The Journal of the Economics of Ageing xxx (2017) xxx–xxx

Contents lists available at ScienceDirect

The Journal of the Economics of Ageing

journal homepage: www.elsevier.com/locate/jeoa

The macroeconomic and welfare implications of rural health insurance and pension reforms in China ☆

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A R T I C L E   I N F O

Article history:
Available online xxxx

JEL classifications:
E62
H55
I13

Keywords:
China
Health
Aging
Healthcare
Pension

A B S T R A C T

We assess the potential impact of rural health insurance and pension reforms on macroeconomic outcomes and social welfare in a dynamic general equilibrium model calibrated to the Chinese economy. We analyze transition paths as well as steady state responses to the new policies. The current reforms in China provide modest rural pensions and reimbursement of a portion of healthcare costs, but at rates that are substantially lower than are already in place in the urban sector. We investigate the potential effect of raising the rural benefit rates to those enjoyed in the urban sector. While both reforms reduce income per capita, we show that the health insurance reforms are potentially welfare improving if they are implemented in a way that leads to reduced out-of-pocket health spending. The welfare gains are driven by rural health insurance providing relief from the risk of catastrophic medical expenditures that can wipe out household savings and force long working hours. A pay-as-you-go rural pension results in a welfare gain in the short-run but welfare loss in the long-run due to the distorting effects of taxes. Despite an increase in required financing due to an aging population, the welfare impact of rural health insurance remains positive when incorporating the projected old-age dependency ratio for the year 2050. However, a pay-as-you-go rural pension creates large income and welfare losses with 2050 demographics.

1. Introduction

In 2006 the Government of China announced a change in its social goals, with less focus on economic growth, and more on social equality and the promotion of a harmonious society. In line with these new guiding principles, there has been a major expansion of the coverage of both public pensions and health insurance, with the establishment of new schemes in the rural sector, and for people in the urban sector not already covered by employment based systems. We focus on the effects of the introduction of the new schemes in the rural sector. Both the rural pension and health insurance coverage involve subsidies from local and central government but have individual contribution requirements. At present the rural schemes have lower benefit levels than for urban employees but there are plans to increase benefits towards urban levels. Despite being voluntary, enrollment in the rural pension and health insurance schemes has been exceptionally high, which is unusual given the experience of low uptake in other countries (Aizer, 2007). For instance, by 2011, enrollment exceeded 300 million for the newly introduced rural pension system. Likewise, rural health insurance was largely absent a decade ago and now boasts over 98% coverage rates (China, 2014). The high enrollment may be due to local government officials having enrollment targets and the use of local incentives to enroll.

The primary goals of these new social insurance schemes are to lessen the healthcare disparities across socioeconomic status and between urban and rural sectors and to ease the growing financial burden of medical expenditures and old-age in rural China. Along with the potential benefits of providing insurance coverage to hundreds of millions in rural China, the expansive scope of the new programs imply significant direct financing costs. Tax financing may create distortions, moreover, researchers have linked China's substantial savings rates to the need to provide for retirement consumption and the uncertainty of future medical expenditures (e.g.

☆ This project was supported by the National Institute of Health (NIH, Grant No.: 5R01AG048037-02). The views expressed herein are those of the authors and do not necessarily reflect the views of the National Insitute of Health.

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http://dx.doi.org/10.1016/j.jeoa.2017.01.004
2212-828X/

Chamon and Prasad, 2010; Bai and Wu, 2014). If the policy reforms reduce individual savings or labor supply, they could also have macroeconomic effects, potentially lowering the capital stock, wages and income per capita. These concerns may be further compounded by the unprecedented aging of the Chinese population that will occur over the coming decades. As pension and healthcare spending is disproportionately concentrated among older individuals, the upcoming demographic change implies potentially large increases in the fiscal outlays of the programs. Moreover, changing demographics could have other general equilibrium effects that worsen the long-term impact of the policies.

In this paper, we quantitatively assess the impact of rural pension and health insurance policies on macroeconomic outcomes and social welfare in a stochastic dynamic general equilibrium model calibrated to the Chinese economy. More specifically, we analyze transition paths as well as steady state responses to the new policies. Our model employs a life-cycle structure within an overlapping generations framework. Individuals enter the economy as young adults and their earnings potential and health evolve stochastically over time. Each period agents face stochastic medical expenditures and choose how much to work, consume, and save. Current period health status affects medical expenditures, labor productivity, and mortality risk. In addition to age, wealth, and health status, we allow for permanent heterogeneity across agents in terms of education and sector (urban or rural).

We model key differences in social insurance systems, labor productivity, and healthcare across the urban and rural sectors. This gives us the required framework to understand the impact of rural social insurance policy changes in China. The government is assumed to operate all pension and health insurance schemes in the model economy. Importantly, our model allows the rural and urban sectors to operate independent pension and health insurance programs that may be financed locally (at the sector level) or through the central government. Social insurance schemes are financed through a combination of proportional labor income and consumption taxes allowing for the redistribution of resources across agents. We evaluate the effects of the rural pension and health insurance schemes against a baseline policy without such programs. We examine the effect of reforms that would raise rural benefits to the levels currently enjoyed by urban employees. We examine the effects of the policies under the year 2000 demographic structure as well as the higher old-age dependency rate that will be seen with 2050 demographics. We also analyze the effect of these policies along the upcoming demographic transition by building a transition path between steady states with the aforementioned demographic structures.

It is important to note that a key assumption in our model is that reimbursement of health spending through the rural insurance scheme will reduce out-of-pocket healthcare spending in the rural sector. Researchers have argued that, in practice, China's healthcare system encourages the provision of excessive and unnecessary care by underpricing basic care and allowing large profit margins on high-tech diagnosis and drugs (e.g. Yip and Hsiao, 2008). The resulting "profit-seeking" behavior potentially leads healthcare providers to capture a majority of the public funds injected into the healthcare system through the new subsidized insurance schemes. Empirical studies have generally found the new rural health insurance scheme has increased healthcare utilization but has little or no effect on out-of-pocket spending or health outcomes (e.g. Wagstaff et al., 2009; Sun et al., 2009; Lei and Lin, 2009; Hou et al., 2014; Cheng et al., 2015). This means that the current rural health insurance is welfare worsening since it has costs but no public benefits. We analyze the effect of effective health insurance that would actually reduce out-of-pocket payments. This would require changing the incentives for over treatment that are present in the current system or developing professional ethics in healthcare to put the patient's interests ahead of profit maximization (Blumenthal and Hsiao, 2015). As such, our policy results should be viewed as the potential results of introducing effective health insurance in conjunction with health systems reforms that promote the efficient delivery of healthcare.

From a welfare perspective, health insurance partially protects individuals against idiosyncratic medical expenditure uncertainty over the life-cycle. Similarly, pay-as-you-go pensions that fund a post retirement annuity payment provide partial insurance against idiosyncratic labor productivity and mortality risk. In addition to reducing risk, the tax funding of these systems means there is a redistribution from the rich to the poor. This occurs within sectors through local taxes but the presence of central government financing in the rural schemes also allows for redistribution from the urban to rural sector. Our approach to welfare is to examine the expected utility of an agent entering the workforce as a young adult. We look at the expected utility of different types by sector and education level, which focuses on the effect of the policies on income, transfers and insurance against risk. We also calculate overall welfare as expected utility averaged over types. This corresponds to asking which economy (with or without policy), the agents would prefer to live under, choosing from behind a "veil of ignorance" as to which type (sector and education level) they will be. Choosing from behind the veil of ignorance gives social welfare gains from redistribution from the rich to the poor since agents are risk averse. We measure welfare changes by the equivalent variation in consumption; how much would consumption have to increase for every agent, in every period, to give the same level of expected utility?

We begin our quantitative analysis by calibrating our model to the Chinese economy as of 2000, with no rural social insurance programs in place. We then compare our 2000 baseline results with the stationary equilibrium produced using the baseline parameter values except for the inclusion of rural health insurance or rural pensions. Introducing effective rural health insurance at benefit levels currently existing for urban employees in China would result in an overall decrease in average hours worked, savings, consumption, aggregate output and an increase in taxes. Nonetheless, the health insurance scheme is welfare improving from a social perspective due to the reduction in the risk of large out-of-pocket spending. Specifically, we find a 11.3% increase in expected welfare (as measured by consumption equivalent variation). When decomposing the welfare effects, the expected gain is over 15.4% in the rural sector. In contrast, there is a 2.4% loss of welfare in the urban sector due primarily to the increase in taxes required to finance the government subsidization of the new rural health insurance. In contrast, we find no net long-term welfare benefits from the reallocation of resources when implementing only the pay-as-you pension system. In fact we find an overall decrease in welfare of around 2.8% for China, with declines of 3.3% in urban welfare and 2.6% in rural welfare. Rural welfare declines despite the transfers from the urban to the rural sector because the public pension reduces savings, investment, and wages in both sectors of the economy. Looking forward, we analyze the effects of demographic change by using the projected 2050 age structure for China. Under the 2050 demographics, welfare gains from rural health insurance become smaller; population aging and a smaller working age share of the population means higher taxes are required to finance the benefits and distortions to the economy are larger. We find the negative welfare effect of pension provision become very large with future demographics; with the future age structure and urban levels of pension provision in the rural sector, we estimate a 12.6% reduction in welfare for China. This warns of the potential costs of introducing a large scale pay-as-you-go pension system in China; population aging may make such a system very expensive. Finally we extend our analysis of comparing stationary equilibria to understanding policy outcomes in transition. Towards this goal, we build a transition path between the stationary equilibria produced under the two demographic structures. We find similar results in transition as well. However, we do find positive welfare gains from the pension reform in the short run.

Our model builds on the structure first proposed by Alan and Kotlikoff (1987) to study the effects of fiscal policy in a general equilibrium setting with overlapping generations. This class of models has been used extensively to analyze social security reform in the US as well as general pension reform in a variety of other contexts.[1] More recently, the framework has been extended to analyze US healthcare reform. For example, Pashchenko and Porapakkarm (2013) model the effects of the Affordable Care Act on personal income while Attanasio et al. (2010) examine the economic effects of different methods of financing Medicare. While primarily limited to the US and Europe, several papers have used computable general equilibrium (CGE) models to examine the impact of population aging on the pension system in China (Wang et al., 2001; Li and Mérette, 2005; Sun, 2007). In these papers, a pay-as-you-go system is found to be unsustainable due to the increasing proportion of China's retired population. In our model the rural pension is sustainable in steady state but has a very high welfare cost due to the high taxes needed for finance. However the major contribution of this paper is the addition of health insurance to the analysis. We find that effective rural health insurance would be sustainable and welfare improving in steady state; despite the taxes needed to finance it there are large gains from the insurance provided and resulting decrease in large out-of-pocket expenditures.

The remainder of this paper is presented as follows. Section 2 begins by providing a brief recent history of social insurance schemes in China. Section 3 builds the economic framework of the model. Section 4 details the calibration strategy and policy experiments. Section 5 describes our welfare measure. Section 6 presents the results of the quantitative analysis. Finally, Section 7 provides concluding remarks.

2. Social insurance in China

2.1. Health insurance

Health insurance coverage was almost universal up until the 1970s in China with public provision of healthcare (Ma et al., 2008). Major reforms, decentralization, and a market based approach in the 1980s led to a reduction in insurance coverage and different systems emerging in the urban and rural sectors. Urban programs that covered urban employees of state or collectively-owned enterprises and government agencies, as well as their dependents continued; these programs were financed with compulsory payroll taxes. In an attempt to extend coverage to employees in the expanding private sector, the Urban Employee Basic Medical Insurance (UE-BMI) program was introduced in 1998 to provide basic medical coverage to all urban formal sector workers (Liu, 2002). The introduction of the Urban Residence Basic Medical Insurance (UR-BMI) program in 2007 provides insurance for urban residents not covered by the UE-BMI— primarily children, students, and previously unemployed elderly (Liu and Zhao, 2014). Unlike the UE-BMI, participation in the residents program was voluntary. In contrast to urban programs, rural heath insurance cooperatives were dissolved following decentralization and the responsibility for health insurance was shifted to local governments. As a result, health insurance coverage fell from nearly universal levels in 1978 to about 7% in 1999 (Barber and Yao, 2010). Facing rising public outcry over increasing healthcare inequalities along socioeconomic lines and between rural and urban areas, the central government introduced a new insurance scheme for the rural sector— the New Rural Cooperative Medical Scheme (NCMS). The program was piloted in several provinces in 2003 and quickly expanded over the next several years to cover all rural areas.

In order to expand coverage quickly, the NCMS was designed to initially provide relatively low benefits while maintaining low premiums. For example, taking into account co-payments, deductibles, and reimbursement ceilings, the average effective reimbursement rate for inpatient care was only 44% in 2010. However, with coverage rates currently approaching universal levels, the central government aims to increase inpatient reimbursement rates to 70% over the coming years (Yip et al., 2012). This is the same approximate rate received by urban employees in the UE-BMI. The new urban residents and rural health insurance schemes are voluntary. However, individual premiums are intended to cover 20% of the cost with the other 80% being shared by central and local government. At the beginning of the rural program there was also a family binding system so that the elderly could only get access to a pension if their children enrolled in the scheme. A major feature of the system was that local government leaders were given targets for enrollment which contributed to a high level of participation and rural health insurance coverage exceeded 90% by 2008 (Yip et al., 2012). Table 1 provides a summary of the current health insurance programs in China.

We model health insurance as providing financial risk protection and reducing out-of-pocket health spending by households. The expansion of health insurance also tends to increase healthcare utilization, and had the potential to improve health outcomes. However the evidence that the increased utilization induced by the provision of health insurance improves health is quite modest even in well designed experimental studies (Baicker et al., 2013; King et al., 2009). Similar results tend to be seen in China where the additional utilization from rural health insurance does not seem to have led to improved heath outcomes, perhaps due to the fee for service structure and potential for over treatment (Blumenthal and Hsiao, 2015). Indeed there is evidence that the incentive system in China means that the gains from increased rural health insurance coverage go to providers rather than patients with little or no financial risk protection being provided (Wagstaff and Lindelow, 2008). However we model the system as providing financial risk protection essentially assuming that the perverse incentives in the supply of health services in China will be removed (Eggleston, 2009).

2.2. Pensions

The reforms of the 1970s not only brought significant changes to health insurance systems, they also affected urban pension schemes. A basic urban pension scheme was first established in 1951— the Basic Old-Age Insurance System for Employees (BOISE). The system was characterized by generous benefits provided by individual state-owned enterprises using pay-as-you-go financing. A series of reforms in the 1980s and early 1990s increased the pooling base to the municipality level and extended coverage to more enterprises. However, high costs and increased competition of the post-reform era placed increased pressure on the system. Ultimately, this unfunded system proved unsustainable resulting in the move to a partially-funded system in 1997, though benefits continued to be high (Feng et al., 2009).

In rural China, a pension system was first established in 1992. The program emerged as a patchwork of schemes run by various

[1] See, for example, studies on the US: Imrohoroglu et al. (1995), Huggett and Ventura (1999), Conesa and Krueger (1999), Kotlikoff et al. (2007) and Imrohoroğlu and Kitao (2012), Spain: Diaz-Gimenez and Dáz-Saavedra (2009), Japan: Okamoto (2013), and Europe: Aglietta et al. (2007).

Table 1
Summary of current health insurance programs.

	Urban		Rural
	UE-BMI	UR-BMI	NCMS
Started	1998	2007	2003
Target population	Formal sector workers	Children, students, uncovered elderly	All
Enrollment (%)	92.3 (2013)	92.9 (2010)	98.7 (2013)
Participation	Mandatory	Voluntary	Voluntary
Revenue source* (%)			
Central government	–	40	40
Local government	–	40	40
Individual	8–10 (of earnings)	20	20
Inpatient reimbursement (%)	70	48	44

* Revenue source reported as % of insurance premium for UR-BMI and NCMS and % of individual earnings for UE-BMI.

levels of governments across the country. It relied heavily on individual and employer contributions leading to claims of inequitable access and benefits across rural populations. The lack of incentive for voluntary contributions resulted in low participation and the system eventually collapsed in 1999. A new pension scheme was launched in 2009. Dubbed the New Rural Social Pension Scheme (NRSPS), the program included more substantial government subsidies but low benefit levels (Vilela, 2013). As a result, voluntary enrollment exceeded 50% by 2011 (China, 2014). In 2011, the Urban Social Pension Scheme (USPS) was introduced to extend pension coverage to adult urban residents not employed in the formal sector. The new program was merged with the existing NRSPS as it follows the same benefit and financing structure. By 2013, enrollment in the two programs reached nearly 500 million (China, 2014).

The current urban and rural pension systems consist of two fundamental components— a basic social pooling pension and an individual account. The individual account is funded primarily by individual contributions with a small contribution required from employers (BOISE) or local governments (NRSPS). The balance of funds in an individual account at retirement determines the pension annuity payment from this component of the system. In contrast, an additional basic pension is guaranteed to participants and is not tied to individual contributions. In the urban system (BOISE), financing of the basic pension is achieved primarily through employer contributions. In contrast, financing of the minimum basic pension is the responsibility of local governments under the NRSPS, though the central government provides heavy subsidization— 100% in central and western regions and 50% in eastern regions (Vilela, 2013). The basic pension benefits are available to current residents over 60 years of age even if they did not contribute to the system. The family binding constraint which required enrollment of adult children to allow the elderly to access the basic pension has now been removed. In our model economy, we focus on the non-contributory basic pension, which is paid for with pay-as-you-go financing.[2] While higher voluntary contributions are possible, the incentives for these are low and almost all contributors choose the minimum contribution and the basic pension (Lei et al., 2013).

Table 2 provides a summary of the current pension programs in China. The last two rows of Table 2 show the revenue source for each program. For example, 17% of earnings is the effective labor income tax rate for the pay-as-you-go basic pensions in the urban sector of China. The targeted basic pension replacement rate (i.e. the percentage of average earnings a retiree receives every period) is 35% for the urban scheme (OECD, 2010). As there are fewer retirees than workers at any given time, the labor income tax used to finance pay-as-you-go pensions is usually somewhat lower than the replacement rate.

Table 2
Summary of current pension programs.

	BOISE	NRSPS/USPS
Started	1951	2009
Target population	Urban formal sector workers	Rural and uncovered urban residents
Enrollment (millions-2013)	322.18	497.50
Participation	Mandatory	Voluntary
Revenue source*		
Basic pension	17% of earnings	Local/Central gov't
Individual account	11% of earnings	Individual

* Total BOISE revenue from a 20% payroll tax on employers and 8% labor income tax on individuals.

2.3. Migrant workers

Internal migration in China faces restrictions with migrants often ineligible for housing, education, or social benefits. Eligibility for public pension and health insurance programs in China is generally tied to an individual's official urban or rural *hukou* designation. Moreover, migrant workers enrolled in the NCMS generally must return to their hometowns for healthcare reimbursement (Yu, 2015). However, with more than 230 million rural migrants across the country, increased pressure is mounting on local city governments to address eligibility concerns. Recently, several cities have established pilot programs which allow migrants to enroll in urban insurance programs regardless of *hukou* status. For example, some cities have included migrants in urban resident schemes such as the UR-BMI and USPS (Yip et al., 2012). Nonetheless, as the primary eligibility criteria remains *hukou* status for social insurance programs in most regions, we calibrate our model to reflect heterogeneity based on urban/rural *hukou*, as opposed to current sector of residence. As later detailed, we estimate productivity and health within sectors by averaging over migrants and non-migrants, leaving the explicit modeling of migrant heterogeneity and internal migration decisions for future work.

3. Economic framework

3.1. Demographics and health status

Consider an economy populated by J overlapping generations. Time is discrete (t) and in each period a new generation is born whose mass grows at rate n. Individuals are assumed to enter the economy with several exogenous characteristics that do not change over the life-cycle. Specifically, each individual is assumed to be of some education type $e \in \mathcal{E}_d$ and belong to some sector

[2] Note that this will likely underestimate the welfare benefits of the pension system as the annuity insurance is partially lost by excluding the individual account component.

$s \in \mathcal{S}$. Let $\Pi^{es}(\mathcal{E}_d, \mathcal{S})$ denote the invariant joint probability measure over education and sector types of an incoming generation.

In each period, individuals are characterized by health status $h \in \mathcal{H}$. Agents are assumed to enter the economy in the highest health state $(\bar{h})$. Health then evolves stochastically over the life-cycle. The stochastic process for health status follows a finite-state Markov chain with stationary transitions over time. The Markov process is assumed to differ by age, sector, and level of education, but is otherwise identical and independent across agents:

$$Q^h_{jest}(h, \mathcal{H}) = Prob(h' \in \mathcal{H} | h, j, e, s) = Q^h_{jes}(h, \mathcal{H}), \forall t.$$

Agents of age j, education e, health status h, and sector s survive to age $j+1$ with positive probability ψ_{jehs}. At age J, individuals die with probability one.

Each period agents realize an idiosyncratic medical expenditure shock $x \in \mathcal{X}$. Medical expenditures are drawn from a stationary distribution that is conditional on current health status and sector:

$$Q^x_{hst}(\mathcal{X}) = Prob(x \in \mathcal{X} | h, s) = Q^x_{hs}(\mathcal{X}),\ \forall t.$$

In this way the persistence of medical expenditure shocks is realized through the persistence of health status. Moreover, the specification is flexible enough to allow for the large disparity in medical expenditures between the urban and rural sectors observed in the data. Let $\Pi^x_{hs}(\mathcal{X})$ denote the time invariant probability measure associated with Q^x_{hs}.

3.2. Preferences and labor productivity

In each period, individuals are endowed with a unit of time that may be devoted to leisure or to earning wages in a competitive labor market. An individual's productivity in the labor market has two components— a fixed age, education, health, and sector specific component (ϵ_{jehs}) estimated directly from the data (see Section 4 for details) and an idiosyncratic shock (η). The stochastic process for the labor productivity shock follows a finite-state Markov chain with stationary transitions over time and which is identical and independent across all agents:

$$Q^\eta_t(\eta, \mathcal{E}) = Prob(\eta' \in \mathcal{E} | \eta) = Q^\eta(\eta, \mathcal{E}),\ \forall t.$$

Let $\Pi^\eta(\mathcal{E})$ denote the time invariant probability measure associated with Q^η. All individuals retire exogenously at age j_r, at which point labor productivity is equal to zero $(\epsilon_{jehs} = 0\ \forall j \geqslant j_r)$.

An agent's preferences over consumption and leisure follow an additive time separable utility function given by:

$$E\left\{\sum_{j=1}^{J} \beta^{j-1} u(c_j, \ell_j)\right\}$$

where β is a per-period discount factor, c consumption, and ℓ hours worked. Expectations are taken with respect to stochastic processes for health status, medical expenditures, and labor productivity.

3.3. Market structure

We assume individuals are unable to insure against idiosyncratic health and labor productivity risk by trading private insurance contracts. Furthermore, we assume there are no annuity markets to insure against mortality risk. Agents may self-insure by saving one-period risk-free bonds that earn interest rate r_t. However, agents are not permitted to maintain a negative asset position between periods (i.e. borrowing is not allowed). A non-negative asset limit ensures agents do not die in debt. Assets from the deceased are distributed evenly in a lump-sum fashion across all individuals entering the economy the following period. These unintended bequests are denoted by Tr_t.

3.4. Social insurance

Government operates two primary social insurance programs in our model. First, a pay-as-you-go pension system for each sector of the economy. This system is defined by a stream of fixed pension payment benefits PB_{st} for each retired individual in sector s. Pension benefits are determined by a replacement rate b_{st} of local average earnings. Second, the government may provide health insurance to cover stochastic medical expenditures. This program is characterized by healthcare reimbursement rates RR_{st} for individuals in sector s.

Social insurance programs may be financed by the central government and/or local (sector) governments. Denote the share of any program financed by local government as λ_{st}, with the remaining $(1 - \lambda_{st})$ to be financed by the central government. Central and local governments run a balanced budget each period. Local government outlays on social insurance programs are financed with proportional consumption and/or labor income taxes $(\tau^c_{st}, \tau^\ell_{st})$. As a majority of central government revenues in China are collected through direct or indirect consumption taxes, we assume central outlays are financed entirely with an additional proportional tax on individual consumption (τ_{ct}).

Finally, we allow government to provide emergency relief in the event of catastrophic medical expenditures. Specifically, if an agent is unable to reach consumption floor $\underline{c}$ in a given period, then it is provided to them by the local government. However, all assets and labor earnings are seized and the agent is required to supply $\bar{\ell}$ units of labor to the labor market. We view this as a succinct way of capturing emergency relief in the form of informal family and community transfers as well as formal government poverty transfer programs. Government shortfalls from this last-resort insurance is financed through sector-specific lump-sum taxes Tx_{st}.

3.5. Technology

Aggregate output (Y_t) is produced by a representative firm using the technology:

$$Y_t = \theta K_t^\alpha N_t^{1-\alpha} \quad \alpha \in (0, 1), \tag{1}$$

where K_t and N_t are the aggregate capital stock and labor inputs (measured in efficiency units) in period t, θ is total factor productivity, and α is the capital share. Output can be consumed (C), invested in physical capital (I) , or expended on healthcare (E):

$$Y_t = C_t + I_t + E_t.$$

Finally, letting δ equal per-period depreciation, the law of motion of capital is given by:

$$K_{t+1} = (1 - \delta)K_t + I_t.$$

3.6. Decision problem

At any given time, an individual can be characterized by a vector of state variables $\zeta = (a, \eta, j, e, h, x, s)$, where is a is current holdings of one-period, risk-free assets, η is a stochastic labor productivity shock, j is age, e is level of education, h is health status, x are stochastic medical expenditures, and s is the urban/rural sector of the economy. Given this state vector, an agent chooses consumption c, labor supply ℓ, and next period assets a' to maximize expected lifetime utility. The decision problem facing an agent may be written:

$$v_t(a, \eta, j, e, h, x, s) = \max_{c, \ell, a'} \Big\{ u(c, \ell) + \beta \psi_{jehs} E_{\eta' h' x'} \left[v_{t+1}(a', \eta', j+1, e, h', x', s) \right] \Big\}$$

subject to

$$c(1+\tau^c_{st}+\tau_{ct})+a'=w_t(1-\tau^\ell_{st})\epsilon_{jehs}\eta\ell$$
$$+(1+r_t)(a+Tr_t(j=1))-x(1-RR_{st})-Tx_{st}+PB_{st}(j\geqslant j_r),$$

$$a'\geqslant 0,\ c\geqslant 0,\ 0\leqslant \ell\leq 1,$$

where value function $v_t(.)$ is the expected discounted lifetime utility of arriving in a period of time with a given state vector. Note that expectations are taken with respect to stochastic processes for health status, medical expenditures, and labor productivity. The first constraint is the budget constraint while the final line gives the borrowing constraint followed by feasibility constraints on consumption and labor. Emergency relief is exogenously given when consumption $\underline{c}$ is unattainable, in which case $a'=0, c=\underline{c}$, and $\ell=\bar{\ell}$.

3.7. Definition of competitive equilibrium

Let $a\in\mathbb{R}_+, \eta\in\mathcal{E}=\{\eta_1,\eta_2,\ldots,\eta_n\}, j\in\mathcal{J}=\{1,2,\ldots,J\}, e\in\mathcal{E}_d=\{e_1,e_2,\ldots,e_n\}$, $h\in\mathcal{H}=\{h_1,h_2,\ldots,h_n\}, x\in\mathcal{X}=\{x_1,x_2,\ldots,x_n\}$, $s\in\mathcal{S}=\{s_1,s_2,\ldots,s_n\}$, and $\mathcal{R}=\mathbb{R}_+\times\mathcal{E}\times\mathcal{J}\times\mathcal{E}_d\times\mathcal{H}\times\mathcal{X}\times\mathcal{S}$. Let $B(\mathbb{R}_+)$ be the Borel σ-algebra of $\mathbb{R}_+$ and $P(\mathcal{E}),P(\mathcal{J}),P(\mathcal{E}_d)$, $P(\mathcal{H}),P(\mathcal{X}),P(\mathcal{S})$ the power sets of $\mathcal{E},\mathcal{J},\mathcal{E}_d,\mathcal{H},\mathcal{X},\mathcal{S}$, respectively. Let $\Sigma_\mathcal{R}\equiv B(\mathbb{R}_+)\times P(\mathcal{E})\times P(\mathcal{J})\times P(\mathcal{E}_d)\times P(\mathcal{H})\times P(\mathcal{X})\times P(\mathcal{S})$. Let $\mathcal{M}$ be the set of all finite measures over the measurable space $(\mathcal{R},\Sigma_\mathcal{R})$.

Definition 1. Given a sequence of pension replacement rates $\{b_{st}\}_{t=1}^\infty$, healthcare reimbursement rates $\{RR_{st}\}_{t=1}^\infty$, local government financing shares $\left\{\lambda^p_{st},\lambda^h_{st}\right\}_{t=1}^\infty$, and initial conditions K_1 and Φ_1, a competitive equilibrium is a sequence of functions for individuals $\{v_t,c_t,a'_t,l_t\}_{t=1}^\infty$, production plans for the firm $\{N_t,K_t\}_{t=1}^\infty$, prices $\{r_t,w_t\}_{t=1}^\infty$, tax rates $\{\tau_{st},\tau_{ct},Tx_{st}\}_{t=1}^\infty$, pension benefits $\{PB_{st}\}_{t=1}^\infty$, transfers $\{Tr_t\}_{t=1}^\infty$, and measures $\{\Phi_t\}_{t=1}^\infty, \Phi_t\in\mathcal{M}$ such that:

1. Given prices, tax rates, pension benefits, healthcare reimbursements, transfer rates, and initial conditions, for each t, v_t solves the agent's decision problem (with associated policy functions $c_t,\ a'_t,\ \ell_t$).
2. Prices w_t and r_t satisfy:

$$r_t=\theta\alpha\left(\frac{N_t}{K_t}\right)^{1-\alpha}-\delta$$
$$w_t=\theta(1-\alpha)\left(\frac{K_t}{N_t}\right)^{\alpha}.$$

3. Local government budgets are balanced[3]:

$$\tau^\ell_{st}w_tN_{st}+\tau^c_{st}\int c(\zeta)\Phi_t(d\zeta(s))=$$
$$\lambda^p_{st}PB_{st}\int\Phi_t(d\zeta(s,j\geqslant j_r))+\lambda^h_{st}RR_{st}\int x(\zeta)\Phi_t(d\zeta(s)),$$

$$Tx_{st}\int\Phi_t(d\zeta(s))=\int\max\{\underline{c}-w_t(1-\tau^\ell_{st})\epsilon_{jehs}\eta\bar{\ell}$$
$$-(1+r_t)(a+Tr_t(j=1))+x(1-RR_{st})+Tx_{st}$$
$$-PB_{st}(j\geqslant j_r),0\}\Phi_t(d\zeta(s)),$$

where

$$PB_{st}=\frac{b_{st}w_tN_{st}}{\int\Phi_t(d\zeta(s,j<j_r))}.$$

4. Central government budget is balanced:

$$\tau_{ct}\int c(\zeta)\Phi_t(d\zeta(s))=\sum_s\left[(1-\lambda^p_{st})PB_{st}\int\Phi_t(d\zeta(s,j\geqslant j_r))+\left(1-\lambda^h_{st}\right)RR_{st}\int x(\zeta)\Phi_t(d\zeta(s))\right].$$

5. Transfers are given by:

$$Tr_{t+1}=\frac{\int(1-\psi_{jeh})a'_t(\zeta)\Phi_t(d\zeta)}{\int\Phi_{t+1}(d\zeta(j=1))}.$$

6. Markets clear:

$$K_{t+1}=\int a'_t(\zeta)\Phi_t(d\zeta),$$
$$N_t=\int\epsilon_{jehs}\eta\ell_t(\zeta)\Phi_t(d\zeta),$$
$$Y_t+(1-\delta)K_t=\int\{c_t(\zeta)+x_t(\zeta)\}\Phi_t(d\zeta)+K_{t+1}.$$

7. Law of motion:

$$\Phi_{t+1}=f_t(\Phi_t)$$

where the function $f_t:\mathcal{M}\to\mathcal{M}$. Denoting $Z\equiv\{A\times E\times J\times E_d\times H\times X\times S\}\in\Sigma_\mathcal{R}$, function f_t can be written explicitly as:

(a) For all J such that $1\notin J$:

$$\Phi_{t+1}(Z)=\int P_t(\zeta;Z)\Phi_t(d\zeta),$$

where if $a'_t(\zeta)\in A,\ j+1\in J,\ e\in E_d,\ s\in S$:

$$P_t(\zeta;Z)=Q^\eta(\eta,E)Q^h_{jes}(h,H)Q^x_{hs}(X)\psi_{jehs},$$

else $P_t(\zeta;Z)=0$.

(b) For all $J=\{1\}$:

$$\Phi_{t+1}(A\times E\times\{1\}\times E_d\times H\times S)=$$
$$\Pi^\eta(E)\Pi^{es}(E_d,S)\Pi^x_{hs}(X)(1+n)^t$$

if $0\in A,\ \bar{h}\in H$, else $\Phi_{t+1}(Z)=0$.

Definition 2. A stationary equilibrium is a competitive equilibrium where individual policy functions, prices, tax rates, and per capita transfers are constant over time and aggregate variables grow at the same constant rate (n).

4. Calibration

We use a calibrated version of the model to quantitatively assess the impact of Chinese pension and healthcare reform on aggregate outcomes and welfare. We begin by choosing a model parametrization that matches key features of the Chinese economy and demographics circa 2000. As detailed in this section, some parameters are calibrated from microeconomic survey data while others are set so that the model matches observed macroeconomic aggregates. We use micro data from the China Family Panel Studies (CFPS) to estimate parameters for health and survival transitions by age, medical expenditures by age and health state, labor productivity by age, and the exogenous distribution of new agents over education and sector types. The CFPS is a nationally representative longitudinal survey of Chinese families and communities. We use both waves of the study currently available— 2010 and 2012.

We conduct policy analyses with the calibrated model by comparing our baseline results with those produced using the baseline parameter values except for (a) including a rural health insurance system or (b) including a rural pension system. These experiments involve both benefits to consumers in terms of pension payments

[3] $\Phi(\zeta(s))$ and $\Phi(\zeta(s,j\geqslant j_r))$ denote the total measure of agents and measure of retired agents in sector s, respectively.

and reimbursement of healthcare expenditures, but also costs in the form of contributions to the systems and higher general taxation to balance the government budget when the system is subsidized. Lastly, we conduct an analogous comparison under an alternate population growth rate, this analysis is meant to capture the effect of policy under the projected demographic structure for China in 2050.

4.1. Demographics and preferences

Each model period is assumed to represent two calendar years. Individuals enter the economy at age 20 (model period $j = 1$) and die with probability one at age 94 (model period $J = 38$). The growth rate of new 20 year old individuals in each two-year cohort (n) for the initial steady state is set at 9.7% in order to match an old-age dependency ratio of 11% from 2000 (UN, 2012).[4] For our alternate demographic scenario we target the projected dependency ratio for 2050 of 51%, implying a cohort growth rate of 0.5%. In our main analysis we assume exogenous retirement for all agents at age 60 (model period $j_r = 21$) to match the current age of pension eligibility. We do this for simplicity and due to a lack of available labor income data for the elderly. In practice, prior to pension reform many rural elderly worked past age 60, with a non-trivial share working into their seventies (Pang et al., 2004). In sensitivity analysis, we examine the implications of extended working lives of the rural elderly on our results by allowing for endogenous retirement in the rural sector.

We use the official sector designation, or *hukou*, to classify each individual as urban or rural in the CFPS data. We choose this designation because eligibility for public social insurance programs is tied to an individual's *hukou* status, as opposed to actual residence. We group individuals into three educational attainment categories— no school, some primary school, and some high school or more. Incoming agents in the model economy are distributed across sector and education types according to the distribution found in CFPS (see Table 3).

Preferences over consumption and leisure are assumed to follow a standard Cobb-Douglas utility function:

$$u(c_j, \ell_j) = \frac{\left[c_j^{\gamma}\left(1-\ell_j\right)^{1-\gamma}\right]^{1-\sigma}}{1-\sigma},$$

where σ controls risk aversion and γ determines the relative weight of consumption. We set σ and γ to target an inter-temporal elasticity of substitution of 0.5 and average hours worked of one-third in our 2000 baseline economy. Lastly, β is set to match an annual capital-output ratio of 2.8 in 2000 (Feenstra et al., 2015).

Table 3
Demographics and preference parameters.

Parameter	Value	Target/source
Cohort growth n		
2000	0.097	Old dependency ratio (11%)
2050	0.005	Old dependency ratio (51%)
Retirement age j_r	60	Age of pension eligibility
Rural probability		
No school	0.28	CFPS
Primary school	0.39	CFPS
High school +	0.07	CFPS
Urban probability		
No school	0.03	CFPS
Primary school	0.11	CFPS
High school +	0.12	CFPS
Risk aversion σ	3.49	IES = 0.5
Discount factor β	0.89	K/Y = 1.4 (PWT 8.1)*
Consumption weight γ	0.40	Average hours = 1/3

* An annual capital-output ratio of 2.8 implies a biennial value of 1.4.

4.2. Health and survival transitions

We use both waves of the CFPS to estimate health transitions and survival probabilities. We begin by grouping respondents into two-year age intervals to map into the demographic structure of the model.[5] We then assign individuals as good, fair, or poor health, based on their self-reported health status.[6] Table 4 shows the share of individuals reporting each health status by education and sector designation in 2010. On average, the higher education groups reported to be in better health states. However, there were only mild differences between sectors, with the rural realizing higher percentages at the tails of the health state distribution.

Health transitions are estimated by running an ordered probit of 2012 self-reported health status on education, urban/rural sector, 2010 health status, and a cubic function of age. Fig. 1 shows select health transition probabilities for the high and low education groups in the urban and rural sectors. The low education group is about 25% more likely to remain in the poor health state than the high education group, and 19% less likely to remain in the good health state. Analogous numbers for the rural compared to urban sector are much smaller at about 2% and 1%. The probability of remaining in good health falls sharply as individuals age regardless of education or sector. Conversely, the likelihood of falling from good health to poor heath increases.

As the CFPS also reports incidence of death between waves, we estimate mortality rates using a probit model analogous to that for health transitions. As expected, mortality rates increase with age and decrease with health status. Fig. 2 plots the mortality rate by health status as well as mortality rate premiums for selected characteristics.[7] Mortality premiums reflect the change in probability of death between good/poor health, urban/rural sector, or high/low education. For example, the good health premium is the percentage point decrease in mortality rate of an individual in good health relative to a individual in poor health. All premiums are less than one percentage point at age twenty but increase quickly with age. The good health premium is the largest, reaching 7.3 percentage points by age eighty. Analogous numbers for urban and high education premiums at age eighty are 0.5 and 3.8 percentage points, respectively.

4.3. Medical expenditures

We assume medical expenditures depend on health status and sector, but are stochastic, and can take one of two values. We estimate these values by first dividing individuals in the CFPS into percentiles based on reported annual medical expenditures.[8] As has been documented in other countries, the expenditure distribution is highly skewed with a thick right tail driven by a limited number of catastrophic events. We calculate the mean expenditures among those in the bottom 90 percentiles of the expenditure distribution.

[4] The UN dependency ratio is of people older than 64 to those aged 20–64, though we calibrate to match the retired to working-age population in the model.

[5] We choose two-year periods because waves of the CFPS were collected two years apart.

[6] 2010 classification: Good = "healthy", Fair = "fair", Poor = "relatively unhealthy", "unhealthy", or "very unhealthy". 2012 classification: Good = "excellent", "very good", or "good", Fair = "fair", Poor = "poor".

[7] Reported mortality rates are calculated holding other regressors at their overall mean.

[8] Total expenditures computed by adding reported total cost of hospitalization and disease/injury in the 2012 wave.

Table 4
Self-reported health status from 2010 wave of CFPS (%).

Health status	Education			Sector	
	Low	Middle	High	Urban	Rural
Good	35.6	48.7	53.5	44.5	46.3
Fair	34.2	37.4	38.0	42.3	34.1
Poor	30.3	14.0	8.6	13.2	19.7

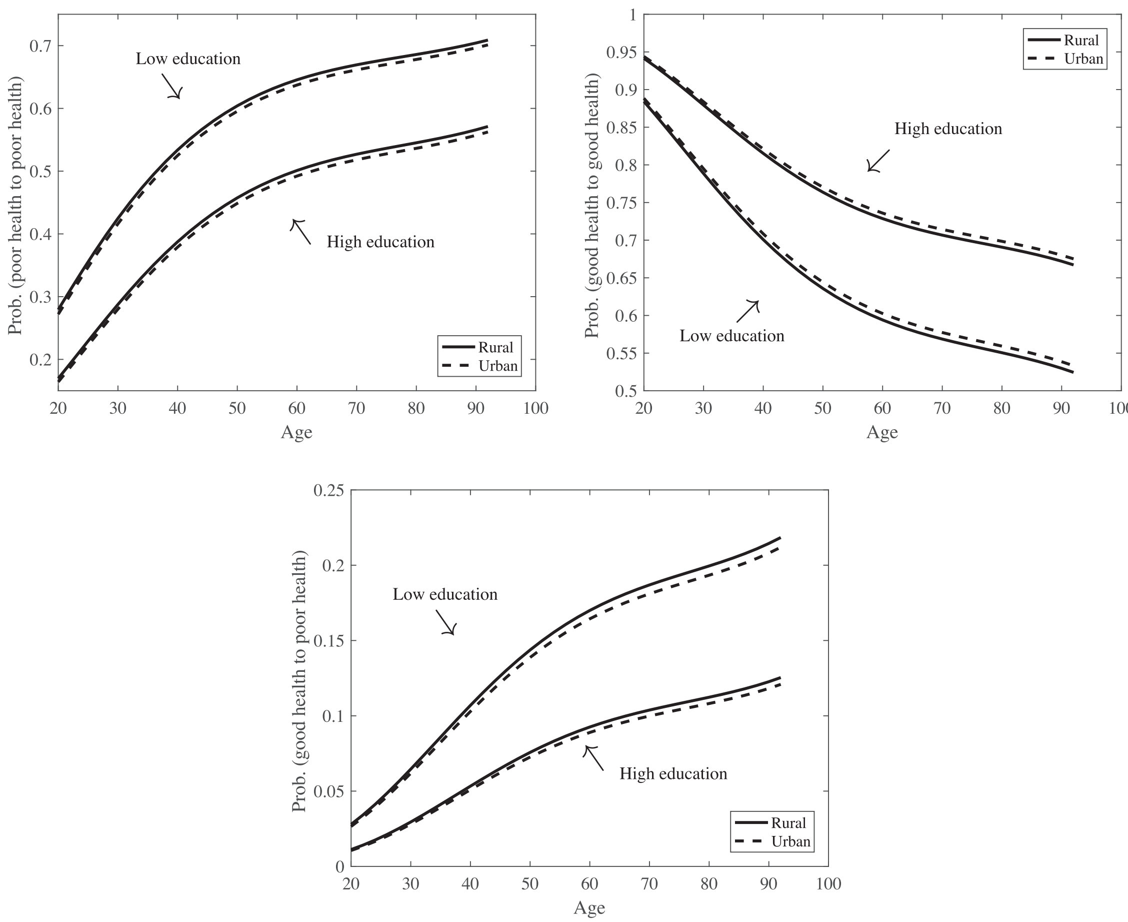


Fig. 1. Health transition probabilities.

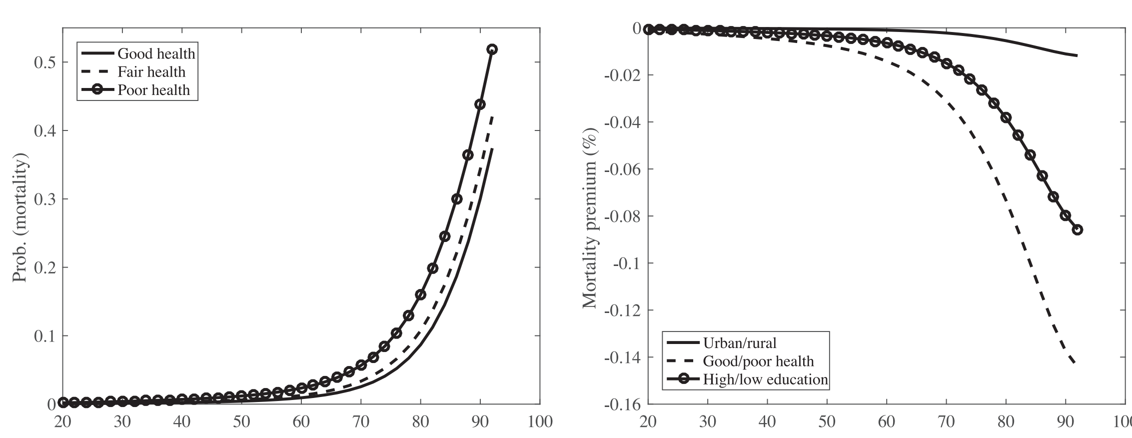


Fig. 2. Mortality.

Table 5
Medical expenditures (% of output per capita).

Health status	Urban		Rural	
	Low	High	Low	High
Good	1.0	26.5	0.6	16.3
Fair	3.0	48.7	1.3	29.9
Poor	10.7	135.9	5.1	74.5

* Low indicates mean medical expenditures over 1 to 90th percentile and high 91 to 100th.

Analogously we obtain the mean across the top 10 percentiles. Corresponding to our percentile cut-points, the probability of realizing the low/high expenditure state each period is set at 0.9 and 0.1, respectively.[9] Table 5 shows the average reported expenditures (as a share of output per capita) by health status, sector, and percentile range. On average, the healthy spend less than the unhealthy and the urban sector spends more than the rural. Moreover, there are large differences in the value between low and high expenditure states. For example, the high expenditure value for a rural individual with poor health is about 15 times higher than the value of the low expenditure estimate. We set low/high medical expenditures in the model equal to the per capita output shares reported in Table 5 for our 2000 baseline economy. We then keep the value of expenditures constant for all other policy scenarios and under the 2050 demographic structure. We do not allow for a relative price increase in healthcare costs over time – which would make health insurance more expensive – and might occur in a response to a rise in demand with increased health insurance coverage (Long et al., 2013).

4.4. Labor productivity

We estimate fixed type-specific labor productivity ϵ_{jehs} from the two available waves of the CFPS by first regressing log of hourly income on age, age-squared, health status, and an individual fixed effect. We then regress the residual on our time invariant covariates (education and sector) in order to estimate productivity differences across agent types. Combining our results, an agent from the high education group is estimated to have 119% higher wages than the low education group, holding other regressors at their overall mean. The analogous urban sector and good health premiums are smaller at 10% and 2%, respectively. The life-cycle productivity estimates for an individual in fair health by sector and high/low education are plotted in Fig. 3. Productivity increases steadily until age fifty, at which point it begins to decline slowly until retirement.

We estimate the Markov chain for the stochastic component of productivity by assuming an underlying AR(1) process in logs:

$$\ln(\eta') = \rho \ln(\eta) + \epsilon_\eta, \quad \epsilon_\eta \sim N\left(0, \sigma_\eta^2\right).$$

Parameters governing the stochastic process for productivity shocks are taken from the estimates of Fan et al. (2010). The authors estimate the parameters of the stochastic component of log-earnings using data from the 2002 Chinese Household Income Project (CHIP). Adjusting the estimates for our biennial time period results in values of $\rho = 0.939$ and $\sigma_\eta^2 = 0.118$. We then use the Tauchen method to approximate this process with a Markov chain over four discrete states.

[9] Implicit in this specification is the perfect persistence of annual medical expenditures within each two-year model period. A new independent expenditure state is realized every two-years (one model period).

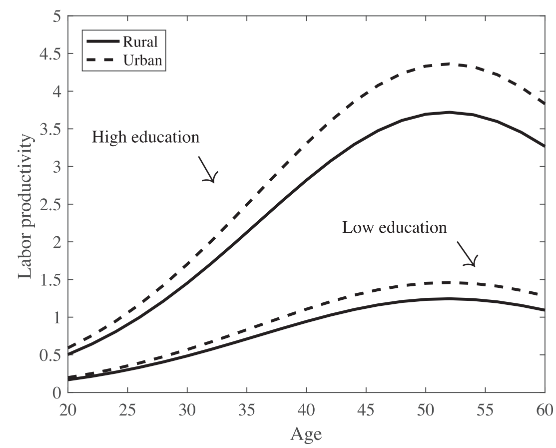


Fig. 3. Life-cycle profile of labor productivity: fair health.

Table 6
Technology parameters.

Parameter	Value	Target/source
Capital share α	0.5	PWT 8.1
Period depreciation δ	0.12	I/Y = 0.31
Factor productivity θ	1	Normalization

4.5. Technology

We set α to match the capital share of income for China in 2000 while the depreciation rate δ is set to match an investment-output ratio of 0.31 in the 2000 baseline economy (Feenstra et al., 2015). Total factor productivity (TFP) θ is normalized to one. (See Table 6).

4.6. Government and policy experiments

The pension replacement rate in the urban sector is set at 35%, the target rate for the social pooling component of the current system (OECD, 2010). Urban medical expenditure reimbursement rates are set to match the average inpatient rate of 70% (Yip et al., 2012). These rates are assumed to remain constant across all policy and demographic scenarios. Urban pension and health insurance schemes are assumed to be funded through local payroll taxes in the urban sector and are unsubsidized by the central government.

We assume there is no rural pension or health insurance system in our baseline economy to approximate very low coverage circa 2000. We then conduct three alternate policy experiments where we introduce either (1) a rural pension program, (2) a rural health insurance program, or (3) both programs jointly. The rural pension scheme is implemented with a replacement rate set at 35% of average local earnings to match the urban sector. Rural healthcare reimbursement rates are set at 70%, the stated target rate of Chinese policymakers and current rate under the urban scheme (Yip et al., 2012). We assume 40% of both rural social insurance programs are paid for by the central government, with the remaining

Table 7
Pension and health insurance parameters.

Parameter	Urban	Rural policy experiment			
		Baseline	Pension	Health insurance	Both
Healthcare rate *RR*	0.70	0.00	0.00	0.70	0.70
Pension rate *b*	0.35	0.00	0.35	0.00	0.35
Local share of financing					
Health insurance λ^h	1.00	–	–	0.60	0.60
Pension insurance λ^p	1.00	–	0.60	–	0.60

Table 8
Steady state results for rural policy experiments – 2000 demographics ($n = 0.097$).

	Baseline	Pension	Health insurance	Both
Output per capita	1.00	0.97	0.97	0.94
% change from baseline	–	−3.10	−2.80	−6.03
Capital per capita	1.40	1.34	1.37	1.30
% change from baseline	–	−4.39	−2.43	−7.10
Consumption per capita	0.65	0.63	0.63	0.61
% change from baseline	–	−2.65	−3.33	−6.06
Health expenditure per capita	0.04	0.04	0.04	0.04
Urban (% of total)	37.56	37.56	37.56	37.56
Rural (% of total)	62.44	62.44	62.44	62.44
Investment per capita	0.31	0.29	0.30	0.29
Average hours worked	0.33	0.32	0.30	0.30
% change from baseline	–	−2.00	−9.03	−10.44
Wage rate	0.70	0.69	0.70	0.69
Interest rate (%)	23.38	23.86	23.24	23.79
Urban labor tax (%)	9.83	9.95	9.83	9.98
Rural consumption tax (%)	0.00	1.67	2.80	4.56
Central consumption tax (%)	0.00	0.70	1.17	1.90
Fiscal outlays (% of GDP)				
Healthcare	1.11	1.14	3.03	3.14
Pension	0.76	1.91	0.78	1.92
Emergency relief (E.R.)	0.38	0.24	0.11	0.03
Accidental bequests (% of GDP)	2.57	2.51	2.57	2.51
Urban population on E.R.(%)	0.25	0.35	0.32	0.41
Rural population on E.R.(%)	4.27	2.84	1.67	0.73
CEV (%)	–	−2.76	11.35	7.81

60% financed by local rural government through local taxes. This matches the average central government financing share of health insurance programs currently in place in rural China, though it is somewhat lower than the 50–100% central government subsidy of the current rural pension schemes. Finally, as labor taxes are notoriously difficult to collect in rural areas dominated by small local farms, we assume all local government outlays on rural social insurance programs are financed though proportional consumption taxes. For convenience, Table 7 summarizes all pension and health insurance parameters across policy experiments.

Lastly, we set the emergency relief consumption floor $\underline{c}$ at 8% of output per capita in our baseline 2000 economy. This approximates the official rural food poverty line for China in 2000 (Zude, 2004). Similar to medical expenditures, we then keep the value of $\underline{c}$ constant for all other policy scenarios and under the 2050 demographic structure to isolate the effects of other policy changes. We set required labor for emergency relief $\bar{\ell}$ at the average labor supply in our baseline of one-third. In sensitivity analysis we examine the welfare implications of adjusting these two parameters.

5. Welfare measure

In order to quantify the welfare effects of alternate policy scenarios we use a consumption equivalent variation measure to compare corresponding steady states. Our welfare measure is akin to asking by what percentage consumption has to be increased in all future periods and contingencies (holding leisure constant) for an agent about to be "born" (i.e. $j = 1$) in the baseline steady state to achieve the same ex ante lifetime utility as some new steady state. Given our functional form for utility, the welfare measure is formally given by:

$$CEV = \left[\frac{\Omega(v_{new}(0,\eta,1,e,\bar{h},x,s))}{\Omega(v_{old}(0,\eta,1,e,\bar{h},x,s))}\right]^{1/\gamma(1-\sigma)} - 1$$

where

$$\Omega(v(.)) = \sum_{\eta,x,e,s} \Pi^{\eta}(\mathcal{E})\Pi^{es}(\mathcal{E}_d,\mathcal{S})\Pi^{x}_{hs}(\mathcal{X})v(.).$$

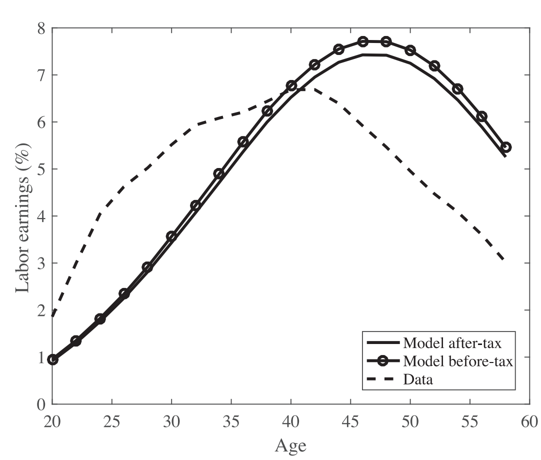


Fig. 4. Life cycle profile of labor earnings: model vs data.

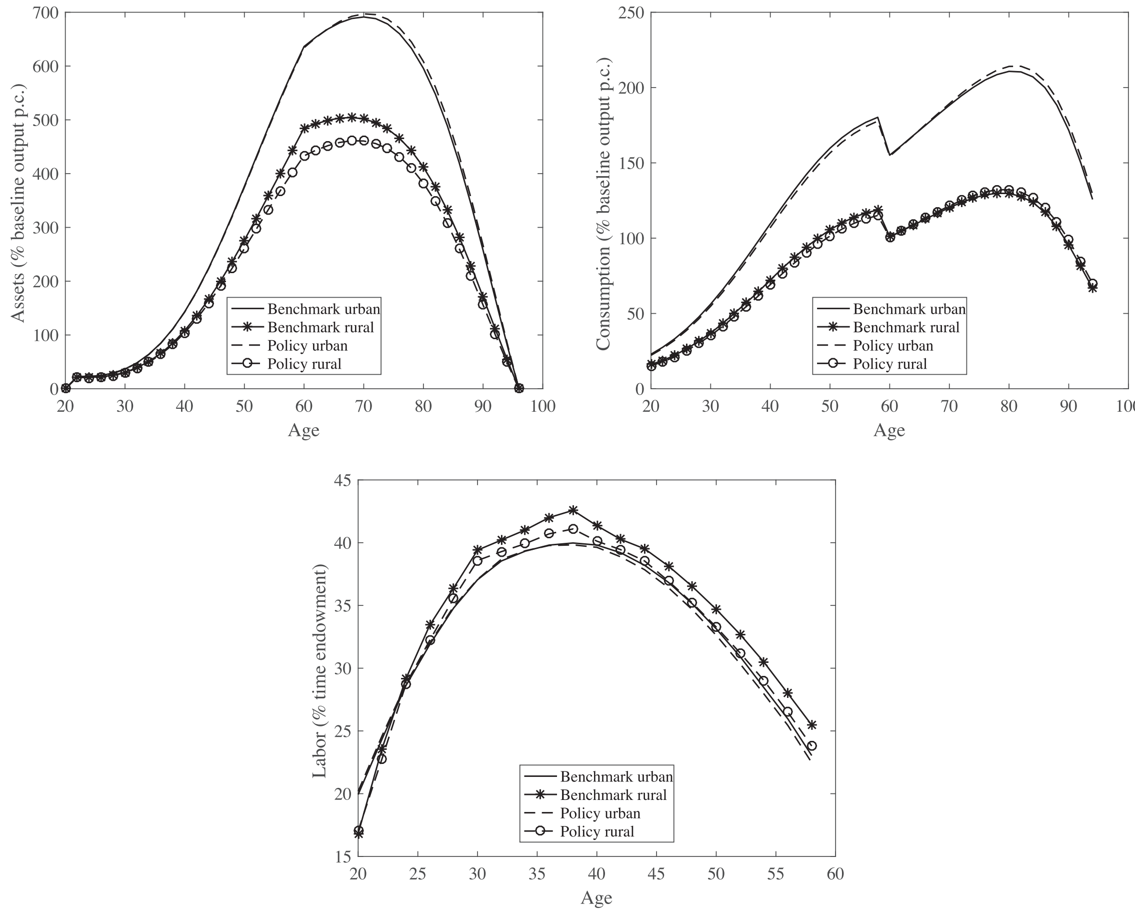


Fig. 5. Life-cycle profiles for 2000 demographics: pension reform.

For example, a $CEV = 0.1$ implies the new steady state results in a welfare increase for an unborn agent equivalent to receiving 10% higher consumption in the old steady state (in all possible states of the world and holding leisure constant at the old steady state allocation).

This welfare measure corresponds to choosing between steady states from behind a "veil of ignorance" about one's position in society and assuming behind the veil people will be indifferent between choices that offer the same expected utility (Harsanyi, 1975). Two steady states are equivalent in welfare terms if the expected utility of an agent is the same where we take the expectation over both future uncertainty on health and productivity shocks but are also uncertain which type (based on education and sector) we are at age 20 when we enter the model. The welfare measure may also be decomposed by sector by conditioning expected lifetime utility on entering the economy as an urban or rural agent. The measure is also convenient for dividing welfare into the effect stemming from changes in consumption versus leisure allocation. Moreover, the consumption effect can be decomposed into welfare gains from changes in average consumption and gains from the redistribution of consumption across types and over states of the world. An analogous decomposition is possible for leisure.[10]

6. Results

6.1. Baseline economy

We begin with a discussion of baseline results (i.e. an economy without rural social insurance programs) under the 2000 demographic structure. The first column of Table 8 provides baseline outcomes with a population growth rate set so that the steady state age structure matches the 2000 old-age dependency ratio. Recall that baseline capital holdings, investment, and hours worked were targeted during calibration of the model. However, though not targeted during calibration, the model does remarkably well in matching medical expenditures as a share of output from the data. Specifically, medical expenditures are 4.2% of output in the baseline economy compared to 4.6% in the data for 2000. Similarly, fiscal outlays on healthcare by the government are 1.11% in the baseline compared to 1.76% in the data (World Bank Indicators). Moreover, given our calibrated capital-output ratio, the baseline real rate of return on capital of 23% per two years implies an annual rate of 11%. This is consistent with the results of Bai et al. (2006), who estimate the annual return to capital in China in 2000 in the 10–20% range, depending on their specification. It is important to note that this is an estimate of the return to capital and not the risk-free interest rate which may be considerably lower.

The urban sector accounts for 37.6% of the aggregate medical expenditures in the economy, with the rural sector accounting for the remaining 63.4%. The net national savings rate in the baseline is 19.33% in the urban sector and 14.49% in the rural.[11] For the urban pension system, fiscal outlays are 0.76% of aggregate output in our baseline economy. Official statistics estimate revenue from the urban pension program closer to 2.3% of GDP for 2000 (China, 2014).[12] However, this includes both the basic pension and individual account components of the system. Moreover, prior to the reforms of the mid-nineties the urban pension scheme was entirely

[10] See Conesa et al. (2009) for details on decomposing the measure into consumption/leisure and level/redistribution effects.

[11] Net national savings rate is defined as $\frac{Y_t - C_t - E_t - \delta K_t}{Y_t - \delta K_t}$.

[12] Expenditures are estimated at 2.1% of GDP.

unfunded. This resulted in a cohort of retirees depending on pay-as-you-go financing for the entirety of their pension payments. These generous so-called "legacy" pensions resulted in inflated spending on the system which is absent in the baseline steady state of our model economy.

Empirically, it is estimated that 3.5% of the rural population fell below the official food poverty line in 2000 (Zude, 2004). This compares quite well to the 4.27% of the rural population requiring emergency relief in our baseline economy. In contrast, only 0.25% of urban agents require emergency relief in the baseline. In total, fiscal outlays on emergency relief are 0.38% of baseline GDP. This also seems quite reasonable as total transfer income reportedly received by households in 2000 was approximately 0.87% of GDP.[13]

We further assess the fit of the model to the data by comparing our baseline results to several additional empirically observed outcomes not targeted during calibration. Fig. 4 compares the life-cycle profile of labor earnings in the baseline economy to empirical estimates from the National Transfer Accounts. Earnings are reported as a percentage of the total average income for all working age groups combined. There is a similar hump shape profile in both the baseline model economy and the data, though labor earnings in the model peak several years later. The model profile is primarily driven by our life-cycle productivity estimates which also peak close to age 50. Type-specific productivity estimates combined with idiosyncratic productivity shocks also serve as the primary determinants of wealth inequality in the model. The model somewhat over-predicts the amount of wealth inequality relative to empirical estimates, with a baseline Gini coefficient of 0.77 compared to 0.55 in the data for the year 2000 (Davies et al., 2008).

6.2. Policy experiments

The first two columns of Table 8 provide a comparison between the 2000 baseline economy with no rural social insurance programs in place and the steady state produced with only the rural pension reform, holding demographics constant. Introducing the pension program results in new central and rural consumption taxes as well a small increase in the urban labor tax rate. As expected with the new insurance mechanism in place, there is a significant drop in aggregate savings accompanied by an increase in the annual interest rate. Together, a reduction in aggregate labor supply and capital stock results in a decrease in output of 3.1% and consumption of 4.4%. As detailed in the following sub-sections, while the proportional tax structure and central government subsidy results in some redistribution from the rural pension program, the reallocation of resources across agents is not able to counteract the negative macroeconomic effects of the policy, resulting in an estimated welfare *loss* of 2.8%. This result is consistent with much of the existing literature which finds positive long-run economic and welfare effects of eliminating pay-as-you-go pension systems in the presence of market imperfections.

The third column of Table 8 shows results when only the rural health insurance program is introduced. In this experiment, introducing health insurance uniformly reduces out-of-pocket expenditures by 70% for all rural agents. Similar to the pension reform experiment, the health insurance program results in a decrease in aggregate capital, output, and consumption, as well as an increase in taxes. However in contrast to pensions, the health insurance experiment results in an estimated welfare *gain* of over 11%. In this case, welfare improvements from insurance and the redistribution of resources are not off-set by the adverse macroeconomic effects of implementing the policy. As detailed in the following sub-sections, provision of health insurance results in a considerable shift of resources to agents that realize a high medical expenditure shock. Moreover, insurance against such potentially catastrophic expenditures in the future allows agents to adjust behavior over their entire life-cycle in a welfare improving manner. As a result, the welfare gains from insurance and redistribution (both across agents and over the life-cycle) is much higher from health insurance as compared to the pay-as-you-go pension system.

Lastly, column four provides results when pension and health insurance programs are introduced jointly. Macroeconomic declines are amplified compared to introducing each policy in isolation. Likewise, there is a larger increase in tax rates to fund the rural social programs. However, the positive welfare effects of health insurance outweigh the negative effects of the pension program, resulting in a net welfare gain over the baseline equivalent to a 7.8% increase in the consumption of an unborn agent.

6.3. Life-cycle profiles

In order to further understand the implications of the policy experiments, this section presents average life-cycle profiles for asset holdings, labor supply, and consumption under alternate reform scenarios. Fig. 5 begins with life-cycle profiles for the urban and rural sectors both before and after the pension reform experiment. The vertical axis in all asset and consumption life-cycle profiles is per capita assets/consumption as a percentage of baseline output per capita. In the benchmark (i.e. no rural social insurance programs), assets holdings in both sectors peak shortly after retirement, though an average urban agent holds considerably more assets than an average rural agent over the entire life-cycle. As shown in Table 8, average nationwide consumption per capita is 65% of output per capita in the baseline. The life-cycle profiles show consumption per capita is lower than the overall national average for ages below 40 and higher at older ages in both sectors—especially for urban agents where it reaches over 200% after retirement. However, it should be noted that the relative masses of each age group and sector is very different. For instance, the urban sector with much higher average consumption than the national average only makes up 23% of the total population. Also, due to population growth, the size of younger age-groups is considerably larger compared to the older age-groups. For labor supply, the vertical axis is the fraction of time endowment spent working in the labor market. In both sectors labor supply has as inverted-U shape with hours peaking around age 40.

On average, introducing the rural pension program results in a decline in savings over the entire life-cycle of rural agents, as they require fewer asset holdings after retirement. As the urban sector effectively subsidizes the program through central taxes, rural retirees are able to consume somewhat higher amounts with the program in place. However, prior to retirement, rural agents consume less due to higher taxes and lower wages, though they do enjoy marginally higher leisure in the latter half of their working life.

The average urban agent experiences a small increase in assets after retirement due to the general equilibrium effects of the pension reform resulting in higher interest rates. The higher asset holdings lead to a small increase in consumption after retirement, though increased taxes and lower wages result in an decline in consumption averaged over the entire life-cycle. The changes in interest rate, labor tax, and wages also lead to a very subtle shift in the labor supply of urban agents toward younger ages on average.

Figs. 6–8 show analogous life-cycle profiles before and after the health insurance reform experiment. The general equilibrium effects of the policy change are small for wages and urban labor

[13] Authors estimation using per capita transfer income data from China Statistical Yearbook (China, 2014) and netting out 2.1% of GDP for pension expenditures and 4.6% for public medical expenditures.

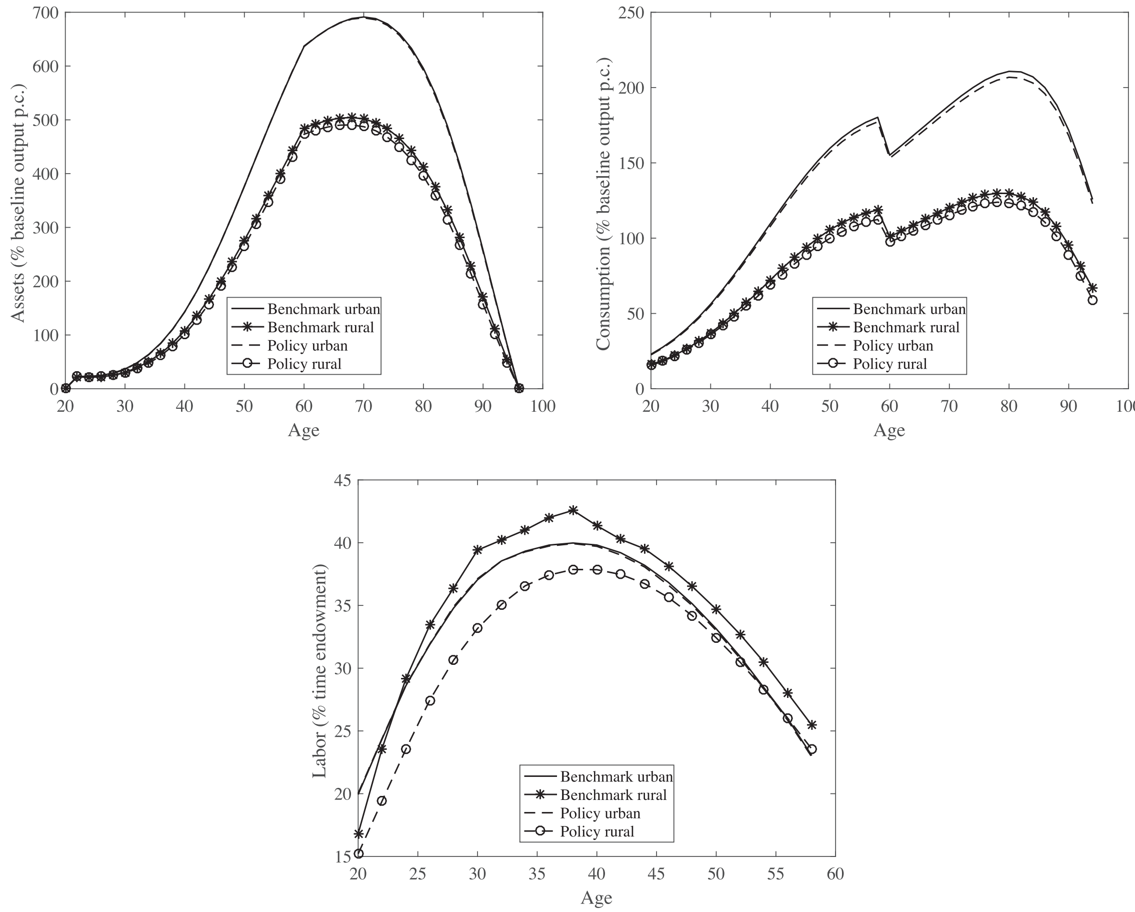


Fig. 6. Life-cycle profiles for 2000 demographics: health insurance reform.

tax, resulting in very little change in asset holdings and labor supply for urban agents over the life-cycle. However, there is still a small decline in urban consumption due to the new central consumption tax.

After introducing health insurance, rural agents save and consume less over their entire life-cycle on average, but enjoy a significant increase in leisure (Fig. 6). Note that relative to the rural pension program, the savings response is much smaller and labor supply response much larger as a result of introducing health insurance. Moreover, compared to older agents, younger individuals realize a significantly higher decline in labor supply and a relatively smaller decline in consumption. As younger individuals are less productive, their baseline consumption/leisure allocations correspond to a lower utility level than older agents prior to the policy change. As a result, the pattern of reallocation across ages is welfare improving from the perspective a unborn rural agent. Thus despite the direct benefit of health insurance occurring disproportionately at old-ages, the utility gains are primarily realized during early stages of life.

Response to health insurance coverage is not the same for all types of rural agents. Rather, and as quantitatively demonstrated in the sub-Section 6.4, leisure and consumption are reallocated among rural types in a welfare improving manner. To illustrate this point, Fig. 7 shows the same set of life-cycle profiles for rural agents conditional on realizing low or high medical expenditures. The policy change results in a small average increase in savings for the high expenditure group reflected in higher asset holdings. In contrast, there is reduction in the savings for those with low medical expenditures. Moreover, compared to the low expenditure group, consumption falls relatively less for those with high medical expenditures at all points in the life-cycle as a result of the increased insurance coverage, though effects are more pronounced in the years following retirement.

Quantitatively, the most important effect of the policy is the decline in labor supply for both high and low medical expenditure groups. However, the welfare gain from the reduction in labor supply is considerably larger for the high expenditure group as they are working significantly more prior to the policy change. Moreover, there is also a welfare improving reallocation of labor supply evident across other rural agent types. For example, Fig. 8 shows the labor supply profile of rural workers in good/poor health and of high/low education. Similar to young agents, individuals of poor health or low education are less productive and experience lower utility consumption/leisure allocations than other agents prior to the policy change. In response to the policy, the larger declines in labor supply for those of poor health or low education imply a welfare improving reallocation of resources across health and education groups.

6.4. Decomposition of welfare effects

As the policies affect the urban and rural sectors differently, we begin our decomposition exercise by conditioning our welfare measure on entering the economy as an urban or rural agent. We then further decompose our measure based on the effects stemming from changes in consumption versus leisure allocation. Finally, these results are decomposed into gains from level changes in average consumption/leisure and gains from the redistribution across agent types and over the life-cycle.

Table 9 shows the results of the welfare decomposition exercise for the isolated pension and health insurance reforms. Within each sector, the two policies produce similar level declines in average

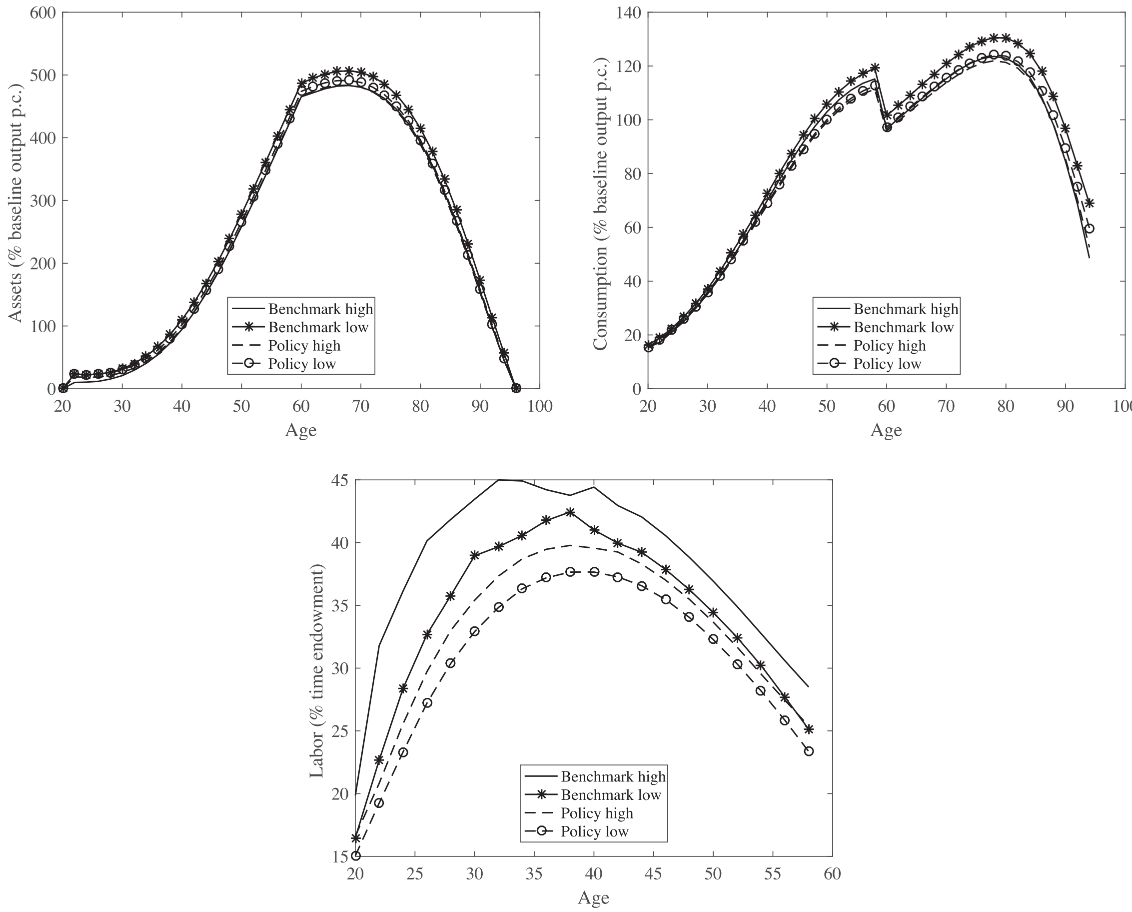


Fig. 7. Life-cycle profiles for 2000 demographics: health insurance reform by medical expenditure for rural sector.

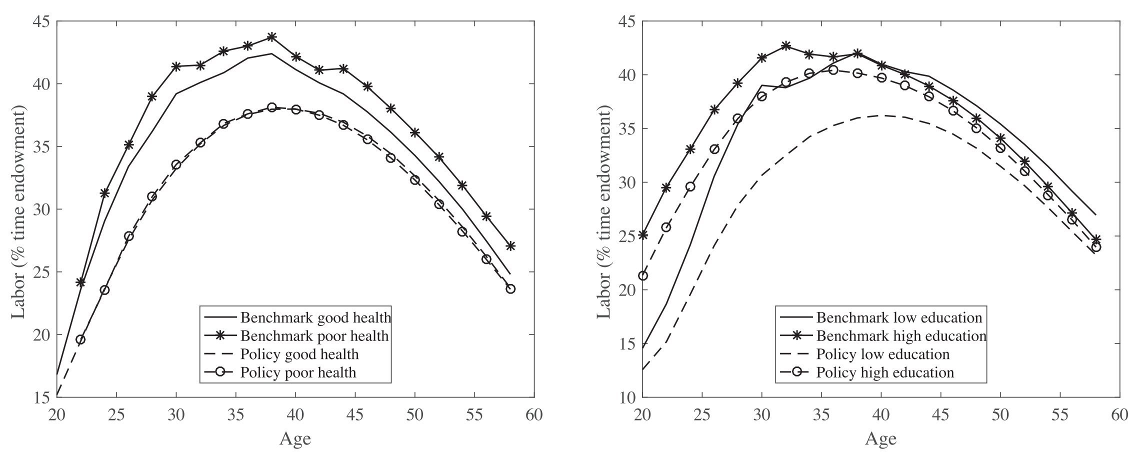


Fig. 8. Life-cycle profiles for 2000 demographics: health insurance reform by health and education for rural sector.

consumption, but the effects are strongest in the rural sector. Specifically, the pension and health insurance programs result in average consumption per capita declines in the rural sector of 3.23% and 4.30%, respectively. Analogous declines are much smaller in the urban sector (1.65% and 1.63%, respectively). Similarly, the increase in average leisure is significantly higher in the rural sector, especially under the health insurance reform. Moreover, introducing health insurance induces sizable welfare improvements from the reallocation of resources across agents and over the life-cycle. Specifically, and as detailed in the previous subsection, health insurance results in a relatively large reduction in labor supply for less productive rural agents (e.g. young, low education, or poor health) and for rural agents realizing high medical expenditures. Young rural agents and those with high medical expenditures also enjoy relatively more consumption.

In contrast to health insurance reform, the decline in hours worked from the subsidized pension system occurs as rural agents approach the end of their working life as they choose to accumulate fewer assets for retirement. However, higher taxes and lower wages induce rural agents to increase labor supply early in the

Table 9
Welfare decomposition.

CEV (%)	Pension			Health insurance		
	Urban	Rural	China	Urban	Rural	China
Total	−3.35	−2.61	−2.76	−2.44	15.44	11.35
Consumption						
Level	−1.65	−3.23	−2.65	−1.63	−4.30	−3.33
Distribution	−0.90	−1.12	−1.34	−0.06	1.99	1.13
Leisure						
Level	0.02	0.78	0.57	0.01	3.51	2.55
Distribution	−0.85	1.04	0.71	−0.78	14.66	11.28

life-cycle when consumption is much lower. As a result, the welfare benefit from reallocation of leisure in the rural sector is much lower under the pension compared to health insurance reform. All together, the expected welfare of an unborn rural agent increases 15.4% under the health insurance reform compared to a decline of 2.6% from the pay-as-you-go pension system.

In contrast to the rural sector, there are negative distribution effects for consumption *and* leisure in the urban sector under *both* the pension and health insurance reforms. This implies not only that urban agents are worse off due to aggregate macroeconomic declines, but the expected welfare loss in the urban sector is amplified by the unfavorable redistribution of consumption and labor supply across agents. From the perspective of an urban agent, the rural pension program only induces higher taxes, lower wages, and higher returns to asset holdings. These changes result in an unequal consumption and labor supply response— the urban poor choose to consume less and work more relative to the urban rich. As a result, the urban poor bear a larger share of the welfare burden from subsidizing the rural pension program. This combined with overall level declines in urban consumption results in more than a 3.3% decrease in the expected welfare of an unborn urban agent due to the rural pension reform. A similar but weaker result holds for urban agents under the health insurance policy experiment— a welfare loss of 2.4%. Though urban taxes are somewhat higher under health insurance compared to pension reform, the general equilibrium effects on wages and interest rates are weaker resulting in a smaller expected welfare loss from redistribution in the urban sector.

6.5. Future demographics

As pension and healthcare spending is disproportionately concentrated among older individuals, the upcoming aging of the Chinese population implies potentially large increases in the cost of rural social insurance programs. In order to quantitatively assess the interaction between policy reforms and upcoming demographic changes, this sections presents results from the same policy experiments above under the projected old-age dependency ratio for China in 2050.

Column one of Table 10 shows baseline results (i.e. no rural social insurance programs) when moving to the 2050 demographic structure. As individuals tend to accumulate assets over the life-cycle, there is a sharp rise in per capita capital compared to the 2000 baseline resulting from the aging of the population (refer to Table 8 for 2000 results). This leads to nearly a 50% increase in per capita output despite a decline in the share of working-aged population and average hours worked compared to the 2000 baseline. The increased capital holdings also lead to a significantly lower interest rate. As pension and healthcare spending is disproportionately concentrated among older individuals, the demographic change also results in increased per capita spending on baseline urban social insurance programs. Total per capita medical

Table 10
Steady state results for rural policy experiments-2050 demographics ($n = 0.005$).

	Baseline	Pension	Health insurance	Both
Output per capita	1.48	1.31	1.43	1.27
% change from baseline	–	−11.34	−3.07	−14.25
Capital per capita	3.12	2.61	3.00	2.50
% change from baseline	–	−16.28	−3.92	−19.85
Consumption per capita	1.02	0.92	0.99	0.89
% change from baseline	–	−9.97	−2.87	−12.78
Health expenditure per capita	0.05	0.05	0.05	0.05
Urban (% of total)	38.44	38.44	38.44	38.44
Rural (% of total)	61.56	61.56	61.56	61.56
Investment per capita	0.27	0.23	0.26	0.22
Average hours worked	0.27	0.25	0.26	0.24
% change from baseline	–	−7.86	−4.73	−12.39
Wage rate	1.06	1.00	1.05	0.99
Interest rate (%)	11.35	12.75	11.56	13.01
Urban labor tax (%)	23.36	23.80	23.44	23.89
Rural consumption tax (%)	0.00	6.65	2.10	8.99
Central consumption tax (%)	0.00	2.87	0.92	3.86
Fiscal outlays (% of GDP)				
Healthcare	0.97	1.09	2.59	2.93
Pension	3.46	8.65	3.51	8.65
Emergency relief (E.R.)	0.50	0.12	0.29	0.01
Accidental bequests (% of GDP)	4.57	4.22	4.56	4.19
Urban population on E.R. (%)	0.01	0.05	0.01	0.05
Rural population on E.R. (%)	6.58	0.68	5.50	0.20
CEV (%)	–	−12.64	3.35	−10.06

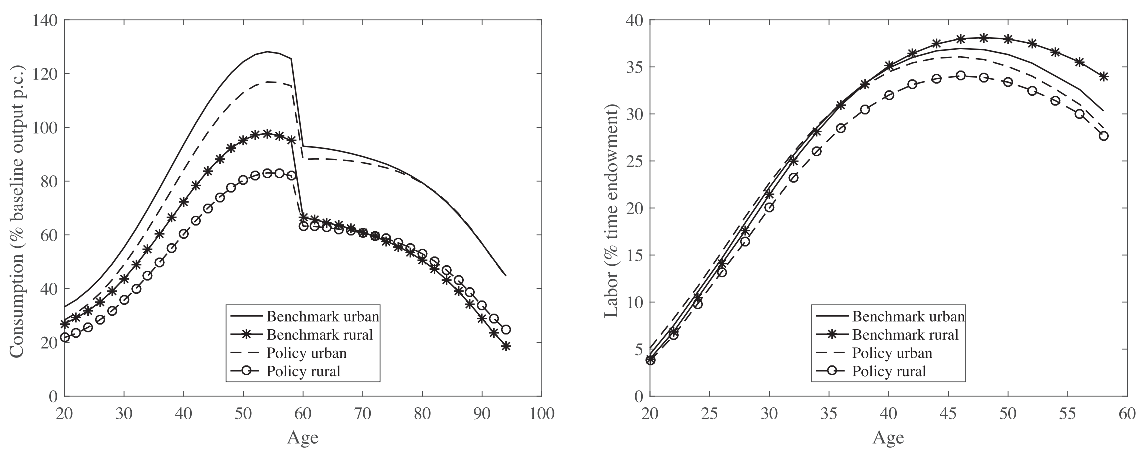
Please cite this article in press as: Bairoliya, N., et al.. The Journal of the Economics of Ageing (2017), http://dx.doi.org/10.1016/j.jeoa.2017.01.004

Table 11
Welfare decomposition: 2050 demographics.

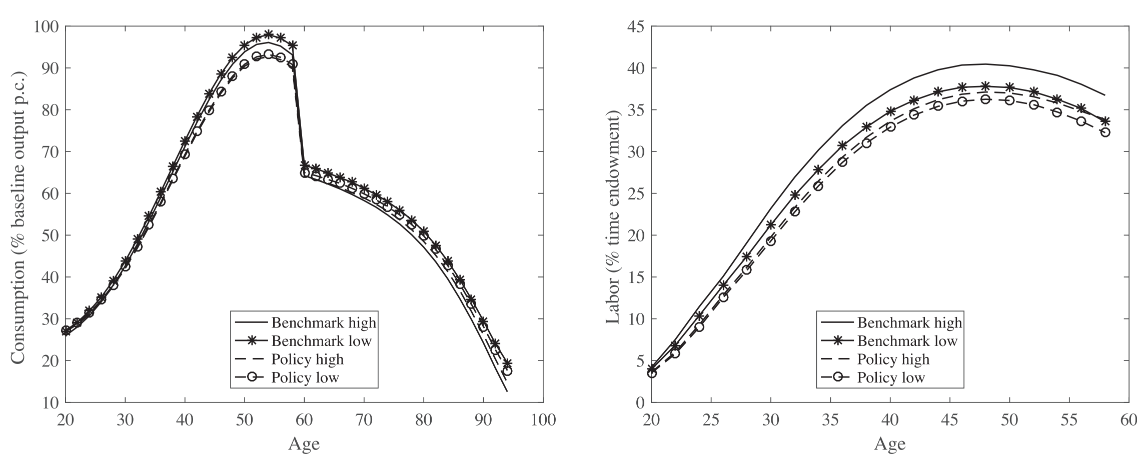
CEV (%)	Future pension			Future health insurance		
	Urban	Rural	China	Urban	Rural	China
Total	−13.13	−12.49	−12.64	−2.85	5.29	3.35
Consumption						
Level	−7.27	−11.37	−9.97	−1.88	−3.38	−2.87
Distribution	−1.76	2.95	1.41	−0.26	6.25	4.57
Leisure						
Level	0.17	1.54	1.16	0.07	0.94	0.70
Distribution	−4.68	−6.09	−5.70	−0.81	1.27	0.81

expenditures increase by 26%, though fiscal outlays on urban health insurance as a share of GDP slightly decreases due to the increase in output. In contrast, fiscal outlays on the urban pension system rise sharply to almost 3.5% of output, raising the urban labor tax to over 23%.

The last three columns in Table 10 show the policy experiment results under the new demographic structure. With the pension reform, aggregate macroeconomic indicators move in a similar direction in response to the policy changes as under the 2000 demographics but are amplified in magnitude. Fiscal outlays for pensions are considerably higher due to the increased share of older agents in the population. Comparing the percentage change from the baseline under alternate demographics shows that the reform is much more costly to implement in a hypothetical economy with roughly a five times higher dependency ratio. With this considerable increase in macroeconomic costs, the pension reform now results in a substantial welfare loss equivalent to a 12.6% decrease in the consumption of an unborn. Similar to the pension results, under the health insurance reform, there are stronger declines in per capita output and capital relative to 2000 demographics. However, the percentage decline in consumption and hours worked are smaller in magnitude. As a result, the net welfare gains from the health insurance policy remain positive at over 3.3%. However, as shown in the final column, these gains are no longer able to counteract the negative welfare impact of the pension reform when both programs are introduced jointly into the economy.



(a) Pension reform.



(b) Health insurance reform by medical expenditure for rural sector.

Fig. 9. Life-cycle profiles for 2050 demographics.

Welfare decomposition results for the 2050 demographic scenario are shown in Table 11. The pattern of negative welfare results in the urban sector for both pension and health insurance are similar as under the 2000 demographics but have increased in magnitude. In the rural sector, the higher wage rate and accidental bequests under the 2050 baseline policy scenario results in lower hours worked on average and less variance in hours worked across agent types. This leaves smaller welfare gains from an increase or reallocation of leisure in the rural sector in response to the policy reforms (see Fig. 9). However, relative to 2000 demographics, there is a more favorable reallocation of consumption in response to both pension and health insurance experiments. This occurs as consumption losses are disproportionately realized at middle-ages, when the life-cycle consumption profile is peaking. Moreover, for health insurance reform there are also consumption gains for the high medical expenditure group after retirement.

6.6. Transition dynamics

So far, we have analyzed the impact of pension and health insurance reforms in the long-run by comparing steady state outcomes for a given demographic structure. In order to understand the macroeconomic and welfare effects of the pension and health insurance policies in the short-run, we analyze the transition

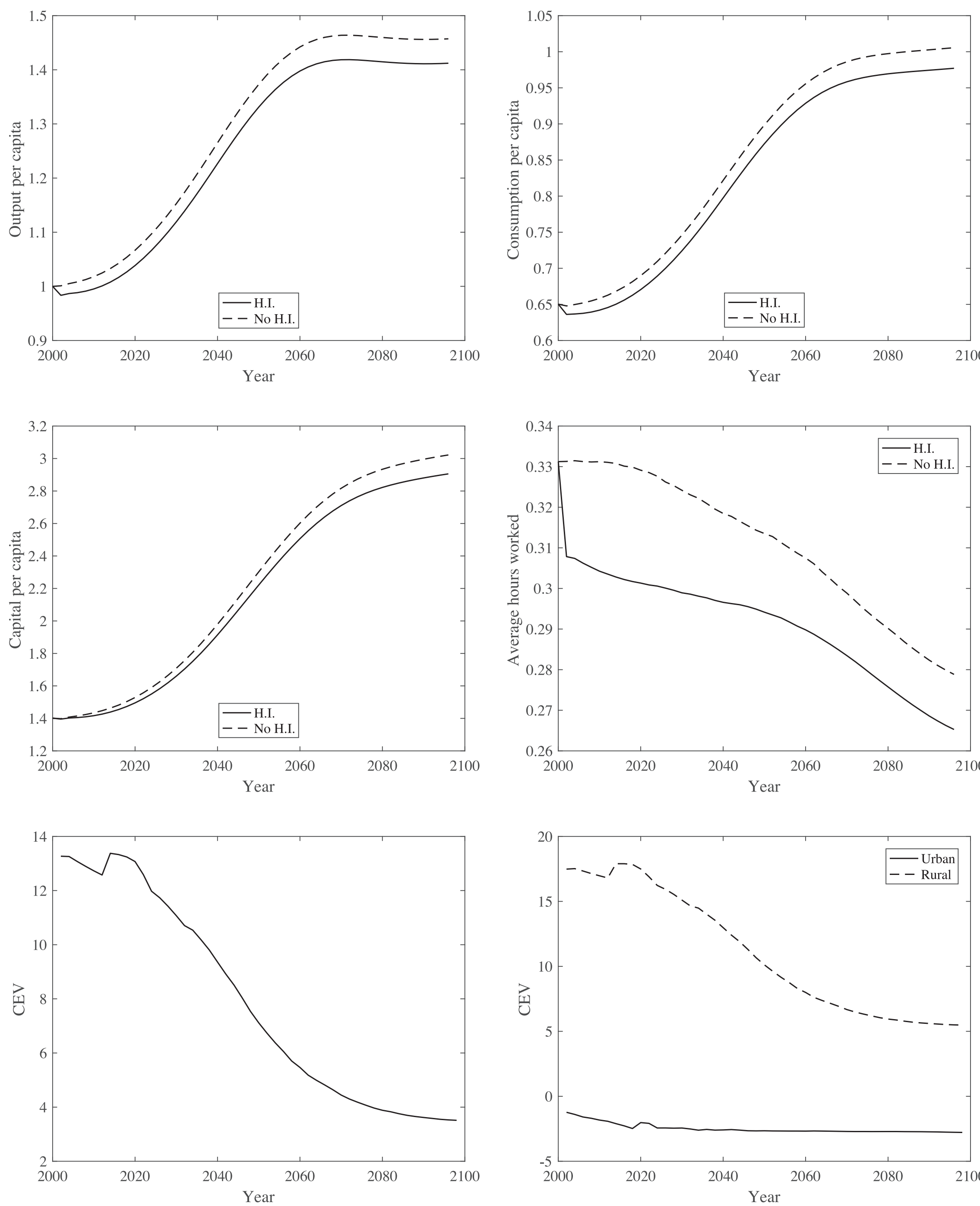


Fig. 10. Transition dynamics: health insurance reform.

dynamics in this section. Also, China is experiencing a demographic transition which would result in a roughly fivefold increase in the old-age dependency ratio within the next few decades. This could potentially have implications for policy outcomes which are not understood by analyzing stationary equilibria alone. Hence we construct a transition path between our initial and final steady states (as discussed in earlier sections) to understand how the reforms will interact with the changing population structure. For this, we gradually change the population growth rate between 2000 and 2050 and implement the reform in the first transition period after the initial steady state. Figs. 10 and 11 show the transition results. First we find that the demographic change itself results in an increase in output, consumption and capital per capita and a reduction in average hours worked all along the transition path. An increase in average output is mainly driven by the increase in capital stock as capital is mostly concentrated among the older population. An increase in old-age dependency also increases the burden on pension and health insurance programs in the urban sector which results in a rise in labor income taxes. This combined with the increasing size of older population results in a decline in average work hours along the transition.

Fig. 10 shows the results for the health insurance reform. Implementing the rural health insurance program in the first transition period results in a sharp drop in average output, consumption,

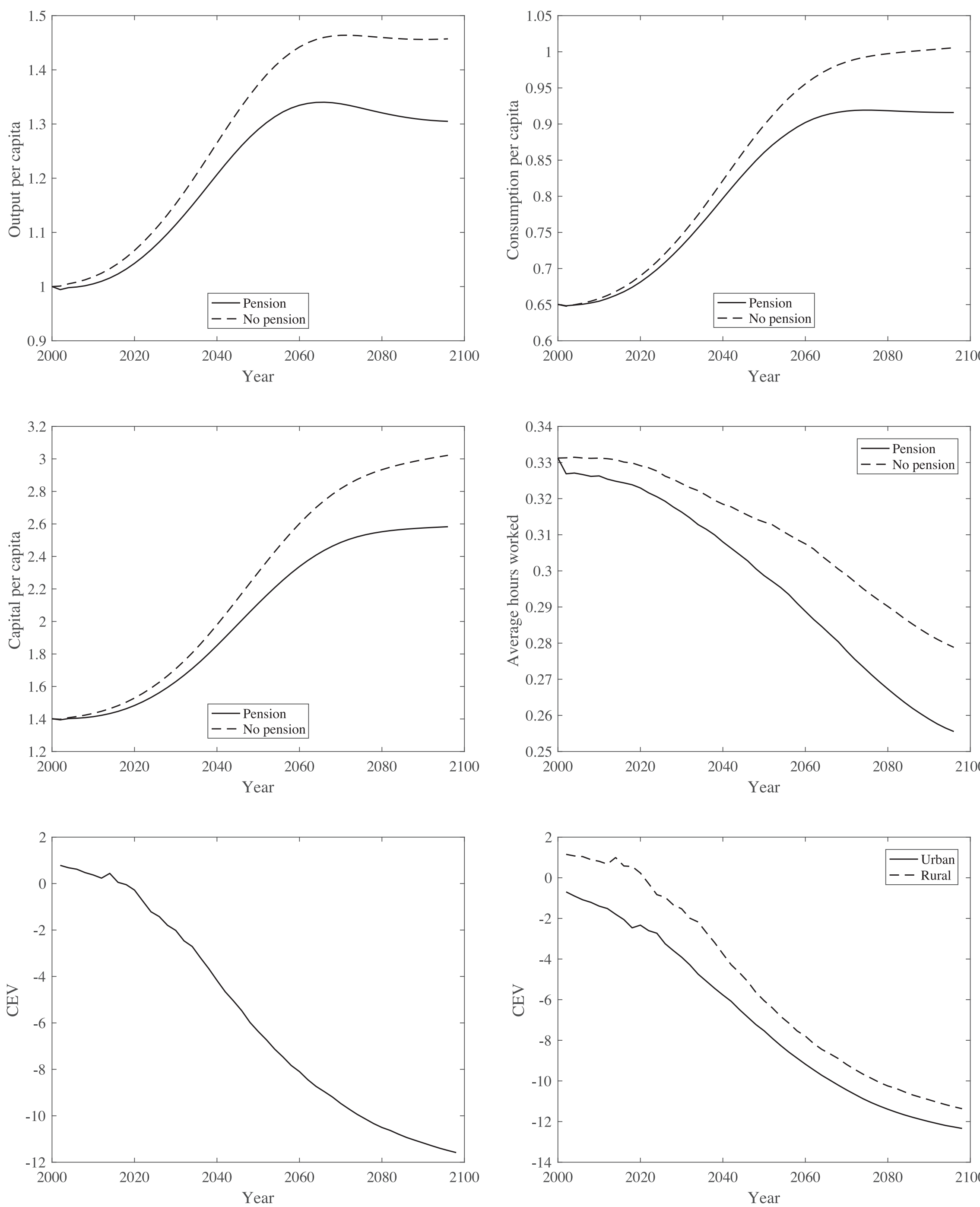


Fig. 11. Transition dynamics: pension reform.

and hours worked in that period. After the first period however, output, consumption and capital begin to grow along the transition path due to the aging population. But the levels remain lower than the transition economy without any health insurance reform. This is consistent with our steady state results where we find that the health insurance policy results in a drop in macroeconomic variables. Average hours decline along the transition path but the decline is much more compared to the transition economy without the policy. This is mainly due to the fact that the health insurance program in the rural sector, by insuring agents against catastrophic medical expenditure risk, results in a reduction in labor supply. Even though there are macroeconomic declines from implementing the rural health insurance program along the transition path, we find significant welfare improvements. We use the same welfare measure as described earlier but now we compare the expected life time utility of an unborn agent in a world with and without health insurance policy at each point in time along the demographic transition. The policy results in welfare gains all along the transition path but the gains are higher in the short-run than in the long-run steady state. This is again consistent with our steady state analysis where we find bigger welfare improvements from the health insurance policy in the steady state with smaller old-age dependency ratio. Similarly we also find that the policy results in welfare losses for the urban sector. These welfare losses in the urban sector increase with the aging population along the transition.

Next, we look at the transition dynamics from the pension reform in the rural sector (refer to Fig. 11). The macroeconomic variables behave in a similar way. We find that the pension reform results in a small drop in output, consumption, capital and hours worked relative to the transition economy without the reform. However, we find that these declines in macroeconomic variable — relative to the transition economy without pensions — grow bigger over time with population aging. Contrary to the steady state analysis, we find that the pension reform results in small welfare gains in the rural sector in the short-run.

6.7. Sensitivity analysis

As our welfare results primarily stem from the reallocation of resources— particularly in favor of disadvantaged populations— this section begins by investigating the sensitivity of our results to alternate parameter specifications for emergency relief and preferences over consumption and leisure. We then examine sensitivity to the assumption of an exogenous retirement age in the rural sector, to future mortality changes and lastly to economic growth. When examining sensitivity of results to a particular parameter change or retirement specification, we re-calibrate our model to match the same empirical data targets as our benchmark specification for the remaining parameters.

6.7.1. Emergency relief parameters

We begin by exploring how changes in the generosity of emergency relief affects our welfare results (see Table 12). Recall that emergency relief in our model captures informal family and community transfers as well as formal government poverty transfer programs. More generous emergency relief decreases the precautionary savings motive and potentially limits the negative consequences of catastrophic medical expenditures and/or old-age on the poor. With a very generous consumption floor of 15% and no labor requirement, the estimated welfare effect of the joint rural insurance programs falls considerably but remains positive at over 5%. The share of individuals on emergency relief in the baseline also increases to over 14% of the population. In contrast, when the consumption floor is cut to 2% and required labor set at two-thirds of the time endowment, welfare gains increase to over 16% while the share on emergency relief falls to less than 1%. Thus while the magnitude of welfare gains are somewhat sensitive to emergency relief parameters, the joint reforms have net positive effects over a range of plausible values.

6.7.2. Preference parameters

As policy reforms are found to have different impacts on consumption versus leisure, we next examine the sensitivity of results to preference parameter specification. Table 13 presents the percentage change from the baseline for select outcomes after introducing the joint reforms under 2000 demographics for different preference parameter values. We begin by considering alternate values of γ while adjusting σ to maintain the benchmark intertemporal elasticity of substitution (IES) of 0.5. With a higher value of γ there is relatively more weight on consumption resulting in a smaller adjustment in labor supply in response to the social insurance policies. As a result, there are smaller aggregate declines in output and consumption. Nonetheless, our consumption equivalent variation measure decreases with a higher γ as welfare gains are primarily occurring from reallocation along the leisure margin.

Table 12
Sensitivity analysis: emergency relief parameters.

	CEV (%)			Pop. on E.R. (%)		
$(\underline{c}, \bar{\ell})$	0.0	**0.33**	0.67	0.0	**0.33**	0.67
2%	7.19	8.12	16.93	0.83	0.83	0.70
8%	7.11	**7.81**	13.32	3.98	**3.17**	2.36
15%	5.79	4.09	12.61	14.08	11.63	6.53

The welfare results are for the joint pension and health insurance reform. Bold numbers indicate benchmark values. The first column indicates different values for $\underline{c}$ and the second row different values for $\bar{\ell}$.

Table 13
Sensitivity analysis: preference parameters.

	Consumption weight (γ)			Risk aversion (σ)		
	0.30	**0.40**	0.50	6.97	**3.49**	1.64
IES	0.50	**0.50**	0.50	0.30	**0.50**	0.80
Average hours	−12.27	**−10.44**	−7.96	−11.13	**−10.44**	−10.52
Aggregate output	−7.18	**−6.03**	−5.17	−6.85	**−6.03**	−6.25
Consumption output ratio	−7.02	**−6.06**	−5.23	−6.65	**−6.06**	−6.23
CEV (%)	13.36	**7.81**	4.61	10.57	**7.81**	8.62

Reported numbers are % change from the baseline from joint reform experiment under 2000 demographics. The column in bold indicates the benchmark values.

Next we examine sensitivity of results to changes in σ while adjusting γ to maintain the benchmark average hours worked of one-third. For comparison to our benchmark IES of 0.5, we choose alternate values of σ such that the implied IES equals 0.3 and 0.8. The decline in output and consumption is slightly larger with the lower or higher elasticity as labor supply is more responsive to the policy change. However, the larger decline in average hours worked results in a small net increase in welfare in comparison to the benchmark specification. With the largest decline in labor supply, the low IES leads to the highest estimated welfare gain across the range of elasticities.

6.7.3. Endogenous retirement

We check robustness of our results to endogenous retirement in the rural sector. Specifically, we re-estimate our baseline economies and conduct all policy experiments while allowing rural agents to endogenously choose their supply of labor until age 90. We use the results from our probit model of labor productivity to extrapolate estimates for agents over the age of 60. Moreover, after age 60, rural agents receive their pension payment regardless of their labor supply decision. Select steady state results under the new model specification are presented in Table 14.

The welfare estimates from the pension system under both demographic scenarios are very similar to the benchmark results with exogenous retirement. On one hand, allowing the rural elderly to work effectively serves as an additional insurance mechanism against uncertain medical expenditures and mortality in old-age. As a result, the welfare benefits to the elderly of introducing the rural social insurance schemes are somewhat lessened under the new specification. However, rural agents must no longer exclusively rely on savings to fund consumption after age 60, leading to a shift in the asset distribution towards younger ages. As a result, there is now a significantly smaller decline in capital in response to the rural pension system. For example, under 2000 demographics, the average capital stock falls by 0.4% compared to 4.4% with exogenous retirement (see Table 8). On net, the welfare results from the pension scheme remain similar to the benchmark specification.

Despite endogenous retirement serving as an alternate insurance mechanism for medical shocks in old-age, the welfare result is also very similar for health insurance reform under the 2000 demographics. This occurs as the entering young agents receive relatively fewer bequests so health insurance is somewhat more valuable to them. However, when moving to 2050 demographics, the population structure shifts significantly towards the elderly where health insurance is now relatively less valuable due to the ability to work if needed. As a result, the welfare impact falls to 1.4% from a benchmark value of 3.3% with exogenous retirement. However, when isolating each insurance system, the finding of welfare gains from health insurance and losses from pay-as-you-go pensions continues to hold when allowing for endogenous retirement in the rural sector.

6.7.4. Mortality changes

In our analysis of future demographics, we have assumed that the entire increase in the old-age dependency ratio is due to reductions in fertility. However, population aging could also be partially driven by reductions in mortality rates. In this exercise, we scale

Table 14
Sensitivity analysis: endogenous retirement.

	Demographics: 2000		Demographics: 2050	
	Pension	Health insurance	Pension	Health insurance
Average output	−0.67	−3.14	−3.64	−3.84
Average capital	−0.40	−3.04	−2.99	−5.24
Average consumption	−2.60	−3.54	−11.39	−3.49
Average hours	−0.85	−8.93	−4.31	−5.45
CEV (%)	−2.03	11.47	−12.50	1.37

Reported numbers for aggregate variables are % change from the baseline.

Table 15
Sensitivity analysis: 2050 demographics with mortality changes.

	Fertility change only		Fertility and mortality change	
	Pension	Health insurance	Pension	Health insurance
Average output	−11.34	−3.07	−10.77	−3.03
Average capital	−16.28	−3.92	−15.20	−3.78
Average consumption	−9.97	−2.87	−9.51	−2.87
Average hours	−7.86	−4.73	−7.87	−5.09
CEV (%)	−12.64	3.35	−11.66	4.61

Reported numbers for aggregate variables are % change from the baseline.

Table 16
TFP growth and pension reform (2050 demographics).

	Benchmark	1% growth	
	(No growth)	Indexed	Not indexed
CEV total (%)	−12.64	−12.46	−9.82
Urban	−13.13	−13.17	−10.96
Rural	−12.49	−12.26	−9.50
Urban labor tax (%)	23.80	23.70	21.45
Rural consumption tax (%)	6.65	6.68	6.01
Central consumption tax (%)	2.87	2.88	2.58
Fiscal outlays (% GDP)	8.65	8.64	7.68

down the mortality risk associated with each relevant state (education, sector, health, and age) by a constant factor. We calibrate this factor to match the average probability of survival from age 80 to 85 as projected for the Chinese population in the year 2050.[14] A reduction in mortality rates and an increase in life expectancy is often associated with an increase in the age onset of morbidity and an increase in healthy life expectancy (Gu et al., 2009; Salomon et al., 2013). In our framework this could lead to better age specific health and lower age specific health spending. However, recent evidence from the United States points towards the possibility of earlier onset of morbidity due perhaps to changes in health behaviors, particularly rising obesity levels (Crimmins and Beltrán-Sánchez, 2011). Rising obesity and high rates of smoking among men in China mean that we are uncertain that healthy life expectancy will continue to increase in the future. As with the issue of possible future rises in the cost of healthcare in China, our uncertainty about future trends in the age of onset of morbidity means we simply assume that current rates remain stable into the future. We would note however that the two effects may be partially offsetting so that rising costs would counteract savings from lower morbidity rates.

In this experiment we re-calibrate our model to match the old-age dependency ratio of 51% in 2050. This exercise results in a 24% reduction in mortality probability for each state and a cohort growth rate of 1.05% (as opposed to 0.5% when mortality is held constant). Increases in expected lifespan from the reduction in mortality increases savings in general to fund old-age consumption and medical expenditures. However, as shown in Table 15, allowing for future mortality rate declines does not significantly change our policy results. The second and third columns reiterate the effect of pension and health insurance policy under the future demographic structure brought by fertility changes alone. The last two columns are policy experiments in an economy marked by future declines in both fertility and mortality. When incorporating reductions in mortality, we find that both pension and health insurance programs result in slightly smaller macroeconomic declines than our earlier experiments for future demographics. The welfare effects are also somewhat improved for both programs, though remain negative for the pension system.

6.7.5. Productivity growth

We have so far abstracted from any productivity growth in our analysis of social insurance programs in China. However, as the pension system in China is only partially indexed to wage growth, such productivity changes may have important implications when using pay-as-you-go financing. In particular, indexing pensions to wages not only implies higher benefits in the presence of economic growth, but also a relatively higher tax burden on the labor force. In this section, we test the robustness of our pension policy results to TFP growth by assuming that θ in Eq. (1) grows at an annual rate g.

Table 16 compares select results from the benchmark steady state for pension reform under the 2050 demographics to analogous results incorporating a 1% annual TFP growth rate.[15] When allowing for TFP growth, we conduct experiments both with and without pensions indexed to wages.[16] When pension benefits are indexed, we find relatively small reductions in welfare losses from the pension reform as compared to the no growth scenario. However, when benefits are not indexed to wage growth, the negative welfare effect of pension reform falls by about 20%— from a CEV of 12.6% to 9.8%. As expected, this difference is primarily driven by the reduction in tax burden— fiscal outlays as a share of GDP are about 10% lower under no growth (8.7%) compared to growth without indexed pensions (7.7%).

[14] UN medium variant 5-year mortality projections for the period 2045–2050 (UN, 2012).

[15] TFP growth implies an adjustment in our discount rate β. For 2000 demographics we assume indexed pension benefits and use the average annual TFP growth rate from 1990–2000 of 1.23% (Feenstra et al., 2015). We then back out the implied discount rate under TFP growth (i.e. $\beta^{TFP} = \beta/(1+g)^{\gamma(1-\sigma)}$).

[16] For simplicity, pensions not indexed to wage growth are estimated by discounting the average current period sector earnings back to the age of retirement using the TFP growth rate: $PB_{st} = (b_{st} w_t N_{st}) / \left(\int \Phi_t(d\zeta(s, j < j_r))(1+g)^{j-j_r} \right)$, where $(j - j_r)$ is the number of periods since retirement.

7. Conclusions

A primary feature of the recent healthcare and pension reforms in China has been the unprecedented expansion of coverage to rural areas of the country. In this paper, we develop a dynamic general equilibrium model useful for understanding the macroeconomic and welfare effects of these social insurance reforms in China. Importantly, we model key differences in health, labor productivity, mortality, public financing structures, and eligibility for social insurance programs across the urban and rural sectors. We allow health to evolve stochastically over the life-cycle and influence mortality, productivity, and medical expenditures. We find that the introduction of rural health insurance to our baseline economy results in large gains in social welfare (especially in the short-run), despite a decline in income per capita, due to avoiding extreme out-of-pocket healthcare expenditures and reducing risk to households. Welfare gains are reduced but remain positive when the old-age dependency ratio is increased to projected future levels for China. The pay-as-you-go pension system results in a small net welfare gain in the short-run but welfare loss in the long-run which is amplified by the anticipated demographic changes out to 2050.

Our model is not without limitations. For example, we do not account for any rise in the relative cost of medical care above average inflation and instead hold relative costs fixed over time in our analysis. In order to reduce computational burden, we allow for persistence in medical spending only through persistence in health status and we use only a coarse grid on medical expenditures where we are not able to fully capture the long right tail of medical spending. However, rising relative medical care costs, direct persistence in medical expenses, and risk for even larger medical expense shocks would only increase the financial risk protection from the rural health insurance program. As such, by not fully capturing these details, our model may only provide a lower bound for welfare gains from the rural health insurance program.

In addition to simplifying medical expenditures, we also do not explicitly model the supply-side of the healthcare system or insurance coverage for non-workers or internal migrants. We also do not include the individual account component of the Chinese pension systems, which effectively acts as an annuity purchase after retirement. A more realistic model may also allow for endogenous evolution of health which could mitigate some of the medical expense risk faced by individuals. However, these pose considerable additional modeling challenges and increased computational burden. Addressing these limitations leaves scope for important future research. However, we view this paper as an important step toward understanding the potential economic and welfare implications of China's large and complex social insurance reforms.

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