Three Essays on Macroeconomic Policy, Development Economics and Economic Growth

DISSERTATION
of the University of St. Gallen,
School of Management,
Economics, Law, Social Sciences
and International Affairs
to obtain the title of
Doctor of Philosophy in Economics and Finance

submitted by

NAVARAT TEMSUMRIT

from

Thailand

Approved on the application of

Prof. Guido Cozzi, PhD

and

Prof. Andrew Abbott, PhD

Dissertation no. 4972

Difo-Druck GmbH, Untersiemau 2020

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The University of St.Gallen, School of Management, Economics, Law, Social Sciences and International Affairs hereby consents to the printing of the present dissertation, without hereby expressing any opinion on the views herein expressed.

St.Gallen, November 15, 2019

The President:

Prof. Dr. Thomas Bieger

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Abstract

In order to fulfil the requirements for the degree of Doctor of Philosophy in Economics and Finance, at the University of St.Gallen, after the completion of the course-work and research phases, I hereby to provide the cumulative dissertation. The dissertation consists of three essays on macroeconomic policy, development economics and economic growth.

The first chapter examines empirically the relationship between the cyclical pattern of fiscal policy in democratic developing countries and their quality of political institutions. This chapter uses updated data to analyse 63 developing countries from 1980 to 2013 and robustly shows that pro-cyclical fiscal policy exist in both democratic and non-democratic developing countries. The main contributions of this chapter are controlling the endogeneity issue by using the instrumental variable method and investigating the interactions between political institutions variables and the cyclicality of fiscal policy. The results suggest that an improvement in the level of institutional quality plays an important role to restrain pro-cyclical fiscal policy. These effects are larger in democratic countries than non-democratic ones. Additionally, the maturity and stability of a democratic regime influence in restraining the implementation of pro-cyclical fiscal policy.

The second chapter studies the effects of demographic transition and unfunded pension system in affecting the economic growth in Thailand. We modify the traditional Overlapping Generation (OLG) model to allow individuals heterogeneity in their ages and exogenously assign to work either in the formal or informal sector. The results from our model suggest that the non-contribution pension system or old-age security schemes hinder the economic growth of the economy with a high share of the informal sector and low fertility rate like Thailand. An increase in the non-contribution pension payouts or the universal old-age allowance also reduces the investments in children's education. It produces the costs to the young workers, whose proportion is shrinking due to a shift in the demographic transition. Ultimately, we may need to transfer the current regimes towards a fully funded pension system and social security schemes or expanding the tax base to the informal sector.

The third chapter studies the effects of the elderly labour supply choices on economic growth. We extend the traditional OLG model in which the elderly have choices to either stay or leave the labour market after their retirement age. Our main contribution is that the model considers the role of supportive government policies which provide positive externalities and augment the elderly health stock. An increase in the health-related human capital stock allows the elderly to enter or continue working at older age. The model characterises the unique equilibrium and shows that the costs of working after retirement, the health stock of the elderly and balancing supportive government policies play an important role to the labour supply of the elderly and thus, economic growth.

Zusammenfassung

Um die Voraussetzungen zur Erlangung des Titels «Doctor of Philosophy in Economics and Finance, at the University of St.Gallen» zu erfüllen, reiche ich hiermit meine kumulative Dissertation ein. Die Dissertation besteht aus drei Essays über makroökonomische Politik, Entwicklungsökonomie und ökonomisches Wachstum.

Das erste Kapitel behandelt den empirischen Zusammenhang zwischen fiskalpolitischen Zyklen in demokratischen Entwicklungsländern und deren Qualität politischer Institutionen. Das Kapitel zeigt Evidenz für prozyklische Fiskalpolitik in demokratischen sowie nicht-demokratischen Entwicklungsländern. Der Hauptbeitrag dieses Kapitels besteht darin, das Problem endogener Variablen mit Instrumentalvariablen zu lösen sowie die Interaktionen zwischen politischen Institutionen und der Zyklikalität der Fiskalpolitik zu untersuchen. Die Resultate zeigen, dass eine Verbesserung der politischen Institutionen eine entscheidende Rolle spielt, um prozyklische Fiskalpolitik einzuschränken. Diese Effekte sind stärker in demokratischen Ländern. Ausserdem beeinflussen Reife und Stabilität des demokratischen Regimes die Einschränkung der Einführung prozyklischer Fiskalpolitik.

Das zweite Kapitel untersucht die Effekte des demografischen Wandels und eines ungedeckten Rentensystems auf ökonomisches Wachstum in Thailand. Wir modifizieren das überlappender Generationen (OLG) Modell so, dass Individuen heterogen in ihrem Alter sind und weisen ihnen exogen entweder Arbeit im formalen oder informalen Sektor zu. Die Resultate des Modells zeigen, dass das beitragsunabhängige Rentensystem oder Alterssicherungssystem ökonomisches Wachstum in Thailand hindert. Eine Erhöhung der Auszahlungen im beitragsunabhängigen Rentensystem oder im Alterssicherungssystem kann Investitionen in die Ausbildung der Kinder reduzieren. Es bringt dies Kosten für die jungen Arbeiter mit sich, dessen Anteil in der Bevölkerung aufgrund des demografischen Wandels sinkt. Deshalb scheint es notwendig, zu einem Rentensystem und Alterssicherungssystem zu wechseln, welche vollständig kapitalgedeckt sind.

Das dritte Kapitel modelliert das traditionelle OLG Modell mit der Möglichkeit für die ältere Generation, nach deren Pensionierung entweder den Arbeitsmarkt zu verlassen oder im Arbeitsmarkt zu verbleiben. Der Hauptbeitrag dieses Kapitels ist die Untersuchung der Rolle der Regierungspolitik, welche positive Externalitäten auf den Humankapitalstock der älteren Generation haben kann. Eine Erhöhung des altersbedingten Humankapitalstocks erlaubt es, dass die ältere Generation in den Arbeitsmarkt eintritt respektive in diesem verbleibt. Das Modell charakterisiert das einzige Gleichgewicht und zeigt, dass die Kosten der Arbeit nach der Pensionierung, die Gesundheit der älteren Generation und ausgleichende Regierungsmassnahmen eine entscheidende Rolle für die Erwerbsbeteiligung der älteren Generation, und somit ökonomisches Wachstum, spielen.

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Chapter 1

Does Democracy Affect Fiscal Policy Cyclicality? Evidence from Developing Countries

1.1 Introduction

A large body of existing research points to the tendency of many developing economies implement procyclical fiscal policies. That is, that governments reduce spending and increase taxation during an economic downturn, and increase spending and reduce taxation during an economic boom. The fiscal policy procyclicality is considered to be sub-optimal for the countries in both good and bad states. During the downturn, private consumption and investments are plunged due to less demand and they are more deteriorated if governments implement contraction policies. The same logic applies during booms, procyclical fiscal policy is harmful to the economy by overheating it. Cutting taxes and increasing government spending, together with the higher aggregate demand from the private sector, push the economy towards a too optimistic state. Although the implementation of the procyclical fiscal policy is sub-optimal one, many evidence point to the procyclical fiscal policy in developing countries. The previous research attempt to explain why countries, especially, developing ones chose to implement procyclical fiscal policy. There are two main strands explaining this issue: firstly, procyclical fiscal policy is caused by an imperfection and credit constraints in the international credit market [see, for example, Gavin and Perotti, 1997; Kaminsky, Reinhart and Végh, 2005; Caballero and Krishnamurthy, 2004; Calderón, Duncan and Schmidt-Hebbel, 2010; Aghion, Hemous and Kharroubi, 2014 and etc]. Second standpoint sees the political factors, e.g. the distortion of the political regime, the quality of political institution or the political polarisation as the root causes of the procyclical fiscal policy [see, e.g. Tornell and Lane, 1998; Talvi and Vegh, 2005; Manasse, 2006; Alesina, Campante and Tabellini, 2008;

Calderón and Hebbel, 2008 and etc].

This chapter takes the standing point of the political factors as a root cause of the procyclical fiscal policy in developing countries. However, instead of using either the quality of political institutional or the political regime in explaining the cyclical pattern of fiscal policy, this chapter points out the interaction effects of the political regime and an institutional quality in affecting the cyclical behaviour of fiscal policy.

The main contributions of this chapter are two folds: firstly, we use instrumental variable approach (IV) to control the endogeneity problem since previous literature barely show the causal inference between the cyclical component of government spending and the output level. Secondly, this chapter considers more aspects of the political economy factors, e.g. political regime, quality of the institutions, the maturity of political regime, in affecting cyclical behaviour of fiscal policy. The reason behind this is that developing countries usually faced a political regime breakdown or reversals during their transition towards democracy. For example, a revival of an authoritarian or semi-authoritarian system for some period of time in Bangladesh in 2007, Nigeria in 2000-2001 or regime breakdown in Thailand during 2006-2010 and 2013 onwards and etc.

Our findings suggest that both democratic and non-democratic developing countries implement procyclical fiscal policy, but the higher the level of institutional quality is, the less procyclical public spending will be. Better institutional quality, therefore, acts as a tool to prevent a severe procyclical fiscal policy. Moreover, the effects of an improving level of institutional quality on restraining procyclical fiscal policy are larger in democratic countries than non-democratic ones. Lastly, more mature and stable democratic countries tend to implement less procyclical fiscal policy.

The remaining of this chapter is organised as follows: Section 1.2 provides a brief theoretical background and previous empirical evidence of this literature. Section 1.3 introduces the data used in this chapter. Section 1.4 sets up the empirical strategy used for the analysis. The results produced by various econometric methods are discussed in Section 1.5. Section 1.6 performs a robustness check by allowing democracy to be instrumented by the former colony and the choices of setting an institution of settlers data. Section 1.7 concludes the main findings.

1.2 Cyclical Pattern of Fiscal Policy: Theory and Evidence

According to the Neoclassical and Keynesian views, fiscal policy is considered to be one of the efficient tools to stabilise the short-run economic fluctuations and promote the long-run economic growth. It works through the use of taxation and government spending.[1] To stabilise the output fluctuations, a decent fiscal policy should be able to prevent the overheating economy during booms and boosting economy during recessions; this is called "countercyclical fiscal policy". The countercyclical pattern of fiscal policy helps the economy to avoid recession due to its reciprocal processes. This means that during a recession government injects some liquidity into the economy since private consumptions and investments are contracted. An increase in the productions due to higher demands from public sector creates more job for the workers, which helps to reduce the unemployment rate, and generates income for the households. The households, therefore, can increase their consumptions and the demand for goods. This process helps to pull the economy out of recession.

Instead of implementing countercyclical fiscal policy, many researchers document that developing countries usually follow procyclical fiscal policy. Governments raise their spendings and cut taxes during booms and decrease their spendings in recession.[2] The sub-optimal procyclical fiscal policy is harmful to long-term economic growth [Frankel, Vegh and Vuletin, 2013; McManus and Ozkan, 2012; Woo, 2009].

In the empirical perspective, Gavin and Perotti [1997] were the first to study the fiscal policy cyclicality. They find that Latin American countries tend to implement procyclical fiscal policy, while developed countries mostly follow a countercyclical pattern. They suggest that the imperfection of the international credit markets is a root cause of procyclical fiscal policy in Latin America. The imperfection of the international credit markets impedes access to sources of funds during economic downturns. Thus, countries are not able to boost the economy during recessions and procyclical fiscal policy is the only choice for the government [See, for example, Caballero and Krishnamurthy, 2004; Kaminsky, Reinhart and Végh, 2005; Aghion, Hemous and Kharroubi, 2014and Suzuki, 2015.]. The paper by Caballero and Krishnamurthy [2004] points out that procyclical fiscal policy happens mostly in the developing countries due to the lack of financial depth or supply of funds from both the private and public sectors. As a consequence of that, there will be no enough funds injecting to boost the economy during the recession, while during the booms, governments crowd-out the investments due to slow fiscal adjustments. Not only in the countries level that imperfection in credit markets causes procyclical spendings. The paper by Aghion, Hemous and Kharroubi [2014] studies the firm level and documents that firms in the sector which can access to the external credit tend

[1]Note that fiscal policy, we mean in this chapter, is considered to be discretionary fiscal policies since most of our sample countries are developing countries, which have a lower proportion of income tax and social transfer in comparison to developed countries. The automatic stabilisation policy would not play a significant role to smooth the economy during the fluctuations.

[2]Tax policies are not widely used as discretionary fiscal policy responding to short-run economic fluctuation since it has already embedded into automatic fiscal stabilisation. Moreover, changing tax policies is quite difficult in practice due to the lag of implementation. Therefore, our analysis here intends to use only government spending as a fiscal policy indicator.

to have countercyclical spending implementation. This affects their growth in the long-run through enhancing productivity and R&D projects. Suzuki [2015] uses the model which fiscal policy entirely depends on the default option and finds that procyclical fiscal policy exists due to the imperfection of credit markets. However, her model does not allow the government to make political distortion or any irrational decisions. If this assumption is relaxed, we may find that the reason behind the procyclical fiscal policy can also be explained by political economy factors.

Political factors become a popular explanation to procyclical behaviour of fiscal policy and have been studied by many researchers. For example, the paper by Talvi and Vegh [2005] documents the implementation of procyclical fiscal policy in developing countries which mainly is explained by the political distortion. In their model, the implementation of a budget surplus, using full tax smoothing, is too costly for the developing countries because the tax base in moany developing countries are quite volatile. The optimal choice for the government is, therefore, implementing procyclical fiscal policy. However, for G7 countries, they document acyclical fiscal policy. Alesina, Campante and Tabellini [2008] agree that countries which have credit constraints may lead to fiscal policy procyclicality, but having credit constraints show a sign of weak political institutions. Constrained budget during economic recessions equally signals corruptible tendencies to the market, thereby impairing the country's ability to obtain funding on the market. Even if governments are able to access sources of funds, their costs of borrowing will be sustainably high which hamper governments ability to generate economic stimuli when needed most. The seminal paper by Alesina, Campante and Tabellini [2008] constructs the model to est empirically 83 countries from 1960 to 2003. They conclude that the democratic countries with higher corruption induce the implementation of fiscal policy procyclicality. This is because the voters may exert political pressure on their government and demand more spendings when they observe fiscal surplus since they know that the government engages in the political agency problem.

Other explanations of procyclical fiscal policy are voracity effects[3] and variety of social polarisations like income, education or political power inequality. Lane [2003] tests the OECD countries cyclical behaviour of fiscal policy and suggests that procyclical fiscal policy will be more pronounced in the countries where there is a separation of political power. Woo [2009] studies the social polarisation in income, educational distribution and cyclical fiscal policy. He finds that the more polarisation in income, the more volatile fiscal spendings are. Moreover, if the policymakers have less patient, fiscal policy tends to also be procyclical. The paper by Abbott and Jones [2011] studies cyclical of social protections' spendings of the OECD countries as a fiscal policy proxy. They suggest that cyclical behaviour of the social protections depends on the degree of political polarisation and the public borrowing

[3]See, e.g. Tornell and Lane [1998], Lane and Tornell [1998] and Lane [2003] for more explanation.

constraint. They also find that procyclicality does not exist only in the total consumption of the central government. The sub-central government spendings and intergovernmental transfers are likely to be more procyclical than the central government spending due to political pressure within the distribution of political power [Abbott and Jones, 2013].

Apart from political issues, series of work by Calderón et al. [2004], Calderón, Duncan and Schmidt-Hebbel [2004], Calderón and Hebbel [2008], Calderón, Duncan and Schmidt-Hebbel [2010], Calderón, Duncan and Schmidt-Hebbel [2016] explain the procyclical pattern of fiscal policy mainly by the quality of institutions. Calderón, Duncan and Schmidt-Hebbel [2010] argue that both advanced and developing economies with stronger political institution tend to implement countercyclical macroeconomic policies rather than the procyclical ones. Similar to Ilzetzki and Végh [2008], Ilzetzki [2011], and Halland and Bleaney [2011], they find that a higher quality of political institution have a positive effect towards implementation of the countercyclical fiscal policy. More recent paper by Céspedes and Velasco [2014] finds that an improvement in the institutional quality helps to reduce procyclical fiscal policy, though they focus the study on the commodities rich developing countries.

After reviewing the previous literature, the political factors and the quality of political institution seem to be the main factors related to the fiscal policy procyclicality in developing countries. Many previous studies point out the importance of having a good quality of a political institution and democracy, few focus their studies on the interactions between the political factors like the political regime and the quality of political institution in affecting the fiscal policy cycle. This chapter, therefore, focuses the analysis on an interaction between the institutional quality and the political regime, especially democratic regime, in affecting the procyclical fiscal policy in developing countries.

1.3 Data

We use the unbalanced panel data of developing countries from 1980 to 2013 for our empirical study. We do not include countries which have changed their economic status from developing to developed income over the study period, e.g. South Korea and Chile. The small island countries and some developing countries which have a huge break in their data are also excluded from the analysis. In total, we have 63 developing countries as a sample and their economic status do not change during the period of study even though the countries reach higher GDP per capita.[4] The summary statistic of key variables is displayed in Table 1.1. [5]

The main dependent variable for the analysis is **fiscal policy cycle** which is measured by Government Spending Gap. We use the difference between real final government consumption

[4]We present the map of sample countries and their GDP per capita in the year 1990, 2000 and 2013 in appendix A.

[5]See more details on the data description in the appendix A

and its trend since we would like to capture the cyclical behaviour of the fiscal policy. The main independent variables are **business cycle** and **interaction effects terms between democracy and business cycle**. Output Gap is used as an indicator for the business cycle which captures the variation of the real GDP from its trend. Both real GDP per capita and real government final consumption per capita are obtained from the World Development Indicators (WDI). We transform them into logarithmic form before calculating their trend and their cyclical components, respectively.

Democracy, in this study, is defined by the minimalistic definition: the countries which hold fair and free elections are considered to be in the democratic regime. It measured by the Democracy Index from the POLITY IV project. The Democracy Index ranges from -10 to 10. -10 to -6 indicates "Autocracy", whereas a score between +6 and +10 indicates "Democracy". Countries score between -5 and +5 are measured as "Anocracy", i.e. neither democratic nor autocratic political systems or it is a loose definition of a regime which mixes both democratic and autocratic features. We also revalue the Democracy Index to be 0-6 for Autocracy, 7-15 for Anocracy and 16-20 for Democracy in order to simplify the interpretation. Therefore, the dummy variable for democracy is equal to 1 if the score is higher than or equal to 16, otherwise, it is classified into a non-democratic regime.

Other independent variables are **institutional quality** and **maturity of democracy**. The definition of institutional quality is widely discussed among social scientists. However, there is no clear cut what exactly the meaning of institutional quality. This chapter follows the definition of institutional quality from Kaufmann, Kraay and Mastruzzi [2009] and adopt the institutional quality indicators from the Worldwide Governance Indicators (WGI). The indices are provided in percentile rank from 0 to 100. Higher percentile rank indicates better quality of the institutions. The indices are provided for the years 1996, 1998, 2000 and 2002-2013. The maturity of democracy is constructed firstly by calculating a number of year in democracy, which we also show in Table 1.1. We use the democracy indices and the Legislative and Executive Indices of Electoral Competition dataset (LIEC and EIEC). LIEC and EIEC are obtained from the Political Institutions Database [Beck et al., 2001; Keefer, 2007]. The LIEC and EIEC range from 1 to 7. The higher the score is, the more presences of competitive elections are. If the democracy indices score ≥ 16 and LIEC and EIEC score > 4, then we will count as 1 year of being in democracy and continue counting if these criteria are met. When the countries lose either democracy indices score ≥ 16 or LIEC and EIEC score > 4, then the number of year in democracy goes back to 0 and start counting at 1 once both criteria are met. The dummy variable for maturity of democracy is equal to 1 if number of year in democracy ranges between 1 and 10 consecutive years (for 10 years dummy), between 11 and 20 consecutive years (for 20 years dummy), more than 21 consecutive years (for 30 years dummy), respectively, otherwise, it equals zero.

Some others control variables like Trade Openness and the degree of Financial Openness are transformed into logarithmic form. Trade openness is measured by the ratio of exports plus imports of goods and services as a share of GDP. The data is taken from the World Development Indicators (WDI). Financial openness index is adopted from Chinn and Ito [2008].[6] These indices consider the extent of cross-border financial transactions and lie between 0 and 1. Score 0 means that financial markets are completely closed and 1 is the highest degree of financial openness.

Table 1.1
Summary Statistics of Key Variables

Variable	Mean	Std. Dev.	Min.	Max.	N
Output Gap	-0.001	0.026	-0.193	0.206	1900
Government Spending Gap	-0.004	0.08	-1.405	0.598	1900
Trade Openness	1.821	0.244	1.045	2.343	1899
Financial Openness	0.373	0.317	0	1	1725
Total Factor Productivity Growth	0.877	2.18	-25.97	18.938	1135
Air Temperature (Celsius)	20.129	6.047	4.776	29.583	1393
Air Precipitation (100 s mm / year)	11.374	7.943	0.066	48.348	1393
Democracy Index	11.812	6.592	0	20	1900
Legislative Indices of Electoral Competition (LIEC)	5.97	1.745	1	7	1872
Executive Indices of Electoral Competition (EIEC)	5.524	1.981	1	7	1870
Number of Year in Democracy	5.754	8.431	0	35	1900
Control of Corruption	1.495	0.301	0.165	1.947	976
Government Effectiveness	1.57	0.239	0.591	1.939	976
Political Stability and Absence of Violence and Terrorism	1.426	0.362	-0.326	1.981	976
Regulatory	1.555	0.288	0.458	1.907	976
Rule of Law	1.493	0.265	0.379	1.92	976
Voice and Accountability	1.478	0.32	0.284	1.94	976
Average 6 Institutional Quality	1.503	0.23	0.603	1.884	976
Dummy_Asian	0.362	0.481	0	1	1900
Dummy_Subsaharan	0.369	0.483	0	1	1900
Dummy_LatinAmerica	0.269	0.444	0	1	1900

Source: Author's own calculation.
Notes: Table presents summary of key statistic using for the empirical analysis. The Average 6 institutional quality is the average value of 6 institutional quality indices: Control of Corruption, Government Effectiveness, Political Stability and Absence of Violence and Terrorism, Regulatory Quality, Rule of Law and Voice and Accountability.

For instrumental variables data, the **Total Factor Productivity growth** data is provided for 38 developing countries from 1980 to 2010 by World Productivity Database. The Total Factor Productivity is calculated by using the Dynamic Growth Accounting-Harrod neutral with the Cobb-Douglas production function with an assumption of a constant return to scale. The capital stock is based on the perpetual inventory method (PIM) with an annual

[6]The indices are constructed based on the binary dummy variables coded by the IMF's Annual Report on Exchange Arrangements and Exchange Restrictions (AREAER). The binary dummy variables cover 4 main restrictions on the external accounts as follows: the presence of multiple exchange rates, the restrictions on current account transactions, the restrictions on capital account transactions and the requirement of the surrender of export proceeds.

depreciation rate of 6 per cent and the initial capital stock includes 10 years of investment. The labour input is based on the Labour Force (LF) and is derived from Penn World Table 6.1 [Anders Isaksson, 2007]. **Mean of yearly air temperature and air precipitation** dataset are taken from the Terrestrial Air Temperature and Precipitation: 1900-2006 Gridded Monthly Time Series, Version 1.01, constructed by Willmott, Robeson and Matsuura [2007] as suggested in Dell, Jones and Olken [2012].[7]

Table 1.1 illustrates the summary statistics of the key variables of 63 countries from 1980 to 2013. In total, we have about 1900 observations. The average output gap and government spending gap are equal to -0.001 and -0.004, respectively. Financial openness index of our selected developing countries is about 0.373 on average, while the highest degree of financial openness is represented by a score of 1. Financial markets in developing countries are still considered not freely open. On average, the total factor productivity growth of our sample is 0.877, with large variation between 18.938 and -25.97. The democracy indices are varied across countries although the average score is 11.812, which indicates anocracy. For example, the democracy indices for the countries like Costa Rica and Mauritius score 20, while the countries like Gabon or Swaziland score 1. The last panel of Table 1.1 shows political institutions descriptive statistics. On average, political institutions variables of this region are 1.503 which could be interpreted as having credible political institutions. However, the scores are quite different across countries.

1.4 Identification Strategy

The baseline model specification for unbalanced panel data with cross-sectional units $N = 1, 2, ..., 63$ and periods $T = 1, 2, ..., 33$ in order to explain a change in the cyclical component of government total spending is as follows:

$$\begin{aligned} G_{i,t} = \beta_1 OutputGap_{i,t} + \beta_2 G_{i,t-1} + \beta_3 Democracy_{i,t} + \beta_4 InstQual_{i,t} \\ + \beta_5 X'_{i,t} + \mu_i + \lambda_t + u_{i,t} \\ i = 1, 2, ..., 63 \; t = 1, 2, ..., 33 \end{aligned} \tag{1.1}$$

where $G_{i,t}$ denotes the government spending gap of country i at time t (percentage deviation of government spending per capita from its trend) as a proxy of fiscal policy cycle. $OutputGap_{i,t}$ represents the output gap (percentage deviation of output per capita from its trend) as a proxy of the business cycle. We include $G_{i,t-1}$ (lagged government spending gap) into our

[7] For more detail on Air Temperature and Air Precipitation data, see Dell, Jones and Olken [2012].

model follow the usual literature of the dynamic model. Other independent variables are democracy dummy $Democracy_{i,t}$ and institutional quality $InstQual_{i,t}$. Matrix $X'_{i,t}$ contains other observable factors e.g. the imperfection of an international credit market, trade openness and other control variables.

Country-specific effect μ_i is added to control unobserved heterogeneity of country. λ_t is a time dummy. $u_{i,t}$ is an error term followed an i.i.d. process. For the Ordinary Least Squared with Fixed Effects (OLE-FE) estimations, we assume that $u_{i,t}$ is not correlated with other independent variables on the right-hand side equation. So that the estimators from OLS-FE are unbiased and consistency.

For this specification, we interest in the coefficient β_1 which capture the cyclical behaviour of fiscal policy. It measures in what percentage deviation of output from its trend affects the percentage deviation of public spending from its trend. In the next part, we relax the restriction on $u_{i,t}$ and allow it to correlate with other control variables.

1.4.1 Endogeneity Issues

Although we might be able to eliminate time-invariant unobserved heterogeneity by introducing countries specific effect into our model specification, there still be a possibility that we omitted some unobserved variables. These omitted variables will stay in the error term and once we relax the assumption $Cov(u_{i,t}, X'_{i,t}) \neq 0$, our specification is suffered by endogeneity issues. This means that the error term is correlated to the independent variables on the right-hand side of the equation, in this case, it is the output gap. Another concerning issue is that causality might run simultaneously on both sides of the equation. That is β_1 capture not only the fiscal policy cycle but also the fiscal multiplier. These also raise the endogeneity problem which makes our estimators biased and inconsistency.

To overcome the endogeneity problem, one could set up the quasi-random experiment to obtain the causal effect of interested estimators. However, in reality, it is difficult to set a randomly assigned experiment for macroeconomics dataset. We adopt the Instrumental Variable(IV) approach to overcome the endogeneity issue.

The Dynamic Panel Data Model approach is used for *Internal* IV[8]. For an *External* IV[9], we employ the Total Factor Productivity Growth (TFP) as an instrumental variable for the endogenous output gap.

Some previous literature on fiscal policy cycle, e.g. Alesina, Campante and Tabellini [2008] and Ilzetzki and Végh [2008], have already mentioned the possibility of having endogeneity problem. The paper by Alesina, Campante and Tabellini [2008] use the level of the output

[8]Using differencing of lagged dependent variables as a set of the instrumental variable for the endogenous independent variable in the level equation.

[9]Using exogenous instrumental variables from outside of the model.

gap of the region i except the country i itself for controlling the endogenous output gap of country i. This instrumental variable may neglect the spillover effect within the region, which in turn make an IV correlated to the error term of the structural model. Other related paper on using an IV for output level are Brückner, Chong and Gradstein [2012], Brückner [2012] and Brückner and Gradstein [2014]. They use the level of rainfall, oil price multiply by a term of trade as instrumental variables for endogenous output level. We cast doubt on the endogeneity of rainfall since it may induce the level of public spending or our fiscal indicator e.g. variation of rainfall level could cause flood or drought in a country which may be correlated directly to the government spendings. For oil price as an instrumental variable, it may fit only some specific group of countries, i.e. heavy oil exporting countries.

This chapter explores the alternative instrumental variables to mitigate the endogeneity issue. Economists have long seen the TFP as one source of growth generators. According to macroeconomics theory, change in TFP is interwoven to the output level through many channels. Galí [2004] and Basu, Fernald and Kimball [2006] show that technology shocks appear directly to change in the permanent level of output. In order to get an unbiased and consistent estimator by using IV approach, two conditions need to be satisfied: no direct effect of the instrument on the outcome variable (exclusion restriction) and the instrument must have a non-zero effect on the treatment variable (validity).

To test the validity of the TFP growth as an instrumental variable for the output gap, we then regress the endogenous independent variables, the output gap, on the TFP growth and the control variables to obtain the estimations of the first stage. The estimator of the first-stage shows positively significant. An increase in the TFP growth increases the potential output; the gap between actual and potential output normally gets bigger. We conclude that the TFP growth may be a **valid instrument**: $Cov(OutputGap, TFPgrowth) \neq 0$ for an endogenous output gap.

Another point is that we expect the TFP growth to be uncorrelated to the error term in the structural equation. That is $Cov(u, TFPgrowth) = 0$. although the **exclusion restriction** is quite difficult to test, we check the correlation between government spending gap and the TFP growth by regressing the government spending gap on the TFP growth. The estimation shows that these two variables are not directly correlated to each other. Moreover, the TFP growth usually affects the supply side of the economy (trend part of the output gap), while the government spending affects the demand side (the actual part of output gap). Therefore, we would neither expect the TFP growth to be correlated to some unobserved variables nor will affect directly to the government spending gap through this channel. The first stage of the IV approach is given by the following equations:

$$
\begin{aligned}
OutputGap_{i,t} = \pi_0 &+ \pi_1 TFPgrowth_{i,t} + \pi_4 X'_{i,t} \\
&+ \mu_i + \lambda_t + \varepsilon_{i,t} \\
&i = 1, 2, ..., 38 \quad t = 1, 2, ..., 33
\end{aligned}
\tag{1.2}
$$

where $OutputGap_{i,t}$ denotes the output gap of country i in year t. $TFPgrowth_{i,t}$ is TFP growth of country i in year t which we computed from dynamic growth accounting method and $X_{i,t}$ is the set of other exogenous variables. For the second-stage, we regress the government spending gap on the fitted values from the first-stage and get the reduced form as follows:

$$
\begin{aligned}
G_{i,t} &= \beta_1 Outp\hat{u}tGap_{i,t} + \beta_2 G_{i,t-1} + \beta_3 Democracy_{i,t} \\
&\quad + \beta_4 InstQual_{i,t} + \beta_5 X'_{i,t} + u_{i,t} \\
u_{i,t} &= \mu_i + \lambda_t + \varepsilon_{i,t} \\
&\quad i = 1, 2, ..., 38 \quad t = 1, 2, ..., 33
\end{aligned}
\tag{1.3}
$$

where $Outp\hat{u}tGap_{i,t}$ is the fitted value from the first-stage regression and β_1 is the parameter which measures the cyclical pattern of fiscal policy.

1.4.2 Lagged Dependent Variable Issues

We also perform the model specification with other econometric approaches, namely the Dynamic Panel Data Analysis using the General Methods of Moment (GMM) and the System General Methods of Moment (SYS-GMM). Since the model specification is dynamics, we include the lagged dependent variable as a regressor into the model. This may lead to a serial correlation problem by their structure. We follow the approaches from the Dynamic Panel Data and use the set of instrumented lagged-dependent variable from the difference-equation to instrument the endogenous regressor in the level equation [Manuel Arellano and Olympia Bover, 1995; Richard Blundell and Stephen Bond, 1998].[10] The transformed Difference equation used in the GMM approached is written by the following equation:

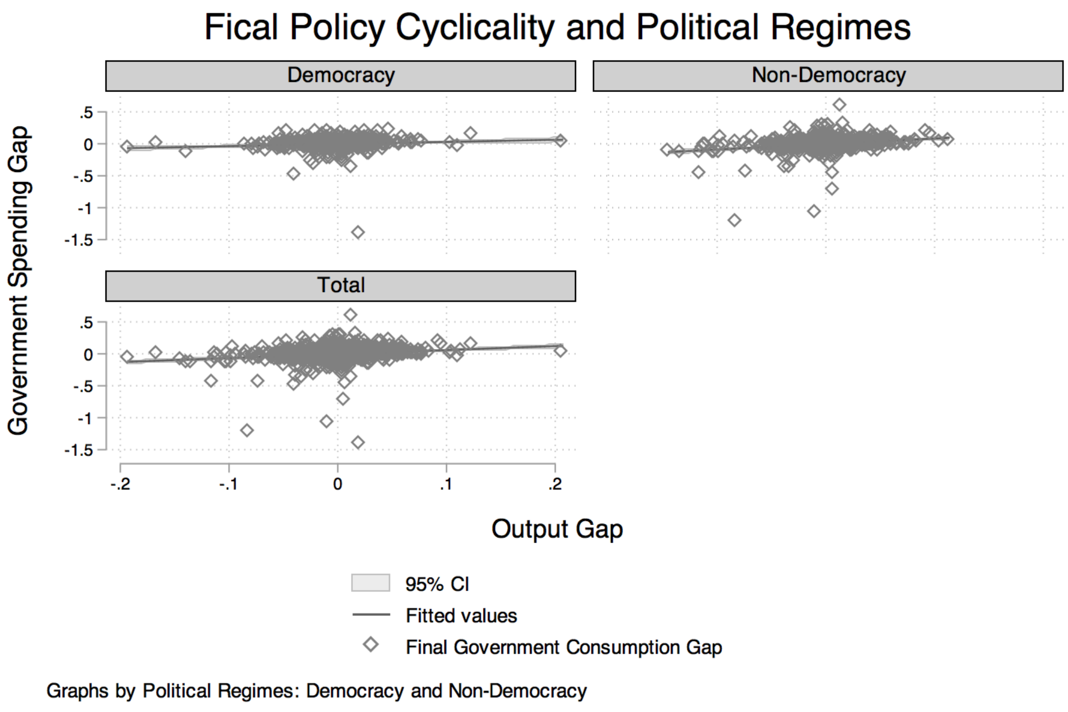
[10] See more detail of Dynamic Panel Data model in appendix B.

$$\begin{aligned} \Delta G_{i,t} &= \beta_1 \Delta OutputGap_{i,t} + \beta_2 \Delta G_{i,t-1} + \beta_3 \Delta Democracy_{i,t} \\ &\quad + \beta_4 \Delta InstQual_{i,t} + \beta_5 \Delta X'_{i,t} + \Delta u_{i,t} \\ u_{i,t} &= \mu_i + \lambda_t + v_{i,t} \\ &\quad i = 1, 2, ..., 63 \quad t = 1, 2, ..., 33 \end{aligned} \tag{1.4}$$

where $X'_{i,t}$ is the set of control variables. The coefficient β_1 measures the fiscal policy cycle of the country i at time t. It is expected to be positive when the country implements procyclical fiscal policy and to be negative when the country implements the countercyclical fiscal policy.

1.5 Results and Discussion

Fig. 1.1. The Cyclical Patterns of Fiscal Policy by Countries Political Regimes



Source: Author's own calculation.
Notes: The figure illustrates the positive relationship between the government spending gap and the output gap of the developing countries by their political regimes. The government spending gap, on the y-axis, is the percentage difference of the actual real government final consumption per capita from its trend. On the x-axis, the output gap is calculated by the cyclical component of the output per capita. This figure also shows the fitted value with 95 per cent of the confidential interval.

This section presents the results from various methods and discusses the main and marginal effects of democracy and the quality of political institution on the fiscal policy cyclicality.

Figure 1.1 depicts the relationship between government spending gap and output gap (grey diamond) by countries political regimes: democracy and non-democracy, and their fitted values (grey line). The fitted values are the product from OLS-FE model specification and the estimates are significant at 1 per cent level. The y-axis represents the government spending gap and the x-axis shows the output gap. Each diamond represents the output gap and government spending gap of our sample countries from 1980 to 2013.

Positive slopes of the fitted values in Figure 1.1 imply that the percentage deviation of output from its trend induces public spending to deviate from its trend in the same direction. This effect has been observed in both non-democratic and democratic developing countries, top-left and top-right panels, respectively. This implies that public spending in both democratic and non-democratic developing countries are procyclical. The bottom-left panel illustrates the positive relationship between the percentage change of output from its trend and public spending gap for overall samples. This figure shows that the procyclical public spending is implemented by the sample countries no matter what their political regimes are. To quantitatively test the relationship between the public spending cyclicality and the institutional quality in the democratic environment, we perform various specifications and provide the results and discussions in the following section.

1.5.1 Procyclical Fiscal Policy in Developing Countries

Baseline Model

We regress the government spending gap on the output gap and control variables of developing countries over 1980 to 2013 using the specifications of the model from the previous section. The analysis is performed in various approaches, for example, the ordinary least squared (OLS), Fixed Effect (FE), Instrumental Variable Approach with 2 Stage Least Squared (IV-2SLS), Dynamic Panel Data Analysis (GMM and SYS-GMM).

Table 1.2 presents the fiscal policy procyclicality in the developing countries sample. The coefficients of the output gap show positively significantly different from zero in all approaches. The columns 3 and 4 show the analysis using the IV approach, which allows a reduction in the standard error, and an increase in the positive effects of the output deviation on the government spending gap. This mean that for each one percentage change in the deviation of the output from its trend, the government spending tends to deviate from its trend in the same direction. This results robustly indicate the procyclical fiscal policy in developing countries.

In the columns 5 and 6, we perform the analysis using the GMM and System GMM approaches, respectively. They also show the procyclical fiscal policy although the standard errors from both models are increased. Columns 7 and 8, we perform the analysis using the Dynamic GMM (or Difference-GMM in Arellano and Bond [1991]) and Dynamic System GMM (or Difference System GMM) which give us the consistent results to other approaches. The standard error in Dynamic System GMM is lower than the normal OLS model with a lagged of the dependent variable. The estimators of the Dynamic System GMM approach show us the consistent and unbiased estimators than the OLS one in this case.

Turning to look at the political variables, an increase in the level of control of corruption induces higher government spending. That is there is costs of implementation and improving the institutional quality which raise higher public spending. The coefficients for the control of corruption are positive and significantly different from zero in all approaches except for the IV. The coefficients for the democracy dummy show significantly negative towards the fiscal policy cycle in the FE, IV-FE and System GMM approaches. This implies that the developing countries with democracy tend to implement less procyclical fiscal policy than the non-democratic ones.

In summary, Table 1.2 presents the incidences of fiscal policy procyclical in developing countries. A political regime which coincides with a lower procyclical fiscal policy is a democratic regime. The democratic regime creates a supportive environment for the government to implement countercyclical fiscal policy. Another point is that an improvement in the institutional quality, e.g. more restrictions or monitoring governments' corrupted behaviour, leads to a higher public spending. As a robustness checks, we also replicate the baseline model with an average value of 6 institutional quality instead of using only the control of corruption as a proxy for institutional quality, the results are in line with the results presented on the Table1.2.

1.5.2 An Interaction between Democracy and Institutional Quality in Affecting Fiscal Policy Cyclicality

In this part, we introduce the interaction effects terms to our analysis. This helps to expand the understanding of the relationship among political variables in affecting government spending behaviours. Table 1.3, 1.4 and 1.5 present the results of our specifications with the interaction effects terms between the output gap, the political regime (democracy) and the proxy of the institutional quality (the control of corruption and the average 6 indices of the institutional quality) in various approaches, i.e. OLS, FE, IV-2SLS, GMM and Dynamic GMM.

The main results from Table 1.3 simply suggest that the developing countries show a sign of implementing the procyclical fiscal policy. However, as the level of control of corruption is higher, the countries implement less procyclical fiscal policy. The effects of an improving

Table 1.2
The Fiscal Policy Cyclicality in Developing Countries (Baseline Model)

	(1) (OLS)	(2) (FE)	(3) (IV-FE)	(4) (IV-2SLS)	(5) (LD-GMM)	(6) (LD-SYSGMM)	(7) (DY-GMM)	(8) (DY-SYSGMM)
Output Gap	0.841***	0.827***	14.89*	11.40*	1.306***	1.900***	1.034***	0.503**
	(5.73)	(5.47)	(2.00)	(2.48)	(7.13)	(9.94)	(19.32)	(2.89)
L.Gov Gap	0.244***	0.228***	0.705*	0.616***	0.0866*	0.253***	0.0628***	0.0389
	(6.43)	(5.77)	(2.56)	(3.38)	(2.47)	(8.65)	(10.78)	(1.35)
Trade Openness	-0.0146	-0.0351	0.515	0.0238	-0.122*	0.0929*	-0.156***	-0.167**
	(-1.06)	(-0.79)	(1.31)	(0.47)	(-2.33)	(1.99)	(-9.25)	(-2.67)
Financial Openness	0.00324	-0.0156	-0.106	0.0132	0.0108	-0.0455	0.00928	0.0142
	(0.36)	(-0.72)	(-0.89)	(0.45)	(0.37)	(-1.52)	(0.96)	(0.47)
Control of Corruption	0.0226*	0.0421*	-0.0845	0.00141	0.150***	0.107***	0.157***	0.0810***
	(2.37)	(2.02)	(-0.70)	(0.04)	(5.70)	(4.41)	(13.22)	(7.81)
Dummy_Democracy	-0.00845	-0.0482**	-0.130*	-0.00664	-0.00664	-0.0371*	0.00535	0.0141
	(-1.38)	(-3.27)	(-2.01)	(-0.33)	(-0.33)	(-1.97)	(0.77)	(1.23)
First-stage								
TFP Growth			0.0006*	0.0006*				
			(0.0003)	(0.0002)				
N	883	883	456	456	883	883	652	652
FE	No	Yes	Yes	No	No	No	No	No
R-squared	0.11	0.11	0.09	-	-	-	-	-

Source: Author's own calculation.
Notes: Table estimates the fiscal policy cyclicality of developing countries using various econometric methods: OLS(Ordinary Least Squared), FE(Ordinary Least Squared with Fixed Effects), IV-FE(Instrumental Variable with Fixed Effect), IV-2SLS(Instrumental Variable with 2 Stages Least Squared), LD-GMM (Linear Dynamic Panel Data Estimations), LD-SYSGMM(System Linear Dynamic Panel Data Estimations), DY-GMM(Dynamic Generalised Method of Moments or Difference Generalised Method of Moments) and DY-SYSGMM(Dynamic System Generalised Method of Moments or System Difference Generalised Method of Moments). The Government Spending Gap is a dependent variable. L.Gov Gap represents Lagged Government Spending Gap. This table is omitted the estimator results of constant term and all estimators for time dummy. We instrumented the Output Gap by the Total Factor Productivity Growth for the Instrumental Variable approach. The TFP growth is computed by the Dynamic Growth Accounting - Harrod Neutral model with the Cobb-Douglas production function and assumed to be constant return to scale. t statistics are in parentheses and * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

institutional quality are also larger in the democratic nations than the non-democratic ones.

Firstly, the coefficients for the output gap in all models both OLS-FE and IV-2SLS approaches are positive and significantly different from zero at either 0.1 or 1 per cent level. This implies that each percentage change of the actual output deviating from its trend induces the government spending to deviate from its trend more than 1 per cent, except for the columns 3 and 7 which there are no output gap in the interaction effects terms. Columns 1 and 5 show that the estimates of interaction effects terms ($output\ gap * democracy$) are significantly negative at 0.1 per cent level which implies that democracy helps to restrain an implementation of the procyclical fiscal policy in the developing countries.

Secondly, we further analyse the fiscal policy cyclicality of the democratic and the non-democratic countries by using the marginal effects approach, partial derivative of the model with respect to the interested independent variables, in this case, we mean the output gap. The results suggest that the democratic countries with a stronger institutional quality tend to implement less procyclical fiscal policy. Moreover, the effects of an improvement in the control of corruption or institutional quality in containing the procyclical fiscal policy are more pronounced in the democratic countries than thenon-democratic ones.

In the column 1, it shows that an increase in one percentage point of the output gap in the democratic nations leads to a higher government spending gap about 0.15 percentage points ($1.54 - 1.39 = 0.15$), while in the non-democratic countries, the government spending gap tends to increase about 1.54 points as the output deviates 1 percentage from its trend. The marginal effects of fiscal policy cycle in column 5 present that the non-democratic countries tend to implement more procyclical fiscal policy than the democratic countries. For the democratic countries, the marginal effects show that as the output deviates from its trend 1 per cent, the government spending will deviate from its trend $4.42 - 6.02 = -0.6$ per cent, which implies the countercyclical fiscal policy, while the non-democratic countries show the procyclical fiscal policy (4.42) instead.

Table 1.3
An Interaction between Political Regimes and Corruption in Affecting Fiscal Policy Cyclicality (the OLS-FE and the IV-2SLS)

	OLS-FE				IV-2SLS			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Output Gap	1.54***	4.50***	0.82***	1.45***	4.42**	8.76***	0.35	3.65**
	(7.53)	(8.13)	(5.45)	(7.17)	(3.25)	(6.96)	(0.72)	(2.82)
L.Gov Gap	0.236***	0.242***	0.228***	0.234***	0.393***	0.360***	0.257***	0.369***
	(6.06)	(6.31)	(5.77)	(5.99)	(5.40)	(6.28)	(4.26)	(5.18)
Trade Openness	-0.0289	-0.0257	-0.0338	-0.0316	-0.0171	-0.0207	-0.0318	-0.0206
	(-0.66)	(-0.60)	(-0.76)	(-0.72)	(-0.70)	(-0.92)	(-1.33)	(-0.86)
Financial Openness	-0.0173	-0.0123	-0.0156	-0.0169	0.00312	0.00836	0.00517	0.00391
	(-0.81)	(-0.58)	(-0.71)	(-0.78)	(0.20)	(0.57)	(0.33)	(0.25)
Dummy_Democracy	-0.05**	-0.05***	-0.03	-0.05**	-0.007	-0.01	0.03	-0.007
	(-3.22)	(-3.61)	(-0.68)	(-3.23)	(-0.66)	(-1.35)	(0.55)	(-0.71)
Control of Corruption	0.04	0.02	0.05	0.04	0.02	0.008	0.05*	0.02
	(1.92)	(0.98)	(1.64)	(1.80)	(1.38)	(0.48)	(2.02)	(1.32)
Output Gap*Dummy_Democracy	-1.39***				-6.02**			
	(-5.10)				(-3.05)			
Output Gap*Control of Corruption		-2.67***				-5.82***		
		(-6.89)				(-6.50)		
Control of Corruption*Dummy_Democracy			-0.009				-0.03	
			(-0.27)				(-0.77)	
Output Gap*Control of Corruption*Dummy_Democracy				-0.79***				-3.02*
				(-4.57)				(-2.56)
First-stage								
TFP Growth					0.0007*	0.003***	0.0004	0.0007*
					(0.0003)	(0.0007)	(0.0003)	(0.0003)
TFP Growth*Dummy_Democracy					-0.0004			
					(0.0007)			
TFP Growth*Control of Corruption						-0.002***		
						(.0005)		
TFP Growth*Control of Corruption*Dummy_Democracy								-0.026
								(.034)
N. Observations	883	883	883	883	456	456	456	456
R-squared	0.13	0.16	0.11	0.13	0.08	0.19	0.07	0.1

Source: Author's own calculation.
Notes: Table estimates an interaction between political regimes and the control of corruption, as a proxy for the institutional quality, in affecting the fiscal policy cycle using the OLS-FE and the IV-2SLS approaches. The Government Spending Gap is a dependent variable. L.Gov Gap represents Lagged Government Spending Gap. This table is omitted the estimator results of constant term and all estimators for time dummy. We instrumented the Output Gap by the Total Factor Productivity Growth for the Instrumental Variable approach. The TFP growth is computed by the Dynamic Growth Accounting - Harrod Neutral model with the Cobb-Douglas production function and assumed to be constant return to scale. t statistics are in parentheses and * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Columns 2 and 6 add the interaction effects terms ($output gap * control of corruption$) into the model. The estimates confirm that developing countries implement procyclical fiscal policy as expected. Additionally, as the quality of the control of corruption becomes higher, the procyclical fiscal policy is then less pronounced. The marginal effects are analysed by using the coefficients and the value of the control of corruption from the descriptive statistics in the Table 1.1.

As expected, we document that the magnitudes of the quality of institution can contain the fiscal policy procyclicality. For example, using the estimated coefficients of the interaction effects terms from the column 2 in Table 1.3 and the value of the control of corruption from Table 1.1. We show that if the control of corruption, as a proxy for institutional quality, is high enough, the country would implement the countercyclical fiscal policy. The effects of the improvements of institutional quality are more pronounced especially in the democratic environment $4.5 - 0.05 - (2.67 * 1.947) = -0.74$.[11] These results show that with the better institutional quality, the government spending tend to be less procyclical.

Coefficients of the output gap from columns 3 and 7 also show the significant positive signs which present the fiscal policy procyclicality, although, some of them are not significant. This confirms the main results that developing countries implement the procyclical fiscal policy. Moreover, as the quality of institution increases, the procyclical fiscal policy is less implemented as we can see from the negative sign of the interaction effects terms.

Next, we use the interaction effects terms ($output\, gap * control\, of\, corruption * democracy$) for the analysis of the columns 4 and 8. The estimates document that although the democratic governments have a low level of the institutional quality (it is assumed to be 0.165 from the descriptive statistic in the Table 1.1), the fiscal policy still tends to be less procyclical than the non-democratic countries about 10 to 13.6 per cent. For example, from column 8, the marginal effects of democratic countries are calculated by $3.65 - (3.02 * 1 * control\ of\ corruption)$. Using the minimum value of institutional quality value, we get $3.65 - (3.02 * 1 * 0.165) = 3.15$, while the marginal effect for the non-democratic one will be 3.65. This implies that if both democratic and non-democratic countries have fairly weak institutional quality, the democratic countries tend to implement less procyclical fiscal policy than the non-democratic one about 13.6 per cent.

In summary, we can conclude the main results from the analysis as follows: firstly, the fiscal policy in developing countries are procyclical. However, a democratic environment and a stronger institutional quality are keys to ease the procyclical fiscal policy. Secondly, we also find that the magnitudes of an improvement in the institutional quality in affecting the fiscal policy cycle are more pronounced in the democratic environments than the non-democratic ones.

In order to check the robustness, we replicate the analysis as in Table 1.3 using other econometric methods: the GMM and the Dynamic GMM. The results are presented in the Table 1.4 and the Table 1.5. The main results are quite similar to the previous exercises. That is the procyclical fiscal policy robustly exists in the developing countries. Additionally, an im-

[11] We use the partial derivative and the values of the control of corruption, which ranges between 0.165 to 1.947, from the descriptive statistics in Table 1.1 to check the marginal effects on the fiscal policy cycle. In this case, the marginal effects of a stronger institutional quality in non-democratic countries equal to $4.5 - (2.67 * control\ of\ corruption) = 4.5 - (2.67 * 1.947) = -0.69$. If the quality of controlling corruption is lower (assumed to be minimum value 0.165 from the Table 1.1), the marginal effects will then be $4.5 - (2.67 * control of corruption) = 4.5 - (2.67 * 0.165) = 4.05$ which implies procyclical fiscal policy.

provement in the institutional quality leads to less procyclical fiscal policy implementation, and the effects are more effective in the democratic nations than the non-democratic ones.

Table 1.4
An Interaction between Political Regimes and Corruption in Affecting Fiscal Policy Cyclicality (the GMM and the System GMM)

	GMM				SYS-GMM			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Output Gap	1.88***	5.98***	1.28***	1.83***	2.65***	7.55***	1.90***	2.56***
	(8.52)	(10.64)	(6.98)	(8.39)	(11.97)	(14.13)	(9.95)	(11.71)
L.Gov Gap	0.099**	0.12***	0.075*	0.096**	0.26***	0.29***	0.25***	0.26***
	(2.90)	(3.57)	(2.14)	(2.80)	(9.44)	(10.35)	(8.58)	(9.31)
Trade Openness	-0.113*	-0.0928	-0.120*	-0.117*	0.102*	0.0861	0.0936*	0.100*
	(-2.23)	(-1.84)	(-2.30)	(-2.29)	(2.29)	(1.95)	(2.01)	(2.23)
Financial Openness	0.0199	0.0160	0.00579	0.0180	-0.0271	-0.0103	-0.0479	-0.0287
	(0.70)	(0.57)	(0.20)	(0.63)	(-0.94)	(-0.36)	(-1.60)	(-1.00)
Dummy_Democracy	-0.005	-0.005	0.25***	-0.005	-0.03	-0.027	0.02	-0.03
	(-0.25)	(-0.28)	(4.15)	(-0.27)	(-1.85)	(-1.51)	(0.30)	(-1.79)
Control of Corruption	0.16***	0.1***	0.23***	0.15***	0.12***	0.06**	0.12***	0.12***
	(6.21)	(3.86)	(7.23)	(6.05)	(5.18)	(2.81)	(4.23)	(5.04)
Output Gap*Dummy_Democracy	-1.59***				-2.26***			
	(-5.78)				(-7.96)			
Output Gap*Control of Corruption		-3.70***				-4.69***		
		(-9.28)				(-12.05)		
Control of Corruption*Dummy_Democracy			-0.18***				-0.04	
			(-4.52)				(-1.00)	
Output Gap*Control of Corruption*Dummy_Democracy				-0.96***				-1.36***
				(-5.50)				(-7.50)
N. Observations	883	883	883	883	883	883	883	883

Source: Author's own calculation.
Notes: Table estimates an interaction between the political regimes and the control of corruption, as a proxy for the institutional quality, in affecting the fiscal policy cycle using the GMM and the SYS-GMM approaches. The Government Spending Gap is a dependent variable. L.Gov Gap represents Lagged Government Spending Gap. This table is omitted the estimator results of constant term and all estimators for time dummy. We instrumented the Output Gap by the Total Factor Productivity Growth for the Instrumental Variable approach. The TFP growth is computed by the Dynamic Growth Accounting - Harrod Neutral model with the Cobb-Douglas production function and assumed to be constant return to scale. t statistics are in parentheses and * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 1.4 also shows that the democratic environment encourages the countries to implement less procyclical fiscal policy, but the countries also have to bear the costs of setting those regime up. One big different of using the GMM estimators and the OLS-FE or IV-2SLS is that the control of corruption's coefficients show the significantly positive sign in all models using the GMM approach. This only happens in some models using the OLS-FE or IV-2SLS approaches. The results highlight the fact that an improvement in the institutional quality inevitably increases the public spending in both democratic and non-democratic developing countries. However, once the institutions are strong enough to battle the rent-seeking behaviour or corrupted government, the fiscal policy becomes less procyclical. For another robustness check, we also test this specification in various econometric approaches and also other instrumental variables which can be access through the Appendix C.[12]

Table 1.5 replicates the previous model from Table 1.3 with the interaction effects terms and Table 1.4 using the Dynamic GMM and System Dynamic GMM approaches. These

[12]We also try other instrumental variables, e.g. Air Temperature and Air Precipitation as instrumental variables for the output gap, the results are consistent in term of sign although some estimates are not significant. The analysis is presented in the appendix C.

Table 1.5
An Interaction between Political Regimes and Corruption in Affecting Fiscal Policy Cyclicality (the Dynamic GMM and the System Dynamic GMM)

	DY_GMM				DY_SYS-GMM			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Output Gap	1.72***	5.58***	0.90***	1.69***	1.40***	3.74***	0.58**	1.12***
	(17.06)	(17.45)	(11.59)	(24.25)	(5.48)	(6.78)	(3.19)	(6.41)
L.Gov Gap	0.0774***	0.0992***	0.0477***	0.0727***	0.0953***	0.0655	0.0414	0.00948
	(18.56)	(28.42)	(9.22)	(14.39)	(9.10)	(1.57)	(1.08)	(0.34)
Trade Openness	-0.134***	-0.124***	-0.147***	-0.131***	-0.165*	-0.233**	-0.241**	-0.128
	(-9.16)	(-6.87)	(-8.27)	(-8.67)	(-2.04)	(-2.81)	(-2.99)	(-1.86)
Financial Openness	0.0127	0.0131	0.00943	0.0102	-0.0257	-0.00806	0.00432	0.00839
	(1.55)	(1.20)	(1.34)	(1.00)	(-1.00)	(-0.26)	(0.55)	(0.80)
Dummy_Democracy	0.002	0.0009	0.25***	0.004	0.009*	-0.009	0.08	0.01
	(0.21)	(0.09)	(9.43)	(0.59)	(2.36)	(-0.61)	(1.03)	(0.81)
Control of Corruption	0.17***	0.11***	0.24***	0.16***	0.07***	0.051*	0.12***	0.07***
	(16.49)	(13.35)	(23.13)	(24.39)	(6.61)	(2.20)	(4.59)	(5.16)
Output Gap*Dummy_Democracy	-1.42***				-0.83**			
	(-10.59)				(-2.61)			
Output Gap*Control of Corruption		-3.37***				-2.24***		
		(-14.83)				(-5.89)		
Control of Corruption*Dummy_Democracy			-0.17***				-0.06	
			(-10.31)				(-1.42)	
Output Gap*Control of Corruption*Dummy_Democracy				-0.84***				-0.4**
				(-15.36)				(-2.69)
N. Observations	652	652	652	652	652	652	652	652

Source: Author's own calculation.
Notes: Table estimates an interaction between the political regimes and the control of corruption, as a proxy for the institutional quality, in affecting the fiscal policy cycle using the Dynamic GMM and the Dynamic SYS-GMM approaches. The Government Spending Gap is a dependent variable. L.Gov Gap represents Lagged Government Spending Gap. This table is omitted the estimator results of constant term and all estimators for time dummy. We instrumented the Output Gap by the Total Factor Productivity Growth for the Instrumental Variable approach. The TFP growth is computed by the Dynamic Growth Accounting - Harrod Neutral model with the Cobb-Douglas production function and assumed to be constant return to scale. t statistics are in parentheses and * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

methods allow a set of lagged dependent variable to become regressor under the condition of no serial-correlation across the error terms. The results document similar aspects to the other approaches. It confirms that the developing countries both democratic and non-democratic ones implement the procyclical fiscal policy. Moreover, an improvement in the institutional quality helps democratic countries to implement less procyclical fiscal policy.

Table 1.6 estimates an interaction between the political regimes and the institutional quality in affecting the fiscal policy cycle using the OLS-FE and IV-2SLS approaches but we use the average of 6 indices of the institutional quality as a proxy for institutional quality instead of using only the control of corruption. The results suggest quite similar propositions as the previous exercises. That is that the procyclical fiscal policy is broadly implemented in the developing countries both democratic and non-democratic ones. However, the democratisation and an improving institutional quality help to reduce the procyclical fiscal policy. The effects of the improvements in the institutional quality are also more pronounced in the democratic nations than the non-democratic ones.

In summary, by using various econometric methods, we find that the procyclical fiscal policy robustly exists in the developing countries. To reduce the fiscal policy procyclicality, the countries need to improve their institutional quality, e.g., the higher standard of control of corruption, improvements in the regulatory, the effectiveness of government policy and etc.

Table 1.6
An Interaction between Political Regimes and Average Institutional Quality in Affecting Fiscal Policy Cyclicality

	OLS-FE				IV-2SLS			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Output Gap	1.56***	6.43***	0.84***	1.50***	4.64***	18.13***	0.44	4.14**
	(7.64)	(7.76)	(5.61)	(7.39)	(3.42)	(6.54)	(0.91)	(3.11)
L.Gov Gap	0.237***	0.256***	0.226***	0.235***	0.396***	0.447***	0.268***	0.381***
	(6.06)	(6.62)	(5.73)	(6.02)	(5.43)	(7.00)	(4.45)	(5.26)
Trade Openness	-0.0288	-0.0263	-0.0414	-0.0304	-0.0225	-0.0270	-0.0389	-0.0258
	(-0.66)	(-0.61)	(-0.94)	(-0.69)	(-0.88)	(-1.12)	(-1.57)	(-1.03)
Financial Openness	-0.0179	-0.0137	-0.0149	-0.0176	0.00215	0.00725	0.00904	0.00297
	(-0.83)	(-0.64)	(-0.68)	(-0.82)	(0.14)	(0.48)	(0.58)	(0.19)
Dummy_Democracy	-0.049***	-0.052***	-0.32***	-0.049***	-0.01	-0.015	-0.12	-0.01
	(-3.38)	(-3.65)	(-3.97)	(-3.38)	(-0.95)	(-1.44)	(-1.68)	(-1.00)
Average	0.037	0.018	-0.06	0.034	0.04	0.03	0.02	0.04
	(0.95)	(0.47)	(-1.35)	(0.89)	(1.56)	(1.41)	(0.52)	(1.56)
Output Gap*Dummy_Democracy	-1.4***				-6.3**			
	(-5.14)				(-3.22)			
Output Gap*Average		-3.83***				-11.8***		
		(-6.85)				(-6.26)		
Average*Dummy_Democracy			0.18***				0.07	
			(3.41)				(1.49)	
Output Gap*Average*Dummy_Democracy				-0.8***				-3.48**
				(-4.79)				(-2.87)
First-stage								
TFP Growth					0.0007*	0.004***	0.0006*	0.0007*
					(0.0003)	(0.001)	(0.0003)	(0.0003)
TFP Growth*Dummy_Democracy					0.0002			
					(0.0005)			
TFP Growth*Average						-0.003***		
						(0.001)		
TFP Growth*Average*Dummy_Democracy								0.00003
								(0.0005)
N. Observations	883	883	883	883	456	456	456	456
R-squared	0.14	0.16	0.12	0.13	0.06	0.14	0.08	0.08

Source: Author's own calculation.
Notes: Table estimates an interaction between political regimes and the average 6 indices of institutional quality in affecting the fiscal policy cycle using the OLS-FE and IV-2SLS approached. **Average** is the average value of six institution indices: Control of Corruption, Government Effectiveness, Political Stability and Absence of Violence and Terrorism, Regulatory Quality, Rule of Law, and Voice and Accountability. The Government Spending Gap is a dependent variable. L.Gov Gap represents Lagged Government Spending Gap. This table is omitted the estimator results of constant term and all estimators for time dummy. We instrumented the Output Gap by the Total Factor Productivity Growth for the Instrumental Variable approach. The TFP growth is computed by the Dynamic Growth Accounting - Harrod Neutral model with the Cobb-Douglas production function and assumed to be constant return to scale. t statistics are in parentheses and * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Moreover, the political regime, especially democratic regime, also acts as a complement to the improvements in the institutional quality.

1.5.3 Fiscal Policy Cyclicality in The Mature Democratic Nations

In this part, we explore further whether the maturity of democracy would affect countries public spending cyclicality. The seminal paper by Keefer [2007] points out the credibility in pursuing the good public provision of government in young democracies. Most young democracies' governments tend to be more corrupt and having a poor quality of political institutions. This increases more wasteful public spendings than the mature ones. To further analyse this issue, we introduce the maturity of democracy dummy variables. The variables are measured by matching the number of consecutive years that countries are in the democratic regime and their electoral competition score (LIEC and EIEC). The Maturity of democracy dummy variables equal 1 if both conditions are satisfied: democracy index is higher than 16 and LIEC and EIEC score is higher than 4 out of 7 as we discussed in the data section. If there is a reversal in countries political regime, we count the number of years in democracy again from 0. With this method, we expect to capture the political transition effects on government spending cyclical.

Table 1.7
The Effects of Maturity of Democracy and Control of Corruption in Affecting Fiscal Policy Cyclicality

	10 Years Old		20 Years Old		30 Years Old	
	(OLS)	(IV-2SLS)	(OLS)	(IV-2SLS)	(OLS)	(IV-2SLS)
Output Gap	0.568	0.198	0.12	-0.002	-0.17	-0.42*
	(0.36)	(0.43)	(0.20)	(0.18)	(0.17)	(0.16)
Control of Corruption	0.09	-0.02	0.01	-0.03	0.07	-0.01
	(0.04)	(0.01)	(0.02)	(0.009)	(0.05)	(0.01)
N. Observations	146	86	180	106	119	61
FE	Yes	No	Yes	No	Yes	No
R-squared	0.27	0.19	0.14	0.02	0.18	0.33

Source: Author's own calculation.
Notes: Table estimates the effects of the maturity of democracy and the control of corruption, as proxy for the institutional quality, in affecting the fiscal policy cycle using the OLS and the IV-2SLS approaches. The Government Spending Gap is a dependent variable. We instrumented the Output Gap by the Total Factor Productivity Growth for the Instrumental Variable approach. The TFP growth is computed by the Dynamic Growth Accounting - Harrod Neutral model with the Cobb-Douglas production function and assumed to be constant return to scale. t statistics are in parentheses and * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. "FE" represents the question whether the model includes countries fixed effect. With-in R-squared are presented at the bottom of this table.

Table 1.7 presents the effects of maturity of democracy on fiscal policy cycle. We classified the maturity of democracy into 3 groups: 10 years old, 20 years old and 30 years old. Columns 1, 3 and 5 are conducted by the OLS approach, while columns 2, 4 and 6 are performed by using IV-2SLS. With the OLS approach, countries which stayed consecutively under the democratic regime for 10 and 20 years still implement procyclical fiscal policies. However, the degree of procyclical reduces from 0.56 for 10 years old to 0.12 for 20 years old. Columns 5 and 6 of Table 1.7 show that fiscal policies of the countries, which stay firmly in the democratic regime for 30 years or above, are countercyclical fiscal policy.

Turning to analyse the results from IV-2SLS approach in columns 2, 4 and 6. The same patterns are observed. The more mature democratic environment encourages countries to implement less fiscal policy procyclicality. The fiscal policy in countries with 20 and 30 years of democracy are likely to be less procyclical than the 10 years ones. Although the estimators for 10 and 20 years are not significant, they show the reduction in the fiscal policy procyclicality. The coefficient for the output gap of 30 years dummy in column 6 turns to be negative which implies that more mature democratic countries tends to implement less fiscal policy procyclicality.

Table 1.8
The Effects of Maturity of Democracy and Institutional Quality on Fiscal Policy Cyclicality

	10 Years Old		20 Years Old		30 Years Old	
	(OLS)	(IV-2SLS)	(OLS)	(IV-2SLS)	(OLS)	(IV-2SLS)
Output Gap	0.57	0.20	0.11	-0.004	-0.15	-0.42*
	(0.31)	(0.43)	(0.19)	(0.18)	(0.16)	(0.16)
Average	0.09	- 0.02	0.08	-0.009	0.14*	-0.01
	(0.09)	(0.02)	(0.06)	(0.002)	(0.06)	(0.01)
N. Observations	146	86	180	106	119	61
FE	Yes	No	Yes	No	Yes	No
R-squared	0.28	0.33	0.15	0.02	0.21	0.65

Source: Author's own calculation.
Notes: Table estimates the effects of the maturity of democracy and the average of 6 indices of institutional quality, in affecting the fiscal policy cycle using the OLS and the IV-2SLS approaches. **Average** is the average value of six institution indices: Control of Corruption, Government Effectiveness, Political Stability and Absence of Violence and Terrorism, Regulatory Quality, Rule of Law, and Voice and Accountability. The Government Spending Gap is a dependent variable. We instrumented the Output Gap by the Total Factor Productivity Growth for the Instrumental Variable approach. The TFP growth is computed by the Dynamic Growth Accounting - Harrod Neutral model with the Cobb-Douglas production function and assumed to be constant return to scale. t statistics are in parentheses and * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. "FE" represents the question whether the model includes countries fixed effect. With-in R-squared are presented at the bottom of this table.

Table 1.8 performs the same analysis as in the Table 1.7, but using an average of 6 political institutions indices as a proxy for institutional quality in stead of using only the control of corruption. The estimates suggest that countries with more mature democracy implement less procyclical fiscal policy than the younger ones. The coefficients of the output gap reduce gradually from 0.57 in column 1 to 0.11 and -0.15 in columns 3 and 5, respectively. The results with an IV-2SLS approach in columns 2, 4 and 6 propose the same implication. The more mature of the democratic system, the government spending tends to be less procyclical. The fiscal policy turns to be countercyclical for the countries grouped with 30 years or above in democratic regime. The analyses in this section imply that more mature democratic countries tend to implement less procyclical fiscal policies compared to the younger ones.

1.6 Robustness Checks

1.6.1 Instrumented The Democracy

In this section, we exploit the type of colonial origins of the developing countries during the European colonial period to estimate the effects of an interaction between democracy and the institutional quality in affecting the fiscal policy cyclicality. The colony countries are classified into two types according to the mortality rate of the European settlers and their average protection against expropriation risk from 1985 to 1995 [Daron Acemoglu, Simon Johnson and James A Robinson, 2000, 2002].

That is the country which the settler will set up a good institution usually have a higher average protection against expropriation risk and a lower rate of the settler mortality. On the other way around, the colony countries with a lower average protection against expropriation risk and a higher rate of the settler mortality is usually set up with a worse institution (extractive resource) by the colonial countries. The seminal paper by Acemoglu, Johnson and Robinson [2000] suggests that these settlement choices of the colonial rulers influence the colony countries' current political regime and their current economic performance.

This chapter uses the average protection against expropriation risk from 1985 to 1995 data from Acemoglu, Johnson and Robinson [2000] and the estimated settlers mortality data from Curtin [1965, 1968, 1989, 1998]; Curtin et al. [1978] to classify which of the former colony countries are chosen by the settlers to set a good institution or just for an extractive resource regime.[13]

The idea is that if the former colony countries have an average protection against expropriation risk during 1985 to 1995 higher than the average value of all other former colony countries in the observations and the lower estimated settlers mortality data than the average of all other former colony countries, then, the colonial ruler may choose to settle a good institution there. This means that better institution in the past may affect the stability of setting democratic regime at the present day.[14]

[13]For more detail on the data explanation, see Acemoglu, Johnson and Robinson [2000]. The summary statistics of key variables used for endogenised democracy are provided in appendix A.

[14]See more discussion on this topic in Cervellati, Fortunato and Sunde [2006], Gradstein [2007] and Knutsen [2011].

Therefore, we construct the interaction effects term between $Former\ Colony_{i,t} * Setting\ Institution_{i,t}$ to use as an instrument for the democratic regime of the colony countries. The following equation shows the first-stage specification when we allow the democracy of the former colony countries to be instrumented by the historical colonial data and the institutional setting choices of the colonial rulers.

$$\begin{aligned} Democracy_{i,t} = \rho_1 + \rho_2(FormerColony_{i,t} * SettingInstitution_{i,t}) \\ + \rho_4 X'_{i,t} + \mu_i + \lambda_t + u_{i,t} \\ i = 1, 2, ..., 63\ t = 1, 2, ..., 33 \end{aligned} \tag{1.5}$$

where $FormerColony_{i,t}$ is the dummy variable which equals to 1 if the country has been colonised before, otherwise equals to 0. The $SettingInstitution_{i,t}$ is the dummy variable which proxies the political regime of the colony countries at the present day. It equals to 1 if the colony country has a higher value of Average Protection against Expropriation Risk during 1985-1995 than the average colony countries and lower estimated mortality rate of the settlers than the average colony countries, otherwise, it equals to 0. The protection against expropriation proxy for the current institutions and is measured on a scale of 1 to 10 (10 indicating the lowest risk of expropriation). $SettingInstitution_{i,t}$ equals to 1 meaning that those countries are chosen by the settlers to set a good institution instead of applying the extractive resource regime. For the second-stage, we regress the government spending gap on the fitted values of democracy from the first-stage and get the reduced form as follows:

$$\begin{aligned} G_{i,t} &= \beta_1 Outp\hat{u}tGap_{i,t} + \beta_2 G_{i,t-1} + \beta_3 Dem\hat{o}cracy_{i,t} \\ &\quad + \beta_4 InstQual_{i,t} + \beta_5 X'_{i,t} + u_{i,t} \\ u_{i,t} &= \mu_i + \lambda_t + \varepsilon_{i,t} \\ &\quad i = 1, 2, ..., 38 \quad t = 1, 2, ..., 33 \end{aligned} \tag{1.6}$$

where $Outp\hat{u}tGap_{i,t}$ is the fitted value of the output gap by the TFP from the first-stage regression and $Dem\hat{o}cracy_{i,t}$ is the fitted value of democracy by the interaction effects between the former colony and setting a good institution from the first-stage regression. β_1 is the parameter which measures the cyclical pattern of fiscal policy. Our interests are on whether democracy does affect the fiscal policy cycle (β_3) and whether there is an interaction effect between democracy and the institutional quality in affecting the fiscal policy cycle of the developing countries.

Table 1.9 presents the results of the effects between the political regime (democracy) and the institutional quality in affecting the fiscal policy cyclicality in the case which we instrumented the political regime by countries historical colonial data.

Table 1.9
An Interaction between Democracy and Average Institutional Quality in Affecting Fiscal Policy Cyclicality (Instrumented The Democracy)

	OLS-FE				IV-2SLS			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Output Gap	0.905***	0.925***	0.928***	0.931***	4.175**	4.368***	3.813**	4.112**
	(5.75)	(5.86)	(5.90)	(5.91)	(3.21)	(3.38)	(3.03)	(3.21)
Control of Corruption	0.0483*				0.0241		0.0216	
	(2.32)				(1.41)		(1.23)	
Average		0.0402				0.0343		0.0334
		(1.03)				(1.39)		(1.34)
Settinginstitution*Colony*OutputGap	-0.768	-0.783						
	(-1.79)	(-1.82)						
Settinginstitution*Colony*OutputGap*CoC			-0.436					
			(-1.69)					
Settinginstitution*Colony*OutputGap*Average				-0.452				
				(-1.73)				
OutputGap*Democracy					-5.416**	-5.726**		
					(-2.85)	(-3.02)		
OutputGap*CoC*Democracy							-3.056**	
							(-2.64)	
OutputGap*Average*Democracy								-3.337**
								(-2.84)
N	883	883	883	883	456	456	456	456
R-squared	0.103	0.098	0.093	0.097	0.109	0.096	0.102	0.089

Source: Author's own calculation.
Notes: Table estimates an interaction between democracy and the average institutional quality in affecting the fiscal policy cycle using the OLS-FE and the IV-2SLS approaches. The Government Spending Gap is a dependent variable. We instrumented the Output Gap by the Total Factor Productivity Growth for the Instrumental Variable approach. The TFP growth is computed by the Dynamic Growth Accounting - Harrod Neutral model with the Cobb-Douglas production function and assumed to be constant return to scale. We instrumented the Democracy by the Historical Colony and the Type of Institutional Setting by the Settlers. **Average** is the average value of six institution indices: Control of Corruption, Government Effectiveness, Political Stability and Absence of Violence and Terrorism, Regulatory Quality, Rule of Law, and Voice and Accountability. **CoC** stands for the Control of Corruption. t statistics are in parentheses and * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

The results in columns 1, 2, 3 and 4 are performed by using the OLS approach, while we use the IV-2SLS approach for the results in columns 5, 6, 7 and 8. As we expected, the main results robustly show the fiscal policy procyclicality in the developing countries with all positively significant estimators. In columns 1, 3, 5 and 7, the control of corruption is used as a proxy of the institutional quality, while we use the average value of 6 institutional indices for the columns 2, 4, 6 and 8.

We introduce the interaction effects term between democracy (instrumented by *setting insti tution∗colony*) and the output gap into the model in columns 1, 2, 5, and 6. Both approaches, the OLS-FE and IV-2SLS, provide a negative sign for the interaction effects term's estimators, although, they are not significant for the OLS-FE method. This implies that the former colony countries where the settlers set a good institution tends to perform the countercyclical fiscal policy; the countries with democratic regime tend to implement countercyclical fiscal policy. For example, the marginal effects of the model in columns 5 and 6 are $4.175 - 5.416 = -1.241$ and $4.368 - 5.726 = -1.358$, respectively. Without the effects of the democratic regime, the countries implement the procyclical fiscal policy 4.175 and 4.368, respectively.

In the columns 3 and 7, we add the interaction effects term between democracy (instrumented by the $setting\,institution * colony$), the institutional quality proxy (the control of corruption) and the output gap to test the relationship between the political regime and the institutional quality in affecting the fiscal policy cyclicality. The results from the model suggest that as the quality of the political institution increases, the country tends to implement less procyclical fiscal policy; the marginal effects of the fiscal policy cyclicality are $0.928 - (0.436 * CoC)$ for the model in column 3 and $3.813 - (3.056 * CoC)$ for the model in column 7. As there is more control of the corruption (the CoC value increases), the marginal effects of the fiscal policy cyclicality turn negative which imply the countercyclical fiscal policy.

Instead of analysing only the control of corruption as a proxy of the institutional quality, we perform the same model specification as in the columns 3 and 7 using the average value of 6 political institutional quality indices for the model in columns 4 and 8. The results are in line with the model in columns 3 and 7. Both the model in columns 3 and 8 show that the democratic countries tend to implement less procyclical fiscal policy than the countries in non-democratic environment. This implies that under the democratic regime, procyclical fiscal policy is less pronounced than under the non-democratic regime. Moreover, as the quality of the political institution has been developed, the magnitudes of procyclical fiscal policy are restrained. We conclude these findings that the democratic regime and a better quality of the political institution act complement to one another in restraining the procyclical fiscal policy implementation.

1.7 Conclusion

According to the macroeconomic policy prescription, the countries could do better during the economic fluctuations by implementing the countercyclical fiscal policy. However, previous existing research underlines the tendency of many developing economies to implement procyclical fiscal policy. That is the government reduces the spending and increase the taxation during an economic downturn and increases the spending and reduces the taxation during an economic boom. The empirical evidence points out that the quality of the political institutions and the democratic regime are key factors in affecting the fiscal policy cyclicality. However, the interaction between these two factors has not yet been extensively explored. Moreover, the analysis of other political factors such as the maturity of political regime is still lack in this literature.

This chapter, therefore, aims to investigate the effects of the political regime, especially democracy, and an institutional quality in affecting fiscal policy cyclicality in developing countries. Our main contributions are two folds: Firstly, we focus the analysis on an interaction between the democratic regime and the quality of institutions in affecting the fiscal policy cyclicality. Furthermore, we examine the effects of the maturity of democracy on a cyclical pattern of fiscal policy. Using an updated dataset of 63 developing economies from 1980 to 2013, we conduct various econometric approaches such as the OLS-FE, IV-2SLS, GMM and System GMM to explore these research questions and deal with the endogeneity problem.

Our main results confirm that both democratic and non-democratic developing countries implement the procyclical fiscal policy. However, in the democratic environments with a better institutional quality are keys for the countries to restrain the procyclical fiscal policy. Secondly, the results suggest that as the institutional quality becomes more effective, the countries tend to follow less procyclical fiscal policy. Additionally, the magnitudes of an improvement in the institutional quality in affecting the fiscal policy cyclicality are larger in the democratic environment than the non-democratic ones. Although the democratic governments have a low level of institutional quality, they still tend to implement less procyclical fiscal policy than non-democratic governments by about 13.6 per cent. Lastly, this chapter suggests also that the maturity and stability of the democratic regime help the countries to implement less procyclical public spending than the young democratic countries. According to the results suggested in this chapter, the policy makers simply cannot deny the interwoven between the politics and the economic. An improvement in the political institutional quality and a stability in the political regime are key factors for both democratic and non-democratic developing countries to escape from procyclical fiscal policy implementations.

Chapter 2

Ageing Population, Pension System and Economic Growth: Overlapping Generation Model with Informal Sector

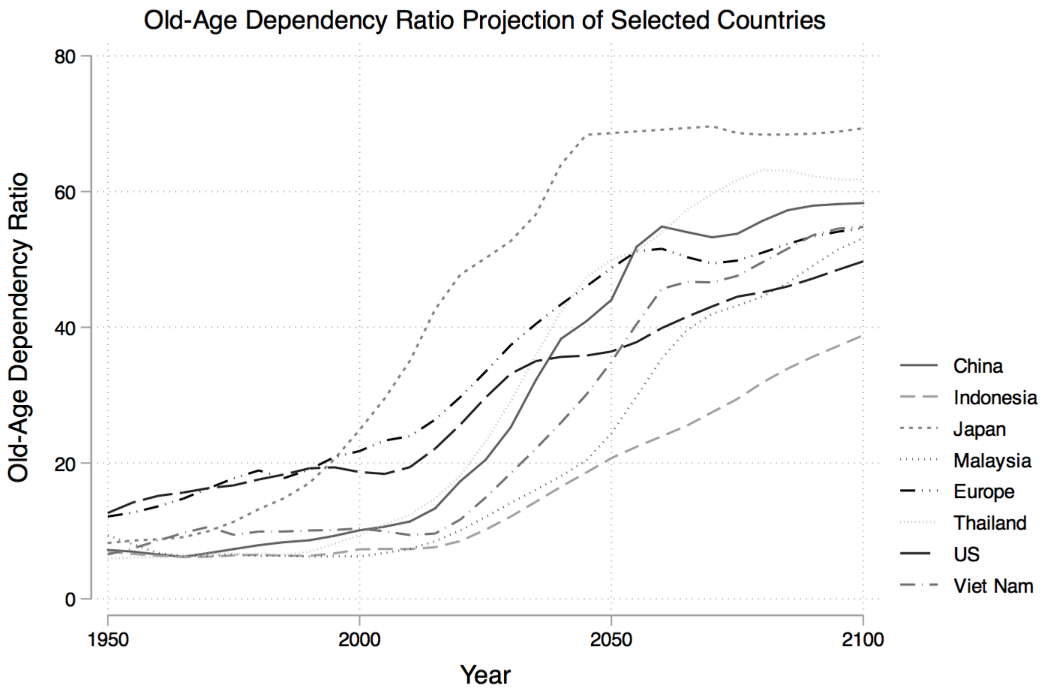
2.1 Introduction

Many developing Asian countries currently face the challenges of a shift in the demographic transition towards ageing society. The total fertility rate (TFR) decreases substantially over the past 3 decades, together with a longer life span of the elderly. Recall also that those emerging countries have not yet reached the same income level as those advanced ones. Among South-East Asian countries, where the level of income are quite similar to Thailand, Thailand moves relatively fast towards ageing society. Figure 2.1 shows the projections of the old-age dependency ratio of selected countries. It can be seen from the graph that Thailand's demographic picture is projected toward ageing society by 2020 (old-age dependency ratio reaches 20%), while other Asian countries, e.g. Indonesia, Malaysia or Vietnam, will enter ageing society by 2050, 2040 and 2030, respectively. The ratio of old-age dependency of Thailand will reach 55 per cent by 2055. This ratio is even higher than those advanced countries, e.g. the US or European countries. This issue poses big challenges to the future of pension system, social security schemes and intergenerational transferring policies of Thailand.

The important message here is that many emerging countries will face the challenges of a shift in demographic transition towards ageing society, while they are still trapped in the middle-income gap. In order to provide decent old-age social security schemes and welfare to retired people, the proper amount of tax revenue is required to finance those schemes.

Nonetheless, expanding tax base in order to increase tax revenue in developing countries is quite difficult due to another key characteristic of the developing economies. That is developing economies have larger size of the informal sector[1] in comparison to the advanced ones. Schneider [2002]; Schneider and Enste [2000] document that developing countries have the size of informal sector about 41-80 per cent of their Gross National Income (GNI), and the countries within a transition have approximately around 38 per cent, while the advanced countries have the average size of informal sector approximately only 18 per cent of their official GNI.

Fig. 2.1. Old-Age Dependency Ratio Projection of Selected Countries



Source: Author's own calculation
Notes: The figure represents the estimated of old-age dependency ratio of eight selected countries. The old-age dependency ratio is calculated by the percentage of the population aged above 65 to the working age population (age 15-64). Note that after the year 2017, the lines represent the projections of the old-age dependency ratio of selected countries. Data source is the World Bank Databank.

These characteristics of informality induce some impacts on human capital accumulation and economic growth through the household's behaviours and resource allocations. Neglecting the informal sector may distort the macroeconomic effects of population dynamics and pension system in affecting economic growth. Therefore, this chapter attempts to fill the gap of this

[1] The definitions of the informal economy are also varied across researchers. The activities could be either legal or illegal. However, this chapter follows the definition of the informal sector from De Soto et al. [1989] and Schneider and Enste [2000]. That is, the "Informal Sector" is defined as the economic activities which are not regulated by legal and not complied to government imposed-taxes and regulations.

literature by extending the analysis of an informal sector from the traditional neoclassical Overlapping Gneration (OLG) model. Then, we apply the model to analyse the effects of unfunded pension systems and non-contribution social security schemes on economic growth through the human capital channel: an allocation to children's education of the formal and informal workers' households.

The model can characterise the local equilibrium solution. So that we use it for the numerical experiments which are calibrated using the data of Thai economy. The main findings in the scenario that there is a reduction in fertility rate and an increase exogenously in the share of formal workers are as follows. Firstly, an increase in both unfunded pension payments and universal old-age allowance do not induce a higher investments in children's education of both the informal and formal workers' households at all. They rather change their consumption's profiles. In total, human capital accumulation due to generosity schemes is reduced. Secondly, an increase in the universal old-age allowance and pension payments significantly reduce the incentives to save of informal workers, while slightly increase for the formal workers. In total, savings are reduced due to an increase in the universal old-age allowance and pension payments. It lessens the accumulation of physical stock in the new steady state.

The remaining of this chapter is organised as follows: Section 2.2 reviews related literature on the pension system, population dynamics and economic growth. Section 2.3 presents our basic model. Section 2.4 analyses the perfect foresight equilibrium of the model in competitive environments. Then, we calibrate the model based on the data of the Thai economy in Section 2.5. Section 2.6 presents the simulation results and further discusses the macroeconomic effects in the context of economic growth. Section 2.7 concludes the chapter.

2.2 Literature Review

2.2.1 Ageing Population, Pension System and Economic Growth

This study is related to two main large bodies of literature: firstly, the effects of unfunded pay-as-you-go (PAYG) pension system and a change in demographic transition in affecting human capital accumulation, thus, economic growth. Secondly, the macroeconomic effects of an informal sector on economic growth.

In the traditional Overlapping Generation (OLG) Model by Samuelson [1958], Diamond [1965] and Samuelson [1975], the population growth is normally treated as an exogenous variable. Diamond [1965] explains the pension system with exogenous population growth, no technological change and non-altruistic parents. Therefore, unfunded-pension regime or PAYG pension system can be operated as long as the fertility rate is still higher than the interest rate, since there will always be enough working population to pay for the benefits of the elderly. Gary S Becker [1960], Becker and Barro [1988] and Cigno and Rosati [1992] fill the gap of this literature by adding a change in population dynamics into economic growth theorem which makes the dynamics inefficiency in the OLG model possible. In the light of population dynamics analysis, Becker, Murphy and Tamura [1990*b*] and Cigno [1991, 1992] explore human capital accumulation as an engine for economic growth. These pioneers develop many interesting growth models which include demographic indicators, e.g. endogenous fertility rate, number of children, level of children's education and etc.

Adding the aspect of family and children, individuals could see their children as both insurance and consumption goods [see the expression in Dasgupta [1995] and Wigger [1999]]. Individuals start to invest more in their children's education. This increases human capital accumulation which boosts economic growth. Fougère and Mérette [1999] explore the macroeconomic effects of population ageing on economic growth in 7 OECD countries using the OLG model. The model makes use of the endogenous human capital accumulation as an engine for economic growth. They suggest that the population ageing induces human capital formation since people tend to invest in their education (human capital) when young and invest in physical capital when older. As the economy has been developed further, the opportunity costs of having children also increase [see, for example, Barro and Becker [1989][2] and Becker, Murphy and Tamura [1990*a*][3]], and public insurance or public pension system becomes an important part in both inter- and intra-generational transferring policies.

Once introducing the unfunded pension system into the model, PAYG taxes together with a shift in demographic transition could crowd-out the investments on children's education. Thus, resulting in a reduction in human capital and economic growth slow down. Wigger [1999] shows that the effect of the pension system on economic growth depends on the size of intergenerational redistribution. The smaller size of pension system may stimulate growth, but an increase in the size of pension system due to longer life expectancy may reduce growth in the long term. Ehrlich and Kim [2007] similarly find the adverse effect of unfunded pension taxes on economic growth through the change in family choices of investing in human capital. Cipriani and Makris [2012], construct the OLG model with endogenous longevity to analyse the effect of the PAYG system on human capital. Their paper suggests that PAYG helps to redistribute the risk among generations, but reduces the incentive of human capital accumulation which could be harmful to long-term economic growth. Accordingly, to ensure

[2]Barro and Becker [1989] develop a model with an endogenous choice of fertility. Their findings suggest a positive relationship between interest rate and fertility. That is, in a steady state, higher costs of child-rearing reduces the population growth and increases the incentive to invest in capital stock.

[3]Becker, Murphy and Tamura [1990*a*] study the OLG model with endogenous fertility and human capital. They conclude that the rate of return on human capital does not necessarily diminish as human capital increases. The steady state has two possibilities which depend on an initial endowment of the countries. Countries with human capital intensive, the costs of an increase in human capital stock one more unit is less than the cost of rearing one more child, while in less developed countries, the opposite is true. In steady state, developed countries, therefore, choose to increase their human capital and have lower fertility rate, while countries with a lower initial level of human capital have higher fertility rate in the long-run equilibrium.

positive growth, the government needs to reduce the PAYG and gradually transfer to the fully funded pension system [Cipriani and Makris, 2012].

More recent works expand the OLG model with endogenous population dynamics variables such as labour supply, fertility, retirement age, longevity and life expectancy to explain the interwoven of demographic transition, pension system and economic growth. For example, the analysis on the optimum pension systems and sustainability of the current pension system have been studied by Abio, Mahieu and Patxot [2004], Fanti and Gori [2012], Cipriani [2014], Cipriani [2016] and Chen [2016].[4]

Then, it comes to the literature on pension reform and transition to fully funded pension regime. Among others, Song et al. [2015] consider firstly the OLG model with endogenous labour supply in emerging countries like China, where wage growth increases rapidly at the beginning and then gradually declines to a steady point. Their paper points out that under this circumstance, the optimum for both generations to share the benefits of the fast-growing economy is to delay the reform of the pension system to 2050. This is because reforming the pension at the moment will bring heavy burdens to current generations and increase the incremental small benefits to future generations. However, this chapter will not cover the analysis of the pension reforms or explaining the transition towards fully funded pension regimes. We would like to focus more on the effects of informality, population ageing and unfunded pension system in affecting economic growth passing through the children's human capital accumulation.

This chapter also relates to a big literature on the impacts of informal economy on welfare and economic growth. Loayza [1996] studies the causes of informal economy and impacts on economic performance using endogenous economic growth model. Loayza's model set up the environment where economic growth is driven only by congestion in public services. When government imposes higher tax rates, together with less government compliance, labour moves to work in the informal sector. Gupta and Barman [2015] also include the analysis

[4] The paper of Abio, Mahieu and Patxot [2004] employs endogenous fertility to analyse the linkage between number of children and pension system in affecting economic growth. Their model highlights the difference between male and female labour supply which determine the fertility choices and demographic transition. They suggest the new optimum pension regime which the benefits go into the proportion to the labour force participation. Fanti and Gori [2012] uses the OLG model with endogenous fertility to study the effects of demographic transition on the PAYG pension system. They find that a decrease in fertility rate needs not to reduce the pension payout in the PAYG system. However, Cipriani [2014] uses both exogenous and endogenous fertility rates in the OLG model and finds that in both cases the reduction in fertility rate and an increase in longevity reduce the pension payout. This situation clearly affects the sustainability of the PAYG pension system in the long term. Chen [2016] develops the OLG model with both endogenous and exogenous retirement age to study the interaction between fertility rate and PAYG pension scheme. His findings suggest that an increase in fertility rate tends to reduce pension payout as the output elasticity to capital is high (developing countries), but an increase in fertility rate tends to increase pension payout in the countries with high elasticity to capital and tax rate (developed countries). Similar to Cipriani [2016], the chapter finds that an increase in old age population may not necessarily decrease the PAYG pension payout since the old age people will automatically adjust their labour supply by themselves using endogenous retirement model.

of the informal sector in their endogenous growth model. However, the study focuses on the environmental issues.

We observe from previous literature that some characteristics of emerging countries, e.g. fast-growing wage growth, have been added to the analysis of the pension system and economic growth. However, none considers adding the informal sector into the analysis of the effects of pension system and population dynamics on economic growth. The closest papers to our study, in term of modelling the informality, are the papers of Keuschnigg, Davoine and Schuster [2013], Hsu, Huang and Yupho [2015] and Baksa, Munkacsi et al. [2016]. The paper by Keuschnigg, Davoine and Schuster [2013] focuses more on the impacts of ageing and informality in affecting the PAYG pension system, but does not consider the analysis on human capital accumulation and economic growth. Baksa, Munkacsi et al. [2016] model the economy with the informal sector to analyse mainly the labour market policies, e.g. unemployment benefits. Hsu, Huang and Yupho [2015] study the welfare of health insurance coverage using the OLG model with the informal sector when universal health insurance is financed by labour income tax. They suggest that the higher labour income tax is required to cover the health insurance or expand the tax base to an informal sector, in case of the economy moves towards ageing society. Unlike Hsu, Huang and Yupho [2015], this chapter focuses more on the effects of the elderly schemes on economic growth rather than the health insurance coverage. We construct the model explaining long-term economic growth through the households allocation to children's education in the setting that fertility rate reduces and economy has informal sector.

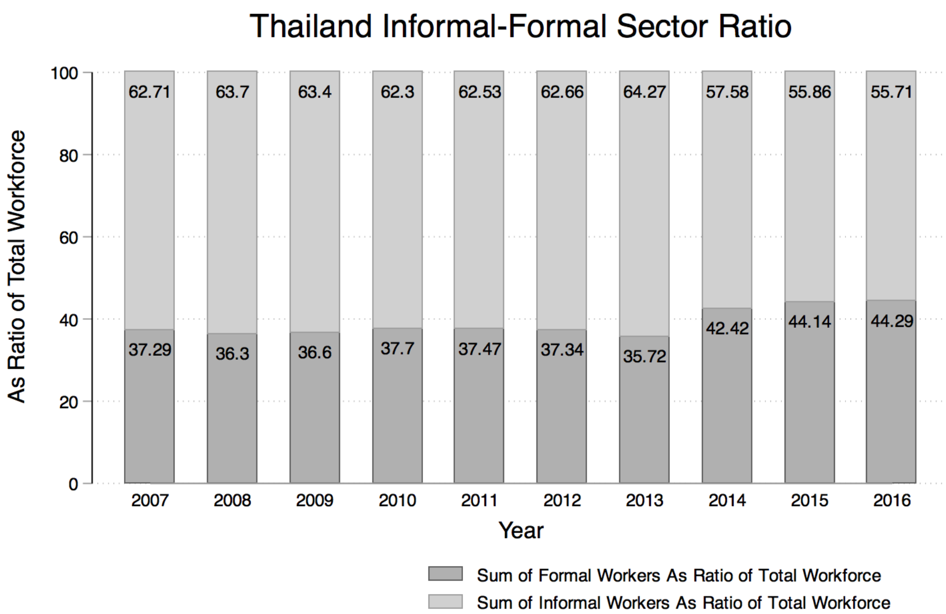
2.2.2 Brief Background on Public Pension System in Thailand

Our model intends to explain the impacts of population ageing and elderly pension scheme in Thailand, where the economy has a large size of informal sector (about 60 per cent of their GDP) and moves relatively fast towards ageing society. We observe that in Thailand, the informal workers do not comply with government imposed-taxes and social contributions, but they are covered in some basic social security schemes, e.g. the universal old-age allowance. A large size of informal sector, therefore implies more spending on the non-contribution social security schemes which may affect long-term economic growth of the country.

Figure 2.2 illustrates the ratio of informal and formal workers to the total workforce in Thailand from the year 2007 to 2016. Informal sector accounts for approximately 60 per cent of the total workforce since 2007. Although the share of informal sector has gradually decreased over time from 63 per cent in the year 2007 to 55.71 per cent in the year 2016, the share of informal sector is still very high compared to the countries in the same level of income.

As Thailand becomes an ageing society, the concerns on the public pension schemes are getting more serious. Normally, benefits provided by the government for elderly people are concentrated in advanced countries, while the elderly in emerging or poorer countries mostly depend their consumption after retired on their accumulated earnings, savings and children transfers. However, as a family size decreases due to a reduction in fertility, transfers from children to old parents are also declined. Therefore, there is a need for proper intergenerational redistribution policies from government side.

Fig. 2.2. Thailand's Ratio of Formal and Informal Sector



Source: Author's own calculation
Notes: The bar chart depicts the ratio of formal and informal workforce in Thailand from 2007 to 2016. The data of formal and informal workforce are collected from National Statistic Office of Thailand (NSO), the report of the situations of the informal sector in Thailand.

In Thailand, the formal workers usually contribute part of their income to the pension fund. Either governments or their employers top up a fraction of their pension taxes and they will receive the pension once they are retired. For the informal workers, before 2009, there are no coverages for the elderly at all. Since 2009, Thailand has expanded the old-age social security benefits to the universal old-age allowance which provide the coverage to all registered elderly Thais who have age above 60 and are not receiving any pension, salary or any forms of government supports, e.g. residing in public residential care facilities for the elderly [Prachuabmoh, 2012].[5] The allowance for the elderly is currently universal and financed by tax revenue paid by the formal workers. The universal old-age allowance is a non-contributory

[5]This universal old-age allowance is a monthly basis and increases progressively by the age of the elderly:

scheme which raises a lot of questions whether this allowance should be group targeted or universal [Suwanrada, Sukontamarn and Bangkaew, 2018].

This chapter attempts to model the situation of Thailand's old-age pension system and social security scheme at the moment in order to analyse the impacts on long-term economic growth. The old-age allowance is universal for workers in both sectors, but the workers in the formal sector also receive the pension payouts as a proportion to their income and previous labour supply when they retired. We would like to analyse how a change in pension payouts and universal old-age allowance influences the formal and informal households' choices to invest in their children's education and savings. Then, the analysis moves on towards the long-term economic growth passing through investments in children's human capital.

2.3 Model

The model constructed in this chapter is in line with the seminal papers of Ben-Porath [1967], Becker, Murphy and Tamura [1990*a*] and Cipriani and Makris [2012] in term of having the analysis of human capital, children's education and pension system in the model. Parents care about their children's education and make a decision on the level of education for their children. Level of education affects directly their wage rate through an increase in productivity. Parents decide the level of education for their children which also determines exogenously their children's career path whether to work in the formal or informal sector.

The economy is populated by agents being a member of the overlapping generations society. Each agent in the model is born at time t, is a member of cohort j and lives for two periods: young (working period) and old age. At time t the economy has already had initial old age population, which is represented by c_t^o. Total measure of all generations is normalised to 1.

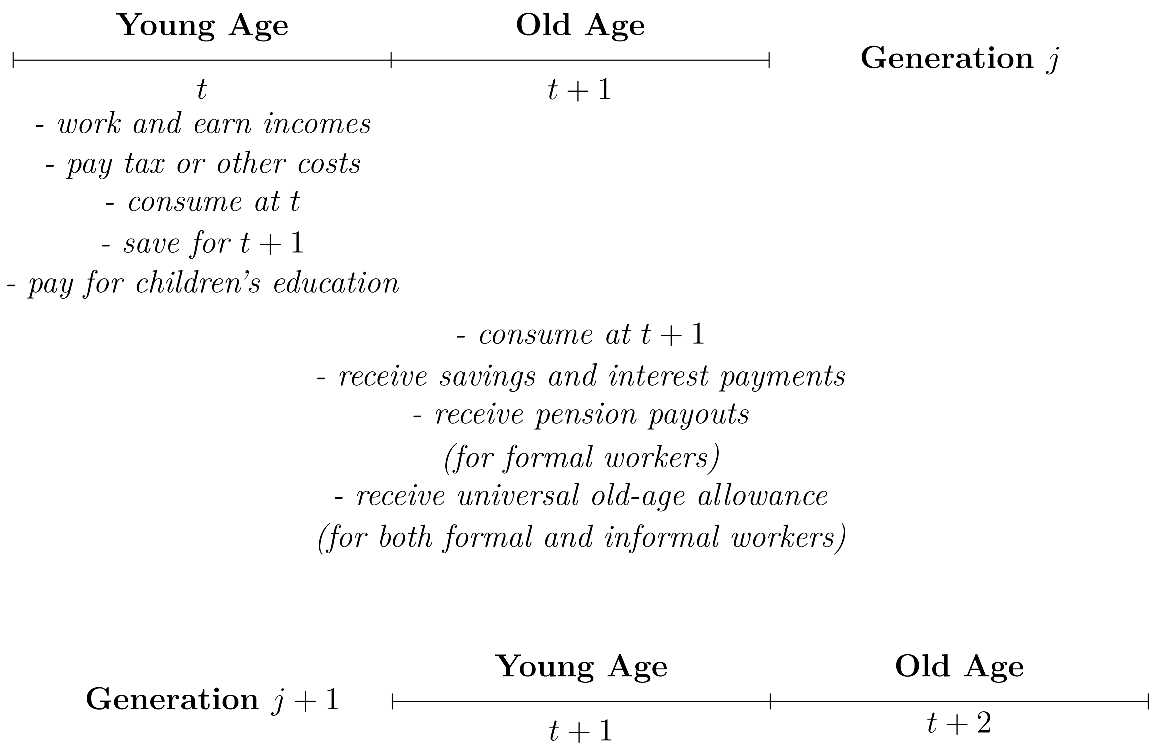
Young-agents spend their time working and earn their incomes which depend on their levels of human capital accumulation. The human capital of each individual in period t equals the function of their education level which was decided and invested differently by their parent's educational preference, $\phi^i; i \in$ {informal sector, formal sector}. Chu, Furukawa and Zhu [2015] show that parents influence a lot on their children's educational level. This implies that the parental preference for education affects the choices of investment in children's human capital and, therefore, economic growth.

Workers exogenously work either in the informal or formal sector. Any changes in the proportion of workers in the formal and informal sectors are due to exogenous factors, e.g. government policies.

age 60-69 will receive 600 THB (approximately 19.35 USD, using exchange rate 1 USD $\approx$ 31 THB), age 70-79 will receive 700 THB (approximately 22.60 USD), age 80-89 will receive 800 THB (approximately 25.80 USD) and age above 90 will receive 1000 THB (approximately 32.25 USD) monthly until they pass away (Department of Older Persons, 2019).

In this model, the difference between those who work in the formal and informal sector is that the formal workers pay labour income taxes, τ_t, and receive both universal old-age allowance, b_{t+1}, and pension payouts P_{t+1}, as a proportion of their previous provided labour supplies, l_t, once they are retired. For the informal workers, they pay zero labour income taxes but have to bear some costs of working in the informal sector, χ_t. For example, the costs of reallocation or fees when they are detected by the authorities. These costs are also a proportion to their incomes. However, the costs of working in the informal sector are always lower than the labour income tax rate which keep some people continue to work in the informal sector.

Fig. 2.3. Household's Time Line



Source: Author's own construction.
Notes: Chart presents the allocations of resources of individuals by time line.

We assume that the costs of being informal workers is also proportional to the labour income tax rate; that is $\chi_t = \bar{\chi} \cdot \tau_t$.[6] The informal workers also receive universal old-age allowance when they are retired.[7] We also assume that the monthly universal old-age allowance cannot exceed the monthly pension payouts received by the formal workers.[8]

[6] For the numerical exercises of this chapter, we assume that informal workers pay the cost rate around 30% of labour income tax rate, $\bar{\chi} = 0.3$.

[7] Recall that the statutory retirement age in Thailand is at the age of 60

[8] In Thailand, the old-age allowance is about 8-20% of the pension depending on how many years of formal

Figure 2.3 presents the allocations of resources of individuals who were born at time t, belong to generation j by time chart. In term of consumption, the young agents distribute their incomes at time t to their consumptions c_t^y, savings for their retirement period s_t and their children educational expenses, a. We assume that the costs of children's education rises as the number of children, η, increases. The expenses of children's education, a, are proportional to the parent's effective income. Young-agents during working period are responsible only for their children's educational expenses. The formal workers' elderly make their consumption decisions, c_{t+1}^o, based on their savings when they were young, interest payments, the pension payouts and the universal old-age allowance benefits. For the informal workers, their consumptions in the old-age depend on savings, interest payments and the universal old-age allowance.

2.3.1 Household

In this model, all agents have perfect foresight and are identical in preference and technology. The utility function is an instantaneous utility function. It captures the utility which individuals derive from their consumptions at time t and $t+1$, leisures and investments in children's education. Parents are altruistic in this model. This chapter adopts the two-period life-cycle model for the analysis since we assume that children during their childhood do not make any economic decision [Becker, 1964]. The lifetime utility of each agent i who was born in time t and belongs to generation j is given by the following equation:

$$U_{j,t}^i = [ln(c_t^{iy}) + \theta(1 - l_t^i) + \phi^i ln(e_{t+1}^i)] + \beta[ln(c_{t+1}^{io})] \tag{2.1}$$

where $i \in$ {Informal (I), Formal (F)}. Agents when young decide their own consumption, c_t^y, hours worked, l_t, and how much to invest in their children's educational level, e_{t+1}^i. Time allocated to work and/or leisure is normalised to one, which implies that $0 \leq l_t \leq 1$. An increase in one more unit of leisure has marginal utility increased by θ and $1 > \theta > 0$. Additionally, an increase in consumption and investments in their children's educational level also increases the agent's utility. β denotes the time preference discounted factor between young and old-age and $\beta \in (0, 1)$. ϕ^i is a parameter showing an increase in the marginal utility of parents when invest one more unit in their children's education. In other words, it is the parental preference for children's educational level and $\phi^i > 0$. Note also that $\phi^F > \phi^I$ since parents who work in the formal sector have more incentive and feasibility to provide a

worker's paid contribution and their average last 60 months of salary. For more information on the calculation of pension received for the formal workers, please visit https://www.sso.go.th/wpr/. Then, we use the pension received after retirement which is calculated based on the method from https://www.sso.go.th/wpr/ to compare with the old-age allowance. We obtain the ratio of the universal old-age allowance which both formal and informal workers received to the pension which only the formal workers received.

higher educational level to their children than the informal workers' parents. This is due to the parents' level of education and expected income [See, e.g. Sathar and Lloyd [1994] and Brown [2006]. Sathar and Lloyd [1994] studies the mother's educational level and investments in children's human capital. They show that the pakistani families which mother has higher educational level tend to invest more in their children's education. Similar to the paper by Brown [2006] which shows that in rural of China, more educated parents invest more in their children's human capital. This effect still exists after controlling the income, demographic variables and health status of the children]. As a child, parents have a big influence on which schools and what subjects their children are going to study and also based on the financial status of the parent. Therefore, the human capital of the children in this chapter is exogenously determined by educational preferences of their parents.

Human Capital

Current human capital accumulation is the function of educational level E_t which grows at the same rate as technology, A_t, and population, L_t. Educational level is stationalised by technological level and population growth so that the education does not give infinite productivity but rather acts as having more effective workers in this model.

$$H^i_{t+1} = 1 + \gamma^i \frac{E^i_{t+1}}{A_{t+1}L_{t+1}} \tag{2.2a}$$

$$e^i_{t+1} \equiv \frac{E^i_{t+1}}{A_{t+1}L_{t+1}} \tag{2.2b}$$

where $i \in$ {Informal (I), Formal (F)}, H_t denotes human capital of effective labour and parameter γ^i represents the productivity of each type of effective workers which cooperate to their wages later on. The labour supply of each generation is determined by the average wage, productivity and human capital of each generation j. $l_t = l(w_t, \gamma^i, e^i_t)$. At time t, there exists predetermined initial educational level of formal workers' parents, e^F_0, and also the initial educational level of informal workers' parents, e^I_0.

Young Cohort

The consumption level of the workers in the formal sector, c^{Fy}_t, and the informal sector, c^{Iy}_t, of generation j at time t are given by the following equations, respectively:

$$c_t^{Fy} = (1 - \tau_t) H_t^F w_t^F l_t^F - s_t^F - e_{t+1}^F a\eta \tag{2.3a}$$

$$c_t^{Iy} = (1 - \chi_t) H_t^I w_t^I l_t^I - s_t^I - e_{t+1}^I a\eta \tag{2.3b}$$

For the agent who works in the formal sector, s_t^F is the private net savings as a proportion of their income. l_t^F denotes the number of hours worked. $H_t^F w_t^F (1 - \tau_t)$ represents effective wage after labour income tax, where τ_t is labour income tax rate and $0 < \tau_t < 1$. Educational costs per child proportionally to parent's income are denoted by $e_{t+1}^F a\eta$. We assume that parents invest only positive or 0 amount on their children's education, but no negative due to altruism. e_{t+1}^F is the level of education of children of formal workers. a is the costs of education per child, and η is the number of children denoted by fertility rate. For agents who work in the informal sector, they also save and pay for their children's education. The only different is that χ_t represents some costs of working in the informal sector instead of labour income tax. Recall also that $\chi_t = \bar{\chi} \cdot \tau$.

Old Cohort

The consumption level of the old-age person who worked in the formal sector is represented by c_{t+1}^{Fo} and for the informal sector is c_{t+1}^{Io}. They are given by the following equations, respectively:

$$c_{t+1}^{Fo} = r_{t+1} s_t^F + P_{t+1} l_t^F + b_{t+1} \tag{2.4a}$$

$$c_{t+1}^{Io} = r_{t+1} s_t^I + b_{t+1} \tag{2.4b}$$

where $P_{t+1} l_t^F$ is a pension payouts for the formal workers which is growing at the same rate as the level of GDP and their labour supply from previous period. $P_{t+1} = \bar{P} \cdot Y_{t+1}$. The more formal workers provided their labour supply in the period before, the more pension they will receive once they retired. r_{t+1} represents the real gross interest rate. b_{t+1} is non-contribution universal old-age allowance. It is also growing at the same rate as the level of GDP. That is $b_{t+1} = \bar{b} \cdot Y_{t+1}$. This means that as the economy grows, the non-contribution old-age allowance for the elderly is also increased proportionally to the GDP.

Budget Constraint

Combine the consumptions when young and old age together, we can write the life time inter-temporal budget constraint of the agent $i = \{Formal \text{ or } Informal\}$, who belongs to generation j, at time t as follows:

$$c_t^{Fy} + \frac{c_{t+1}^{Fo}}{r_{t+1}} = (1-\tau_t)(1+\gamma^F e_0^F)w_t^F l_t^F - e_{t+1}^F a\eta + \frac{P_{t+1}l_t^F}{r_{t+1}} + \frac{b_{t+1}}{r_{t+1}} \tag{2.5a}$$

$$c_t^{Iy} + \frac{c_{t+1}^{Io}}{r_{t+1}} = (1-\chi_t)(1+\gamma^I e_0^I)w_t^I l_t^I - e_{t+1}^I a\eta + \frac{b_{t+1}}{r_{t+1}} \tag{2.5b}$$

The flow of the agent's lifetime consumption discounted by real gross interest rate cannot exceed the lifetime income after taxes and benefits received from the government. Each agent of generation j maximises her expected lifetime utility, equation (2.1), subject to the lifetime budget constraints of the formal workers and informal workers, equations (2.5a) and (2.5b), respectively.

2.3.1.1 Formal Sector Household

The formal workers' households maximise their lifetime utility subject to the lifetime budget constraint which can be written as follows:

$$\begin{aligned}
&\underset{c_t^{Fy}, c_{t+1}^{Fo}, l_t^F, s_t^F, e_{t+1}^F}{\text{Max}} \quad ln(c_t^{Fy}) + \theta(1-l_t^F) + \phi^F ln(e_{t+1}^F) + \beta[ln(c_{t+1}^{Fo})] \\
&\text{s.t.} \quad c_t^{Fy} + \frac{c_{t+1}^{Fo}}{r_{t+1}} = (1-\tau_t)(1+\gamma^F e_0^F)w_t^F l_t^F - e_{t+1}^F a\eta + \frac{P_{t+1}l_t^F}{r_{t+1}} + \frac{b_{t+1}}{r_{t+1}}
\end{aligned} \tag{2.6}$$

We solve the maximisation problem by setting up the Lagrangian and differentiate the Lagrangian with respect to endogenous variables of the model, $c_t^{Fy}, c_{t+1}^{Fo}, l_t^F, s_t^F, e_{t+1}^F$. Then, we obtain the individual optimal choices of consumption, labour supply, investments in children's education and savings as follows:

$$c_t^{iy*} = \frac{c_{t+1}^{io*}}{r_{t+1}\beta} \tag{2.7}$$

Equation (2.7) is the consumption Euler equation in which agents trade-off their consumption between present and future. One unit of consumption today equals future consumption discounted by interest rate and time preference. Then, we maximise the first-order condition of the Lagrangian with respect to labour supply of the formal workers. This give us the optimal choices of labour supply of formal workers' households as follows:

$$l_t^{F*} = \frac{r_{t+1}(1-\tau_t)(1+\gamma^F e_0^F)w_t^F + r_{t+1}\theta(e_{t+1}^F a\eta + s_t^F) + P_{t+1}}{r_{t+1}\theta(1-\tau_t)(1+\gamma^F e_0^F)w_t^F} \tag{2.8}$$

$$l_t^{F*} = \frac{1+\beta+\phi^F}{\theta} - \frac{b_{t+1}}{r_{t+1}(1-\tau_t)(1+\gamma^F e_0^F)w_t^F + P_{t+1}} \tag{2.9}$$

Equation (2.8) shows an optimal level of the household's labour supply of formal workers' households. A rise in the effective wage and investments in children's education increase agent's incentive to provide more labour supply. Plugging the optimal children's educational investments and the optimal savings of the formal workers' households into equation (2.8) and re-write the optimal allocation of labour supply of formal workers' households as equation (2.9).

The optimal investments in children's education can also be calculated by maximising the first-order condition of the Lagrangian with respect to investments in children's education. Then, we acquire the optimal allocation to children's education of formal workers' households as follows:

$$e_{t+1}^{F*} = \frac{\phi^F[r_{t+1}(1-\tau_t)(1+\gamma^F e_0^F)w_t^F + P_{t+1}]}{r_{t+1}\theta a\eta} \tag{2.10}$$

Equation (2.10) shows an optimal level of household's choices for educational level of their children. The higher income after taxes and pension payouts are, the more allocation towards their children's education. Moreover, we can see from Equation (2.10) that an increase in the fertility rate and costs of education per child reduce the households' allocations towards investments in children's educational level.

Next, we combine the optimal consumption level, labour supply choices and lifetime budget constraint to solve for the optimal savings of the formal workers' households, as presented in equation (2.11):

$$s_t^{F*} = \frac{\beta r_{t+1}(1-\tau_t)(1+\gamma^F e_0^F)w_t^F - P_{t+1} - \phi^F P_{t+1}}{r_{t+1}\theta} - \frac{b_{t+1}(1-\tau_t)(1+\gamma^F e_0^F)w_t^F}{r_{t+1}(1-\tau_t)(1+\gamma^F e_0^F)w_t^F + P_{t+1}} \tag{2.11}$$

It can be seen that an increase in the effective labour income induces more household's net savings, while an increase in the universal old-age allowances and pension payouts reduce savings incentive of the households.

2.3.1.2 Informal Sector Household

The informal workers' households also maximise their lifetime utility subject to their lifetime budget constraint as follows:

$$\begin{aligned} &\underset{c_t^{Iy}, c_{t+1}^{Io}, l_t^I, s_t^I, e_{t+1}^I}{\text{Max}} && ln(c_t^{Iy}) + \theta(1 - l_t^I) + \phi^I ln(e_{t+1}^I) + \beta[ln(c_{t+1}^{Io})] \\ &\text{s.t.} \quad c_t^{Iy} + \frac{c_{t+1}^{Io}}{r_{t+1}} = (1 - \chi_t)(1 + \gamma^I e_0^I) w_t^I l_t^I - e_{t+1}^I a\eta + \frac{b_{t+1}}{r_{t+1}} \end{aligned} \tag{2.12}$$

Again, we solve the maximisation problem by setting up the Lagrangian and differentiate the Lagrangian with respect to endogenous variables of the model, $c_t^{Iy}, c_{t+1}^{Io}, l_t^I, s_t^I, e_{t+1}^I$. Then, we acquire the individual optimal choices of consumption as in equation (2.7), labour supply, choice of children's educational level and savings of the informal workers' households as follows:

$$l_t^{I*} = \frac{1}{\theta} + \frac{(s_t^I + e_{t+1}^I a\eta)}{(1 - \bar{\chi} \cdot \tau_t)(1 + \gamma^I e_0^I) w_t^I} \tag{2.13}$$

$$l_t^{I*} = \frac{1 + \beta + \phi^I}{\theta} - \frac{b_{t+1}}{r_{t+1}(1 - \chi_t)(1 + \gamma^I e_0^I) w_t^I} \tag{2.14}$$

Equation (2.13) shows that an increase in the costs of working in the informal sector and parental preference for investments in children's education increase the incentives for agents to provide more labour supply. Recall that the burden from imposed labour income tax should be higher than costs of being an informal worker $\tau_t > \chi_t$[9] and we also assume the costs of working in the informal sector are a fraction of formal worker's labour income taxes, $\chi_t = \bar{\chi} \cdot \tau_t$. Therefore, $0 < \bar{\chi} < 1$ and there exists an incentive for working in the informal sector. From equation (2.13), we can also see that an increase in the universal old-age allowance reduces household's allocation to the labour supply. Then, we plug the optimal allocations to children's educational level and the optimal savings of the informal workers' households into equation (2.13). We re-write the optimal labour supply provided by the informal workers' households as an equation (2.14).

For the optimal investments in children's education, we maximise the first-order condition of the Lagrangian with respect to investments in children's education of the informal workers and yield the optimal allocation of investments in children's education of the informal workers'

[9]For more detail on incentives and factors determinant of informal sector, see Loayza [1996] and Schneider and Enste [2000].They explain one of the factors causes people to stay in the informal sector is higher burden of income taxes in the formal sector.

households as follows:

$$e_{t+1}^{I*} = \frac{\phi^I(1-\bar{\chi}\cdot\tau_t)(1+\gamma^I e_0^I)w_t^I}{\theta a\eta} \tag{2.15}$$

Equation (2.15) shows the optimal allocation to investments in children's education of the informal workers' households, which depend positively on the parental educational preference and wage after taxes paid, and depend negatively on the number of children in the family and costs of education. Next, we combine the optimal consumption level, labour supply choices and lifetime budget constraint to solve for the optimal savings of the informal workers' households.

$$s_t^{I*} = \frac{\beta(1-\bar{\chi}\cdot\tau_t)(1+\gamma^I e_0^I)w_t^I}{\theta} - \frac{b_{t+1}}{r_{t+1}} \tag{2.16}$$

Equation (2.16) is the optimal savings of informal workers' households. Household's optimal savings is an increase in function of income after paying the costs of working in the informal sector, while an increase in the non-contribution old-age allowance reduces the incentives of informal workers' households to save.

Now that we have the optimal allocations of consumption, labour supply, investments in children's education and savings of both formal and informal workers' households.[10] We combine the allocation choices of savings and investments in children's education of the households in both sectors and obtain the aggregate level of savings and investments in children's education of the economy. The aggregate savings can be written as follows:

$$\begin{aligned} s_t =& s_t^{F*} + s_t^{I*} \\ s_t =& \left[\left(\frac{\beta r_{t+1}(1-\tau_t)(1+\gamma^F e_0^F)w_t^F - P_{t+1} - \phi^F P_{t+1}}{r_{t+1}\theta}\right) - \left(\frac{b_{t+1}(1-\tau_t)(1+\gamma^F e_0^F)w_t^F}{r_{t+1}(1-\tau_t)(1+\gamma^F e_0^F)w_t^F + P_{t+1}}\right)\right] \\ &+ \left[\frac{\beta(1-\bar{\chi}\cdot\tau_t)(1+\gamma^I e_0^I)w_t^I}{\theta} - \frac{b_{t+1}}{r_{t+1}}\right] \end{aligned} \tag{2.17}$$

Form equation (2.17), aggregate savings is an increasing function of income after taxes or informality costs. Moreover, an increase in the non-contribution old-age allowance and pension payouts reduce the incentives to save for both types of households. Equation (2.17) also shows that the preference for children's education of formal workers' parents appear in the

[10]The full derivations of the household sides can be found in Appendix D.

aggregate savings, while informal workers' parents preference for children's education does not appear in the aggregate savings equation. This implies that higher parental preference for children's education of formal households reduce aggregate savings, while the parental preference for children's education of informal households do not affect much on the aggregate savings of the economy. Next, we can derive the net allocations to investments in children's education for both formal and informal workers' households by combining equations (2.10) and (2.15). We obtain the aggregate investments in children's human capital as follows:

$$
\begin{aligned}
e_{t+1} = &\quad e^{F*}_{t+1} + e^{I*}_{t+1} \\
e_{t+1} = &\quad \left[\frac{\phi^F[r_{t+1}(1-\tau_t)(1+\gamma^F e_0^F)w_t^F + P_{t+1}]}{r_{t+1}\theta a\eta}\right] + \left[\frac{\phi^I(1-\bar{\chi}\cdot\tau_t)(1+\gamma^I e_0^I)w_t^I}{\theta a\eta}\right]
\end{aligned} \tag{2.18}
$$

Equation (2.18) displays three interesting facts: firstly, a higher income after taxes or informality costs and parental preferences towards children's educational level induce households to allocate their resources more to their children's educational investments. Secondly, higher pension payouts for the formal workers coincide with higher aggregate allocation to children's education (not taking into account higher labour income taxes or costs of working in informal sector to finance these social benefits), while the universal old-age allowance does not appear in equation (2.18) as an additional boost for children's educational investments at all. Lastly, an increase in the educational costs and the number of children per household lessen the allocations to children's education investments in aggregate level. Then, we combine equations (2.9) and (2.14) to obtain the aggregate labour supply of both formal and informal households which can be written as follows:

$$
\begin{aligned}
l_t = &\quad l_t^{F*} + l_t^{I*} \\
l_t = &\quad \left[\frac{1+\beta+\phi^F}{\theta} - \frac{b_{t+1}}{r_{t+1}(1-\tau_t)(1+\gamma^F e_0^F)w_t^F + P_{t+1}}\right] \\
&+ \left[\frac{1+\beta+\phi^I}{\theta} - \frac{b_{t+1}}{r_{t+1}(1-\chi_t)(1+\gamma^I e_0^I)w_t^I}\right]
\end{aligned} \tag{2.19}
$$

Equation (2.19) shows an increase in the parental preference on children's education both for the formal and informal households, ϕ^F and ϕ^I, induce households to provide more labour. Additionally, pension payouts also increase the households' incentives to work more, while the opposite is applied when there is an increase in the universal old-age allowance.

2.3.2 Firms and Production

On the production side, the economy has only one sector, producing one good with three factors of production: physical capital K_t, human capital H_t, and effective labour A_tL_t. We assume that produced goods from both the formal and informal sector are identical since the utility-gained from consuming goods produced in the formal or from informal sector is indifferent for the consumers. Although they can distinguish the good produced from the formal to the informal one, e.g. consumers having dinner in the restaurant will receive a receipt, while consuming from street food do not. However, both places fulfil their hungers and increase their utilities. The firm's production function takes the form of Cobb-Douglas production function with physical capital K_t, human capital H_t and effective labour A_tL_t, which is in line to the human capital model by Lucas Jr [1988].

$$Y_t = F(K_t, H_t, A_tL_t) = K_t^{\alpha} H_t^{\varphi} (A_tL_t)^{1-\alpha-\varphi} \tag{2.20}$$

where α and φ denotes the shares of physical and human capital income, respectively. α and $\varphi \in (0, 1)$. We can easily write down the output per effective labour as follows:

$$\frac{Y_t}{A_tL_t} = F\left(\frac{K_t}{A_tL_t}, \frac{H_t}{A_tL_t}, 1\right) \Rightarrow y_t = k_t^{\alpha} h_t^{\varphi} \tag{2.21}$$

In the perfect competitive market, firms maximise their profits with respect to the factors of input. All earnings are distributed to pay for the factors of production and the price of the factors of production are paid at their rates of marginal productivity.

$$\underset{K_t, L_t}{\text{Max}} \quad K_t^{\alpha} H_t^{\varphi} (A_tL_t)^{(1-\alpha-\varphi)} - R_tK_t - w_tA_tL_t$$

$$\frac{\partial F}{\partial K_t} = R_t = \alpha K_t^{\alpha-1} H_t^{\varphi} (A_tL_t)^{(1-\alpha-\varphi)}$$

$$R_t^* = \alpha k_t^{\alpha-1} h_t^{\varphi} \tag{2.22}$$

where $k_t \equiv \frac{K_t}{A_tL_t}$ and $h_t \equiv \frac{H_t}{A_tL_t}$, represent capital stock per effective labour and human capital stock per effective labour, respectively. With the arbitrary condition between the real gross rental rate of capital R_t, and real interest rate r_t, the following condition applies: $r_{t+1} = R_{t+1} + 1 - \delta$. The physical capital is depreciated at a constant rate δ and the human capital is depreciated at constant rate μ. Both δ and μ lie between the values 0 and 1. We assume that the physical capital is fully depreciated from one period to another in this step which implies that the real rental rate of capital in equilibrium equals to real gross interest rate and physical capital are paid by their marginal productivity of capital: $R_t^* = r_t^* = \alpha k_t^{\alpha-1}$. We obtain the wage rate of perfect competitive market by differentiating the profit function with respect to the effective labour. Then, in the equilibrium, the effective labour are also paid at their marginal productivity of labour as follows:

$$\frac{\partial F}{\partial L_t} = w_t A_t = (1-\alpha-\varphi) K_t^{\alpha} H_t^{\varphi} (L_t A_t)^{(-\alpha-\varphi)} A_t$$

$$w_t^* = (1-\alpha-\varphi) k_t^{\alpha} h_t^{\varphi}; \quad k_t = \frac{K_t}{A_t L_t}, h_t = \frac{H_t}{A_t L_t} \tag{2.23}$$

where $k_t = \frac{K_t}{A_t L_t}$ and $h_t = \frac{H_t}{A_t L_t}$ represents physical and human capital per effective worker, respectively.

2.3.3 Demography

The whole population N_t, consists of two generations: the old age and the young. There is no migration introduced in this model. The young generation or working-age population exogenously work either in the formal or informal sector. So, the aggregate labour supply of the economy equals the combinations of the labour supply from the formal sector l_t^F, and from the informal sector, l_t^I as follows:

$$N_t = N_t^y + N_t^o \tag{2.24a}$$

$$N_t^y = L_t = l_t^F + l_t^I \tag{2.24b}$$

In this model, the population grows at constant rate n which implies that the labour force is growing also at rate n. Then, total labour force of the current period equals total labour force of previous period which grows at rate n, that implies $L_{t+1} = (1+n)L_t$.

2.3.4 Fiscal Policy

The government keeps budget balanced. This means that labour income tax revenues from the current formal workers and informality fees have to be equal to the net payments for both pension payouts for the formal workers, and the non-contributory old-age allowance for both formal and informal workers.

$$\Big[\rho\tau_t w_t^F(1+\gamma^F e_0^F)l_t^F + (1-\rho)\chi_t w_t^I(1+\gamma^I e_0^I)l_t^I\Big](1+n) = (b_{t+1}+P_t)\rho + b_{t+1}(1-\rho) \quad (2.25)$$

where ρ is the share of formal worker to total workforce and the total workforce is normalised to 1. Recall also that both the universal old-age allowance and pension payouts are growing at the same rate of GDP. This means that $b_{t+1} = \bar{b}\cdot k_{t+1}^{\alpha}h_{t+1}^{\varphi}$ and $P_{t+1} = \bar{P}\cdot k_{t+1}^{\alpha}h_{t+1}^{\varphi}$. The costs of being informal workers are also a fraction of labour income tax rate which implies $\chi_t = \bar{\chi}\cdot\tau_t$. Using the equilibrium prices of effective labour [equation (2.23)] and real rental rate [equation (2.22)]. Plugging them into the optimal labour supply of formal and informal workers' households [equations (2.9) and (2.14)], we obtain the optimal tax policy as follows:

$$\tau_t = \frac{\bar{P}\rho + \bar{b}}{(1+n)(1-\alpha-\varphi)\Big[\rho(1+\gamma^F e_0^F)l_t^F + (1-\rho)\bar{\chi}(1+\gamma^I e_0^I)l_t^I\Big]} \quad (2.26)$$

and re-write as a function of all endogenous and exogenous variables as

$$\tau_t = f^{\tau}(k_t, h_t, \tau_t; \phi^F, \theta, \gamma^F, \gamma^I, \bar{P}, \bar{b}, e_0^F, e_0^I, n, \bar{\chi}, \alpha, \varphi, \rho) \quad (2.27)$$

where $l_t^F = \frac{1+\beta+\phi^F}{\theta} - \frac{\bar{b}}{\alpha(1-\tau_t)(1+\gamma^F e_0^F)(1-\alpha-\varphi)k_t^{\alpha-1}h_t^{\varphi}+\bar{P}}$ and $l_t^I = \frac{1+\beta+\phi^I}{\theta} - \frac{\bar{b}}{\alpha(1-\bar{\chi}\cdot\tau_t)(1+\gamma^I e_0^I)(1-\alpha-\varphi)k_t^{\alpha-1}h_t^{\varphi}}$. It can be seen clearly from equation (2.26) that an increase in the pension payouts for the formal workers and a rise in universal old-age allowance induce higher labour income tax rate to the formal workers. The results are in line with Hsu, Huang and Yupho [2015] that the burdens of an increasing of public unfunded health insurance coverages go directly to the formal workers. Expanding tax base to informal workers may be another way to lessen these burdens on the formal workers.

2.3.5 Law of Motion of Physical Capital

The law of motion of physical capital explains that the physical capital in the current period is determined by the physical capital from the period before deducted by depreciation and new investments from the period before.

$$K_{t+1} = (1-\delta)K_t + I_t \quad (2.28)$$

We assume that the depreciation rate of physical capital $\delta = 1$ which implies that the whole physical capital from the period before is completely worn out each year. In the equilibrium, total savings or demand for physical capital equals total investments $S_t = I_t$. Then, we get the market clearing conditions of capital and physical capital per effective labour as follows:

$$K_{t+1} = I_t = S_t = Y_t - C_t$$

$$\frac{K_{t+1}}{A_{t+1}L_{t+1}} = \frac{S_t}{A_t(1+g)\cdot L_t(1+n)} \tag{2.29}$$

$$k_{t+1} = \frac{s_t}{(1+n)(1+g)}$$

where k_{t+1} presents the dynamics of physical capital per effective worker. The technological productivity growth at time t grows at rate g and follows the technological dynamics: $A_{t+1} = (1+g)A_t$. Using the aggregate optimal households' savings from equation (2.17) and the equilibrium prices of effective labour and rental price of physical capital, equations (2.23) and (2.22), the dynamics of physical capital can be derived as follows:

$$\begin{aligned} k_{t+1} = \frac{1}{(1+g)(1+n)} \cdot \Bigg\{ \left[\frac{\alpha\theta + \bar{P} + \phi^F \bar{P} + \bar{b}\theta}{\alpha\theta}\right] k_t + \left[\frac{\beta(1-\tau_t)(1+\gamma^F e_0^F)(1-\alpha-\varphi)k_t^{\alpha} h_t^{\varphi}}{\theta}\right] \\ + \left[\frac{\beta\alpha(1-\bar{\chi}\cdot\tau_t)(1+\gamma^I e_0^I)(1-\alpha-\varphi)k_t^{2\alpha-1}h_t^{2\varphi}}{\theta}\right] \\ - \left[\frac{\bar{b}(1-\tau_t)(1+\gamma^F e_0^F)(1-\alpha-\varphi)k_t^{\alpha}h_t^{\varphi}}{\alpha(1-\tau_t)(1+\gamma^F e_0^F)(1-\alpha-\varphi)k_t^{\alpha-1}h_t^{\varphi} + \bar{P}}\right] \Bigg\} \end{aligned} \tag{2.30}$$

and re-write as a function of all endogenous and exogenous variables as

$$k_{t+1} = f^k(k_t, h_t, \tau_t; \phi^F, \theta, \gamma^F, \gamma^I, \bar{P}, \bar{b}, e_0^F, e_0^I, n, g, \bar{\chi}, \alpha, \varphi). \tag{2.31}$$

2.3.6 Human Capital

The human capital in the current period is accumulated from the human capital of the period before and new investments in level of education deducted by its depreciation. Then, the law of motion of human capital is

$$H_{t+1} = (1-\mu)H_t + E_{t+1}. \tag{2.32}$$

where μ is the depreciation rate of human capital. When one does not use or practise the knowledge for so long, knowledge fades away and needs time to revise. However, in this step we assume that $\mu = 1$ for simplicity. That is the human capital depends only on new investments in children's education. In order to see human capital per effective labour, we divide H_{t+1} by $A_{t+1}L_{t+1}$ and obtain the human capital per effective worker as follows:

$$\frac{H_{t+1}}{A_{t+1}L_{t+1}} = \frac{E_{t+1}}{A_{t+1}L_{t+1}}$$
$$h_{t+1} = \frac{e_{t+1}}{(1+g)(1+n)} \tag{2.33}$$

Using the aggregate optimal households' investments in children's education from equation (2.18) and the equilibrium prices of effective labour and rental price of physical capital, equations (2.23) and (2.22), the dynamics of human capital can be derived as follows:

$$h_{t+1} = \frac{1}{(1+g)(1+n)} \cdot \Bigg[\frac{\phi^F(1-\tau_t)(1+\gamma^F e_0^F)(1-\alpha-\varphi)k_t^\alpha h_t^\varphi}{\theta a \eta} + \frac{\phi^F \bar{P} k_t}{\alpha \theta a \eta} + \frac{\phi^I(1-\bar{\chi}\cdot\tau_t)(1+\gamma^I e_0^I)(1-\alpha-\varphi)k_t^\alpha h_t^\varphi}{\theta a \eta}\Bigg] \tag{2.34}$$

and re-write as a function of all endogenous and exogenous variables as

$$h_{t+1} = f^h(k_t, h_t, \tau_t; \phi^F, \phi^I, \theta, \gamma^F, \gamma^I, \bar{P}, e_0^F, e_0^I, n, g, \bar{\chi}, \alpha, \varphi, a, \eta). \tag{2.35}$$

2.4 Steady State Analysis

The dynamics general equilibrium of the model which we describe above has the sequence of $\{c_t^{Fy}, c_{t+1}^{Fo}, l_t^F, s_t^F, e_{t+1}^F, c_t^{Iy}, c_{t+1}^{Io}, l_t^I, s_t^I, e_{t+1}^I, k_t, w_t, r_t, h_t\}$ for a given h_0 and k_0. These sequences are in equilibrium when the agents maximise their utility, firms maximise their profit and pay the price for factors of production at market rate, and market clearing in the goods market. Once those paths are known, we obtain the path of $\{c_t^{Fy}, c_{t+1}^{Fo}, l_t^F, s_t^F, e_{t+1}^F, c_t^{Iy}, c_{t+1}^{Io}, l_t^I, s_t^I, e_{t+1}^I, w_t, \tau_t, r_t, k_t, h_t\}_{t=1}^\infty$ in equilibrium.

In the steady state, changes in physical and human capital per effective labour are constant which imply $k_{t+1} = k_t = k^*$ and $h_{t+1} = h_t = h^*$, respectively. The labour income tax rate is also constant, $\tau_t = \tau^*$, in the steady state. Assuming that we have a constant population growth $n = 0$ and constant technological growth $g = 0$ by now. The physical capital in the steady state can be written as follows:

$$k^* = \left[\frac{\alpha\theta}{\alpha\theta + \bar{P} + \phi^F \bar{P} + \bar{b}\theta}\right]\left[\frac{\beta(1-\tau^*)(1+\gamma^F e_0^F)(1-\alpha-\varphi)k^{*\alpha}h^{*\varphi}}{\theta}\right.$$
$$+\frac{\beta\alpha(1-\bar{\chi}\cdot\tau^*)(1+\gamma^I e_0^I)(1-\alpha-\varphi)k^{*(2\alpha-1)}h^{*(2\varphi)}}{\theta} \tag{2.36}$$
$$\left.-\frac{\bar{b}(1-\tau^*)(1+\gamma^F e_0^F)(1-\alpha-\varphi)k^{*\alpha}h^{*\varphi}}{\alpha(1-\tau^*)(1+\gamma^F e_0^F)(1-\alpha-\varphi)k^{*(\alpha-1)}h^{*\varphi}+\bar{P}}\right].$$

Human capital stock in the steady state is

$$h^* = h^{*\varphi}k^{*\alpha}\left[\frac{\phi^F(1-\tau^*)(1+\gamma^F e_0^F)(1-\alpha-\varphi)}{\theta a\eta}\right.$$
$$\left.+\frac{\phi^I(1-\bar{\chi}\cdot\tau^*)(1+\gamma^I e_0^I)(1-\alpha-\varphi)}{\theta a\eta}\right]+\frac{\phi^F \bar{P}k^*}{\alpha\theta a\eta} \tag{2.37}$$

and labour income tax rate in the steady state is

$$\tau^* = 1/\left\{\rho(1+\gamma^F e_0^F)\left[\frac{1+\beta+\phi^F}{\theta} - \frac{\bar{b}}{\alpha(1-\tau^*)(1+\gamma^F e_0^F)(1-\alpha-\varphi)k_t^{*\alpha-1}h_t^{*\varphi}+\bar{P}}\right]\right.$$
$$\left.+(1-\rho)\bar{\chi}(1+\gamma^I e_0^I)\left[\frac{1+\beta+\phi^I}{\theta} - \frac{\bar{b}}{\alpha(1-\bar{\chi}\cdot\tau^*)(1+\gamma^I e_0^I)(1-\alpha-\varphi)k_t^{*\alpha-1}h_t^{*\varphi}}\right]\right\} \tag{2.38}$$
$$\cdot\left\{\frac{\rho\bar{P}+\bar{b}}{(1+n)(1-\alpha-\varphi)}\right\}$$

where $\bar{P}, \bar{b}, \phi^F, \phi^I, \rho, \eta, e_0^F, e_0^I, \bar{\chi}, \alpha, \varphi$ are exogenous variables and k^*, h^*, τ^* are endogenous state variables. Using equations (2.36), (2.37) and (2.38) to solve numerically the system of equations and obtain numerical results of the physical capital, human capital and labour income tax rate in the steady state. The system of equations contains three steady state equations with three unknown endogenous variables. Unfortunately, we cannot solve the system analytically since a system of three steady state equations need to solve simultaneously.

Therefore, the numerical exercises are provided and discussed in the next section to ensure the hypothesis of the dynamics of macroeconomic variables.

Let us assume that the parameters' values lie between zero and one; $\alpha, \varphi, \beta, \mu, \delta, a, \tau, \bar{\chi} \in (0,1)$. Additionally, recall $\phi^F \geq \phi^I$ and $\gamma^F \geq \gamma^I$ which implies that the formal workers' parents have higher preference for their children's educational level than the informal workers and the productivity according to the educational level of the formal workers are higher than the informal ones. η or fertility rate is positive value. Moreover, as the pension payouts for the formal workers have to be higher than the non-contribution universal old-age allowance which government pays to both formal and informal workers, that is $\bar{P} > \bar{b}$.

Theorem 1. *With all parameters' values follow previous assumptions entering the model, the equilibrium solutions are locally determined and they are stable.*

Proof. With the different values of parameters entering the model running by *Dynare*, the model has zero eigenvalue larger than one in the modulus and has zero forward-looking variable. The rank is verified and perfect foresight solutions are found. Therefore, the unique and stable solution of the dynamics system at the steady-state does exist, and the equilibrium solution is locally determined. □

Since we cannot access the comparative static analysis of the system of equations, k_t, h_t, τ_t in steady state by using the implicit function theorem, this chapter analyses the macroeconomic effects with numerical exercises. The numerical experiments are provided in the next section.

2.5 Numerical Analysis

We calibrate the model based on Thai economy and Thailand's pension and the universal old-age allowance data in order to examine quantitatively the effects of change in fiscal policy parameters on the human capital accumulation of the formal and informal households, thus economic growth. All parameters, that are chosen to match the model, come from the previous literature related to human capital and economic growth.

The household preference and demographic parameters related to the numerical exercises are $\beta, \theta, a, \gamma^F, \gamma^I, \eta$. For the discount factor, $\beta = \frac{1}{(1+i)}$, where i is normal standard discount rate taken the value of around 0.04 similar to Chu and Cozzi [2011]. Therefore, the discount factor β, takes a value of 0.99 in this exercise. An increase in the marginal utility of having one more unit of leisure θ, is adopted from the quantitative macroeconomic model literature by Krueger [2005]. It takes the value of 2.62.

For the children's educational expenses as a percentage of parents income a, we take the data of the education expenditure per head per year to the GDP per capita from Socio-economic survey, NSO. The average household education expenditure in Thailand is 22000

THB (around 806 USD, using the exchange rate 1 USD ≈ 31 THB) per head per year and the annual income per capita of Thailand is 6883 USD[11]. Therefore, the education expenses account for about 10% of parents income.

For the formal and informal worker parent's preference on their children's education γ^F and γ^I. The paper by Chu, Furukawa and Zhu [2015] points out that the parents invest in their children's education partly due to an increase in their utility when their children get educated and they show that the preference of parent on children's education affects directly the growth path. Parental preference for children's education could affect long-term economic growth passing through human capital accumulation. However, if the parental preference for education is much higher than the ratio of the 1+marginal utility of leisure to the depreciation of human capital. Then, it reduces the economic growth due to crowding-out effects. This chapter takes the values of parental preference for children's education of formal workers from Chu, Furukawa and Zhu [2015] which exactly equals the threshold value $\frac{1+\theta}{\mu}$. We presume that the preference of informal parents on their children's education is lower than the formal workers' parent, which takes the value of $0.6 * (\frac{1+\theta}{\mu})$.

According to the World Bank, the trend of fertility rate or births per woman in Thailand has substantially reduced from 3.39 births per woman in 1980 to around 1.48 in 2015. Therefore, we take the initial value of fertility rate (number of births per women) at 4 for the initial value and 2 for end value entered to our model in order to see the effects of a reduction in the fertility rate.

The parameters related to the formal and informal sector in Thailand mostly have been calibrated using data from the Nation Statistic Office (NSO) of Thailand. According to the Thai Nation Statistic Office (NSO), the report on the situation of the informal sector indicates that the educational level of the informal workers tends to have slightly increased over time. In 2016, the majority of the informal workers, about 33.3 per cent, have no education or lower than the primary school level, 27.2 per cent achieved primary school level, 16 per cent and 13.8 per cent have secondary school and high school level, respectively and only 9.5 per cent of the informal workers achieve the higher educational level. Table 2.1 presents the share of formal and informal workers who achieved higher education. The average from the year 2011 to 2016 of the percentage of the formal and informal workers who achieve the higher education are 30.09 per cent and 8.1 per cent, respectively. The e_0^F and e_0^I, which represent the initial level of education of the formal worker parents and informal worker parents take the values of 0.3 and 0.08, respectively.

For the production function and firms related parameters, the value of parameters enters the model followed standard growth model literature. Production function's parameters follow classic Cobb-Douglas production function where the share of capital income α, lies between

[11] See also Organization For Economic Cooperation and Development [2013].

Table 2.1
Thailand's Share of Workers Achieved Higher Education by Sector

Year	Share of workers achieved higher education to total workforce	
	Formal sector	**Informal sector**
2011	0.265	0.074
2012	0.290	0.072
2013	0.287	0.082
2014	0.295	0.089
2015	0.351	0.086
2016	0.350	0.090

Source: Author's own construction.
Notes: Table presents the share of formal and informal workers achieved higher education to the total workforce in the formal and informal, respectively. Data is taken from the report of informal worker situation in Thailand, National Statistic Office (NSO).

20-30 per cent of total income. The values for Thailand are quite diverse according to the different calculation methods. This chapter takes the standard capital income share at 0.3 from Cheewatrakoolpong and Boonprakaikawe [2010] and the share of human capital income, value of 0.3. For the physical capital and human capital depreciation rate, this numerical exercises take the value of $1 - (1 - 0.10)^T$ follow the paper by Stokey and Rebelo [1995]; where T is the number of periods. We use $T = 50$, implies the economy run for 50 periods.
In term of fiscal policy choices and the old-age social security regime, the parameters entering the model has been calibrated according to the data from the Social Security Office (SSO), Thailand. According to Social Security Office (SSO) of Thailand, the old-age allowance is about 8 per cent of the pension payouts depending on how many years that the formal workers have paid to contribute to pension.
The pensioners have to contribute not less than 180 months. They will receive about their average last 60 months of salary as pension payouts but not more than certain amount.[12] Then, we use the pension received per month after retirement which is calculated by the method from SSO to compare with the universal old-age allowance per month. We obtain the ratio of the universal old-age allowance, which both formal and informal workers received, to the normal pension payouts, which only the formal workers received, as a percentage of GDP. The government expenditure on pension in Thailand accounts for around 7 per cent of the GDP [OECD, 2012]. The government expenses on the universal old-age allowance

[12]For more information on the calculation of pension received for the formal workers, please visit https://www.sso.go.th/wpr/

approximately 8 per cent of the pension for formal workers, that is $0.07 * 0.08 = 0.0056$ or 0.56 per cent of GDP level. We take the value 0.07 for pension payouts for those who work in the formal sector as a percentage of GDP and 0.0056 for the universal old-age allowance for our simulation.

Table 2.2
Value of Parameters Entering Model Simulation

Variable	Sign	Value	Reference
Physical capital income share	α	0.3	Cheewatrakoolpong and Boonprakaikawe [2010]
Human capital income share	φ	0.3	Cheewatrakoolpong and Boonprakaikawe [2010]
Physical capital depreciation rate	δ	$1-(1-0.10)^T$	Stokey and Rebelo [1995]
Human capital depreciation rate	μ	$1-(1-0.10)^T$	Stokey and Rebelo [1995]
Discount factor or time preference	β	0.99	Chu and Cozzi [2011]
Parental preference for children's education of the formal worker	ϕ^F	$\frac{1+\theta}{\mu}$	Chu, Furukawa and Zhu [2015]
Parental preference for children's education of the informal worker	ϕ^I	$0.6*(\frac{1+\theta}{\mu})$	Adapted from Chu, Furukawa and Zhu [2015]
Educational productivity of formal worker	γ^F	0.246	NSO
Educational productivity of informal worker	γ^I	0.1	NSO
Education level of formal worker	e_0^F	0.3	NSO
Education level of informal worker	e_0^I	0.08	NSO
Fertility rate	η	$\eta \in \{1,2,4,6\}$	The World Bank
Marginal utility of having leisure	θ	2.62	Krueger [2005]
Costs of education per children (as % of income)	a	0.2	Socio-economic Survey, NSO
Costs of working in the informal sector proportional to the formal sector	$\bar{\chi}$	0.3	Loayza [1996]
Pension Premium for those who work in formal sector (as % of GDP)	$\bar{p}$	0.7	SSO and OECD [2012]
Basic old-age allowance (as % of GDP)	$\bar{b}$	0.0056	SSO and OECD [2012]
Proportion of people working in informal sector	ρ	0.4	NSO

Source: Author's own construction.
Notes: Tables shows the parameters' values enter into the model for calibration.

The costs of working in the informal sector $\bar{\chi}$, is around 30 per cent of the registered labour income tax rate.[13] So, the value entering the model is 0.3.
For the share of the formal sector to total workforce, ρ, Figure 2.2 shows that the share of formal worker is approximately 37 per cent in year 2007 and increases to 45 per cent in 2016.

[13]See more detail of the costs of working in the informal sector in [Loayza, 1996]

The value of 0.4 enters to our model for numerical exercises as initial value and ρ is set to 0.5 for the end value. This is to see the effects of an increase in the share of formal sector and its impact on economic growth in long-term. The data of a share of formal sector to total workforce in Thailand are from NSO.
In summary, the parameters entering the model are calibrated as in Table 3.1. We provide a detailed discussion of the numerical results in the next section.

2.6 Results and Discussion

The main policy exercises we conduct in this chapter are varying the intensity of the universal old-age allowances and the pension payouts in order to check the dynamics of the investments in children's education of both the formal and informal sectors' households, labour tax income rate, human capital and physical capital accumulation. These effects influence dynamics change in the output per effective worker, thus economic growth from initial steady state to the new one.
In this setting, we analyse the effects of changes in pension payouts and universal old-age allowance in the circumstance that country has a reduction in the fertility rate (from 4 to 2 births per women) and an increase in the share of formal sector (from 0.4 to 0.5).
Policy experiments which we test are as follows:

1. The macroeconomic effects of an increase in the universal old-age allowance.

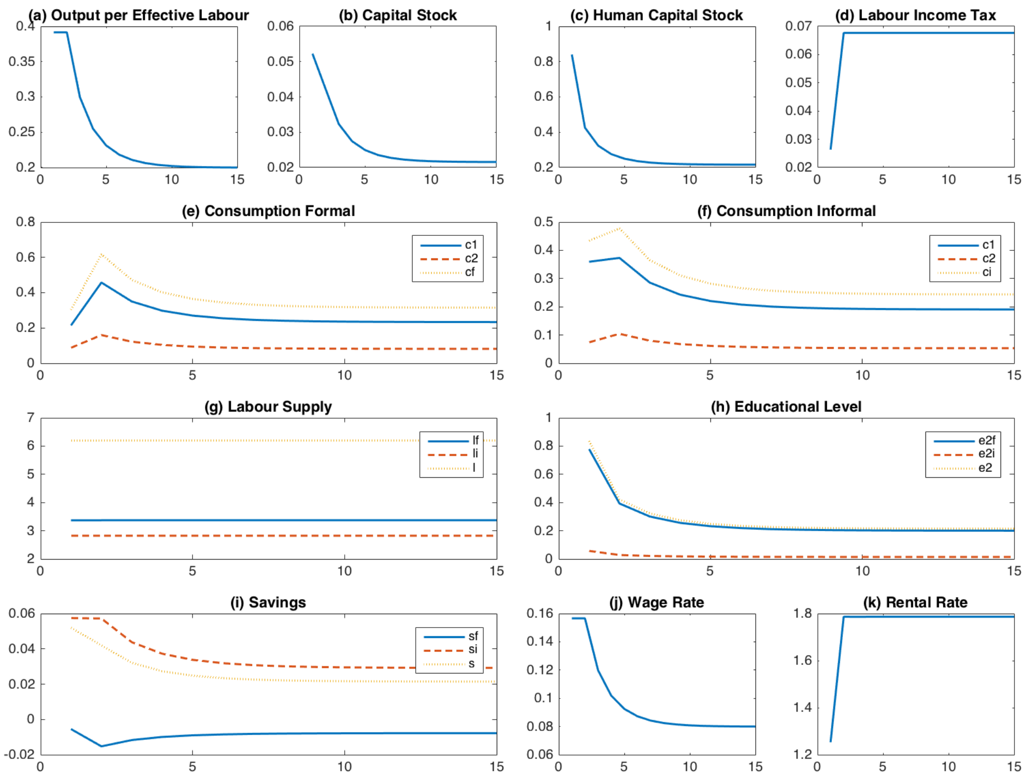
2. The macroeconomic effects of an increase in the pension payouts.

2.6.1 Impacts of an Increase in Pension Payouts

Figure 2.4 illustrates the impacts of an increase in pension payouts on the dynamic macroeconomic variables in the circumstances that there are a reduction in fertility rate and an increase in a share of a formal sector.
The impacts on the consumption level of the formal workers' households are shown in the Panel (e). We observe that an increase in the pension payouts helps to increase the individual's income once they are retired, so $c2$ slightly increases from its initial level, although it slips down and converges to almost the same level as the initial steady state. These effects are a result of pension payouts increasing and a reduction in a fertility rate. The effect from an increase in pension payouts encourages individuals having higher income when they are retired which increase their level of consumption. However, a reduction in fertility means that less young workers pay taxes to finance higher pension payouts for the elderly. When we compare the old-age consumption of the informal workers in Panel (f) to the formal one,

we see that the level of consumption of the old-age formal workers are higher, although the movements of their dynamics are some what the same.

Fig. 2.4. The Effects of an Increase in Pension Payouts ($\bar{P}$)



Source: Author's own calculation.
Notes: This figure presents the dynamics patterns macroeconomic variables affected by a change in the pension payouts from 7 per cent to 14 per cent of the level of GDP in the circumstances that there is a reduction in fertility rate (from 4 to 2 births per woman) and a share of formal sector increases (from 40 per cent to 50 per cent). The outputs are obtained from MATLAB and DYNARE.

Turning to analyse the dynamics of young formal workers' consumption level, $c1$, in Panel (e), we see that there is a sharp rise directly after an increase in pension payouts. These come from 2 effects: Firstly, an increase in pension payouts which allow an individual to distribute and smooth their consumption over their life time. Secondly, a reduction in fertility rate which implies more resources to allocate to the consumption both in young and old-age. We also try to model the circumstances when the fertility rate does not change, in that case, the consumption of the young simply reduces. This implies that the income effects which allow young workers to consume more come from a reduction in fertility side, rather than an increase in the pension payouts.

Moreover, a higher pension payouts now induces a higher labour income taxes in the future since the government would like to keep their budget balanced; government spendings equals government revenues. This is presented by a fall in young formal workers' consumptions after period 2.[14] This fall of the consumption level converges to the new steady state where is slightly higher than the initial one.

In case of young informal workers' consumption level, we observe a small increase at the beginning, then follow by a relatively sharp decline in their consumption level. Since the informal workers do not receive the pension payouts, there is no income to smooth over time. A reduction in fertility rate allows them to allocate their resources to consume more, although the effect is small compared to the fees they have to pay (recall that informality fees is a fraction of labour income taxes). As the labour income taxes increase due to higher pension payouts, the fees of working in informal sector also are also increased. The total consumptions of the formal workers are increased to a higher level in the new steady state, while the opposite applies to the informal workers when pension payouts are increased.

The interesting point is that an increase in the pension payouts does not induce a higher investments in the children's education at all. In Panel (h), we can see easily that both formal and informal workers invests less in the educational level of their children. Although the fertility rate is reduced in this scenario, reductions in income effects due to higher taxes payments to support higher pension payouts prevail. Formal workers decrease their investments in children's education for more than 50 per cent from 0.7 to 0.2, while the informal workers lower investments in children's education to almost 0. This results in lowering human capital accumulation in the new steady state as it is presented in Panel (c).

Since the incomes are decreased due to higher taxes, the dynamics pattern of savings show gradual decline for both types of household. Although there follows by a slight increase for the formal workers' households, it remains negative. Therefore, the total savings of the economy are reduced over time as we can see from the dotted line in Panel (i). Lower savings imply fewer investments and result in a lower level of capital stock in the new steady state as in Panel (b). Then, Panel (k) shows that a reduction in the physical capital stock, while other things remain unchanged, increases the marginal productivity of physical capital and raises up the rental rate. Panel (j) shows that wage rate is lower because lowering stock of physical and human capital reduce marginal productivity of effective labour. This means that the wage rate also is reduced due to lower demand for labour.

We can see from Panels (b) and (c) that an increase in the pension payouts reduces both physical and human capital in the new steady state. These two variables, k and h, affect a decline in the output per effective workers as it is shown in Panel (a). In a nutshell, higher

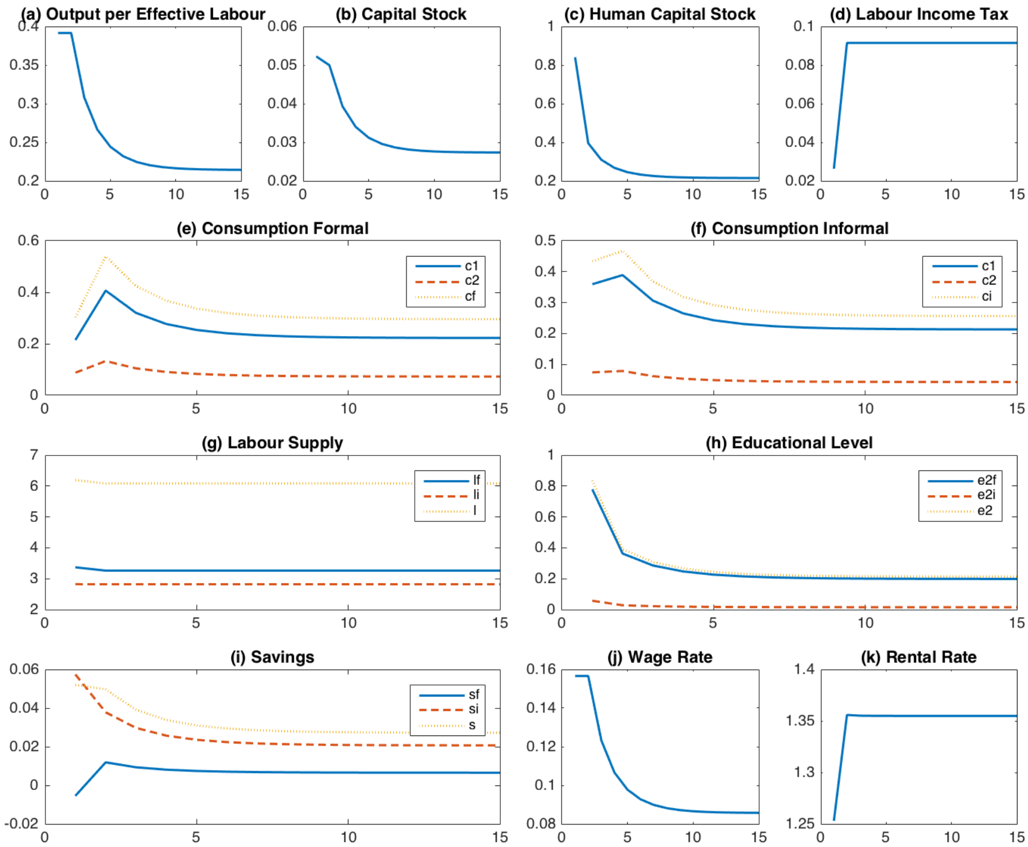
[14]These effects are in line with the Ricardian Theorem. The real government spending on the current period will be paid out by the present value of taxes in the later period. See more on Ricardo [1821].

pension payouts in the OLG model with formal and informal sectors cause a decline in the dynamics of output per effective workers, thus economic growth.

2.6.2 Impacts of an Increase in Universal Old-Age Allowance

The last numerical experiment from our model is to increase the non-contribution universal old-age allowance from 0.56 per cent to 7 per cent of the GDP level. The analysis follows circumstance which fertility rate is reduced and there is an increase in a share of the formal sector. Figure 2.5 presents the effects of an increase in the universal old-age allowance on the dynamics patterns of various macroeconomic variables.

Fig. 2.5. The Effects of an Increase in Universal Old-Age Allowance ($\bar{b}$)



Source: Author's own calculation.
Notes: This figure presents the dynamics patterns macroeconomic variables affected by a change in the universal old-age allowance from 0.56 to 7 per cent of the level of GDP in the circumstances that there is a reduction in fertility rate (from 4 to 2 births per woman) and a share of formal sector increases (from 40 per cent to 50 per cent). The outputs are obtained from MATLAB and DYNARE.

The impacts of an increase in non-contribution old-age allowance on consumption level are quite similar to the previous exercise for both formal and informal workers' households. We observe that an increase in non-contribution old-age allowance does not help to increase investments in children's education either. It reduces the allocations towards investments in children's education due to a higher labour income tax rate. Besides, people care more on increase in their consumption level compared to investments in their children's education. This is because an increase in the social security schemes are relatively small to spend on educational investments. This results in lowering of investments in children's educational level and human capital stock in the new steady state [see, Panels (h) and (c).].

The difference thing between an increase in the pension payouts and in the universal old-age allowance is that in the case of an increase in pension payouts, the labour supply of both sectors remain constant, while in case of an increase in the universal old-age allowance, the labour supply reduces. This is because the pension payouts are attached to the previous labour supply of the formal workers. It can be seen from Panel (g) that when the universal old-age allowance is increased, the formal workers reduce their supply of labour.

Since an increase in the old-age allowance is associated with higher labour income tax rate, savings are also supposed to be reduced which we observe from Panel (i). Savings of the informal workers reduce substantially when there is an increase in the old-age allowance, while formal workers increase their savings a bit higher than it was in the initial steady state. However, the total savings of economy are reduced which implies that a higher non-contribution social security schemes crowd-out the household's incentive to save. Once again a lower savings means less investments in new physical capital. If the physical capital is depreciated overtime, the economy will face lower physical capital stock in the new steady state as it is shown in Panel (c). When there is a lower stock of physical capital, while the other things remain unchanged, marginal productivity of physical capital is increased. There will be more demand for physical capital and raises the rental price up as we can see in Panel (k).

Wage rate is also reduced in this case due to firstly, a decline in the marginal productivity of labour since both physical and human capital stock are reduced. Secondly, a lower labour supply of formal worker due to a higher income. These two effects drag the wage rate in the new steady state down to the lower level than the initial steady state.

Both dynamics of physical and human capital are reduced when the policy suggests to increase the universal old-age allowance. Eventually, generosity unfunded social security policies reduce the long-term level of output per effective worker in the new steady state as presented in Panel (a). In summary, a higher non-contribution universal old-age allowance reduces long-run economic growth by depleting human capital and physical capital accumulations of the economy.

2.7 Conclusion

A shift in the demographic transition towards ageing society puts pressure on many countries' pension regimes. These effects are not been pronounced only among advanced countries but also the emerging countries as well. Thailand is one of the emerging countries facing a sharp rise in the elderly population due to a decline in the fertility rate and an increase in their life expectancy at birth. Unlike those, the industrialised countries, one more interesting characteristic of Thailand and some other emerging countries is having a high share of informal workers to the total workforce. In Thailand case, the informal sector accounts for approximately 55 per cent of the total workforce in year 2016. A large share of the informal sector, together with a shift in the demographic transition, have been neglected in most of the analysis on the economic growth model. Therefore, this chapter contributes to the literature by adding the analysis of an informal sector into the neoclassical economic growth model. This chapter studies the effects of a reduction in fertility rate, share of an informal sector and an increase in the unfunded pension system or universal old-age allowance in affecting economic growth. We focus on the channel of human capital accumulation through investments in children's education of both formal and informal workers' households. The analysis uses the Overlapping Generation (OLG) model which individuals differ in their age and exogenously work either in the formal or informal sector. Our model characterises the local and uniqueness equilibrium solutions.

The findings from numerical exercises, which is calibrated using data of the Thai economy, suggest the following propositions. Firstly, the increase in unfunded pension payouts and non-contribution old-age allowance do not imply higher investments in children's education, but rather change the consumption profiles of the workers. Secondly, higher pension payouts and old-age allowance crowd-out households' incentives to save which implies lowering physical capital stock in steady state. The results suggest that as the pension payouts and old-age allowance increase, the physical capital and human capital are reduced, thus reduction in the level of output per effective worker. This implies hindered economic growth in the new steady state.

The policy recommendations suggested by our model are that the non-contribution pension system or old-age security may not be a good choice for an economy with a large informal sector and low fertility rate like Thailand. An increase in the non-contribution pension payouts or the universal old-age allowance may reduce the investments in children's education and it comes with the costs to the young workers, whose proportion is shrinking due to a shift in the demographic transition. In the long-run output per effective labour is hindered by higher labour income taxes, especially on the formal workers. Ultimately, we may need a transferring regime towards fully funded pension and social security schemes or expanding the tax base more to the people who work in the informal sector.

Chapter 3

Working after Retirement? Elderly Labour Force Participation and Economic Growth

3.1 Introduction

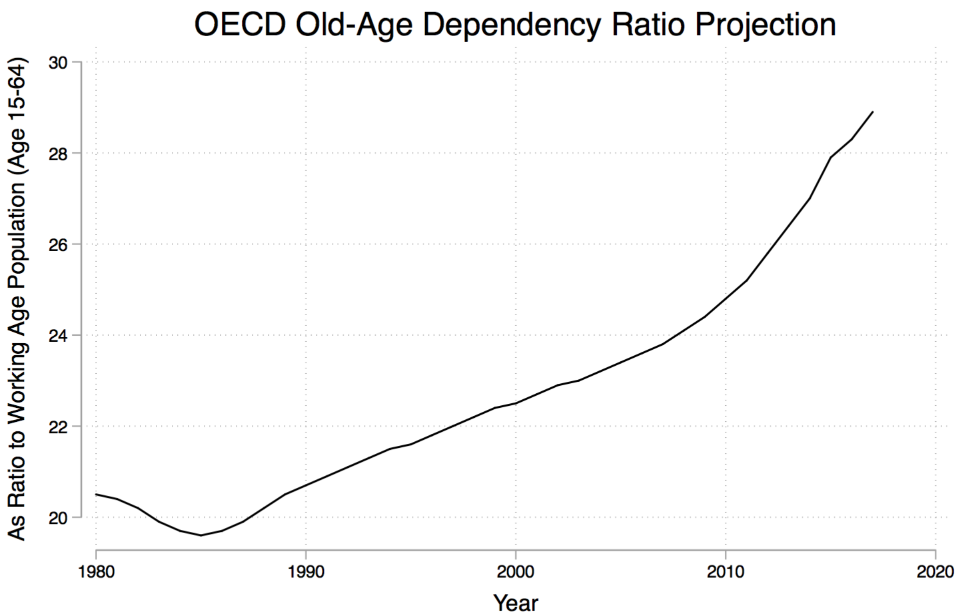
Many societies, especially advanced economies, in the world have been experiencing a shift in demographic structures toward ageing society over the past few decades. There is a significant reduction in fertility rate and a steady increase in life expectancy. These two factors drive changes in the proportion of the old age and working age population which result in a rapid increase in the old age dependency ratio. Figure 3.1 illustrates the projection of the average old-age dependency ratios as a percentage of the working age population of the OECD countries. An increase in the old age dependency ratio of high-income countries starts to take-off from around 18 per cent during the 1980s to almost 30 per cent in 2017. The OECD countries have entered ageing society since 1987 and since then the old-age dependency ratio projection shows a rapid increase for over the past 30 years.

The challenges of moving towards ageing society in various regions have been extensively studied by many researchers. Some of the challenges posed by ageing are disease burden, an increase in expenditures on healthcare and deteriorated health status, labour-force shortages, lack of savings and other potential problems with old-age income security.[1] This chapter, however, would like to scope down to focus mainly on the shortage of labour supply of the

[1]See, for example, Cutler [1990] and Bloom, Canning and Lubet [2015]. The seminal paper by Cutler [1990] shows the facts about the US ageing situations; They project a decline in the support ratio (a rise in the economic dependency) can be continuously observed after 2000. These situations affect directly to consumption behaviours, labour supply of the economy, savings, thus the long-term economic growth. The paper by Bloom, Canning and Lubet [2015] discusses critically the impacts of ageing and current policies respond to a shift in demographic transitions. The policies are still unfit in terms of health and labour force participation arrangements.

advanced countries. According to the International Labour Organisation (ILO) report, the average of OECD countries shows the lowest labour force participation rate of people age 55-64 and older than 64 compared to other regions [World Health Organization, 2001].

Fig. 3.1. The Projection of Old-Age Dependency Ratio (as Percentage of Working-Age Population)

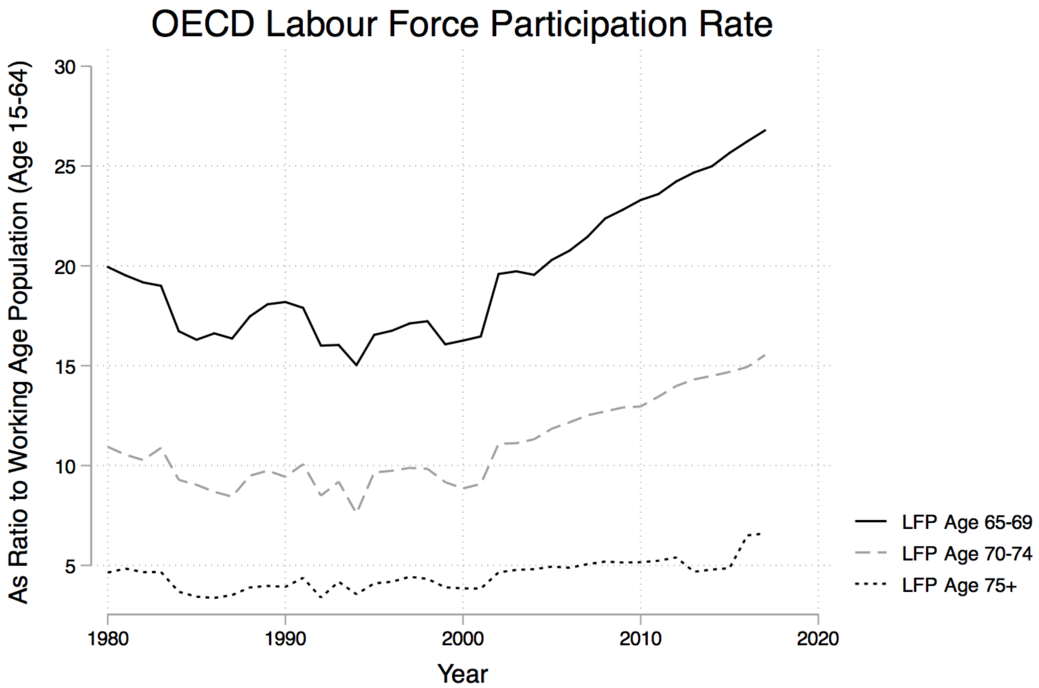


Source: Author's own calculation.
Notes: The figure displays the projection of old-age dependency ratio as a percentage of the working-age population (age 15-64). This figure uses the Labour Force Statistics From OECD statistic website. The old-age dependency ratio here represents the average level of the total OECD countries. The demographic old-age dependency ratio is defined as the number of individuals aged 65 and over per 100 people of working age defined as those aged between 15 and 64. The graph of old-age dependency ratio in other regions and other levels of income would also show similar upwards trend.

Although the shortage of labour and its impacts on economic growth remain one of the important points to concern regarding the ageing issue, evidence from OECD statistic shows a gradual increase in labour force participation of older-age population (age above 64) over the past 20 years. Similarly to the observations of Maestas and Zissimopoulos [2010], the elderly labour force participation starts to rise from the year 2000 after a long decline for a century which is in line with an increase in life expectancy of the person at birth.
Figure 3.2 illustrates a share of older-age labour force participation to total labour force of the OECD countries by age group from 1980 to 2017. For the age group 65-69, the elderly labour force participation rate has increased by 35 per cent, from 20 per cent in 1990 to around 27 per cent in 2017, noticing that a sharp rise in older-age employment starts in

2001. The similar trend also applies to the other age groups. There is a rapid increase in the older-age labour force participation by 45 per cent for the age group 70-74 and by 62.5 per cent for the age group 75 and above.

Fig. 3.2. Elderly Labour Force Participation Rate of OECD Countries



Source: Author's own calculation.
Notes: Figure presents the aggregate elderly labour force participation rate of the OECD countries by age group. The dataset is obtained from OECD statistic website, Labour Force Statistics by age and sex. The labour force participation rate of the persons who are age 64-69, age 70-74 and above 75 is calculated from the labour force participation of the mentioned age group as a ratio to working age population (age 15-64), respectively. The definition of employment status follows the International Labour Organisation (ILO) guideline.

Many research points out various key determinants for the elderly to continue working after their statutory retirement age. Those main reasons are the elderly health status, their financial conditions such as the income of the elderly, and social security benefits. In this chapter, we would like to focus on the health-related human capital stock of the elderly and their choices of working after retirement age. Although literature on labour force participation and health status of the elderly has been extensively studied, they are mostly documented by empirical evidence. The theoretical developments of this field are falling behind and needs to catch up with empirical perspectives. Therefore, this chapter seeks to fill the gap by constructing the model to describe the health-related human capital effects, older-age labour force participation and how they affects the economic growth.

To approach that point, this chapter is also related to the knowledge of overlapping generation (OLG) model approach in neoclassical growth theorem.[2] The seminal paper of traditional overlapping generation model by Diamond [1965] allows us to investigate the issues of the life-cycle decisions and the effects on economic growth in the long-run. Diamond's two-period OLG model with purely exchange overlapping economy investigates the effects of government debt on competitive equilibrium in the growth model. The economy is a one-good sector which is produced by the supply of young labour. Goods in this economy can be stored and transferred between individuals of different generations or saved to their retirement ages. This is what different from Samuelson [1958]'s model which goods cannot be stored to the next period. Our model adopts the basic environment from Diamond [1965], and let individuals chose to retire or not in the second period according to their health-related human capital stock.

The literature on modelling elderly labour supply choices have not yet been extensively investigated. The seminal paper by Matsuyama [2008] introduces this issue with one-sector neoclassical growth model. His paper considers the interdependency of elderly labour force participation and economic growth using the extension of OLG model from Diamond (1965). He finds that a relatively high incomes when agents are young affects their savings behaviour in the next period and their retirement choices. His paper argues that, with the assumption of income effects when young dominate the price effect when old, agents with higher income when young save more and retire early which leads to a higher capital-labour ratio in the next period. In the model with exogenous retirement and labour force participation of the elderly is mapped to a constant value over time, the economy converges to the unique steady state and the persistence of growth depends only on the share of the capital income.

The models which are more related to longevity and the choices of working after retirement are presented by De Abreu Pessoa, Ferreira et al. [2005], Bloom et al. [2007] and Aísa, Pueyo and Sanso [2012]. Their papers mainly show that longer life expectancy determines the retirement choices of the older-age persons. Their approaches compare the expected utility of the elderly of which they choose to retire and not retire.[3] Although both Bloom

[2]The Overlapping Generations (OLG) Model is firstly introduced by Allais (1947), then, it has been developed extensively by Samuelson [1958], and Diamond [1965] In the OLG model, the economy lasts forever, although agents have limited period of life. The agents differ in their age: old and young which adds the heterogeneous implication into the model, while the others neoclassical growth models like Solow [1956] growth model or optimal growth model ignore it.

[3]The paper by Bloom et al. [2007] suggests that the retirement choices of the elderly are determined exogenously by life expectancy. As life expectancy increases, disutility from working reduces. That is an increase in life expectancy implies all individuals have better health at all ages and they can work more. For De Abreu Pessoa, Ferreira et al. [2005], the results are contrasted to Bloom et al. [2007] owing to different assumptions. Results from De Abreu Pessoa, Ferreira et al. [2005] suggests that longer life expectancy tends

et al. [2007] and De Abreu Pessoa, Ferreira et al. [2005] study the effects of life expectancy on economic growth, their models do not allow heterogeneity among elderly productivity. The model by Aísa, Pueyo and Sanso [2012] fills the gap by allowing the different in productivity among agents in the same cohort e.g. human capital or their educational attainment. Still, the heterogeneity in health status of the elderly remains absent.

This chapter investigates similar aspects as the paper by Matsuyama [2008] and employs some aspects of heterogeneity among the elderly from Aísa, Pueyo and Sanso [2012]. However, firstly, we focus more on the differences in health-related human capital stock of the older-age agents as an aspect of productivity difference. Secondly, instead of focusing only on an increase in life expectancy, we consider in term of "Active Ageing"[4] which means that the elderly require good health to continue being active in the labour market. Since an increase in life expectancy does not mean being healthy enough to encourage the elderly to be active ageing and provide their labour supply in the old age. In order to promote the active ageing, the solidarity of the health policies and program implemented by both government and private sector are required. Additionally, this chapter considers to construct a model explaining the health-related human capital stock of the old agents which can be augmented by the supportive government regulations in affecting the older-age labour supply choices.

Apart from focusing on the health-related human capital of the elderly, we employ the dynamics of the positive externalities, which normally are used in the context of environmental economics, to analyse in the OLG model. This chapter modifies the positive externalities from supportive government regulations. These supportive government policies or regulations generate positive externalities for the elderly health-related human capital stock. We hypothesise that the positive externalities from government regulations influence labour supply choices of the elderly when they retired. This chapter is the first to combine these two aspects and fills the gap of the literature by constructing the model of elderly labour supply choices which can be enhanced by the government regulations and considering its impacts on economic growth.

The results from our model provide a unique equilibrium solutions and they are locally determined. We find that the persistence of growth depends not only on the share of capital income, but also the factors related to the choices of elderly labour force participation such as health-related human capital stock of the elderly, positive externalities on elderly health from government regulations and the costs of providing such programs. This shows that the trade-off between the costs of working after retirement age and health stock, which can be augmented by government policies, of the elderly determine their labour supply choices.

to explain earlier retirement since agent's productivity reduces relatively as fast as increases in their life expectancy. Therefore, labour supply of the older-age is reduced rather than increased by a reduction in disutility from working like in Bloom et al. [2007].

[4]The term "Active Ageing", is adopted from the World Health Organisation (WHO), refers to "continuing involvement in socially productive activities and meaningful works" (WHO, 2002).

The remaining of this chapter is organised as follows: Section 3.2 reviews related literature and some stylised facts about older-age labour force participation. Section 3.3 presents the basic model explaining the choices of labour supply of the elderly and showing the mechanism of the elderly trade-off between health-related human capital and costs of working after retirement. Section 3.4 analyses the competitive equilibrium and the steady state of the model. Section 3.5 presents assumptions and comparative static analysis. Section 3.6 tests numerically the model and discusses the results suggested by model calibration. Then, we conclude the chapter in section 3.7.

3.2 Stylised Facts

3.2.1 Reasons for Working after Retirement

According to the previous research, the elderly consider two main factors whether they will continue working in their older-age. Those are their financial conditions including their incomes, pension benefits and social security retirement schemes and another main factor is the elderly health conditions.

The effects of pension systems, particularly in advanced economies, on retirement decisions have been extensively explored. For example, the series of papers by Gruber and Wise [1999], Gruber and Wise [2002] and Gruber and Wise [2008]. Gruber and Wise [1999] document that the accrual rate, which is calculated from the expected gain from social security wealths (ssw_t) by postponing retirement age for one year ($ssw_{t+1} - ssw_t$), in all studied countries, are negative. Negative accrual rate pushes an incentive for people to retire earlier since the expected return of receiving pension one year later is lower than the year before. In Gruber and Wise [2002] and Gruber and Wise [2008], they study the social security schemes of selected countries including Belgium, Canada, France, Germany, Italy, Japan, Netherlands and Spain, and their effects on old age retirement decisions. The social security replacement rate benefits were used as a proxy for all financial generosity of the social security systems. The more generous the pension schemes are, the earlier old age workers choose to retire. These effects are quite robust for many advanced countries, although they have different labour market policies and institutions across one another. Admittedly, pension schemes and social securities for the elderly influence the elderly choices of working after retirement age at some certain degree. However, not only financial incentives affect the elderly labour supply choices. The paper by Manoli and Weber [2016] estimates labour supply elasticity in response to retirement benefits in Austria. They suggests that financial incentives affects partially retirement decision and there exists other factors beyond financial incentives in affecting the retirement decisions of the elderly.

Health status also shows significant effects on older-age employment. More investments in health care increase the ability to work during the older-age. Working in a proper portion and better health are also complementary factors to each other. Costa [1998] studies the evolutions of the American retirement patterns. He finds that the effects of poor health on labour participation are more pronounced with age. Chronic conditions such as heart disease, arthritis and other musculature skeletal conditions, and respiratory disorders, are proved to cause a reduction in earnings and labour supply choices of middle-aged men. McGarry [2004] investigates empirically the effects of health conditions on the older-age expected retirement decisions. The paper finds that a change in retirement plans is strongly correlated to a change in old-age health conditions. Moreover, her study shows that the health effects outweigh changes in income, wealth or other financial variables.

Similarly, a paper by Kalwij and Vermeulen [2005] uses updated data of eleven OECD countries from the SHARE projects to test the impacts of health on the elderly labour force participation. Their paper analyses various aspects of health indicators, e.g. obesity, maximum hand grip strength, activities of daily life (ADLs), physical and mind conditions. They find a close link between good health and labour supply choices of the elderly, specifically in age group 50-64. Their results suggest that the participation rate for men in Austria, Germany and Spain increase by 10 per cent when the individuals are healthy, while the picture is similar to women in Netherlands and Sweden. The counter-factual tests display similarly that more than one third of male workers drop out of their jobs due to health problems. The effects are found in many countries such as Denmark, Germany, Spain, Sweden and Switzerland. Better health keeps people continue to work in their older age.

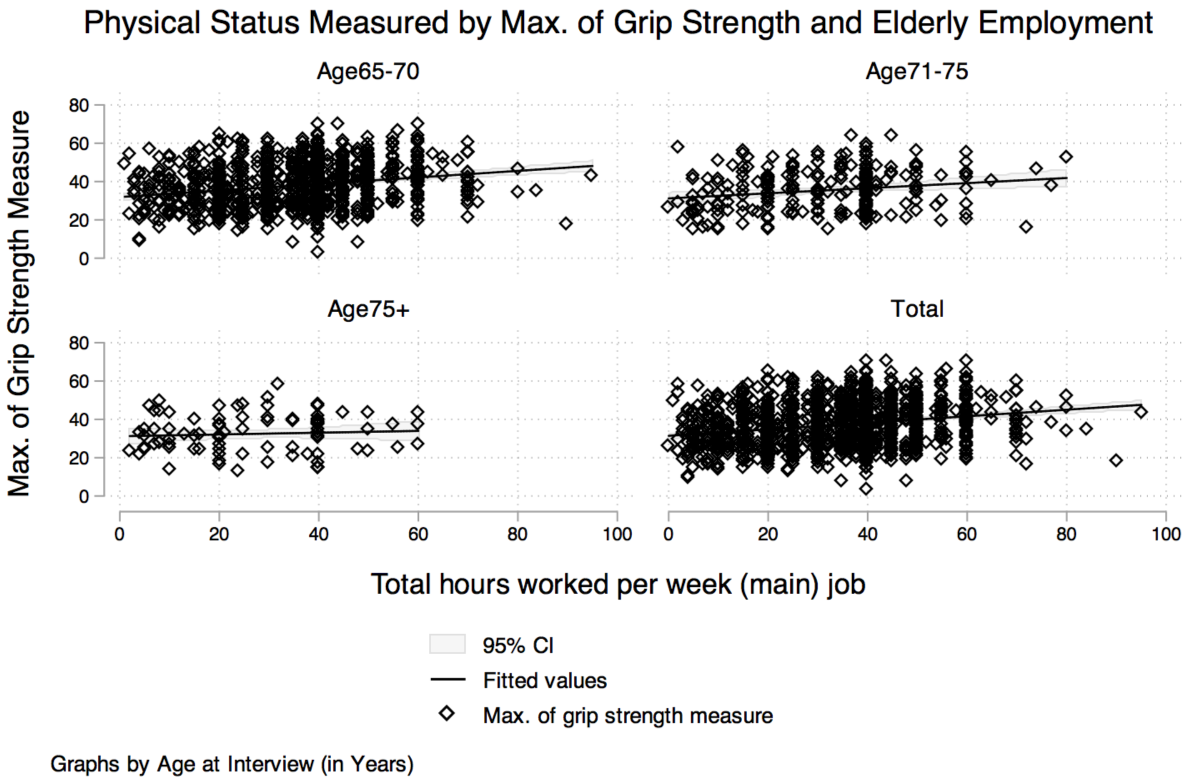
There is also a report of declining of poor and/or fair health of the old age group 70 and above which reflects higher ability to participate in the active activities [Martin et al., 2007]. The paper by Capatina [2015] also suggests that health may affect individuals choices passing through these four channels: productivity, medical expenditures, survival rate and time availability. Although health effects each individual in the different degree and quite vary across each types, economic decisions, especially labour supply is determined mainly by health through these four channels.

More recent empirical evidence on health effects on older-age labour force participation has been studied by Wahrendorf et al. [2017]. The paper uses the Survey of Health, Ageing and Retirement in Europe (SHARE) datasets[5] to study health conditions of the elderly and their decisions to stay longer in labour market. Their results suggest that old age people who continue to work tend to have better health compared to the counterpart in the same age cohort in both physical and mental conditions. Being in good health condition, therefore encourages people to work after their retirement age and helps increase the working capacity

[5]Their paper uses data from the Survey of Health, Ageing and Retirement in Europe (SHARE) Waves 1, 2, 3 (SHARELIFE), 4, 5 and 6, see Börsch-Supan et al. [2013] for more details on how they collected the household level data.

in the ageing society.
In order to see the correlation between the health status and the elderly labour supply, this chapter also employ the dataset from the easySHARE which is a part of The Survey of Health, Ageing and Retirement in Europe (SHARE) to distinctly analyse this issue. This dataset is collected at the household level of 27 European countries including Israel. It comprises of the data on health, socio-economic status and family networks for individual age above 50.

Fig. 3.3. Health (Max. Grip) and Elderly Labour Force Participation



Source: Author's own calculation.
Notes: Figure presents the relationship between maximum hand grip strength and the elderly labour force participation and the linear fitted valued with 95% of confidential interval. The data is acquired from the easySHARE data set (DOI: 10.6103/SHARE.easy.611), see Gruber, Hunkler and Stuck [2014] for the methodological details. The easySHARE release 6.1.1 is based on SHARE Waves 1, 2, 3 (SHARELIFE), 4, 5 and 6 (DOIs: 10.6103/SHARE.w1.611, 10.6103/SHARE.w2.611, 10.6103/SHARE.w3.611, 10.6103/SHARE.w4.611, 10.6103/SHARE.w5.611, 10.6103/SHARE.w6.611). This Figure is produced based on the data from Wave 6 (the data is collected in the year 2015) and the individuals who have their age on the interviewed date above 64. The similar trend can also be found in the other Waves.

For illustrating the stylised facts of elderly health and labour supply, this chapter uses the maximum hand grip strength as a measure of elderly health and ability to supply labour after retirement.[6] We find a positive correlation between maximum grip strength and elderly labour force participation.

Figure 3.3 presents the relationship between healthiness of the elderly (using maximum hand grip strength as a measurement) and their labour supply by age groups. It can be seen that the higher maximum grip strength is positively correlated to the longer total hours worked per week for the main job of the elderly age group 65-69, 70-75 and total aspect. This actually shows that health improves elderly labour force participation.

3.2.2 Government Policies, Health and Elderly Labour Force Participation

This chapter also analyses the dimension of government policies in supporting the older-age labour force participation. We observe how the government expenditure on elderly benefits excluding pensions and social securities benefits affect the elderly labour force participation. We employ the dataset of the OECD elderly cash benefits as a measurement of supportive government policies which augment health conditions of the elderly. According to the OECD data, the cash benefits apply to the main social policy areas for the old age including the survivors, incapacity-related benefits, health, family, active labour market programmes, unemployment, housing, and other social policy areas. These cash benefits do not include pension benefits and other social securities insurances.

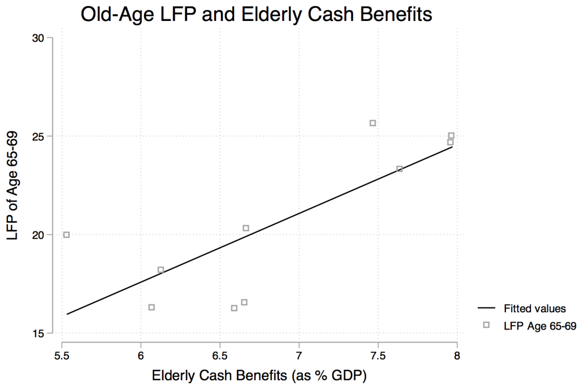
Figures 3.4 shows the relationship between health status, elderly labour supply and supportive government policies. Figures 3.4a illustrates the public expenditures on old-age and survivors cash benefits (as percentage of the level of GDP) on the x-axis and the labour force participation of the elderly (age group 65-69) on the y-axis. It shows that an increase in the elderly cash benefits raises labour force participation of the older-age people (age group 65-69). The correlations also apply to age group 70-74 and 75 and above.

We can see the positive link between the supportive government policies which augment elderly health conditions and the elderly labour force participation. Figure 3.4b depicts the health status of older-age persons (age 65 and above) and old-age and survivors cash benefits. The elderly health status relatively improve as the cash benefits from the government policies

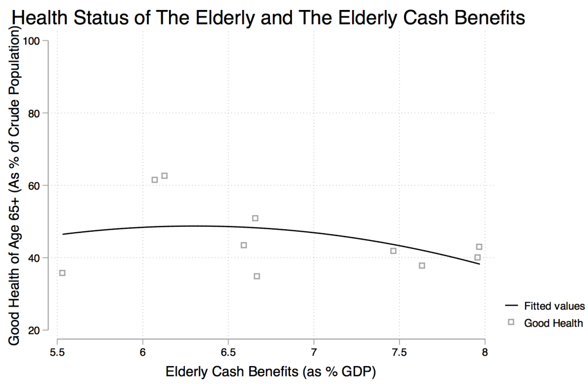
[6] We do not use life expectancy as a proxy for health because living longer does not mean the person will pursue good health conditions during their lifetime. Absence from work due to illness could also be a good measurement for healthiness, but people usually use the absent due to illness also as a reason to do private business. The Body Mass Index (BMI) and weight and tall can also measure the nutrition intake and healthiness of the person. However, this measurement has hump-shape effects. That is the person who has BMI below 18 is considered to be too thin and the effect reverses for BMI during 18-25. The person who has BMI Above 25 will be considered as reaching obesity. To avoid complicated interpretation, we use maximum grip strength as a health measurement and the ability to work. Furthermore, many jobs, e.g. agricultural and farming, office works, accounting, secretary, controlling machine and etc, require certain strength of hand-grip to pursue the tasks.

increase, although the effects fade away as the cash benefits reach the optimum point about 6 to 6.25 per cent of the GDP level. We also try with others age groups, e.g. 71-75 and age group above 75. The graphics illustrate similar trend of the relationship between elderly labour force participation and elderly cash benefits as Figures 3.4a and the positive relationship between elderly health status and elderly cash benefits as Figure 3.4b.

Fig. 3.4. Elderly Health Status, Labour Force Participation (LFP) and Public Expenditure for Elderly Cash Benefits



(a) Elderly Cash Benefits and Elderly Labour Force Participation



(b) Elderly Cash Benefits and Elderly Health Status

Source: Author's own calculation.

Notes: Figures show the relationship between the health status, elderly labour supply and public expenditure on the elderly cash benefits. The figures employ the dataset of labour force participation rate, social expenditures on old-age and survivors cash benefits as percentage of GDP and perceived health status of the person's age above 65 from the OECD stats from 1980 to 2017. Data on social expenditures on old-age and survivors cash benefits as percentage of GDP comes from the OECD Social Expenditure Database (SOCX). It covers 36 OECD countries from 1980 to year 2015/2016 and estimates for the year 2017. For the good health of the person who has age above 65 (as percentage of the crude population), we take the data of each individual countries and calculate the aggregate for the OECD.

We can see from the figure 3.4 that government policies via old-age cash benefits help to improve the elderly health status at some certain degree. Better health during old-age, therefore, points towards higher labour force participation of the elderly. Although preliminary data analysis suggested the previous propositions, not so many model try to construct it. Therefore, this chapter fills the gap of this literature by constructing the model explaining elderly labour supply choices and analysing how labour supply choices of the elderly affects long-term economic growth.

3.3 Model

3.3.1 Environment

Consider an extended traditional two-period overlapping generation model (OLG) builds on top of the model by Diamond [1965]. The economy is populated by agents being a member of the overlapping generation society and is a pure exchange between generations. There is no altruism and no uncertainty of surviving. In other words, death is certain for everyone in this model. Thus, each agent, from generation i and is born at time t, lives for period t and $t+1$. They are endowed with their labour and not consumption goods. When they become old in time $t+1$, new generation $i+1$ is born. Thus, the economy run indefinitely and generation i agents pass away in period $t+2$.

In this model, individuals live for two periods: the working period and retirement period. Each period of time t, there will be two generations overlapped to each other, e.g. at time t, the economy has two generations: individuals who were born at time t, denoted as generation i, are in their working period and the old who were born in time $t-1$, generation $i-1$, as retires. At time t the economy already has an initial old age population, which is given and represented by c_t^o. The total measure of all generations is normalised to 1.

Young or working generations work and earn competitive market wage w_t at time t. The young agents allocate their resources at time t to consumption at time t, c_t^y, savings at time t, s_t, and pay the lump-sum tax, τ_t. We assume that the lump-sum taxes will be used to finance government regulations which provide positive externalities to the productivity (health-related human capital stock) of the older-age who continue working after their retirement. The examples of supportive government policies or regulations could be some subsidized activities or government programs which reduce the depreciation of health-related human capital stock of the old, e.g. environmental regulations within the area of old age residents[7], medical-related assistants, physical and cognitive trainings hubs for the elderly and etc.

When old (retirement period) at time $t+1$, each of the elderly j, who is a member of generation i, chooses either to continue supplying their labour or not depending on each individual's health-related human capital. The elderly, who chose not to continue working, receive savings and its interest payment to finance their consumption in period $t+1$, c_{t+1}^o, while the one who continues to provide their labour supply, $z_{j,t+1}^o$, earns market wage rate at time $t+1$, that is $w_{t+1}z_{j,t+1}^o$. The statutory retirement age is assumed to be the second period of life, but individuals are not obliged to leave the labour market. When the older-age keeps continue working after their statutory retirement age, we assume that they pay no taxes in

[7] Gutiérrez [2008] studies the dynamic inefficiency of the economy which is polluted by pollutions using OLG model. The pollutions produce negative externalities and rather impact when agents become old through higher costs of health care.

period $t+1$. This means that for the elderly who continue working after their retirement age, he or she will have two sources of income: saving and its interest payment, and earnings from working after retirement.

Although providing labour after mandatory retirement age increases the elderly incomes during older-age, it also comes up with some costs or disutility according to work [Aísa, Pueyo and Sanso, 2012; Dedry, Onder and Pestieau, 2017]. We assume there is fixed costs $\gamma_{t+1} > 0$, e.g. time availability, skills-needed and health issues of the elderly. The costs of working after retirement is growing at the same rate as the level of output. we can write it down as $\gamma_{t+1} = \bar{\gamma} \cdot Y_{t+1}$. This means that since the economy is developed over time, some particular advancements may engage within the development procedures. The persons who are seeking for a job in older-age need to adapt or augment their skills for job descriptions which change over time. Skills needed today may not be the same skills in 30 years ago. They may need to emerge in more trainings in order to be able to work. The process of development over time increases the costs of working during the older-age of the elderly. According to World Economic Forum (2018), skills needed for the 21st century are focused more on creativity and problem-solving skills, communication, collaboration and digital literacy skills, and one-third of the skills-needed now are different to the skill-needed 20 years ago.

3.3.2 Household

All agents in this model have perfect foresight and are identical in their preferences and technological progress. The lifetime utility of individuals who were born in time t, belong to generation i, therefore is given by

$$U_{t,i} = u(c_t^y) + \beta u(c_{t+1}^o) \tag{3.1}$$

where β is time discount factor which shows an individual's consumption preference between young and old age. c_t^y is consumption of the agent when young at time t and c_{t+1}^o denotes old-age consumption at period $t+1$. The utility function is an instantaneous utility function which captures the utility of an individual derived from their consumption at time t and $t+1$. Utility function u is twice continuously differentiable, and we assume that $u'(\cdot) > 0$ and $u''(\cdot) < 0$. The budget constraint of young and old cohorts are presented by equations (3.2) and (3.3), respectively, as follows:

$$c_t^y = w_t - s_t - \tau_t \tag{3.2}$$

where w_t denotes the wage rate at competitive market. s_t is savings at time t and τ_t represents the lump-sum tax. The lump-sum taxes will be used to finance government regulations which provide positive externalities to augment health stock of old-age workers. Note also that if no elderly works after retirement age, government regulations to support older-age labour force participation will be 0. Thus, τ_t in that conditions will also be 0. We obtain the old-age consumption allocation for 2 conditions as follows:

$$c^o_{t+1} = \begin{cases} s_t r_{t+1} & \text{for } z^o_{j,t+1} = 0 \\ \\ s_t r_{t+1} + z^o_{j,t+1} w_{t+1} - \gamma_{t+1} & \text{for } 0 < z^o_{j,t+1} < 1 \end{cases} \tag{3.3}$$

where w_{t+1} represents wage income in period $t+1$, and r_{t+1} is the real gross interest rate at time $t+1$. $z^o_{j,t+1}$ denotes each elderly j's labour force participation rate after retirement and γ_{t+1} represents fixed costs of working after retirement age of the older-age persons.

3.3.2.1 Heterogeneity in Health Stock of The Elderly

We assume that individuals during their working period are identical, while during the older-age, the heterogeneity in their health-related human capital are taken into account. Let $z^o_{j,t+1}$ be the distribution of elderly labour force participation rate after retirement. The distribution presents each elderly j's health-related human capital stock, in other words, the productivity of each elderly j. The distribution of elderly health stock lies uniformly along with the interval of 0 and 1. That is $z^o_{j,t+1} \approx [0,1]$. The labour supply of the elderly is also the function of their health-related human capital in the previous period t.

$$z^o_{j,t+1} = z_j(h_t) \tag{3.4}$$

where h_t is a stock of health-related human capital of each individual j, member of generation i at time t. The stock of health of the old at time $t+1$ is accumulated when he was young at time t and it can be augmented through the government regulations at time t. These regulations produce positive externalities to increase health stock of the agents when they become old. As from now, when we mention health stock, it implies health-related human capital stock or the productivity of the elderly. Therefore, we can write down the lifetime budget constraint of an agent as follows:

$$c^y_t + \frac{c^o_{t+1}}{r_{t+1}} = \begin{cases} w_t & \text{for } z^o_{j,t+1} = 0 \\ \\ w_t - \tau_t + \frac{z^o_{j,t+1} w_{t+1}}{r_{t+1}} - \frac{\gamma_{t+1}}{r_{t+1}} & \text{for } 0 < z^o_{j,t+1} < 1 \end{cases} \tag{3.5}$$

3.3.2.2 The Conditions of Elderly Labour Force Participation

The incentive condition in which the old-age people will choose to work after their retirement or not depends on the trade-off between costs of working after retirement, γ_{t+1}, and earnings according to the elderly health conditions, $z^o_{j,t+1} \cdot w_{t+1}$. That is the total benefits from working has to be larger than the costs of working after retirement. Then, the elderly will choose to continue working after retirement.

$$z^o_{j,t+1} w_{t+1} = \gamma_{t+1} \tag{3.6}$$

Reminding that the costs of working after retirement also grow at the same rate as the level of GDP per effective labour, $\gamma_{t+1} \equiv \bar{\gamma} \cdot y_{t+1}$, where $\bar{\gamma}$ denotes fixed costs of working at the older-age as a proportion to the level of output. Then, the threshold point of the elderly working decision follows $\overline{z} = \frac{\bar{\gamma}}{(1-\alpha)}$. Since the health-related human capital of the elderly can be augmented by government regulations G_t, the proportion of positive externalities from the supportive government policies, θ, takes part into the dynamics of elderly health-related human capital stock. Thus, the elderly labour supply conditions can be written as follows:

$$\overline{z} = \frac{\bar{\gamma}}{(1-\alpha)} \cdot \frac{1}{\theta} \tag{3.7}$$

where $\overline{z}$ is the reserve point or zero measure of the threshold level which is assumed to be constant for every period. The elderly start to provide their labour supply after retirement if their health-related human capital stock, $z^o_{j,t+1}$, is higher than this threshold. This productivity threshold is stable and grows at the constant rate of costs of working after retirement follows the Kaldor's facts.[8] Under the condition[9] that $\bar{\gamma} \leq (1-\alpha) \cdot \frac{1}{\theta}$, the elderly choices to provide their labour supply after retirement age can be classified into three cases as follows:

$$\begin{cases} z^o_{j,t+1} > \overline{z} = \frac{\bar{\gamma}}{(1-\alpha)} \cdot \frac{1}{\theta} & \text{Provide labour supply after retirement at} \quad 0 < z^o_{j,t+1} < 1 \\ z^o_{j,t+1} = \overline{z} = \frac{\bar{\gamma}}{(1-\alpha)} \cdot \frac{1}{\theta} & \text{Zero measure} \\ z^o_{j,t+1} < \overline{z} = \frac{\bar{\gamma}}{(1-\alpha)} \cdot \frac{1}{\theta} & \text{Not provide any labour supply after retirement} \end{cases} \tag{3.8}$$

An increase in the positive externalities from government regulations to health-related human capital of the elderly reduces the threshold of productivity requirements. If the elderly

[8] In short, the capital to labour ratio and output to labour ratio tend to be constant overtime.

[9] Note also that $\bar{\gamma} \leq (1-\alpha) \cdot \frac{1}{\theta}$ due to our assumption on the distribution of labour supply of the elderly which is uniform and it lies between 0 and 1. This chapter follows the assumption of uniformly distributed labour supply of the elderly from the paper by Aísa, Pueyo and Sanso [2012].

have their health-related human capital stock during their old-age higher than the threshold productivity point $\overline{z}$, then they will choose to provide labour supply after the retirement. Otherwise, the elderly choose not to provide labour supply after their retirement age. Another point is that the share of capital income also affects the threshold level. Countries with a higher share of capital income tend to have a relatively higher threshold than the countries with an initial lower level of physical capital stock. This actually implies that countries with more capital intensive, may need more specific skills than countries which mainly use labour intensive, like agricultural works, which in turn drive the threshold for elderly to work after their retirement age up.

3.3.3 Firms and Production Side

On the production side, the economy produces goods with a technology which uses labour and physical capital at time t. This model simply employs only one good sector which could be produced by both young and old-age persons. The production function follows the Cobb-Douglas production function form, which has two factors of product: the physical capital K_t and the effective labour A_tL_t which can be written as follows:

$$Y_t = F(K_t, A_tL_t) = K_t^{\alpha}(A_tL_t)^{1-\alpha} \tag{3.9}$$

where α denotes the share of physical capital income. Value of α lies between $0 < \alpha < 1$. The production function in terms of per effective labour is $\frac{Y_t}{A_tL_t} = F(\frac{K_t}{A_tL_t}, 1)$. Then, output per effective labour is $y_t = f(k_t) = k_t^{\alpha}$. We assume also that $f'(\cdot) > 0$ and $f''(\cdot) < 0$. As the market is perfectly competitive, the firm's profits are boiled down to zero. This means that no firms gain excess profit than the market rate. Firms maximise their profit and pay the price of physical capital and labour at their competitive market price: rental rate and market wage rate are equal to the marginal product of capital and the marginal product of labour, respectively.

$$\underset{K_t \geq 0, L_t \geq 0}{\text{Max}} \quad K_t^{\alpha}(A_tL_t)^{1-\alpha} - R_tK_t - w_tA_tL_t$$

$$R_t^* = \alpha k_t^{\alpha-1} \tag{3.10}$$

where $k_t = \frac{K_t}{A_tL_t}$ represents capital stock per effective labour. With the arbitrary condition between the real rental rate of capital, R_t and real gross interest rate, r_t, the following condition applies: $r_{t+1} = R_{t+1} + 1 - \delta$. The physical capital is depreciated at constant rate δ and $0 \leq \delta \leq 1$. For simplicity, now we assume that the physical capital stock is fully depreciated after one period. Therefore, $R_t^* = r_t^* = \alpha k_t^{\alpha-1}$.

The wage rate at competitive market will be paid at its marginal productivity of effective labour as follows:

$$w_t^* = (1-\alpha)k_t^\alpha \tag{3.11}$$

3.3.4 Demography

We assume that the economy has no migration. The whole population of this economy N_t consists of two generations: old N_t^o and young N_t^y. New generation is born at each period $t = 1, 2, ...$ Both young and old generations work and provide their labour supply inelastically to the labour market $N_t = N_t^y + N_t^o$. Therefore, we can write briefly the demography of the economy as follows:

$$\begin{aligned} N_t &= N_{t-1} \cdot (1+n) \\ L_t^y &= N_t^y \\ L_t &= L_t^y + L_t^o \end{aligned} \tag{3.12}$$

where N_t represents the whole population of the economy, L_t is aggregate labour supply which consists of both older-age and young workers, and population grows at constant rate n. However, labour supply provided by the elderly is the sum of all older-age individuals who have their health-related human capital stock higher than the threshold. This health-related human capital can be augmented by the government regulations as we have discussed in the previous section. Therefore, the positive externalities from government regulations take part into the elderly health-related human capital distribution. Since the health-related human capital is uniformly distributed, we obtain the mass of retires as an area from 0 to the threshold $\frac{\bar{\gamma}}{(1-\alpha)} \cdot \frac{1}{\theta}$ and the mass of the elderly workers as an area from the threshold $\frac{\bar{\gamma}}{(1-\alpha)} \cdot \frac{1}{\theta}$ to $\frac{1}{\theta}$. The labour supply of the elderly can be written as follows:

$$\begin{aligned} L_t^o = &\quad N_t^o \int_{\frac{\bar{\gamma}}{(1-\alpha)\theta}}^{\frac{1}{\theta}} z_t^o dz \\ L_t^o = &\quad N_t^o \cdot \frac{z^2}{2}\Big|_{\frac{\bar{\gamma}}{(1-\alpha)\theta}}^{\frac{1}{\theta}} \\ L_t^o = &\quad N_t^o \left[\frac{\left(\frac{1}{\theta}\right)^2 - \left(\frac{\bar{\gamma}}{(1-\alpha)\theta}\right)^2}{2} \right]. \end{aligned} \tag{3.13}$$

The aggregate labour supply of the economy $L_t = L_t^y + L_t^o$ implies that

$$
\begin{aligned}
L_t &= N_t^y + N_{t-1}^y \left[\frac{\left(\frac{1}{\theta}\right)^2 - \left(\frac{\bar{\gamma}}{(1-\alpha)\theta}\right)^2}{2} \right] \\
L_t &= L_t^y \left[1 + \frac{1}{(1+n)} \frac{\left(\frac{1}{\theta}\right)^2 - \left(\frac{\bar{\gamma}}{(1-\alpha)\theta}\right)^2}{2} \right]
\end{aligned}
\tag{3.14}
$$

Therefore, the labour supply of the economy is more than the supply of only young workers. Note, however, that $\frac{1}{(1+n)} \frac{\left(\frac{1}{\theta}\right)^2 - \left(\frac{\bar{\gamma}}{(1-\alpha)\theta}\right)^2}{2} < 1$. The higher the positive externalities from government regulations on elderly health stock, the higher the supply of labour from the elderly to the economy, the costs of working after retirement imply the opposite.

3.3.5 The Law of Motion of Physical Capital

The physical capital in the current period is determined by the physical capital from the period before deducted by depreciation and added new investments. The depreciation rate of physical capital stock is denoted by δ and $0 \leq \delta \leq 1$. The law of motion of physical capital is given by

$$
K_{t+1} = (1-\delta)K_t + I_t. \tag{3.15}
$$

The aggregate output of the economy consists of the aggregate consumptions, $C_t = N_t \cdot (c_t^y + c_t^o)$, and the aggregate investments, I_t. That is $Y_t = C_t + I_t$. A change in the capital stock from period t to $t+1$ is represented by the net investments, $K_{t+1} - (1-\delta)K_t = Y_t - C_t$. Assuming that the capital stock is fully depreciated from one period to another, $\delta = 1$. Then, investments at time t is exactly equal to capital stock at time $t+1$. In the equilibrium, total savings or demand for capital equals total investments $S_t = I_t$. Then, the market clearing conditions of the physical capital per effective labour with full rate of capital depreciation, $\delta = 1$, can be written as follows:

$$
\begin{aligned}
\frac{K_{t+1}}{A_{t+1}L_{t+1}} &= \frac{S_t}{A_t L_t (1+g)(1+n)} = \frac{s_t}{(1+g)(1+n)} = s_t \\
k_{t+1} &= \frac{s(w_t, \tau_t, w_{t+1}, h_{t+1}, r_{t+1}, \gamma_{t+1})}{(1+n)(1+g)}
\end{aligned}
\tag{3.16}
$$

In the perfect competitive market, labour and capital are paid by their marginal productivity of labour and physical capital, respectively. Thus, the dynamics of physical capital are

$$\begin{aligned}(1+n)(1+g)k_{t+1} = \quad & s(f(k_t) - f'(k_t)k_t, \tau(k_t), f(k_{t+1}) - f'(k_{t+1})k_{t+1}, \\ & h_{t+1}, f'(k_{t+1}) - \delta, \bar{\gamma} \cdot f(k_{t+1})).\end{aligned} \tag{3.17}$$

The equation above shows that saving is a non-linear equation and it is a function of two state variables: capital stock, k, and health-related human capital stock, h. Therefore, our dynamics system of equations consists of the dynamics equation of physical capital and the dynamics equation of health-related human capital stock.

3.3.6 The Dynamics of Health-Related Human Capital Stock

The older-age labour force participation is a function of the health-related human capital of individual from the previous period:

$$z^o_{j,t+1} = H_{t+1} = z(h_t) \tag{3.18}$$

where $h_t \equiv \frac{H_t}{A_t L_t}$ is the average health-related human capital of the generation i who becomes old at time $t+1$. The dynamics of human capital is determined by a distribution of the health stock of the elderly which is accumulated at time t. In this model, the stock of health can be augmented also by supportive government regulations from the previous period which grows as proportional to the level of output. Government regulations or policies are financed by lump-sum taxes paid by the young workers. Therefore, the dynamics of the health stock of the elderly can be written as follows:

$$\begin{aligned} H_{t+1} &= (1-\mu)H_t + G_t - C(G_t) \\ H_{t+1} &= (1-\mu)H_t + \theta Y_t - \frac{\sigma Y_t}{2} \end{aligned} \tag{3.19}$$

where μ denotes the rate of depreciation of health stock over time. If the aggregate health stock is fully depreciated, the individual's health stock will depend only on the positive externalities from government regulations, G_t. Government regulations or policies is a proportion to the level of GDP per capita in period t. For simplicity, we assume that $G_t \equiv \theta Y_t$ where θ denotes a proportional positive health effects which elderly may get from government regulations. As the level of GDP per capita increases, positive externalities from government institutions are also increased by θ and $0 < \theta < 1$.

In this model, government regulations affect positively health accumulation of the old-age. Better health, thus increases the possibility to work in the older-age. These positive externalities from supportive government regulations come with some costs, $C(G_t)$, but result in positive developments which outweigh the costs. We simply define the costs function as $C(G_t) \equiv \frac{\sigma Y_t}{2}$ where σ is parameter adjusting the costs of proving supportive government regulations and $0 < \sigma < 1$. Therefore, the health-related human capital accumulation per effective labour can be written as

$$\frac{H_{t+1}}{A_{t+1}L_{t+1}} = \frac{(1-\mu)H_t + \theta Y_t - \frac{\sigma}{2}Y_t}{A_t(1+g)L_t(1+n)} \tag{3.20}$$

and

$$h_{t+1} = \frac{1}{(1+g)(1+n)}\Big[(1-\mu)h_t + (\theta - \frac{\sigma}{2})y_t\Big]. \tag{3.21}$$

Health-related human capital stock per effective labour of each generation is determined by the average health stock when they were young deducted by the decaying of health stock, μ, and positive externalities from government regulations. We presume that government regulations propose positive effects on elderly labour force participation and these benefits, θ, outweigh the costs of providing those regulations, $\frac{\sigma}{2}$.

3.3.7 Government Budget

The government keeps the fiscal budget balanced. So that the government spending on regulations, which positively augment the older-age health stock, equals the tax revenues collected from the young working age population.

$$\begin{aligned} \tau_t L_t^y &= \frac{L_t^y}{(1+n)} \cdot \frac{\sigma Y_t}{2}\left[\frac{\left(\frac{1}{\theta}\right)^2 - \left(\frac{\bar{\gamma}}{(1-\alpha)\theta}\right)^2}{2}\right] \\ \tau_t &= \frac{\sigma k_t^{\alpha}}{4(1+n)} \cdot \left[\left(\frac{1}{\theta}\right)^2 - \left(\frac{\bar{\gamma}}{(1-\alpha)\theta}\right)^2\right] \end{aligned} \tag{3.22}$$

An increase in the costs of government regulations, σ, raises taxes to the young workers, while a higher positive externalities, θ, tend to reduce these lump-sum taxes. Moreover, this equation also shows that the higher the costs for the elderly to work after retirement, the lower taxes required to the young workers. There will be intergenerational trade-off because the young have to pay the lump-sum taxes to finance the government programs which support health stock and labour supply of the elderly.

3.4 The Dynamic General Equilibrium

In this section, we assume logarithmic form of household's lifetime utility function. The dynamics general equilibrium of the model have the sequence of $\{c_t^y, c_{t+1}^o, s_t, k_t, h_t\}$. For a given initial values of physical and health-related human capital, k_0 and h_0, the agents maximise their lifetime utility subject to their lifetime inter-temporal budget constraint and firms maximise their profits and pay the price of factors of production at market rate. In the equilibrium, we will obtain the paths of $\{c_t^y, c_{t+1}^o, s_t, w_t, r_t, \tau_t\}_{t=1}^{\infty}$.

$$\underset{c_t^y, c_{t+1}^o}{\text{Max}} \quad ln(c_t^y) + \beta ln(c_{t+1}^o)$$

$$\text{s.t.} \quad c_t^y + \frac{c_{t+1}^o}{r_{t+1}} = \begin{cases} w_t - \tau_t & \text{for } z_{j,t+1}^o = 0 \\ w_t - \tau_t + \frac{z_{j,t+1}^o w_{t+1}}{r_{t+1}} - \frac{\gamma_{t+1}}{r_{t+1}} & \text{for } 0 < z_{j,t+1}^o < 1 \end{cases} \tag{3.23}$$

The first-order condition of the Lagrangian with respect to consumption when young and old give agents the optimal choices of their consumption allocation as follows:

$$\beta r_{t+1} u'(c_{t+1}^o) = u'(c_t^y) \tag{3.24}$$

The consumption Euler equation represents the trade-off between the current and the future consumption of the agent which equals the marginal rate of transformation of the consumption in young to old age. Using equation (3.24) and the lifetime budget constraint, equation (3.5), we yield the optimal savings choices of the households according to their old-age labour supply as follows:

$$s_t = \begin{cases} (\frac{\beta}{1+\beta}) w_t & \text{for } z_{j,t+1}^o = 0 \\ (\frac{\beta}{1+\beta})(w_t - \tau_t) - \frac{w_{t+1} \cdot z_{j,t+1}^o}{r_{t+1}(1+\beta)} + \frac{\gamma_{t+1}}{r_{t+1}(1+\beta)} & \text{for } 0 < z_{j,t+1}^o < 1 \end{cases} \tag{3.25}$$

Recall that when the elderly provide zero labour supply to the labour market, the lump-sum taxes which are collected by government to support the elderly to work after their retirement age will also be zero. Combining the optimal household's allocations equations, (3.2), (3.3), (3.5), (3.6) and (3.18); market clearing conditions equations (3.10) and (3.11); demographic equation (3.14) and government budget balanced equation (3.22), the dynamics of the physical capital per effective labour can be written as follows:

$$k_{t+1} = \begin{cases} k_t^{\alpha}\left[\frac{\beta(1-\alpha)}{1+\beta}\right] & \text{for } \forall z^o_{j,t+1} = 0 \\ \frac{\beta k_t^{\alpha}}{1+\beta}\left\{(1-\alpha) - \frac{\sigma}{4(1+n)\theta^2}\left[1-\left(\frac{\bar{\gamma}}{1-\alpha}\right)^2\right]\right\} & \text{for } \exists z^o_{j,t+1} \in 0 < z^o_{j,t+1} < 1 \\ -\frac{(1-\alpha)k^{\alpha}_{t+1}\left[(1-\mu)h_t+(\theta-\frac{\sigma}{2})k_t^{\alpha}\right]}{(1+\beta)(\alpha k^{\alpha-1}_{t+1}+1-\delta)(1+g)(1+n)} + \frac{\bar{\gamma}k^{\alpha}_{t+1}}{(1+\beta)(\alpha k^{\alpha-1}_{t+1}+1-\delta)} & \end{cases} \tag{3.26}$$

3.4.1 Steady State and Stability Analysis

In the steady state, there are no changes in physical capital and health-related human capital per effective labour, which implies $k_{t+1} = k_t = k^*$ and $h_{t+1} = h_t = h^*$. Assuming that population grows at a constant rate, $n = 0$ and technology also grows at a zero rate, $g = 0$. The physical capital and decaying in health-related human capital from young to old age are fully depreciated. Then, the health-related human capital stock in the steady state is

$$h^* = (\theta - \frac{\sigma}{2}) \cdot k^{*\alpha} \tag{3.27}$$

and the physical capital stock in the steady state is

$$k^* = \begin{cases} \left[\frac{\beta(1-\alpha)}{1+\beta}\right]^{\frac{1}{1-\alpha}} & \text{for } \forall z^o_{j,t+1} = 0 \\ \left\{\frac{\alpha\beta\left[(1-\alpha)-\frac{\sigma}{4}\left[\left(\frac{1}{\theta}\right)^2-\left(\frac{\bar{\gamma}}{(1-\alpha)\theta}\right)^2\right]\right]}{\alpha(1+\beta)-\bar{\gamma}+(1-\alpha)(\theta-\frac{\sigma}{2})k^{*\alpha}}\right\}^{\frac{1}{(1-\alpha)}} & \text{for } \exists z^o_{j,t+1} \in 0 < z^o_{j,t+1} < 1 \end{cases} \tag{3.28}$$

where $\bar{\gamma}$ denotes the costs of working after statutory retirement. θ is the positive externalities augmenting the elderly health stock. σ presents the costs of providing the supportive government regulations.

The further analysis from now on focuses only on the case which the elderly provide their labour supply, $z^o_{j,t+1} \in 0 < z^o_{j,t+1} < 1$.[10] Note that the steady state when $z^o_{j,t+1} = 0$ follows the standard OLG model by Diamond [1965]. Since we cannot solve explicitly the steady-state of the capital stock and health-related human capital stock, we employ the implicit function theorem to solve implicitly the equilibrium solutions of the dynamics system and proceed the analysis to the comparative static, how changes in policy variables affect changes in the

[10] The elderly whose health-related human capital are higher than the threshold level, $\bar{z} = \frac{\bar{\gamma}}{(1-\alpha)} \cdot \frac{1}{\theta}$.

endogenous variables, k^* and h^*. The comparative static analysis will mainly discuss these three key policy variables: $\bar{\gamma}, \theta$ and σ.

Let us presume the following assumptions:

Assumption 1. $\alpha, \beta, \bar{\gamma}, \theta, \sigma \in (0,1)$.

Assumption 2. *The positive externalities from government regulations or policies on elderly employment outweigh the costs of providing those policies. That is* $\theta > \frac{\sigma}{2}$.

Proposition 1. *Given that the Assumptions 1 and 2 hold, (1) The steady state equilibrium is unique; and (2) Equations (3.27) and (3.28) implicitly provide local uniqueness, stable and continuous steady state equilibrium.*

Proof (1). In order to prove the first part of the Proposition 1, the system of equations provides uniqueness and continuity of the equilibrium solutions. Firstly, we define the steady state of k^* and h^* implicitly by a set of the implicit function of k^* and h^*, respectively, as follows:

$$F(k^*, h^*; \alpha, \beta, \bar{\gamma}, \theta, \sigma) = \left[\frac{h^*}{(\theta - \frac{\sigma}{2})}\right]^{\frac{1}{\alpha}} - \left\{\frac{\alpha\beta\Big[(1-\alpha) - \frac{\sigma}{4}[(\frac{1}{\theta})^2 - (\frac{\bar{\gamma}}{(1-\alpha)\theta})^2]\Big]}{\alpha(1+\beta) - \bar{\gamma} + (1-\alpha)(\theta - \frac{\sigma}{2})k^{*\alpha}}\right\}^{\frac{1}{(1-\alpha)}} = 0 \tag{3.29}$$

$$G(k^*, h^*; \alpha, \beta, \bar{\gamma}, \theta, \sigma) = h^* - (\theta - \frac{\sigma}{2})\left\{\frac{\alpha\beta\Big[(1-\alpha) - \frac{\sigma}{4}[(\frac{1}{\theta})^2 - (\frac{\bar{\gamma}}{(1-\alpha)\theta})^2]\Big]}{\alpha(1+\beta) - \bar{\gamma} + (1-\alpha)(\theta - \frac{\sigma}{2})k^{*\alpha}}\right\}^{\frac{\alpha}{(1-\alpha)}} = 0 \tag{3.30}$$

Next, we check the conditions for using implicit function theorem by differentiating the function F and G with respect to all endogenous and exogenous variables of the system.[11] Consequently, it proves that all function F and G have continuous partial derivatives with respect to all endogenous and exogenous variables of the system. Therefore, given that the Assumptions 1 and 2 hold, there exists the neighbourhood of $\alpha_0, \beta_0, \bar{\gamma}_0, \theta_0, \sigma_0$ such that k^* and h^* are the functions of those parameters and implicitly continuously differentiable with respect to all of those parameters.

Another condition for implicit function theorem to work is that the Jacobian matrix of k^* and h^* needs to be non-singular determinants. At the fixed point $(k_0, h_0; \alpha_0, \beta_0, \bar{\gamma}_0, \theta_0, \sigma_0)$ which satisfies the system of equations above, the determinant of the Jacobian matrix is not equal to zero which can be seen by the following equations:

[11]See the detail of the proves of differentiability of functions F and G in the Appendix H.

$$\frac{\partial F}{\partial k^*} = A^{\frac{1}{1-\alpha}} B^{-\frac{2-\alpha}{1-\alpha}} \frac{1}{1-\alpha} \alpha(1-\alpha)(\theta - \frac{\sigma}{2}) k^{*-(1-\alpha)}$$

$$\frac{\partial F}{\partial h^*} = \frac{1}{\alpha} h^{*\frac{1-\alpha}{\alpha}} (\theta - \frac{\sigma}{2})^{-\frac{1}{\alpha}}$$

$$\frac{\partial G}{\partial k^*} = A^{\frac{\alpha}{1-\alpha}} B^{-\frac{1}{1-\alpha}} (\theta - \frac{\sigma}{2})^2 \alpha^2 k^{*-(1-\alpha)}$$

$$\frac{\partial G}{\partial h^*} = 1$$

where $A = \alpha\beta\Big[(1-\alpha) - \frac{\sigma}{4}[(\frac{1}{\theta})^2 - (\frac{\bar{\gamma}}{(1-\alpha)\theta})^2]\Big]$ and $B = \alpha(1+\beta) - \bar{\gamma} + (1-\alpha)(\theta - \frac{\sigma}{2})k^{*\alpha}$. A and B are positive.
We get the Jacobian matrix as follows:

$$\mathbf{J}_{k^*,h^*} = \begin{bmatrix} \frac{\partial F}{\partial k^*} & \frac{\partial F}{\partial h^*} \\ \frac{\partial G}{\partial k^*} & \frac{\partial G}{\partial h^*} \end{bmatrix} = \begin{bmatrix} A^{\frac{1}{1-\alpha}} B^{-\frac{2-\alpha}{1-\alpha}} \frac{1}{1-\alpha} \alpha(1-\alpha)(\theta - \frac{\sigma}{2}) k^{*-(1-\alpha)} & \frac{1}{\alpha} h^{*\frac{1-\alpha}{\alpha}} (\theta - \frac{\sigma}{2})^{-\frac{1}{\alpha}} \\ A^{\frac{\alpha}{1-\alpha}} B^{-\frac{1}{1-\alpha}} (\theta - \frac{\sigma}{2})^2 \alpha^2 k^{*-(1-\alpha)} & 1 \end{bmatrix}$$

The determinant of the Jacobian matrix, therefore, is $|\mathbf{J}_{k^*,h^*}| = \frac{\partial F}{\partial k^*} - \frac{\partial F}{\partial h^*}\frac{\partial G}{\partial k^*} \neq 0$ and under the condition that $\frac{\partial F}{\partial k^*} > \frac{\partial F}{\partial h^*}\frac{\partial G}{\partial k^*}$, the $\mathbf{J}_{k^*,h^*} > 0$. By these proves, it ensures that these functions F and G are mapped well to all values of parameters at fixed point which implies that the implicit function theorem gives us the sufficient conditions for the local uniqueness of the solutions to the system and its continuity dependence on the parameter values.[12] □

Proof (2). To proof the second part of the Proposition 1, the stability of the equilibrium solutions at steady state, we need to further calculate the eigenvalues of the Jacobian matrix, $\mathbf{J}_{k^*,h^*}$. To calculate for the eigenvalues of the Jacobian matrix, we need to know the trace of the Jacobian matrix (T) and the determinant of the Jacobian matrix (D). The system is "stable" if both eigenvalues have the real part less than 0, a "source" if both modulus are greater than 0, and a "saddle" if one eigenvalue is less than 0 and another is greater than 0. Define $|J|$ as determinant of matrix J and T_J is trace of matrix J. According to the first part of the proof of the Proposition 1, the determinant $|\mathbf{J}_{k^*,h^*}|$ is non-zero and $T_J = \frac{\partial f}{\partial k} + (1+n)(1+g) - (1-\mu)$. To calculate the eigenvalues of matrix J, we first define the eigenvalues problems as $J \times v = \lambda \times v$. In this equation J is an $n \times n$ matrix, v is a non-zero $n \times 1$ vector and λ is a scalar (which can be either real or complex number). Any value of λ for which this equation has a solution is known as an eigenvalue of the matrix J. It is sometimes also called the characteristic value. The vector v which corresponds to this value is called an eigenvector. The eigenvalue problem can be rewritten as follows:

[12]More on the implicit function theorem, see the Appendix G.

$$J \times v - \lambda \times v = 0$$

$$J \times v - \lambda I \times v = 0$$

$$(J - \lambda I) \times v = 0$$

If v is non-zero, this equation will only have a solution if $|J - \lambda I| = 0$. With different values of parameters entering the model ran by *Dynare*, we obtain both of the real parts of the modulus of eigenvalues in the opposite sign. This means that the system could be "saddle". However, the system provides one eigenvalue which is larger than one in the modulus and it has one forward-looking variable: h^* (health-related human capital). Therefore, the unique stable solution of the system at the steady state does exist, and the equilibrium solution is locally determined.

□

The Proposition 1 has partially similar results as the paper by Matsuyama [2008]. That is, in the model with exogenous retirement and labour force participation of the elderly is mapped to a constant value over time, the economy converges to the unique steady state. Additionally, we find that the persistence of growth dynamics depend not only on the share of capital income and time preference discount factor but also on the factors related to the choices of the elderly labour force participation. The steady state of physical capital will be decreased or increased depends on the trade-off between positive externalities from supportive government regulations in affecting the health-related human capital of the elderly and the costs of working after the retirement of the old-age person. In term of policy recommendation, the government has to balance these old-age supportive policies and the savings incentives of the young generations since the young workers are the ones who finance those supportive policies for the elderly to enter the labour market.

3.5 Factors Affecting Elderly Labour Supply and Economic Growth

This section analyses the comparative static of factors determining elderly labour supply and how they affect physical capital and health-related human capital in the steady state.

3.5.1 Costs of Working After Retirement Age

Proposition 2. *A change in the costs of working after statutory retirement positively affects changes in physical capital and health-related human capital accumulation in the steady state*

as follows:
$\frac{\partial k^*}{\partial \bar{\gamma}} > 0$ *and* $\frac{\partial h^*}{\partial \bar{\gamma}} > 0$.

Proof. See the Appendix H. □

The intuitions of these results are that higher costs of working after statutory retirement age induce individuals to save more and be likely to invest more on their health when they were young. As savings increase, the accumulation of the physical capital and health-related human capital also increase in the steady state. Moreover, an increase in the costs of working after retirement age makes elderly labour force participation rate lower since most of the elderly will drop out of the labour market once their health stock is lower than the threshold level, Equation (3.8). Lower supply of labour generates higher wage rate. If we assume an increasing savings function, as income increases, savings also increase in the same direction, thus, more capital stock accumulation in the steady state.

3.5.2 Positive Externalities of Government Regulations

Let us assume the solutions of implicit differentiations of steady state physical capital and health-related human capital with respect to the positive externalities of supportive government regulations as follows:

Assumption 3. $\left[\frac{1}{\alpha} h^{*\frac{1}{\alpha}} (\theta - \frac{\sigma}{2})^{\frac{-(1+\alpha)}{\alpha}}\right] + \left[\frac{1}{1-\alpha} A^{\frac{\alpha}{1-\alpha}} B^{\frac{-1}{1-\alpha}} \frac{\alpha\beta\sigma}{2\theta^3}\left[1 - \left(\frac{\bar{\gamma}}{(1-\alpha)\theta}\right)^2\right]\right] > \left[A^{\frac{1}{1-\alpha}} B^{\frac{-(2-\alpha)}{1-\alpha}} k^{*\alpha}\right]$.

Assumption 4. $\left[A^{\frac{\alpha}{1-\alpha}} B^{\frac{-\alpha}{1-\alpha}}\right] + \left[A^{\frac{-(1-2\alpha)}{1-\alpha}} B^{\frac{-\alpha}{1-\alpha}} (\theta - \frac{\sigma}{2}) \frac{\alpha^2\beta}{1-\alpha}\left(\frac{\sigma}{2\theta^3} - \frac{\sigma\bar{\gamma}^2}{2(1-\alpha)^2\theta^3}\right)\right] > \left[A^{\frac{\alpha}{1-\alpha}} B^{\frac{-1}{1-\alpha}} (\theta - \frac{\sigma}{2}) \alpha k^{*\alpha}\right]$.

where $A = \alpha\beta\left[(1-\alpha) - \frac{\sigma}{4}[(\frac{1}{\theta})^2 - (\frac{\bar{\gamma}}{(1-\alpha)\theta})^2]\right]$ and $B = \alpha(1+\beta) - \bar{\gamma} + (1-\alpha)(\theta - \frac{\sigma}{2})k^{*\alpha}$.

Proposition 3. *Given that the Assumptions 3 and 4 hold, a change in the positive externalities from elderly supportive government regulations affects changes in physical capital and health-related human capital accumulation in the steady state as follows:*
$\frac{\partial k^*}{\partial \theta} < 0$, $\frac{\partial h^*}{\partial \theta} > 0$.

Proof. When the Assumption 3 holds, it assures that $F_\theta = \oplus$. Together with the proof from the Proposition 1, which provides the result of $F_{k^*} = \oplus$, the implicit function theorem implies that $\frac{\partial k^*}{\partial \theta} = -\frac{F_\theta}{F_k^*} < 0$. An increase in the positive externalities from government regulations supports the elderly labour force participation but reduces the physical capital stock in the steady state.

Next, the Assumption 4 and the proof of the Proposition 1 must be hold in order to ensure that $G_\theta = \ominus$. Since we know from the Proposition 1. that $G_h^* > 0$. Therefore, $\frac{\partial h^*}{\partial \theta} > 0$ if and only if the Assumption 4 holds. So that an increase in the positive externalities from government regulations supports the elderly labour force participation and helps to improve health-related human capital stock in the steady state. See more detail on the proof of this proposition in the Appendix H. □

An increase in the proportion of positive externalities, θ, encourages higher health-related human capital stock in the steady-state. The intuition is that with higher positive externalities, an increase in one more unit of supportive government policies, aggregate health stock of the economy will be increased higher by the positive externalities. This also implies that an increase in one more unit of taxes paid by the young generates higher positive effects on the elderly labour force participation. However, higher positive externalities crowd-out the agent's incentive to save and thus, lower the physical capital stock in the steady state.

3.5.3 Costs of Providing Government Regulations

For the comparative static of the costs of providing government regulations, we also assume the following assumptions.

Assumption 5. $\left[\frac{1}{2\alpha}h^{*\frac{1}{\alpha}}(\theta-\frac{\sigma}{2})^{\frac{-(1+\alpha)}{\alpha}}\right]+\left[\frac{1}{1-\alpha}A^{\frac{\alpha}{1-\alpha}}B^{\frac{-1}{1-\alpha}}\frac{\alpha\beta}{4\theta^2}\left[1-\left(\frac{\bar{\gamma}}{(1-\alpha)\theta}\right)^2\right]\right] < \left[A^{\frac{1}{1-\alpha}}B^{\frac{-(2-\alpha)}{1-\alpha}}\frac{1}{2}k^{*\alpha}\right]$.

Assumption 6. $\left[\frac{1}{2}A^{\frac{\alpha}{1-\alpha}}B^{\frac{-\alpha}{1-\alpha}}\right]+\left[A^{\frac{-(1-2\alpha)}{1-\alpha}}B^{\frac{-\alpha}{1-\alpha}}(\theta-\frac{\sigma}{2})\frac{\alpha^2\beta}{1-\alpha}\left(\frac{1}{4\theta^2}+\frac{\bar{\gamma}^2}{4\theta^2(1-\alpha)^2}\right)\right] > \left[A^{\frac{\alpha}{1-\alpha}}B^{\frac{-1}{1-\alpha}}(\theta-\frac{\sigma}{2})\frac{\alpha}{2}k^{*\alpha}\right]$.

where $A=\alpha\beta\left[(1-\alpha)-\frac{\sigma}{4}[(\frac{1}{\theta})^2-(\frac{\bar{\gamma}}{(1-\alpha)\theta})^2]\right]$ and $B=\alpha(1+\beta)-\bar{\gamma}+(1-\alpha)(\theta-\frac{\sigma}{2})k^{*\alpha}$.

Proposition 4. *Given that the Assumptions 5 and 6 hold, a change in the costs of providing elderly supportive government regulations affects changes in physical capital and health-related human capital accumulation in the steady state as follows:*
$\frac{\partial k^*}{\partial\sigma}>0$, $\frac{\partial h^*}{\partial\sigma}<0$.

Proof. By saying that the Assumptions 5 and 6 hold, $F_\sigma<0$ and $G_\sigma>0$. Together with the proof of the Proposition 1, it shows that $\frac{\partial k^*}{\partial\sigma}=-\frac{F_\sigma}{F_{k^*}}=-\frac{\ominus}{\oplus}=\oplus$ which means higher costs of providing elderly supportive government policies increases the physical capital stock in steady state. On the other hand, $\frac{\partial h^*}{\partial\sigma}=-\frac{G_\sigma}{G_{h^*}}=-\frac{\oplus}{\oplus}=\ominus$, implies health-related human capital is reduced due to higher costs of providing supportive government policies. See more detail of the proof in the Appendix H. □

The proves using the implicit function theorem suggest that the higher the costs of providing elderly supportive government regulations, σ, the higher the capital stock accumulation in the steady state. However, a higher costs of providing supportive government policies reduces the accumulation of health-related human capital stock. Since the costs of providing one more unit of supportive government policies are higher, marginal benefits of implementing supportive government regulations reduce and result in a reduction of health-related human capital stock.

3.6 Numerical Exercises and Results Discussion

In this section, we calibrate the model based on the OECD data in order to examine quantitatively the effects of change in old age government policies parameters on physical capital and health-related human capital of the economy in the steady state. All parameters are chosen to match the previous literature or calibrations related to the growth model.

For the production function and firms related parameters, the model uses value of parameters from the standard growth model literature. Production function's parameters follow the classical Cobb-Douglas production function where the share of capital income, α, lies between 20-30 per cent of total output. This chapter uses the standard capital income share at 0.3. For the share of human capital income, it takes the value of 0.3. The rates of physical and human capital depreciation, we employ the values of $1-(1-0.10)^T$, where T is the number of period economy run in the OLG model. In the simulation, we presume that $T = 50$. This means that the depreciation rates are approximately 0.99. The population growth rate, n, is the average OECD population growth between 1900 and 2017, obtained from the United Nation database, takes the value of around 1 per cent. Since there is no literature on values of the parameter for the costs of working after retirement age as a percentage of output level, $\bar{\gamma}$. The value of 0.001 is chosen to match the steady state equilibrium.

In term of government policies to support health-related human capital of the elderly, this chapter employs the data of public expenditure (cash benefits for the elderly) as a percentage of GDP. The data shows that over the past few decades, cash benefits for the elderly lies between 6-8 per cent of GDP for the aggregate OECD countries. This chapter, therefore, takes the value of 0.06 for the costs of managing government regulations (as a percentage of GDP), σ. For the positive externalities from government policies, θ, which supports older-age health-related human capital, this chapter chooses the value of 0.07 which implies that positive externalities from government policies is outweighed the costs.

We, then, present the simulation results from the model using *Dynare* in the following part. We capture how elderly labour supply related variables affect the dynamics of level of output, capital stock, consumption level, health stock, and lump-sum tax rate at the new steady state. To simulate the model, the parameters entering the model are calibrated as in Table 3.1.

Traditional impacts of the shortage of working age population on economic growth are that

Table 3.1
Value of Parameters Entering Model Simulation

Variable	Sign	Value	Reference
Physical capital income share	α	0.3	Stokey and Rebelo [1995]
Discount factor or Time preference	β	0.99	Chu and Cozzi [2011]
Physical capital depreciation rate	δ	$1-(1-0.10)^T$	Stokey and Rebelo [1995]
Human capital depreciation rate	μ	$1-(1-0.10)^T$	Stokey and Rebelo [1995]
Costs of working after retirement age	$\bar{\gamma}$	0.001	
Proportion of positive externalities of government regulations (as percentage of GDP)	θ	0.07	
Costs of managing government regulations (as percentage of GDP)	σ	0.06	OECD

Source: Author's own construction.
Notes: Table presents parameters' values enter into the model for calibration of the baseline model.

there will be more capital intensity which reduces the rate of return on capital and raises the wage rate up. This chapter argues that it also depends on the elderly labour supply choices which trade-off between their health status and the costs of working after their retirement age.

3.6.1 The Effects of an Increase in Costs of Working after Retirement

Our first experiment is to increase the costs of working after retirement age from 0.1 per cent to 1 per cent of the level of GDP. Figure 3.5 presents the dynamics pattern affected by a change in the costs of working after retirement age. It shows that an increase in the costs of working after retirement increases the threshold for the elderly to decide whether or not to participate in the labour market.

The threshold is increased from 0.02 to 0.2[13] which implies higher barrier for the elderly to enter or stay in the labour market. Individuals may anticipate this situation and have invested more in their health stock since they were young as we can see from higher health-related human capital stock of the economy in Panel (c). However, higher costs of working after retirement influence the elderly to drop out of the labour market. Wage rate is increased due to less labour supply which induces higher savings [see Panels (h) and (f)]. An increase in savings boosts higher physical capital stock per effective labour, thus lowering marginal products of capital (rental rate). Higher physical capital stock and health-related human

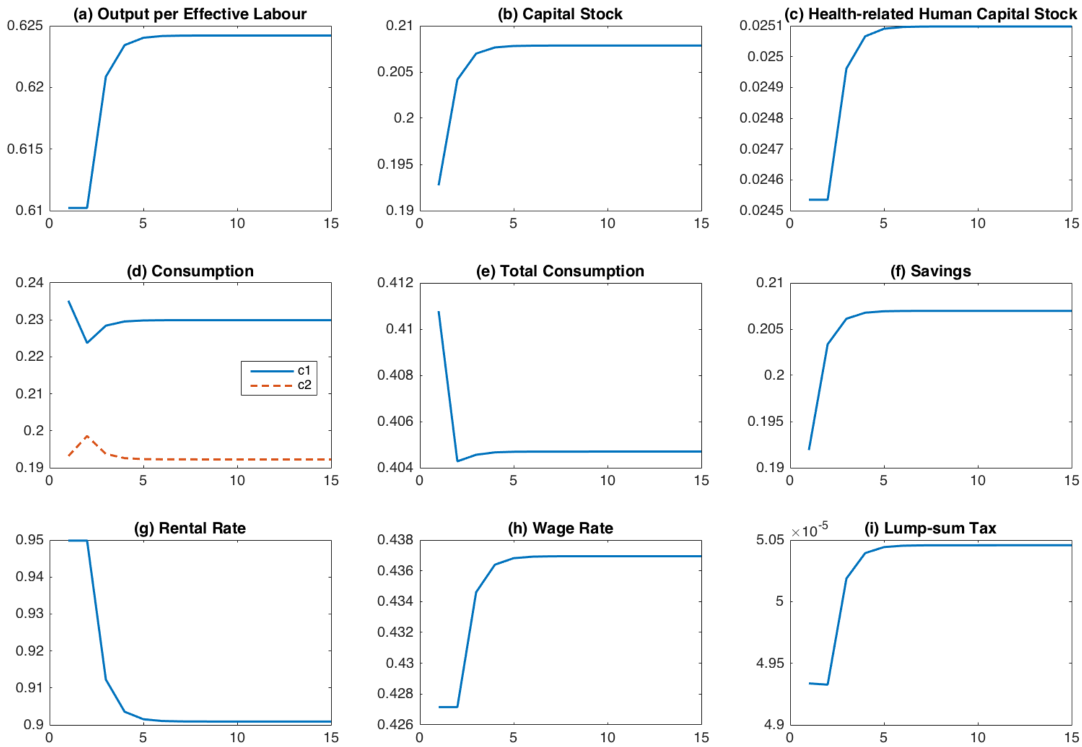
[13]The threshold can be calculated by $\bar{z} = \frac{\bar{\gamma}}{(1-\alpha)\theta}$.

capital stock generate higher output level in the new steady state [see Panel (a)].

Turning to look at the household's consumption allocation in Panel (d), the consumption level of the elderly increase from 0.19 to 0.2 in the first two periods, then slowly decrease and converge back to the point below the initial steady state. This is due to less elderly can participate in the labour market. So, their incomes are lower which implies lower level of consumptions.

We also observe a tiny increase in the lump-sum taxes as in Panel (i). Since promoting elderly labour force participation needs more funds financed by the young, lump-sum taxes are slightly increased and that reduce the consumption level of the young population. This makes their consumption level converges to the lower level than its initial steady state. The total lifetime consumption level is decreased to the lower level than the initial steady state as it depicts in Panel (e).

Fig. 3.5. The Effects of an Increase in Costs of Working After Retirement Age ($\bar{\gamma}$)



Source: Author's own calculation.

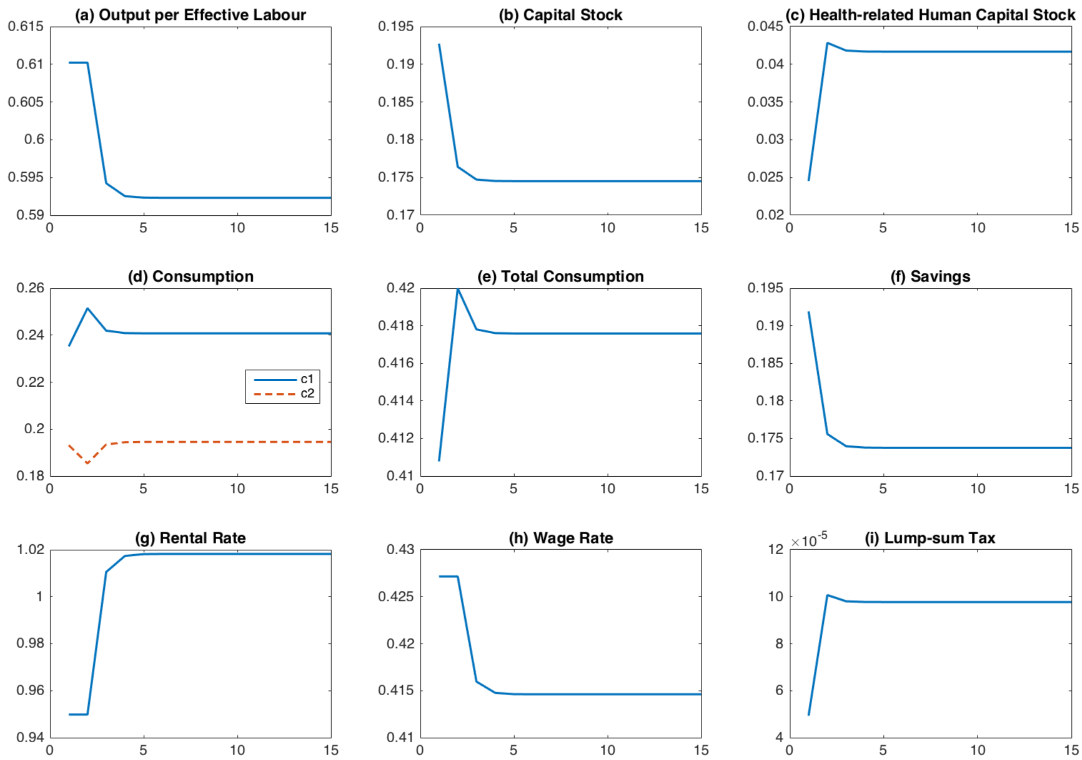
Notes: Figure presents the dynamics pattern of macroeconomic variables affected by a change in the costs of working after retirement age from 0.1 per cent to 1 per cent of the level of GDP. Note that in panel (c) health-related human capital indicates the health stock of the whole economy. $c1$ and $c2$ in panel (d) denote consumption level of the young worker and consumption level of the elderly, respectively. The outputs are obtained from MATLAB and DYNARE.

Overall the effects of an increase in the costs of working after retirement age induce the individuals to save more and generate a higher output per capita in the new steady state.

3.6.2 The Effects of an Increase in Positive Externalities from Government Regulations

Figure 3.6 presents the dynamics pattern affected by an increase in the positive externalities of the supportive government policies from 7 per cent to 10 per cent of the level of GDP. Since the sign of changes in the positive externalities of government policies on capital stock in steady state depend also on additional assumptions when we analytically prove, we test the numerical experiments to robustly strengthen the Proposition 3.

Fig. 3.6. The Effects of an Increase in Positive Externalities from Government Regulations (θ)



Source: Author's own calculation.
Notes: Figure presents the dynamics pattern of macroeconomic variables affected by a change in the positive externalities due to supportive government policies from 7 per cent to 10 per cent of the level of GDP. Note that in panel (c) health-related human capital indicates the health stock of the whole economy. $c1$ and $c2$ in panel (d) denote consumption level of the young worker and consumption level of the elderly, respectively. The outputs are obtained from MATLAB and DYNARE.

Figure (3.6) shows that an increase in the positive externalities due to supportive government regulations has several effects as follows:

Firstly, an increase in the positive externalities due to supportive government policies promotes a noticeable higher health-related human capital stock of the elderly and economy as a whole as it depicts in the Panel (c). A sharp rise in health-related human capital starts from period 1 to period 2, then, slightly drops. From period 5, it converges to the level which is higher than the initial steady state. Figure 3.6, Panel (i), shows direction of the lump-sum taxes as similar as health-related human capital. Higher positive externalities from the elderly supportive government policies raise the lump-sum taxes to the young workers. The interesting point is that although the lump-sum taxes are higher, the consumption level of the young is increased at the beginning, then slightly moved down, but to a higher level than an initial point as it portrays in Panel (d). The reason is that a higher marginal benefit of implementing supportive government regulations, one more unit of tax paid to the government can create more additional values to the elderly health stock. Therefore, we observe a decline in the old consumption level first, then, lifting up to a higher level due to the effects of higher positive externalities from the elderly positive government regulations. The overall consumption level of the individual is depicted in Panel (e) and shows a sharp increase of about 0.1 per cent. Although it converges down, the level is higher than the initial steady state.

Secondly, it helps to decrease the threshold for the elderly to enter the labour market which allows more elderly to continue working after retirement age. An increase in the labour force participation of the elderly induces more supply of labour in the labour market, which drags the wage rate down for both the young and old working population [see Panel (h)]. Lower income results in fewer savings and fewer investments as it is shown in Panel (f). This leads to lower capital stock and level of output in the new steady state, Panels (a) and (b).

Not only an increase in the supportive government policies for the elderly affects negatively on physical capital stock, social securities retirement regimes or generosity pension regimes also reduce the savings incentive of the household. Feldstein [1974] finds that social securities for retirement age suppress savings incentive of the American by 30 to 50 per cent.

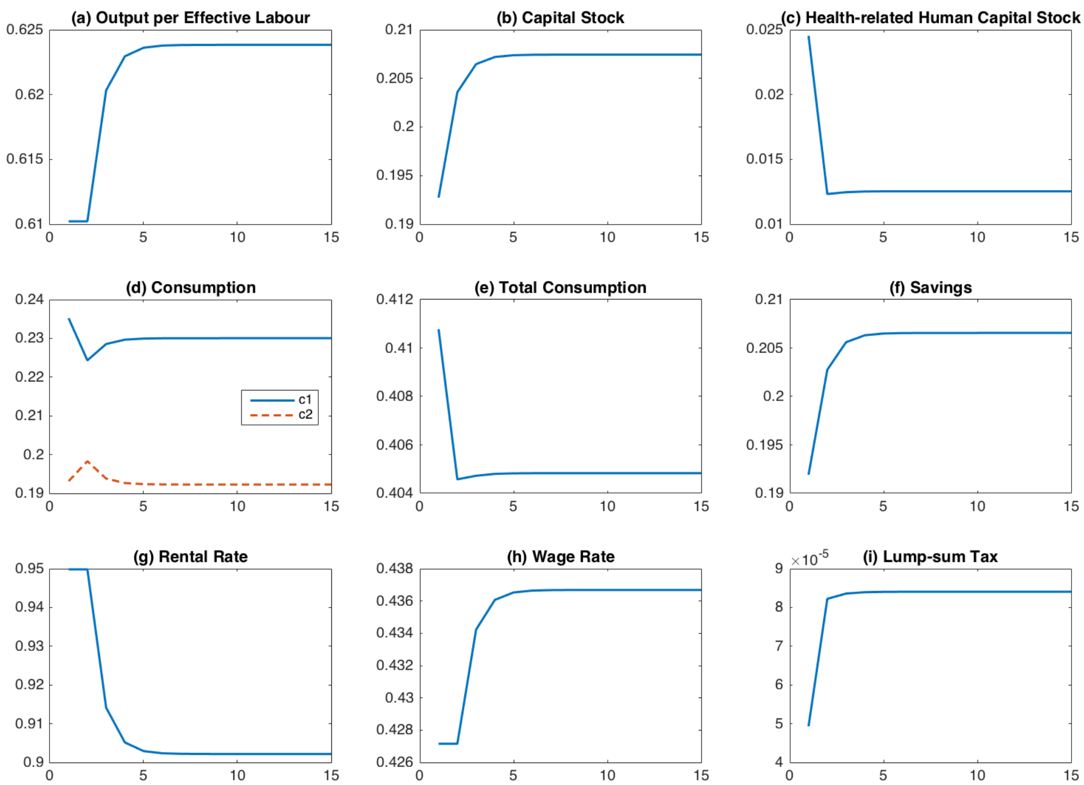
Moreover, the fact that the threshold for the elderly to enter or stay in the job market is lower also reduces an incentive of an individual to save when they were young since they anticipate the opportunity to work after retirement. A decrease in saving incentive reduces the capital accumulation and, therefore, lowering the level of output per effective worker in the new steady state. We, therefore, observe a dramatic decrease in the savings about 9 per cent from the initial steady state.

The overall effects of an increase in the positive externalities from the government supportive policies degenerate the incentive to save and lowering the capital stock in the new steady state which implies a declining of the level of output per effective worker in the new steady state.

3.6.3 The Effects of an Increase in Costs of Providing Government Regulations to Support The Elderly

The next numerical experiment is that we increase the costs of providing the elderly with supportive government policies from 6 per cent to 10 per cent of the level of GDP. Since the sign of changes in the costs of providing government policies on capital stock in steady state depend also on additional assumptions when we analytically prove, we test the numerical experiments to robustly strengthen the Proposition 4.

Fig. 3.7. The Effects of an Increase in Costs of Providing Government Regulations to Support The Elderly (σ)



Source: Author's own calculation.
Notes: Figure presents the dynamics pattern of macroeconomic variables affected by a change in the costs of providing the elderly supportive government policies or regulations from 6 per cent to 10 per cent of the level of GDP. Note that in panel (c) health-related human capital indicates the health stock of the whole economy. $c1$ and $c2$ in panel (d) denote consumption level of the young worker and consumption level of the elderly, respectively. The outputs are obtained from MATLAB and DYNARE.

Figure 3.7 illustrates the dynamics pattern of macroeconomic variables affected by a change in the costs of providing the elderly supportive government policies. Firstly, we observe that an increase in the costs of providing supportive government regulations reduces the health-related human capital stock in the new steady state as it depicts in Panel (c). Since the costs of providing one more unit of supportive policies are higher, the marginal benefits of implementing supportive government regulations reduce and result in a reduction of health-related human capital stock. To enhance the participation of the elderly in the labour market, the government has to finance more in the elderly supportive programs which induce a higher lump-sum taxes paid by the young, see Panel (i). When we compare to the previous case, an increase in the positive externalities of government policies, we can see that once the government decides to implement the elderly supportive regime, the lump-sum taxes to the young worker are always increased. However, unlike a higher positive externalities' case, an increase in the costs of providing government policies does not boost the health stock of the elderly, see Panel (c). Fewer elderly access to the labour market, while the young pay more taxes. The consumption level of both the old and the young, depict in Panel (d), are lower than the initial steady state. The total consumption of the whole economy is dramatically decreased by about 0.5 basis points as illustrates in Panel (e).

Another point is that the labour supply of the economy is reduced due to lowering participation rate of the elderly. This raises the real wage rate up, see Panel (h). Higher income induces more savings, thus investments in new physical capital stock. Together with the incentives of young workers to save more, since they anticipate that the higher costs of providing supportive government policies for the elderly implies a lower rate of elderly labour force participation. The young may not be able to work when they become old. Thus, they have more incentive to save as it depicts in Panel (f). The more savings coincides with the more physical capital accumulation, thus raises the level of output per effective worker as they are shown in Panels (a) and (b), respectively.

In summary, the higher costs of providing supportive government policies to support elderly health conditions increases an incentive of individuals to save more, which helps to generate more physical capital stock and level of output in the new steady state, although household's consumption level is reduced.

This chapter points out the importance of the effects of the government regulations on the elderly health-related human capital conditions and elderly labour supply. Then, we show how changes in policies affect long-term economic growth using a very simple neoclassical OLG model. We find that the elderly, in this perfect foresight model, anticipate and the trade-off between their health-related human capital and the benefits from supportive government regulations before choosing to continue working after their retirement age. A higher health-related human capital of the elderly keeps the elderly to stay longer in the labour market, but it is clear that such policies also increase the financial burden to the young passing through higher tax payments. The policymakers, therefore, need to balance between the positive benefits from keeping the elderly in the labour market and a reduction in the utility and consumption level of the young in order to maintain sustainable growth at the time where the country moves towards ageing society.

3.7 Conclusion

Over the past few decades, many parts of the world have experienced a shift in demographic structure towards an ageing society. This phenomenon raises many issues such as sustainability of the pension system, shortage of labour, health care expenditure and most of all, economic growth slows down. This chapter focuses only on the issue of labour shortage due to a shift in the demographic transition towards ageing society since labour is one of the most important factors of inputs to boost economic growth.

While we are pressured with the impacts of a shrink of the working-age population, the data from many OECD countries capture the gradual increase in the older-age labour force participation since the 1990s. Therefore, this chapter investigates theoretically the elderly choices of working after the retirement age and their effects on economic growth. We analyse the research question by using the neoclassical two-period overlapping generation model which the elderly can choose to either continue providing their labour supply after retirement or leave the labour market. The elderly decisions depend on the trade-off between the elderly costs of working after retirement and their health-related human capital.

Many researchers agree that health is one of the most important factors to encourage longer labour force participation, especially to the older age. Our model extends the traditional literature by allowing the health-related human capital stock of the elderly can be augmented by positive externalities from supportive government regulations. The main contribution of this chapter to the literature is that we introduce the role of government policies or regulations to generate positive effects on the elderly health stock. Then, we study the impacts of supportive government policies and the health status of the elderly in affecting economic growth.

At the equilibrium, our model provides unique and stable solutions of the dynamics system at the steady-state which are locally determined. The results from the comparative statics analysis show that the persistence of growth dynamics depend on not only the share of capital income, but also factors related to the choices of elderly labour force participation, for example, the costs of working after the retirement age of the elderly and health-related human capital stock of the elderly.

The results from the model suggest that the elderly supportive government policies play an important role in lifetime households' decisions. Higher positive externalities from supportive government policies or regulations to the elderly, e.g. improving elderly health care services, re-organising the residential area for the elderly or any training programs for the older-age, allowing the elderly to participate more in the labour market. However, it reduces the household's income by adding lump-sum taxes to the young working-age population. Together with the reduction in the incentive of the household to save when they were young since they anticipate to work when they become old. Lower net savings deplete the accumulation of capital which is the engine for economic growth. On the other hand, higher costs of working after retirement and higher costs of providing supportive government policies raise anticipated individuals' savings incentive to be higher and generate higher level of output per capita in the new steady state.

Therefore, policymakers need to consider both aspects of the supportive government policies and elderly costs of working after retirement in order to promote elderly labour supply policies which are effective, fair and equal intergenerational distribution and generate sustainable growth in the long-run.

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Appendices

First Chapter Appendices

A Data Description

We use unbalanced panel data of 63 developing countries from 1980 to 2013 for our empirical study. Developing countries in our sample are low and medium income countries classified by the World Development Indicator.[1]

Cyclical of Fiscal Policy

The main dependent variable is cyclical of fiscal policy which is measured by Government Spending Gap. Government spending gap is the percentage difference of actual real government final consumption per capita from its trend component which we calculate by using Hodrick-Prescott filtered with $\lambda = 1600$.

Business Cycle

Our main independent variables are **business cycle**. We use Output Gap as an indicator for the business cycle and it is calculated by the cyclical component of the output per capita. Its trend component is calculated by using Hodrick-Prescott filtered with $\lambda = 1600$. Both real GDP per capita and real government final consumption per capita dataset are provided by the World Development Indicators (WDI) and we transform it into logarithmic form before calculating trend and a cyclical component, respectively.

Democracy Index

Democracy is defined by minimalistic definition: countries which hold fair and free elections are considered to be the democratic regime. It measured by Democracy index from the POLITY IV project. It ranges from -10 to 10. -10 to -6 indicates "Autocracy", whereas a score between +6 and +10 indicates "Democracy". Countries score between -5 and +5 are measured as "Anocracy", i.e. neither democratic nor autocratic political systems. These political system indices are supported by key measurements of the quality of executive recruitment, the constraints on executive authority, political competition, and the institutionalised qualities of governing authority [Marshall and Jaggers, 2002]. We add 10 to all democracy values for easier interpretation. So, the democracy scores currently lie between 0 to 20. The dummy variable for democracy is equal to 1 if the score is higher than or equal to 16, otherwise, it is classified into the non-democratic regime.

Institutional Quality

An institutional quality definition is widely discussed among social scientists; however, there is no clear cut what exactly the meaning of institutional quality. This article follows the definition of institutional quality or governance from [Kaufmann, Kraay and Mastruzzi, 2009] and adopt the institutional quality indicators from the Worldwide Governance Indicators (WGI). Institutional quality is defined as "the traditions and institutions by which authorities in countries are exercise'": Firstly, the process by which government are selected, monitored and replaced (Voice and

[1]The term "developing countries" are mostly replaced by "developing economies" since many indicators of developing countries which related to well being, e.g. birth rate, mortality rate, life expectancy and etc, have been well developed over the past few decades. This chapter uses the term developing country as it means developing economies.

accountability and Political stability indices). Secondly, the capacity of the government to effectively formulate and implement sound policies (Government effectiveness and Regulatory quality indices). Thirdly, the respect of citizens and the state for institutions that govern economic and social interactions among them (Rule of law and Control of Corruption indices). The indices reflect 6 dimensions of institutional quality and capture 3 mains points as explained above. They are constructed by surveying the perception towards an institutional quality of related groups from all household, business, public sector, non-profit organisations worldwide. The indices are provided in percentile rank from 0 to 100. Higher percentile rank indicates better institutions. We transform it into logarithmic form to capture institutions quality of the countries at the same level. The indices are provided for the years 1996, 1998, 2000 and 2002-2013.

Maturity of Democracy

The maturity of democracy is constructed by using democracy indices and the Legislative and Executive Indices of Electoral Competition dataset (LIEC and EIEC) from the Political Institutions Database, as it was suggested by Keefer [2007] and Beck et al. [2001]. The Legislative and Executive Indices of Electoral Competition range between 1 to 7. The higher the score is, the more the presence of competitive elections. For example, the countries which have more than one party in the central election, but only one party can win would be scored 4. Then, we match these indices to the democracy indices from POLITY IV project. The dummy variable for maturity of democracy is equal to 1 if their democracy indices score higher than or equal to 16 and LIEC and EIEC score more than 4 for 1-10 (for 10 years dummy), 11-20 (for 20 years dummy), more than 21 (for 30 years dummy) consecutive years, respectively, otherwise, it equals zero.

Trade Openness

Trade openness is measured by the ratio of exports plus imports of goods and services as a share of GDP, a standard measure of the degree of trade openness of each country. The data is taken from the World Development Indicators (WDI).

Financial Openness

We adopt the Chinn and Ito [2008] financial openness indices. The indices are constructed based on the binary dummy variables coded by the IMF's Annual Report on Exchange Arrangements and Exchange Restrictions (AREAER). The binary dummy variables cover 4 main restrictions on the external accounts which indicate the presence of multiple exchange rates, the restrictions on current account transactions, the restrictions on capital account transactions and the requirement of the surrender of export proceeds. These indices consider the extent of cross-border financial transactions. they lie between 0 and 1, score 0 means completely closed financial markets and 1 is the highest degree of financial openness.

List of Sample Countries

Our data used for the analysis is unbalanced panel data of 63 developing countries during 1980 to 2014 as it is presented in the Table 2.

Table 2
List of Sample Countries

Country Name	Year Begin	Year End
Albania	1996	2014
Algeria	1980	2014
Armenia	1991	2014
Bangladesh	1980	2014
Belarus	1991	2014
Azerbaijan	1992	2012
Bhutan	2000	2014
Bolivia	1980	2014

Botswana	1980	2014
Bulgaria	1980	2014
Brazil	1980	2014
Cameroon	1980	2014
Colombia	1980	2014
China	1980	2014
Congo	1980	2014
Costa Rica	1980	2014
Dominican Republic	1980	2014
Cuba	1980	2013
Ecuador	1980	2014
Egypt	1980	2014
El Salvador	1980	2014
Gabon	1980	2014
Georgia	1994	2014
Guatemala	1980	2014
Honduras	1980	2014
Indonesia	1980	2014
India	1980	2014
Iran	1980	2014
Jordan	1980	2014
Kazakhstan	1992	2014
Kenya	1980	2014
Kyrgyz Republic	1992	2014
Lao PDR	2000	2014
Lesotho	1980	2013
Lebanon	1994	2014
Macedonia	1990	2014
Malaysia	1980	2014
Mauritania	1980	2014
Mauritius	1980	2014
Mexico	1980	2014
Moldova	1992	2014
Montenegro	2006	2014
Morocco	1980	2014
Namibia	1990	2014
Nicaragua	1980	2014
Pakistan	1980	2014
Nigeria	1981	2014
Panama	1980	2014
Paraguay	1991	2014
Philippines	1980	2014
Peru	1980	2014
Romania	1990	2014
Serbia	2006	2014
South Africa	1980	2014
Sudan	1980	2011
Swaziland	1980	2011
Tajikistan	1993	2013

Thailand	1980	2014
Tunisia	1980	2013
Turkey	1987	2014
Ukraine	1991	2014
Vietnam	1994	2014

Source: Author's calculation
Notes: Table shows the list of countries and range of year of the observations. In total, there are 63 countries from 1980 to 2013.
Table 3 presents the summary statistic of key variables used for the analysis of the effects of maturity of democracy regime on fiscal policy cyclicality and also for the analysis when we allow democracy to be endogenoised.

Table 3
Summary Statistics of Key Variables for Endogenised Democracy

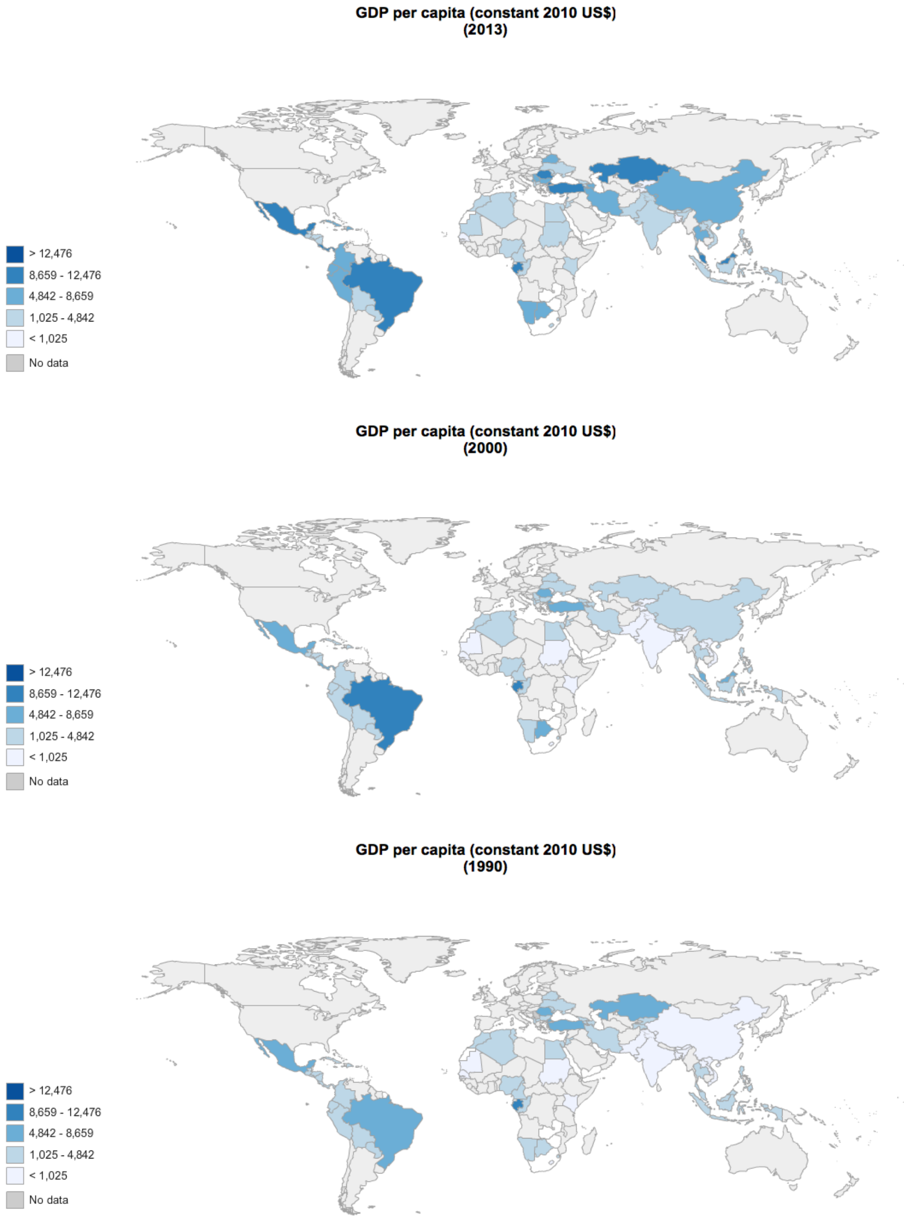
Variable	Mean	Std. Dev.	Min.	Max.	N
Output Gap	-0.001	0.026	-0.193	0.206	1900
Government Spending Gap	-0.004	0.08	-1.405	0.598	1900
Trade Openness	1.821	0.244	1.045	2.343	1899
Financial Openness	0.373	0.317	0	1	1725
Total Factor Productivity Growth	0.877	2.18	-25.97	18.938	1135
Air Temperature (Celsius)	20.129	6.047	4.776	29.583	1393
Air Precipitation (100 s mm / year)	11.374	7.943	0.066	48.348	1393
Democracy Index	11.812	6.592	0	20	1900
Legislative Indices of Electoral Competition (LIEC)	5.97	1.745	1	7	1872
Executive Indices of Electoral Competition (EIEC)	5.524	1.981	1	7	1870
Number of Year in Democracy	5.754	8.431	0	35	1900
Control of Corruption	1.495	0.301	0.165	1.947	976
Government Effectiveness	1.57	0.239	0.591	1.939	976
Political Stability and Absence of Violence and Terrorism	1.426	0.362	-0.326	1.981	976
Regulatory	1.555	0.288	0.458	1.907	976
Rule of Law	1.493	0.265	0.379	1.92	976
Voice and Accountability	1.478	0.32	0.284	1.94	976
Average 6 Institutional Quality	1.503	0.23	0.603	1.884	976
Dummy_Asian	0.362	0.481	0	1	1900
Dummy_Subsaharan	0.369	0.483	0	1	1900
Dummy_LatinAmerica	0.269	0.444	0	1	1900
Dummy_YoungDemocracy	0.222	0.415	0	1	1900
Dummy_MiddleDemocracy	0.154	0.361	0	1	1900
Dummy_OldDemocracy	0.089	0.285	0	1	1900
Dummy_Colony	0.93	0.255	0	1	1900
Dummy_Settinginstitution	0.226	0.418	0	1	1900
Dummy_colonial_france	0.166	0.372	0	1	1900
Dummy_colonial_spain	0.269	0.444	0	1	1900
Dummy_colonial_uk	0.202	0.401	0	1	1900
Dummy_colonial_others	0.275	0.447	0	1	1900

Source: Author's own calculation.
Notes: The Average 6 institutional quality is the average value of 6 institutional quality indices: Control of Corruption, Government Effectiveness, Political Stability and Absence of Violence and Terrorism, Regulatory Quality, Rule of Law and Voice and Accountability.

Figure 8 illustrates the map of our sample countries which is classified by their income per capita in the year 1990, 2000 and 2013. The country which has GDP per capita higher than 12,476 USD constant to the year

2010 is considered to be advanced economies. According to Figure 8, our sample countries have not changed their economic status from developing to advanced economies over time, although their GDP per capita has been improved gradually.

Fig. 8. Economic Status Defined by GDP per Capita of Selected Sample Countries in Year 1990, 2000 and 2013



Source: Author's calculation
Notes: Graphics illustrate the GDP per capita of selected countries in year 1990, 2000 and 2013. The shades of blue colour represents how high level of income of the countries are. Our sample focuses on the developing economies by the definition of the World Bank.

B Methodology: Dynamic GMM Estimator

As we have already mentioned before that the OLS estimators raise up some econometric issues. This chapter thus adopts Panel data with Fixed Effect, Instrumental variable approach and the Dynamic GMM estimators as empirical strategies for our empirical analysis. This part will explain briefly the development of Dynamic GMM estimators which the author summarised from Baltagi [2008].[2]

Dynamic GMM was developed by Arellano and Bond [1991]. Their Dynamic GMM contains 2 stages of estimation: First-stage uses GLS (General Least Square) on First-differencing equation which are developed by Anderson and Hsiao [1981].[3] Then, they use the preliminary results from the first step to get consistent estimators in the second-stage [Baltagi, 2008].

Firstly, Anderson and Hsiao [1981] suggested to first-difference the model in order to get rid of time and country specific characteristic (μ_i and λ_t), and use $\Delta y_{i,t-2} = (y_{i,t-2} - y_{i,t-1})$ or $y_{i,t-2}$ as an IV for $\Delta y_{i,t-1} = (y_{i,t-1} - y_{i,t-2})$. This would be a good instrumental variable since it is not correlated to the difference of error term, $\Delta v_{i,t} = (v_{i,t} - v_{i,t-1})$, as long as $v_{i,t}$ does not have serial correlation with error term in other period.

However, although this method help reducing unbiased and inconsistency since we sweep the fixed effect and find IV for our lagged dependent variable, it is not efficiency. This is because there is no use of all available information of moment condition and the difference of the error term.

Arellano and Bond [1991] therefore additionally developed the two stages GMM estimators which performs GLS (General Least Square) on differencing equation developed first by Anderson and Hsiao [1981] and use the preliminary results from the first step to getting consistent estimators in the second stage as follows;

$$y_{i,t} = \delta_1 y_{i,t-1} + u_{i,t} \quad u_{i,t} = \mu_i + \lambda_t + v_{i,t}$$

While, $v_{i,t}$ and $\mu_i \sim iid(0, \sigma v^2$ and $\sigma\mu^2)$. Then, take the difference of the equation above and one will get,

$$y_{i,t-3} - y_{i,t-2} = (y_{i,t-2} - y_{i,t-1}) + (v_{i,t-3} - v_{i,t-2})$$

We could use $y_{i,t-1}$ as an IV for equation above. The information will be lost for two periods since it begins on a period of $T = 3$.

$$y_{i,t-4} - y_{i,t-3} = (y_{i,t-3} - y_{i,t-2}) + (v_{i,t-4} - v_{i,t-3})$$

Then, once again we could address $y_{i,t-2}$ as an IV for $(y_{i,t-3} - y_{i,t-2})$. When we continue doing this process, one would get the set of IV as follows;

$$\text{Set of instrumental Variable} = (y_{i,t-1}, y_{i,t-2}, ..., y_{i,T-2}); \quad t = 1, 2, ..., T$$

These set of IV will be included when performing first-stage GLS and get the unbiased and consistent estimator $\hat{\delta_1}$.

$$W'\Delta y = W'(\Delta y_{i,-1})\delta + W'\Delta V$$

$$\hat{\delta_1} = [(\Delta y_{i,-1})'W(W'(I_n \otimes G)W)^{-1}W'(\Delta y_{i,-1})]^{-1} \\ [(\Delta y_{i,-1})'W(W'(I_n \otimes G)W)^{-1}W'(\Delta y)]$$

[2]For more detail, please find out in Baltagi, Badi. Econometric analysis of panel data. Vol. 1. John Wiley and Sons, 2008.

[3]They do first-differencing to the model in order to get rid of time and country specific characteristics (μ_i and λ_t), and use lagged level of dependent variable with first-differencing $\Delta y_{i,t-1}$ as an IV for $\Delta y_{i,t-2} = (y_{i,t-2} - y_{i,t-1})$. Lagged dependent variable with first-differencing is considered to be a good instrumental variable since it is correlated to the first-difference of dependent variable, but it is not correlated to the first-difference of the error term, $\Delta v_{i,t} = (v_{i,t} - v_{i,t-1})$. As long as $v_{i,t}$ follows independent and identically distributed process (i.i.d.) in both cross-sectional i and time period t, which means that the error term is not serial correlated, then $\Delta y_{i,t-1}$ is good IV.

While W is the matrix of a set of IV. V represents a matrix of the error term. In order to optimise this estimator δ_1, Δv or $(I_n \otimes G)$ is replaced by differencing residuals obtained from the earlier stage $E[\Delta v, (\Delta v)']\sigma^2$. This part proofs that GMM estimator developed by Arellano and Bond [1991] has already used the information from differencing error term in the period before. This calculation of second-stage GMM estimators has been shown as follows;

$$\hat{\delta_2} = [(\Delta y_{i,-1})' W \hat{V} N^{-1} (W' \Delta y_{i,-1})]^{-1} [(\Delta y_{i,-1})' W \hat{V} N^{-1} (W' \Delta y)]$$

Where $V_N = \sum_{i=1}^{N} W_i' (\Delta v_i)(\Delta v_i)' W_i$. Even though our sample does not contain large N as usual panel data, this method still gives us a consistency estimator. Besides, GMM also designed for the situation when one has large N and fixed T data. The problem of large N and a few periods of T will be solved as N reaches ∞. Therefore, the GMM estimator is efficient, unbiased, and requires no knowledge concerning the initial condition or the distribution of v_i μ_i or λ_t.

In case there are some exogenous variables in the model, the difference model will also provide us with a set of IV of exogenous variables. Then, the set of IV (W) will be included when performing first-stage GLS and get the unbiased and consistent estimator $\hat{\delta_1}$ as follow.

$$W' \Delta y = W' (\Delta y_{i,-1}) \delta + W' (\Delta X) \beta + W' \Delta V$$

While X denotes the matrix of all exogenous variables in this model, and V is the matrix of the error term. We will then obtain the first stage estimator $\hat{\delta_1}$ and $\hat{\beta_1}$.

$$\begin{pmatrix} \hat{\delta_1} \\ \hat{\beta_1} \end{pmatrix}$$

$$= [(\Delta y_{i,-1}, \Delta X)' W \hat{V} N^{-1} (W' (I_n \otimes G) W)^{-1} W' (\Delta y_{i,-1} \Delta X)]^{-1}$$
$$[(\Delta y_{i,-1}, \Delta X)' W \hat{V} N^{-1} (W' (I_n \otimes G) W)^{-1} W' (\Delta y)]$$

Where, ΔX is the matrix of exogenous variables with $N(T-2)K$ dimension on $\Delta x_{i,t}$. Following equation illustrates the second-stage GMM estimators $\hat{\delta_2}$ and $\hat{\beta_2}$.

$$\begin{pmatrix} \hat{\delta_2} \\ \hat{\beta_2} \end{pmatrix}$$

$$= [(\Delta y_{i,-1}, \Delta X)' W (W' (I_n \otimes G) W)^{-1} W' (\Delta y_{i,-1} \Delta X)]^{-1}$$
$$[(\Delta y_{i,-1}, \Delta X)' W (W' (I_n \otimes G) W)^{-1} W' (\Delta y)]$$

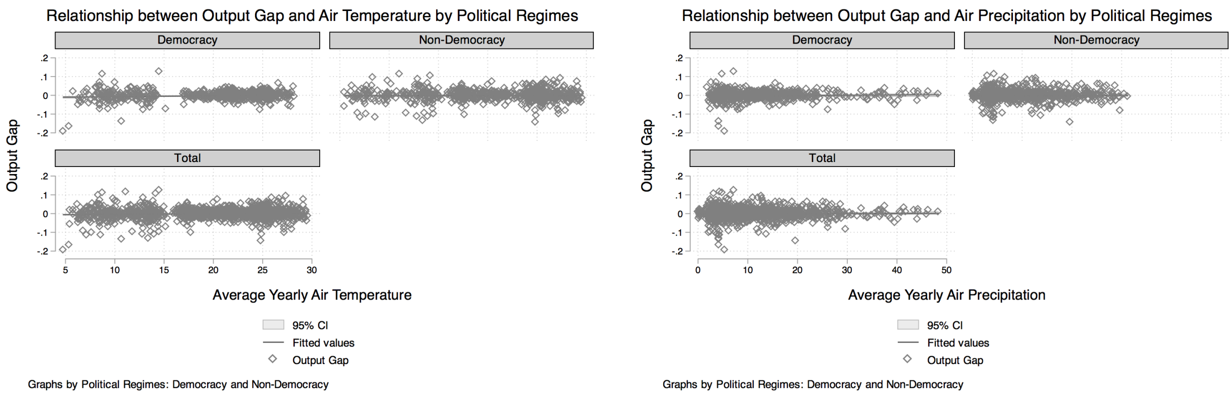
Then, we obtain unbiased, consistent, and efficient estimators. We adapt Dynamic GMM to our model specification as it is presented by the following equation;

$$\Delta G_{i,t} = \alpha + \beta_1 \Delta OutputGap_{i,t} + \beta_2 \Delta G_{i,t-1} + \beta_3 \Delta X'_{i,t} + u_{i,t}$$
$$u_{i,t} = \mu_i + \lambda_t + v_{i,t}$$
$$i = 1, 2, ..., 63 \quad t = 1, 2, ..., 33$$

Where $X'_{i,t}$ is the set of control variables. Coefficient β_1 measures the fiscal policy cyclicality of country i. It is expected to be positive when the country implements procyclical fiscal policy and to be negative when there is a presence of countercyclical fiscal policy.

C Additional Instrumental Variables: Air temperature and Air Precipitation

For robustness checks, we try other external instrumental variables such as Air temperature and Air Precipitation as instrumental variables for output gap. First, we consider the relationships between the output gap and air temperature and air precipitation, respectively, as they are presented by Figure 9.
There is a bunch of previous literature suggest strong relationship between temperature and economic performance e.g. Dell, Jones and Olken [2012], Nordhaus [2006], Sachs [2003], Dell, Jones and Olken [2009], Dell, Jones and Olken [2014] and etc. Dell, Jones and Olken [2012] study the relationship between historical air temperature and precipitation and economic growth. They document that an increase in 1 degree Celsius of air temperature reduces economic growth by 1.3 percentage point on average. Their results are quite strong, especially in low-income countries. We, therefore, adopt average air temperature and air precipitation dataset to implement in the model as IV for endogenous output gap.
Figures 9a and 9b illustrate the relationship between endogenous independent variable, output gap, and other two instrumental variables, yearly average air temperature and yearly average air precipitation (grey squares) by countries political regimes: democracy and non-democracy, and their fitted values (grey line). Figure 9a depicts the relationship between endogenous independent variable, output gap, and yearly average air temperature. Although we can see positively relationship between the output gap and average air temperature, the estimation is not significant. Average air temperature has no strong effect on the level of output, thus the output gap. We doubt on using average temperature as an IV for output gap since it may lead to a weak instrumental variable issue.



(a) Average Yearly Air Temperature **(b) Average Yearly Air Precipitation**

Fig. 9. The Relationship between Output Gap and Air Temperature/ Air Precipitation by Countries Political Regimes
Source: Author's calculation. The figures illustrate the relationship between air temperature/ air precipitation and output gap by political regimes. On the y-axis, it is the percentage difference of actual output per capita from its trend component. On the x-axis, they show air temperature and air precipitation in panel (a) and (b), respectively. These figures also show the fitted values with 95% of the confidential interval.

We further check validation of IV by investigating first-stage results. First-stage results in Table 4 suggest that Air temperature may not be a proper IV for output gap although the estimates of a reduced-form present similar sign which shows procyclical fiscal policy in developing countries. All estimates with interaction effects terms suggest that improving institutional quality reduces fiscal policy procyclicality in our sample and still confirm procyclicality in developing countries even though they are not significant except the estimates of the coefficient of output gap from the model 2 in column 4.
From Figure 9b we can see that the correlation between average air precipitation and the output gap is not significantly different from zero for all democratic and non-democratic samples. It turns out that air

Table 4
Regression Results: Additional IV (Air Temperature)

	Baseline Model		Interaction Effects Terms (IV-2SLS)			
	(IV-FE)	(IV-2SLS)	(1)	(2)	(3)	(4)
Output Gap	1.479	1.253	1.055	5.746**	0.865	1.053
	(0.24)	(0.06)	(1.24)	(2.65)	(1.51)	(1.22)
L.Gov Gap	0.233*	0.274	0.275***	0.294***	0.271***	0.274***
	(2.40)	(1.08)	(5.06)	(5.64)	(5.04)	(5.01)
Trade Openness	-0.0297	-0.0228	-0.0232	-0.0243	-0.0245	-0.0224
	(-0.09)	(-0.16)	(-1.01)	(-1.10)	(-1.05)	(-0.97)
Financial Openness	-0.0380	0.0111	0.0103	0.0125	0.0119	0.0121
	(-0.79)	(0.20)	(0.60)	(0.80)	(0.73)	(0.70)
Democracy	-0.101**	-0.0138	-0.0149	-0.0158	0.0184	-0.0143
	(-3.18)	(-0.55)	(-1.42)	(-1.58)	(0.40)	(-1.36)
Control of Corruption	0.0338	0.0298	0.0303*	0.00942	0.0422	0.0296
	(0.31)	(0.28)	(1.96)	(0.54)	(1.88)	(1.86)
Output Gap*Democracy			-0.600			
			(-0.36)			
Output Gap*Control of Corruption				-3.627*		
				(-2.33)		
Control of Corruption*Democracy					-0.0222	
					(-0.73)	
Output Gap*Control of Corruption*Democracy						-0.155
						(-0.14)
First-stage						
Air Temperature	0.002	0.00003	0.001	0.003	0.002	0.002
	(0.002)	(0.00001)	(0.002)	(0.002)	(0.002)	(0.002)
Air Temperature*Dummy_Democracy			0.0004			
			(0.0005)			
Air Temperature*Control of Corruption				-0.002		
				(0.001)		
Air Temperature*Control of Corruption*Dummy_Democracy						(-0.00008)
						(0.0004)
R-squared	0.13	0.13	0.13	0.19	0.11	0.12
N	463	463	463	463	463	463

Notes: Government Spending Gap is a dependent variable. L.Gov Gap represents Lagged Government Spending Gap. This table is omitted the estimator results of constant term and all estimators for time dummy. We instrumented the Output Gap by Yearly Average Air Temperature for the Instrumental Variable approach. t statistics are in parentheses and * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

participation has no strong correlation to the output gap. Table 5 repeats the estimations of baseline model with and without interaction effects terms. The first-stage results suggest no strong correlation between our endogenous independent variable and its instrument and the estimates show no significant in all models, although the sign of estimators in all model are consistent to the results in Table 1.2.

Table 5
Regression Results: Additional IV (Air Precipitation)

	Baseline Model		Interaction Effects Terms (IV-2SLS)			
	(IV-FE)	(IV-2SLS)	(1)	(2)	(3)	(4)
Output Gap	-6.619	20.69	1.330	4.684	0.817	1.544
	(-0.48)	(0.16)	(1.56)	(1.86)	(1.42)	(1.85)
L.Gov Gap	0.133	0.520	0.279***	0.289***	0.270***	0.282***
	(0.66)	(0.31)	(5.17)	(5.49)	(5.03)	(5.21)
Trade Openness	-0.448	0.115	-0.0219	-0.0239	-0.0249	-0.0200
	(-0.61)	(0.12)	(-0.95)	(-1.08)	(-1.07)	(-0.87)
Financial Openness	-0.0592	0.0628	0.00909	0.0126	0.0117	0.0101
	(-0.67)	(0.17)	(0.54)	(0.81)	(0.72)	(0.60)
Democracy	-0.118*	0.00855	-0.0153	-0.0154	0.0188	-0.0147
	(-1.98)	(0.05)	(-1.47)	(-1.54)	(0.41)	(-1.41)
Control of Corruption	0.169	-0.0730	0.0294	0.0140	0.0427	0.0267
	(0.70)	(-0.10)	(1.91)	(0.76)	(1.90)	(1.70)
Output Gap*Democracy			-1.080			
			(-0.67)			
Output Gap*Control of Corruption				-2.819		
				(-1.54)		
Control of Corruption*Democracy					-0.0225	
					(-0.74)	
Output Gap*Control of Corruption*Democracy						-0.679
						(-0.65)
First-stage						
Air Precipitation	-0.0003	0.00001	-0.0005	-0.0005	-0.0003	0.0005
	(0.0005)	(0.0001)	(0.002)	(0.001)	(0.0005)	(0.0008)
Air Precipitation*Dummy_Democracy			0.0003			
			(0.0006)			
Air Precipitation*Control of Corruption				-0.0001		
				(0.0001)		
Air Precipitation*Control of Corruption*Dummy_Democracy						(-0.00001)
						(0.0005)
R-squared	-	-	0.14	0.18	0.11	0.13
N	463	463	463	463	463	463

Notes: Government Spending Gap is a dependent variable. L.Gov Gap represents Lagged Government Spending Gap. This table is omitted the estimator results of constant term and all estimators for time dummy. We instrumented the Output Gap by Yearly Average Air Precipitation for the Instrumental Variable approach. t statistics are in parentheses and * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Since both Air temperature and Air precipitation have no strong correlation to the output gap, we presume that they might be weak instrumental variables, and it could lead to strong biased and inconsistent estimators since significance test and confidential interval may have incorrect size. In summary, this section is built to show the concern on using Instrumental Variable Approach and test others instrumental variables. We investigate others two potential instrumental variables for output gap; Air Temperature and Air Precipitation. Both provide the same sign in all estimators as the results in Table 1.2, although the significance of estimators are absent.

Second Chapter Appendices

D Full Derivations of Household Side

This appendix provides a full derivation of the households in both formal and informal sectors. We will start with the formal workers' households optimal choices, then the informal ones and lastly, the aggregate of both sectors' households.

Formal sector

The life time utility function of each individual depending on their consumption when young and old, labour supply and educational level of their children as follows:

$$U = ln(c_t^{iy}) + \theta ln(1 - l_t^i) + \phi^i ln(e_{t+1}^i) + \beta ln(c_{t+1}^{io}) \tag{D.1}$$

where $i \in$ {Formal and Informal }
Young Cohort's Budget Constraint

$$c_t^{Fy} = (1 - \tau_t)(1 + \gamma^F e_0^F) w_t^F l_t^F - s_t^F - e_{t+1}^F a\eta \tag{D.2}$$

Old Cohort's Budget Constraint

$$c_{t+1}^{Fo} = r_{t+1} s_t^F + P_{t+1} l_t^F + b_{t+1} \tag{D.3}$$

Life Time Budget Constraint

$$c_t^{Fy} + \frac{c_{t+1}^{Fo}}{r_{t+1}} = (1 - \tau_t)(1 + \gamma^F e_0^F) w_t^F l_t^F - e_{t+1}^F a\eta + \frac{P_{t+1} l_t^F}{r_{t+1}} + \frac{b_{t+1}}{r_{t+1}} \tag{D.4}$$

Households choose to maximise their consumption, labour supply, savings and educational level for their children subject to their budget constraint

$$\begin{aligned} &\max_{c_t^{Fy}, c_{t+1}^{Fo}, l_t^F, s_t^F, e_{t+1}^F} \quad lnc_t^{Fy} + \theta ln(1 - l_t^F) + \phi^F ln(e_{t+1}^F) + \beta lnc_{t+1}^{Fo} \\ &\text{s.t.} \quad c_t^{Fy} + \frac{c_{t+1}^{Fo}}{r_{t+1}} = (1 - \tau_t)(1 + \gamma^F e_0^F) w_t^F l_t^F - e_{t+1}^F a\eta + \frac{P_{t+1} l_t^F}{r_{t+1}} + \frac{b_{t+1}}{r_{t+1}} \end{aligned} \tag{D.5}$$

Set up Lagrange equation as follows:

$$\begin{aligned} L = {} & lnc_t^{Fy} + \theta ln(1 - l_t^F) + \phi^F ln(e_{t+1}^F) + \beta lnc_{t+1}^{Fo} \\ & + \lambda \left\{ (1 - \tau_t)(1 + \gamma^F e_0^F) w_t^F l_t^F - e_{t+1}^F a\eta + \frac{P_{t+1} l_t^F}{R_{t+1}} + \frac{b_{t+1}}{r_{t+1}} - c_t^{Fy} - \frac{c_{t+1}^{Fo}}{r_{t+1}} \right\} \end{aligned} \tag{D.6}$$

and from the first-order condition, solving for the maximisation problem and we obtain the individual optimal choices of consumption, labour supply and choice for children education as follows:

$$
\begin{aligned}
\frac{\partial L}{\partial c_t^{Fy}} : \quad \frac{1}{c_t^{Fy}} &= \lambda \\
\frac{\partial L}{\partial c_{t+1}^{Fo}} : \quad \frac{\beta}{c_{t+1}^{Fo}} &= \frac{\lambda}{r_{t+1}} \\
c_t^{Fy*} &= \frac{c_{t+1}^{Fo*}}{r_{t+1}\beta}
\end{aligned}
\tag{D.7}
$$

Equation **??** shows the consumption Euler equation which agents trade-off their consumption between present and future.

$$
\begin{aligned}
\frac{\partial L}{\partial l_t^F} : \theta = & \quad \lambda\left[(1-\tau_t)(1+\gamma^F e_0^F)w_t^F + \frac{P_{t+1} l_t^F}{r_{t+1}}\right] \\
\lambda = & \quad \frac{\theta r_{t+1}}{r_{t+1}(1-\tau_t)(1+\gamma^F e_0^F)w_t^F + P_{t+1}} \\
l_t^{F*} = & \quad \frac{r_{t+1}(1-\tau_t)(1+\gamma^F e_0^F)w_t^F + P_{t+1} + \theta r_{t+1}(s_t^F + e_{t+1}^F a\eta)}{r_{t+1}(1-\tau_t)(1+\gamma^F e_0^F)w_t^F \theta}
\end{aligned}
\tag{D.8}
$$

Equation D.8 shows an optimal level of household's labour supply. An increase in effective wage and investing in children education increase an incentive of agent's labour supply.

$$
\begin{aligned}
\frac{\partial L}{\partial e_{t+1}^F} : \frac{\phi^F}{e_{t+1}^F} &= \lambda a\eta \\
e_{t+1}^F &= \frac{\phi^F}{\lambda a\eta} \\
e_{t+1}^{F*} &= \frac{\phi^F[r_{t+1}(1-\tau_t)(1+\gamma^F e_0^F)w_t^F + P_{t+1}]}{r_{t+1}\theta a\eta}
\end{aligned}
\tag{D.9}
$$

Equation D.9 shows an optimal level of household's choice for educational level for their children. The higher income after tax and pension is, the more allocation towards their children's education. Next, we combine optimal consumption level, labour supply choice and budget constraint to solve for optimal savings of household who works in the formal sector.

$$c_t^{Fy} + \frac{c_{t+1}^{Fo}}{r_{t+1}} =(1-\tau_t)(1+\gamma^F e_0^F)w_t^F l_t^F - e_{t+1}^F a\eta + \frac{P_{t+1}l_t^F}{r_{t+1}} + \frac{b_{t+1}}{r_{t+1}}$$

$$c_t^{Fy}(1+\beta) =(1-\tau_t)(1+\gamma^F e_0^F)w_t^F l_t^F - e_{t+1}^F a\eta + \frac{P_{t+1}l_t^F}{r_{t+1}} + \frac{b_{t+1}}{r_{t+1}}$$

$$(1+\beta)\Bigg[(1-\tau_t)(1+\gamma^F e_0^F)w_t^F l_t^F - s_t^F - e_{t+1}^F a\eta\Bigg] =(1-\tau_t)(1+\gamma^F e_0^F)w_t^F l_t^F$$

$$- e_{t+1}^F a\eta + \frac{P_{t+1}l_t^F}{r_{t+1}} + \frac{b_{t+1}}{r_{t+1}}$$

Plug optimal labour supply and optimal choice of children's education into the equation above, we can get optimal savings for formal worker household as follows:

$$s_t^{F*} =\frac{\beta r_{t+1}(1-\tau_t)(1+\gamma^F e_0^F)w_t^F - P_{t+1} - \phi^F P_{t+1}}{r_{t+1}\theta} - \frac{b_{t+1}(1-\tau_t)(1+\gamma^F e_0^F)w_t^F}{r_{t+1}(1-\tau_t)(1+\gamma^F e_0^F)w_t^F + P_{t+1}} \tag{D.10}$$

Equation D.10 implies that an increase in effective labour income increases net savings of household, while an in crease in universal old-age allowance and pension proportional to income reduce household's savings as expected.

Informal sector

Young Cohort's Budget Constraint

$$c_t^{Iy} = (1-\chi_t)(1+\gamma^I e_0^I)w_t^I l_t^I - s_t^I - e_{t+1}^I a\eta \tag{D.11}$$

The Old Cohort's Budget Constraint

$$c_{t+1}^{Io} = r_{t+1}s_t^I + b_{t+1} \tag{D.12}$$

and The Life Time Budget Constraint

$$c_t^{Iy} + \frac{c_{t+1}^{Io}}{r_{t+1}} = (1-\chi_t)(1+\gamma^I e_0^I)w_t^I l_t^I + \frac{b_{t+1}}{r_{t+1}} - e_{t+1}^I a\eta \tag{D.13}$$

Households choose to maximise their consumption, labour supply, savings and educational level for their children subject to their life time budget constraint as follows:

$$\begin{aligned} \underset{c_t^{Iy},c_{t+1}^{Io},l_t^I,s_t^I,e_{t+1}^I}{\text{Max}} \quad & ln(c_t^{Iy}) + \theta(1-l_t^I) + \phi^I lne_{t+1}^I + \beta ln(c_{t+1}^{Io}) \\ \text{s.t.} \quad & c_t^{Iy} + \frac{c_{t+1}^{Io}}{r_{t+1}} = (1-\chi_t)(1+\gamma^I e_0^I)w_t^I l_t^I + \frac{b_{t+1}}{r_{t+1}} - e_{t+1}^I a\eta \end{aligned} \tag{D.14}$$

Set up the Lagrange equation and from the first-order condition with respect to all endogenous variables, we get the optimal household's decision as follows.

$$\begin{aligned}L &= lnc_t^{Iy} + \theta(1 - l_t^I) + \phi^I lne_{t+1}^I + \beta lnc_{t+1}^{Io} \\ &+\lambda\left\{(1 - \chi_t)(1 + \gamma^I e_0^I)w_t^I l_t^I + \frac{b_{t+1}}{r_{t+1}} - e_{t+1}^I a\eta - c_t^{Iy} - \frac{c_{t+1}^{Io}}{r_{t+1}}\right\}\end{aligned} \tag{D.15}$$

Solving for the maximisation problem, we get the individual optimal choice of consumption, labour supply and choice for children education as follows

$$\begin{aligned}\frac{\partial L}{\partial c_t^{Iy}} : \quad \frac{1}{c_t^{Iy}} &= \lambda \\ \frac{\partial L}{\partial c_{t+1}^{Io}} : \quad \frac{\beta}{c_{t+1}^{Io}} &= \frac{\lambda}{r_{t+1}} \\ c_t^{Iy*} &= \frac{c_{t+1}^{Io*}}{r_{t+1}\beta}\end{aligned} \tag{D.16}$$

Equation D.16 shows the consumption Euler equation which agents from informal sector trade-off their consumption between present and future.

$$\begin{aligned}\frac{\partial L}{\partial l_t^I} : \theta &= \lambda\left[(1 - \chi_t)(1 + \gamma^I e_0^I)w_t^I\right] \\ \lambda &= \frac{\theta}{r_{t+1}(1 - \chi_t)(1 + \gamma^I e_0^I)w_t^I} \\ l_t^{I*} &= \frac{1}{\theta} + \frac{(e_{t+1}^I a\eta + s_t^I)}{(1 - \chi_t)(1 + \gamma^I e_0^I)w_t^I}\end{aligned} \tag{D.17}$$

Equation D.17 shows an optimal level of household's labour supply. An increase in effective wage and investing in children education increase an incentive of agent's labour supply.

$$\begin{aligned}\frac{\partial L}{\partial e_{t+1}^I} : \frac{\phi^I}{e_{t+1}^I} &= \lambda a\eta \\ e_{t+1}^I &= \frac{\phi^I}{\lambda a\eta} \\ e_{t+1}^{I*} &= \frac{\phi^I(1 - \chi_t)(1 + \gamma^I e_0^I)w_t^I}{\theta a\eta}\end{aligned} \tag{D.18}$$

Equation D.18 shows an optimal level of household's choice for educational level for their children. The higher income after informal tax is, the more allocation towards their children's education. Next, we combine optimal consumption level, labour supply choice and budget constraint to solve for optimal savings of household who works in the informal sector.

$$c_t^{Iy} + \frac{c_{t+1}^{Io}}{r_{t+1}} = (1-\chi_t)(1+\gamma^I e_0^I)w_t^I l_t^I - e_{t+1}^I a\eta + \frac{b_{t+1}}{r_{t+1}}$$

$$c_t^{Iy}(1+\beta) = (1-\chi_t)(1+\gamma^I e_0^I)w_t^I l_t^I - e_{t+1}^I a\eta + \frac{b_{t+1}}{r_{t+1}}$$

$$(1+\beta)\left[(1-\chi_t)(1+\gamma^I e_0^I)w_t^I l_t^I - s_t^I - e_{t+1}^I a\eta\right] = (1-\chi_t)(1+\gamma^I e_0^I)w_t^I l_t^I - e_{t+1}^I a\eta + \frac{b_{t+1}}{r_{t+1}}$$

Plug the optimal labour supply and optimal choice of children's education into the equation above, we can get optimal savings for formal worker household as follows:

$$s_t^{I*} = \frac{\beta(1-\chi_t)(1+\gamma^I e_0^I)w_t^I}{\theta} - \frac{b_{t+1}}{r_{t+1}} \tag{D.19}$$

An increase in effective labour income increases net savings of household, while an in crease in universal old-age allowance and pension proportional to income reduce household's savings as expected. Household maximizes their consumption when young and old, labour supply and children educational expense according to r_t, w_t from perfect competitive market.

E Model Equations

The following conditions characterise the equilibrium of the dynamic model.

$$c_t^{Fy} = (1-\tau_t)(1+\gamma^F e_0^F)w_t^F l_t^F - s_t^F - e_{t+1}^F a\eta \tag{E.1}$$

$$c_t^{Iy} = (1-\chi_t)(1+\gamma^I e_0^I)w_t^I l_t^I - s_t^I - e_{t+1}^I a\eta \tag{E.2}$$

$$c_{t+1}^{Fo} = r_{t+1}s_t^F + P_{t+1}l_t^F + b_{t+1} \tag{E.3}$$

$$c_{t+1}^{Io} = r_{t+1}s_t^I + b_{t+1} \tag{E.4}$$

$$c_t^f = c_t^{Fy} + \frac{1}{(1+n)}c_t^{Fo} \tag{E.5}$$

$$c_t^I = c_t^{Iy} + \frac{1}{(1+n)}c_t^{Io} \tag{E.6}$$

$$c_t = c_t^f + c_t^I \tag{E.7}$$

$$e_{t+1}^F = \frac{\phi^F[r_{t+1}(1-\tau_t)(1+\gamma^F e_0^F)w_t^F + P_{t+1}]}{r_{t+1}\theta a\eta} \tag{E.8}$$

$$e_{t+1}^I = \frac{\phi^I(1-\chi_t)(1+\gamma^I e_0^I)w_t^I}{\theta a\eta} \tag{E.9}$$

$$e_{t+1} = e_{t+1}^F + e_{t+1}^I \tag{E.10}$$

$$l_t^F = \frac{r_{t+1}(1-\tau_t)(1+\gamma^F e_0^F)w_t^F + r_{t+1}\theta(e_{t+1}^F a\eta + s_t^F) + P_{t+1}}{r_{t+1}\theta(1-\tau_t)(1+\gamma^F e_0^F)w_t^F} \tag{E.11}$$

$$= \frac{1+\beta+\phi^F}{\theta} - \frac{b_{t+1}}{r_{t+1}(1-\tau_t)(1+\gamma^F e_0^I)w_t^F + P_{t+1}} \tag{E.12}$$

$$l_t^I = \frac{1}{\theta} + \frac{(s_t^I + e_{t+1}^I a\eta)}{(1-\chi_t)(1+\gamma^I e_0^I)w_t^I} \tag{E.13}$$

$$= \frac{1+\beta+\phi^I}{\theta} - \frac{b_{t+1}}{r_{t+1}(1-\chi_t)(1+\gamma^I e_0^I)w_t^I} \tag{E.14}$$

$$l_t = l_t^F + l_t^I \tag{E.15}$$

$$s_t^F = \frac{\beta r_{t+1}(1-\tau_t)(1+\gamma^F e_0^F)w_t^F - P_{t+1} - \phi^F P_{t+1}}{r_{t+1}\theta} - \frac{b_{t+1}(1-\tau_t)(1+\gamma^F e_0^F)w_t^F}{r_{t+1}(1-\tau_t)(1+\gamma^F e_0^F)w_t^F + P_{t+1}} \tag{E.16}$$

$$s_t^I = \frac{\beta(1-\chi_t)(1+\gamma^I e_0^I)w_t^I}{\theta} - \frac{b_{t+1}}{r_{t+1}} \tag{E.17}$$

$$s_t = s_t^F + s_t^I \tag{E.18}$$

$$y_t = k_t^\alpha \tag{E.19}$$

$$r_t = \alpha k_t^{\alpha-1} h_t^\varphi - \delta \tag{E.20}$$

$$w_t = (1-\alpha-\varphi)k_t^\alpha h_t^\varphi \tag{E.21}$$

$$k_{t+1} = \frac{1}{(1+n)(1+g)}\Bigg[(1-\delta)k_t + s_t\Bigg] \tag{E.22}$$

$$h_{t+1} = \frac{1}{(1+n)(1+g)}\Bigg[(1-\mu)h_t + e_{t+1}\Bigg] \tag{E.23}$$

$$\tau_t = \frac{\bar{P}\rho + \bar{b}}{(1+n)(1-\alpha-\varphi)[\rho(1+\gamma^F e_0^F)l_t^F + (1-\rho)\bar{\chi}(1+\gamma^I e_0^I)l_t^I]} \tag{E.24}$$

$$P_{t+1} = \bar{P} * y_{t+1} \tag{E.25}$$

$$b_{t+1} = \bar{b} * y_{t+1} \tag{E.26}$$

$$\chi_t = \bar{\chi} * \tau_t \tag{E.27}$$

where;
c_t^{Fy} = Consumption of the young formal worker
c_{t+1}^{Fo} = Consumption of the old formal worker
c_t^{Iy} = Consumption of the young informal worker
c_{t+1}^{Io} = Consumption of the old informal worker
c_t^F = Consumption of the formal worker
c_t^I = Consumption of the informal worker
c_t = Aggregate consumption
e_{t+1}^F = Education of the children of the formal worker
e_{t+1}^I = Education of the children of the informal worker

e_{t+1} = Aggregate education of the children
l_t^F = Labour supply of the formal worker
l_t^I = Labour supply of the informal worker
l_t = Aggregate labour supply
s_t^F = Savings of the formal worker
s_t^I = Savings of the informal worker
s_t = Aggregate savings of the formal worker
y_t = Output per effective labour
r_t = Real rental rate
w_t = Wage rate
k_{t+1} = Capital stock
h_{t+1} = Human capital stock
$P_t = \bar{P} * y_t$ = Pension payouts for the formal workers
$b_t = \bar{b} * y_t$ = Universal old-age allowance
τ = Labour income tax rate for formal worker
$\chi = \bar{\chi} * \tau$ = Costs of working in the informal sector

The lists of endogenous variables, exogenous variables and parameters are shown in the following part.
Endogenous variables: $c1f, c2f, cf, c1i, c2i, ci, c, e2f, e2i, e2, sf, si, s, lf, li, l, y, k, h, w, r,\ \tau$
Exogenous variables: χ, P, b, n, g
Parameters: α, β, φ, ϕ^F, ϕ^I, γ^F, γ^I, η, δ, μ, θ, a, $\bar{\chi}$, ρ, $\bar{P}$, $\bar{b}$, $e1f$, $e1i$
where;
α = Share of capital income
β = Time preference
φ = Share of human capital income
ϕ^F = Formal workers' parental preference for children education
ϕ^I = Informal workers' parental preference for children education
γ^F = Productivity of the education of the formal worker
γ^I = Productivity of the education of the informal worker
η = Fertility rate
δ = Depreciation rate of capital
μ = Depreciation rate of human capital
θ = Substitutional rate between supplying labour and having leisure
a = Costs of children rearing
$\bar{\chi}$ = Costs of working in the informal sector
ρ = Proportion of people who work in the formal sector to total workforce
$\bar{P}$ = Pension payouts rate
$\bar{b}$ = Universal old-age allowance rate
$e_0^F(e1f)$ = Educational level of the formal worker
$e_0^I(e1i)$ = Educational level of the informal worker

In this dynamics model, both h and k are predetermined variables, no forward-looking variable in this case. The steady state has been solve by *fsolve* function in *Matlab*. The following is the *Dynare* code of the dynamics equilibrium of the model.

```
// Preamble
var c1f c2f cf c1i c2i ci c e2f e2i e2 sf si s lf li l y k h w r chi p b ttau;
varexo n g p_bar b_bar etta rrho;
parameters alppha betta phif phii gammaf gammai  deltta mmu thetta aa chi_bar e1f e1i varrphi ;

//Parameter values

T = 50; // Number of period an individual lives (for each 2-period model)
deltta= 1 - (1 - 0.10)^T; // Physical capital depreciation rate
thetta = 2.62; // Marginal disutility of providing labour
alppha = 0.3; // The weight of capital income in Cobb-Douglas production function
```

```
betta = 0.99; // Time preference of consumption between old and young period
varrphi = 0.3;  // The weight of human capital income in Cobb-Douglas production function
mmu = 1 - (1 - 0.10)^T; // Human capital depreciation rate
phif = (1+thetta)/(mmu); // Parental preference on children education of formal worker
phii = (0.6)*(1+thetta)/(mmu); //Parental preference on children education of informal worker
gammaf = 0.246; // Productivity from education of formal worker
gammai = 0.1; // Productivity from education of informal worker
//etta = 2; // Fertility-preference parameter (range between {1, 2, 4, 8})
aa = 0.11; // Costs of education per children (of income)
chi_bar = 0.3; // Costs of working in the informal sector as a fraction of tax
e1f = 0.3; // Educational level of the formal worker parent generation
e1i = 0.08; // Educational level of the informal worker parent generation
//p_bar = 0.07; // Pension Premium for those who work in formal sector as%GDP
//b_bar = 0.005; // Universal old-age allowance as % GDP
//rrho = 0.4; // Proportion of the population work in formal sector

//Model
model;

//household
(E.1) c1f = (1-ttau)*(1+gammaf*e1f)*w*lf - sf - e2f*aa*etta ;
(E.3) c2f = r*sf + p*lf + b ;
(E.5) cf = (1-ttau)*(1+gammaf*e1f)*w*lf - sf - e2f*aa*etta + (1/(1+n))*(r*sf + p*lf + b) ;

(E.2) c1i = (1-chi)*(1+gammai*e1i)*w*li - si - e2i*aa*etta ;
(E.4) c2i = r*si + b ;
(E.6) ci = (1-chi)*(1+gammai*e1i)*w*li - si - e2i*aa*etta + (1/(1+n))*(r*si + b) ;

(E.7) c = (1-ttau)*(1+gammaf*e1f)*w*lf - sf - e2f*aa*etta + (1/(1+n))*(r*sf + p*lf + b)
+ (1-chi)*(1+gammai*e1i)*w*li - si - e2i*aa*etta + (1/(1+n))*(r*si + b) ;

(E.8) e2f = phif*(r*(1-ttau)*(1+gammaf*e1f)*w+p)/r*thetta*aa*etta ;
(E.9) e2i = phii*(1-chi)*(1+gammai*e1i)*w/thetta*aa*etta ;
(E.10) e2 = phif*(r*(1-ttau)*(1+gammaf*e1f)*w+p)/r*thetta*aa*etta
+ phii*(1-chi)*(1+gammai*e1i)*w/thetta*aa*etta ;

(E.12) lf = (1+betta+phif/thetta) - b/(r*(1-ttau)*(1+gammaf*e1f)*w+p);
(E.14) li = (1+betta+phii/thetta) - b/r*(1-chi)*(1+gammai*e1i)*w;
(E.15) l = (1+betta+phif/thetta) - b/(r*(1-ttau)*(1+gammaf*e1f)*w+p)
+ (1+betta+phii/thetta) - b/r*(1-chi)*(1+gammai*e1i)*w;

(E.16) sf = betta*r*(1-ttau)*(1+gammaf*e1f)*w-p-phif*p/r*thetta
- b*(1-ttau)*(1+gammaf*e1f)*w/r*(1-ttau)*(1+gammaf*e1f)*w+p ;
(E.17) si = betta*(1-chi)*(1+gammai*e1i)*w/thetta - b/r ;
(E.18) s = betta*r*(1-ttau)*(1+gammaf*e1f)*w-p-phif*p/r*thetta
- b*(1-ttau)*(1+gammaf*e1f)*w/r*(1-ttau)*(1+gammaf*e1f)*w+p
+ betta*(1-chi)*(1+gammai*e1i)*w/thetta - b/r ;

//firms
(E.19) y = k(-1)^alppha*h(-1)^varrphi;
(E.20) w = (1-alppha-varrphi)*y;
(E.21) r = alppha*y/k -deltta ;

//law of motion
(E.22) k = ((1-deltta)*k(-1)+s)/(1 + n)*(1 + g);
(E.23) h = ((1-mmu)*h(-1)+ e2)/(1 + n)*(1 + g);
```

```
//add
(E.24) ttau = (p_bar*rrho+b_bar)/(1+n)*(1-alppha-varrphi)*(rrho*(1+gammaf*e1f)*lf
+(1-rrho)*chi_bar*(1+gammai*e1i)*li);
(E.25) p = p_bar*y;
(E.26) b = b_bar*y;
(E.27) chi = chi_bar*ttau;

end;

///// Declare initial values /////
initval;

k = 0.1369  ;
h = 0.6578  ;
ttau = 0.0696;
g = 0;
n = 0;
p_bar = 0.07;
b_bar = 0.0056;
rrho = 0.4;
etta = 2;

y = k^alppha*h^varrphi;
w = (1-alppha-varrphi)*y;
r = alppha*y/k -deltta ;

p = p_bar*y;
b = b_bar*y;
chi = chi_bar*ttau;

c1f = (1-ttau)*(1+gammaf*e1f)*w*lf - sf - e2f*aa*etta ;
c2f = r*sf + p*lf + b ;
cf = (1-ttau)*(1+gammaf*e1f)*w*lf - sf - e2f*aa*etta + (1/(1+n))*(r*sf + p*lf + b) ;

c1i = (1-chi)*(1+gammai*e1i)*w*li - si - e2i*aa*etta ;
c2i = r*si + b ;
ci = (1-chi)*(1+gammai*e1i)*w*li - si - e2i*aa*etta + (1/(1+n))*(r*si + b) ;

c = (1-ttau)*(1+gammaf*e1f)*w*lf - sf - e2f*aa*etta + (1/(1+n))*(r*sf + p*lf + b)
+ (1-chi)*(1+gammai*e1i)*w*li - si - e2i*aa*etta + (1/(1+n))*(r*si + b) ;

sf = betta*r*(1-ttau)*(1+gammaf*e1f)*w-p-phif*p/r*thetta
- b*(1-ttau)*(1+gammaf*e1f)*w/r*(1-ttau)*(1+gammaf*e1f)*w+p ;
si = betta*(1-chi)*(1+gammai*e1i)*w/thetta - b/r ;
s = betta*r*(1-ttau)*(1+gammaf*e1f)*w-p-phif*p/r*thetta
- b*(1-ttau)*(1+gammaf*e1f)*w/r*(1-ttau)*(1+gammaf*e1f)*w+p
+ betta*(1-chi)*(1+gammai*e1i)*w/thetta - b/r ;

e2f = phif*(r*(1-ttau)*(1+gammaf*e1f)*w+p)/r*thetta*aa*etta ;
e2i = phii*(1-chi)*(1+gammai*e1i)*w/thetta*aa*etta ;
e2 = phif*(r*(1-ttau)*(1+gammaf*e1f)*w+p)/r*thetta*aa*etta
+ phii*(1-chi)*(1+gammai*e1i)*w/thetta*aa*etta ;

lf = (1+betta+phif/thetta) - b/(r*(1-ttau)*(1+gammaf*e1f)*w+p);
li = (1+betta+phii/thetta) - b/r*(1-chi)*(1+gammai*e1i)*w;
```

```
l = (1+betta+phif/thetta) - b/(r*(1-ttau)*(1+gammaf*e1f)*w+p)
+ (1+betta+phii/thetta) - b/r*(1-chi)*(1+gammai*e1i)*w;

end;
steady;
check;

///// Declare end values /////
// 3 cases: rrho = 0.7, p_bar = 0.14, b_bar = 0.07
endval;

k = 0.1369  ;
h = 0.6578  ;
ttau = 0.0696;
g = 0;
n = 0;
p_bar = 0.07;
b_bar = 0.04;
rrho = 0.4;
etta = 2;

y = k^alppha*h^varrphi;
w = (1-alppha-varrphi)*y;
r = alppha*y/k -deltta ;

p = p_bar*y;
b = b_bar*y;
chi = chi_bar*ttau;

c1f = (1-ttau)*(1+gammaf*e1f)*w*lf - sf - e2f*aa*etta ;
c2f = r*sf + p*lf + b ;
cf = (1-ttau)*(1+gammaf*e1f)*w*lf - sf - e2f*aa*etta + (1/(1+n))*(r*sf + p*lf + b) ;

c1i = (1-chi)*(1+gammai*e1i)*w*li - si - e2i*aa*etta ;
c2i = r*si + b ;
ci = (1-chi)*(1+gammai*e1i)*w*li - si - e2i*aa*etta + (1/(1+n))*(r*si + b) ;

c = (1-ttau)*(1+gammaf*e1f)*w*lf - sf - e2f*aa*etta + (1/(1+n))*(r*sf + p*lf + b)
+ (1-chi)*(1+gammai*e1i)*w*li - si - e2i*aa*etta + (1/(1+n))*(r*si + b) ;

sf = betta*r*(1-ttau)*(1+gammaf*e1f)*w-p-phif*p/r*thetta
- b*(1-ttau)*(1+gammaf*e1f)*w/r*(1-ttau)*(1+gammaf*e1f)*w+p ;
si = betta*(1-chi)*(1+gammai*e1i)*w/thetta - b/r ;
s = betta*r*(1-ttau)*(1+gammaf*e1f)*w-p-phif*p/r*thetta
- b*(1-ttau)*(1+gammaf*e1f)*w/r*(1-ttau)*(1+gammaf*e1f)*w+p
+ betta*(1-chi)*(1+gammai*e1i)*w/thetta - b/r ;

e2f = phif*(r*(1-ttau)*(1+gammaf*e1f)*w+p)/r*thetta*aa*etta ;
e2i = phii*(1-chi)*(1+gammai*e1i)*w/thetta*aa*etta ;
e2 = phif*(r*(1-ttau)*(1+gammaf*e1f)*w+p)/r*thetta*aa*etta
+ phii*(1-chi)*(1+gammai*e1i)*w/thetta*aa*etta ;

lf = (1+betta+phif/thetta) - b/(r*(1-ttau)*(1+gammaf*e1f)*w+p);
li = (1+betta+phii/thetta) - b/r*(1-chi)*(1+gammai*e1i)*w;
l = (1+betta+phif/thetta) - b/(r*(1-ttau)*(1+gammaf*e1f)*w+p)
+ (1+betta+phii/thetta) - b/r*(1-chi)*(1+gammai*e1i)*w;
```

```
end;
steady;
check;


//Computation
simul(periods=5000);
```

Files name: for solving the steady state, see files name **rootktauh__250419__worked.m** and file **main__ktauh250419__worked.m**. For the model running in *Dynare*, see file name **paper2__250419__worked.mod**.

Third Chapter Appendices

F Model Equations

In this dynamics model, there are endogenous variables, exogenous variables and parameters as follows:
Endogenous variables: $c1, c2, c, y, k, h, w, r, s, \gamma, \tau$
Exogenous variables: $\bar{\gamma}$, θ, σ
Parameters: α, β, δ, μ, g, n
Then, the following equations will be used to characterise the solutions for those endogenous variables.

$$c_t^y = w_t - \tau_t - s_t \tag{F.1}$$

$$c_{t+1}^o = s_t r_{t+1} + w_{t+1} z_{j,t+1}^o - \gamma_{t+1} \tag{F.2}$$

$$s_t = (\frac{\beta}{1+\beta})(w_t - \tau_t) - \frac{w_{t+1} \cdot z_{j,t+1}^o}{r_{t+1}(1+\beta)} + \frac{\gamma_{t+1}}{r_{t+1}(1+\beta)} \tag{F.3}$$

$$c_t = c_t^y + \frac{1}{(1+n)} c_t^o \tag{F.4}$$

$$k_{t+1} = \frac{1}{(1+n)(1+g)} \left[(1-\delta)k_t + s_t \right] \tag{F.5}$$

$$z_{t+1}^o = h_{t+1} = \frac{1}{(1+n)(1+g)} \left[h_t(1-\mu) + (\theta - \frac{\sigma}{2}) y_t \right] \tag{F.6}$$

$$\gamma_{t+1} = \bar{\gamma} \cdot y_t \tag{F.7}$$

$$y_t = k_t^\alpha \tag{F.8}$$

$$r_{t+1} = R_{t+1} + 1 - \delta = \alpha k_t^{\alpha-1} + 1 - \delta \tag{F.9}$$

$$w_t = (1-\alpha) k_t^\alpha \tag{F.10}$$

$$\tau_t = \frac{\sigma k_t^\alpha}{4(1+n)} \cdot \left[\left(\frac{1}{\theta}\right)^2 - \left(\frac{\bar{\gamma}}{(1-\alpha)\theta}\right)^2 \right] \tag{F.11}$$

Note that $h_{t+1} = \frac{H_{t+1}}{A_{t+1}L_{t+1}}$, $h_t = \frac{H_t}{A_t(1+g)L_t(1+n)}$, $k_{t+1} = \frac{K_{t+1}}{A_{t+1}L_{t+1}}$, $k_t = \frac{K_t}{A_t(1+g)L_t(1+n)}$.
where;
c_t^y = Consumption of the young
c_{t+1}^o = Consumption of the old

c_t = Aggregate consumption
s_t = Aggregate savings
y_t = Output per effective labour
r_t = Real rental rate
$w_t = w_{t+1}$ = Wage rate
k_{t+1} = Capital stock
$z^o_{j,t+1} = h_{t+1}$ = Health-related human capital stock which determine labour supply of the elderly
τ = Lump-sum tax
γ_{t+1} = Costs of working after retirement
α = Share of capital income
β = Time preference
δ = Depreciation rate of capital
μ = Depreciation rate of health-related human capital
$\bar{\gamma}$ = Proportion of costs of working after retirement to level of GDP
θ = Positive externalities from supportive government policies
σ = Costs of providing supportive government policies
g = Technological progress
n = Population growth
In the steady state, the equilibrium solutions are characterised by the following equations

$$k^* = \frac{1}{(1+n)(1+g)} s(w(k^*), \tau(k^*), r(k^*), h^*(k^*), \gamma(k^*)) \tag{F.12}$$

$$s^* = \frac{\beta(w^* - \tau^*)}{(1+\beta)} - \frac{w^* z^*}{(1+\beta)(1+r^*-\delta)} + \frac{\gamma^*}{(1+\beta)(1+r^*-\delta)} \tag{F.13}$$

$$z^* = h^* = \frac{(\theta - \frac{\sigma}{2})k^{*\alpha}}{(1+n)(1+g)-(1-\mu)} \quad ; (\theta - \frac{\sigma}{2}) > 0 \tag{F.14}$$

$$w^* = (1-\alpha)k^{*\alpha} \tag{F.15}$$

$$r^* = \alpha k^{*(\alpha-1)} \tag{F.16}$$

$$\tau^* = \frac{\sigma k^{*\alpha}}{4(1+n)} \cdot \left[\left(\frac{1}{\theta}\right)^2 - \left(\frac{\bar{\gamma}}{(1-\alpha)\theta}\right)^2\right] \tag{F.17}$$

$$\gamma^* = \bar{\gamma} k^{*\alpha} \tag{F.18}$$

Since the steady state cannot solve analytically, we numerically calculate the steady state values by function *fsolve* from *Matlab* and show the dynamics pattern of economic variables by running perfect foresight dynamic model using *Dynare*.

```
//Neoclassical growth model with elderly labour force participation
///// Declare variables /////

var y c c1 c2 k s w r h tau gamma check1 check2;
varexo g n bar_gamma theta sigma ;
parameters alppha betta delta mu ;


///// Declare parameter values /////
T = 50; // length of time period//
alppha= 0.3; //share of capital income//
```

```
betta= 0.99; // discount rate, time preference //
delta = 1 - (1 - 0.10)^T; // depreciation rate//
mu= 1 - (1 - 0.10)^T; //decaying of health from young to old age//
//sigma= 0.06; //cost of providing government regulations (cash benefits to elderly%GDP)//
//theta= 0.07; //positive externality of providing government regulations (%GDP)//
//bar_gamma = 0.001; //cost of working after retirement age(%GDP)//



///// The model /////
model;

// period 1 flow of funds constraint (young spend their wages)
(F.1) c1 = w - tau - s;
// period 2 flow of funds constraint (old spend their savings)
(F.2) c2 = (r+1-delta)*s + h*w - bar_gamma*y;
// savings function
(F.3) s = betta*(w-tau)/(1 + betta) - (w*h)/(r+1-delta)*(1+betta)
+ bar_gamma*y/(r+1-delta)*(1+betta);
// aggregate consumption is the sum of consumption of both cohorts
(F.4) c = c1 + (1 / (1 + n)) * c2;
// equation of motion for capital per effective worker
(F.5) k = ((1 - delta) / ((1 + n) * (1 + g))) * k(-1) + s/(1 + n)*(1 + g);
//equation of motion for health-related human capital per effective worker
(F.6) h = (1/(1 + n)* (1 + g)) *((1-mu)*h(-1) + (theta-sigma/2)*y);
//cost of working after retirement age
(F.7) gamma = bar_gamma*y;
// Cobb-Douglas production technology (per effective worker)
(F.8) y = k(-1)^alppha;
// capital is paid at its net marginal product
(F.9) r = alppha*y/k(-1);
// labor is paid at its marginal product
(F.10) w = (1 - alppha) * y;
//lump-sum tax//
(F.11) tau = ((sigma*k(-1)^alppha)/4*(1+n)*theta^2) *(1-(bar_gamma^2/(1-alppha)^2));
// check that zero profit condition is satisfied
check1 = y - r * k(-1) - w;
// check that consumption Euler equation holds
check2 = 1/c1 - betta*(1 + r(+1)-delta)*1/c2;


end;


///// Declare initial values /////

initval;

bar_gamma = 0.001;
g = 0.1 ;
n = 0.1;
theta = 0.07 ;
sigma = 0.06 ;
k  = 0.2130;
h = (1/(1+n)*(1+g)-(1-mu))*(theta-sigma/2)*k^alppha;
y  = k^alppha;
```

```
gamma = bar_gamma*y;
w  = (1 - alppha)*y;
r  = alppha*y/k;
tau = ((sigma*k^alppha)/4*(1+n)*theta^2) *(1-(bar_gamma^2/(1-alppha)^2));
s  = betta*(w-tau)/(1 + betta) - (w*h)/(r+1-delta)*(1+betta) + bar_gamma*y/(r+1-delta)*(1+betta);
c1 = w - tau - s ;
c2 = (r+1-delta)*s + h*w - bar_gamma*y;
c  = c1 + (1 / (1 + n)) * c2;


end;
steady;
check;

///// Declare end values /////
// 3 cases: bar_gamma = 0.01, theta = 0.1, sigma = 0.1//
endval;

bar_gamma = 0.01;
g = 0.1 ;
n = 0.1;
theta = 0.07 ;
sigma = 0.1 ;
k  = 0.2130;
h = (1/(1+n)*(1+g)-(1-mu))*(theta-sigma/2)*k^alppha;
y  = k^alppha;
gamma = bar_gamma*y;
w  = (1 - alppha)*y;
r  = alppha*y/k;
tau = ((sigma*k^alppha)/4*(1+n)*theta^2) *(1-(bar_gamma^2/(1-alppha)^2));
s  = betta*(w-tau)/(1 + betta) - (w*h)/(r+1-delta)*(1+betta) + bar_gamma*y/(r+1-delta)*(1+betta);
c1 = w - tau - s ;
c2 = (r+1-delta)*s + h*w - bar_gamma*y;
c  = c1 + (1 / (1 + n)) * c2;


end;
steady;
check;

//Simulation

simul(periods=5000);
```

The file is provided in the additional materials. See more in **paper3_170419.mod** file for *Dynar*e code and for *Matlab* solver, see rootkh170419.m and main170419.m

G Technical Issues

For every static economic problem, the model can be written as a parametrised system of equations of the form $F(x;\alpha) = 0$ $F : X \times \Omega \to \mathbb{R}^n, F \in C^1$ which means that function F maps value of x and α to real number and function F is continuously differentiable. $x \in X \subseteq \mathbb{R}^n$ is vector of endogenous state variables and $\alpha \in \Omega \subseteq \mathbb{R}^m$ is a vector of parameters that summarize larger environment in which the system is embedded. For given value of α, the equation of the model will determine equilibrium or solution values x^* of the state vector x, that is $x^* : \Omega \to X$. To solve for steady state of the system we need to solve the $F(x;\alpha) = 0$ and we want to know what happen to the solutions following the process from its regular or normal state or path, caused by an outside influence (perturbation). We are concerned with the following issues

- Number of equilibria, existence and local uniqueness
- Continuity: If only one equilibrium exists after the change, is it close to the old one?
- Comparative statics
- Are certain properties of the equilibrium (e.g. stability) preserved after the parameter change?

How can we find the equilibrium solutions?

We have to check local uniqueness, existence, continuity and stability of the steady state equilibria. This will give us the proposition. Stability (Sink) means that small deviations from long-run equilibrium are dampened by self-correcting features of the economy or by cleverly designed policies. We have to check the eigenvalue of the Jacobian matrix whether it provides the same amount of the real modulus of eigenvalue which is larger than one and the number of forward-looking variables. Then, comparative statics analysis can be conducted by using the implicit function theorem.

Implicit Function Theorem and Comparative Statics

Let $f : \mathbb{R}^n \times \mathbb{R}^m \to \mathbb{R}^n$ be continuously differentiable and $F(x; \alpha) = 0$. Suppose (x^0, α^0) solve the system and Jacobian of endogenous variables does not vanish at (x^0, α^0), $\mid D_x F(x^0; \alpha^0) \mid \neq 0$, then, we have

- For all α in the neighbourhood of α^0, there exists a unique x^* in neighbourhood x^0 such that $F(x^*; \alpha) = 0$ which means the system define locally equilibrium value of endogenous variable x^* as a function of α ; $x^* = x(\alpha)$.
- $x(\alpha)$ is continuously differentiable.

Then, the comparative static question can be answered by differentiation because the solution is mapped well in the neighbourhood of parameter,α^0, and inherit the differentiability from F. Plugging the solution $x(\alpha)$ back into the system yields the identity $F[x(\alpha); \alpha] = 0$.
It will still hold if we do total differentiation with respect to α for both side

$$D_\alpha F(x^*; \alpha^0) D\alpha + D_x F(x^*; \alpha^0) Dx(\alpha^0) = 0 \tag{G.1}$$

$$\frac{Dx(\alpha^0)}{D\alpha} = -\frac{D_\alpha F(x^*; \alpha^0)}{D_x F(x^*; \alpha^0)} \tag{G.2}$$

So that, the implicit function theorem gives us the sufficient conditions for the local uniqueness of the solutions to the system and its continuous dependence on the parameters [Azariadis, 1993].

H Comparative Statics

We define the steady state of k^* and h^* implicitly by a set of the implicit function of k^* and h^*, respectively as follows:

$$F(k^*, h^*; \alpha, \beta, \bar{\gamma}, \theta, \sigma) = \left[\frac{h^*}{(\theta - \frac{\sigma}{2})}\right]^{\frac{1}{\alpha}} - \left\{\frac{\alpha\beta\Big[(1-\alpha) - \frac{\sigma}{4}[(\frac{1}{\theta})^2 - (\frac{\bar{\gamma}}{(1-\alpha)\theta})^2]\Big]}{\alpha(1+\beta) - \bar{\gamma} + (1-\alpha)(\theta - \frac{\sigma}{2})k^{*\alpha}}\right\}^{\frac{1}{(1-\alpha)}} = 0 \tag{H.1}$$

$$G(k^*, h^*; \alpha, \beta, \bar{\gamma}, \theta, \sigma) = h^* - (\theta - \frac{\sigma}{2})\left\{\frac{\alpha\beta\Big[(1-\alpha) - \frac{\sigma}{4}[(\frac{1}{\theta})^2 - (\frac{\bar{\gamma}}{(1-\alpha)\theta})^2]\Big]}{\alpha(1+\beta) - \bar{\gamma} + (1-\alpha)(\theta - \frac{\sigma}{2})k^{*\alpha}}\right\}^{\frac{\alpha}{(1-\alpha)}} = 0 \tag{H.2}$$

where $\bar{\gamma}$ denotes the costs of working after statutory retirement age. θ is the positive externalities to the elderly augmented from the government regulations. σ presents the costs of providing the supportive regulation to the elderly and k^*, h^* are endogenous state variables.

It can be seen that the function F is differentiable with respect to all endogenous and interested exogenous variables as follows:

$$F_{k^*} = A^{\frac{1}{1-\alpha}} B^{\frac{-(2-\alpha)}{1-\alpha}} \frac{1}{1-\alpha} \alpha(1-\alpha)(\theta - \frac{\sigma}{2}) k^{*-(1-\alpha)} = \oplus \tag{H.3}$$

$$F_{h^*} = \frac{1}{\alpha} h^{*\frac{1-\alpha}{\alpha}} (\theta - \frac{\sigma}{2})^{\frac{-1}{\alpha}} = \oplus \tag{H.4}$$

$$F_{\bar{\gamma}} = -\left[A^{\frac{\alpha}{1-\alpha}} B^{\frac{-1}{1-\alpha}} \frac{\alpha\beta\sigma\bar{\gamma}}{2\theta^2(1-\alpha)^3} + A^{\frac{1}{1-\alpha}} B^{\frac{-(2-\alpha)}{1-\alpha}} \frac{1}{1-\alpha} \right] = \ominus \tag{H.5}$$

$$\begin{aligned} F_{\theta} = & -\left[\frac{1}{\alpha} h^{*\frac{1}{\alpha}} (\theta - \frac{\sigma}{2})^{\frac{-(1+\alpha)}{\alpha}} \right] - \left[\frac{1}{1-\alpha} A^{\frac{\alpha}{1-\alpha}} B^{\frac{-1}{1-\alpha}} \frac{\alpha\beta\sigma}{2\theta^3} \left[1 - \left(\frac{\bar{\gamma}}{(1-\alpha)\theta} \right)^2 \right] \right] \\ & + \left[A^{\frac{1}{1-\alpha}} B^{\frac{-(2-\alpha)}{1-\alpha}} k^{*\alpha} \right] \end{aligned} \tag{H.6}$$

$$\begin{aligned} F_{\sigma} = & \left[\frac{1}{2\alpha} h^{*\frac{1}{\alpha}} (\theta - \frac{\sigma}{2})^{\frac{-(1+\alpha)}{\alpha}} \right] + \left[\frac{1}{1-\alpha} A^{\frac{\alpha}{1-\alpha}} B^{\frac{-1}{1-\alpha}} \frac{\alpha\beta}{4\theta^2} \left[1 - \left(\frac{\bar{\gamma}}{(1-\alpha)\theta} \right)^2 \right] \right] \\ & - \left[A^{\frac{1}{1-\alpha}} B^{\frac{-(2-\alpha)}{1-\alpha}} \frac{1}{2} k^{*\alpha} \right] \end{aligned} \tag{H.7}$$

where $A = \alpha\beta\Big[(1-\alpha) - \frac{\sigma}{4}[(\frac{1}{\theta})^2 - (\frac{\bar{\gamma}}{(1-\alpha)\theta})^2]\Big]$ and $B = \alpha(1+\beta) - \bar{\gamma} + (1-\alpha)(\theta - \frac{\sigma}{2})k^{*\alpha}$

$***$ Note that the sign of F_θ is indeterminacy and we show that $F_\theta = \ominus$ If $\left[\frac{1}{\alpha} h^{*\frac{1}{\alpha}} (\theta - \frac{\sigma}{2})^{\frac{-(1+\alpha)}{\alpha}} \right] + \left[\frac{1}{1-\alpha} A^{\frac{\alpha}{1-\alpha}} B^{\frac{-1}{1-\alpha}} \frac{\alpha\beta\sigma}{2\theta^3} \left[1 - \left(\frac{\bar{\gamma}}{(1-\alpha)\theta} \right)^2 \right] \right] > \left[A^{\frac{1}{1-\alpha}} B^{\frac{-(2-\alpha)}{1-\alpha}} k^{*\alpha} \right]$.

The sign of F_σ is also indeterminacy and we show that $F_\sigma = \oplus$ If $\left[\frac{1}{2\alpha} h^{*\frac{1}{\alpha}} (\theta - \frac{\sigma}{2})^{\frac{-(1+\alpha)}{\alpha}} \right] + \left[\frac{1}{1-\alpha} A^{\frac{\alpha}{1-\alpha}} B^{\frac{-1}{1-\alpha}} \frac{\alpha\beta}{4\theta^2} \left[1 - \left(\frac{\bar{\gamma}}{(1-\alpha)\theta} \right)^2 \right] \right] > \left[A^{\frac{1}{1-\alpha}} B^{\frac{-(2-\alpha)}{1-\alpha}} \frac{1}{2} k^{*\alpha} \right]$.

The implications of the effects of changes in parameters value on the physical capital stock in the steady state are characterised as follows:

$$\frac{\partial k^*}{\partial \bar{\gamma}} = -\frac{F_{\bar{\gamma}}}{F_{k^*}} = -\frac{\ominus}{\oplus} = \oplus \tag{H.8}$$

$$\frac{\partial k^*}{\partial \theta} = -\frac{F_{\theta}}{F_{k^*}} = -\frac{\ominus}{\oplus} = \oplus \tag{H.9}$$

$$\frac{\partial k^*}{\partial \sigma} = -\frac{F_{\sigma}}{F_{k^*}} = -\frac{\oplus}{\oplus} = \ominus \tag{H.10}$$

These imply that an increase in the costs of working after statutory retirement age coincides the higher physical capital accumulation in the steady state. Higher costs of working after statutory retirement age induces individuals to save more during the young age; as savings increases, the more accumulation of physical capital in the steady state. The positive externalities from supportive government regulations to the elderly also generate more physical capital accumulation in the steady state, while an increase in the costs of providing those supportive policies reduces the accumulation of physical capital in the steady state.

Next, the analysis on health-related human capital in the steady state will be discussed. It can be seen that the function G is differentiable with respect to all endogenous and interested exogenous variables as follows:

$$G_{k^*} = A^{\frac{\alpha}{1-\alpha}} B^{\frac{-1}{1-\alpha}} (\theta - \frac{\sigma}{2})^2 \alpha^2 k^{*-(1-\alpha)} = \oplus \tag{H.11}$$

$$G_{h^*} = 1 = \oplus \tag{H.12}$$

$$G_{\bar{\gamma}} = -\left[A^{\frac{\alpha}{1-\alpha}} B^{\frac{-1}{1-\alpha}} (\theta - \frac{\sigma}{2}) \frac{\alpha}{1-\alpha} + A^{\frac{-(1-2\alpha)}{1-\alpha}} B^{\frac{-\alpha}{1-\alpha}} (\theta - \frac{\sigma}{2}) \frac{\alpha^2 \beta \sigma \bar{\gamma}}{2\theta^2 (1-\alpha)^3}\right] = \ominus \tag{H.13}$$

$$\begin{aligned} G_{\theta} = &-\left[A^{\frac{\alpha}{1-\alpha}} B^{\frac{-\alpha}{1-\alpha}}\right] - \left[A^{\frac{-(1-2\alpha)}{1-\alpha}} B^{\frac{-\alpha}{1-\alpha}} (\theta - \frac{\sigma}{2}) \frac{\alpha^2 \beta}{1-\alpha} \left(\frac{\sigma}{2\theta^3} - \frac{\sigma \bar{\gamma}^2}{2(1-\alpha)^2 \theta^3}\right)\right] \\ &+ \left[A^{\frac{\alpha}{1-\alpha}} B^{\frac{-1}{1-\alpha}} (\theta - \frac{\sigma}{2}) \alpha k^{*\alpha}\right] \end{aligned} \tag{H.14}$$

$$\begin{aligned} G_{\sigma} = &\left[\frac{1}{2} A^{\frac{\alpha}{1-\alpha}} B^{\frac{-\alpha}{1-\alpha}}\right] + \left[A^{\frac{-(1-2\alpha)}{1-\alpha}} B^{\frac{-\alpha}{1-\alpha}} (\theta - \frac{\sigma}{2}) \frac{\alpha^2 \beta}{1-\alpha} \left(\frac{1}{4\theta^2} + \frac{\bar{\gamma}^2}{4\theta^2 (1-\alpha)^2}\right)\right] \\ &- \left[A^{\frac{\alpha}{1-\alpha}} B^{\frac{-1}{1-\alpha}} (\theta - \frac{\sigma}{2}) \frac{\alpha}{2} k^{*\alpha}\right] \end{aligned} \tag{H.15}$$

where $A = \alpha\beta\Big[(1-\alpha) - \frac{\sigma}{4}[(\frac{1}{\theta})^2 - (\frac{\bar{\gamma}}{(1-\alpha)\theta})^2]\Big]$ and $B = \alpha(1+\beta) - \bar{\gamma} + (1-\alpha)(\theta - \frac{\sigma}{2})k^{*\alpha}$.

*** Note that the sign of G_θ is indeterminacy and we show that $G_\theta = \ominus$ If $\left[A^{\frac{\alpha}{1-\alpha}} B^{\frac{-\alpha}{1-\alpha}}\right] + \left[A^{\frac{-(1-2\alpha)}{1-\alpha}} B^{\frac{-\alpha}{1-\alpha}} (\theta - \right.$

$\frac{\sigma}{2})\frac{\alpha^2\beta}{1-\alpha}\left(\frac{\sigma}{2\theta^3} - \frac{\sigma\bar{\gamma}^2}{2(1-\alpha)^2\theta^3}\right)\Bigg] > \left[A^{\frac{\alpha}{1-\alpha}}B^{\frac{-1}{1-\alpha}}(\theta - \frac{\sigma}{2})\alpha k^{*\alpha}\right].$

The sign of G_σ is also indeterminacy and we show that $G_\sigma = \oplus$ If $\left[\frac{1}{2}A^{\frac{\alpha}{1-\alpha}}B^{\frac{-\alpha}{1-\alpha}}\right] + \Bigg[A^{\frac{-(1-2\alpha)}{1-\alpha}}B^{\frac{-\alpha}{1-\alpha}}(\theta -$ $\frac{\sigma}{2})\frac{\alpha^2\beta}{1-\alpha}\left(\frac{1}{4\theta^2} + \frac{\bar{\gamma}^2}{4\theta^2(1-\alpha)^2}\right)\Bigg] > \left[A^{\frac{\alpha}{1-\alpha}}B^{\frac{-1}{1-\alpha}}(\theta - \frac{\sigma}{2})\frac{\alpha}{2}k^{*\alpha}\right].$

Then, we get the implication of the effects of change in interested parameters value on health stock in steady state as follows

$$\frac{\partial h^*}{\partial \bar{\gamma}} = -\frac{G_{\bar{\gamma}}}{G_{h^*}} \qquad = -\frac{\ominus}{\oplus} = \oplus \tag{H.16}$$

$$\frac{\partial h^*}{\partial \theta} = -\frac{G_{\theta}}{G_{h^*}} \qquad = -\frac{\ominus}{\oplus} = \oplus \tag{H.17}$$

$$\frac{\partial h^*}{\partial \sigma} = -\frac{G_{\sigma}}{G_{h^*}} \qquad = -\frac{\oplus}{\oplus} = \ominus \tag{H.18}$$

These imply that an increase in the costs of working after retirement age induces higher health-related human capital accumulation in the steady state. Similar to the an increase of θ, positive externalities from government policies in supporting elderly labour supply, tends to generate more health stock in the steady state, while an increase in the costs of providing these supportive policies, σ, reduces the health-related human capital accumulation in the steady state.

Curriculum Vitae

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