assets in the retirement account into annuity payments for the rest of their life.

The government collects a consumption tax τ_C to finance lump sum transfer y_{min} as assistance for unemployed and disable old people who are unable to work and matching contributions for informal workers who contribute to the pension scheme. The government budget clears in every period. Thus, consumption tax rate is set to ensure

balance government budget.

$$\tau_c \sum_{i=1}^N \sum_{j=1}^J c_{i,j} = \sum_{j=1}^{J_r-1} P_u^j y_{min} + \sum_{j=J_r}^J \sum_h P_h^j y_{min} \quad (4.1)$$

where P_u^j denotes the probability of being employed at age j . P_h^j is the probability of receiving the negative health shock (disable) at age j .

4.1.3 Employment shocks and Labor Income

There are two sectors of employment where workers may work for wage income: formal and informal sectors. In the formal sector, workers are mandated to contribute to pension system in the active years of employment and receive pension or retirement benefits when they retire from formal work. Agents who do not get employment in the high wage formal sector, work in the informal sector while awaiting for opportunity to work in the formal sector. Informal workers do not contribute to the social security hence do not earn any pension right when working in the informal sector. The rest of agents are unemployed.

All young individuals with age $j < J^r$ work and supply labor inelastically when given opportunity to work in either formal or informal sector until age J^r . We assume endogenous retirement from informal employment for old people and as such agents can continue to work in the informal sector as long as they want and are capable.¹

Agents receive $w^m \eta_j^{m,e} l_j$ as wage income, where w^m is the aggregate wage per labor efficiency unit in sector of employment m . $\eta_j^{m,e}$ represents deterministic age-dependent productivity at age j for individual with education status e and employment status m . l_j is the amount of labor supply.

All individuals face employment and sector of employment uncertainties and consequently income. At the beginning of every period workers receive sector of employment

¹This is very critical feature in developing countries and has important implications on savings. The opportunity for lifetime employment may reduce savings during young age of an individual by using old age labor supply to smooth consumption along the life cycle.

shock that determines the sector of employment and unemployment status. The employment shock results from rationing of formal sector vacancies for informal workers and unemployed people. We assume that the probability of getting formal employment is a function of previous sector of employment, education status and age. Thus, the individual sector of employment state $m \in \{1, 2, 3\}$ is assumed to follow a three-state first order Markov process. An agent with $m = 1$ and $m = 2$ is given the opportunity to work in formal sector and informal sector respectively. Unemployed agents state is given by $m = 3$. The age and education dependent transition probability distribution between the current employment state m and the next period's sector of employment state m' is given by the 3×3 matrix $P_{m,e}^j(m', m)$.

4.1.4 Old age Health shocks

Agents with age $j = J', \dots, J$ experience health shock at the beginning of every period. Agents that receive the negative health shock are unable to work to earn income.² We assume that the probability of receiving negative health shock depends on age as older people are more likely to become disable with permanent loss of earning potential. The age dependent health state of an agent is given by $h \in \{0, 1\}$. An agent with $h = 1$ has good health and can work to earn income if desired while agent with $h = 0$ has a bad health status hence unable to work for the remaining period of his/her life.

4.1.5 Preferences

Young agents choose consumption, voluntary pension contribution, and ordinary savings to maximize expected utility. Given health shock realization, old agents of age $j = J', \dots, J$ choose hours worked, consumption and savings to maximize expected utility. Agents choose consumption, labor, and pension contributions to maximize expected

²We abstract from health care expenditure that may result from receiving negative health shock in order to concentrate on loss of income associated with disability and sickness.

lifetime utility which can be expressed as:

$$E \left[\sum_{j=1}^J \beta^{j-1} \left(\prod_{t=1}^{j-1} \psi_t \right) U(c_j, l_j, \hat{c}_j) \right], \quad \text{where } l_j = \bar{l} \text{ if } j < J' \quad (4.2)$$

where c_j , \hat{c}_j , and l_j represent an individual's consumption, total cash on hand (wealth available for consumption) and labor supply at age j , respectively. The preference structure assumes that agents in this economy have self-control problems. In every period of their life, agents face temptations for present gratification by consuming their entire wealth as argued in Gul and Pesendorfer (2004). Time inconsistency and self-control problems are usually faced by individuals when making dynamic decisions as high value (in terms of satisfaction) is placed on immediate consumption relative to future consumption. The utility function of an agent with self control preference as described by Gul and Pesendorfer (2001) is stated as follows:

$$U(c, l, \hat{c}) = u(c, l) + v(c, l) - v(\hat{c}, l) \quad (4.3)$$

where the functions $u(\cdot)$ and $v(\cdot)$ are von Neumann-Morgenstern utility functions that represent the momentary and “temptation” utilities respectively.³ Thus, c represents the “commitment” consumption with \hat{c} being the temptation consumption.⁴ The psychological cost or dis-utility (self-control cost) of exercising self control in choosing c instead of the tempted consumption \hat{c} is given by $v(c, l) - v(\hat{c}, l)$. Thus, individuals who yield to temptation and consume \hat{c} (so that $c = \hat{c}$) do not incur any dis-utility since $v(c, l) - v(\hat{c}, l) = 0$.

³In related literature time inconsistent preferences in the spirit of Liabson (1997) has been used. The main difference between self-control preferences and time-inconsistent preferences is that the former do not imply dynamic inconsistency (Kumru and Thanopoulos, 2011). Preferences are perfectly consistent. Agents can perfectly commit to future actions and do not regret their past actions. Moreover, self-control preferences allow agents to exercise self-control, an option not existing in time-inconsistent preferences.

⁴Clearly, agents that face consumption temptation may also face temptation to reduce hours supply (see also Bucciol, 2011). The temptation consumption, \hat{c} , is the total available wealth or cash on hand or the highest possible consumption that an individual could be tempted to consume for a given available resources in a given period. However, it is not important in our setup, since our main concern is getting policies to serve as commitment device and help to reduce self control cost of saving.

Self-Control

Self-control problems and procrastination have been cited as among the major reasons for under-saving for retirement (see for example Madrian and Shea, 2001; Choi et al., 2003; Thaler and Benartzi, 2004). Tanaka and Murooka (2012) suggest that lack of access to retirement saving plans, such as Individual Retirement Accounts (IRA), 401(k) retirement savings plan, and social security in USA makes it difficult to resist temptation and save. Indeed, the preponderance of empirical evidence on the demand and use of commitment devices regarding savings suggest not only the existence but also the awareness of self-control problems. The commitment devices are therefore strategically used to alleviate the self-control that makes savings difficult. For example, in a randomized field experiment conducted by Dupas and Robinson (2013), an interest-free bank account with a withdrawal penalty were offered to participants. They found a high take-up rate of the interest-free bank account with commitment, suggesting the use of saving commitment devices to reduce self-control problems. Ashraf et al. (2006), also through field experiment (together with Filipino bank), suggest that time-inconsistent agents are more likely to take-up savings account with commitment features without any other advantage in terms of interest rates when compared with other savings products.

Rotating savings and credit associations (ROSCAs)⁵. are one of the most common saving arrangements in many developing countries where there is lack of access to formal savings arrangements such as retirement account. Tanaka and Murooka (2012) reviewed literature on the use and contributions of ROSCA and found that ROSCA has been widely used by different countries and at different stages of development. Among other advantages, ROSCA is primarily used by its participants as saving-commitment devices (Gugerty, 2007; Anderson and Baland, 2002). Basu (2011) shows that for

⁵In a ROSCA, people make regular periodic contributions to a pool with one member receiving all the contributions in the pool of each meeting. In principle, an individual can accumulate personal savings equivalent to total contributions received in a pool for the same periods

hyperbolic discounters, ROSCA would work as an effective commitment device even in the absence of contractual obligations and punishment by appealing to them to willingly forego instant gratification.

All these studies suggest the existence and awareness of self control problems concerning savings and consumption. O'Donoghue and Rabin (2001) refer to these individuals who are aware of their self-control problems as sophisticated time-inconsistent who would use commitment devices to prevent the negative consequences of their behavior. Thus, we explicitly model temptation and self-control problems following Gul and Pesendorfer (2001).

4.1.6 Agents' problem

In the beginning of every period, individual agent of education type e receives the employment shock m or health shock h . After realization of sector of employment or health shocks, individuals make decisions about consumption and savings to maximize the expected lifetime utility.

Young agents' problem

In the beginning of every period, young agents receive employment shock that determines their total labor income. They then make decisions on consumption, ordinary savings and retirement savings. At beginning of every period, the state of agents is given by education status (e), age (j), assets in ordinary account (a), asset in pension account (a^R) and employment status (m). The state of young agents is given by $s = (e, j, a, a^R, m)$.

Thus, given prices and tax rates, government matching contribution rate, a young individual of age $j = 1, \dots, J^r - 1$ solve the dynamic problem below:

$$V(s) = \max_{c, a', q \in [0, \bar{q}]} \left\{ u(c, \bar{l}) + v(c, \bar{l}) - v(\hat{c}, \bar{l}) + \beta \psi_j \sum_{(m')} P_m^{j,e}(m'|m) V(s') \right\} \quad (4.4)$$

subject to

$$c + a' + q = (1 + r)a + W^y \quad (4.5)$$

$$W^y = \begin{cases} (1 - \tau_1 - \tau_2)w^F \eta_j^e \bar{l} & \text{if } m = 1 \\ w^N \eta_j^e & \text{if } m = 2 \\ y_{min} & \text{if } m = 3 \end{cases} \quad (4.6)$$

$$a^{R'} = \begin{cases} (1 + r)a^R + \tau_2 w^F \eta_j^e \bar{l} + q & \text{if } m = 1 \\ (1 + r)a^R + q(1 + \tau_q) & \text{if } m = 2 \text{ or } m = 3 \end{cases} \quad (4.7)$$

$$a' \geq 0; \quad c \geq 0; \quad 0 \leq q \leq \bar{q}. \quad (4.8)$$

q is the amount of contribution an individual deposits into retirement or pension account. τ_q is the matching contributions rate (or subsidy rate) offered by the government. Equation 4.7 represents how pension account accumulates over time for both formal workers ($m = 1$) and informal workers ($m = 2$) and unemployed ($m = 3$). W^y is disposable labor income or assistance to unemployed agents given by Equation 4.6 for both formal, informal workers and unemployed.

Old and Formal retired Agents' problem

In the beginning of each period during retirement age, old and formal retired agents of age $j = J', \dots, J$ receive a permanent health shock that affect their earning potential. They then decide on labor hours if they are healthy as well as savings. The state of adult agents at beginning of every period is given by $s = (e, j, a, m, h)$. Thus, the old agents

solve the following problem ⁶

$$V(s) = \max_{c, a', l \in \{0, \bar{l}\}} \left\{ u(c, l) + v(c, l) - v(\hat{c}) + \beta \psi_j \sum_{(h')} P_h^j(h'|h) V(s') \right\} \quad (4.9)$$

$$c + a' = w^N \eta_j \cdot l \cdot I_h + y_{min} \cdot (1 - I_h) + (1 + r)a + (1 + r)a^R \cdot I_{j=J_r} + ss^{m,e} + beq \quad (4.10)$$

$$a' \geq 0; \quad c \geq 0; \quad ss^{m,e} \geq 0. \quad beq \geq 0; \quad (4.11)$$

$I_h = 1$ if the agent is healthy and can work and 0 otherwise. $I_j = 1$ if $j = J_r$ and 0 otherwise. $ss^{m,e}$ is the pension for retired formal sector workers that depends on education status. Informal workers donot have pension ($ss^{m,e} = 0$). beq is lump sum bequest transfer to the survival old people financed by accidental bequest resulting from assets left by deceased old people.⁷

4.2 Data, Estimation and Calibration

This section describes our parameter selection and some Ghanaian dataset used. To estimate the employment, income, and health shocks in the benchmark model, we mainly use the recent Ghana Living Standard Survey (GLSS 6) data from the Ghana Statistical Service. The data are basically cross-sectional with retrospective information on current and past employment episodes. We use parameters that are discussed in this

⁶We do not model family support explicitly though important for pension in developing countries. However, it has been documented that there is a decline in family arrangement of support for the elderly in Ghana (Aboderin, 2004; Ogwumike et al., 2005). It is against this background that the new pension system which is intended to cover the informal workers was introduced. But like in many developing countries with informal pension arrangements, the pension participation is still low in Ghana. At the same time, old people are poorer than the general population in countries without social pension (Kakwani and Subbarao, 2005). Thus, the study abstracts from material family support. In addition, we also conduct sensitivity analysis of income transfer to the disable and sick agents to explore how those changes could affect the results of the policy if we consider better family support system as higher income transfer.

⁷Bequest is introduced in experiments but not in the baseline analysis.

section and summarized in Table 4.1 to calibrate the benchmark economy to match data from Ghana. We calibrate our model under the assumption that the model period is one year.

4.2.1 Demographics

The demographic parameters are chosen as follows: individuals are assumed to be born at the real-time age of 21 and they can live a maximum of $J = 60$ years, to the real-time age of 80 and die for sure after age 80. For all ages under 80, the survival probabilities ψ_j are taken from UN life tables.

The formal sector workers retire at model age $J' = 40$ equivalent to mandatory retirement age of formal sector workers of 60. When informal pension is introduced, the model age $J' = 40$ is also assumed to be the age of withdrawal of accumulated savings.⁸ The retired formal sector workers and informal sector workers can continue to work in the informal sector after $j = 40$ until they experience health shock that renders them invalid to work.

4.2.2 Preference

Following Jung and Tran (2012) we abstract from the choice of labor hours during the youthful age $j < J'$ in order to concentrate on old agents' of age $j \geq J'$ labor supply which is very common in developing countries due to the absence of universal pension system. The $u(c, l)$ function is characterized by a Constant Relative Risk Aversion (CRRA) utility function with consumption, c_j , and leisure, $1 - l_j$ as the arguments. The temptation utility function $v(\cdot)$ is assumed to be equal to fraction, λ , of $u(\cdot)$. Thus, the instantaneous utility from consumption and leisure as well as temptation utility are

⁸As opposed to retirement age, Palacios and Orszag (2015) use 'age of withdrawal' to indicate that most participants in the informal pension schemes will not necessarily retire from working upon reaching this age

given as

$$u(c, l) = \frac{\left[c^\phi (1 - l_j - \chi_j \cdot I_{wk})^{1-\phi} \right]^{1-\sigma}}{1-\sigma}; \quad v(c, l) = \lambda u(c, l) \quad (4.12)$$

and therefore

$$U(c, l) = u(c, l) + \lambda u(c, l) - \lambda u(\hat{c}, l), \text{ where } l_j = \bar{l} \text{ if } j < J^r \quad (4.13)$$

$$\hat{c} = (1+r)a + W^y \quad \text{for } j = 1, \dots, J_r - 1 \quad (4.14)$$

$$\hat{c} = w^N \eta_j \cdot l \cdot I_h + y_{min} \cdot (1 - I_h) + (1+r)a + (1+r)a^R \cdot I_{j=J_r} + ss^{m,e} \text{ for } j = J_r, \dots, J \quad (4.15)$$

The curvature parameter σ measures the inter-temporal elasticity of substitution between present consumption and future consumption and consumption in different states and therefore affects retirement and precautionary savings. The parameter λ determines the sensitivity of agents to temptation for present consumption. Parameter χ_j is age dependent utility cost of labor force participation that increases with age and measured in terms of lost leisure time (Kitao,2015). We assume that $\chi_j = 0$ for $j = 1, \dots, J_r - 1$ and turns positive for age $j = J_r, \dots, J$ so that only old people face labor force participation cost.

Since the retirement savings account available for informal workers in our benchmark model does not offer any advantage over ordinary savings which also serves as medium for precautionary savings, we assume that only tempted agents would contribute to retirement savings account. Thus, the self control and tempted agents value commitment through savings in illiquid asset. The degree of temptation parameter⁹ λ is chosen to target the percentage of workers that voluntarily contribute to pension scheme

⁹Two studies have estimated the size of the degree of temptation with high standard deviation. DeJong and Ripoll(2007) estimated the degree of temptation parameter to be 0.073 while Huang et al.(2005) estimated it to be 0.206. We do not know any estimates from Ghana and any other developing country.

in order to reduce self control cost of wealth accumulation or as a commitment device. In the data¹⁰ about 1.5% of agents contribute to retirement account.¹¹

The exogenous labor supply of young agents is normalized to 0.4. The endogenous labor hours of old people is then matched to their labor supply as a percentage young workers labor supply. The data indicate that, on average, old people working hours per week is 80% of young workers average work hours. The preference parameter measuring the weight of consumption relative to leisure ϕ for age $j = Jr, \dots, J$ is set so that old people working hours on average is about 80% of that of working hours of the young workers.

To capture labor force participation and voluntary retirement from informal employment, we calibrate the age dependent utility cost of labor force participation χ_j so that the model's old age employment rate for old people matches the steadily decline of employment rate in the data. Following Kitao (2015), the age-dependent utility cost follows a non-linear function of the form $\chi_j = \kappa_1 j^{\kappa_2}$. Figure 4.1 shows old age employment rate by age group.

The risk aversion parameter σ is set at 0.70, which together with ϕ translate into relative risk aversion of 0.712 which is well within the commonly used parameter in numerical simulations analysis literature.

We choose discount factor β to match the consumption profile of workers based on the household survey data. The model R ($R = 1 + r$) is the gross return on a riskless asset. We set R to 1990-2010 average real return on 3-month Treasury bill of 1.045.

¹⁰About 150,000 informal sector contributes to the informal pension scheme. see <http://africabusiness2020.com/2017/05/16/pension-funds-ghanas-informal-sector> and National Pensions Regulatory Authority (2015). GLSS (2014) reports a population of about 10.7 million within age 20 – 59 age bracket.

¹¹Given that major factors affecting household savings including employment uncertainties, sickness and disability, and mortality rates are well characterized in the model, we calibrate the temptation parameter to match the pension participation rate. It means that the temptation in the model will capture the residual of saving effect, which cannot be explained by control factors. The observed participation rate even though it is very low can only be identified by the temptation parameter. We find a very small level of the temptation parameter (0.013) to match the participation rate. Without the temptation parameter, we cannot capture the participation rate that is observed in the data. In essence our utility function is general form of the standard CRAA utility function as it becomes CRAA when the temptation parameter is set to zero.

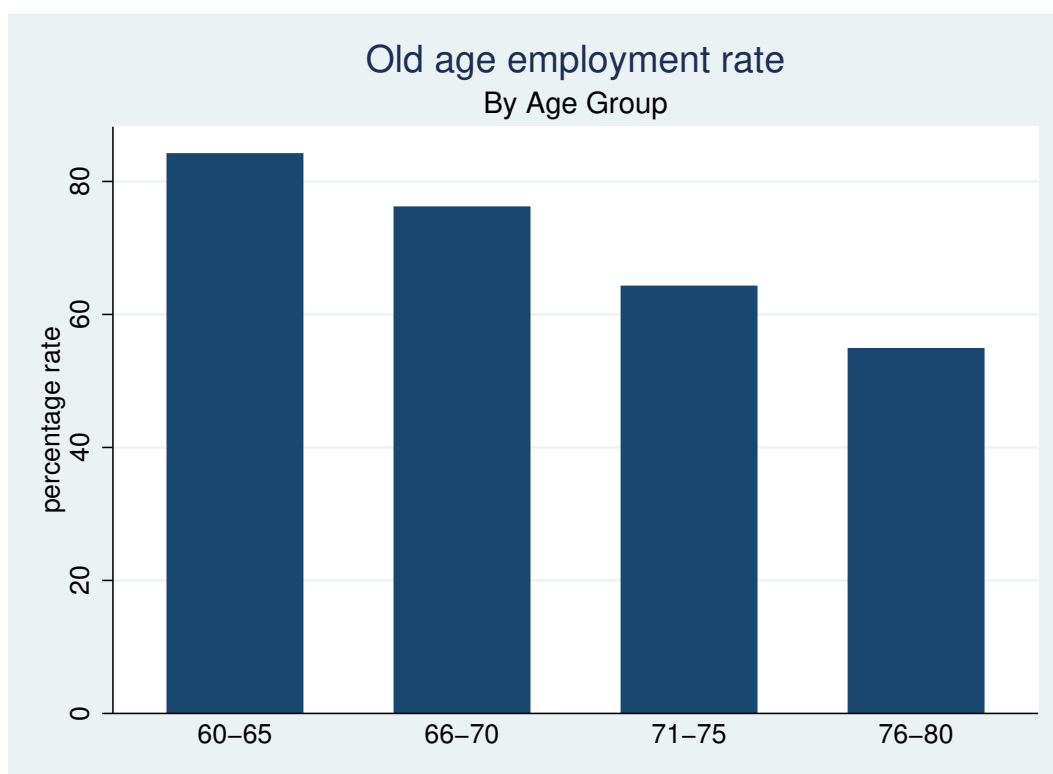


Fig. 4.1 Employment rate

4.2.3 Employment shocks and labor income

The transition matrix of unemployment-informal-formal employment status is derived from the question on current employment and a retrospective question of past employment over the one-year period. Individuals are categorized into formal and informal employment using information on availability of pension or social security retirement income of the current employment to categorize individuals into formal and informal workers. Though the GLSS classifies individuals into formal and informal workers which is based on firms' records keeping level, we believe availability of social security meets the aim of this study.

Following the literature of informal employment as a buffer employment in wait for job in formal sector, we assume that formal sector workers do not move to informal

employment nor become unemployed.¹² Giving this assumption, the initial distribution of employment statuses are adjusted so that the model's formal-informal-unemployment fractions match the target employment status shares of agents below the compulsory retirement age, J^r which is 60 in Ghana. The data indicates that the share of high educated and low educated workers are 29% and 71% of the total labor force for workers with ages ranging from 21 to 59.

Gross wage income of a worker in employment sector m and education status e is given by $y_j^{m,e} = w^m \eta_j^{m,e} l_j$. We assume that l_j is exogenous for $j = 1, \dots, Jr - 1$ and becomes elastic after age $j \geq Jr$. w^m is the aggregate wage per labor efficiency unit in sector of employment m . $\eta_j^{m,e}$ represents deterministic age-dependent productivity at age j for an individual with education level e working in employment sector m . We normalize w^N to one and calibrate w^F so that the ratio of average net wage income of formal and informal employment matches the ratio from the data.

The specific deterministic component of labor income is calibrated to the life-cycle wage rate per unit of time. The wage-age profile is estimated for both formal and informal workers based on wage information from GLSS 6. Specifically, the following OLS equation is estimated for workers in each sector of employment¹³:

$$\log(w_i) = \beta_0 + \beta_1 age + \beta_2 age^2 + X_i \gamma \quad (4.16)$$

where X is other covariates including education, sex, and location. The coefficients of age and age^2 is used to construct age-income profile for workers in each sector. The estimated wage profile given by the efficiency index η_j is intended to provide a realistic

¹²Giving labor protection in the country, few workers are laid off in the formal sector in special circumstance such as firm collapse. Indeed, the transition matrix provided evidence of limited movement from formal to informal or unemployment

¹³Due to insignificant of data for low educated formal workers, we construct their profile to match the ratio of high educated formal workers income to that of low formal workers. The profiles are then adjusted to match the ratio of formal workers income to that informal workers.

cross-sectional age distribution of earnings at a point in time. The life-cycle wage profile of formal and informal workers are shown in Figure 4.2.

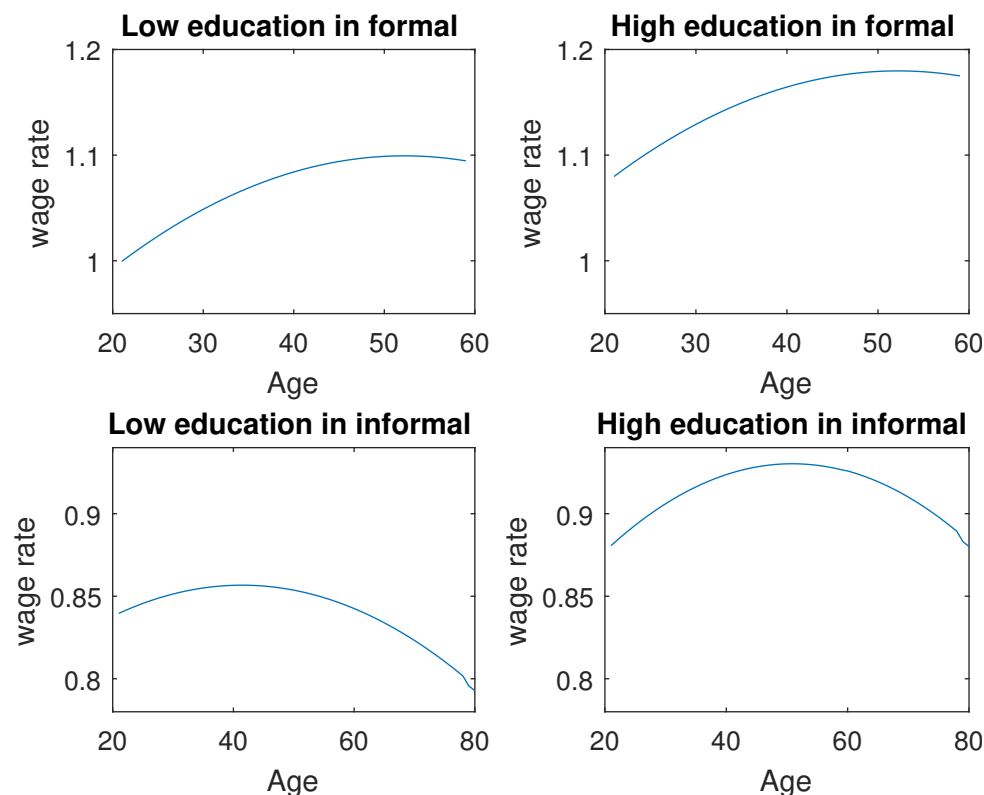


Fig. 4.2 Wage Profiles by education level and employment sector

4.2.4 Health Shocks

The age dependent probability of encountering permanent health shock that renders old agent unable to work to earn income is also calculated from the GLSS 6 data. The probability is estimated from a question that ask reasons why old agents do not work. Responses including disability and sickness are used to calculate the probability of old person of age j experiencing a negative health shock that force them out of the labor market activities.

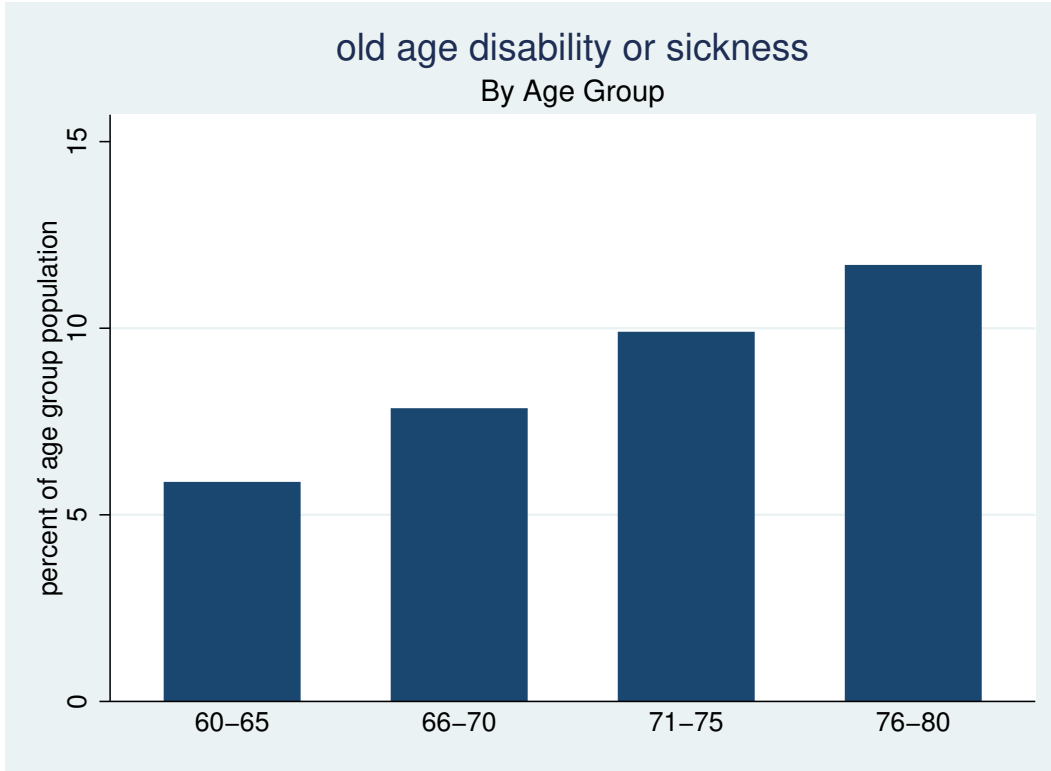


Fig. 4.3 Negative health shock

4.2.5 Social Security System and Government

Social security system collects contribution from formal sector workers and pay pensions to retired formal sector workers. We use statutory contribution rates for both basic pension and fully funded pension. Statutory contribution rates are 11% and 5% for basic pension and fully funded tier 2 pension respectively. While basic pension pays annuity pension, the second tier pension pays lump sum upon retirement. The amount of annual pension to retired formal workers ss is calculated as follows:

$$ss = b * W_{J_r-1}^{fe} \quad (4.17)$$

where $W_{J_r-1}^{fe}$ is the formal sector wage income for individual with education e at age $J_r - 1$. A replacement rate (b) of 0.375 which is the rate associated with the minimum number of years (15) of contributions required to be eligible for pension is selected.

The tier 2 pension is given as lump sum upon reaching the compulsory retirement age J' . Thus, at the end of period $J' - 1$, the value of tier two pension is converted into ordinary savings account which is liquid and therefore available for consumption.

We assume that the government administers income transfer to non-working people in the economy. It would also pay for the matching contributions expenditure or savings subsidy in our policy experiments. The income transfer old disable and unemployed households is set arbitrarily to 10% of lowest formal sector wage.¹⁴ We assume that the only instrument available to government is consumption tax. In developing countries, due to the smaller share of formal sector, the large part of government revenue are usually raised through consumption taxes instead of income taxes. The consumption tax rate is adjusted to ensure balanced budget in every period.

Table 4.1 Baseline parameter values

Parameter	Interpretation	Value	Comment/Source
j	Model period	1	equivalent to 1 year
J'	Compulsory Retirement age	40	equivalent to age 60
J	Maximum years after labor force entry	60	equivalent to 80 years
ψ_j	Survival probability at age j	see text	
σ	Risk aversion parameter	0.70	
λ	degree of temptation	0.013	
ϕ	Weight on consumption	0.96	match elderly work hours
$\{\kappa_1, \kappa_2\}$	Disutility of labor force participation	$\{0.0142, 0.916\}$	match elderly work hours
β	Annual discount factor	0.970	To match national savings rate
R	Gross rate of return	1.045	
τ_1	Tier 1 Contribution rate	0.11	
τ_2	Tier 2 Contribution rate	0.05	
η_m	age-income profiles for worker in sector m	see text	
$P_m^j(m' m)$	Employment status transition matrix	see text	estimated from GLSS (2012)
$P_h^j(h' h)$	Health shock	see text	estimated from GLSS (2012)

¹⁴Since the results are likely to be affected by the amount of the income transfer, we perform sensitivity checks using different amount to gauge the effect of the transfer on our results.

4.2.6 Welfare Evaluation measure

An ex-ante life-time value of an agent in the benchmark economy is defined as

$$V^{bm} = E_0 \left[\sum_{j=1}^J \beta^{j-1} \left(\prod_{t=1}^{j-1} \psi_t \right) U(c_j^*, l_j^*, \hat{c}_j^*) \right] \quad (4.18)$$

Welfare change for a policy reform is measured by consumption equivalence variation (CEV) as consumption equivalent lump-sum compensation required to make sure agents are indifferent between living in the benchmark economy and living in the economy with the policy change.

$$V^{reform} = E_0 \left[\sum_{j=1}^J \beta^{j-1} \left(\prod_{t=1}^{j-1} \psi_t \right) U((1+CEV)(c_j^*), l_j^*, (1+CEV)(\hat{c}_j^*)) \right] \quad (4.19)$$

Giving the utility function in equation 4.12,

$$CEV = \left(\frac{V^{reform}}{V^{bm}} \right)^{\frac{1}{\phi(1-\sigma)}} - 1 \quad (4.20)$$

The *CEV* denotes the fraction by which consumption must be increased in the baseline to compensate for the increase in welfare generated by the reform. A positive *CEV* suggests that a given reform increase welfare in comparison with the baseline. A negative *CEV* on the other hand implies that baseline policy is preferred to the alternative reform.

4.3 Results

In order to obtain numerical solutions to the model and conduct a quantitative analysis of retirement scheme, we need to choose particular values for the parameters of the model. The strategy of numerical analysis that we use first establishes a reasonable

benchmark model economy that characterizes some key features of the current Ghanaian economy.

In this section, we first present the calibration result of the benchmark model with no matching contributions for informal pensions and discuss how our model matches the data. Next, we specify and discuss a variety of implementations of the voluntary pension programs for informal sector workers on market aggregates and welfare in the context of developing countries.

4.3.1 Benchmark economy

We match our benchmark economy with option for voluntary retirement savings to key variables such as old age employment rate and participation in voluntary retirement scheme by informal workers as well as the age-consumption profile in Ghana. It is important to emphasize that the objective of the calibration exercise is not to exactly estimate the fundamental parameters (RRA and discount factor) of the Ghanaian economy but to search for parameters that makes the model consistent with the consumption profile. Our model economy is able to match key variables: the employment shares, average working hours of old people and pension participation rate. The benchmark model outcomes and data are shown in Table 4.2. The model consumption profile for workers matches well the consumption profile from the data as shown in Figure 4.4.¹⁵

Table 4.2 Model Outcomes

Variable	Baseline Model	Data
Formal employment share (%)	12.83	12.37
Informal employment share (%)	83.05	83.23
Unemployment share (%)	4.12	4.41
Old people working hours	0.31	0.32
Participation in Retirement Scheme (%)	1.92	1.50

¹⁵We match pre-retirement consumption profile because informal workers who contribute to the pension scheme are yet to experience retirement.

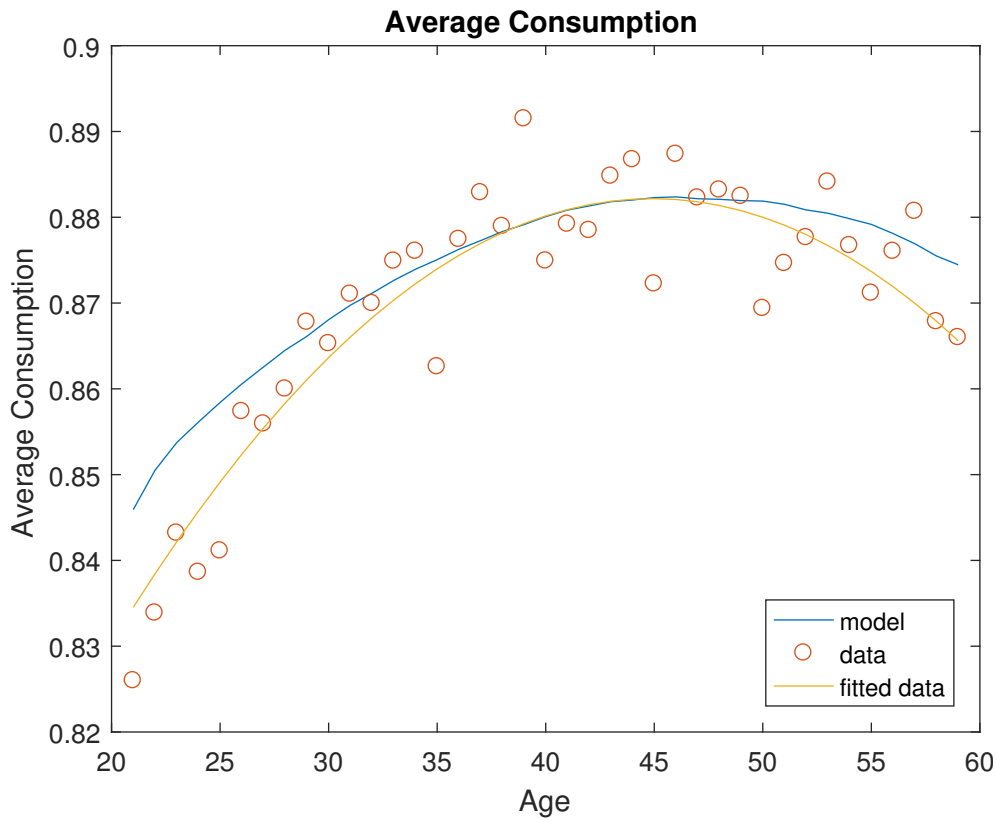


Fig. 4.4 Consumption-Age Profile

4.3.2 Introducing government Sponsored Matching contributions

We start the benchmark economy without a matching contributions program for informal sector workers and calibrate this version to the economy of Ghana. We then assume that the government introduces a matching contributions to all informal sector workers who are below age 60 and make contributions to the voluntary pension scheme. The generosity of the government matching is determined by the magnitude of the matching rate τ_q . The magnitude of the matching rate determines the returns on contributing to pension scheme relative to ordinary savings account that also serves as buffer stock saving for precautionary purpose (Deaton,1991). In all our policy experiment we assume that the government can finance the expenditure on matching contributions using revenue from consumption taxes.

We consider a policy reform of introducing a tax-financed matching contributions program with 100% matching rate¹⁶. Three different benefits payment options of the scheme are considered including lump sum payments, partial annuity (75% lump sum and 25% annuity), and full annuity payments are considered. We report the impact of these reforms on key aggregate variables and welfare in subsections below.

Following Fehr and Kindermann (2010), when there is annuitization of retirement account assets, old agents at age $j = J', \dots, J$ receive fixed benefit x which is a function of accumulated assets at the time of retirement at J' . This is calculated as follows:

$$x_j = x_{J'} = \frac{(1 + r_{J'}) a_{J'}^R}{\sum_{j=J'}^J \prod_{i=J'+1}^j (1 + r_i)^{-1}} \quad (4.21)$$

where $r_i = \frac{1+r}{\psi_i} - 1$ and $r_{J'} = \frac{1+r}{\psi_{J'}} - 1$. This implies that periodic returns for annuitized assets, $r_i > r$. $a_{J'}^R$ and $r_{J'}$ are the accumulated savings in the pension account and periodic annuitized returns at the time of retirement, respectively.

Table 4.3 Quantitative Results of Policy Experiments

	Baseline	Lump sum	Partial Annuity	Full Annuity
Welfare change-High educated	—	-1.839	-1.012	1.050
Welfare change-Low educated	—	-0.502	1.189	4.677
Welfare change-Social Average %	—	-0.898	0.535	3.595
Young Savings rate(%)	0.428	10.329	33.315	35.499
Old age consumption per capita	0.710	1.706	1.846	2.508
Pension Participation rate(%)	1.915	79.585	79.748	77.205
Old age Employment rate(%)	91.470	91.470	91.470	91.470
Old age work hours	0.310	0.288	0.285	0.272
Consumption tax rate(%)	0.424	4.648	4.903	4.701

Welfare

In our framework, the government sponsored matching contributions to informal workers voluntary contributions to pension scheme has three effects. First, it provides

¹⁶Palacios and Robalino (2010) suggests a level of the matching of not less than 100% in order to induce pension savings from informal workers.

redistribution from the rich formal workers and old people to the poor and young informal workers by subsidizing their future consumption. All consumers pay consumption tax but only informal workers who contribute to the pension scheme benefit from the program. The subsidy is expected to improve welfare since life-time consumption of poor informal workers improves after retirement. However, tax also affects consumption of all individuals including old people and this will reduce consumption and welfare. Thus, welfare effects can be negative or positive depending on the strength of each effect. Second, shielding large assets into pension scheme, matching contributions reduces the cost of self-control thereby increasing welfare compared accumulating assets in ordinary savings account. Thus, by encouraging individuals to voluntarily contribute into pension scheme, matching contributions helps to redistribute income from periods of relatively high and stable income but subject to overspending to old age period when labor income is unreliable and low. This inter-temporal redistribution of consumption improves welfare (Akerlof, 1998). Third, the compulsory purchase of annuity of pension assets which provides mortality premium or insurance for survival old agents may also improve social welfare.

The welfare effects of various reforms are indicated in the first three rows of Table 4.3. The results suggest that the policy would have differential effect on individuals with different education status. Low educated individuals, who usually work in the informal sector and therefore are eligible for matching contributions provided by government experience higher welfare gain when there is partial or full annuity compared to the gains of high educated individuals as indicated in row 1 and 2. Matching contributions policy with 100% matching rate and full annuitization of pension savings raises the welfare of low educated and high educated agents by 4.68% and 1.05% percent of consumption equivalent, respectively. High educated workers forms the larger proportion of formal sector workers and therefore would pay the high consumption tax resulting from matching contributions policy without having access to its benefit. However, there are some high educated workers who also benefit from the policy as they work in the

informal sector. Thus, in the case of full annuity, the benefit of high educated informal workers outweighs that of high educated formal workers hence welfare gain equivalent to 1.05% of baseline consumption. The welfare change in terms of social average indicates that the policy of 100% matching and full annuity improves welfare equivalent to 3.60% of baseline consumption. The improvement of welfare with regard to matching contributions and full annuity results from redistribution and annuity. First, the matching contributions policy redistributes income from formal workers to informal workers (conditional on savings into pension account) through pensions savings subsidy. Jung and Tran (2012) also find that in developing countries with large income gap between formal and informal workers social pension program generates welfare gain. Second, through annuity informal workers benefit from insurance and therefore reduction in risks associated with becoming poor and a rise in lifetime income that result from sharing of accidental bequest to survival agents. Fehr and Kindermann (2010b) finds that, mandatory annuitization by implicitly redistributing from future to existing generations through reduction in unintended bequest improves efficiency in a general equilibrium model. The annuitization of retirement savings provides longevity insurance against an uncertain life span (Hubbard and Judd, 1987). Annuity pays a mortality premium during the retirement period and higher reduction in welfare loss associated with self control costs. The reduction in self control costs associated with savings is generated by diverting savings into pension scheme and annuitization of pension assets. Savings in pension scheme provides commitment for agents who suffer from temptation and incur self control costs by accumulating large assets for longer period.

In the case of matching contributions and lump sum payments of pension savings, both high educated and low educated workers suffer welfare loss. Here, only redistribution effect through pension savings work. There is no annuity hence no insurance from pension. The accumulated assets are used as insurance against the risk of low income during old age. In spite of the fact that the poor informal workers benefits from redistribution, the rise in taxes to finance the redistribution dampens the effect

of the redistribution hence generating welfare loss for all agents. Thus, the negative effects from consumption tax outweighs the benefit of redistribution and reduction in self control costs. Consumption tax rate rises from 0.42% in the baseline economy to 4.65% in the economy with matching contributions and lump sum payments policy. Moreover, since assets for deceased are not accounted for accumulating higher savings by postponing consumption from periods when survival are low to period of high survival also dampens the benefits of redistribution. Row 3 of Table 4.3 suggests that lump sum with matching policy is inferior to the current policy of no matching in spite of the intra-temporal and inter-temporal redistributions associated with these policies. Social average welfare reduced by consumption equivalent of 0.90% of life-time consumption in the baseline economy.

For Partial annuity, where only 25% of accumulated pension savings are annuitized, matching contributions policy would generate welfare gains equivalent to 1.19% of life-time consumption in the base line economy for low educated workers who are the major beneficiary of the saving subsidy. High educated workers suffer welfare loss as negative welfare effect of a higher consumption tax generates welfare for formal educated workers is higher than the gains of redistribution accrued to informal high educated workers. However, the policy leads to social average welfare gain equivalent to 0.54% of life-time consumption resulting from there higher proportion of low educated workers (71%) in the economy. Tax on consumption rises from 0.42% to in the baseline economy to 4.90% in the case of partial annuity higher than tax rates in the economy with full annuity (4.70%) and lump sum (4.65%).

Savings rate

Table 4.3 indicates that the average savings rate by young cohort rises by about 23.25 percent, 75.40 per cent and 80.68 percent when government sponsored matching contributions of 100 per cent matching rate is accompanied by lump sum payments, partial

and full annuity respectively. The high returns on retirement savings associated with matching contributions for informal workers encourage them to increase savings. The increase in overall savings rate among the young cohort results from redistribution from high income earners to low income earners. The redistribution in the form of matching from the rich formal workers to the poor informal workers help to increase overall savings rate among the young people. The rich formal workers have access to a certain future pensions and therefore have low propensity to save toward retirement. The poor informal workers without any pension, however, have relatively higher propensity to save for the old age. Thus, taxing consumption to subsidize savings among the low income informal workers with high propensity to save improves the economy-wide savings.

In general, the matching contributions policy of providing pension to informal workers by subsidizing pension savings increase savings rate among the young workers who are below the retirement age. However, savings rate differs among the alternative benefits payment options. Full annuitization with matching contributions generates higher savings rate (35.50%) compared with partial annuity (33.32%) and lump sum payment (10.33%). In terms of percentage points changes from the baseline savings rate, savings rate is rises about 9.90 per cent, 32.89%, and 35.07% for lump sum, partial annuity and full annuity respectively.

4.3.3 The role of accidental bequest

In the previous sections, the accidental bequests were not accounted for. Thus, policies that encourage savings but do not redistribute accidental bequest may be welfare depressing for the society due to the loss of asset when an agent is deceased. In Table 4.4 we allow government to tax all the accidental bequest of old agents and transfer them to the survival old individuals as lump sum. Here, there is no loss of asset when an agent dies hence the beneficial (welfare) effect of redistribution through

matchings contributions can be properly measured against the cost of financing the matching contributions expenditure. We compare the results with a policy of matching contributions with lump sum and full annuity.

Table 4.4 Effects of Transfer of Accidental Bequest

	Baseline+BEQ	Lump sum+BEQ	Full Annuity
Welfare change-High educated	—	0.334	1.049
Welfare change-Low educated	—	2.342	4.675
Welfare change-Social Average %	—	1.746	3.594
Young Savings rate(%)	0.428	7.005	35.499
Old age consumption per capita	0.710	1.651	2.508
Pension Participation rate(%)	1.915	69.648	77.205
Old age Employment rate(%)	91.470	91.470	91.470
Old age work hours	0.310	0.290	0.272
Consumption tax rate(%)	0.424	3.143	4.701
Matching EXP/GDP (%)	—	3.210	3.830

As can be seen in Table 4.4, both high educated and low educated workers get welfare gains equivalent to 0.33% and 2.34% life-time consumption in the baseline economy respectively. For social average welfare, the subsidy associated with matching contributions and lump sum improves welfare of agents by about 1.75 percent of the baseline consumption with bequest. Compared to full annuity results repeated on column 4, the welfare improvements (high educated workers, low educated workers and social average) associated with matching contributions and full annuity is preferable to that of lump sum payments though full annuity entails higher consumption tax rate (4.70%) compared to lump sum (3.14%).

However, the availability of unconditional transfer to the survival old people through sharing of accidental bequests, the response to matching contributions policy is very low in terms of both participation and savings rate. Comparing lump sum when accidental bequest are distributed among the old people and full annuity, savings rate for lump sum is low (7.01%) compared to 35.50% for full annuity. The participation rate is 69.65% for lump sum compared to full annuity (77.21%). The availability of accidental bequest (which are distributed unconditionally) reduces the necessity to save for retirement as

the risk of falling into poverty is reduced. Thus, the accidental bequests weakened the effect of matching contributions (savings subsidy) by reducing pre-retirement savings. Hence low participation, low contribution and low savings rate. However, annuity provides conditional distribution of bequest hence it serves as incentive for pension participation, higher contributions and therefore higher savings rate. To benefit from accidental bequest, an agent need to participate and accumulate larger asset in the retirement account, leading high savings rate for full annuity.

The fiscal costs associated with matching contributions with lump sum payment option is lower than that of full annuity due to lower contributions and therefore low expenditure on subsidy payments or matching costs. Thus consumption tax of 3.14% associated with lump sum is lower than 4.70% for the case of full annuity. The higher pension participation and savings response to full annuity and matching contributions policy require high consumption tax to finance the subsidy. In terms of GDP, the matching contributions expenditure for lump sum and annuity payments amounts to 3.21% and 3.83% of GDP respectively.

Life Cycle Profiles

Table 4.5 and Figure 4.5 show pattern of pension participation rates and old age labor supply for the two policy options (matching contributions with lump sum (bequest) and full annuity as benefit payments options) and baseline with bequest.

Pension Participation Table 4.5 shows workers participation in pension scheme in response to 100% matching contributions by age groups and benefit payment options. Participation is defined as a positive contribution to the pension scheme. Comparing column 2 with columns 3–4 in Table 4.5, it can be seen that matching contributions increases participation in pension scheme. The matching contributions induces workers of all ages to contribute into pension scheme. The results also indicate that participation in the voluntary pension scheme depend on the benefit payments option. Participation

rate for 40+ olds workers is high when there is full annuity as the insurance, extra returns through mortality premium improves incentive for pension saving and therefore encourage higher participation.

Table 4.5 Participation

Age	Baseline(+BEQ)	Lump sum(+BEQ)	Full Annuity
21-30	0.000	81.410	81.410
31-40	0.000	85.439	85.439
41-50	0.000	61.350	78.856
51-59	9.358	43.418	58.768

Old age Labor supply Old age employment rates and labor supply are low in countries with pension system with massive coverage. We examine the labor market implications of government matching contributions and benefit payment options for old people. The availability of high accumulated assets or annuity pension for informal workers during old age will likely reduce aggregate labor supply of the old people through income effect.

Figure 4.5 indicates that annuity by providing stable consumption throughout retirement period has substantial impact on old age labor supply. Jung and Tran (2012) through general equilibrium also found that social pension reduces elderly labor supply and participation in a model calibrated to Brazil. Access to old-age pension benefits is reported to have a strong effect on decision of retirement of rural workers in Brazil (Filho, 2008). This suggests that availability of secured periodic benefits such as pension allow old agents to make choice about labor supply and employment and in this case old age labor supply reduce substantially (Kidd and Whitehouse, 2009). Lump sum payments also lead to a decline in labor supply but at lower rate compared to the case of full annuity.

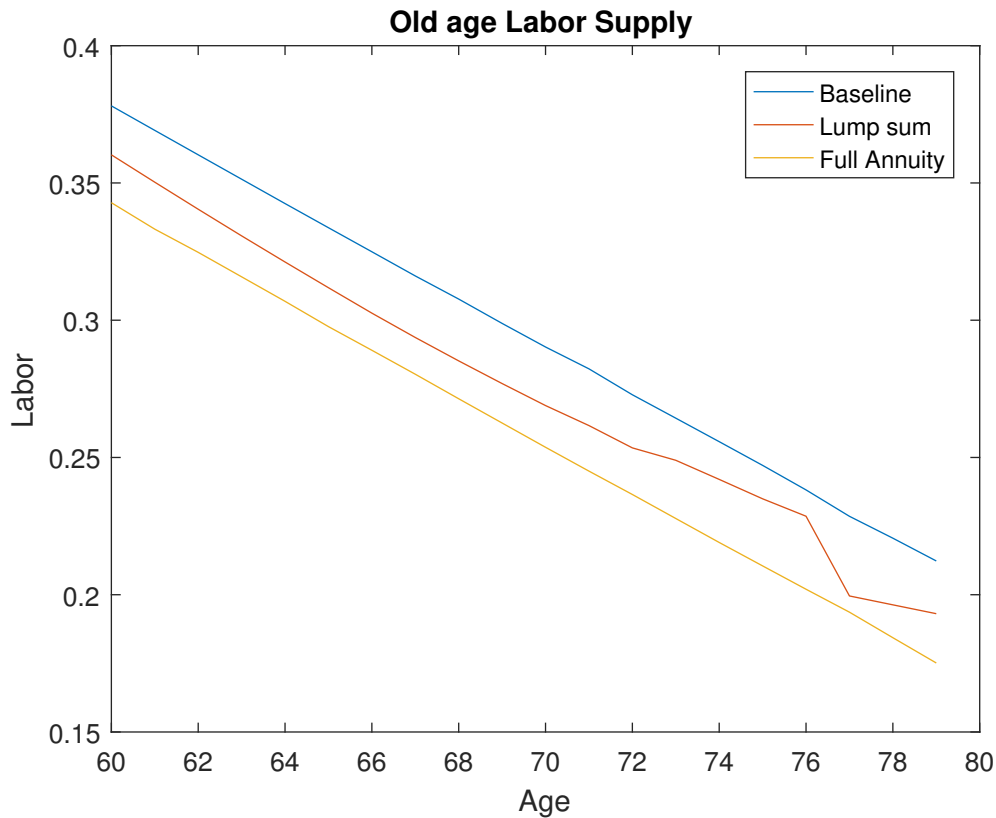


Fig. 4.5 Old age Labor Supply

4.3.4 Optimal Matching Contributions Rate

In this section we characterize the optimal matching rate and discuss the implication of different matching rate on pension participation, contribution and consumption when there is compulsory annuitization.

Table 4.6 Optimal Matching Contributions Rate with Full Annuity

	Baseline	0%	50%	100%	150%	159%	160%	175%	200%
Welfare change-High educated	—	0.662	0.991	1.050	0.797	0.698	0.651	0.238	-1.498
Welfare change-Low educated	—	1.029	3.129	4.676	5.701	5.815	5.790	5.713	4.465
Welfare change-Social Average %	—	0.920	2.494	3.595	4.234	4.284	4.252	4.074	2.677
Young Savings rate(%)	0.428	13.311	25.420	35.499	45.205	47.142	47.399	50.909	56.865
Old age consumption per capita	0.710	1.122	1.782	2.507	3.396	3.599	3.627	4.037	4.980
Pension Participation rate(%)	1.915	69.293	74.949	77.205	71.328	68.551	70.422	68.603	83.571
contribution per capita	0.000	0.049	0.049	0.060	0.073	0.076	0.077	0.086	0.117
Old age Employment rate(%)	91.470	91.470	91.470	91.470	86.432	82.022	81.930	68.521	62.759
Old age work hours	0.310	0.302	0.288	0.272	0.244	0.238	0.236	0.239	0.246
Consumption tax rate(%)	0.424	0.399	2.345	4.702	7.311	7.844	7.943	9.127	12.419

Table 4.6 presents results for different matching contributions rates with full annuity payment option. The results indicate that with the utilitarian welfare measure where average welfare of all agents are considered, the matching rate that maximizes social welfare is 159%. Matching contributions rate of 159% generates welfare gains equivalent to lifetime consumption of 5.82% and 0.698% of the baseline consumption for low educated and high educated workers respectively. The Rawlsian social welfare criterion which maximizes the welfare of the poor (low educated in this study) also suggests that a matching contributions rate of 159% that is used to subsidize the pension savings maximizes the welfare of the low educated (*ex ante* poor people in this model). In the Rawlsian social welfare function, the expected lifetime values of agents with lower education and therefore income is maximized by the government. Thus, the optimal matching contributions rate for Rawlsian welfare measure coincides with that of utilitarian welfare measure of social average. This is not surprising since low educated workers are about 71% of the total labor force. The need for higher matching contributions rate that transfer income to the poor results from the fact that there is high inequality between high and low educated workers as well as between formal and informal workers.

Savings rate associated with the optimal matching rate of 159% is 47.14% compared to the baseline savings rate of 0.43%. The higher savings rate results from the higher pension participation and average contribution of about 68.55% and 0.76 respectively. Many studies in developed countries find that matching contributions affects participation but not contribution (see for example Marian, 2015 for review on this literature). Holzmann et al. (2015) also suggest that matching contributions is moderately effective in increasing program participation but less effective in raising contributions level in high income countries. Palacios and Robalino (2010) however suggest that the level of matching should be high relative to earnings to induce participation and amount of contribution in developing countries.

Consumption tax rate rises from 0.42% in the baseline economy to 7.84% in the optimal matching rate economy as higher revenues are raised by government to finance

the expenditure on matching contributions. The higher consumption tax rate associated with increased matching contributions rate result partly from the fact that the higher incentive encourage higher participation and contribution. Also since more consumption are shifted to after retirement, the tax base shrink necessitating higher consumption tax to finance the increased expenditure on matching contributions. Employment rate and old age work hours also reduced from 91.47% and 0.31 hours in the baseline economy to 82.02% and 0.24 hours respectively in the optimal matching economy.

The results also indicate that annuity without any matching contributions (pure effect of annuity) improves welfare equivalent to 1.03% and 0.67% of lifetime consumption in the baseline economy for low and high educated workers respectively. Here, there is no pre-retirement saving subsidy on pension savings but conditional redistribution of deceased assets. Thus, the policy provides mortality premium for survival old agents as well as insurance against longevity. Fehr and Kindermann (2010b) find similar results that mandatory annuitization of retirement savings leads to an increased contribution to retirement account in order to gain from longevity insurance and still receives bequest from the deceased. The incentive created by these two benefits of annuity encourage participation of about 69.30% generating savings rate of 13.31%. Thus, if there is no self selection in pension savings due to differences in individual survival probabilities, then 0% matching rate with annuity is able to encouraged people to save into the pension scheme to have access to life time annuity income. The implication of effect of 0% matching contributions rate suggest that developing countries without fiscal space to finance unfunded pension or unconditional transfer can still expand the coverage of their pension system by designing it with annuity component. By using pension or retirement account to redistribute bequest in the form of annuity, poverty could be reduced with higher savings rate.

The results from Table 4.6 also suggest a positive relationship between savings rate and matching contributions rate. Fehr and Kindermann (2010b) find that mandatory annuitization of withdrawals after retirement increase savings in tax-favored accounts

leading to a rise in aggregate savings. A higher savings subsidy through matching contributions encourage higher savings through an increase in pension contributions. Since formal workers have access to pension and therefore are not saving toward retirement, the increase in consumption tax does not have its equivalent effect on savings rate, hence leading to a rise in savings rate. This implies that if targeted to low income households who are likely to save very little without subsidy, matching contributions may improve savings rate in the economy.

4.3.5 Sensitivity Analysis

Income Transfer

In our benchmark model, the income transfer to non-working individuals (unemployed and sick people) was set to 10% of minimum wage income of formal workers. The amount of income transfer to non-working individuals could impact on incentive to save and also participate in the pension scheme. Thus, we examine how the incentives of informal workers could be affected by the income transfer. Table 4.7 presents results of different rates of income transfer on pension participation and contributions in response to 100% matching contributions rate.

Table 4.7 The role of Income Transfer

	50% of BS	baseline(BS)	200% of BS	300% of BS	500% of BS
Young Savings rate(%)	35.888	35.499	34.987	34.427	33.439
Pension Participation rate(%)	76.730	77.205	77.630	77.775	78.031
Old age work hours	0.272	0.272	0.273	0.274	0.275
Average contribution	0.060	0.060	0.059	0.058	0.056

The results indicate that changes in income transfer do not significantly affect pension scheme participation rate and average contribution. A rise of income transfer of about 500% increases participation by less than 0.6% and reduced contribution by 8.1%. In addition, there is no significance changes in savings rate, employment rate and hours of work. The implication of this result is that the existence of better family

support and other transfer may not have significant effect on the results of the matching contributions policy.

The role of Temptation and Self-control

In this section, we explore the role of self-control on the response to the matching contribution policy. The temptation parameter is set to zero ($\lambda = 0$) and we match the model to the consumption profile with discount factor of 0.95. The pension participation rate, savings rate, contribution and labor supply response from the baseline economy without temptation and self-control problems and an experiment with 100% matching contribution rates are reported in Table 4.8. For ease of comparison, we also report baseline and similar experiment with tempted and self-control agents ($\lambda = 0.013$).

Table 4.8 shows that in the baseline non-tempted agents do not participate and contribute to the pension scheme. This is not surprising since the pension scheme do not offer any advantage over ordinary savings account for the non-tempted agents. Moreover, the pension scheme lacks liquidity therefore non-tempted agents do not save in the pension scheme. However, for tempted agents, the opportunity to reduce self-control costs by saving into the pension scheme is an incentive for them to participate and contribute to pension scheme. Thus, the existence of temptation and self-control problem provide a fundamental trade off associated with pension contributions – reducing self-control cost vs lower liquidity.

Thus, even without any advantage (in terms of returns) of pension scheme, tempted agents participate and contribute to pension account even though very low rate of participating of about 1.92% in the baseline. This supports Ashraf et al. (2006) empirical finding in Philippines that self-control agents signed for commitment savings accounts relative normal savings account. The importance holding of illiquid assets as commitment devices has been discussed by Laibson (1997) that tempted agents would

save into illiquid assets so they can prevent over-consumption even if the interest rate on illiquid assets is less than the interest rate of liquid assets.

Table 4.8 The role of Temptation/Self-control

Indicator	Self-control		No Self-control	
	baseline	Annuity with 100% MC	baseline	Annuity with 100% MC
Column	1	2	3	4
Young Savings rate(%)	0.428	35.499	0.425	18.215
Pension Participation rate(%)	1.915	77.205	0.000	40.480
Old age work hours	0.310	0.272	0.310	0.295
Average contribution	0.000	0.060	0.000	0.059

The tempted and self-control agents benefits from commitment provided by the pension scheme in addition to the subsidy. The result indicates that even though temptation parameter is small, it induces large impact on the response to policy interventions as tempted agents value commitment device and therefore participate more in the pension scheme leading to high savings rate. Thus, the response of self-control agents to the policy in terms of participation, contributions and savings are higher compared to that of the non-tempted agents as reported in columns 2 and 4 of Table 4.8.

4.4 Conclusion

In this chapter we have developed a life cycle model to examine welfare and savings impact of government sponsored matching contributions on voluntary pension scheme for informal workers in developing countries. Agents in this economy suffer from temptations with self-control costs of holding wealth à la Gul and Pesendorfer (2001). Our setup for the analysis consists of overlapping generations of 60-period lived *ex ante* heterogeneous individuals facing mortality risk and individual income risk emanating from employment and health status uncertainties. There is absence of private credit markets, including markets for private annuities. Individuals supply their labor inelastically whenever they are given an employment opportunity to work in formal or informal sector of employment until a mandatory retirement age. After mandatory retirement

age for workers, individuals make employment decisions on participation and hours of work in the informal sector. To insure against uncertainties in income and for old-age consumption when labor income is relatively low even when work, individuals in our economy save through private asset holdings and personal retirement account. Old age consumption is supported by savings, retired formal workers pension and labor income from informal employment. The model is calibrated to data from Ghana for quantitative and qualitative analysis.

We find that informal workers can be incentivized to participate and contributes to pension system through *ex ante* redistribution (pension savings subsidy or matching contributions) and/or mandatory annuity. This would have the capacity to expand the pension coverage, reduce old age poverty and improves welfare in developing countries. Welfare gains due to insurance and redistribution effects of pension savings subsidy and mandatory annuity dominate welfare losses emanating from consumption taxes. Low educated poor informal workers are net beneficiaries from the policy. Moreover, national savings rate among workers also increase in response to the matching contributions policy that subsidizes pension contributions.

Our results also indicate that matching contributions rate (savings subsidy) of about 159% is optimal in terms of maximizing social average welfare and the welfare of the poor (low educated). The study also shows that a mandatory annuitization of pension savings even without government matching workers contributions still possess the ability to incentivize informal workers to contribute with welfare enhancing effect. This suggests that developing countries with limited fiscal space to finance transfer to the increasing aged population can still design pension system that expand the coverage to informal workers by mandating annuitization of pension savings. Our simulations result also suggests that higher matching contributions rate targeted to low income informal workers is associated with an increase in national savings.

Fiscal costs that would be incurred in implementing the matching contributions programs intended to encourage informal workers to contribute to pensions in an effort

to expand pension coverage would depend on the matching rate. We estimate that consumption taxes would increase by 2.72 and 4.28 percentage points to implement matching contributions with lump sum and annuity payments respectively. In terms of GDP, the two programs are estimated to cost the Ghanaian government about 3.21% and 3.80% for lump sum payments and mandatory annuity respectively. However, mandatory annuitization of pension savings without matching contributions program would also improve welfare with no additional fiscal cost. Thus, depending on the fiscal space available for governments of developing countries, mandatory annuitization of pension savings with varying matching rates could be implemented to improve welfare of elderly and at the same time boost households savings.

Chapter 5

Conclusion

This chapter summarizes the key findings from chapter 3 and 4. The policy implications that can be deduced from the findings are also discussed. In addition, we also briefly discuss possible related areas for future research.

5.1 Summary of Studies

The dissertation examines issues on taxation and pension policies in developing countries with large informal sector. Specifically, we first determined the optimal labor and capital income tax and examined the role of informal sector and human capital investment. Second, we study how pension coverage in developing countries could be expanded and the role that incentives could play in extending pension to informal workers. The role of different benefits payments options (lump sum and annuity payments) in influencing participation and contribution to informal pension schemes in developing countries are also discussed through simulated experiments.

To address these issues, two different models were developed. First, a two-sector general equilibrium overlapping generation model with endogenous formal-informal labor supply and human capital investment was developed to determine the optimal capital and labor income taxation. Second, we developed a life cycle model that consists

of overlapping generations of 60-period lived individuals facing mortality risk and individual income risk emanating from employment and health status uncertainties to examine the impacts of various pension policies.

For the quantitative analyses, Ghana is used as an example given its large size of informal sector employing about 88% of total workers. Moreover, it has recently developed a pension system for informal and self employed workers who do not participate in the traditional wage related social security in the formal sector. In each study, the model was calibrated to match an appropriate key economic variables of the Ghanaian economy. The calibrated models were used to quantitatively determine the optimal income taxations and examine pension related policies and assess their impact on savings and social welfare.

Our quantitative analyses on the determination of optimal income taxation first suggested that optimal capital income tax is higher than currently applied capital income tax in Ghana. Optimal labor income tax rate is lower than the current rate. Our result suggests that in an economy with large informal sector, capital income taxes should not be zero. It suggests that presence of low productive informal makes formal work more elastic and as such labor income tax push workers into the low informal sector leading to allocative inefficiency. To reduce allocative inefficiency governments of developing country should tax labor income at lower rate than capital income. Moreover, the finding of non-zero capital income tax still prevails even when there is no allocative inefficiency in the economy resulting from the fact that labor income tax still distorts human capital investment which necessitates a positive capital income tax to mitigate the negative impact of labor tax. In addition, even if informal sector can be taxed, optimal tax design still requires a non-zero capital income tax due to the presence of human capital investment which will be more elastic compared to financial savings. We thus find that neglecting informal sector in tax design would lead to understating optimal capital income tax and overstating labor income tax and the difference is quantitatively significant. The parental decision on educational or

human capital investment of their offspring is also important for sharing the burden of income tax optimally. Non-consideration of education decision of parents leads to an underestimation of capital income tax and overestimation of labor income.

Second, for redistributive income taxation, our results still suggest a higher capital income tax compared to labor income tax is optimal. Moreover, for redistributive policy, an optimal tax design required both larger capital and labor income tax compared to a non-redistributive policy. However, in the absence of allocative inefficiency cost of formal-informal labor supply, a relatively higher labor tax compared to capital tax is optimal suggesting that informal sectors limits the use of labor income tax even for redistribution. Thus, in developing countries with large informal sector and wage inequalities, taxation of capital income is preferred to that of labor income for redistribution purposes.

Our simulations results on the incentive scheme to expand the pension coverage in developing countries suggest that, first matching contributions could be a potent instrument to encourage voluntary contribution from the informal sector that will ensure adequate income and consumption for old people in developing countries.

Second, our results indicate that benefits payment options are important for participation and contribution: we find that annuity payment option which provides old age longevity insurance, mortality premium encourages higher participation, contribution, ensure poverty reduction and welfare improvement. In addition, targeting pension savings subsidy through matching contributions policy would increase national savings.

Third, our results on the optimal matching rate suggest a high matching rate above 100% for both the low educated welfare and social average welfare. However, we also find that 0% matching contribution rate with mandatory annuity of pension savings is welfare enhancing, increases pension participation rate and contributions by informal workers. Higher level of matching contributions by providing a higher *ex – ante* redistribution to the poor informal workers are found to increase pre-retirement saving rate.

Overall, we find that in developing countries with sizable informality where workers lack formal arrangement for risk-sharing coupled with low income, welfare gains resulting from redistribution and insurance is high and dominates welfare losses associated with taxation that finance those redistribution expenditure. Moreover, savings commitment device provided by pension scheme and its associated incentive for informal workers who suffer from temptation and self-control problems would increase savings rate.

5.2 Policy Implications

This dissertation characterizes optimal income taxation and investigates informal pensions policies in a developing country with a sizeable informal sector in chapter 3 and chapter 4, respectively.

Chapter 3 primarily determined the optimal capital income tax and labor income tax policy in a developing country with large informality and examined the roles of informal sector and human capital investment. Results from our calibrated model provided the following policy implications. First, capital income tax should be higher than labor tax in an economy with large informal sector because it (labor tax) generates larger distortions including labor allocation and education investment compared to capital income tax. Lower labor income tax rate helps reduces factor (labor) mis-allocation of pushing more workers into the low productive informal sector. Capital income tax does not directly affect net wage in the formal sector, hence there is no incentive for workers to move from the formal sector to the informal sector hence has less distortion.

Second, the size of informal sector and its efficiency cost should be considered in the design of tax policies in developing countries. Non-consideration of the size of informal sector and its implication on the use of labor income tax in revenue generation may lead to overestimation of labor income tax that might not be realized.

Incentives to encourage voluntary pension participation and contribution by informal workers to expand pension coverage in developing countries were examined in chapter 4. The results from the analysis suggest the following policy implications and recommendations. First, matching contributions policy should be used to encourage pension savings of informal workers, expand the pension coverage and increase household savings rate in developing countries.

Second, according to the experiments related to benefits payments options, our results suggest that a mandatory annuitization of pension savings would encourage higher participation, contributions and improves social welfare. Incorporating mandatory annuity into voluntary fully funded pension system is capable of offering adequate incentives to expand pension coverage, reduce old age poverty by offering stable income and insurance against longevity risks as well as redistribute income from the rich to the poor with low fiscal costs.

Lastly, since provision of social protection against old age poverty and at same time increasing savings rate for long term growth are among the important goals of developing countries, our study suggests that government financed matching contributions is an appropriate instrument to provide social protection and embark on redistribution without any adverse effect on savings and asset accumulation. Indeed, matching contributions can be used to increase savings and accelerate capital accumulation if targeted to the low income earners.

5.3 Areas of Future Research

Our studies relating to informality, optimal income taxation and pension policies in this dissertation are limited in terms of scope and methodology. Therefore we suggest possible research areas relating to our dissertation that should be investigated further in the future.

First, on the determination of optimal capital and labor income taxation, a well designed realistic life cycle model incorporating progressive taxation would be an important extension of this study. Moreover, the heterogeneity in our model is very limited and having more heterogeneity in terms of skill acquisition and human capital will help. In addition, the study could be extended by incorporating human capital investment subsidy in order to examine the mitigating effect of capital income taxation given widespread use of education subsidy across the globe.

Second, our study on pension policies in developing countries abstracts from bequest savings motive of agents. Since workers may intend to leave bequest to their children, their response to pension subsidy and mandatory annuitization of pension savings may be low compared to the findings of this study. With bequest motive pension account annuitization would be less attractive with obvious effect of participation, contribution and savings. Thus, consideration of bequest motives of savers would be an important improvement to this study as well as the design of pension policies in developing countries.

Third, our study on pension coverage expansion employs partial equilibrium analysis. However, the increase in savings and therefore capital accumulation in response to matching contributions policy would definitely impact on growth and welfare. Thus, our study could be expanded to general equilibrium in order to account for the asset and labor market effect on the economy.

It will also be important to compare cost-benefits of matching contributions (conditional *ex ante* transfer) to *ex post* targeted social pensions to old people in the informal sector. With increasing life expectancy among the elderly people in many developing countries, health demand and therefore expenditure will become an important component of spending of elderly people. Therefore a study that incorporates health expenditure will offer better policy relating to matching contributions, pension and health insurance in developing economies.

References

- Aboderin, I. (2004). Decline in material family support for older people in urban Ghana, Africa: Understanding processes and causes of change. *Journal of Gerontology: Psychological Sciences, Social Sciences*, 59, 128–137.
- Adams, N., Salisbury, D.& VanDerhei, J. (2015). Matching Contributions in 401(k) Plans in the United States. In *Matching Contributions for Pensions: A Review of International Experience*, ed. R. Hinz, R. Holzmann, D. Tuesta, and N. Takayama, 289–309, Washington, DC: World Bank.
- Aiyagari, S. R. (1995). Optimal Capital Income Taxation with Incomplete Markets , Borrowing Constraints, and Constant Discounting. *Journal of Political Economy* , 103(6), 1158–1175.
- Akerlof, G. A. (1998). Comment on "Self-Control and Saving for Retirement". *Brookings Papers on Economic Activity*, 1(1998), 91–196.
- Amaral, P. S. & Quintin, E. (2006). A competitive model of the informal sector. *Journal of Monetary Economics*, 53(7), 1541–1553.
- Ambec, S. & Treich, N. (2007). Roscas as Financial Agreements to Cope with Self-Control Problems. *Journal of Development Economics*, 82(1), 120–137.

- Anderson, S. & Baland, J-M. (2002). The Economics of Roscas and Intrahousehold Resource Allocation. *Quarterly Journal of Economics*, 117(3), 963–995.
- Ashraf, N., Karlan, D. & Yin, W. (2006). Tying Odysseus to the Mast: Evidence from A Commitment Savings Product in the Philippines. *Quarterly Journal of Economics*, 121(2), 635–672.
- Atkeson, A., Chari, V. V. & Patrick, J. K. (1999). Taxing Capital Income: A Bad Idea. *Federal Reserve Bank of Minneapolis Quarterly Review*, 23(3), 3–17.
- Atkinson, A. B. & Sandmo, A. (1980). Welfare Implications of the Taxation of Savings, *Economic Journal*, 90, 529–549.
- Besley, T. & Persson, T. (2013). Taxation and Development. *Chapter 2 in Handbook of Public Economics*, Volume 5.
- Beverly, S. G & Sherraden, M. (1999). Institutional determinants of saving: implications for low-income households and public policy, *Journal of Socio-Economics*, 28, 457–473.
- Bigsten, et. al.(2000). Rates of Return on Physical and Human Capital in Africa’s Manufacturing Sector. *Economic Development and Cultural Change*, 48, 4, 801–827.
- Braun, J. & Loayza, N. V. (1994). Taxation, Public Services, and the Informal Sector in a Model of Endogenous Growth. *POLICY RESEARCH WORKING PAPER*, World Bank, 1334 .
- Browning, M. & John, B. (1990). Consumption and Income Taxation. *Oxford Economic Papers*, 42(1), 281–292.

- Bucciol, A. (2011). A Note on Social Security Welfare with Self-control Problems. *Macroeconomic Dynamics*, 15, 579–594.
- Busato, F., Bruno, C., & Guido M. R. (2012). Equilibrium implications of fiscal policy with tax evasion: A long run perspective. *International Review of Law and Economics*, 32(2), 197–214.
- Basu, K. (2011). Hyperbolic Discounting and the Sustainability of Rotational Savings Arrangements. *American Economic Journal: Microeconomics*, 3, 143–171.
- Cagetti, M. & De Nardi, M. C. (2006). Entrepreneurship , Frictions , and Wealth. *Journal of Political Economy* , 114(5), 835–870.
- Caucutt, E. M. and Kumar, K. B. (2003). Education Policies to Revive a Stagnant Economy: The Case of Sub-Saharan Africa, *Manuscript*, University of Southern California.
- Caucutt, E. M. & Kumar, K. B. (2006). Education for all. A welfare-improving course for Africa? *Review of Economic Dynamics*, 10(2007), 294–326.
- Caucutt, E. M., Imrohoroglu, S. & Krishna, B. K. (2003). Growth and welfare analysis of tax progressivity in a heterogeneous-agent model. *Review of Economic Dynamics*, 6(3), 546–577.
- Caucutt, E. M. & Krishna, B. K. (2003). Higher Education Subsidies and Heterogeneity: A Dynamic Analysis. *Journal of Economic Dynamics and Control*, 27, 1459–1502.
- Cerda, R. A. & Saravia, D. (2013). Optimal taxation with heterogeneous firms and informal sector. *Journal of Macroeconomics*, 35(1), 39–61.

- Chamley, C. (1986). Optimal Taxation of Capital Income in General Equilibrium with Infinite Lives. *Econometrica*, 54(3), 607–622.
- Choi, J. J., Laibson, J & Madrian, B. C. (2011). \$100 Bills on the Sidewalk: Suboptimal Investment in 401(K) Plans. *Review of Economics and Statistics*, 93(3), 748–763.
- Conesa, J. C., Kitao, S & Krueger, D. (2009). Taxing Capital ? Not a Bad. *The American Economic Review*, 99(1), 25–48.
- Correia, I. H. (1996). Should capital income be taxed in the steady state? *Journal of Public Economics*, 60(1), 147–151.
- Cremer, H, Pestieau, P & Jean-Charles, R. (2003). Capital income taxation when inherited wealth is not observable. *Journal of Public Economics*, 87, 2475–2490.
- Cuff, Katherine et al. (2011). Optimal Policies with an Informal Sector. *Journal of Public Economics*, 95(11), 1280–1291.
- Deaton, A. (1991). Saving and Liquidity Constraints. *Econometrica*, 59(5), 1221–48.
- DeJong, D.N. & Ripoll, M. (2006). Do self-control preferences help explain the puzzling behavior of asset prices? *Journal of Monetary Economics*.
- Dessy, S. & Stphane, P. (2003). Taxes, inequality and the size of the informal sector. *Journal of Development Economics*, 70(1), 225–233.
- Doepke, Matthias (2015). Accounting for Fertility Decline During the Accounting Transition to Growth. *Journal of Economic Growth*, 9(3), 347–383.
- Doepke, M. & Zilibotti, F. (2005). The Macroeconomics of Child Labor Regulation. *American Economic Review*, 95(5), 1492–1524.
- Dorfman, M. (2015). Pension Patterns in Sub-Saharan Africa, *Discussion Paper No. 1503, Social Protection and Labor*.

- Duflo, E., William, G., Liebman, J., Orszag, P., & Saez, E. (2006). Saving Incentives for Low- and Middle-Income Families: Evidence from a Field Experiment with H&R Block. *Quarterly Journal of Economics*, 121(4), 1311–1346.
- Dworak-Fisher, K. (2008). Encouraging Participation in 401(k) Plans: Reconsidering the Employer Match. *U.S. Bureau of Labor Statistics Working Paper* 420.
- Dupas, P. & Robinson, J. (2013). Savings Constraints and Microenterprise Development: Evidence from a Field Experiment in Kenya. *American Economic Journal: Applied Economics*, 5(1), 163–192
- Engelhardt, Gary V., & Anil, K. (2007). Employer Matching and 401(k) Saving: Evidence from the Health and Retirement Study. *Journal of Public Economics*, 91(10), 1920–443.
- Engen, E. M., Gale, W. G. & Scholz, J. K. (1994). Do saving incentives work? *Brookings Papers on Economic Activity*, 1: 85–180.
- Erosa, A. & Gervais, M. (2002). Optimal taxation in life-cycle economics. *Journal of Economic Theory*, 369(2), 338–369.
- Erosa, A. & Koreshkova, T. (2007). Progressive taxation in a dynastic model of human capital. *Journal of Monetary Economics*, 54, 667–685
- Fehr, H & Kindermann, F. (2010a). Private retirement savings and mandatory annuitization, *Int Tax Public Finance*, 17, 640–661.
- Fehr, H & Kindermann, F. (2010b). Pension Funding and Individual Accounts in Economies with Life-cyclers and Myopes, *CESifo Economic Studies*, 56, 3.
- Filho, I. E. (2008). Old-age Benefits and Retirement Decisions of Rural Elderly in Brazil. *Journal of Development Economics*, 86(1), 129–146.

- Fleming, M., Roman, J. & Farrel, G.(2000). The shadow economy. *Journal of International Affairs*, 53(2), 387–409.
- Fortin, B., Nicolas M., & Luc, S. (1997). Taxation, wage controls and the informal sector. *Journal of Public Economics*, 66(2), 293–312.
- Gale, W. G. & Scholz, J. K.(1994). Intergenerational transfers and the accumulation of wealth. *Journal of Economic Perspectives*, 8(4),145–160.
- Garriga, C. (2001). Optimal fiscal policy in overlapping generations models. *Documents de treball (Facultat d’Economia i Empresa. . . . 2180* .January, 1–25.
- Gervais, M. (2012). On the optimality of age-dependent taxes and the progressive U.S. tax system. *Journal of Economic Dynamics and Control*, 36(4), 682–691.
- Ghana Statistical Service (GLSS) (2014). Labor Force Survey Report. Ghana Living Standards Survey Round 6 (GLSS 6).
- Golosov, Mikhail, Narayana Kocherlakota, and Aleh Tsyvinski (2003). Optimal Indirect and Capital Taxation. *Review of Economic Studies* 70(3), 569–587
- Gul, F. & Pesendorfer, W. (2001). Temptation and self-control. *Econometrica* 69, 1403–1435.
- Gul, F. & Pesendorfer, W. (2004). Self-control and the theory of consumption.*Econometrica*, 72, 119–158.
- Gunther, I. & Andrey, L. (2012). Informal employment in developing countries: Opportunity or last resort? *Journal of Development Economics* 97(1), 88–98.
- Harris, J.R. & Todaro, M.P. (1970). Migration, unemployment and development: a twosector analysis. *The American Economic Review*, 60 (1), 126–142.

- Hart, K. (1973). Informal income opportunities and urban employment in Ghana. *The Journal of Modern African Studies*, 11, 61–89.
- Heckman, J. J. (1976). A life-cycle model of earnings, learning and consumption. *Journal of Political Economy*, 4, 511–544.
- Heckman, J.J. & Hotz, V. (1986). An investigation of labor market earnings of Panamanian males. *Journal of Human Resources*, 21, 507–542.
- Holzmann, R., Hinz, R. & Tuesta, D. (2015). “Early Lessons from Country Experience with Matching Contribution Schemes.” In *Matching Contributions for Pensions: A Review of International Experience*, ed. R. Hinz, R. Holzmann, D. Tuesta, and N. Takayama, 3–25, Washington, DC: World Bank
- Hsu, M. & Yang, C. C. (2013). Optimal linear and two-bracket income taxes with idiosyncratic earnings risk. *Journal of Public Economics*, 105, 58–71.
- Hubbard, R. G., & Judd, K. L. (1987). Social Security and Individual Welfare: Precautionary Saving, Borrowing Constraints and the Payroll Tax. *American Economic Review*, 77 (4), 630–46.
- Huberman, G., Sheena, S. I., & Wei, J. (2007). Defined Contribution Pension Plans: Determinants of Participation and Contribution Rates. *Journal of Financial Services Research*, 31(1), 1–32.
- ICTD/UNU-WIDER (2016), ‘Government Revenue Dataset’,
<https://www.wider.unu.edu/project/government-revenue-database>
- Imrohoroglu, A., Imrohoroglu, S. & Joines, D.H. (1998). The effect of tax-favored retirement accounts on capital accumulation. *American Economic Review*, 88(4), 749–768.

- International Labour Office (1973). *Employment, Incomes and Inequality: A Strategy for Increasing Productive Employment in Kenya*. ILO, Geneva.
- International Labour Office (2013). *Women and Men in the Informal Economy: A Statistical Picture*. Second Edition.(Geneva:International Labour Organization).
- International Labour Organization (2009). *The informal economy in Africa: Promoting transition to formality: Challenges and strategies*.(Geneva:International Labour Organization).
- International Monetary Fund (IMF) (2007). *Ghana: Selected Issues*. Country Report No. 07/208.
- Jacobs, B. & Bovenberg, A. L. (2010). Human capital and optimal positive taxation of capital income. *Int Tax Public Finance*, 17, 451–478.
- Jones, L. E. , Manuelli, R. E. & Rossi, P. E. (1993). Optimal Taxation in Models of Endogenous Growth. *Journal of Political Economy*, 101(3), 485–517.
- (1997). On the Optimal Taxation of Capital Income. *Journal of Economic Theory*, 73, 93–117.
- Judd, K. L. (1985). Redistributive taxation in a simple perfect foresight model. *Journal of Public Economics*, 28.1, 59–83.
- . (1999). Optimal taxation and spending in general competitive growth models. *Journal of Public Economics*, 71.1, 1–26.
- Jung, J., & Tran, C. (2012). The extension of social security coverage in developing countries. *Journal of Development Economics*, 22(2), 439-458.

- Kakwani, N., & Kalanidhi, S. (2005). Ageing and Poverty in Africa and the Role of Social Pensions. *Working Paper*, 8, International Poverty Centre–United Nations Development Programme, Brasilia.
- Kanbur, R. et al. (2015). Optimal taxation and public provision for poverty reduction. *WIDER Working Paper*, 2015 / 054.
- Kidd, S. & Whitehouse, E. (2009). "Pensions and Old-Age Poverty." In *Closing the Coverage Gap: The Role of Social Pensions and Other Retirement Income Transfers*, ed. R. Holzmann, D. A. Robalino, and N. Takayama, 187–202. Washington, DC: World Bank.
- Kitao, S. (2015). Fiscal cost of demographic transition in Japan, *Journal of Economic Dynamics & Control*, 154 (2015) 37–58.
- Kocherlakota, N. R. (2005). Zero Expected Wealth Taxes: A Mirrlees Approach to Dynamic Optimal Taxation. *Econometrica*, 73(5), 1587–1621.
- Kumru, C. S. & Thanopoulos, A. C. (2011). Social security reform with self-control preferences. *Journal of Public Economics*, 95, 886–899.
- Laibson, D. I., Repetto, A. & Tobacman, J. (1998). Self-control and saving for retirement. *Brookings Papers on Economic Activity*, 1, 91–172.
- La Porta, R. & Andrei, S. (2014). Informality and Development. *Journal of Economic Perspectives*, 28(3), 109–126.
- Leal, O., Julio, C. (2014). Tax collection, the informal sector, and productivity. *Review of Economic Dynamics*, 17(2), 262–286.
- Leung, C. and Nan-Kuang, C. (2006). Intrinsic cycles of land price: a simple model." *Journal of Real Estate Research*, 28(3), 293–320.

- Loayza, N. 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, 29-162.
- Love, D. (2007). "What can the Life-cycle Model Tell us About 401(k) Contributions and Participation?" *Journal of Pension Economics and Finance* 6, 147–85.
- Madrian, B. C. (2015). "Matching Contributions and Savings Outcomes: A Behavioral Economics Perspective." In *Matching Contributions for Pensions: A Review of International Experience*, ed. R. Hinz, R. Holzmann, D. Tuesta, and N. Takayama, 289–309, Washington, DC: World Bank.
- Madrian, B. C. & Shea, D. F. (2001). The Power of Suggestion: Inertia in 401(K) Participation and Savings Behavior. *Quarterly Journal of Economics*, 116(4), 1149–1187.
- Mitchell, O. S., Stephen, P. U., & Tongxuan, Y. (2007). Turning Workers into Savers? Incentives, Liquidity, and Choice in 401(k) Plan Design. *National Tax Journal*, 60 (3), 469–89.
- Moon, Hyungpyo (2015). "Matching Contributions and Compliance in Korea's National Pension Program." In *Matching Contributions for Pensions: A Review of International Experience*, ed. R. Hinz, R. Holzmann, D. Tuesta, and N. Takayama, 161–176, Washington, DC: World Bank.
- National Pensions Regulatory Authority (2015). ANNUAL REPORT.
- Niño-Zarazúa, M., Laurence, R. & Tarp, F. (2016). Global Inequality: Relatively Lower, Absolute Higher. Review of Income and Wealth, Series 00, Number 00.

- Nguyen-Thanh, D. & Strupat, C. (2012). Is the Burden Too Small? Effective Tax Rates in Ghana. *Ruhr Economic Papers*. #389
- O'Donoghue, T. & Rabin, M. (2001). Choice and Procrastination. *Quarterly Journal of Economics*, 116(1), 121–160.
- Ogwumike, F. O., & Aboderin, I. (2005). Exploring the links between old age and poverty in Anglophone West Africa: Evidence from Nigeria and Ghana. *British Society of Gerontology*, 15(2), 7–15.
- Palacios, R., & Robalino, D. A. (2009). “Matching Defined Contributions: A Way to Increase Pension Coverage.” In *Closing the Coverage Gap: The Role of Social Pensions and Other Retirement Income Transfers*, ed. R. Holzmann, D. A. Robalino, and N. Takayama, 187–202. Washington, DC: World Bank.
- Palacios, R. & Orszag, M. (2015). “Implementation Issues in Low- and Middle-Income Countries.” In *Matching Contributions for Pensions: A Review of International Experience*, ed. R. Hinz, R. Holzmann, D. Tuesta, and N. Takayama, 311–331, Washington, DC: World Bank.
- Papke, L. E. (1995). Participation in and Contributions to 401(k) Pension Plans. *Journal of Human Resources*, 30(2), 311–325.
- Papke, L. E. & James, M. P. (1995). Survey Evidence on Employer Match Rates and Employee Saving Behavior in 401(k) Plans. *Economics Letters*, 49 (3), 313–317.
- Peichl, A. (2014). Flat-rate tax systems and their effect on labor markets. *IZA World of Labor*.
- Penalosa, C. G. & Turnovsky, S. J. (2005). Second-best optimal taxation of capital and labor in a developing economy. *Journal of Public Economics*, 89, 1045–1074

- Peterman, W. B. (2016). The Effect of Endogenous Human Capital Accumulation on Optimal Taxation. *Review of Economic Dynamics*, 21, 46–71.
- Prado, M. (2011). Government policy in the formal and informal sectors. *European Economic Review*, 55(8), 1120–1136.
- Restrepo-Echavarria, P. (2014). Macroeconomic volatility: The role of the informal economy. *European Economic Review*, 70, 454–469.
- Ribe, H., David A. R., & Ian, W (2010). Achieving effective social protection for all in Latin America and the Caribbean: from right to reality. World Bank Publications.
- Sallie M. (2016). How America Pays for College 2016. Report, Sallie Mae.
- Saracoglu, D. S. (2008). The informal sector and tax on employment: A dynamic general equilibrium investigation. *Journal of Economic Dynamics and Control*, 32(2), 529–549.
- Schoonbroodt, A. and Tertilt, M. (2014). Property rights and efficiency in OLG models with endogenous fertility. *Journal of Economic Theory*, 150, 551–582.
- Shehu, E. & Nilsson, B. (2014). Informal employment among youth: Evidence from 20 School-to-work Transition Surveys. Work4Youth Publication Series No. 8, International Labour Organization, Geneva.
- Social Security and National Insurance Trust (2012). Annual Report
- Stantcheva, S.(2015). Optimal Income, Education and Bequest Taxes in an Intergenerational Model.
- Tanaka, T & Murooka, T (2012). Self-Control Problems and Consumption-Saving Decisions: Theory and Empirical Evidence. *The Japanese Economic Review*, 63(1), 23–37.

- Tanzi, V., & Zee, H. H. (2000). Tax Policy for Emerging Markets: Developing Countries.
- Thaler, R. H. & Benartzi, S. (2004). Save More Tomorrow: Using Behavioral Economics to Increase Employee Saving *Journal of Political Economy*, 112(1), 164–187.
- Todaro, M. (1989). Economic Development in the Third World. Longman, New York.
- Todaro, M.P. (1969). A model of labor migration and urban unemployment in less developed countries. *American Economic Review*, 59, 138—148.
- Turnovsky, S. J., & Basher, M. A. (2009). Fiscal policy and the structure of production in a two-sector developing economy. *Journal of Development Economics*, 88(2), 205–216.
- UNESCO Institute for Statistics (2011). Financing Education in Sub-Saharan Africa Meeting the Challenges of Expansion, Equity and Quality.
- World Bank (1994). Averting the Old Age Crisis. Washington, DC: Oxford University Press.