ARC Centre of Excellence in Population Ageing Research

Working Paper 2021/33

Extending Pension Policy in Emerging Asia: An Overlapping-Generations Model Analysis for Indonesia

George Kudrna, John Piggott and Phitawat Poonpolkul

Extending Pension Policy in Emerging Asia: An Overlapping-Generations Model Analysis for Indonesia[*]

George Kudrna[†]   John Piggott[‡]   Phitawat Poonpolkul[§]

December 2021

Abstract

This paper examines the economy-wide effects of government policies to extend public pensions in emerging Asia – particularly pertinent given the region's large informal sector and rapid population ageing. We first document stylized facts about Indonesia's labour force, drawing on the Indonesian Family Life Survey (IFLS). This household survey is then used to calibrate micro behaviours in a stochastic, overlapping-generations (OLG) model with formal and informal labour. The benchmark model is calibrated to the Indonesian economy (2000-2019), fitted to Indonesian demographic, household survey, macroeconomic and fiscal data.

The model is applied to simulate pension policy extensions targeted to formal labour (contributory pension extensions to all formal workers with formal retirement age increased from 55 to 65), as well as to informal labour (introduction of non-contributory social pensions to informal 65+). First, abstracting from population ageing, we show that: (*i*) the first set of pension policy extensions (that have already been legislated and are being implemented in Indonesia) have positive effects on consumption, labour

---

[†]Corresponding author; CEPAR, UNSW Business School, UNSW Sydney; e-mail: g.kudrna@unsw.edu.au.

[‡]CEPAR, UNSW Business School, UNSW Sydney.

[§]Puey Ungphakorn Institute for Economic Research (PIER), Bank of Thailand, Thailand.

supply and welfare (of formal workers) (due largely to the formal retirement age extension); (*ii*) the introduction of social pensions targeted to informal workers at older age generates large welfare gains for currently living informal elderly; and (*iii*) the overall pension reform leads to higher welfare across the employment-skill distribution of households.

We then extend the model to account for demographic transition, finding that the overall pension reform makes the contributory pension system more sustainable but the fiscal cost of non-contributory social pensions more than triples to 1.7% of GDP in the long run. As an alternative, we examine application of a means-tested social pension system within the overall pension reform. We show that this counterfactual reduces the fiscal cost (of social pensions) and further increases the welfare for both current and future generations.

1 Introduction

Emerging Asia can be characterised by large informal employment and, consequently, very low retirement incomes and high inequality among elderly populations (e.g., see Kudrna et al. (2021a)). In this paper, we focus on Southeast Asian (SEA) economies, where informal employment can account for more than 80% of the workforce (International Labour Office (ILO), 2018). Furthermore, this populous Asian region is confronting rapid population ageing, e.g., with projections for Indonesia showing an increase in the old-age dependency ratio of almost 5-fold between 2020 and 2100 (United Nations (UN), 2019). Similar projections exist for Thailand, Vietnam (currently the world's most rapidly ageing nations) and other populous SEA economies.

Pension policy in many of these jurisdictions is largely inadequate, and often has no reach whatsoever into informal employment. This is especially the case for those elderly whose earning capacity is exhausted. The situation is compounded by poorly developed private financial governance structures (e.g., see Chomik and Piggott (2015), World Bank (2016) and Kudrna et al. (2021a)). Demographic change will transform SEA economies within a generation and major social protection policy formulation will be required in coming decades to avoid considerable human suffering.

The objective of this paper is to study the economy-wide effects of pension policy extensions in the emerging Asian economy context with its large informal labour. We focus on pension reform policy extensions targeted to (*i*) formal labour (i.e., contributory, pay-as-you-go (PAYG) pension extensions to all formal workers (linked to their former earnings) and an increasing formal retirement age), and (*ii*) informal labour (i.e., introduction of non-contributory social pensions paid to all informal households aged 65 and over). The first set of policy extensions has already been legislated and is currently being implemented gradually in Indonesia (e.g., the retirement age is gradually increasing to 65 in 2044, from 55 in 2012 (Organisation for Economic Co-operation and Development (OECD), 2018)). For informal workers, we propose (and examine) non-contributory social pensions. We also consider a means-tested social pension alternative, with non-contributory social pensions that can be paid to all households aged 65 and over which are subjected to a means test that includes private assets and PAYG pensions. We study public pension reforms under stationary demographics but also under demographic transition towards pronounced population ageing (with the old-age dependency ratio projected to increase by almost 5-fold to over 50% by 2100).

In order to undertake this quantitative analysis, we develop a stochastic overlapping generations (OLG) model which consists of overlapping generations of heterogeneous households, a production sector and a government sector with taxation and PAYG public pensions applicable to formal labour. The model is based on the seminal computable OLG model developed by Auerbach and Kotlikoff (1987) and it incorporates many features of the model by

Song et al. (2015) applied to China. It is extended here to incorporate formal and informal workers that face stochastic labour productivity and are subject to different policy rules. The benchmark model is calibrated to the Indonesian economy (2000-2019), fitted to Indonesian demographic, household survey, macroeconomic and fiscal data. The model accounts for a detailed representation of Indonesia's labour market (drawing on the Indonesian Family Life Survey (IFLS)), as well as of government tax and pension policies in Indonesia.

Based on the model simulations, these are our key findings:

- The first set of pension policy extensions (particularly the extended formal retirement age policy) has positive effects on consumption, labour supply and welfare of formal workers (that are no longer forced to retire from formal employment at age 55);

- The introduction of social pensions targeted to informal workers at older age generates large welfare gains for currently living informal elderly (of over 10% of their resources);

- The overall pension reform (consisting of (i) and (ii)) leads to higher welfare across the employment-skill distribution of households; and

- Indonesia's population ageing will generate some pronounced fiscal costs, which are shown to be mitigated by the examined changes to PAYG pensions as well as by the means testing of social pensions – with pension reforms generating higher average welfare gains under this demographic transition.

Some relevant OLG developments In the context of demographic ageing, the OLG model is a core construct, and has been used and developed for policy analysis in developed countries since the pioneering work of Auerbach and Kotlikoff (1987). This type of macroeconomic model captures economy-wide interactions, including inter-temporal interactions, which need to be considered in assessing the impacts of alternative social policy paradigms. Importantly, the framework accommodates the life-cycle behaviour of households whose lifespans overlap and a government sector with detailed tax and spending policy settings. Given these properties, the OLG model has become a standard economic tool for studying ageing and public policy issues in advanced economies. See, for example, Kitao (2014), Nishiyama (2015), McGrattan and Prescott (2017) and Hosseini and Shourideh (2019) for the US; Braun and Joines (2015) and Kitao (2015) for Japan; and Kudrna et al. (2015, 2019, 2021b) for Australia. Fehr (2016) provides a recent review, reporting the major advances in OLG methodology and applications over the past 30 years. The Congressional Budget Office uses an OLG model for its long run work, and the Australian Treasury is currently building their Overlapping-Generations for Australia (OLGA) model.

Until now, OLG models to guide social policy have almost exclusively been constructed for developed countries and are almost non-existent in the emerging SEA economies. The

development of sophisticated economic modelling in that region, to explicitly incorporate the impact of an ageing demographic and formal-informal labour to assess the impact of alternative age-related social policy initiatives, is long overdue (Lee et al., 2016).

In most cases where OLG modelling has been undertaken in an emerging Asian economy context, interactions with the informal sector are ignored. For example, Widjaja (2008) develops a one sector model for Indonesia, dealing only with the formal sector; and similar studies have been undertaken for China (e.g., Song et al., 2015; Curtis et al, 2015; Imrohoroglu and Zhao, 2018). Our contribution to this literature is to account for observed differences in household lifecycle behaviour between formal and informal workers (and uncertain labour productivity and earnings), calibrated to match Indonesian household survey (IFLS) data in our model.

There is a limited body of macro-development literature that studies public policy reforms in emerging Latin-American economies, using OLG modelling with formal and informal labour. For example, Jung and Tran (2012) develop their stochastic 2-sector OLG model with an application examining the implications of extending social security to the informal sector in Brazil. There were also more recent papers on social security reforms in Chile, using OLG models with taxed formal labour, untaxed informal labour and home production (e.g., see Albagli et al. (2020) and McKiernan (2021)). Similarly, the recent paper by Esteban-Pretel and Kitao (2021) develops a structural model of heterogeneous agents with sectoral choice in a dual economy and their applications are to labour market policies in Mexico.

Note that our analysis of the IFLS data indicates that emerging Asian economies (i.e., represented by Indonesia in this paper) are quite different to Latin American countries that typically have a much smaller informal economy ($< 50\%$) – largely due to government policy and regulations (see Levy, 2008). By contrast, in Indonesia the informal labour force is much larger (around 80%) and the IFLS data indicates that only about 10% of informal labour (of prime working age) move to formal employment, while more than half of formal workers move to informal employment around the formal retirement age. As detailed further in the text, our model is closely calibrated to match these micro behaviours specific to emerging Asian economies, using Indonesian data.

This paper is structured as follows. In Section 2, we document key stylized facts about the labour force in Indonesia, drawing on IFLS data. Section 3 provides a description of the OLG model used. The model calibration to Indonesia is presented in Section 4. Section 5 reports and discusses the economy-wide effects of extending public pensions in Indonesia, including life cycle, welfare, macroeconomic and fiscal implications. We consider both the legislated policy changes to formal PAYG pensions (i.e., PAYG pensions for all formal labour and the increasing formal retirement age), as well as the introduction of non-contributory social pensions targeted to informal elderly. In Section 6, we examine the economy-wide effects of population ageing and the pension policy extension, including the reform with a

means-tested social pension alternative. Section 7 offers some conclusions.

2 Indonesian labour force

In this section, we document stylized facts about the labour force in emerging Asia, drawing on the recent studies by Kudrna et al. (2020, 2021a).[1] We focus on Indonesia and its IFLS data (that is used to calibrate the household behaviour in the OLG model described in the next section). Note that similar observations for labour force are observed in other emerging Asian countries (of Southeast Asia in particular), such as Vietnam and Thailand (e.g., see ILO (2018), Kudrna et al. (2020, 2021a)).

Below, we first provide a brief description of the IFLS, our definition of informal employment and data selection details. We then provide a data analysis of the Indonesian labour force – documenting its composition, labour productivity, hours worked, labour earnings, and also labour transitions.

2.1 Indonesian Family Life Survey

The Indonesian Family Life Survey (IFLS) is an ongoing longitudinal survey in Indonesia, representative of about 83% of the Indonesian population and containing over 30,000 individuals living in 13 of the 27 provinces in the country (see Strauss et al. (2016)).[2] It consists of five waves that were initiated in 1993, 1997, 2000, 2007, and 2014.

These surveys are information-rich socio-economic surveys which collect a wide range of data for studying life cycle behaviour and outcomes for the Indonesian population.[3] Data on employment, labour force participation, education, health, income, expenditure, housing, fixed assets and durable goods are collected by the IFLS. In this section, we focus on the labour force data, using the IFLS waves 3 to 5 for years 2000, 2007 and 2014.[4]

---

[1]In our analysis, the labour market has a direct link with taxation and social security pension coverage – hence impacting economic behaviour and wellbeing at older age. More details on the pension policy in Indonesia are provided in the model and calibration sections of the paper. Kudrna et al. (2021a) provide a recent cross-country comparison of the pension systems (coverage and benefits, including social pensions) in emerging East Asian (EA) and SEA countries.

[2]Data and documentation can be accessed at https://www.rand.org/well-being/ social-and-behavioral-policy/data/FLS/IFLS.html.

[3]Note that the IFLS covers the whole life cycle, collecting data for household heads aged 18 and over, whereas the Health and Retirement Survey (HRS) in the US and many other HRS-related surveys in other countries cover only older ages - 45 and over.

[4]Note that these last three waves of the IFLS (2000-2007-2014) provide the most updated information and necessary background for the analysis of both labour force in Indonesia. These surveys and their procedures were reviewed and conducted by the RAND corporation, and in Indonesia by the University of Gadjah Mada – the oldest and the largest state university in Indonesia (see https://www.rand.org/well-being/social-and-behavioral-policy/data/FLS/IFLS.html).

2.2   Definition of informal employment

We closely follow the international statistical definition of informal employment established by the International Labour Organization (ILO 2018, p.9). According to their definition, informal employment consists of (*i*) "employees if their employment relationship is not subject to national labour legislation, income taxation, social protection or entitlement to certain employment benefits", and (*ii*) others, with non-fixed premises and a size of five employees or less.

In this paper, we use medical benefits from employers in the form of health insurance and/or any other medical expenditure as the indicator of formality for employees. Specifically, if individuals in the IFLS report that they have received neither health insurance nor any medical benefits from their employers, we code them as informal workers.[5] For all those who report that they are self-employed, we also code them as informal workers. Note that most of them are working in agriculture as farmers or for small and unregistered household businesses. The same assumption has been used by, for example, Cuevas et al. (2009) to determine the informality for self-employment in Indonesia.[6]

2.3   Data selection

In documenting labour (or employment) informality in Indonesia, we draw on IFLS 2000-2014, using the above-mentioned definition of informal employment. The focus is on the labour force of working age population, reporting on (*i*) labour force composition; (*ii*) life cycle earnings, productivity and labour supply; and (*iii*) employment transitions over the life cycle. We make the following restrictions for our output sampling:

- We use data for male workers only. The main reason for this restriction is that the labour market participation in developing countries is such that women are less likely to have a continuous job compared to men.[7]

- We restrict the age of formal workers to a range from 20 to 54 years (based on the formal retirement age of 55 years during the period covered by the selected IFLS data[8]), utilising data at the individual level for age, education, employment status,

---

[5]Given the availability of relevant information in the IFLS, this method of identifying informal workers is in line with ILO (2018), which utilizes the "entitlement to and benefit from paid sick leave" as an indicator to determine informal employment for an employee.

[6]There is also the legal-status-of-firm definition of (in)formality, i.e., whether enterprises are registered (UU Ketenagakerjaan No. 13 of 2003 by the Ministry of Manpower and Transmigration, discussed by Nasip and Pradipto, 2016). This definition has been used, for example, by Rothenberg et al. (2016), also documenting a large and persistent informal sector in Indonesia, using firm-level data.

[7]Kudrna et al. (2020) also provide some labour force data for females.

[8]Note that the retirement age (normal pension age) was increased to 56 in 2012 for employees in the private sector. Currently, the retirement age is 57 years and it has been legislated to gradually increase to age 65 by 2043 (OECD 2018). For public servants, the standard retirement age was 56, but they could retire

labour earnings and transition probabilities.[9]

- We retain farmers and the self-employed in the sample, since they are very populous groups in developing countries.

- People with no jobs (6.6% of total interviews across the IFLS 2000, 2007 and 2014) and people who report themselves as "unpaid family workers" (3.6%) are excluded.

- We also remove those with hours worked < 10 hours per week (and outliers with hours > 99 hours per week) (about 10% of the sample).[10]

- People are defined as "high" skill only if they completed high school (i.e., 12 years of schooling).[11]

- All observations with missing information are also removed from the constructed sample.[12]

2.4 Composition of labour force

The composition of Indonesia's labour force is presented in Table 1, using all three IFLS waves and also each wave separately, in order to document the recent trends. In the table, we decompose the labour force into four types, defined above as formal-low, formal-high, informal-low and informal-high (skill) types.

---

at age 50, with a minimum of 20 years of service (Muliati and Wiener 2014).

[9] For informal workers, we report their earnings and productivity up to age 60.

[10] This is typically assumed by related empirical literature (e.g., see Freestone 2018).

[11] This definition differs to that commonly used for OECD countries where those defined as high skill have some tertiary education (OECD 2020). Further note that according to World Bank (2020), the median year of schooling for Indonesian males aged 25+ equates to less than ten in 2018. However, we use 12 years of schooling as a cut-off, since this is now a mandated minimum school attendance in Indonesia.

[12] The summary statistics for the overall sample (combining the IFLS 2000, 2007 and 2014) can be provided upon request.

Table 1: Composition of labour force (males aged 20-54)

Employment type[a]	Skill type[b]	2000	2007	2014	Overall[c]
Formal	Low	6.0%	4.0%	5.6%	5.1%
	High	16.4%	16.5%	20.7%	18.0%
	(Total)	22.4%	20.5%	26.2%	23.1%
Informal	Low	56.1%	50.0%	42.8%	49.1%
	High	21.6%	29.5%	31.0%	27.7%
	(Total)	77.6%	79.5%	73.8%	76.9%
No. of observations[c]		6,784	8,522	9,926	25,232

Notes: [a]See Section 2.2 for informal employment definition used; [b]Based on educational attainment, with High depicting those with 12 years of schooling; [b]Derived from all three waves - IFLS 2000, 2007 and 2014; [c]Number of observations used in each IFLS wave and all three waves combined under Overall.

First, we focus on the overall sample (in the column "Overall"). The (overall) shares of each type are: 5.1% for formal-low, 18% for formal-high, 49.1% for informal-low, and 27.8% for informal-high – implying about 77% of labour is informal. Note that the informal-low type represents the largest share of the labour force, amounting to almost 50% of working age population (with 25,232 observations across the three IFLS waves). In contrast, most formal workers are high skill (completed high school) representing 18% of the sample, with only about 23% of total employment being formal.

Next, we compare the results from the different IFLS waves. Table 1 indicates that informal employment increased by about 2 p.p. between 2000 and 2007 (to almost 80% of the sample) but overall, there has been a (rather small) decline in informal employment by 3.8 p.p. between 2000 and 2014. This demonstrates the "persistent" property of informal employment. However, the skill composition of the labour force, and particularly of informal workers, has changed significantly in the same period from 2000 to 2014. As shown, the share of the informal-high type has increased by almost 10 p.p. in 2014, compared to 2000. The share of all high skill (in both formal and informal employment) has increased to over 50% of the sample in 2014, from about 38% in 2000. The cohort-specific analysis of the composition of Indonesia's labour force (which is not shown here but can be provided upon request) shows that the increase (in the proportion of high skill in the population) is particularly significant for young cohorts – who gain education and yet often still remain in informal employment.

2.5 Earnings, productivity and labour supply

Above, we have shown persistently large informal employment in Indonesia. In this subsection, we document the labour earnings, hours worked and labour productivity of the sample

over the working life cycle. These lifecycle variables are plotted in Figure 1 for the four (employment-skill) types of workers, with the mean observations (depicted by markers) and quadratic (in age) estimates (depicted by lines). The labour earnings variable (for each individual in the sample) is constructed as the total of salary (bonus included) from the main job and extra jobs (if any) or the net profit from an own-farm or non-farm business.[13] Labour supply is defined as hours worked per year (normalised by annual time endowment of 5,460 hours per year) and labour productivity as earnings per hour worked.[14]

In Figure 1(a), we plot labour earnings (ln of annual male earnings across the three IFLS waves) over the ages of 20-54 for formal types and 20-60 for informal types, with all the profiles normalised by earnings (ln of annual labour earnings) of the informal-low type aged 20 (=15.58). The objective is to compare life cycle earnings across the four types of workers. As shown by the figure, individuals in formal employment have significantly higher earnings compared to those operating in informal employment. The slope of the earnings profile for formal workers is steeper over early working years, increasing more significantly than for informal workers, who, on average, experience gradually declining earnings at older ages. The skill type also matters, as high skill types are shown to earn significantly more than low skill types. For example, Figure 1(a) shows that the formal-high type workers in the age group 50-54 earn on average about eight times more than the informal-low type workers of the same age group.
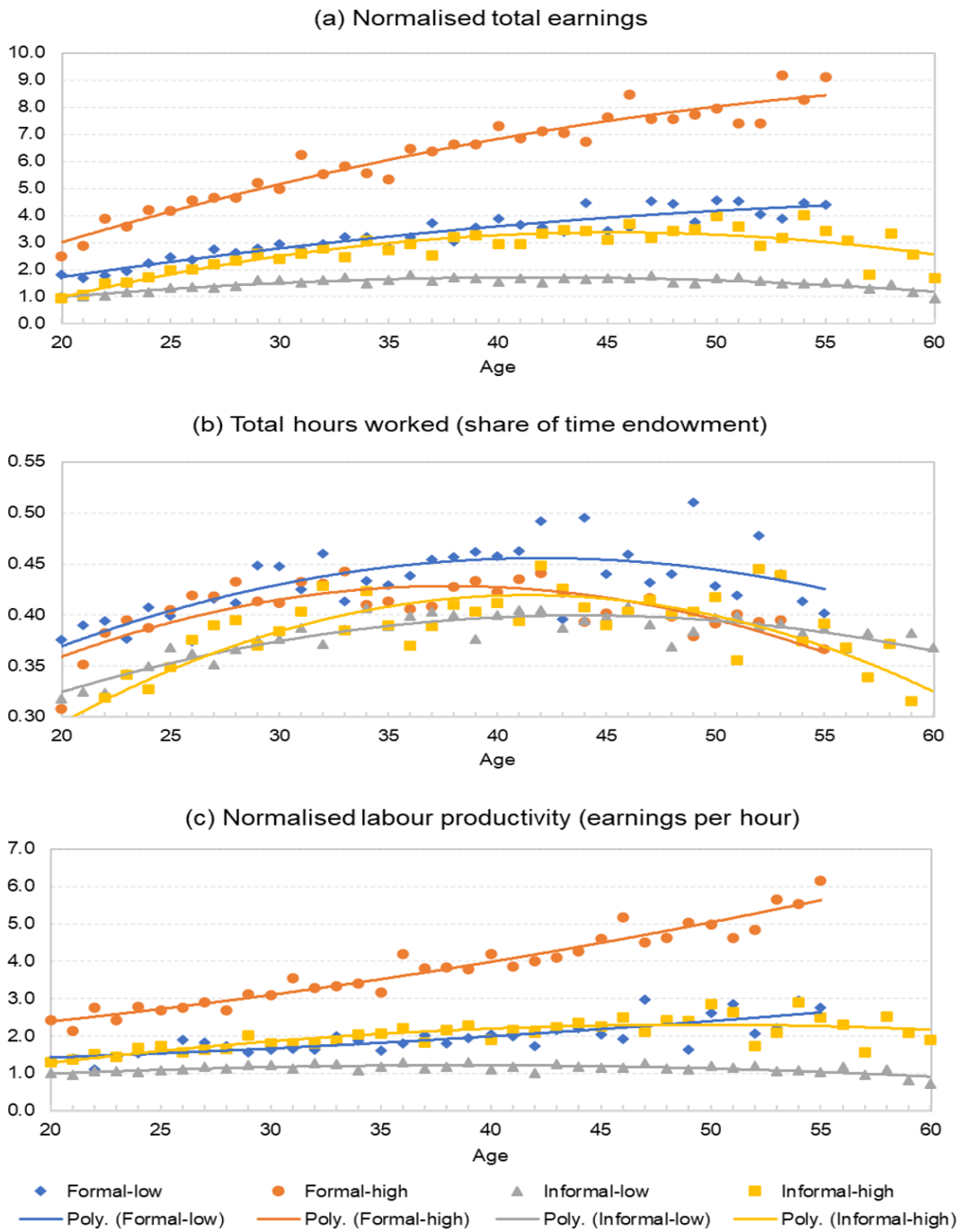
As indicated by Figure 1(b), one of the reasons for high earnings inequality is lower (average) hours worked by informal workers. We can show that by restricting our data sample (i.e., excluding those with low and irregular hours worked) average hours worked by informal workers increase significantly.[15] This implies that many informal workers work low and irregular hours. The differences in labour supply by employment-skill type worsens earnings inequality. As indicated in Figure 1(c), the labour productivity gaps are somewhat smaller than the gaps in total earnings, with labour productivity of formal-high types being up to 6 times higher than that of informal-low type.[16]

---

[13]By nature, a formal worker is mainly a wage worker, while an informal worker is usually self-employed. Note that for an informal worker, as they only report the net profit from their business (or their household business), it is difficult to distinguish between labour earnings and capital earnings. Therefore, we use the net profit in the calculations of their earnings in full. When pooling up data from different survey years, the Consumer Price Index (CPI) obtained from the International Financial Statistics (IFS) is used to construct real annual earnings.

[14]In the model developed in the next section we use the labour productivity profiles (and the stochastic process) as inputs for calibrating household life cycle decisions but also target the model-generated earnings and hours by age and employment type to data provided in this sub-section.

[15]This empirical investigation using alternative data samples is available from the authors upon request.

[16]Recall that we define high skill as those with 12 years of schooling, which is different to the definition of high skill in the developed economy context that counts those with tertiary education as high skill (e.g.,

(a) Normalised total earnings

(b) Total hours worked (share of time endowment)

(c) Normalised labour productivity (earnings per hour)

Legend:
- Formal-low (blue diamond)
- Formal-high (orange circle)
- Informal-low (grey triangle)
- Informal-high (yellow square)
- Poly. (Formal-low) — blue line
- Poly. (Formal-high) — orange line
- Poly. (Informal-low) — grey line
- Poly. (Informal-high) — yellow line

Source: IFLS 2000-2014.

Figure 1: Labour earnings, supply and productivity by age and employment-skill type

We have also calculated the variance of log productivity by employment type.[17] Note that the variance measure (of labour productivity uncertainty) is higher for informal workers.

2.6   Employment transitions

In this subsection, we investigate sectoral (or employment type) transitions for those between waves 2007 and 2014 and their labour earnings observed in 2014. We keep only people who appear in the two consecutive survey years. Table 2 reports the results for selected age groups (of males) using either those in formal or informal employment in 2007 and their employment type observed in 2014. The transitional probabilities are presented as a percentage of those in each category (formal and informal) staying in that category or moving to the other category in 2014.[18] Their average annual labour earnings are observed in 2014 and reported in units of 1,000 Indonesian Rupiah (IDR).

---

bachelor's degree and above). Using that definition, both earnings and productivity gaps (by this socio-economic status) would be much higher.

[17]Given the 7-year gaps between the IFLS surveys, we use the cross-section data across the IFLS 2000, 2007 and 2014 waves, but here we use main job (MJ) earnings and hours (rather than all job (AJ) earnings and hours used above in Figure 1).

[18]Note that the third category (not reported in Table 2) is all those with no job or low hours worked (see the data selection), which is also included in the transitional probability matrix. Note that the reported percentages do not add to 100%, with the remaining percentage (to 100%) representing those either in formal or informal in 2007 moving to "no job" category.

Table 2: Employment transitions and earnings (males, selected age groups)

Employment in 2007	Age group in 2007	Employment in 2014[a]		Labour earnings in 2014[b]	
		Formal	Informal	Formal	Informal
Formal	25-29	61.4%	34.9%	48,418	29,484
	30-34	72.4%	24.1%	52,984	27,418
	35-39	73.6%	25.0%	51,785	34,331
	40-44	68.8%	27.6%	61,314	31,021
	45-49	77.6%	18.7%	69,243	23,654
	50-54	29.8%	56.1%	62,483	29,771
	25-49	69.8%	27.1%	55,540	29,782
Informal	25-29	17.2%	75.0%	33,716	21,644
	30-34	11.5%	80.5%	35,916	19,338
	35-39	10.3%	82.9%	40,163	20,139
	40-44	6.9%	84.5%	32,497	18,123
	45-49	5.6%	86.3%	31,847	17,349
	50-54	3.5%	86.6%	22,692	13,974
	25-49	11.1%	81.1%	35,234	19,526

Notes: Using IFLS in 2007 and 2014, we calculate (a) transition probabilities (percentage of those in given employment in 2007 staying in that employment or transitioning to different employment in 2014 (note that remaining percentage to 100% represents those with no job or low hours (not displayed)) and (b) their average annual labour earnings in 2014 expressed in units of 1,000 Indonesian Rupiah (IDR).

Several observations can be drawn from Table 2. First, focusing on those of primary working ages 25-49, we show that only a small fraction of informal workers are moving to the formal sector, with only about 11% of those in informal employment in 2007 switching to formal employment in 2014. However, the proportion of workers moving from formal employment to the informal sector was higher (about 27%, as shown in the table).[19] Second, the probability of those in either formal or informal employment in 2007 staying in that employment in 2014 increases for older age groups. For example, informal workers aged 25-29 stay in that sector in 2014 with probability of about 80%, while for those aged 45-49, it is only about 5% who moves to formal employment. For formal workers aged 25-29 in 2007, the probability of staying in that employment is about 61%, while the probability goes up to 76.5% for those aged 45-49 in 2007. However, for older formal workers (aged 50-54 in 2007) who stay in the workforce (aged 57-61) in 2014, the probability of moving to informal employment increases significantly to over 56%.

---

[19]Note that we focus on cohorts of prime working age 25-49 (rather than those up to 54). This is because the waves are 7 years apart and the formal retirement age was 56 for the IFLS wave conducted in 2014 – effectively forcing many formal workers older than 50 in 2007 to move to no job category or to informal employment.

Table 2 also shows that the stayers (in formal employment) have significantly higher earnings compared to the movers at every age, and that the gap between their earnings widens by age. However, the movers from informal employment are shown to have higher earnings than the stayers. While the gap between earnings increases initially, it declines at older ages. The significantly higher earnings in formal employment seem to support the ILO's view that "most people enter (or transition out of formal employment to) the informal economy not by choice, but as a consequence of a lack of opportunities in the formal economy and in the absence of other means of livelihood" in developing countries.[20]

We now turn to the model structure.

3   The model

In this section, we formulate a stochastic general equilibrium model, which consists of overlapping generations of heterogeneous households (by sectoral and educational attainments), profit-maximizing firms, a government sector with taxation and PAYG public pensions applicable to formal labour. The model incorporates many features of the OLG model developed Song et al. (2015) for China, but it is extended here to incorporate formal and informal labour facing stochastic labour productivity and different policy rules. The model is calibrated to Indonesia, where around 80% of total employment is informal.

We first provide a non-technical overview of our overlapping-generations-for-emerging-economy (OLG-EE) model, followed by a detailed description of each of the sectors of the model, and the model equilibrium with market clearing conditions.

3.1   Overview

We construct an OLG model with formal and informal labour (or employment type) where agents face uncertain labour earnings and lifespan over the life cycle. It is a general equilibrium model that consists of a household sector (with formal and informal workers), a production sector (that demands labour and capital from all types of workers) and a government sector (with government tax and pension policy).

The household sector is populated by overlapping generations of heterogenous households.[21] Hence, the model accounts for both inter-generational as well as intra-generational heterogeneity. Specifically, in this early version of the model, there are 16 overlapping generations (representing age cohorts 20-24, 25-29,...., 95-99) in each time period, with each generation consisting of 4 types of households – formal low-skill, formal high-skill, informal

---

[20]See page 1 (Preamble) of ILO Recommendation R204 (2015), available at: https://www.ilo.org/dyn/normlex/en/f?p=NORMLEXPUB:12100:0::NO::P12100_ILO_CODE:R204

[21]Note that the terms – workers, households, agents and individuals frequently used in this section are interchangeable.

low-skill and informal high-skill types. When entering the model, each individual is assigned a permanent skill type and faces stochastic labour productivity (differentiated by household type) and survival over the life cycle.[22] Households are assumed to make rational decisions about their consumption and savings, and about leisure, labour supply and retirement, accumulating financial assets over their life cycle. Their optimization problem is to maximize their expected discounted lifetime utility derived from consumption and leisure, and bequests (left upon death) subject to their budget and time constraints. Hence, the model incorporates the precautionary-saving, intended bequest and saving-for-retirement-consumption motives (to save), differentiated by the household types.

The model incorporates the formal and informal types of households that face different government policy rules.[23] Their labour supply is elastic, both types of workers making labour-leisure and retirement decisions. Only the formal workers are subject the retirement age set at $j_R = 8$ (55-59 age group). After that age, these households could continue to work, but their labour productivity is assumed to drop to the productivity of the respective skill type of those in informal employment.[24] In the benchmark model, we assume that only the formal high-skill type ($\approx 18\%$ of the workforce) participates in public PAYG pensions, paying the contributions and collecting public pensions from j_R. All informal workers (as well as formal low-skill workers ($\approx 5\%$ of the workforce)) do not receive any public benefits in the benchmark model, and so they rely on their private resources, including labour earnings and transfers at older age. However, the government tax policy largely exempts informal workers from any taxation. In the model, we do this by modelling progressive earnings, capital income and consumption expenditure tax functions, with those with low incomes and consumption hardly paying any tax.[25]

---

[22] Note that in this OLG-EE model version, the benchmark economy does not allow for the choice between formal and informal employment, assuming perfect labour market frictions in the economy. As a sensitivity check, we plan to relax these (perfect) labour market frictions and model this choice (still subject to strong labour market frictions which we observe from the IFLS), based on, for example, Esteban-Pretel and Kitao (2021), with the choice partially impacted by government policy.

[23] As discussed in the previous section, our definition of informal labour (or informal employment) follows the widely used definition by ILO (2018) that classifies all own-account employers and all contributing family members as being in informal employment and for employees to be considered as informal, the employment relationship should not be subject to national labour legislation, income taxation, social protection or entitlement to certain employment benefits. Drawing on the IFLS data, we use any medical spending and health insurance benefits from employers as the policy defining informal employees. Note that this narrower definition underestimates the size of informal employment, but only by about 5 p.p., with recent estimates using a broader definition by ILO (2018) for Indonesia showing over 80% of the workforce being informal (using the broader definition, i.e., also including social security contributions).

[24] This is to account for the observed transition to informal employment around retirement (pension access) age but earning much lower labour income, as indicated in the previous section.

[25] We see this as a stylized fact in emerging Asia, where goods produced for informal sales (on the side of the road) are low costs and would not be taxed. This type of consumption expenditure can be made by both informal and formal labour, and the same applies for formal goods (of higher values) that can be purchased also by informal workers, but much less frequently than by formal workers. In the benchmark model, we do not model two consumption goods, but we account for this heterogeneity indirectly through

The production sector consists of representative (perfectly-competitive) firms demanding labour and capital from both formal and informal workers to produce a single output good, according to the standard Cobb-Douglas production function. Solving the firms' profit maximization problem then determines factor prices – the wage and interest rates. Hence, there is a common final consumption good produced that is then consumed by formal and informal household types.[26]

The government faces a budget constraint that, on one side, includes revenues from taxing incomes and consumption of largely formal households and, on the other side, expenditures on government consumption and interest on government debt. The income tax is progressive with the taxable income including labour earnings and pension incomes. The model also features progressive capital income and consumption taxation, each with the given flat tax rate and exemption. For example, the consumption tax revenue is collected from imposing a flat consumption tax rate on consumption expenditure above a certain threshold. Hence, the price of consumption is lower for most informal workers, with many paying no consumption tax.

The government also runs a PAYG public pension system with defined benefit pensions based on former earnings applicable only to formal-high skill workers. The benefits are PAYG financed by payroll taxes imposed on the current formal-high skill workers. In the benchmark economy, all other types of workers pay no or low taxes but also do not receive any public benefits at older age – hence relying on their earnings, asset income and bequest receipts (redistributed within the employment-skill type, and also to older cohorts).

The benchmark model assumes the closed economy market structure with no foreign debt and trade balance, but with endogenous factor prices (i.e., the wage and interest rates) set to their respective marginal products. When studying the proposed pension reform, we also consider the small open economy framework, with the foreign sector but with exogenous (and unchanged) factor prices.

We now proceed to providing the details for the demographic structure, the sectors and the equilibrium of the proposed OLG-EE model.

3.2 Demographics and distributional measure of households

The model economy is populated by overlapping generations of heterogeneous households with age $j \in \mathcal{J} = \{1, .., J\}$. Upon entering the model at the beginning of $j = 1$, each

---

progressive taxation, with exemptions that, for example, in relation to consumption, imply (mainly low value) consumption spending of informal workers is largely untaxed.

[26] As one of the robustness checks, we consider an alternative approach, drawing on entrepreneurs models (e.g. Kitao (2008), Fehr and Hofbauer, 2016) where we model all informal labour as self-employed working for and investing in their business. We show that the examined policy changes generate outcomes that are qualitatively the same and quantitatively very similar to those derived from the model described in this section.

household is assigned a permanent household (employment-skill) type $s \in \mathcal{S} = \{1, .., S\}$ according to the probability distribution ϖ_i.[27] The model assumes a stationary demographic structure with a constant population growth rate n and lifespan uncertainty given by survival probabilities ψ_j – conditional probabilities of surviving from age $j - 1$ to age j with $\psi_1 = 1$ and $\psi_{J+1} = 0$.[28]

Households make consumption and saving, labour supply and retirement decisions. These decisions depend on the available resources, the existing tax and pension systems, and also on the current and expected future labour productivity $\eta_j \in \mathcal{E}$. The workers in both formal and informal employment supply labour, receiving different effective wage rates, with their respective labour productivities estimated from the IFLS data. We assume that formal workers at age j_R face significant declines in their productivity, now set to that of informal employment. They can work past j_R but fund their consumption mainly from their savings and pension benefits (paid only to formal high-skill households up to their maximum age J). Formal workers are subject to government tax and pension policy, while informal workers solely rely on their private resources, including labour income, private assets, and transfers.

Consequently, a household faces the following state vector:

$$z_j = (j, s, a_j, ep_j, \eta_j) \in \mathcal{Z} = \mathcal{J} \times \mathcal{S} \times \mathcal{A} \times P \times \mathcal{E}$$

where $a_j \in \mathcal{A} = [0, \infty]$ denote *current* total assets that are initially zero ($a_1 = 0$) and restricted throughout the whole life cycle to be non-negative, i.e., households might be liquidity constrained. As indicated above, until reaching retirement age j_R, formal workers (of high-skill type) accumulate earnings points $ep_j \in P$ which determine their pension benefits. All workers also receive productivity shock at each age j, which follows a skill-specific finite-state Markov process.

The population is fragmented into subgroups $\zeta(z)$, according to the initial distribution at age $j = 1$, as well as mortality, population growth, the Markov processes and optimal household decisions. Let $X(z)$ be the corresponding cumulated measure to $\zeta(z)$. The initial distributional measure of households at age $j = 1$ is then

$$\int_{\mathcal{I} \times \mathcal{E} \times \mathcal{S}} \mathrm{d}X(z_1) = 1 \qquad \text{with} \quad z_1 = (1, s, 0, 0, \eta_1) \tag{1}$$

with the cohort size of newborn households normalised to be unity. Let $\mathbf{1}_{k=x}$ be an indicator function that returns 1 if $k = x$ and 0 if $k \neq x$. Then the law of motion for the measure of

---

[27] As already indicated, there are 4 types of households in the model – formal-low, formal-high, informal-low and informal-high skill types, with the labour force composition and labour productivity estimated using the IFLS 2000-2014.

[28] Note that in Section 6 we examine the effects of demographic transition, the model is fitted to changing demographics – population growth rate n_t and survival probabilities $\psi_{j,t}$ over time.

households follows

$$\zeta(z_{j+1}) = \frac{\psi_{j+1}}{1+n} \int_{\mathcal{Z}} \mathbf{1}_{a_{j+1}=a_{j+1}(z_j)} \times \mathbf{1}_{ep_{j+1}=ep_{j+1}(z_j)} \times$$
$$\times \pi(\eta_{j+1}|\eta_j) \mathrm{d}X(z_j), \tag{2}$$

where $\pi(\cdot)$ denotes the transition probabilities for labour productivity of workers (of each skill type) from one period to the next.

Note that in the model description provided below, the state index z is omitted with households distinguished only according to their age j (and for the employment-skill specific parameters by household type s).[29]

3.3 Household sector

Preferences Households (of types s) have preferences over streams of consumption c_j and leisure $1 - l_j$ (where l_j is labour supply with time endowment normalized to one) and also bequests (or transfers) left, if not survive to age $j + 1$.[30] The expected discounted lifetime utility function is additively separable and given by:

$$E\left[\sum_{j=1}^{J} \beta^{s,j-1} \left(\prod_{i=1}^{j} \psi_i\right) \left\{u(c_j, 1 - l_j) + \beta^s(1 - \psi_{j+1})\mathcal{B}(\bar{b}_{j+1})\right\}\right], \tag{3}$$

where we assume the standard Cobb-Douglas period utility form of

$$u(c, l) = \frac{\left((\frac{c}{\mu_j})^{\gamma_j^s}(1 - l)^{1 - \gamma_j^s}\right)^{1 - \sigma}}{1 - \sigma},$$

and the bequest function given by

$$\mathcal{B}(\bar{b}) = q_1 \left[1 + \frac{\bar{b}}{q_2}\right]^{1 - \sigma_b},$$

where any future annual utility $u(c_j, 1 - l_j)$ (assumed to be of the standard Cobb-Douglas utility specification) is discounted by the type-specific discount factor β^s and uncertain survival to future years $\left(\prod_{i=1}^{j} \psi_i\right)$. The utility function parameters include the coefficient of relative risk aversion σ, the expenditure share of ordinary consumption γ_j^s (note that this

---

[29] Since in this section, we focus on the benchmark steady state solutions, we also omit time periods t in the state index above. For the transition path analysis, time periods are included the state index z.

[30] In this subsection, we will omit the state index z for every variable, and households are only distinguished according to their age j. Since some parameters describing household preferences and in households' optimization problem are also household type specific, we indicate these parameters by including the household type s.

parameter is household type- and age-specific, calibrated to match observed labour supply profiles by household type in the IFLS data), equivalence scale parameter μ_j (that accounts for changing household composition over the life cycle and the number of dependents). The bequest motive function follows De Nardi (2004), with the term q_1 reflecting the parent's concern about leaving bequests, q_2 measuring the extent to which a bequest is a luxury good (i.e., indicating that bequests are less likely to be made by those in informal employment) and σ_b governing the relative risk aversion for the bequest. Bequests (that are also skill specific) are equal to assets $(\bar{b}_{j+1} = (1+r)a_{i+1})$ left by those agents who do not survive to $j+1$.

At the beginning of each period, each worker with assets a_j and bequest transfers $\bar{b}_j$ (and earning points ep_j only for formal workers) realizes the current productivity level η (also skill-specific) and then decides on consumption, savings, labour supply at age j and when to retire. In what follows, we describe the optimization problem of a household type s.

Households' problem The optimization problem (i.e., value function maximizations subject to per-period budget and time constraints) can be expressed as

$$V_j = \max_{c_j, l_j, a_{j+1}} \left\{ u(c_j, l_j) + \beta^s \left(\psi_{j+1} E_j \left[V_{j+1} | \eta \right] + (1 - \psi_{j+1}) \mathcal{B}(\bar{b}_{j+1}) \right) \right\} \tag{4}$$

subject to the constraints (distinguished by formal and informal employment)

$$a_{j+1} = \begin{cases} (1+r)a_j + \widetilde{y}_j + b_j + p_j - T^y(\widetilde{y}_j) - T^r(\widetilde{a}_j) - (c_j + T^c(\widetilde{c}_j)), & \text{if formal,} \\ (1+r)a_j + y_j + b_j - c_j, & \text{if informal,} \end{cases} \tag{5}$$

$$c_j > 0, 0 \le l_j \le 1, a_{j+1} \ge 0,$$

and $a_1 = 0$. The expectation operators E_j in equation (4) are with respect to the stochastic processes of η. According to the per-period budget constraint (4) for formal workers, future assets a_{j+1} are derived from current assets (including interest income), gross labour income (net of PAYG pension contributions paid the rate of τ^p up to the contribution ceiling of $3\bar{y}$ – three time average economy-wide labour earnings) $\widetilde{y}_j = y_j - \tau^p \min[y_j; 3\bar{y}]$, bequests b_j and pensions p_j less progressive income taxes $T^y(\cdot)$, capital income taxes $T^r(\cdot)$ and consumption expenditure (including consumption taxes, $T^c(\cdot)$).[31] Note that gross labour income equals $y_j = we_j\eta \, l_j$, where w is the economy-wide wage rate (normalized to one in the benchmark), age- (and household type-) specific labour productivity $e_j\eta$ and labour supply l_j. Labour productivity consists of the deterministic part e_j per time unit and the transitory component η_j that evolves stochastically over time according to an AR(1) process.[32] Consumption and

---

[31]Taxation and pension benefits are discussed in more detail in the government sub-section below.

[32]Specifically, the transitory component is assumed to have an AR(1) autoregressive structure:

$$\eta_j = \rho\eta_{j-1} + \epsilon_j \quad \text{with} \quad \epsilon_j \sim N\left(0, \sigma_\epsilon^2\right) \quad \text{and } \eta_0 = 0,$$

leisure have to be positive, with the latter $(1 - l_j)$ restricted by 20 discrete labour supply options equally spaced between 0 and 1.[33] Finally, we do not allow for negative assets, with the borrowing constraint $a_{j+1} \geq 0$ imposed on all households.[34]

3.4 Production sector

The production sector is characterized by an aggregated firm (representing a large number of perfectly-competitive firms) that demands capital K and effective labour L from both formal and informal households to produce aggregate output good Y, according to the Cobb-Douglas production technology:[35]

$$Y = \kappa \left(K \right)^{\alpha} \left(L \right)^{1-\alpha},\tag{6}$$

where α denotes the capital shares in production and κ is the productivity constant. Capital is rented from households at the riskless rate and depreciates at the depreciation rate δ.

The factor prices – wage rate w and interest rate r – are determined competitively by their respective marginal productivity conditions:

$$w = (1 - \alpha)\kappa \left(\frac{K}{L} \right)^{\alpha},\tag{7}$$

$$r = \alpha\kappa \left(\frac{L}{K} \right)^{1-\alpha} - \delta.\tag{8}$$

This approach of the production sector modelling is traditionally applied in developed-country OLG models. However, in our emerging economy model, we account for employment-specific inputs to the production, and as shown in the previous section, these differ significantly by employment type (e.g., formal-high types with much higher labour productivity compared to informal workers).[36]

There are alternative approaches for modelling the production sector that could be applied to emerging Asia. First, one could draw on the entrepreneurs OLG models (e.g., Kitao (2008) and Fehr and Hofbauer (2016)) and as mentioned above, we consider this approach in

---

where ρ is the persistence parameter and ϵ_j is the innovation of the process. The idiosyncratic innovation term ϵ_j is normally distributed with mean zero and variance, σ_{ϵ}^2. Note that ρ and σ_{ϵ}^2 are also skill-specific, but to simplify the expression we do not include the state s.

[33]Note that the model can be solved for leisure/labour also as a continuous choice, with leisure constrained by $0 \leq l_j \leq 1$.

[34]Note that in the quantitative analysis section one of the counterfactuals introduces social pensions sp for informal households aged $j \geq 65$, which means that the budget constraint for informal households would need to include sp, with the aggregate expenditure on social pensions also included on the expenditure side of the government budget discussed in the government sector subsection below.

[35]As one of the sensitivity checks, we also consider an alternative approach of modelling the production sector, drawing on entrepreneurs models (see below).

[36]Note that we can calculate the output produced by formal inputs, which, in our benchmark economy, is about 40% of overall output (despite only about 20% of workers being formal). In Loayza and Meza-Cuadra (2018), the share of formal output in Indonesia is even higher, estimated at about 46% in 2019.

the sensitivity analysis. More specifically, all informal workers are treated as self-employed with the full income earned from both labour and capital included in their budget constraint (5). In this framework, total output then consists of output from to the formal sector production and informal output (produced by self-employed). As in the benchmark OLG-EE model, here we also abstract from the sectoral choice (with the same household distributions as in the benchmark model), but we model investment choice by informal households who now could invest in their business or into the formal sector capital stock (as it is assumed in entrepreneurs OLG models).

Second, one could follow Jung and Tran (2012) who employ a two-sector economy, represented by formal and informal firms both with different technologies (with now sector-specific productivity and capital share parameters). Note that in Jung and Tran (2012), the factor prices (the interest and wage rates) cannot change unless any production sector parameter and/or the corporation tax rates change. For most of their simulations, the results relate only to partial equilibrium effects (with constant factor prices).

Third, one could also use the approach in OLG models with different production sectors and world regions (e.g., Fehr et al. 2009). These models account for different consumption bundles, also distinguishing different consumption and producer prices. More specifically, Fehr et al. (2009) assume six different goods, some traded and some non-traded goods, and with six different sets of prices of goods, but with one wage rate and one interest rate. The issue with this approach is that its complexity makes the policy results hard to explain and, more importantly, such modelling restricts general equilibrium and behavioural effects of a policy change.

We instead model one output (and so one consumption) good, but with the model capturing closely life-cycle economic behaviour of households (estimated from the IFLS data), which is impacted by government policy differentiated by employment type. We argue that this approach approximates heterogeneity in consumption, with informal labour mainly consuming low-price consumption goods, which are not taxed.

3.5 Government sector

The government is responsible for collecting revenues from taxing households' labour income, capital income and consumption (all paid mainly by formal workers), in order to pay for its general consumption and interest on government debt. It is also responsible for regulating the PAYG pension system with payroll taxes financing public benefits (in this benchmark model, only applicable to formal-high type workers). The modelling of fiscal and pension policies is described in more detail below.

PAYG financed pensions   We assume a PAYG financed pension system, so that contributions (of those in formal high-skill employment) are directly used to finance benefits of

(the formal high-skill) pensioners. The payroll tax rate is levied on labour income of formal high-skill workers, up to the contribution ceiling of $3\bar{y}$.[37] The resulting contributions are used to update the so-called earning points ep (that are used to link pension benefits to former earnings):

$$ep_{j+1} = ep_j + \min\left[\frac{y_j}{\bar{y}}; 3\right] / (j_R - 1),\qquad(9)$$

where $\bar{y}$ is the average economy wide earnings level of the working age population (in our case of those aged 20 to 54).[38] After reaching the retirement age j_R, pension benefit p is computed as the product of the accumulated earning points ep and the so-called pension value with the benefit amount for each individual earning point. For simplicity, we define the pension value as a fraction κ of average income $\bar{y}$, so that the pension benefit (for formal high-skill households only) is given as

$$p = ep \times \kappa \times \bar{y}.\qquad(10)$$

This also implies an intra-generationally fair formal pension system, with little redistribution within the cohort.[39]

The total expenditure of this public pension program[40] is given by

$$P_A = \sum_{j \geq j_R}^{J} \int_{\chi} p(z) dX(z).$$

Finally, the budget constraint of this pension system (in the benchmark applied to formal high-skill households only) balances aggregate benefits P_A by endogenous payroll taxes at the rate τ^p levied on the contribution base CB, i.e.

$$\tau^p CB = P_A \qquad \text{with} \qquad CB = \sum_{j=1}^{J_R-1} \int_{\mathcal{Z}} \min[y(z); 3\bar{y}] dX(z).\qquad(11)$$

Taxes The government collects taxes to finance its spending programs. Specifically, it collects taxes from taxing households – their labour earnings, capital income, and consumption. The model incorporates separate progressive tax policies impacting labour income, capital income, and consumption expenditure (but even in relation to consumption only applied to formal workers).

---

[37]This is based on OECD (2018) data for Indonesia.

[38]Note that those formal workers earning average income $\bar{y}$ get 1/8 for each year in the formal sector, hence for them $ep_j = 1$ at $j \geq JR$. Further note that this formula can be easily changed so that the benefit is completely flat (independent of formal earnings).

[39]Note that this formula can be easily adjusted to allow for more redistribution within the cohort, assuming, for example, the bend points formula calculating old age social security benefits for the US retirees (see Kitao, 2014; Hosseini and Shourideh, 2019).

[40]We use a scaling pension parameter that is calculated so that we match the observed ratio of the public pension expenditure to GDP (P_A/Y). This is discussed in more detail in the next section.

The household's taxable labour income $\tilde{y}$ (which includes labour earnings net of payroll tax up to the contribution ceiling) is taxed under the 2017-18 progressive income tax schedule $T(\tilde{y})$, i.e.,

$$\tilde{y} = y - \tau^p \min[y(z); 3\bar{y}]. \tag{12}$$

We assume that the capital income tax is collected on the household size rather than taxing the production sector. In the model, all household types are subject to capital income taxation, but we incorporate savings exemption $\bar{a}$ that is not taxed, effectively removing most informal household types from capital income taxation. The capital income tax function $T^r(\cdot)$ (with the flat capital income tax rate τ^r applied to taxable capital income above the savings exemption $\tilde{a}$) can be expressed as:

$$T^r(\cdot) = \begin{cases} 0, & ra(z) \leq \bar{a} \\ \tau^r ra(z), & ra(z) > \bar{a} \end{cases}. \tag{13}$$

Similarly, consumption taxation is imposed on all household types, but we incorporate consumption floor $\bar{c}$ that is not taxed, effectively removing most informal household types from taxation of their consumption. The consumption tax function $T^c(\cdot)$ (with the flat consumption tax rate τ^c applied to taxable consumption above the consumption exemption) is given as:

$$T^c(\cdot) = \begin{cases} 0, & c(z) \leq \bar{c} \\ \tau^c c(z), & c(z) > \bar{c} \end{cases}. \tag{14}$$

The government total tax revenue TR consists of revenues from the three different taxation sources: household income tax T^Y, capital income tax T^R and consumption tax T^C, with these government tax receipts expressed as

$$\begin{aligned} T^Y &= \int_{\mathcal{Z}} T^y(\tilde{y}(z))\mathrm{d}X(z) \\ T^R &= \int_{\mathcal{Z}} T^r(\tilde{a}(z))\mathrm{d}X(z) \\ T^C &= \int_{\mathcal{Z}} T^c(\tilde{c}(z))\mathrm{d}X(z). \end{aligned} \tag{15}$$

Budget balance   The government collects taxes in order to finance general government expenditure G and interest payments on its debt. In the steady state, the government budget constraint becomes

$$T^Y + T^R + T^C = G + (r - n)B_G, \tag{16}$$

where B_G denotes net government debt, r is the interest rate and n is the population growth rate.[41] and g is the technological growth rate.

3.6   Equilibrium

Given the government fiscal and pension policy, a stationary recursive equilibrium is a set of value functions $\{V(z_j)\}_{j=1}^J$, household decision rules $\{c_j(z_j), l_j(z_j), a_{j+1}(z_j)\}_{j=1}^J$, distribution of bequests $\{b(z_j)\}_{j=1}^J$, time-invariant measures of households $\{\zeta(z)\}_{j=1}^J$, such that the following conditions are satisfied:

1. households make optimal decisions by maximizing value function (4) subject to their respective constraints (5);

2. factor prices are competitive, determined by (7) and (8);

3. the aggregation holds

$$L = \int_{\mathcal{Z}} e_j \eta_j l_j(z_j) \mathrm{d}X(z_j)$$

$$C = \int_{\mathcal{Z}} c(z_j) \mathrm{d}X(z_j)$$

$$A = \int_{\mathcal{Z}} a(z_j) \mathrm{d}X(z_j);$$

4. The laws of motion (1) and (2) for the measure of households hold;

5. bequests satisfy

$$\int_{\mathcal{Z}} b(z_j) dX(z_j) = \int_{\mathcal{Z}} (1 - \psi_{j+1}) \big[(1+r)(a_{j+1}(z_j)) \big] \mathrm{d}X(z_j); \tag{17}$$

6. the government budget (16) and PAYG pension budget (11) are balanced by choosing τ^c and τ^p, respectively[42];

---

[41]The model incorporates (exogenous) technological growth, $g > 0$. Hence, in the budget balance the expenditure side becomes $G + (r - n - g - gn)B_G$

[42]Note that in the initial steady state, we calculate fiscal adjustment parameters for the earnings tax, the capital income tax and the consumption tax as well as for the public pension expenditure to match the observed tax or expenditure ratio to GDP. Hence, for example, the consumption tax rate τ^c is the effective tax rate – the product of the statutory rate and the consumption tax adjustment parameter. More details on these fiscal adjustment parameters are provided in the calibration section. Further note that in the benchmark model, we adjust government consumption G to balance the government budget. Under each examined policy counterfactual, G is kept at the benchmark level and τ^c is used as the budget-equilibrating policy instrument.

7. the capital market clears:

$$K = A - B_G - B_F, \tag{18}$$

with net foreign debt $B_F = 0$ in the closed economy;

8. the goods market clears:

$$Y = C + (n + \delta)K + G + NX, \tag{19}$$

with net export $NX = 0$ in the closed economy and $NX = (n - r)B_F$ in the small open economy.[43]

4   Calibration of the benchmark model

The benchmark model economy is assumed to be in an initial steady state equilibrium, which is calibrated to Indonesia. The parameter values of the benchmark model are presented in Table 3.

---

[43] In the economy with technological growth $g > 0$, the steady state gross investment is $I = (n+g+ng+\delta)K$ and in SOE, net export is $NX = (n + g + ng - r)B_F$. Also the household budget constraints (5) would need to be augmented so that we now have $(1 + g)a_{j+1} = ...$

Table 3: Values of Main Parameters of Benchmark Model

Description	Value	Source
Demographics		
Population growth rate (% p.a.)	2.92	Calibrated[a]
Conditional survival probabilities	-*	Data[a]
Fraction of households of labour and skill types	-*	Data[b]
Utility function		
Coefficient of relative risk aversion	2	Literature[c]
Consumption weight parameter	-*	Data/Calibrated[b]
Subjective discount factor (p.a.)	[0.995; 0.99]	Calibrated
Household equivalence scale	-*	Data[b]
Bequest function parameters	-*	Literature[d]
Endowment and productivity		
Time endowment (hours p.a.)	5460	Assumed[e]
Labour productivity profiles	-*	Estimated[b]
Stochastic labour productivity process	-*	Estimated[b]
Technological growth rate (% p.a.)	2.05	Data[f]
Technology		
Production constant	1.50	Calibrated
Capital share	0.38	Calibrated
Depreciation rate (% p.a.)	3.7	Calibrated
Policy parameters		
(Formal) Pension benefit (% of ybar)	22.8	Data/Calibrated[g]
Pension access age (J_R)	55-59	Data
Pension contribution (or payroll tax) rate (%)	5.46	Data/Calibrated[g]
Labour earnings tax (progressive tax schedule)	-*	Data/Calibrated[h]
Capital income (corporate) tax rate (%)	20.99	Data/Calibrated[h]
Consumption tax rate (%)	9.49	Data/Calibrated[h]
Government debt to GDP (%)	31.37	Data

Notes: *See the text; [a]Demographic data based on UN (2019) for Indonesia 2020, with population growth rate calibrated to match the current old-age dependency ratio of 10.56%; [b]These values derived/estimated from IFLS 2000-2014. [c]This value is standard in related literature (e.g., see Kudrna et al. (2021)); [d]Parameterization of bequest function based on DeNardi (2004) and Cho and Sane (2013); [e]This represents 15 non-sleeping hours per day, in the model normalized to one; [f]Matching per capita GDP growth rate for Indonesia (World Bank, 2020); [g]Derived from OECD(2018); [h]Derived from IMF(2019).

Below, we provide the details of the benchmark model calibration to demographic, household survey and macroeconomic and fiscal data for Indonesia (with the parameter values in Table 3).[44] We also present and discuss the main life cycle and macroeconomic solutions of this benchmark model and provide comparisons with Indonesian data.

---

[44]Note that the model comes with the calibration database, which includes the spreadsheets with (and the description of) all the data used in calibrating the benchmark model (and in Section 6, incorporating the demographic transition). This database can be provided upon request from the corresponding author.

4.1 Demographics

Households become economically active at age 20 (representing age group 20-24 or the model age $j = 1$) when they are assigned a household type and face a random survival up to the maximum age of 99 (or age group 95-99) (represented by the maximum model age $J = 16$).[45] Hence, the model consists of 16 overlapping generations (or age cohorts), with each generation containing four types of households based on employment and skill type.

The demographic parameters include the life cycle survival rates, ψ_j, and the population growth, n, that both determine the age structure and size of the population. The survival rates are taken from UN (2019) for Indonesia (for a cohort of both sexes born in 2015-20). Note that they imply the life expectancy at birth of 71.4 years. The population (and steady state cohort) growth rate $n = 2.92\%$ p.a. is then calculated (calibrated) to target the old-age dependency ratio of 10.56% in 2020 (i.e., ratio of the population aged 65+ to the population aged 20-64).[46]

As for the household heterogeneity, the model targets the (average) intra-generational shares (by employment-skill type) (denoted by state s in the model description), derived from the IFLS 2000-2014. As reported in Section 2, these shares are: 5.1% for formal-low, 18% for formal-high, 49.1% for informal-low, and 27.8% for informal-high (implying 77% of labour being informal, which compares closely to over 80%, reported in ILO 2018).[47]

4.2 Endowments, preferences and technology

Endowments The model assumes the time endowment of 5460 non-sleeping hours per year (or 15 non-sleeping hours per day), that is normalised to one. Hence the impact on household labour supply discussed later in this section are presented as the fraction or share of time endowment spent working. The model also incorporates technological progress via the so-called time-augmenting progress with an exogenous growth rate, that (together with the population growth rate) determines the real GDP growth rate (of 5% according to World Bank (2020) data for the growth rate averaged over 2000-2019), with $g = 2.05\%$ in the model.[48]

---

[45] We plan to extend the model to incorporate the full life cycle of adult households (aged 20 to 100), hence to $J = 80$. For computational reasons (particularly for the transition path solutions), this initial version assumes 16 age groups.

[46] Note that $n = 2.92\%$ p.a. which is higher than the current growth rate of the Indonesian total population. Since we assume the steady state economy of this benchmark model, one should think of this rate averaged over last several decades.

[47] As discussed above, in this benchmark model we assume perfect labour market frictions preventing movements between the household types. As shown in the empirical section (using the IFLS), these frictions are important, but not perfect. We plan to relax these frictions and allow for the sectoral (i.e., employment type) transitions in a follow up paper.

[48] Note that the aggregate variables in the steady state equilibrium of the model then grow at the rate of $(1 + g)(1 + n)$.

Labour productivity estimated for each employment-skill type consists of a deterministic, age-specific part and a transitory component, which follows an AR(1) process. The estimates for a quadratic approximation of labour productivity (i.e., wage per hour, based on hours worked in all jobs), based on IFLS 2000-2014, were plotted in Figure 1(c) and discussed in Section 2. Here we provide only a brief summary of the main features. The formal-high types have significantly higher (and steeper) productivity than any other type. The formal-low and informal-high types have very similar labour productivity, while the informal-low type has very low (and almost flat) labour productivity. Those in formal employment face the retirement (from formal employment) age j_R, with their labour productivity assumed to be reduced to the level experienced by their respective skill type in informal employment. For those households in informal employment, we estimate their labour productivity to age 60 after which it is assumed to decline at a constant rate, reaching zero at the maximum age J (representing the age group 95-99). The stochastic component is calibrated to match the observed variance of log labour productivity over the working life cycle of 20-54 years.

Preferences The periodic utility in consumption and leisure is of the standard Cobb-Douglas functional form, with the consumption weight parameter γ (being calibrated for the model to approximate labour supply (hours worked) by age and employment-skill type. Note that we target average and lifecycle hours worked over ages 20-54 years for the four (intra-generational) types of households – formal-low, formal-high, informal-low and informal-high types. Following Imrohoroglu and Kitao (2009), the risk aversion parameter is set to $\sigma = 2$, implying the inter-temporal elasticity of substitution at $1/\sigma = 0.5$. The subjective discount factor β is employment specific, lower for the informal types, which are more time impatient. This parameter (i.e., discount factor for formal types) and the bequest motive parameter $q_1 = 3$ are calibrated for the benchmark model to approximate Indonesia's capital to output ratio of about 3.8 in 2018 (World Bank 2020).[49] The remaining parameters of the bequest function $q_2 = 10.6$ and $\sigma_b = 1.5$ are taken from De Nardi (2004) and Cho and Sane (2013).

Following Kaas et al. (2021) and Nishyiama and Smetters (2005), we also incorporate the household equivalence parameter μ, which is age-specific and derived from the IFLS 2000-2014 data. The objective is to account for a changing household size over the life cycle by incorporating the adjusted consumption (of dependents) in the utility function.

Technology The Cobb-Douglas functional form is also assumed for our production function. In this calibrated version of the model, we assume that there is only one aggregated sector that demands capital and labour from both formal and informal workers. The technology level of the Cobb-Douglas production function set $\kappa = 1.5$ is such that the wage rate is

---

[49]Note that the estimated ratio by Loayza and Meza-Cuadra (2018) for Indonesia in 2020 is $K/Y = 3.56$.

one in the benchmark economy. The income share of capital is set at $\alpha = 0.38$.[50] The depreciation rate of the capital stock is set to $\delta = 0.037$, (which together with the population and technological growth rates determines private gross investment, with the model targeting the private investment to GDP ratio of 0.338 (World Bank (2020) data for Indonesia 2018-19).

4.3   Government policy

As discussed, only the formal-high (skill) types of households are subject to formal pension policy, paying contributions during their working years and collecting pension benefits for $j \geq j_R$.[51] The pension benefits (for the formal sector workers) are set in the benchmark model to target the overall public pension expenditure to GDP at 1% (based on OECD, 2018). Note that we calculate a scalar (adjustment parameter) to match this ratio. The implied pension replacement rate is 22.8% of the average formal sector earnings.[52] The social contribution (or payroll tax) rate (that is imposed on labour earnings up to the ceiling of 3 times average earnings (OECD, 2018)) is determined endogenously to balance the PAYG public pension budget in (11). The resulting pension contribution rate is $\tau^p = 5.2\%$.

   In the benchmark model, we target the observed ratio of government debt to GDP ($g_y = 31.37\%$) (based on IMF (2019) Government Finance Statistics for Indonesia). The labour income taxation is subject to Indonesia's progressive income tax schedule. We use the near exact approximation of the schedule in 2017-18. Also, as already discussed, we calculate an income tax scalar (or adjustment parameter) for the benchmark model solution to match the observed personal income tax revenue at 0.85% of GDP in 2018-19 (IMF, 2019). Similar adjustment parameters for the capital income and consumption taxation are used to match the corporate tax revenue at 4% of GDP and the consumption tax revenue at 5% of GDP, respectively. For these revenues, we also use the statutory tax rates and the respective exemptions (of capital income and consumption expenditure that are not taxed), with the resulting effective capital income and consumption tax rate being $\tau^r = 20.9\%$ and $\tau^c = 9.5\%$ in the benchmark model. Finally, in the benchmark model we adjust government consumption to balance the government budget in (16).

---

[50]Note that the parameter α is used to target the interest rate r (of about 6% p.a. generated by this benchmark model).

[51]Note that this assumption (of removing formal-low types from the PAYG pension systems) closely representing the current Indonesian coverage by formal pensions (where only government workers and some private sector workers are covered by the public pension schemes). However, it has already been legislated that all workers in the formal sector to be (gradually) covered.

[52]This calibrated model does not account for any link of the pension benefit to former labour earnings. In the next version of the model, we plan to incorporate this feature. Note that this would require an additional state for earnings points, as indicated in the model description in the previous section. Further note that the earnings points can also be used to account for private or funded pensions (see Fehr et al. 2021). We could also incorporate a redistributive benefit formula such as the bend points formula used in calculating the US social security benefits (e.g., see Kitao 2014; Hosseini and Shourideh 2019).

## 4.4   Benchmark solution and Indonesian data

The benchmark solution is obtained by numerically solving the model for the initial steady state equilibrium, with the parameters and the government policy settings specified above. The model (for both long run steady state as well as transition path solutions) is computed in Fortran. We use the value function iteration procedure to solve the dynamic programming problem of the households and the Gauss-Seidel iterative method to solve for this benchmark steady state equilibrium (and all the counterfactuals). The Gauss-Seidel algorithm involves choosing initial guesses for some variables and then updating them by iterating between the production, household and government sectors until convergence (see Kudrna and Woodland (2011) and Fehr and Kindermann (2018) for more details).

The main model-generated results at both the household life cycle and aggregate levels (and how they compare to Indonesian data) are presented and discussed below.

Lifecycle household profiles   The benchmark solutions for selected life cycle household profiles are depicted by Figure 2. The figure includes average and employment-specific profiles of consumption (net consumption expenditure), labour supply (hours worked), total income (labour earnings, asset income, pension income and transfers), and total assets. The consumption, total income and assets are presented relative to the economy-wide average labour income, while the labour supply variable is measured as fraction of annual time endowment (of 5,460) (hence directly comparable to the IFLS targets in Figure 1(b)). In this section, we present average "formal" and "informal" values (by accounting for low and high skill type weights in each employment type) and overall "average" values generated by the benchmark model.

The age-profiles in Figure 2 exhibit standard hump-shape. For example, the age-profiles of household consumption in Figure 2(a) are increasing during working ages and then declining, with the shape reflecting the hump-shaped productivity profiles (in Figure 1(b)) (impacting labour earnings), the hump-shaped consumption preference parameter profiles[53], survival probabilities (that start declining significantly at older ages) and also the (undeveloped) government policy (with the mandatory retirement (from formal employment) age) and the transfers. The same features of the model impact labour supply plotted in Figure 2(b), where we target normalised hours worked during prime working years 20-54 from the IFLS 2000-2014 (presented in Section 2). The formal employment retirement age is set at the age group

---

[53]As discussed above, the shapes of the consumption weight parameter γ is estimated, using hours worked in all jobs for each employment-skill type (normalised by informal-low type at 20-24 and scaled up or down to match average hours worked by employment-skill type). The values of γ are reported in the calibration database that can be provided upon request.

| (a) Consumption | (b) Labour supply |
| (c) Total income | (d) Total assets |
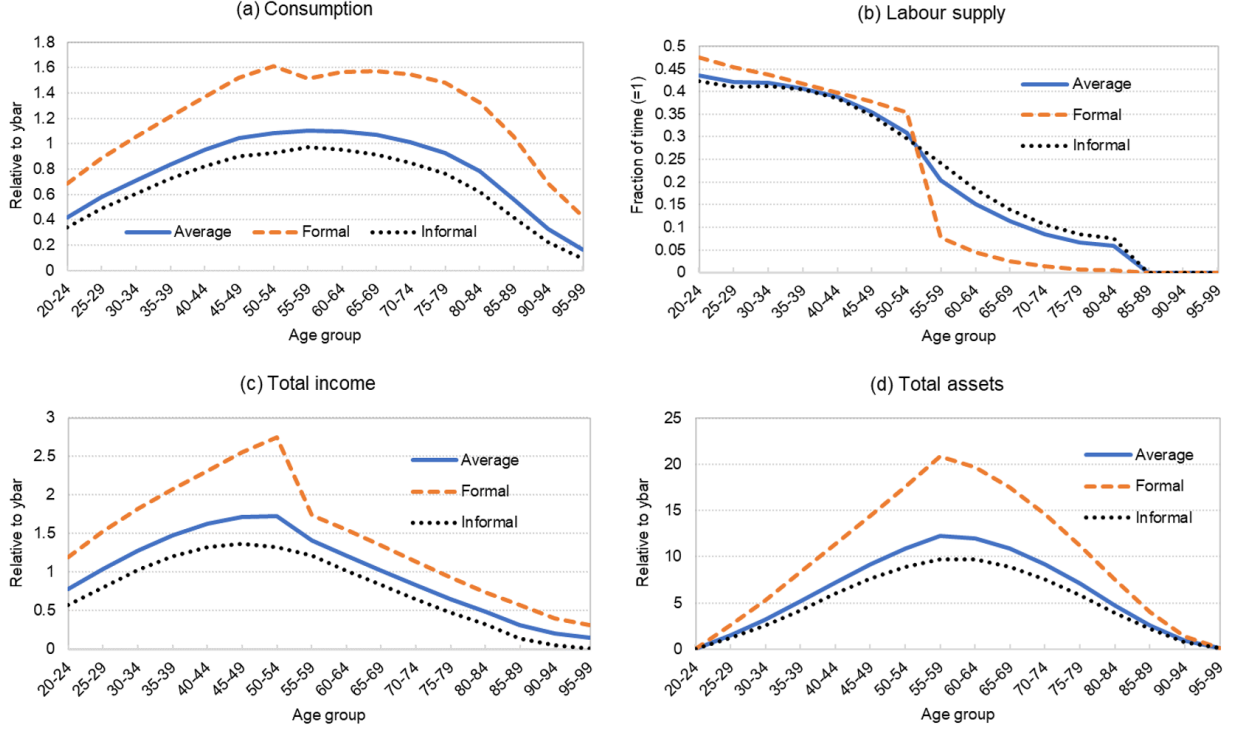
Notes: Benchmark model generated life cycle solutions distinguished by employment type and on average.

Figure 2: Benchmark model solutions over the life cycle

55-59 ($j_R = 8$) in the benchmark economy. At $j \geq j_R$, formal households are endowed with much lower productivity (set to informal employment productivity) and they also receive their public pension benefits. In particular, the former assumption has a significant impact on their labour supply, with labour supply (of formal workers) declining sharply at j_R, which has also been shown in Section 2, documenting the IFLS labour force data. Labour supply of informal workers at older ages is high, on average over 20% of their time endowment. There is significant gap between total income and assets between formal and informal employment types (as indicated in Figures 2(c) and 2(d)), and this gap further increases when comparing formal-high with informal-low skill types.[54]

Macroeconomic and fiscal data   The selected macroeconomic and fiscal variables (most of which are used as the calibration targets) generated by this benchmark model are presented in Table 4, which also provides comparison with Indonesian data (drawing on World Bank (2020), Loayza and Meza-Cuadra (2018) for macro targets, IFLS 2000-2014 for aggregated labour supply data, IMF (2019) for fiscal data and OECD (2018) for pension policy data).

---

[54]Note that we plan to extend our empirical analysis to also study the IFLS household asset questionaries, providing, for example, the total and financial asset age-profiles by employment-skill type.

Table 4: Comparison of Benchmark Solution with Indonesian Data

Variable	Benchmark model	Indonesia 2018-2019[*]
Expenditures on GDP (% of GDP)		
Private consumption	56.70	57.93
Investment	33.80	33.77
Government consumption	9.50	8.75
Trade balance	0.00	-0.49
Fiscal policy calibration targets (% of GDP)		
Public pension expenditure	1.00	1.00
Labour income tax revenue	0.85	0.85
Corporation tax revenues	4.00	4.00
Consumption tax revenues	5.00	5.01
Government debt	31.37	31.37
Macro calibration targets		
Capital-output ratio	3.76	3.82
Hours (average)	0.401	0.401
Hours (formal-low)	0.442	0.434
Hours (formal-high)	0.409	0.406
Hours (informal-low)	0.379	0.379
Hours (informal-high)	0.388	0.387

Sources: *Aggregate demand data are derived from World Bank (2020) data for Indonesia 2018-19; Pension expenditure is taken from OECD (2018); Fiscal data from IMF (2019); Capital-output ratio is derived from World Bank (2020); Hours worked (presented as average labour supply share of time endowment for those 20-54) are derived from IFLS 2000-2014.

As indicated in Table 4, this calibrated benchmark model replicates the Indonesian economy and fiscal policies very closely, targeting many fiscal policy and macroeconomic data. As discussed, we calibrate the fiscal adjustment tax and pension expenditure parameters to match the composition of Indonesia's government budget (using OECD (2018) and IMF (2019) data), and we calculate government consumption to balance the government budget (with the model-generated $G = 8\%$ of GDP, that closely compares to 7% of GDP in 2018-19 based on IMF (2019)). The model is fitted to household survey (IFLS 2000-2014) data, matching the observed labour market composition (averaged over the (primary) working ages), and also approximating hours worked and earnings (with hours worked on average and by employment-skill type generated by the model and derived from IFLS 2000-2014 also presented in Table 4).

5 Quantitative analysis

In this section, we apply the calibrated model to explore the economy-wide implications of pension policy reforms in Indonesia, including the effects on household lifecycle behaviour, macroeconomic aggregates (including output, capital stock, consumption and labour as well as budget implications) and household welfare.

The investigated policy reforms aim to extend pension coverage (and adequacy) of both those defined as formal and informal workers. Specifically, we examine the following four counterfactual policies:

1. Extension of PAYG social security pensions to all formal workers, including formal-low skill types that under this policy change are subject to the same rules as the formal-high type in the benchmark model (paying the same social security contribution rate to balance (11), with their pension benefit calculated as in (10)).

2. Policy 1 defined above plus an increasing formal retirement (or PAYG pension access) age, increased to $j_R = 10$ (representing the age group 65-69), from the benchmark model retirement age $j_R = 8$ (age group 55-59). Note that this pension reform (or its detailed model equivalent representation in this paper) has already been legislated and is currently being gradually implemented in Indonesia (see OECD, 2018; Muliati and Wiener, 2014).

3. Introduction of non-contributory social pensions sp paid to all older people in the informal sector aged $j \geq j_R$ (with $j_R = 10$). These benefits are assumed to be non-contributory, i.e., there is no payroll tax financing the benefits. Instead, the social pension expenditure becomes part of the general government budget constraint (i.e., extending the expenditure side of (16)), which is assumed to be balanced by adjusting the consumption tax rate under each counterfactual in this section. Specifically, the social pension benefit is set to 6.5% of GDP per capita, which represents the International Poverty Line (IPL) for Indonesia (or about $US693.5 (PPP 2011) p.a. per capita in 2019, as reported by World Bank 2021).[55]

4. Overall pension reform package incorporating both Policies 2 and 3 – extending public pension coverage across the entire population.

The focus here is on the closed economy simulations with general equilibrium effects through endogenous factor prices. Note that all the calibrated fiscal policy variables and/or

---

[55]Note that this social pension reform proposal follows the policy assumptions of Kudrna et al. (2021a) who have provided a recent review of retirement income policy in East and Southeast Asia. Kudrna et al. (2021a) also used a simple projection model of the social pension expenditure, fitted to the United Nations (2019) population data for Indonesia 2020-2100. Their projections also allow for different demographic projections, benefit levels and eligibility ages but abstract from any behavioural and general equilibrium effects, which are accounted for in this OLG model.

parameters (i.e., the earnings and corporation tax rates, government consumption and debt, and the formal sector pension replacement rate) are kept at their benchmark values under this pension policy counterfactual. The government budget constraint and the PAYG formal sector pension constraint are balanced by adjusting τ^c and τ^p, respectively (as described in Section 3).

In the following, we first present and discuss the long run steady state implications of the four policy counterfactuals, for household life cycle behaviour, macroeconomic and fiscal variables and for the welfare of heterogeneous households. We then focus on the transition path implications, assuming the current demographic structure (as implemented in the benchmark model).

5.1 Long run steady state implications

There are two types of solution to OLG models. The first is the steady state solution. A steady state solution applies if we assume that the policy settings and all exogenous variables are given and constant, and that there has been sufficient time for the economy to adjust completely to these settings. In this case, the endogenous variables (such as the wage rate, for example) are constant through time. Households of different generations (within the same employment-skill type) face exactly the same economic environments (though at different calendar times) and so behave in exactly the same way. On the production side, the steady state decisions of the firms remain unchanged through time also.

The second solution is the transition path solution from one steady state to another. Transition path solutions involve adjustments over many periods to move the economy from one steady state solution to another. In this context, endogenous variables change over time until they converge to the new steady state. During this transition, households and the firms face a changing economic environment and so their decisions also change through time, not just because of increasing age in the case of households.

In this sub-section, we focus on the steady state implications, providing the discussion of the main behaviour implications over the life cycle first and then presenting aggregated solutions for the macroeconomic, fiscal and welfare effects (in the long run).

5.1.1 Household economic behaviour over life cycle

The lifecycle implications are plotted in Figure 3 for consumption, labour supply and total assets of formal workers (directly impacted by Policies 1 and 2) and of informal workers (directly impacted by Policy 3).[56] The average lifecycle implications (values averaged across all employment-skill types) resulting from Policy 4 (the overall pension reform including

---

[56]Note that in the model, all workers are also impacted indirectly, through changes in the factor prices (the wage and interest rates), in the payroll and consumption tax rates (equilibrating the PAYG pension and government budgets, respectively) and in bequest transfers.

all counterfactuals) for household consumption, labour supply, total income and assets are then depicted by Figure 4. In each figure, the comparison is provided with the respective benchmark model solution.

Pension policy extensions for formal workers The two reforms targeted to formal workers include Policy 1 with the extension of PAYG social security pensions to all formal workers (in our model, now also including formal-low types of workers), and the higher pension access age (increased gradually from 55 to 65 by 2044) applied to all formal workers under Policy 2. Note that formal-low type workers only represent about 5% of the workforce (or about 25% of formal employment) and their consumption and assets are significantly lower compared to formal high-skill types. These factors imply that the impacts of Policy 1 (PAYG pensions extension to formal-low skill workers) are rather small on (average formal) consumption and assets. But as indicated in Figure 3 (consumption left panel), this policy generates consumption smoothing over the lifecycle, reducing it slightly over the working age (because of PAYG pension contributions) and increasing it at older age (due to receiving pension benefits). As shown in Figure 3 (assets left panel), the policy generates lower savings over the lifecycle which are offset by public pension extensions. This is a stylized fact applied to developed countries (e.g., see Kudrna et al. (2021b); Hosseini and Shourideh (2019)). However, in our emerging economy case, these trade-offs are shown to be small.

The retirement age extension (under Policy 2) is shown to have a much bigger impact on the lifecycle decisions of formal workers. As seen, consumption of formal workers increases over the entire life cycle, and particularly at older age. These workers are also shown to reduce their labour supply for most of their working years but in this new (steady state) economy with the increased retirement (from formal employment) age, older workers work significantly more and also have have more assets. Because of lower labour supply during the working years, formal workers save less and accumulate lower assets at younger ages, but at older ages (they are more productive, work more and so) they have more assets. This policy seems to be particularly beneficial in the (Asian) emerging economy context, where retirement ages are low (below 60) (see Kudrna et al. 2021a).

Social pensions for informal workers The lifecycle impacts of Policy 3 are plotted in right-hand panel graphs of Figure 3 for informal workers (since they are directly impacted by this policy which pays these non-contributory pensions to all informal workers aged 65+). Recall that the social pension benefit is modest at 6.5% of GDP per capita and the social pension expenditure is a part of the government budget and in our simulations, financed by an increased consumption tax rate balancing the government budget.
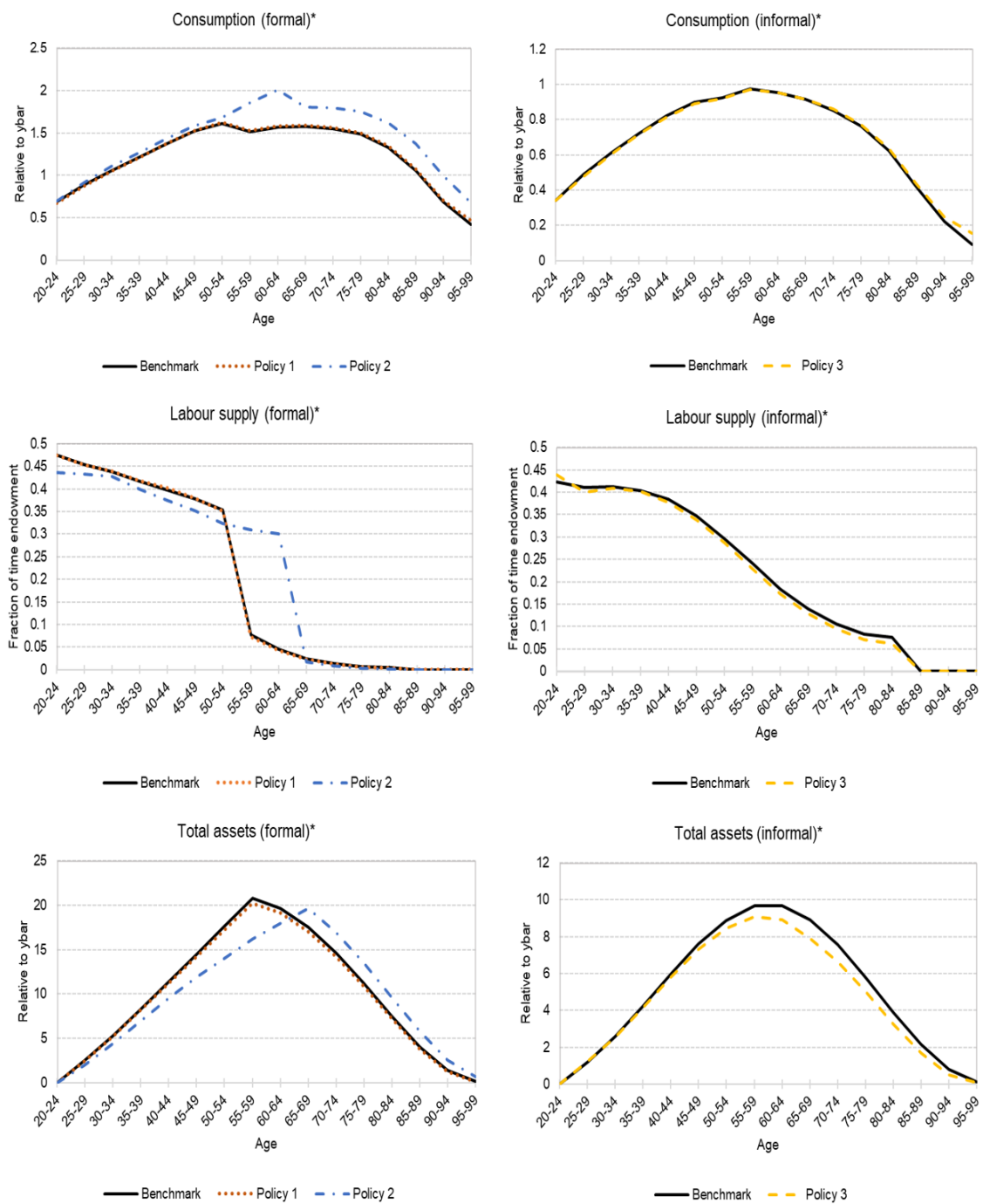
Notes: *Model generated life cycle solutions under pension policy alternatives by employment type; ybar refers to benchmark average earnings; Time endowment is assumed to be 5460 hours p.a.

Figure 3: Policy effects on household behaviour (by employment type)

(a) Consumption (mean)*

(b) Labour supply (mean)*

(c) Total income (mean)*

(d) Total assets (mean)*
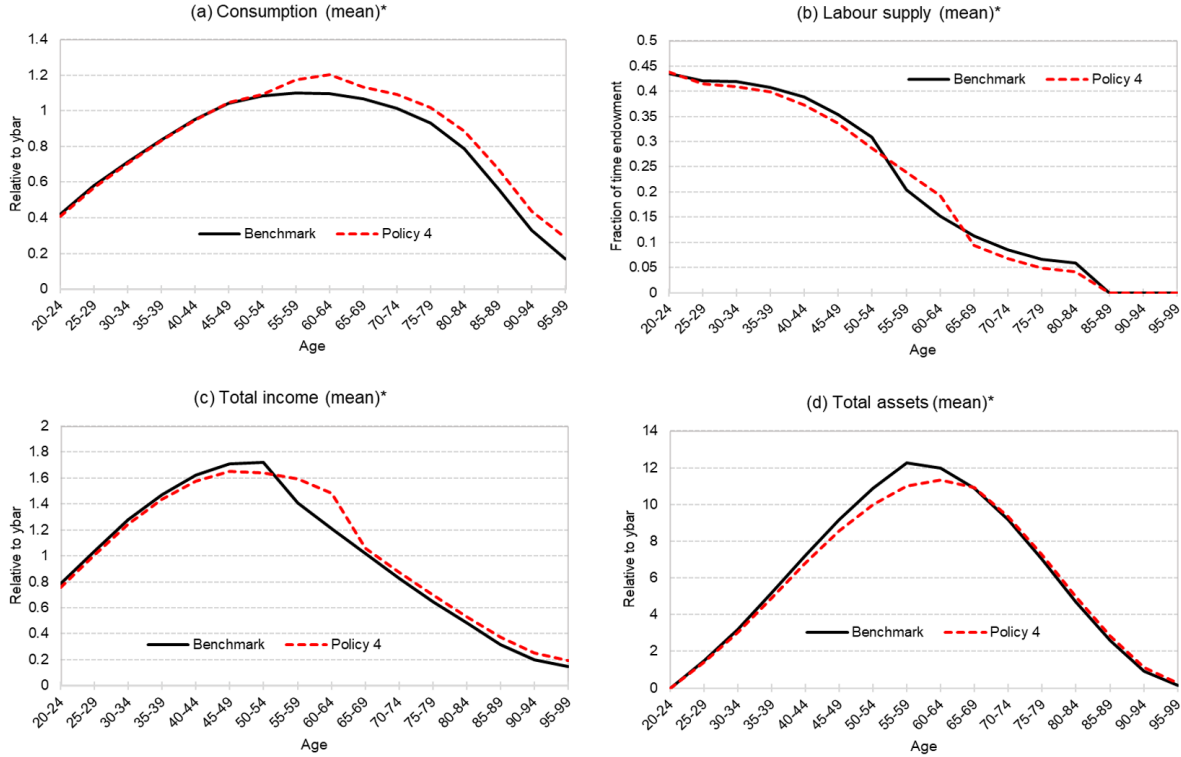
Notes: *Model generated life-cycle solutions under benchmark and overall reform (Policy 4); ybar refers to benchmark average earnings; Time endowment is assumed to be 5,460 hours p.a.

Figure 4: Average lifecycle solutions for main household variables

As expected, this new public pension program generates a consumption smoothing for informal workers. In the long run, their consumption declines somewhat during the working years (partly due to an increase in the consumption tax rate, as discussed below), but it increases at older age. As for the labour supply effects, this policy generates an income effect, lowering hours worked over the life cycle. However, the income effect is small because of a very modest social pension benefit. Note that these social pensions are non-contributory and there is no link between the benefit and former labour supply and earnings (implying the pure income effect). Similarly to the PAYG (contributory pension) extension in Policy 1, Policy 3 is also shown to lower lifecycle assets (of those in informal employment). However, it should be emphasised that these are the long run effects. As we will show in next subsection when discussing the transition path implications, this social pension policy generates large welfare gains for the informal workforce, particularly in the short run and for current elderly populations of informal-low types of households.

Overall pension reform   The (average) lifecycle consumption, labour supply, total income and assets under the overall pension reform (Policy 4) and benchmark are plotted in

Figure 4. As indicated, these profiles are driven by the effects of individual policies of this reform on different employment-skill types of households, discussed above. Specifically, (average) consumption at older ages increases significantly, because of higher consumption of formal workers (impacted particularly by the higher retirement age policy) and also higher consumption of informal workers at older age (that is supported by social pensions).

The public pension extensions (both for formal and informal workers) have negative impact on labour supply during the prime working ages, but the higher retirement age policy increases average labour supply for age group 55-64 (due to increased hours by formal workers). The changes in labour supply (and so earnings) (relative to benchmark) partly explain the lifecycle differences in total income and assets, depicted by Figures 4(c) and 4(d). Total income also includes (PAYG and social) pension payments, and so it is not surprising that total income of older cohorts is significantly higher than under the benchmark model. The increased total income prior to the new retirement age is then due to higher effective labour supply. The (average) assets of households increase only slightly at older age (in the long run, compared to benchmark)), with asset increases at older age constrained by increased total consumption expenditure (with net consumption plotted in Figure 4(a) increased by a higher consumption tax, discussed below).

5.1.2 Macroeconomic, fiscal and welfare implications

We now discuss the macroeconomic, fiscal and welfare implications of the four policy counterfactuals (in the long run) that are reported in Tables 5 and 6.

Note that macroeconomic and fiscal variables are obtained by aggregating the values for the household economic decisions over the life cycle (reported above), weighted by cohort sizes and adjusted to account for the population and economic growth rates. In Table 5, we report the macroeconomic effects on the selected variables as a percentage change from the benchmark model, while in Table 6, the fiscal effects are presented as a percentage of benchmark GDP in the long run.

The long-run welfare effects (reported in Table 5 for average welfare and welfare by employment and skill types) are calculated using Hicksian equivalent variation (both in households' consumption and leisure relative to the benchmark solution). The welfare effects relate to new-born households (in Table 5), representing a percentage change in consumption and leisure over their life cycle that would make them (on average and by employment type) as well-off under the benchmark model as under the policy reform. Hence, the positive sign implies a welfare gain, while a welfare loss (relative to benchmark) is given by the negative sign (see Table 5 for the welfare effects).

Table 5: Macroeconomic and welfare effects of policy counterfactuals in long run*

Variable	Policy 1	Policy 2	Policy 3	Policy 4
Effective labour	0.16	2.62	-0.61	1.84
Wage rate	-0.17	-1.98	-0.93	-2.90
Average earnings	0.00	-0.03	-0.01	-0.04
Output (GDP)	-0.01	0.59	-1.54	-1.11
- Private consumption	0.15	2.60	-0.94	1.48
- Gross investment	-0.28	-2.63	-3.02	-5.74
- Net export (change)	0.00	0.00	0.00	0.00
Capital stock	-0.28	-2.63	-3.02	-5.74
Household wealth	-0.24	-2.39	-2.79	-5.26
Net foreign assets (change)	0.00	0.00	0.00	0.00
Interest rate (p.p.)	0.02	0.27	0.12	0.39
Welfare effects[a]				
- Average	-0.12	0.83	0.11	0.90
- Formal	-0.53	2.89	-0.17	2.66
- Informal	0.01	0.21	0.19	0.37
- Formal-low	-2.49	0.98	-0.23	0.69
- Formal-high	0.02	3.43	-0.16	3.22
- Informal-low	0.02	0.27	0.33	0.55
- Informal-high	-0.01	0.11	-0.05	0.04

Notes: *% changes relative to benchmark equilibrium (if not stated otherwise); [a]Equivalent variation measure in % of initial resources.

Table 6: Fiscal effects of policy counterfactuals in long run*

Variable	Benchmark	Policy 1	Policy 2	Policy 3	Policy 4
PAYG pension costs	1.00	1.17	0.70	0.99	0.69
Social pension costs	0.00	0.00	0.00	0.48	0.48
Total tax revenue	9.85	9.86	9.96	10.38	10.49
- Labour income tax	0.85	0.84	0.95	0.83	0.93
- Capital income tax	4.00	4.00	4.09	3.98	4.07
- Consumption tax	5.00	5.01	4.91	5.57	5.49
Consumption tax rate (p.p.)[a]	9.49	0.01	-0.40	1.07	0.69
PAYG cont. rate (p.p.)[a]	5.46	0.01	-2.43	-0.01	-2.43

Notes: *% of benchmark GDP (if not stated otherwise); [a]Effective rate in % under benchmark and percentage point (p.p.) change (from benchmark rate) under each policy counterfactual.

In the discussion of these aggregated results below, we follow the same structure, as in the case of behavioural lifecycle effects. That is, we first focus on (*i*) Policies 1 and 2 aimed at formal workers, then on (*ii*) Policy 3 (with non-contributory social pensions to all informal workers), and finally on (*iii*) Policy 4 (the overall pension reform). In each of the

three subsections that follow, we first discuss macroeconomic and fiscal effects, and then the welfare effects – the most important policy outcomes for formulating any public policy.

Pension policy extensions for formal workers The PAYG pension extension to formal-low skill types (under Policy 1) generates only small macroeconomic effects (due to the reasons already noted above). As expected, the impacts of this policy on the capital stock and household assets (in Table 5) are negative (with this public policy financed by PAYG contributions offsetting private savings). The most significant impact this policy has is on the pension expenditure that is shown to increase by 17% relative to benchmark. The overall spending is still only about 1.17% of GDP (a much lower spending on public pensions than in developed countries). In terms of welfare effects, the policy reduces the long run welfare of formal-low type workers that now have to make PAYG contributions (at the same rate as formal-high types at over 5% of gross wages). This negative welfare impact in the long run has also been found in related literature (applied to developed countries).

The retirement age extension for all formal workers (included in Policy 2) has positive impacts on effective labour supply and consumption per capita, both up by 2.6% relative to the benchmark. However, the capital stock declines by 2.6% in the long run as households work and save, on average, less than under the benchmark model (with the lower retirement age). Note that we apply the same assumption for labour productivity of formal workers that declines at j_R (which under this scenario has been increased to 65). The fiscal outcomes of this policy in Table 6 show lower pension expenditure (by 30% relative to the benchmark), and higher labour and capital income tax revenues.[57] This implies tax cuts in the PAYG contribution (payroll tax) rate (balancing the pension budget) and the consumption tax rate (balancing the government budget). In Table 6 (under Policy 2), the former is shown to decline by 2.43p.p. (to about 3.03% of gross wages). Moving to the welfare effects in Table 5 (under Policy 2), On average, households experience a long run welfare gain of 0.83%, with the largest gain of 3.43% attained by future born generations of formal-high types of households (now benefiting from increased labour productivity at older ages). There are some positive indirect effects of this policy on the welfare of informal households, but the effects are small compared to directly affected formal households.

Social pensions for informal workers As seen in Table 5 (the results in the third column for Policy 3), most macroeconomic variables are impacted negatively by Policy 3 in the long run. More specifically, the two inputs to production – the effective labour supply and the capital stock – decline by about 0.6% and 3%, respectively. Because of the declines in both production inputs, the output or GDP would decline in the long run under the pension

---

[57]Note that even though we extend the PAYG pension coverage to all formal sector, the PAYG pension expenditure falls because of the formal retirement (pension access) age.

reform.[58] As for the fiscal implications, Table 6 shows that this social pension reform would cost (in terms of the social pension expenditure) only 0.48% of GDP, requiring the budget-equilibrating consumption tax rate to increase by 1.07 p.p. These pension and tax changes (and other general equilibrium effects) have implications for household welfare, which are discussed next.

However, as also shown in Table 5, the social pension reform has positive (long run) welfare effects on informal-low type households (the largest group of the population), with an increase of 0.33% in the long run. This leads to a higher average welfare (by 0.11% in the long run), despite a welfare loss by formal workers negatively impacted by the increased consumption tax rate. As already indicated, in the next subsection dealing with the transition path implications, we provide more welfare results for this important policy (particularly for the current informal elderly).

Overall pension reform The macroeconomic outcomes for the overall pension reform depicted in the last column of Table 5 (and of Table 6 for fiscal results) shows increased effective labour supply, or average hours worked in efficiency units, (up by 1.84% in the long run) and per capital consumption (by 1.5%), but lower average household assets, capital stock and output per capita. The overall costs of public pensions increase by a modest 0.17% of benchmark GDP. Note that 0.48% of GDP is spent on social pensions and 0.69% of GDP on PAYG pensions, under this Policy 4. The budget-equilibrating policy instruments are impacted as follows. The consumption tax rate would need to increase by 0.69 p.p. (to about 10% in the long run), but the payroll tax rate would decline by 2.43 p.p. (to about 3% of wages in the long run).

Despite the negative impact of the pension reform on the economic output, the reform generates significant welfare gains. As shown in the last column of Table 5 for welfare effects, on average, future born households (on average) would gain about 0.9% of their initial (benchmark) resources. Formal households would gain more (with a gain of 2.66%), compared to informal households (with the welfare gain of 0.37%) in the long run. In the long run, the welfare gains are largely driven by the retirement (from formal employment) age policy directly impacting only formal workers.

Below, we provide the transition path implications and (for example) show that the social pension policy generates large welfare gains to currently alive older cohorts of informal households (particularly to the informal-low type of households that represents almost 50% of the entire workforce in our benchmark model).

---

[58]Note that since in this calibrated version of the model we do not model the two production sectors but only one production sector that demands capital and labour from both formal and informal workers (with the given shares of the two groups), the impact of informal workers on the aggregate output (and capital) is larger than the impacts shown by the data. For example, using Loayza and Meza-Cuadra (2018) estimates for Indonesia in 2016, informal employment accounted for 81% of labour force, while informal sector production accounted only for 54% of overall output (or GDP).

5.2 Transition path implications

In this subsection, we present and discuss the macroeconomic and welfare implications over the transition path.[59] We focus on Policy 4 – the overall pension reform, consisting of Policies 1 and 2 (PAYG pension extensions for formal workers) and Policy 3 (the social pension counterfactual with the benefits paid to all informal workers). We assume that the (non-contributory) social pension policy reform is introduced in the first year of the transition (represented by 2021-25), and so is Policy 1 that extends PAYG pensions to all formal workers. Increasing the formal retirement age policy (incorporated under Policy 2) is implemented gradually, increasing to age 60 in 2021-2025 (in the model, to $j_R = 9$ in $t = 1$), from age 55 under the benchmark model, and then to age 65 in 2041-2045 (in the model, to $j_R = 10$ in $t = 5$), approximating the current policy in Indonesia.[60] The overall pension reform (Policy 4) is announced in 2021-25, when all the actors/agents in the model economy (e.g. different generations of heterogenous households by employment-skill types) learn about the reform and adjust their economic behaviour over time.

Note that these transition path solutions involve adjustments over many periods to move the economy from one steady state solution to another.[61] In this context, endogenous variables (such as the wage rate, for example) change over time until they converge to the new steady state. During the transition path, households and the firms face a changing economic environment and so their decisions also change through time, not just because of increasing age in the case of households. On the firm side, profit maximization is subject to the capital stock evolving over time. As for the computation of the transition path, the generations of the four employment-skill classes alive at the time the policy change is adopted must be treated differently from the steady state simulation. At the time of the policy change, existing generations solve their optimization problems again, but over shorter lifetimes given their ordinary private and superannuation assets accumulated prior to the policy change. The initial assets for these generations are obtained from the benchmark steady state simulation. In contrast with the steady state computation, which solves the optimization problems of just four household types, the transition path program requires the solution of household optimization problems of those households already alive in the first year of the transition (over

their remaining life cycle) and of all future born generations (over their whole life cycle).

Below, we present and discuss the macroeconomic and distributional welfare implications of the overall pension reform (Policy 4) over time – and all its components separately modelled under Policy 2 (PAYG and formal retirement age extensions) and Policy 3 (non-contributory social pensions to all informal workers).

5.2.1 Macroeconomic effects

The macroeconomic implications of Policy 4 (and its components under Policies 2 and 3, extending public pensions in Indonesia) – over the (non-ageing) transition path for selected macroeconomic variables are depicted by Figure 5. The results are presented as a percentage change (in selected years of the transition) relative to the benchmark model. Note that the results for the period 2025 (representing time period of 2021-25) provide the impact effects (in the first period of the announcement of the reform or $t = 1$ in the model), while the effects for 2100 (2096-2100) approximate the long run steady state effects (discussed in the previous subsection and under the assumed stationary demographic environment). More detailed results for the overall pension reform (Policy 4) over this (stationary demographic) transition path are provided in Appendix B.1 (in Table B1).

As indicated in Figure 5, there are some important differences in the short run results, compared to the long run effects. For example, under the overall reform (Policy 4), effective aggregate labour is largely unchanged in 2025 (on impact) but increases significantly in 2045 (for period 2041-45 when second increase in the formal retirement age is adopted) and is higher by over 1.8% in 2100 (compared to the benchmark). This increased effective labour is due to the policy of increasing the formal retirement age (under Policy 2). Note that the labour input increases because of higher productivity of formal workers at the increased retirement ages, allowing them to smooth their consumption and labour supply (hours) over the life cycle. This positive productivity effect outweighs lower average hours worked (by formal workers but also informal workers facing the pure income effect of social pensions on their labour supply, as shown by the effective labour impacts under Policy 3), hence leading to higher effective labour under the overall reform (Policy 4). The increased effective labour supply causes consumption per capita to increase significantly, which is higher by about 3% on impact (in 2021-25). Over the transition path, declining household wealth/assets (and the capital stock) leads to a declining per capita consumption and output (with consumption p.c. up by 1.48% and output p.c. down by 1.11% in the long run, compared to their respective benchmark values.[62]

---

[62] As shown in Appendix B1, under the overall reform (Policy 4), the capital stock follows decreases in household assets over the transition path as the increased public pension coverage reduces private savings.
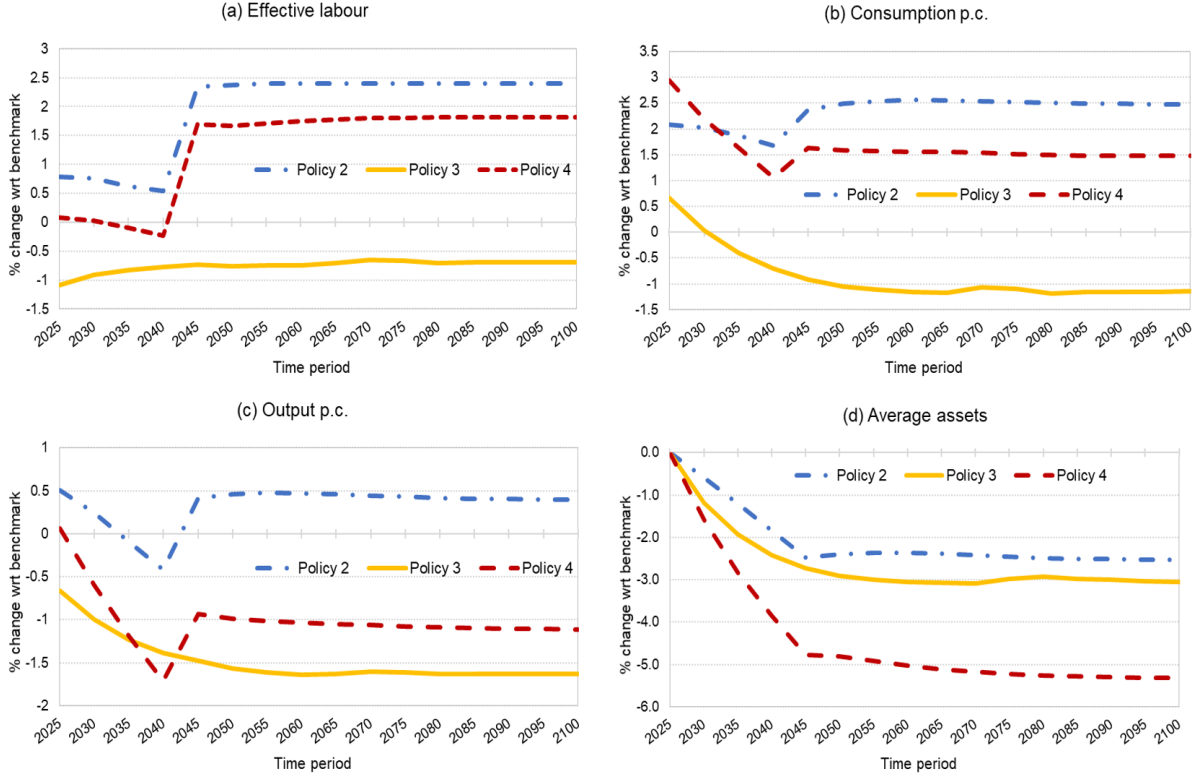
Figure 5: Macroeconomic implications over (non-ageing) transition path

5.2.2 Distributional welfare effects

We now proceed to the discussion of distributional welfare effects over (non-ageing) transition. As discussed above, we use Hicksian equivalent variation (HEV) to measure the welfare effects. For example, the welfare effects of the overall pension reform (Policy 4) are presented here not only in the long run but also over the transition path (for different employment-skill types of households). Specifically, the inter- and intra-generational welfare effects are depicted by Figure 6 (for generations distinguished by age (age group) in 2021-2025, $t = 1$), with the welfare effect $6(a)$ on average and by employment type (under Policy 4); $6(b)$ on formal workers (under Policy 4) (due largely to policy changes under Policy 2); $6(c)$ on informal workers (under Policy 4) and $6(d)$ on informal workers (under Policy 3). Recall the current economic active cohorts are 20 years and older (with the life cycle from 20-24 to 95-99 in the model, and 20 to 95 in Figure 6), while all younger and future born cohorts enter the model during the transition path. As indicated, it takes about 60 years (in 2080) for the welfare

As for the factor prices, the wage rate declines over the transition path, by 2.9% in the long run. This is a consequence of capital shallowing, with a declining capital/labour ratio causing the wage rate to go down and the interest rate to go up. As for the fiscal effects, the social expenditure is constant at 0.48% of benchmark GDP over time (under this stationary demographic structure), the budget-equilibrating consumption tax rate increases by 0.5 p.p. upon impact and by 0.7 p.p. in the long run, under Policy 4.

effects to (very closely) approximate the long run steady state effects.

Figure 6(a) indicates that all generations gain from the overall pension reform (Policy 4). On average, older generations gain up to 13% of remaining resources, while future born generations gain 0.9% in the long run, as depicted by the solid black line in Figure 6(a). The current (short run) welfare gains come from informal workers (benefiting from social pensions), whereas the long run welfare gains are driven by the policies targeting formal workers (particularly the gradual increase in the formal retirement age). As shown in Figure 6(b) with the welfare effects for formal workers, the formal-low skill households of the increased formal retirement age benefit the most in welfare, with a gain of about 3.6% of remaining resources. The figure shows the impact of the gradual increases in j_R to 60 in 2021-25 (in $t = 1$) and 65 in 2041-45 (in $t = 5$), with the observed welfare increases for these cohorts. It could be noted from Figure 6(b) that PAYG pensions introduced to formal-low types (under Policy 1) are actuarily fair as they depend on public pension earnings points accumulated prior to j_R. Hence, this policy (as well as the increased formal retirement age) has no direct impact on formal-low (and -high) types for cohorts aged $j \geq j_R$. Note that in the long run, the largest welfare gain of over 3.2% is attained by the formal-high skill type (directly impacted only by the increased formal retirement age – and so with increased productivity of formal workers at mature age (55-64)).

As seen in Figure 6(c), the largest welfare gain of the overall reform (Policy 4) (in % of remaining resources) is attained by the informal-low type of elderly households, with a gain of 20% for the cohort aged 95-99 in 2021-25. The welfare effects on elderly generations of informal workers are due to the introduction of non-contributory social pensions, as demonstrated in Figure 6(d). And these effects are large, because these generations currently live on very low retirement incomes (which was captured in the benchmark model). For the informal-high type, the long run effects are insignificant, but currently living older cohorts (of that type) would gain almost 10% in welfare.

Recall that we have assumed a stationary demographic environment throughout this section. We augment this assumption in the next section.

6 Population ageing and means-tested social pensions

In this section, we incorporate a demographic transition towards population ageing into the model and then introduce the means-testing of social pensions, as an alternative for Policy 3. The OLG model is fitted to demographic projections derived for Indonesia 2020-2100 (under the medium fertility scenario) from United Nations (2019). More detail on how the demographic transition is incorporated in the model and demographic outcomes over time
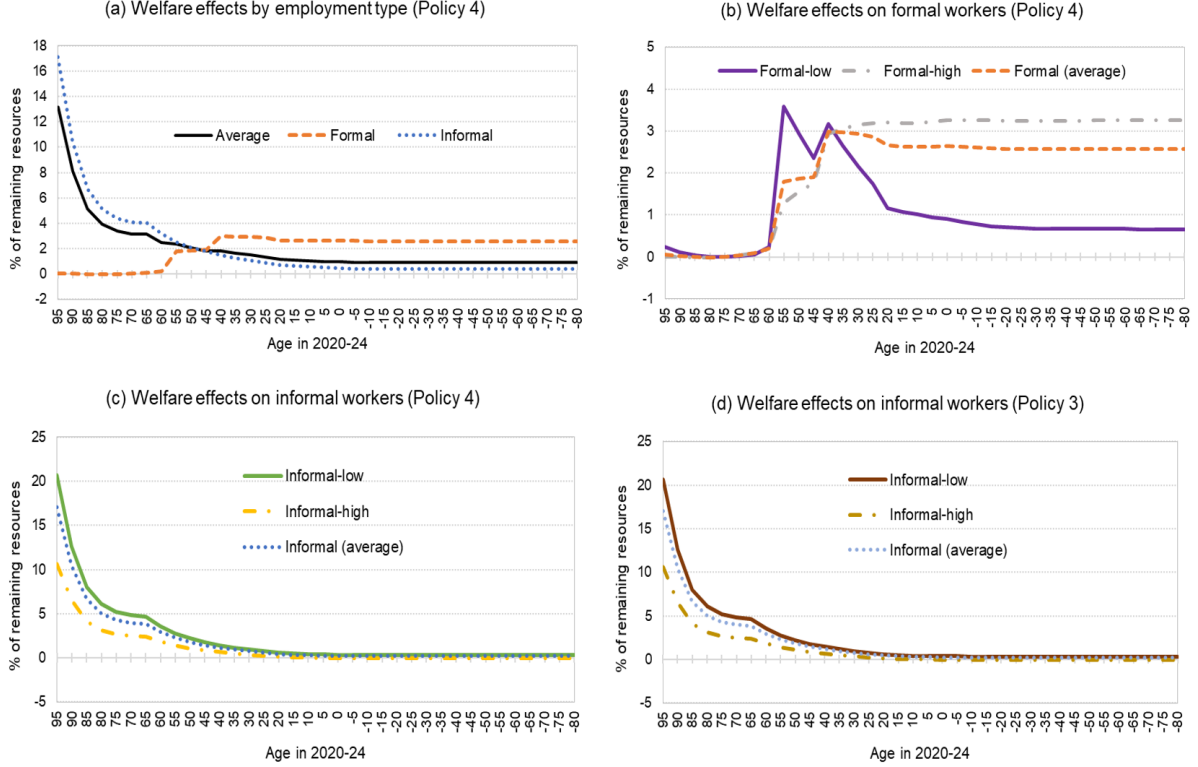
Figure 6: Inter- and intra-generational welfare effects of pension reforms

is provided below. However, we first provide some details on the design and calibration of (our simple form of) the means test attached to social pension benefit. The key objective of this section is to report on the macroeconomic and welfare effects of overall pension reforms under Policy 4 (with non-contributory social pensions to all age-eligible informal workers) and Policy 5 (with means-tested social pensions), accounting for demographic transition toward population ageing.

Means test design and calibration We consider (a simple form) of means testing social pensions, drawing on Kudrna et al. (2021b) and Kudrna (2021), that, here in our emerging economy model, is calibrated to match the (small) social pension expenditure obtained from Policy 4. Under this alternative pension reform (Policy 5), the coverage by these non-contributory social pensions is extended to all age-eligible population ($j \geq 65$), but the social pension benefit sp_j is subject to the following means test:

$$sp_j = \max\left\{\min\left\{sp^{\max}, sp^{\max} - \theta\left(\widehat{y}_j - \widehat{y}_{\min}\right)\right\}, 0\right\}, \tag{20}$$

where $sp^{\max}$ is the maximum social pension benefit , $\widehat{y}_{\min}$ is the income disregard (for age-eligible households to be paid the maximum benefit $sp^{\max}$), $\widehat{y}_j$ ($= ra_j + p_j$) is the assessable

income (that is assumed to include interest earnings ra_j and formal PAYG pensions p_j) and θ is the taper rate, at which sp^{max} is withdrawn for every IDR of $\widehat{y} > \widehat{y}_{\mathrm{min}}$ until $sp = 0$).

We follow the approach introduced by Kudrna (2021) for calibrating the social/age pension means test, drawing on the Australian experience with means tested age pensions. First, we run the steady state simulation of Policy 5 (assuming the stationary demographic environment as in the benchmark model), which is used to calibrate the means test in (20). Specifically, sp^{max} is set to target the total social pension expenditure (=0.48% of GDP as in Policy 4). In choosing the other two parameters of the means test, we draw on the Australian data and set $\widehat{y}_{\mathrm{min}}$ for the model to match the proportion of the population receiving sp^{max} (about 43% of those 65+) and θ to approximate the proportion of those 65+ receiving no social pension. Note that we also assume only a proportion of assets to be included in the means test $ra_j\varphi$, with $\widehat{y}_j = ra_j\varphi + p_j$ and $\varphi = 0.3$.[63]

The steady state results for Policy 5 (under stationary demographics) used to calibrate the means test are presented and, in more detail, discussed in Appendix A. In brief, as shown in Table A1 of Appendix A, the calibrated maximum pension benefit sp^{max} is higher at 8.1% of benchmark GDP and this is closer to the vulnerability line which is 1.5 times the poverty line measure at 6.5% of GDP per capita assumed in Policy 4. The means test is calibrated to approximate the distribution of those aged 65 and over, drawing on the existing distribution of Australian age pensioners. We want to emphasise that the proposed means-tested social pension is affluence tested (not targeted to destitution – the case of the SSI program in the US), with over 70% eligible for the social pension benefit and about 45% receiving the maximum benefit (proposed under Policy 5). Note, however, that under Policy 5, we keep the social pension cost unchanged (at a modest 0.48% of benchmark GDP) by (as indicated above) scaling up sp^{max} to 8.1% of GDP p.c. from 6.5% of GDP p.c. under Policy 4.[64]

The rest of this section is structured as follows. First, we present and discuss the key macroeconomic implications of the demographic transition with the policy as in the benchmark model. We establish this run as the new baseline scenario. Then, we examine the macroeconomic and welfare implications of pension policy responses under this non-stationary population ageing transition. We focus on the overall pension reforms, first adopting Policy 4 (with social pensions to all informal workers) and then Policy 5 (with the means-tested social pension alternative defined above), both under population ageing.

---

[63] In Kudrna (2021), this parameter is age specific set to match share of owner-occupied housing in total assets that is not subject the means test. Here, in the case of Indonesia with a large informal sector, the observed fraction of assets (that can be means-tested) is smaller. However, note that this parameter could provide policy makers with an additional policy instrument to further strengthen the social pension means test over time (if needed).

[64] As indicated in Appendix A, the increase in sp^{max} generates some more labour supply distortions, impacting the economy (presented in Table A2. Importantly, this means tested policy reform further increases the welfare and old-age consumption of those currently alive in need of these social pension payments and their welfare over the transition path when population ageing is considered (as shown below, Policy 4 is also more fiscally sustainable).
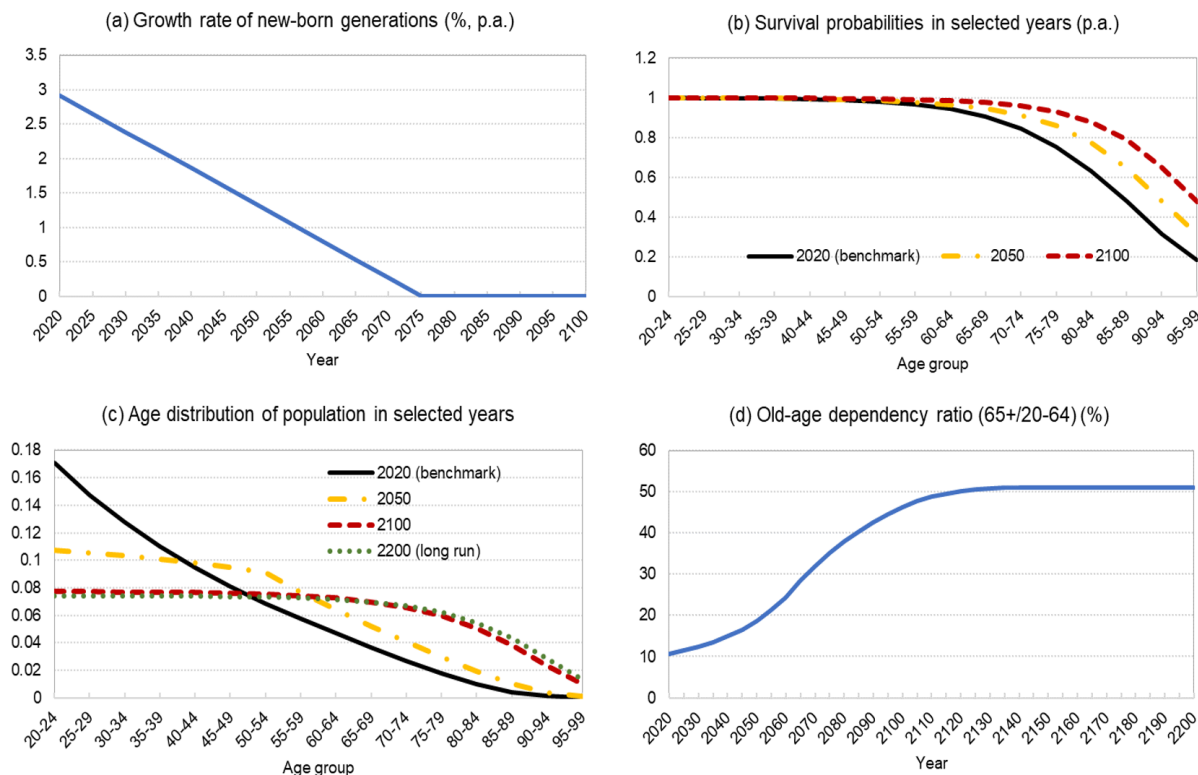
6.1 Economic effects of population ageing

We now outline the demographic transition incorporated into the model (very closely approximating population ageing projections for Indonesia) and present key macroeconomic effects over this demographic transition.

Demographic data The model is fitted to demographic projections derived for Indonesia 2020-2100 (under the medium fertility scenario) from United Nations (2019). Specifically, we use the observed and projected age-specific survival rates, derived from UN (2019). As shown in Figure 7(a), the other demographic input – the growth rate of new-born generations – is assumed to decline (at a linear rate) to zero by 2070, from the benchmark rate (2.92% p.a.), with the objective to approximate a declining growth rate of the total population over time.[65] The policy rules and parameters are kept unchanged, except for the PAYG contribution (payroll tax) rate and the consumption tax rate balancing the PAYG pension and the government budget constraints. The government consumption and debt are also assumed to be constant in per capita terms under this demographic transition. Households learn about this demographic transition and adjust their economic behaviour over time. Factor prices also change over this ageing transition. We consider this demographic transition to be the baseline ageing (no reform) scenario.

The model-targeted developments in demographic variables are shown in Figure 7, with 7(a) the assumed growth rate of new born generations (targeting the population growth rate); 7(b) age-specific survival rates in the selected years; 7(c) cohort shares (or age distribution of the total population) in the selected years and 7(d) old-age dependency ratio (65+/20-64) over the demographic transition. The demographic projections (with the outcomes captured in Figures 7(c) and 7(d)) indicate pronounced population ageing, i.e., declining population growth rates, increasing survival rates (and implied life expectancies, e.g., at age 20 increasing to almost 65 years (of expected life span) in 2100) and shares of elderly populations, resulting in significantly higher old-age dependency ratios in future.[66] As indicated by Figure 7(d), we very closely match the old age dependency ratios over the projection period 2020-2100 derived from the UN (2019) medium population projections (increasing by almost 5-fold to

---

[65]Note that in the long run steady state, the total population growth rate and the growth rate of the new-born generations/cohorts are identical. This is not the case over the demographic transition. Even if we reduced the latter to zero in 2020-24, it would take the whole lifecycle for the former to converge to zero. Further note that for the long run steady state, we cannot have a negative population growth rate (with the lower bound at $n_t = 0$), as the total population would eventually decline to zero. According to UN (2019) (medium population) projection, the total population growth rate in Indonesia will reach zero by 2067 and then it will be negative. Because of our assumption above, in the model n_t converges gradually to zero in future years. Nevertheless, our approach closely approximates the age distributions over 2020-2100, as shown below in Figure 7(c).

[66]Note that the benchmark year 2020 represents Indonesia's population in 1990-2020, with the survival rates (and population growth rate) averaged over the last 30 years.

(a) Growth rate of new-born generations (%, p.a.)

(b) Survival probabilities in selected years (p.a.)

(c) Age distribution of population in selected years

(d) Old-age dependency ratio (65+/20-64) (%)

Notes: (a) and (b) representing the demographic inputs and (c) and (d) model-generated demographic outcomes, with (d) closely matching UN (2019) data for 2020-2100.

Figure 7: Demographic transition data in the model

over 50% in 2100).[67]

Macroeconomic effects   The macroeconomic and fiscal effects of the demographic transition are reported in Table 7, with most results (for per capita variables) presented as % changes relative to the benchmark solution. Recall that the benchmark solution assumes a stationary demographic structure with the survival rates and the population growth rate for Indonesia averaged over the last 30 years – 1990-2020). As opposed to the non-ageing transition paths presented in the previous section, here the population growth rate declines gradually to zero by 2150, after the growth rate of new-born generations (entering the model) is set to zero in 2075 (and kept at zero after that). And so, we also show the economic effects in 2200 (representing the long run steady state economy).[68] As pointed out above, this

---

[67]Note that our approach of incorporating demographic transition provides very close approximation projected developments in population growth rates and cohort shares, while it also allows us to start from a steady state economy. An alternative approach (of fitting OLG models with exact cohort shares from the demographic projection models) used e.g. by Kudrna et al. (2019) assumes an artificial initial steady states (where the goods market condition does not fully clear). In our model, the goods market conditions clear with a much smaller error tolerance level in each t (providing us with a key numerical solution check).

[68]But recall that the old-age dependency ratio increases over 50%, already by 2100.

baseline ageing scenario assumes the government policy rules of the benchmark model (hence applicable predominantly only to formal-high skill types).

Table 7: Macroeconomic effects during demographic transition*

Variable	Time period				
	2025	2035	2055	2100	2200
Effective labour	1.99	1.90	-1.79	-13.40	-15.50
Hours worked[a]	0.06	0.18	0.69	1.13	1.10
Wage rate	-0.32	3.47	10.67	18.46	18.84
Output (GDP)	1.69	5.49	8.76	2.72	0.53
- Private consumption	-2.20	4.10	12.06	11.19	9.72
- Gross investment	7.66	8.06	4.23	-12.99	-17.33
Capital stock	1.19	11.60	28.46	35.73	33.47
Household wealth	-0.45	9.30	24.90	31.14	28.67
Interest rate (p.p.)	0.04	-0.44	-1.25	-2.01	-2.05
Consumption tax rate (p.p.)[b]	0.31	-0.60	-1.10	0.79	1.45
PAYG pension cont. rate (p.p.)[c]	0.12	0.71	3.93	11.82	14.08

Notes: *% change in per capita variables relative to benchmark solution (if not stated otherwise); [a]Average hours for those aged 20-54; [b]Percentage point (p.p.) change in the effective consumption tax rate assumed to balance the government budget (now including the social pension expenditure); [c]Percentage point (p.p.) change in the payroll tax rate assumed to balance the PAYG pension budget for formal workers.

The results in Table 7 are due to (*i*) changes in the cohort shares over the demographic transition (or the age distribution of the total population depicted in Figure 7(*c*)) and (*ii*) behavioural implications, with households responding (in their economic decisions over the life cycle) to increased life expectancies and general equilibrium effects on factor prices and government budget equilibrating policy instruments – the consumption tax and the payroll tax (formal pension contribution) rates. As shown, effective labour supply initially increases (because of the demographic dividend from Indonesia's young population), but over the transition the labour input declines significantly (due to population ageing and more older cohorts with lower productivity and hours). In the long run, the effective labour (labour supply inefficiency units) falls by over 15% (compared to the benchmark level). Note that average hours worked (by 20-54) increase over the transition as households (who are expected to live longer) work more. Household assets go up significantly, by almost 30% in the long run. This is due to (*i*) the cohort effect, with the median age of the population shifting to older cohorts with larger asset holdings; and (*ii*) the behavioural effect, with rational households responding to their increased life expectancy (by over 10 years in 2100, compared to 2020) by increasing savings.

Population ageing is shown to generate capital deepening (increasing the capital labour ratio), which leads to a higher wage rate and a lower interest rate. Although the size of the government is relatively small (with tax revenues of only around 10% of GDP), there are some pronounced fiscal costs due to population ageing. Specifically, the consumption tax rate and the payroll tax (PAYG contribution) rate would need to increase by 1.45 p.p. and 14 p.p. in the long run, respectively. Under this baseline ageing (no reform) scenario, formal-high types would face almost 20% payroll tax rate. And so, it is important that the pension reforms studied in this paper are also fiscally sustainable under population ageing.

6.2 Economic effects of pension reforms under population ageing

We now examine the macroeconomic and welfare implications of the pension reforms under Policy 4 (including social pensions to all informal workers) and Policy 5 (including the means-tested social pension alternative), accounting for the above discussed non-stationary demographic transition path. The macroeconomic and fiscal effects are presented and discussed first, and then we provide a discussion of the welfare effects for different generations and of different employment-skill types.

Macroeconomic effects The macroeconomic and fiscal effects (for selected key variables) are depicted in Figure 8 that for $8(a)$-$8(d)$ are expressed as a % change from the respective benchmark solution and for fiscal impacts in $8(e)$-$8(f)$ as a % point change from the respective benchmark solution. For the comparison, the figure also plots the results for the baseline ageing (no reform) scenario/transition that was discussed above (with the figures in selected year of the transition in Table 7. More specifically, for Figure $8(a)$-$8(d)$, the macroeconomic variables (e.g., consumption) are detrended by the technical progress and population growth rates, and expressed relative to the benchmark solution.[69]
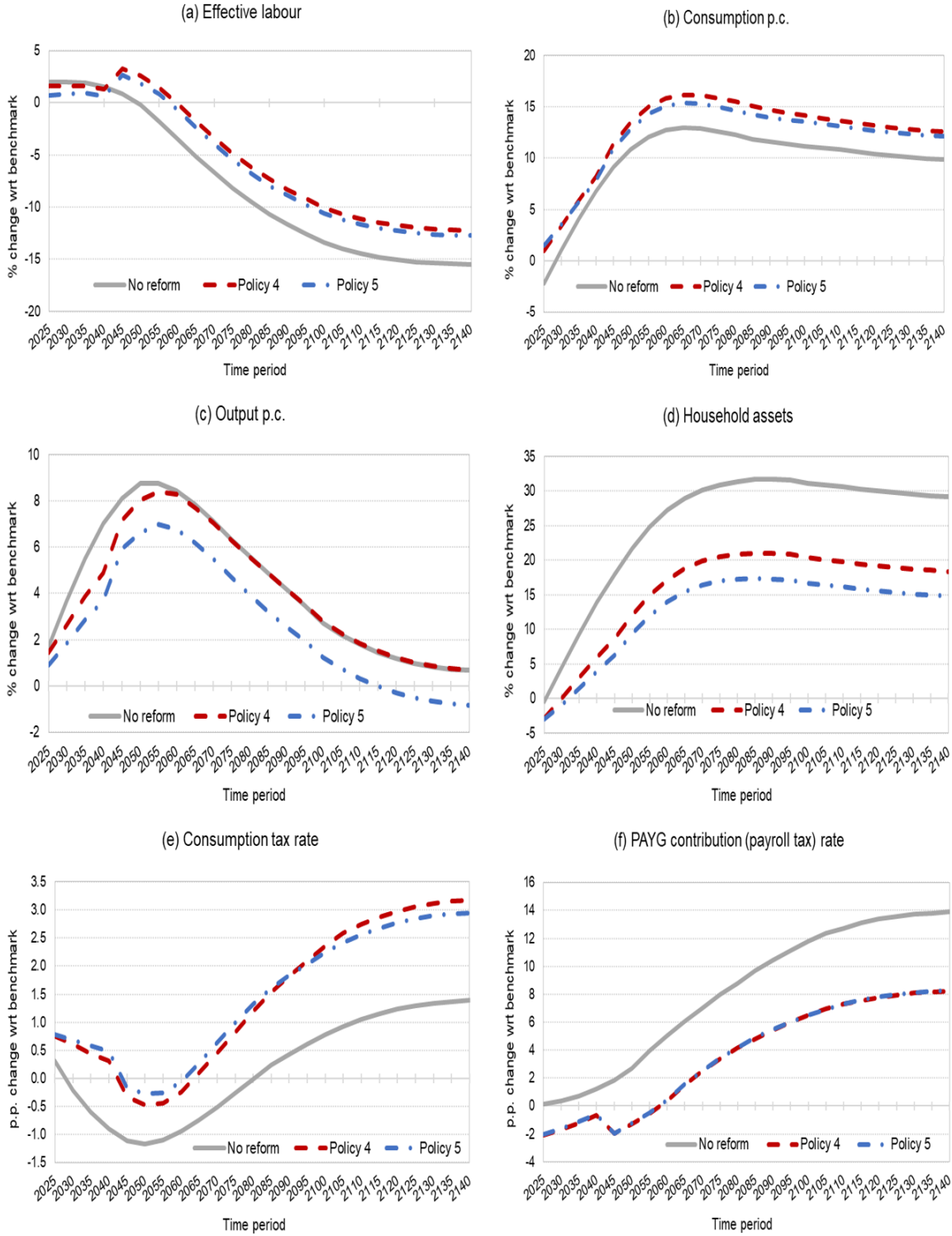
First, we discuss the effects of Policy 4 over the demographic transition. As indicated, the effective labour is higher relative to the no reform scenario, with the overall pension reform helping to mitigate the negative impact of population ageing on effective labour. As already discussed in relation to the transition path results for this reform in the previous section, the higher effective labour (e.g. labour input to production) is mainly caused by the increased formal retirement age policy. Similarly, consumption per capita is impacted positively by the reform due to both policy changes targeted to formal workers as well as social pensions to informal workers at older age. Note that under demographic transition, these effects (increases in effective labour and consumption per capita) are larger than under the stationary demographic transition path (presented in Section 5.2). For example, the long

---

[69]More detailed results (also for other variables) are discussed in Appendix B.2 (and presented in Table $B2$). In Appendix B.2, the comparison of the reforms is made to the baseline ageing (no reform) scenario (rather than to the benchmark solution which is what we do in this sub-section).

run increase in effective labour due to Policy 4 is 3.86% under population ageing (relative to the baseline ageing transition), while in the no ageing environment, the long run increase was 1.84% (as shown in Appendix B). This is due to a changing age distribution of the total population over the demographic transition – increasing for older age groups, that are directly impacted by the reform (e.g., generations aged 55-64 impacted by the increased formal retirement age policy or generations aged 65+ of informal households now benefiting from social pensions).

As under the no-ageing transition path, the public pension policy extension in Policy 4 leads to lower savings, with household assets declining compared to no reform scenario. The social pension expenditure is no longer constant, and (see Table B2 in Appendix B.2) under this demographic transition, it increases more than 3-fold, from 0.52% of GDP in 2021-25 (when the reform is announced) to 1.71% of GDP in the long run. Under Policy 4, this expenditure is now included in the government budget which is assumed to be balanced adjusting the consumption tax rate. Hence, the consumption tax rate is higher over the transition, compared to no reform scenario, (in the long run by 1.75 p.p., compared to the baseline ageing (no reform) rate as reported in Table B2). However, the reform significantly reduces the payroll tax rate (which PAYG finances formal pensions) by about 6 p.p. in the long run (compared to the no reform scenario). This is because of the tax base increases, as under Policy 4 all formal workers are covered by the PAYG pension system and (becuase of the increased formal retirement age) pay payroll taxes over a longer life cycle. Hence, under Policy 4 (including Policy 2), the contributory pension system becomes more fiscally sustainable (or tax affordable for formal workers) in the long run (as indicated in Figure 8(f)).

The pension reforms under Policy 5 (that assumes the non-contributory social pensions to be means tested) is shown to generate more distortions to the economy, compared to Policy 4. Note that only short run consumption per capita is higher under Policy 5, whereas other variables (such as effective labour and household assets) are lower because of the means testing of social pensions. The main objective of the means testing is to direct social pension payments to those in need (to improve targeting of the social pension under Policy 4), as well as to improve fiscal sustainability of social pensions under population ageing. The pension expenditure is lower under Policy 5, at 1.44% of GDP in the long run (compared to Policy 4) and this allows for a lower consumption tax rate (in the economy with means tested pensions). It needs to be pointed out that the social pension system under Policy 5 differs to that under Policy 4. First, it covers a larger proportion of (currently living) elderly populations with the means-tested pensions, including some of those of the formal household type (in particular, formal-low households). Second, the maximum social pension benefit is higher under Policy 5 (by over 20%, compared to the social pension benefit under Policy 4). In the short run, this generates higher consumption per capita, but lower effective labour

(a) Effective labour

(b) Consumption p.c.

(c) Output p.c.

(d) Household assets

(e) Consumption tax rate

(f) PAYG contribution (payroll tax) rate

Note: The results for (a)-(d) (and for (e) and (f)) are presented as a % change (percentage point change) with respect to the benchmark solutions.

Figure 8: Macroeconomic impacts of pension reforms during demographic transition

supply and in the long run, this lowers average output and household assets.[70]

Importantly, as demonstrated below, Policy 5 with the means tested pensions (applied to all age-eligible population) generates higher welfare effects, particularly in the short run (to current elderly populations in need of these payments) but also in the long run (to future-born generations), when compared to Policy 4.

Distributional welfare effects   In this sub-section, we present the distributional welfare effects of pension reforms under Policy 4 and Policy 5 over the demographic transition. As discussed above, we use Hicksian equivalent variation (HEV) to measure the welfare effects. But note that the welfare effects can only be studied under the same preferences, and since population ageing alters the discount factor in the household utility, and under the same demographic transition. Hence, all the results in this subsection are expressed relative to the baseline (no reform) ageing scenario.

In Table 9, we present the welfare effects of Policy 4 and Policy 5 for selected cohorts of different ages in 2021-25, on average (last column) and by employment (and skill) type. As in Figure 6, the current economically active cohorts are aged 20 years and older (here in Table 9, selected cohorts aged 95, 80, 60, 40, 20), while all younger and future born cohorts enter the model during the transition path (depicted by 0, -20, -80 in Table 9), with the effects on the generation aged -80 closely approximating the long run welfare effects.

First, focusing on Policy 4 under population ageing the average welfare effects are greater in the short run as well as in the long run (compared to the non-ageing transition path of the reform in Figure 6 of Section 5). These effects are due to the (stronger) short run welfare changes by currently living older generations of the informal type and the (stronger) future welfare gains by formal high-skill types. Interestingly, some intra-generational welfare effects also differ qualitatively under this demographic transition and the previously examined

---

[70]Note that in Kudrna et al. (2021b), household assets increase as a result of the means-testing of public pensions under population ageing (with higher old-age dependency ratios and life expectancies). Compared to that study, there are some important differences in the present paper in terms of the means test modelling as well as the structure of the OLG model. As for the former, in Kudrna et al. (2021b), the maximum pension benefit does not change (when the means test is introduced or strengthened) and the progressive income tax schedule is adjusted (scaled) to balance the government budget. In the present study, we use consumption tax rate to balance the budget (which is less distortive than progressive income tax changes). And so the reduction in the consumption tax rate under the means tested policy is less positive for the economy than reduced income tax rate would be. As mentioned, in the present study under Policy 5 the maximum social pension benefit is more than 20% higher than under Policy 4, generating further distortions to the economy (but also larger welfare gains particularly to current elderly generations). We have also assumed quite a large exemption of the assets from means testing (see the means tested formula), a much lower exemption is used by Kudrna et al. (2021b).

As for the model structure, Kudrna et al. (2021b) used a deterministic OLG model with small open economy market structure, whereas here we employ a stochastic OLG model with labour income uncertainty, and endogenous wage and interest rates (interacting with population ageing). The sensitivity of the means tested pensions to labour income uncertainty and different market structure requires further research (which will be addressed in the next version of the paper).

stationary or no ageing transition. In the long run, the formal-low and informal-high types would attain lower welfare under Policy 4 in this more population ageing economy. For the formal-low workers this welfare loss is due to them paying the high payroll tax rate (increasing over the transition).[71] For the informal-high types (as all others), they face a higher consumption tax rate under population ageing (because of the higher social pension expenditure), reducing their welfare in the long run.

Table 9: Distributional welfare effects of pension reforms under population ageing*

Scenario	Age in 2021-25	Formal workers			Informal workers			All workers
		Low-skill	High-skill	Average	Low-skill	High-skill	Average	Average
Policy 4	95	0.26	0.01	0.06	24.32	12.87	20.17	15.43
	80	0.00	-0.03	-0.02	7.32	3.81	6.04	4.63
	60	0.35	0.27	0.29	4.48	2.42	3.73	2.93
	40	4.25	3.65	3.78	2.48	1.29	2.05	2.44
	20	2.00	4.34	3.73	1.41	0.48	1.12	1.74
	0	1.05	4.76	3.78	0.98	0.10	0.70	1.44
	-20	-0.30	4.99	3.59	0.80	-0.06	0.53	1.28
	-80	-2.16	5.29	3.32	0.60	-0.22	0.34	1.08
Policy 5	95	17.28	0.69	4.29	27.30	14.72	22.74	18.39
	80	4.66	0.21	1.18	8.69	4.47	7.15	5.76
	60	2.85	0.37	0.92	5.26	2.56	4.28	3.50
	40	5.32	3.86	4.18	2.92	1.37	2.35	2.77
	20	2.91	4.81	4.31	1.67	0.45	1.28	2.00
	0	2.00	5.29	4.42	1.13	-0.04	0.76	1.64
	-20	0.79	5.58	4.32	0.96	-0.20	0.59	1.50
	-80	-0.93	6.02	4.19	0.81	-0.32	0.45	1.37

Note: *Equivalent variation measure (for selected cohorts of different ages in 2021-25) - HEV in % of remaining resources (or initial resources for future-born generations).

Several observations can be drawn from Table 9 when comparing Policy 5 with Policy 4. First, Policy 5 with the means tested social pension alternative increases the average welfare for the current as well as for future-born generations, relative to Policy 4. The currently-living older generations benefit from the *higher* maximum social pension benefit covering a *larger* proportion of the elderly population (65+) in the short run. Note that Policy 5 covers the cohorts of very old ages across the employment-skill type (including those in the formal-low types that (because of the actuarily fair nature of the PAYG pensions) would not get any public pension under Policy 4). In the long run, the average welfare effects

---

[71]Note that in Figure 8(*f*) the payroll tax rate is shown to be much higher under the baseline ageing (no reform) scenario, but this tax rate is only made by formal-high types (as all the policy settings are as under the benchmark model). But here under Policy 4, all formal workers (including formal-low types) pay the same payroll tax rate.

increase due to the improved targeting of social pensions (to those in need), which reduces the proportion of the age-eligible population covered and the fiscal costs of these benefits (allowing for lower consumption tax rate, compared to Policy 4).

It should also be pointed out that Policy 5 (compared to Policy 4) would present the policy makers with more instruments (including, the taper rate, the disregard and the fraction of assessable assets, in addition to the maximum social benefit), to control the total social pension expenditure as the population ages.

7   Concluding remarks

This paper has examined government reforms to public pensions, using a stochastic OLG model, incorporating both formal and informal labour, calibrated to Indonesia. We have examined the economy-wide effects of pension policy extensions to both formal and informal workers, reporting on a range of model simulation outcomes, including the implications for household economic behaviour over the life cycle, macroeconomic implications and distributional welfare effects. We show that pension reform (including the PAYG pension extension to all formal workers, the increased retirement age policy and the introduction of social pensions directed to informal workers) generates higher welfare to all future born generations. We also demonstrate that the social pension policy and particularly the means-tested social pension alternative significantly increase the welfare of currently living informal elderly households.

The results we present are illustrative of the potential power and flexibility of this model in providing quantitative analysis of policy proposals in a consistent economic framework. Aggregate economic impacts, price and quantity adjustments, and distributional effects are all reported. It provides the foundation for many elaborations to be developed by the authors in consultation with both the World Bank and Indonesian partners, including Bappenas. It will also provide the basis for model calibration and development in other emerging Asian economies.

Future extensions may include sectoral choice by households (subject to labour market frictions), alternative and more detailed modelling of the production sector and intergenerational transfers, and modelling of individual ages and years (rather than age groups and time periods). These will enrich and increase the relevance of the policy outcomes from the model, and we plan to account for these extensions in future research.

References

[1] Albagli, E., Arias, A. and Kirchner, M. (2020), "Collective Savings Pension Policy in an Economy with Heterogeneity and Informality", paper presented at 28th Colloquium on Pensions and Retirement Research, UNSW Sydney.

[2] Auerbach, A. and Kotlikoff, L. (1987), *Dynamic Fiscal Policy*, Cambridge: Cambridge University Press.

[3] Braun, R. and Joines, D. (2015), "The implications of a graying Japan for government policy", *Journal of Economic Dynamics and Control* 57, 1-23.

[4] Cho, S. and Sane, R. (2013), "Means tested age pensions and homeownership: Is there a link?", *Macroeconomic Dynamics* 17(6), 1281-1310.

[5] Chomik, R. and Piggott, J. (2015), "Population Ageing and Social Security in Asia", *Asian Economic Policy Review* 10(2), 199-222.

[6] Cuevas, S., Mina, C., Barcenas, M., & Rosario A. (2009), "Informal employment in Indonesia", ADB Economics Working Paper Series 156, 1-44.

[7] Curtis, C., Lugauer, S. and Nelson, M. (2015), "Demographic Patterns and Household Saving in China", *American Economic Journal: Macroeconomics* 7(2), 58-94.

[8] De Nardi, M. (2004), "Wealth Inequality and Intergenerational Links", *Review of Economics Studies* 71, 743-768.

[9] Esteban-Pretel, J. and Kitao, S. (2021), "Labor Market Policies in a Dual Economy", *Labour Economics* 68.

[10] Fehr, H., Jokisch, S. and Kotlikoff, L. (2009), "Dynamic Globalization and its Potentially Alarming Prospects for Low-Wage Workers", FIW Working Paper N.22.

[11] Fehr, H. (2016), "CGE Modeling Social Security Reforms", *Journal of Policy Modeling* 38(3), 475-494.

[12] Fehr, H. and Hofbauer, F. (2016), "Pension reform with entrepreneurial choice", VfS Annual Conference, Augsburg.

[13] Fehr, H. and Kindermann, K. (2018), *Introduction to Computational Economics Using Fortran*, Oxford University Press.

[14] Fehr, H., Hofmann, M. and Kudrna, G. (2021), "Pensions, Income Taxes and Homeownership: A Cross-country Analysis", CEPAR Working Paper 2021/23.

[15] Freestone, O. (2018), "The Drivers of Life-Cycle Wage Inequality in Australia", *Economic Record* 94, 424-444.

[16] Hosseini, R. and Shourideh, A. (2019), "Retirement financing: An optimal reform approach", *Econometrica* 84(4), 1205-1265.

[17] International Labour Office (ILO) (2018), *Women and men in the informal economy: A statistical picture.* Third Edition.

[18] Imrohoroglu, S. and S. Kitao (2009), "Labor supply elasticity and social security reform", *Journal of Public Economics* 93, 867-878.

[19] International Monetary Fund (IMF) (2017), *Regional Economic Outlook. Asia and Pacific: Preparing for Choppy Seas*, World Economic and Financial Surveys, Washington, DC.

[20] IMF (2019), Government Finance Statistics (GFS), IMF Data.

[21] Imrohoroglu, A. and Zhao, K. (2018), "Intergenerational Transfers and China's Social Security Reform", *Journal of the Economics of Ageing* 11, 62-70.

[22] Jung, J. and Tran, C. (2012), "The extension of social security coverage in developing countries", *Journal of Developing Economics* 99, 439-458.

[23] Kitao, S. (2008), "Entrepreneurship, Taxation and Capital Investment", *Review of Economic Dynamics* 11, 44-69.

[24] Kitao, S. (2014), "Sustainable social security: Four options", *Review of Economic Dynamics* 17(4), 756-779.

[25] Kitao, S. (2015), "Fiscal Cost of Demographic Transition in Japan", *Journal of Economic Dynamics and Control* 54, 37-58.

[26] Kudrna, G. (2021), "The Economy-wide Effects of Mandatory Superannuation and its Tax Concessions", Presented at the 29th Colloquium of Pensions and Retirement Research, 1-3 December 2021.

[27] Kudrna, G. and Woodland, A. (2011), "An intertemporal general equilibrium analysis of the Australian age pension means test", *Journal of Macroeconomics* 33, 61-79.

[28] Kudrna, G., Tran, C. and Woodland, A. (2015), "The dynamic fiscal effects of demographic shift: The case of Australia", *Economic Modelling* 50, 105-122.

[29] Kudrna, G., Tran, C. and Woodland, A. (2019), "Facing demographic challenges: Pension cuts or tax hikes?", *Macroeconomic Dynamics* 23(2), 625-673.

[30] Kudrna, G., Tran, C. and Woodland, A. (2021b), "Sustainable and Equitable Pensions with Means Testing in Aging Economies", *European Economic Review.*

[31] Kudrna, G., Le, T. and Piggott, J. (2020), "Review report on demographics, labour force and older people in Indonesia", CEPAR working paper 2020/27.

[32] Kudrna, G., O'Keefe, P. and Piggott, J. (2021a), "Pension Policy in Emerging Asian Economies with Population Ageing: What Do We Know, Where Should We Go?", forthcoming in Bloom, D., Sousa-Poza, A., Sunde, U. (ed.), *Handbook on the Economics of Ageing,* Routledge.

[33] Lee, S-H., Kim, J. and Park, D. (2016), "Demographic Change and Fiscal Sustainability in Asia", ADB Economics Working Paper No. 481, Asian Development Bank, Philippines.

[34] Levy, S. (2008), Good Intentions, Bed Outcomes: Social Policy, Informality, and Economic Growth in Mexico, Brookings Institution Press.

[35] Loayza, N. and Meza-Cuadra, C. (2018), "A Toolkit for Informality Scenario Analysis", Washington, DC: The World Bank.

[36] McGrattan, E. and Prescott, E. (2017), "On financing retirement with an aging population", *Quantitative Economics* 8(1), 75-115.

[37] McKiernan, K. (2021), "Social Security Reform in the Presence of Informality", *Review of Economic Dynamics* 40, 228-251.

[38] Muliati, I. and Wiener, M. (2014), "Pension reform experience in Indonesia", in Clements, B., F. Eich and S. Gupta (eds.), *Equitable and Sustainable Pensions: Challenges and Experience*, International Monetary Fund, Washington, DC.

[39] Nishiyama, S. (2015), "Fiscal Policy Effects in a Heterogeneous-Agent OLG Model with an Ageing Population", *Journal of Economic Dynamics and Control* 61, 114-132.

[40] Organisation for Economic Co-operation and Development (OECD) (2018), Pensions at a Glance Asia/Pacific 2018, OECD Publishing.

[41] Park, D. and Estrada, G. (2011), "Introduction: Why Does Asia Need a Well-Functioning Pension Systems?", in Park, D. (ed.), Pension Systems and Old-Age Income Support in East and Southeast Asia: Overview and Reform Directions, Routledge, UK.

[42] Rothenberg, A., Gaduh, A., Burger, N., Chazali, C., Tjandraningsih, I, Radikun, R., Sutera, C. & Weilant, S (2016), "Rethinking Indonesia's informal sector", *World Development* 80, 96-113.

[43] Song, Z., Storesletten, K., Wang, Y. and Zilibotti, F. (2015), "Sharing High Growth Across Generations: Pensions and Demographic Transition in China", *American Economic Journal: Macroeconomics* 7(2), 1-39.

[44] Strauss, J., Witoelar, F., Sikoki, B. and Wattie, A. (2016), *The Fifth Wave of the Indonesia Family Life Survey: Overview and Field Report*, RAND Labour and Population, Santa Monica, CA.

[45] United Nations (UN) (2019), *World Population Prospects: The 2019 Revision*, United Nations, Department of Economic and Social Affairs, Population Division, New York.

[46] Widjaja, M. (2008), Designing Pension Programs to Strengthen Formal Labour Markets in Developing Countries: The Case of Indonesia, Dissertation, Georgia State University.

[47] World Bank (2016), *Live Long and Prosper: Aging in East Asia and Pacific*, World Bank East Asia and Pacific Regional Report, Washington, DC.

[48] World Bank (2020), World Bank Open Data.

[49] World Bank (2021), Poverty & Equity Brief – Indonesia, World Bank Group.

Appendix

In this appendix, we provide more details about (A) the parameterisation and calibration of the proposed means tested social pension policy under Policy 5 and the steady state results of Policy 5 (and comparison with Policy 4); (B) the transition path effects of Policy 4 (and Policy 5) under stationary and non-stationary demographic structures.

A. Details on means-tested social pensions

Means test design and calibration The means test formula for social pension benefits proposed in (20) is illustrated by Figure $A1$. As discussed, we draw on Kudrna et al. (2021b) and Kudrna (2021) and so the Australian age pension (and its income test), augmented here for the emerging economy framework (which a much lower social pension expenditure). The figure depicts the relationship between the social pension, sp, and assessable income, $\widehat{y} = ra\varphi + p$, with only a fraction φ of household assets being subject to the means testing, while PAYG pension benefits p (to formal workers) being fully included. As discussed in Kudrna et al. (2021b), the presence of means testing divides the elderly population into three groups: (i) those with $\widehat{y} \leq y_{\min}$ receiving the maximum benefit $(sp = sp^{\max})$, (ii) those with $y_{\min} < \widehat{y} \leq y_{\max}$ receiving partial social benefits $(sp = sp^{\max} - \theta(\widehat{y} - y_{\min}))$ and (iii) those with $\widehat{y} > y_{\max}(= y_{\min} + sp^{\max}/\theta)$, receiving no social pension $(sp = 0)$.
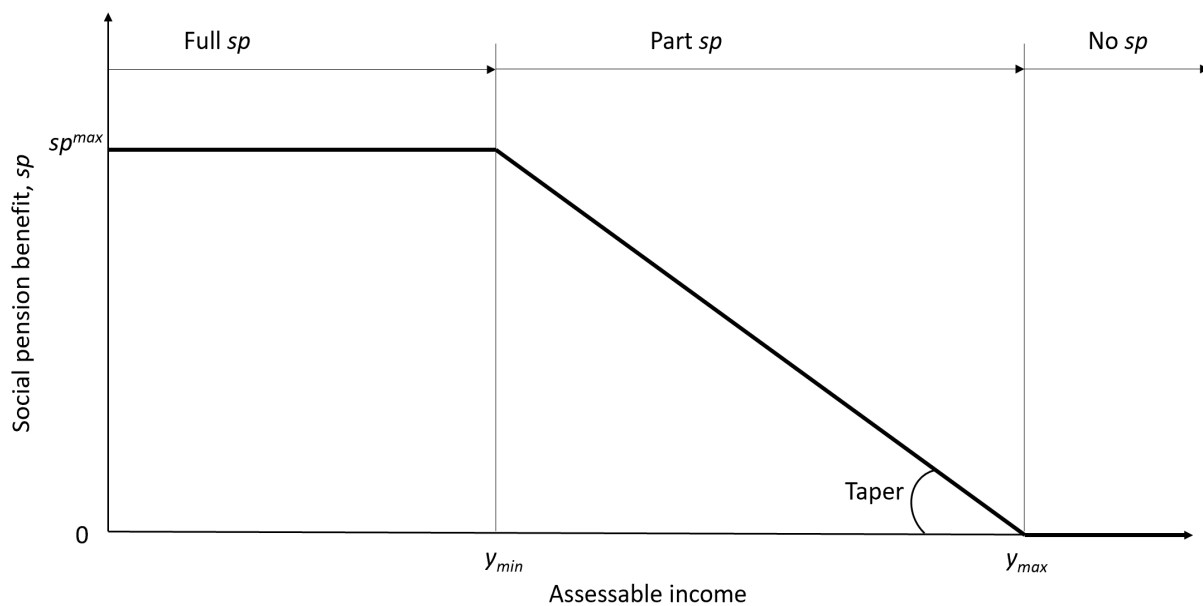

Figure A1. Graphical representation of social pension means test

We run the steady state simulation of Policy 5 (assuming the stationary demographic environment as in the benchmark model), in order to calibrate the means test in (20). The calibration data are reported in Table $A1$ for Policy 5, but also for Policy 4 (with social pension paid to all informal aged 65 and over). Note that under Policy 4, the social pension benefit (at 6.5% of GDP per capita) is paid to all informal households aged 65+. This maximum (non-contributory) benefit is paid to 76.9% of age-eligible population, with the remaining 23.1% being paid PAYG pension but no social pension. Under Policy 5, $sp^{\max}$ is set to target the total social pension expenditure (=0.48% of GDP as in Policy 4). It is shown to be higher, with $sp^{\max} = 0.081$ (or 8.1% of benchmark GDP per capita) under Policy 5.[72] In choosing the other two parameters of the means test (i.e., income disregard and taper), we draw on the Australian data, setting $\widehat{y}_{\min}$ for Policy 5 to approximate the proportion of those receiving $sp^{\max}$ (about 43% of those 65+) and θ to approximate the proportion of those receiving no social pension. We also assume that only a proportion of assets is included in the means test $ra_j\varphi$, with $\varphi = 0.3$.[73]

Table A1: Social pension parameters and means test calibration

Parameters/variables	Policy 4	Policy 5
Maximum (full) social pension benefit[a]	0.065	0.081
Income disregard (free income area)[b]	0	0.12
Taper rate (social pension withdrawal rate)	0	0.4
Fraction of means-tested assets	0	0.3
Proportion of population aged 65+ (%)[c]		
Those on full social pension	76.9	43.2
Those on part social pension	0.0	26.2
Those with no social pension	23.1	30.6

Notes: [a]Relative to GDP per capita; [b]Relative to average earnings, with benchmark GDP p.c./ybar = 1.41; [c]Age-eligible population for social pensions.

Long run effects of means-tested social pensions   The model generated outcomes for macroeconomic and welfare variables under Policy 5 (and Policy 4), assuming stationary

---

[72]Note that since the ratio of GDP p.c. to average (economy-wide) earnings ($\overline{y}$) is about 1.4 (using the benchmark figures), the maximum social pension benefit under Policy 5 is 11.4% of $\overline{y}$. Further note that this proposed social pension rate is significantly lower than the maximum age pension benefit in Australia, which (for single pensioners) amounts to over 30% of $\overline{y}$ (see Kudrna 2021).

[73]In Kudrna (2021), this parameter is age specific set to match share of owner-occupied housing in total assets that is not subject the means test. Here, in the case of Indonesia with a large informal sector, the observed fraction of assets (that can be means-tested) is smaller. However, note that this parameter could provide policy makers with an additional policy instrument to further strengthen the social pension means test over time (if needed).

demographics, are reported in Table $A2$ (for most macroeconomic variables, as % change relative to benchmark solution, and for welfare effects, using HEV defined in Section 5).

Table A2: Economic effects of overall reforms (Policies 4 and 5) in long run*

Variable	Policy 4	Policy 5
Effective labour	1.84	1.55
Wage rate	-2.90	-3.32
Average earnings	-0.04	-0.05
Output (GDP)	-1.11	-1.87
- Private consumption	1.48	1.02
- Gross investment	-5.74	-7.20
Capital stock	-5.74	-7.20
Household wealth	-5.26	-6.80
Interest rate (p.p.)	0.39	0.45
Social pension costs (% of GDP)	0.48	0.48
Consumption tax rate (p.p.)	0.69	0.80
PAYG contribution rate (p.p.)	-2.43	-2.43
Welfare effects[a]		
- Average	0.90	0.86
- Formal	2.66	2.80
- Informal	0.37	0.27
- Formal-low	0.69	1.03
- Formal-high	3.22	3.31
- Informal-low	0.55	0.52
- Informal-high	0.04	-0.16

Notes: *% changes relative to benchmark equilibrium (if not stated otherwise); [a]Equivalent variation measure in % of initial resources.

As shown in Table $A2$, there are some (quantitative) differences in the long run steady state implications between the two reforms (despite the same social pension expenditure under both pension reforms at 0.48% of benchmark GDP). The means-tested social pension alternative (under Policy 5) generates more distortions to life cycle economic decisions of those receiving the benefits, somewhat worsening of macroeconomic and welfare implications in the long run. This is not because of tapering the social benefits, but because of the higher maximum social benefit (that is allowed to adjust to keep the total social expenditure unchanged, as in Policy 4). However, the quantitative differences in these long run results are quite small. Importantly, as demonstrated in Section 6, means testing social pensions under Policy 5 is superior (in terms of welfare implications, particularly on older cohorts) to social pensions under Policy 4, when we account for population ageing.

B. Macroeconomic effects of pension reforms over transition

B.1 Stationary demographics

Table $B1$ reports on the macroeconomic results of Policy 4 (the overall pension reform including formal pension policy changes with all formal workers covered and increasing formal retirement ages as well as the introduction of non-contributory (modest) social pensions paid to all informal workers aged 65+) over the (stationary demographic or no ageing) transition path. Note that these results relate to the discussion provided in Section 5.2 (with some of the results plotted in Figure 6). Recall that the short run (or impact) effects are those in 2021-25 (or 2025 in Table B1) in the first year of the pension reform announcement, and the results for 2100 closely approximate the long run steady state effects (reported in Table 5 for Policy 4).

Table B1: Macroeconomic effects of overall reform (Policy 4) over (no-ageing) transition*

Variable	Time period				
	2025	2035	2045	2055	2100
Effective labour	0.08	-0.10	1.69	1.71	1.81
Hours worked	-0.51	-0.64	-0.91	1.71	-0.91
Wage rate	0.00	-1.05	-2.56	-2.68	-2.86
Output (GDP)	0.07	-1.18	-0.94	-1.01	-1.11
- Private consumption	2.94	1.64	1.63	1.57	1.47
- Gross investment	-4.57	-6.14	-5.39	-5.63	-5.73
Capital stock	0.00	-2.93	-5.08	-5.29	-5.71
Household wealth	0.00	-2.83	-4.78	-4.92	-5.32
Interest rate (p.p.)	0.00	0.14	0.34	0.36	0.39
Social pensions (% of GDP)[a]	0.48	0.48	0.48	0.48	0.48
Consumption tax rate (p.p.)[b]	0.50	0.83	0.67	0.67	0.69
PAYG pension cont. rate (p.p.)[c]	-2.19	-1.73	-2.92	-2.56	-2.41

Notes: *% change relative to benchmark solution (if not stated otherwise); [a]% of benchmark GDP; [b]Percentage point (p.p.) change in the effective consumption tax rate assumed to balance the government budget (now including the social pension expenditure); [c]Percentage point (p.p.) change in the payroll tax rate assumed to balance the PAYG pension budget for formal workers.

B.2 Non-stationary demographics

Here. we provide more details on the macroeconomic results for pension reform under Policy 4 and Policy 5 over the demographic transition. (Rather than relating the effects to the benchmark solution, as in Section 6), the macroeconomic effects in Table $B2$ are presented as (for most variables) a percentage change with respect to the baseline ageing scenario (with the results reported in Table 8). First, focusing on Policy 4, the effective labour increases

significantly, compared to the baseline ageing (no reform) scenario. These increases are more significant under population ageing, driven by increased productivity of (more populous) mature formal workers at the increased retirement age. Hours worked by those 20-54 decline over the demographic transition (as formal workers – now facing higher retirement age and all eligible for PAYG pensions smooth their consumption and labour supply, but als because of the pure income effects of non-contributory social pensions on labour supply of all those who receive these benefits). However, there are some negative effects of Policy 4 and these seem to be greater under population ageing (than in the stationary demographic environment in Section 5.2). For example, pension reforms offset more of private assets under population ageing (down by 8.21% in the long run, compared to the long run baseline ageing (no reform) solution). Under Policy 4, the social pension expenditure amounts to 0.52% of GDP in 2021-25, and it is further increasing over the demographic transition, to 1.71% of GDP in the long run. This expenditure is now included in the government budget, which requires the consumption tax rate to go up over the transition, by 1.75 p.p. (compared to the baseline ageing (no-reform) rate) to 12.7% in the long run.

The pension reforms under Policy 5 (with the means tested pensions) are shown to generate more distortions to the economy, compared to Policy 4. Note that in the short run Policy 5 covers a larger proportion of (currently living) elderly populations with the means-tested pensions, including some of those of the formal household type (in particular, formal-low households). Also, the maximum social pension benefit is higher under Policy 5 (by over 20%, compared to the social pension benefit under Policy 4). In the short run, this generates higher consumption per capita, but lower effective labour supply. There is also greater saving distortion under Policy 5 with this means-tested social pension alternative, with average household assets declining more during the demographic transition under this policy reform. However, note that the expenditure on means tested social pensions under Policy 5 is lower, at 1.44% of GDP in the long run, which allows for a lower budget-equilibrating consumption tax rate, compared to Policy 4.

Table B2: Macroeconomic effects of pension reforms (Policies 4 and 5) under demographic transition*

Variable	Policy 4				Policy 5			
	2025	2055	2100	2200	2025	2055	2100	2200
Effective labour	-0.36	3.28	3.86	3.86	-1.23	2.68	3.28	3.26
Hours worked[a]	-0.88	-1.38	-1.23	-1.27	-1.11	-1.52	-1.47	-1.53
Wage rate	0.14	-3.46	-3.60	-3.64	0.47	-4.17	-4.47	-4.52
Output (GDP)	-0.23	-0.33	0.05	0.02	-0.77	-1.65	-1.44	-1.48
- Private consumption	3.25	2.63	2.68	2.46	3.82	2.02	2.14	2.04
- Gross investment	-5.34	-5.52	-5.15	-5.28	-7.67	-8.02	-7.63	-7.90
Capital stock	0.00	-5.96	-5.88	-5.95	0.00	-8.33	-8.70	-8.75
Household wealth	-2.43	-7.99	-8.21	-8.21	-2.54	-10.39	-11.08	-11.00
Interest rate (p.p.)	-0.02	0.42	0.40	0.41	-0.06	0.51	0.50	0.51
Social pensions (% of GDP)	0.52	0.88	1.60	1.71	0.52	0.85	1.38	1.44
Consumption tax rate (p.p.)[b]	0.44	0.65	1.58	1.75	0.47	0.84	1.46	1.51
PAYG cont. rate (p.p.)[c]	-2.22	-4.46	-5.29	-5.72	-2.17	-4.40	-5.30	-5.72

Notes: *% change in per capita variables relative to baseline ageing transition (if not stated otherwise); [a]Average hours for those aged 20-54; [b]Percentage point (p.p.) change in the effective consumption tax rate assumed to balance the government budget (now including the social pension expenditure); [c]Percentage point (p.p.) change in the payroll tax rate assumed to balance the PAYG pension budget for formal workers.