THREE ESSAYS ON DEVELOPMENT ISSUES: INEQUALITY, POVERTY, AND WELL-BEING

By

HWANG, Sooyoung

Dissertation

Submitted to
KDI School of Public Policy and Management
in partial fulfillment of the requirements
for the degree of

DOCTOR OF PHILOSOPHY
IN DEVELOPMENT POLICY

2022

THREE ESSAYS ON DEVELOPMENT ISSUES: INEQUALITY, POVERTY, AND WELL-BEING

By

HWANG, Sooyoung

Dissertation

Submitted to
KDI School of Public Policy and Management
in partial fulfillment of the requirements
for the degree of

DOCTOR OF PHILOSOPHY
IN DEVELOPMENT POLICY

2022

Professor LEE, Siwook

THREE ESSAYS ON DEVELOPMENT ISSUES: INEQUALITY, POVERTY, AND WELL-BEING

By

HWANG, Sooyoung

Dissertation

Submitted to
KDI School of Public Policy and Management
in partial fulfillment of the requirements
for the degree of

DOCTOR OF PHILOSOPHY
IN DEVELOPMENT POLICY

Committee in charge:

Professor LEE, Si Wook, Supervisor

Professor CHO, Man

Professor YOON, Chun Geun

Professor PARK, Jin

Doctor LEE, Kyu Yub

Approval as of December, 2022

ABSTRACT

This dissertation presents the empirical results of a series of studies on the development issues such as income inequality, poverty, and employee's well-being. The objective of this study is to examine empirical evidence of how technological progress affect income inequality in advanced countries as well as poverty reduction in developing countries, and further to explore the effect of work hour reduction policy on employee well-being. This will enable us to expand our understanding on the effects of technological progress on socio-economic outcomes as well as the impact of labor market policy on worker's satisfaction. This thesis consists of three chapters under the broad banner of three essays on development issues: inequality, poverty, and well-being.

The first essay, *Innovation and Top Income Inequality: Evidence from OECD Countries*, aims to explore the effect of innovation on top income inequality in OECD countries over the period of 1980-2017. Innovation is proxied by the number of patent application. Top income inequality is expressed by top 0.1%, 0.5%, 1%, 10% income shares. Sample countries are 34 high-income countries as most innovations occur in these countries. Using cross-country panel and 2SLS estimations to deal with the endogeneity, I found that innovation has positive and significant impact on top income shares in rich countries. These results are also robust using alternative innovation variables such as patent grant and patent citation data. Based on this finding, I propose three kinds of policy options to reduce rising top income inequality: prevent tax loopholes used by the richest and strengthen tax progressivity for the top riches, lastly enhance educational reforms to improve moral values and thus reduce corruptions.

The second essay, *Financial Innovation, Financial Inclusion, and Poverty: Evidence from Developing Countries*, explores the links between financial innovation and poverty in developing countries. For this, a panel was set up for 103 developing countries over the period of 2004-2018. To address endogeneity, OLS with fixed effects and instrument variable strategy are used. As external instruments, latitude of capital city and legal origins are used for European ex-colonies. The results show that financial innovation measured by Financial Inclusion Index shows negative and significant effects on poverty. This is robust when using alternative Financial Development Index created by IMF. Thus, financial innovation is a useful tool for poverty reduction in developing countries. This implies that financial innovation enhances financial inclusion through easier access to finance, which brings about growth and reduces poverty. This encourages developing countries to make efforts on boosting financial innovation to address poverty issue.

The third essay, *The Effect of Work Hour Reduction on Employee Satisfaction: The Case of Working Hour Reduction Policy in Korea*, investigates the effect of standard 40-hour workweek policy on workers' subjective well-being in Korea. The essential part of the policy was to reduce legal work hour per week from 44 to 40 hours, aiming to improve workers' quality of lives. The policy was implemented in time order by industry and firm size from 2004 through 2011. This policy setting provides us a good opportunity to explore the causal impact of the policy by using DID (difference-in-difference) analysis. I use Korea Labor and Income Panel Study (KLIPS) data to estimate the effect of the policy on life and job satisfaction by applying DID estimation method. I found that the policy has significant effect on life satisfaction with leisure and family income while negative effects on job satisfaction overall. This result is also robust when the dependent variables are converted into binary variables.

Keywords: innovation; top income shares; patent; income inequality; financial innovation; financial inclusion; fin-tech; poverty; standard 40-hour workweek; work hour reduction; life and job satisfaction

ACKNOWLEDGEMENTS

I would like to express my sincere gratitude to my supervisor Prof. LEE, Si Wook, for his kind guidance and support throughout my dissertation period. His advice and comments were so helpful and crucial in completing this work. I also would like to express my deep appreciation to other committee members: Prof. Cho, Man, Prof. Yoon, Chun Geun, Prof. Park, Jin, and Dr. Lee, Kyu Yub (at KIEP) for their insightful comments and suggestions that greatly improved the quality of my dissertation. This work would not be possible without the supports of faculty members and kind staffs at KDI School of Public Policy and Management. KDI School has been a cozy home for my study during doctoral journey. I also thank my colleagues who encouraged academic passions each other at KDI School. My last and deepest gratitude goes to my parents.

TABLE OF CONTENTS

Chapter 1. Innovation and Top Income Inequality: Evidence from OECD Countries

Chapter 2. Financial Innovation, Financial Inclusion, and Poverty: Evidence from 103 Developing Countries

Chapter 3. The Effect of Work Hour Reduction Policy on Employee Satisfactions: The Case of Work Hour Reduction in Korea

LIST OF TABLES

LIST OF ANNEXES

LISTS OF FIGURES

Chapter 1

Innovation and Top Income Inequality: Evidence from OECD countries, 1980-2017

1. INTRODUCTION

Recently unequal distribution of income is one of the most critical economic agendas as it raises many social problems such as conflicts between the rich and poor. The "Occupy Wall Street" movement in 2011 complains that the rich 1% exploit the poor 99%. Thus academic studies to explore causes and consequences of rising inequality are growing. As a source of rising inequality, technology attracted much attention in academia as well as policy makers. But top income inequality is relatively less toughed area. Moreover, there is no consensus on core reasons for rising top income inequality in rich countries since the 1980s. This study is designed to fill this gap.[1] Evidences show that technological innovation shows positive impact on growth (Aghion et al., 2015; Galindo et al., 2014; Schumpeter, 1954). However, today lots of scholars focus on dark side of technology, such as surging income gaps between top riches and the rest. Studies argue that rising inequality comes from various sources such as globalization, technology, financial development, institutional change etc. (Alesina et al. 2004; Blanchard, 2021; Krugman, 2007). Among these, this essay deals with technological progress as a source of rising income inequality in rich economies.

The primary concern in this essay is to find causal links between innovation and top income shares. Thus this work maps out the facets of dark side of technology. But doing this enables us to better understand current technological progress as a source of inequality. The importance of technology cannot be overemphasized in the process of economic growth. In a sense, human history is nothing but a chain of technological progress. For instance, the invention of computer and the internet has dramatically changed the way people work and live, which also contributed to the birth of new industries such as information technology (IT) and giant tech firms. Today innovative firms dominate markets by replacing existing product and production process. In this study I explore the relationship between innovation and top income shares in rich nations, testing the hypothesis that innovation aggravates top income inequality in OECD countries. Top income inequality in this essay refers to the share of income flowing to the top 0.1%, 0.5%, 1%, 10% of income earners in advanced countries.

[1] This essay is motivated by several factors. As noted, no consensus has reached on the root causes of rising top income inequality among rich countries since 1980s. Most top richest in the world are inventors of patent and operate their firms based on patents. Moreover, patent and top income inequality in rich countries shows parallel upward trend. Also the patent and top 1% income share between 1980 and 2005 shows the positive relationship in the U.S. (Aghion et al. 2018).

Traditionally technology has been regarded as one of important sources of economic growth (Romer, 1986; Schumpeter, 1954, Solow, 1957). The landmark study by Solow (1957) shows that capital accumulation is critical to growth, but in neoclassical theory with diminishing returns, long-run growth cannot be gained without technical progress (Solow's residual). This residual which is not explained by labor and capital is called TFP (total factor productivity), which is none other than technological progress. Arrow (1962) developed the concept of 'learn-by-doing'[2] as an attempt to overcome diminishing returns. Learn-by-doing makes it possible to accumulate knowledge and skills, leading to externalities on production and long-run growth. Romer (1986) developed the endogenous growth model focusing on human capital and technology for sustainable development. Technology is endogenously developed within the economic system using labor and capital. Technology is also essential in the 'creative destruction'[3] theory, which argues that creative destruction by firms is the main engine of growth and technology endogenously comes from R&D activities by firms, and this technological progress results in higher productivity and growth (Schumpeter, 1954). However, it seems irony that income gap widens as technology advances.

During the past four decades, income inequality is rising globally, especially in rich countries (Deaton, 2013; Piketty, 2014). But the mechanism of rising income gaps still remains puzzling. Although many studies explored the sources of rising inequality, there is no consensus yet about what is the root cause of rising inequality. In our study we explore causal relationship between innovation and top income shares in advanced economies as an attempt to open up the black box. We focus on rich countries because most innovations occur in these countries. For this, we borrowed various indicators for income inequality including the Gini index and top income shares. The former is the most widely used index of income distribution, but recently many scholars use top income shares to measure top income gaps. Data for top income shares are obtained from *World Inequality Database*[4], which provides extensive data on historical movement of income inequality.

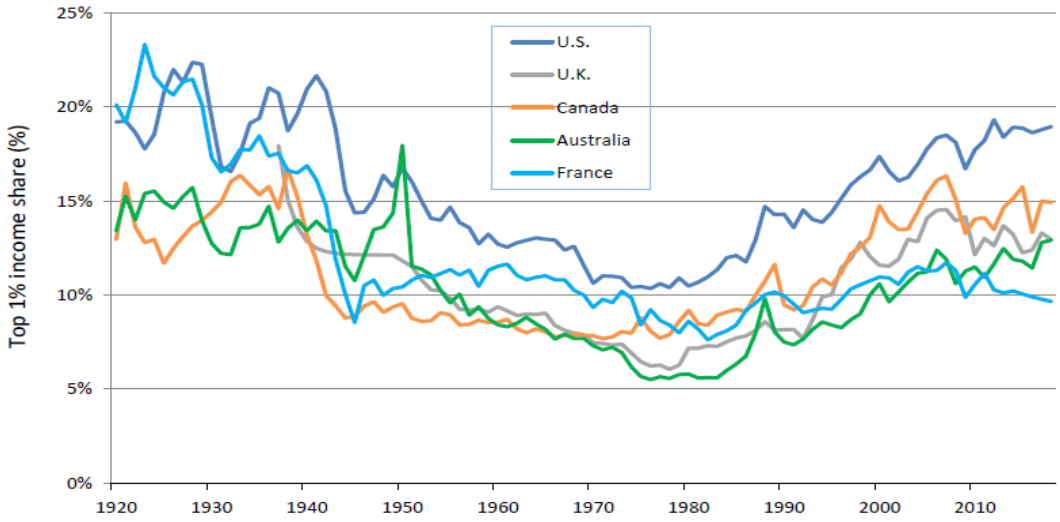
---

[2] This concept was originally created by John Dewey (1859-1952), an American education philosopher. In education theory, this refers to action-oriented learning, meaning that students should experience their environment directly to learn.

[3] This idea appears in *Capitalism, Socialism and Democracy* (1942) written by Joseph Schumpeter, Austrian-American economist, referring to replacement of long-standing practices, old products or production methods by new innovative ones.

[4] The dataset was initially set up in 2011 as *World Top Income Database* to provide free access to country-level income inequality. Over 100 scholars worked together to construct data for the period 20th century for over 70 countries.

Figure 1: Top 1% income share in Anglophone countries plus France, 1920-2018

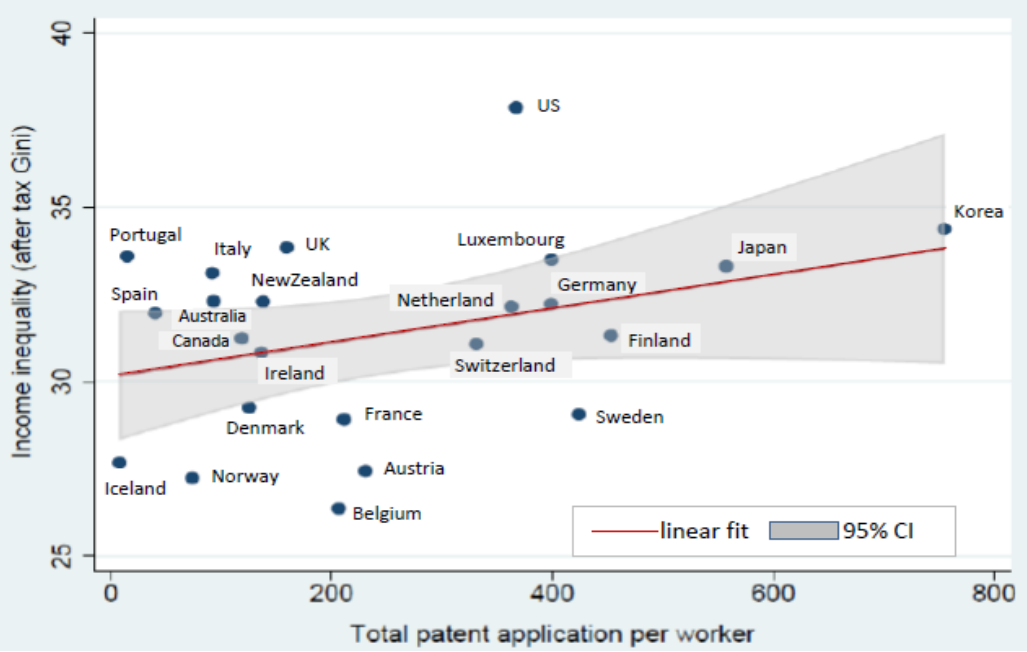


Source: data from World Ineqaulity Database (www.wid.world) and 2018 World Inequality Report

The World Inequality Dataset is constructed based on tax data of each country, making it possible to estimate long-run dynamics of income distribution at the country level. Regarding income inequality study based on tax data, the pioneering work was done by Kuznets (1953), and then Atkinson and Harrison (1978), and more recently by Piketty (2003) who analyzed long-term movements of top income share in France. Atkinson (2005) conducted similar study to Piketty by exploring empirically long-term trends of top income shares in the UK. However, as far as empirical study of inequality is concerned, the US is the most popular target country (Piketty et al. 2003; Saez and Zucman, 2016). In fact, the richest top 1% income share in the US has sharply increased after the 1980s, showing 10.5% in 1980 and 18.8% in 2019 as shown in Figure 1. This ratio is relatively higher than peer advanced countries, compared to 8.2% and 12.9% in the UK, 7.2% and 10.0% in France, during the same period. The rise of top 1% income share since 1980s is common trends across advanced countries as shown in Figure 1. If this is true, then what is the major source of this rising top income gaps in advanced countries? The answer of this question is the primary theme in this empirical study. In fact, income inequality is highly complex phenomena formed by various interacting forces such as technical change and wide spread of globalization (Cozzens, 2008). Recent academic studies show that industrial automation and international trade has changed landscape of local labor markets across rich countries, providing more benefits to skilled and educated workers while unskilled workers lagging behind, leading to rising income gaps in rich countries (Acemoglu et al. 2019;PIIE, 2020).

Technology and trade are underlying factors for rising income inequality, but more important usual suspect may be tax policy as tax is the final tool for income redistribution. Technical progress reduces the demand of factory workers while it raises the demand for high-skilled brain labors such as scientists. Trade also contributes to widening income gaps through changes in organization of labor market which prefers skilled labor. Tax has a highly critical role in bridging income gaps, but in reality it widens disparity between top earners and the rest by applying favorable tax rate for the rich in rich countries. In fact, tax rate in the US and other developed countries has become less progressive during the last 50 years, making tax rate of the rich declined.[5] Tax policy and government role in combating inequality is discussed later in Section 7. Lots of studies analyzed the source of rising inequality, but not many deals with innovation as a driver of inequality. Moreover, those works showed mixed results on the links between innovation and inequality by sample size or different period of time for analysis. Also, existing studies tend to emphasize on positive impact of technology on growth, but relationship between innovation and rising top income inequality has not treated widely. In this vein, this work is meaningful and contributes to the existing literatures.

Figure 2: Scatterplot of innovation and income inequality, 1990-2015



Source: Data from SWIID (Solt, 2020) and www.wipo.int

Notes: Inequality is measured by after-tax Gini (SWIID). Patent is normalized by 100,000 workers.

[5] During the period 1950-2018, average tax rate of bottom 10% of income distribution rose from 16% to 26% in the US while tax rate of top 1% decreased sharply from 57% to 29% on average. Surprisingly, tax rate of Top 400 (Forbes list of super-rich) dropped from 70% to 23% during the same period in the US (Saez and Zucman, 2019).

History reveals that technological progress increases inequality through widening wage gaps between skilled and unskilled workforces. This relationship is well depicted in Figure 2, implying that innovation proxied by number of patents per worker has positive correlation with inequality expressed by after-tax Gini coefficient. Figure 2 embodies the essence of this essay about the relationship between technology and income inequality. I am sure that this study may enrich causal mechanisms through which technology widens income inequality in rich countries. Basically this essay explores the effect of innovation on top income shares in 34 advanced economies. My finding shows that innovation has positive and significant impacts on rising top income shares. For empirical estimation, I include several control variables which are frequently used in the previous similar studies. Human capital is proxied by school enrollment rate (tertiary). Globalization is represented by KOF (Swiss Economic Institute) index, the most widely cited indicator for globalization. Financial development is represented by private credit to GDP ratio. The size of government proxied by the ratio of public expenditure to GDP is also included for control variables.

As confirmed in Figure 1, top income inequality has sharply risen since 1980s among rich countries and accelerated again after global financial crisis of 2007-2008. Surging inequality animated scholars to dig out the causes and consequences of rising income gaps in rich countries (Ostry et al., 2014). This essay may contribute to existing literatures in several ways. This work offers validating the results previously obtained in similar studies. Also this empirical work offers robust results on the effect of innovation on top income inequality. In more detail, first, this work uses various indicators for innovation and top income shares. Patent application and granted data are used as measures of innovation, and patent citations data are also used to prove the robustness. The number of patent is quantity indicator of innovation while citation and granted data are quality measure of innovation. Second, this study uses cross-country panel for 38 years (1980-2017), which may be the longest and most recent dataset to study the effect of innovation on inequality. Third, my findings will enrich existing evidences regarding the relationship between innovation and income inequality.

This essay is configured as follows. Section 2 explains theoretical frameworks such as a Schumpeterian growth model and skill-biased technological change. Section 3 reviews literatures and Section 4 explains variables used in the analysis and discusses construction of data. Section 5 elaborates empirical model and econometric methodology while Section 6 presents main results. In the discussion part of Section 7, the debate on tax policy and the government role to combat rising income inequality is presented. Section 8 concludes.

2. THEORETICAL FRAMEWORKS

To motivate my analysis, I would like to provide a couple of theory frameworks in which innovation and income inequality are correlated each other. Especially I focus on the links between technological change and top income shares based on Schumpeterian endogenous growth model. Also I would like to present theoretical structure to account for skill-biased technological change in the perspective of supply and demand of labor.

2.1 Schumpeterian growth model

I want to discuss a simple Schumpeterian growth model to describe why increased R&D productivity boost up top income inequality based on Aghion et al. (2019) and Jones and Kim (2014). In R&D-based growth model, population is important because it increases the supply of R&D workers, stimulate expanding market size, and thus increase the demand for new technology. As population size is growing, the rate of technology advances and income growth rises accordingly, which are usually called "scale effect". In a Schumpeterian innovation model, first of all, we need to think about the role of entrepreneurs. There are two kinds of entrepreneurs; incumbents and new entrants. Basically innovation is driven by entrepreneurs and it is classified into 'productive innovation' and 'defensive innovation'. The former is performed by both the incumbents and new entrants, leading to the increase in productivity. Instead the latter is undertaken by incumbents to protect their monopolistic profits by blocking new entrants, which does not increase productivity. Therefore, our major concern in this study falls on productive innovation to explore income inequality caused by differentiated productivity between innovators and non-innovators.[6] In this model labor productivity is expressed by the following form when individual innovative firm produces intermediate i at time t : $y_{it} = q_{it}l_{it}$, where y indicates output, l represents the amount of labor, and q symbolizes labor productivity (in this case, capital is supposed to be fixed). When there exists new 'productive innovation' in industry i in time t, the productivity of the industry increases by multiplier (η_H) as the following equation.

$$q_{i,t} = \eta_H q_{i,t-1},$$

[6] Schumpeter explained innovation as bringing about **new products**, new production process, opening new markets, new way of organizing the firms, and new source of supply. Broadly four types of innovation are introduced in Appendix Table A3: products, process, incremental and radical innovations. In this essay, I focus on **product innovations** based on patent ownership and the invention of new products, which would be the source of high productivity and exclusive profits.

where $q_{i,t}$ is current technology vintage, $q_{i,t-1}$ is the previous technology vintage, and η_H is a multiplier term. Therefore innovator firms in this sector obtain technology lead of η_H over potential competitors. Now suppose incumbent's technology is imitated by other firms, so technological lead enjoyed by existing firms shrinks from η_H to η_L with $1<\eta_L<\eta_H$. That is, the technological lead enjoyed by existing firms has two values: η_H with innovation and η_L without innovation. Let us think about income share for entrepreneurs and workers. As labor market is composed of entrepreneurs and workers, the calculation of the worker's wage share is straightforward when we have information on entrepreneur's income share. To obtain income share of entrepreneurs, we need derive the equilibrium profits of the monopolist innovator. These profits depend on mark-ups and aggregate output, and mark-up price imposed by existing producers equals to technology lead (η_{it}) times marginal cost ($MC_{it} = w_t/q_{it}$). Innovation allows technological leaders to enjoy profits and temporarily raise mark-ups from η_L to η_H. Then, suppose μ_t indicates a fraction of high mark-up industries at time t (that is, $\eta_{it} = \eta_H$). Overall, entrepreneur's income share at time t is expressed by the ratio of equilibrium profits to final output, and worker's wage share may be easily obtained from that ratio.[7] Now we can think about top income share of innovative entrepreneurs. In this essay I use the number of patents per worker to measure innovations, assuming that total volume of innovations increases as the population size grows. Therefore the number of patents per worker has the similar property to innovation rate μ in this model. In general, most top incomes belong to innovative entrepreneurs, in other words people who are related with innovations or inventions as long as the ratio of worker to entrepreneur (L) is sufficiently large. To illustrate the relationship between innovation and top income inequality, we can consider following two cases (Aghion et al. 2019): Case 1 is $\alpha/100 < \mu/(1+L)$ when top α % income earners are made up only of entrepreneurs who succeeded in innovation. But in this case a marginal change in innovation has no impact on top income shares.

$$\text{Top\_}\alpha\ \% \ = \frac{\alpha\ (1+L)}{100}\left(1 - \frac{1}{\eta H}\right)$$

[7] $\text{Entrepreneur\_share}_t = \frac{\mu t \prod H,t + (1-\mu t)\prod Lt}{Yt} = 1 - \frac{\mu t}{\eta H} - \frac{(1-\mu t)}{\eta L}$, $\text{worker wage\_share}_t = \frac{w_t L}{Yt} = \frac{\mu t}{\eta H} + \frac{(1-\mu t)}{\eta L}$, where μ_t is innovation rate at time t (fraction of innovative sector), $\prod$ is equilibrium profits, Y_t is total output, η is technical lead.

In contrast, the following case is more realistic to explain top income inequality. This case is $\mu / (1+L) < \alpha/100 < 1 / (1+L)$ when top α % income earners is made up of all entrepreneurs who have succeeded in innovation activity, plus a fraction of those who have not. In this case,

$$\text{Top\_}\alpha\ \% = \mu \left(\frac{1}{\eta L} - \frac{1}{\eta H}\right) + \frac{\alpha\ (1+L)}{100}\left(1 - \frac{1}{\eta L}\right)$$

the rise in the number of innovations results in an increase of top α % income share. That is, innovation shows positive impact on the rise in top income inequality. Especially if applying partial derivative by innovation rate, then we can get the following positive result.

$$\frac{\partial \ln Top\_\alpha\ \%}{\partial \ln\ \mu} = \frac{\mu}{\text{Top\_}\alpha\ \%}\left(\frac{1}{\eta L} - \frac{1}{\eta H}\right) > 0$$

The above equation implies that innovation increases top income inequality and the elasticity of top income share with respect to the number of patents per worker is positive when the number of patents is proportional to the number of successful innovations. If innovation rate is fixed, the elasticity is diminishing in α, decreasing mark-ups of non-innovators (ηL) and increasing mark-ups of innovators (ηH). In this model, it is evident that innovation raises top income inequality. Moreover, we can conceptualize the links between innovation and top income shares by using other renowned theoretical framework of Pareto distribution.[8] Top bracket of income distribution may be characterized by the power law (Pareto, 1896). Heterogeneous entrepreneurs make efforts to gain exponential growth for their income. Also in a given production domain, square root of people produces half of the total output. In this model there are two kinds of dynamic forces to determine income distribution (Jones and Kim, 2014). One is incumbent entrepreneur's efforts for innovation and growth, which increases income inequality through exponential growth in innovators income. The other one is new entrant's efforts by creative destruction, which decreases income inequality through the replacement of existing entrepreneurs by new ones. The interaction process between these two forces results in Pareto distribution. For instance, wide spread of globalization and development of IT industry to expand market size by firms boost income inequality, whereas government policies for innovation encouragement and deregulation to induce new entry of innovative entrepreneurs lead to decrease in income inequality.

[8] Vilfredo Pareto (1848-1923), Italian economist, argued that 20% population owned 80% national wealth in Italy in the late 19th century. Pareto distribution is called Pareto principle or the 80-20 rule. This phenomenon occurs in many part of society including arts, businesses, even in academics. For example, 20% best-selling cars account for 80% of total profits.

2.2 Skill-biased technical change (SBTC) model

The rising income inequality for the last several decades is most probably because of acceleration in skill-biased technological change (Acemoglu, 2002). The widening wage gaps in the U.S. in 1980s attributed to SBTC, combined with the spread of computer and IT industry (Card et al. 2002). Basically this model is about the demand and supply of labor caused by technology change. SBTC is a shift of production method that favors skilled over unskilled labors through increased productivity and relative demand. This channel is known as the foundation of relationship between technology and inequality. This model goes back to Hicks (1932).[9] He argued that the relative price between labor and capital propels firms to reduce relatively costly factor. Traditionally technical change is viewed as factor-neutral.[10] But these days it is skill-biased. According to Acemoglu (2002), technological change in 20th century is skill-biased while that of 19th century seems like skill-replacing.[11] SBTC is based on the idea that technical progress is factor-biased, meaning that the demand of skilled labor increases as technology develops while unskilled labor is replaced by capital such as machines. But technology also creates new jobs, known as "compensation effect". The debate on the links between technology and employment usually focused on this effect. Labor is heterogeneous by education or job training, classified into skilled or unskilled (Griliches, 1969). Evidences show that demand for skills rises as capital deepens, implying that skills and capital are complementary. Some argues that technology is embodied in capital, thus the demand for skills increases. For instance, jobs in IT sector are usually for skilled labor. The factor-bias brought technology into the center of inequality debate. To show conceptual framework of the SBTC, we can consider supply and demand dynamics for both skilled and unskilled labor as shown in Appendix Box 1.

---

[9] John R. Hicks (1904-1989), a British neo-Keynesian economist, introduced the concept of 'elasticity of substitution' between capital and labor. We call the elasticity as 'marginal rate of technical substitution' (MRTS), which tells how firms mix labor and capital to maintain possible output level according to changes in relative price of production factors.

[10] The debate on the impact of technology on employment show long history even before Adam Smith. Classical economists thought that labor and capital are hard to substitute each other but neo-classical and Keynesians thought it is possible. Neo-classical argues that temporary unemployment caused by technical change will be solved by additional supply of capital and wage adjustment in the labor market. Keynesians does not state explicitly on the unemployment caused by technical change but they assert that economy can achieve its equilibrium even under the incomplete employment conditions.

[11] Acemoglu argues that in the 20th century, increased supply of skilled labor caused development of skill-complementary technology because it is more profitable. In contrast, in the 19th century, increased supply of unskilled labors has caused development of 'skill-replacing' technology; In Britain skilled artisans lost jobs with the advent of machines and factory line.

However, despite of clear explanation on inequality, SBTC hypothesis has some limitations (Acemoglu, 2019; Card et al. 2002). First, SBTC explains just small part of the whole story of income inequality. In fact, income inequality shows a considerable heterogeneity across rich countries, implying that technology alone cannot explain rising income gaps. Therefore we need consider other sources such as country-specific institutions, historical and political context etc. to explore more accurately the causes of rising income inequality. Furthermore, many argue that SBTC hypothesis underestimates other sources such as globalization, labor union, government size, deregulation etc. (Alesina et al. 2004; Krugman, 2007; Reich, 2008). Second, SBTC model cannot explain falling real wages of low-skilled workers. Under this model, real wages of all workers must go up due to the rise in labor productivity. But historical data show that real wage of low-skilled workers has fallen and stagnant in the US during years 1988-2008. SBTC predicts that increased demand for skilled labor raises skill premium and then boost up real earnings of all workers (Katz et al. 1992; Acemoglu et al. 2012). Moreover, wage disparity stabilized in the US during the 1990s, despite rapid progress in IT technology. Also SBTC cannot explain the closing of male-female wage gap, stable black-white wage disparity, and sharp increase in education-driven wage difference between young and senior groups during the 1980s in the US.

Recently there is a fresh argument that individual innate ability is much more important than skill itself as a determinant of individual income (Bartel et al. 1999; Galor et al. 2001; Taber, 2001). They argue that rising income gaps in rich countries could be clarified by the fact that rewards on worker's innate ability are greater than rewards for skills. Taber (2001) asserts that monetary rewards on individual innate ability or unobserved capacity are greater than skill itself measured by education level because technology changes rapidly these days. This trend has coincided with rising wage disparities between skilled and unskilled labors. Therefore, rising demand for skilled labor is caused by complementarity between technology and innate ability, not by complementarity between technology and skilled labor (college education). Despite some limitations, however, SBTC model could be useful tool to describe recent income inequality and there is a consensus that current technological change favors skilled labors, replaces the exiting tasks occupied by unskilled workers, and thus aggravates income inequality.

3. LITERATURE REVIEW

In this part, I examine a group of literatures exploring the links between innovation and income inequality in order to gain some insights for my following empirical analysis. As mentioned above, income inequality is a popular research topic, but top income inequality arising from technical change in advanced countries has received relatively smaller attention. Therefore, it is necessary to look closely into prominent empirical literatures studying the links between innovation and top income shares. Among these literatures, study by Jones and Kim (2017) would be placed foremost. Basically they used Schumpeterian growth model to describe the dynamism of top income inequality. They argued that there are two kinds of innovations to bring about growth; innovation by incumbent entrepreneurs and the creative destruction by new entrants. The existing incumbents accumulate experience and knowledge in the process of production while the new entrants innovate through the creative destructions. Innovation by incumbents increases top income shares through exponential rise in their income following the Pareto distribution. But creative destruction by new entrants reduces inequality as new entrant's innovation affects the incumbent's R&D efforts, making growth more inclusive. Thus both innovation by existing firms and creative destruction by new firms are the main drivers in dynamism of top income inequality in this model.

The empirical study by Aghion et al. (2018) is also noteworthy. They explored the causal links between innovation, top income shares, and social mobility by analyzing cross-state and cross-commuting zones panel data in U.S. Their results report that there are positive and statistically significant links between innovation proxied by the number of patents per labor and top income inequality represented by top 1% income share. They prove that innovation such as patents or trademarks increases monopolistic profits of incumbent entrepreneurs, and this serves as the primary source of top income inequality. They conclude that technical innovation increases top income shares in the U.S. but the relationship between innovation and standard inequality such as the Gini index are not statistically significant. They also show that innovation by new entrants influences positively on social mobility in the U.S. Another similar researches by Benos et al. (2019) and Law et al. (2020) also deserve deep attention. The former analyzed unbalanced panel data for 29 economies during the years of

1978-2015 to identify the effect of innovation on top income inequality. They used number of patents per labor to measure innovation and top 1% income share to gauge income inequality. Their finding indicates that innovation activities have positive and statistically significant effects on reducing top income inequality applying OLS regressions as well as instrument variable strategy. They constructed country-level knowledge spillover instrument by using OECD patent citation database, imitating the technique used by Aghion et al. (2018). In contrast, Law et al. (2020) obtained opposite results by analyzing the effect of innovation on income inequality among 23 rich countries. They used three different income inequality indices such as Standardized World Income Inequality Database (SWIID), University of Texas Inequality Project (UTIP), and Estimated Household Income Inequality (EHII). For innovation proxy, they used the number of patent application and granted data per worker. Their findings document that innovation broadens income inequality, which is also robust and significant when applying instrument variables such as one-year lagged innovation and R&D intensity (percent of GDP). In addition they find that globalization and financial development influences positively on rising inequality by applying interaction terms between innovation and the two variables. For analysis, globalization and financial development are measured by KOF index and private credit to GDP ratio, respectively.

Putting together above studies, the most noteworthy point is that innovation has mixed effects on income inequality depending on sample countries and unit of analysis. Moreover, a set of papers is worthy of close attention, analyzing the links between innovation and individual income by using micro-level data. Usually the study about the causality between innovation and income inequality uses two kinds of datasets; micro and macro. The former uses individual or firm-level data while the latter uses country or regional-level data. Unlike many studies using macro-level data, there are considerable strands of literatures analyzing causal impact of innovation on inequality based on micro-level data. Frydman et al. (2015) analyzed firm-level micro data, finding that there is a positive links between innovation and firm executive pay. They argue that pay inequality between top executives and general workers is caused mainly by technical innovation, and this innovation increases the value of investment opportunities. Aghion et al. (2018) constructed individual and firm-level micro

dataset including income, patents, IQ etc. over the period 1988-2012 in Finland to estimate returns to invention for individual innovators. They find that inventors collect just 8% of returns to invention, entrepreneurs take 44% of total gains while blue collar workers take 26%, and the rest goes to white collar workers. Akeigit et al. (2017) analyzed patent and individual-level micro data in the U.S., finding that there exists positive relationship between patent intensity and social mobility during the past 150 years. In fact, the initial stage of empirical works on the links between innovation and income inequality focused on wage gaps between educated and less educated workers based on household micro data. These studies usually use the concept of 'skill-biased technical change' to explain wage gaps between skilled and non-skilled labors. Usually skilled workers refer to college graduates while non-skilled workers high school graduates. The advent of new technologies or new production processes may raise relative demand of skilled labors, leading to the rise in skill-premium (Acemoglu and Autor, 2011; Goldin and Katz, 2007; Katz and Auto, 1999). This skill-premium refers to the relative wage ratio between skilled and non-skilled workers. According to one influential study by Goldwin and Katz (2007), skill-premium or college education premium has increased since the early 1980s in U.S. and this trend lasted until the mid-2000s. This suggests that rising demand for skilled workers has been triggered by technological progress. However, the supply of college graduates does not meet the rising demand of skilled workers, meaning that the race between technology and education is tilted toward technology's advantage (Goldwin and Katz, 2007). Moreover, these days the wide spread of automation and computer systems has been destroying simple and repetitive tasks performing by hand workers (Acemoglu and Auto, 2011).

Until now I've reviewed how technological progress affects income inequality. However, besides technological progress, there are other things to affect income inequality as proved in previous literatures. Therefore, it is meaningful to review those literatures because it gives us information about control variables included in my empirical models. First of all, globalization is most widely mentioned as a usual suspect of rising income inequality in various literatures. The variable of globalization can be broadly classified into two types: trade and financial globalization. According to IMF (2007), developed countries are

characterized by financial globalization while developing countries are characterized by trade globalization. Most recently, Massa, Cheng and Zhang (2021) analyzed 8,760 firms from 91 countries for the period 2001-2013 to explore the impact of financial globalization on top 1% income changes. They find surprising result that the inflow of portfolio investment through mutual funds decreases top 1% income. The major channel for this is that a large inflow of foreign capital induces local rich families to sell their profitable assets, influencing top income share reduced. Financial globalization takes place through two main channels such as FDI (foreign direct investment) and portfolio investment (stocks or bonds), and lots of studies have proved heterogeneous effects of these two elements on income distribution; FDI raises income inequality largely due to skill biased outsourcing of jobs while portfolio investment plays an insignificant role in rising inequality (IMF, 2007; Jaumotte et al. 2013; Milanovic, 2005). But the study by Atanasova et al. (2021) finds different results that globalization measured by KOF index does not affect income inequality represented by Gini index in 20 European economies. They also found that globalization shows positive and significant impact on GDP only in developing countries, but GDP elevates income inequality only among advanced economies.

Another prominent study by Krugman and Venables (1995) gives us deep insight about the effect of globalization on income disparity among countries. They divide global economy into two regions; core and periphery, which represents advanced and emerging countries respectively. They argue that in the early stage of globalization the income of core countries rises at the periphery's expense such as cheap labor cost, but as globalization grows further, the advantage of core countries slows down and leads to rising income among peripherals at the core's expense. The mechanism for this dynamics is due to the increase in transport cost and wage as globalization expands. This is a simple model to explain income disparity between countries and also a useful tool to explain the convergence and divergence of world economy. Asterou et al. (2014) analyzed EU-27 countries panel data during the years 1995-2009, finding that trade tends to equalize income while financial globalization through FDI, capital flow and stock market drives the rise in income inequality. Among these factors, FDI was the highest contributor to income inequality. They used Gini index as a proxy of income

inequality, globalization indicators such as capital account openness, trade volume (percent of GDP), and FDI. But many empirical studies showing opposite results also exist. Trade openness may widen income inequality due to variations in returns to education and skills (Stiglitz, 1998). Other studies by Freeman (1995), Richardson (1995), and Bergh et al. (2010) also find that trade increases income inequality. Taken all together, financial globalization and trade shows mixed results on income inequality by the different sample countries and time period. Financial development also influences pattern of income distribution. Broadly there are two kinds of theories about the links between finance and income inequality. One is inverted-U shape correlation between finance and income inequality, so-called 'financial Kuznets curve'.[12] Financial development raises income inequality to a certain threshold and then inequality declines after the threshold (Greenwood et al. 1990; Fu et al. 2021; Kim et al. 2011). The other theory is negative and linear links between financial development and income inequality (Galor and Zeira, 1993; Banerjee and Newman, 1993; Clarke et al. 2003). The development of financial markets and financial intermediaries provide more chances for the poor to borrow money and invest in profitable instruments, contributing to reducing income inequality. To measure the degree of financial development, the credit-to-GDP ratio and the number of bank branches (per adults) are used. Human capital and institutions are also frequently cited as contributing factors to inequality.

Lee and Lee (2018) analyzed cross-country panel for 95 economies over the period of 1980-2014. They find that educational attainment reduces income inequality, but higher per capita income, trade openness and technological progress make income and educational distribution more unequal. Overall, however, existing studies imply that educational expansion shows mixed impact on income distribution. For institutions, evidence shows inconclusive results on the links between institutions and inequality. A recent study by Asamoah (2021) shows that institutions have quadratic effects on income inequality in rich countries, but negative effects in developing ones, using WGI (institution) and the Gini for 76 countries across the world.

[12] The famous study by Kuznets (1955) found that links between income inequality and economic growth showed inverted-U shape pattern. In initial stage of economic growth, inequality rises, leading to a rise in the income of high paying sectors. But at the later stage of growth the distribution of income becomes more equal. For instance, during the process of transition from agriculture to industry in UK and the US, income inequality sharply rose, but declined after World War I.

4. DATA AND VARIABLES

In this section, I explain variables used in the empirical model and aslo elaborate the construction process of cross-country dynamic panel data. The source of data and the main characteristics of each variable will be discussed. Basically this essay focuses on advanced economies because they have more innovation activities than developing economies.[13] The list of thirty-four high-income countries in our sample is presented in Appendix Table 1.[14]

4.1 Variables

The dependent variable is income inequality indicators such as top income shares. The list of variables used in this essay is provided in Appendix Table 2. For the top income inequality, we use top 0.1%, 0.5%, 1%, and 10% income shares and additionally Gini as a standard indicator for income distribution. The main independent variable is the number of patents per worker to represent innovation level of each country. Other control variables are also used. They are widely employed in the previous studies, including human capital (life expectancy), institutions (World Bank WGI), globalization (KOF), financial development (private credit-to-GDP), government size (public expenditure-to-GDP) and macroeconomic indicators such as unemployment rate and real GDP per capita.

4.1.1. **Innovation**. The data on innovation are taken from World Intellectual Property Organization (WIPO)[15]. As a measure of innovation for each country, I use the number of patent application per worker and patents grant per worker. I use per capita patent, not the total count of patent itself, in order to normalize the size of each country to capture the idea that larger countries tend to innovate more. Labor force data are taken from World Bank WDI. According to WIPO, patent refers to exclusive rights assigned to invention, which can be product or process showing new way of doing something or new solutions for problems.

---

[13] Among 38 OECD member countries, only 34 countries are included in the sample dataset. I dropped 4 countries that have gained the OECD membership recently after 2015, including Latvia, Lithuania, Colombia, and Costa Rica.

[14] Appendix Table1 provides list of sample countries and country-specific information on key variables such as top 1% income share, Gini index, and R&D intensity of each country to capture the inequality and innovation roughly.

[15] The WIPO, a self-funding agency of the UN, was founded in 1967. Its mandate is to protect intellectual property right by enhancing cooperation among countries, holding 193 member countries. Its database is the most comprehensive one for the intellectual property activities in the world. It collects data from various public organizations of each country, including USPTO(US), EPO (Europe), EAPO (Eurasia), and ARIPO (Africa).

The patent owners possess the exclusive power to prevent others from using the patented invention for the specific period, usually 20 years from the application of the patent. In fact, patent statistics as a proxy for innovation and technological progress is widely used in academic papers since it is regarded as the outcomes of successful innovations (Benos et al., 2019; Bottazzi and Peri, 2003; Tebaldi and Elmslie, 2013; Wang, 2013; Aghion et al., 2019). But there exist skeptical views on this usage, arguing that innovations are not affected by patents and also innovation policy varies from one country to another (Boldrin and Levine, 2009; Lerner, 2009). Furthermore, not all innovations are transformed to patents. Also the simple counting of patent may possibly ignore wide heterogeneity in economic value of each patent. Therefore, some argues that alternative measures of innovation including trademarks or R&D expenditure are better proxy for innovation. But these measures are also problematic as a representative proxy of innovation in that all trademarks do not reflect innovations and not all R&D expenditure generates innovations. Moreover, R&D expenditure is not the result of innovation but the source of innovation. Despite the above shortcomings, however, patent is widely used as a measure of innovation or technological progress (Griliches, 1998).

In addition I use patent citation data as qualitative measure of patent in the robustness check. Citation data are taken from OECD Patent Quality Indicators Database, which provides various qualitative indicators of patent such as citations, claims, and family size.[16] Thus, citation data show us technological spillover by the subsequent patents or inventions. Also citation data are useful to analyze knowledge transmission among related inventors, firms and countries using the citing and cited patent data (Hall et al. 2001). But there exists a time gap between patent application and grant, which is known as a 'grant lag', leading to truncation bias of data (Aghion et al. 2019). To overcome this, using shorter sample period is an effective way. I use patent grant data in the robustness checks to prove the main results. Overall, number of patent (application and grant) and citation data is widely used in the academic literatures as a quantity and quality indicator of innovation activities.

[16] The claims of patent capture the breadth of the patent (Lerner, 1994; Akcigit, 2016). The generality index is based on the information on the number of citations received and technology class of patent these citations come from (Squicciarini et al. 2013). The family size of patent refers to the number of public offices at which the patent is protected. Moreover, OECD REGPAT database offers information on the nationality of inventors and applicants of specific patent.

4.1.2 **Income Inequality**. Data for income inequality are obtained from several sources. Data for top income shares come from World Inequality Database (WID) and Gini index are quoted from Standardized World Income Inequality Database (SWIID). WID dataset provides historical time series information on various types of top income shares, among which we take top 0.1%, 0.5%, 1% and 10% income shares of each country. Basically WID database provides the most extensive data on the income distribution of 167 countries for the period of 1870-2019, but I restrict attention to the time span of 1980-2017.

Besides top income shares as dependent variables, I also use standard indicator for income inequality, Gini index, which is obtained from the SWIID. The Gini coefficient is the most widely used indicator for income inequality among scholars. Gini index refers to the relationship of cumulative shares of the population to the cumulative share of the equalized disposable income of individuals. If index value is zero, it implies that income is perfectly or equally distributed in a country, whereas the index of one (or 100%) represents the maximum income inequality among individuals meaning that one person has all the income and the others have nothing in an economy. The Gini index enables us to test whether the Kutnetz Curve exists in our sample countries. That is, using advanced countries income inequality data of Gini, I check right-hand side of inverted U-shape links between income inequality and economic development.[17] So we may test traditional theory that higher rate of technical progress and economic growth is associated with lower level of income inequality among advanced economies. The SWIID provides most comprehensive Gini indicators for more than 160 countries, which are very useful in the cross-country comparative analysis on income distribution. It provides two kinds of Gini index computed by disposable income and by market income. In this empirical study I use the disposable income Gini index to capture the after-tax income distribution of each country. Also in other similar related studies the Gini index by UTIP is widely used to capture the wage inequality among workers in the manufacturing sector.[18]

[17] Recently in most advanced countries income inequality shows highest for the last 50 years. This trend is definitely against the Kuznets curve hypothesis that inequality declines along with economic development. Thus, lots of empirical works focus on finding the determinants of rising income inequality in advanced economies. Technology is one of them.

[18] UTIP (University of Texas Inequality Project) is a research project for measuring inequality in wages and earnings in manufacturing industry. They use Theil's T statistic to compute inequality index from industrial, regional data. Based on UNIDO statistics, they provide global dataset that computes wage inequality index for 151 countries from 1963 to 2015.

4.1.3 **Control Variables**. I add six control variables in the estimation model, which are widely used in previous related literatures. First, I include unemployment rate to control for business cycles of each country. Country-specific business cycles will directly influence on both innovation and top income shares. Another macroeconomic indicator, real GDP per capita captures the level of economic development which is widely known to reduce income inequality (Yang et al. 2017). Both data are taken from World Bank WDI indicators. Human capital is also considered as a control variable, measured by school enrollment rate for tertiary education as used in previous studies (Cheung et al. 2012; Machin et al. 2007; Oketch et al. 2014). Data for tertiary education enrollment are obtained from World Bank WDI indicators. Globalization is widely observed to have significant effects on rising income inequality in developed as well as developing economies (Bergh et al. 2010; Mah, 2013). To measure globalization level of each country, I use the KOF index[19], which is one of the most comprehensive measures of globalization at the country level. KOF index measures the degree of globalization based on three dimensions: economic, political, social dimensions. Among these, I use only economic dimension, ranging from 0 to 100 showing the higher index the higher globalization level. The economic dimension of KOF index includes trade openness and capital liberalization. The data are taken from the KOF website.

Generally most top income earners are usually individuals who work in the field of finance sector in advanced countries (Bell and van Reenen, 2014). This is why I've included financial development as one of control variables. In fact, lots of empirical studies have proved that financial development tends to widen income disparity (Banerjee and Newman, 1993; Tan and Law, 2012). As proxy of financial development, I use private credit-to- GDP ratio, quoted from World Bank WDI indicator. The size of government expenditure also affects both top income shares and innovation activities in an economy. Government size is measured by the ratio of public expenditure to GDP, which is also obtained from the World Bank WDI indicator.

[19] Swiss Economic Institute (KOF) was established in 1938, as one of Switzerland's oldest economic research institute. KOF globalization index is developed by Dreher(2006) for the first time, then renewed by Dreher et al (2008), and now has become one of the most commonly used globalization indicators in empirical researches. This index basically covers all the countries in the world from 1970.

4.1.4 **Instrument Variables**. One of the fatal weaknesses in estimating model for the impact of innovation on income inequality would be so-called endogeneity problem. That means that explanatory variable of innovation correlates with error term in empirical model, which leads to reducing the accuracy of empirical estimation. To address this problem, I've used instrument variable (IV) method to improve the reliability of estimation and draw the causal links between innovation and top income shares. Basically I apply a couple of instruments including research and development (R&D) intensity (R&D expenditure-to-GDP ratio), IP (intellectual property) service charge receipts in Balance of Payment (BOP) of each country. These instruments are already used in the previous empirical studies to solve endogeneity issues (Aghion et al. 2019; Benos et al. 2019; Law et al. 2020). Data on R&D expenditure comes from World Bank WDI indicators. This instrument is calculated by the ratio of R&D expenditure to GDP. Data for IP service charge receipts, which are incomes from the rents of intellectual property, are obtained from IMF database. I apply the natural log for IP service charges receipts (BOP, current U$). Especially I handle IP service charge instrument as the key instrument in my study to draw the causal influence of innovation on income inequality. Countries that have higher number of quality patents will receive larger amount of service charges for the intellectual property rights including patents, trademarks, copyright, and designs from other countries (Benos et al. 2019). This is why I use receipts, not payment data. Basically this service charge comes from non-residents, meaning that it is an exogenous variable. Also lots of studies proved that intellectual property rights protections have positive effect on innovations (Aghion et al. 2015; Beladi et al. 2016). Therefore I expect that service charge instrument is correlated with innovation. Moreover, to avoid any doubts that service charge may affect indirectly top income inequality I will use t+3 lead value of service charge receipts. I assume that t+3 periods for service charge may be exogenous with regard to top income inequality of time period t. Another reason for using t+3 lead value is related to "grant lag" of patent. According to EPO, average time span from patent application to grant is almost 4 years (45.3 months). So I apply t-1 period of patent application data and t+3 periods of service charge.

Table 1: Summary statistics of main variables

Variables	Obs	Mean	Std.Dev.	Min	Max
Innovation					
Patent application/labor	1,292	141.268	197.912	0.052	1249.753
Patent granted/labor	1,292	64.448	96.671	0.067	739.312
Income Inequality					
Top 10%	1,292	34.81	8.72	16.70	64.19
Top 1%	1,292	11.25	5.03	2.51	33.45
Top 0.5%	608	6.08	2.32	2.38	15.18
Top 0.1%	608	2.58	1.45	0.73	8.82
Gini index	1,292	30.05	6.40	17.50	50.70
Controls					
GDP per capita (in log)	1,292	10.16	0.71	8.21	11.62
Public expend (%GDP)	1,268	18.73	4.49	6.36	38.32
Private credit (%GDP)	1,057	87.91	44.72	12.86	304.57
Unemployment (%)	1,292	7.42	4.20	0.40	27.47
Tertiary enrollment (%)	1,292	47.97	24.31	1.43	136.60
Globalization(KOF)	1,268	66.69	14.26	30.87	92.77
Instruments					
IP Service charge (in log)	1,292	5.57	2.57	0.24	11.67
R&D expend (%GDP)	1,292	1.59	0.89	0.13	4.69

Notes : Summary statistics is calculated over the period of 1980-2017. Patent measures are taken per 100,000 workers. Real GDP per capita is calculated in 2010 constant US$ per capita

4.2 Descriptive statistics

I established dynamic panel for 34 high-income economies over the period of 1980- 2017. Some variables have lots of missing values due to the data deficiency such as top 0.1% and top 0.5% income shares. To overcome these drawbacks I conduct additional analysis by restricting sample countries to G7 and European countries that are most available for this data. Country list used in the sample is shown in Appendix Table 1. Summary statistics on variables is shown in the above Table 1. The first two rows report our measure of innovation. The standard deviations of application and grant of patents are larger than their mean values, implying that deviations for these variables are larger among sample countries. Conversely, the Gini and globalization shows very low level of standard deviation, suggesting that they have relatively dense distribution of data across ample countries. Rows 3 through 7 show top income inequality variables plus Gini index. Six control variables and two instruments are also included in the above summary statistics table.

5. EMPIRICAL STRATEGY

In this part, I will explain the identification strategy, including model specification as well as estimation methodology. The objective of this essay is to examine the impact of innovation represented by number of patents on top income inequality. Thus I run regressions for the top income shares (0.1%, 0.5%, 1%, 10%) on our measure of innovation.

5.1 Model Specification

As pointed out above, Schumpeterian growth model argues that economic growth from innovation is achieved by either incumbents or new entrants. Enhancing innovation and new entries elevates entrepreneur's income share and thus aggravates top income inequality. To analyze causal impact of innovation on top income inequality in advanced countries, I set up an empirical model in the following form:

$$Y_{it} = \alpha + \beta_1 Innov_{it} + \beta_2 X'_{it} + B_i + B_t + \varepsilon_{it} \qquad (1)$$

where Y_{it} represents income inequality including top income shares and Gini index, $Innov_{it}$ indicates innovation level of country *i* and year *t,* measured by number of patents per worker including application and granted data of patents. X' is a vector of control variables that may influence income distribution, such like human capital, globalization, real GDP per capita, government size, financial development and institutional quality. Control variables including human capital and GDP per capita are applied for the natural log. B_i and B_t represents the country-fixed effect and year-fixed effect, respectively. The country-fixed effects remove the time-invariant heterogeneity across countries while the year-fixed effects control for time-varying heterogeneity across the time. Thus I explore the links between changes in growth of innovation across countries and changes in growth of top income inequality. If I apply the natural log for innovation and income inequality indicators in estimation, the coefficients measure the elasticity of income inequality with respect to innovation. U_{it} is an idiosyncratic error term. I also estimate the robust standard errors clustered at the country level in all regressions to prevent Type 1 error. The model equation is very similar to that of Aghion et al. (2019) and Benos et al. (2019). More detail estimation methodology is discussed in the following sub-section.

5.2 Estimation Methodology

In the empirical analysis, I apply two estimation methods such as Ordinary Least Squares (OLS) and Two-Stage Least Squares (2SLS) to estimate the impact of innovation on top income inequality. Basically I want to draw out causal inference, not the correlationship between innovation and top income shares. Thus, pooled OLS estimation is not enough for our purpose as it is biased due to inconsistent estimation arising from the endogeneity problem. In theory, the endogeneity issue is caused by three sources. First, when some variables are omitted in the model, estimation outcomes may be misleading and biased. That is, when the variables affecting dependent variable are omitted in the right side of the model, empirical results will be misleading. Second, the reverse causality may lead to biased estimation.[20] As mentioned in theory part, higher innovation leads to higher mark-ups by firms, which boosts entrepreneur's income share. Conversely there also exists the causal links from inequality to innovation; that is, income inequality affects innovation and R&D activities through the changes in the structure and dynamics of consumer's demand and the size of market. Lastly, measurement errors of original data can cause estimation bias, such as false or spurious response by respondents in the survey data. To overcome this endogeneity problem and to minimize the related biases, researchers usually use various econometrical techniques including instrument variable (IV) strategy and panel data analysis.

The IV method is known to be one of the most powerful estimation techniques to draw causal inference in applied econometrics (Angrist and Pischke, 2009). But the most practical problem in using IV strategy is that it is difficult to find appropriate and valid IVs to meet requirements for reliable instruments. Essentially there are a couple of conditions for valid instruments (Angrist et al. 2015). One is 'relevance condition', meaning that the instrument should correlate with the endogenous variable, but should not correlate with the error term or dependent variable. Another condition would be 'exclusion restriction', meaning that the instrument influences the dependent variables only through endogenous variables. These two

[20] The reverse causality in innovation-inequality nexus is argued by several studies (Zweimuller, 2000; Tselios, 2011). As unequal income distribution means smaller market size as only a few people can purchase expensive new products. This hampers innovation. Conversely inequality increases innovation through price effect. The higher willingness to pay of the rich prompts innovation and R&D activities. Tselios (2011) proved that inequality boosts innovations in Europe.

conditions are tested in the following empirical part. Basically I use two instruments including R&D expenditure (percent of GDP) and IP service charge receipts (BOP, current US$). First I conduct pooled OLS estimation to examine broad picture on the links between innovation and top income inequality. Then I will apply 2SLS estimation technique by using two instrument variables to draw the causal inference between innovation and top income shares. The 2SLS estimation is executed in two-steps. In the first step, I run the regression for endogenous variable (innovation) on IP service charge instrument to obtain the fitted value of innovation and check the first condition for the valid IV. The first-stage regression is run by using the following form of equation (2).

$$Innov_{it-1}\_hat = \pi_1 log\,(charge_{it+3}) + \pi_2 X_{it} + B_i + B_t + \nu_{it} \qquad (2)$$

where $innov_{it-1}\_hat$ shows the fitted value of innovation with 1 year time lag, and $charge_{it+3}$ represents IP service charge instrument variable with 3 years lead value to consider the grant lag time span. The remaining control variables are same to the structure model (1). In this first stage estimation I especially focus on the coefficient of service charge instrument (π_1). If it shows statistically significant results, it suggests that instrument is closely related with the endogenous variable, which satisfies the first condition of valid IV. Next I run the regression of the structure model (1) using the above fitted value of innovation as follows.

$$Y_{it} = \alpha + \beta_1 (Innov_{it-1}\_hat) + \beta_2 X'_{it} + B_i + B_t + \varepsilon_{it} \qquad (3)$$

where Y_{it} is our key dependent variables, including top income shares and Gini coefficient. $Innovation_{it-1}$ shows 1 year time lag and the estimated value in the first stage. The coefficient of β_1 is an IV estimator to explain the causal effect of innovation on top income shares. Basically main objective for above 2SLS estimation is to obtain empirical results regarding whether innovation shows causal effect on top income inequality or not. Theoretically IV estimator is local average treatment effect (LATE), which usually shows larger effect than OLS estimator implying that OLS estimation underestimates the links between dependent and endogenous explanatory variable due to the endogeneity bias problems. Therefore, by comparing the size of estimator between IV and OLS estimation results, we can confirm the existence of the endogeneity bias in the structure model.

6. ESTIMATION RESULTS

In this part, I provide empirical results of OLS as well as 2SLS. First I look at the links between innovation and top income shares applying pooled OLS. Next I look at the results of 2SLS using IVs, before applying alternative indicators of inequality and innovation. Finally, I will conduct robustness checks and falsification tests to confirm the main results.

6.1 Main Results

Table 2 provides results from OLS estimation. I run the regressions of top income shares on innovation, using 1 year lagged innovation to capture the time span of inventor's earnings after patent grant (no lagged table is shown in Appendix Table 3). Previous studies argue that inventors' income tends to increase even before patent is granted (Depalo et al. 2014; Bell et al. 2017).[21] Depalo et al. (2014) finds that inventor's earning is the highest at t-1 instead of t.[22] Column 1 in Table 2 uses top 0.1% income share to represent inequality, column 2 uses top 0.5%, column 3 uses top 1%, column 4 and 5 use top 10% and Gini, respectively. The coefficients of innovation are negative and significant for all dependents.

Table 2: Innovation and top income inequality-OLS results

Dependent variable (%)	Top 0.1%	Top 0.5%	Top 1%	Top 10%	Gini
Measure of innovation	Patent application per worker				
	(1)	(2)	(3)	(4)	(5)
Innovation	-0.011***	-0.016***	-0.023***	-0.022**	-0.025***
	(0.004)	(0.005)	(0.010)	(0.011)	(0.010)
Human capital	0.027***	0.048***	0.024***	0.058***	0.035***
	(0.003)	(0.005)	(0.006)	(0.010)	(0.006)
Gdppc (log)	0.670***	-0.117	-2.017***	-4.013***	-2.910***
	(0.198)	(0.300)	(0.297)	(0.502)	(0.274)
Unemployment	0.012***	0.026**	0.025	0.096**	0.184***
	(0.004)	(0.013)	(0.022)	(0.039)	(0.036)
Globalization	0.003	0.025***	0.070***	0.041*	0.012
	(0.005)	(0.006)	(0.011)	(0.019)	(0.012)
Government	-0.119***	-0.255***	-0.594***	-0.910***	-0.847***
	(0.015)	(0.021)	(0.045)	(0.079)	(0.044)
Finance	0.007***	0.012***	0.011***	0.022***	0.030***
	(0.002)	(0.003)	(0.003)	(0.005)	(0.003)
Observations	510	510	1078	1078	1078
No. of countries	34	34	34	34	34
R^2	0.354	0.431	0.315	0.322	0.502

Notes: Panel OLS regressions with country and year fixed effects. Time span is 1980-2017. Innovation is 1 year lagged. Robust standard errors are in parentheses, clustering at the country level. ***, ** and * indicate 0.01, 0.05 and 0.1 levels of significance, respectively.

[21] Firms tend to pay rewards for new inventions right after patent application because they expect profits in the near future. Moreover, firms sell new products before the patent is granted, realizing profits from that innovation. Patent application is good news to firms, making easier access to finance and higher likelihood of IPOs, which raises entrepreneur's income.

[22] Depalo and Adario (2014) argued that this delay is mainly caused by administrative bureaucracy of related public offices.

The OLS result is consistent with previous work by Benos et al. (2019). Column 3 in Table 2 reports that a one unit rise in innovation will result in a 0.023 percent decrease in top 1% income share. In other words with standardized coefficient, using standard deviation in statistics in Table 1, one standard deviation rise in innovation leads to 2.1 points reduction in top 1% income share. The remaining control variables display the expected signs. Human capital shows powerful positive effect on rising inequality while GDP per capita reduces inequality. Globalization tends to increase income inequality while government expenditure reduces inequality. Financial development increases inequality across the whole indicators but the magnitude is relatively smaller. Column 5 reports the impact of innovation on Gini index, showing minus and significant effect. A one unit increase in innovation results in 0.025 percent decrease in Gini index. Thus I assume temporarily that innovation reduces top income shares as well as Gini index under the OLS estimation. However, the OLS estimates do not establish causal links, so we need to depend on alternative estimation such as IV method. Another noteworthy point in the estimation of innovation is time lag of innovation variable. Table 3 shows regression result of top 1% income share on innovation with different time lags. Time lags between top income shares and innovation include variations form 2 to 6 years. The coefficients of innovation shows significance up to six years, but the size reduces with time lag goes on, implying that innovation has temporary effects on top income shares owing to imitation or creative destruction as shown in the theory part.

Table 3: Innovations (with different lags) and top income inequality-OLS

Dependent variable (%)	Top 1% income share					
Measure of innovation	Patent application per worker					
Lag of innovation	2 years	3 years	4 years	5 years	6 years	all lags
	(1)	(2)	(3)	(4)	(5)	(6)
Innovation t-2	-0.022***					-0.010
	(0.008)					(0.021)
Innovation t-3		-0.020***				-0.006
		(0.006)				(0.024)
Innovation t-4			-0.018***			-0.011
			(0.006)			(0.023)
Innovation t-5				-0.017***		-0.006
				(0.005)		(0.022)
Innovation t-6					-0.015***	-0.017
					(0.005)	(0.018)
Controls	yes	yes	yes	yes	yes	yes
Observations	1077	1076	1075	1074	1073	1073
No. of countries	34	34	34	34	34	34
R^2	0.316	0.315	0.314	0.314	0.326	0.326

Notes: Panel data OLS regressions with country and year fixed effects. Time span is 1980-2017. The lag between dependent variable and innovation measures ranges from 2 to 6 years. Autocorrelation and heterosckedasticity robust standard errors are in parentheses, clustered at the country level. The whole table is shown in Appendix Table 4. ***, ** and * indicate 0.01, 0.05 and 0.1 levels of significance, respectively.

Now I run the regression using instrument variable as shown in Table 4. I use IP service charge receipt as instrument to draw the causal effect of innovation on top income inequality by addressing the endogeneity. The coefficients in first row of Table 4 show quite different from those in OLS results. In OLS regressions innovations show negative effects on income inequality. But in 2SLS regressions they show positive and statistically strong effects on top income shares and Gini index. This is consistent with Aghion et al. (2019). The difference between OLS and 2SLS estimation suggests that OLS is biased due to endogenous property of innovation variable. The magnitude of coefficient is the largest (0.216) for the top 0.1% and the smallest (0.023) for top 10% income share, showing much higher income concentration to the top richest. This implies that the influence of innovation on top income shares is concentrated on so-called 'ultra-super riches' in rich countries. Column 1 reports that a one unit rise in innovation leads to 0.216% rise in top 0.1% income share.

Table 4: Innovation and top income inequality-IV results (IP service charge)

Dependent variable (%)	Top 0.1%	Top 0.5%	Top 1%	Top 10%	Gini
Measure of innovation	Patents application per worker				
	(1)	(2)	(3)	(4)	(5)
Innovation	0.216***	0.121***	0.041**	0.023**	0.021*
	(0.031)	(0.027)	(0.020)	(0.011)	(0.009)
Human capital	0.060***	0.099***	0.023***	0.058***	0.035***
	(0.012)	(0.018)	(0.006)	(0.010)	(0.007)
Gdppc (log)	-3.085**	-5.881***	-1.822***	-3.880***	-3.564***
	(1.168)	(1.780)	(0.455)	(0.780)	(0.512)
Unemployment	0.029***	0.019***	0.011**	0.018***	0.213***
	(0.007)	(0.005)	(0.005)	(0.006)	(0.042)
Globalization	0.011	0.046**	0.072***	0.044*	0.010
	(0.011)	(0.017)	(0.012)	(0.020)	(0.013)
Government	-0.137***	-0.282***	-0.603***	-0.917***	-0.806***
	(0.035)	(0.053)	(0.051)	(0.088)	(0.053)
Finance	0.026**	0.039**	0.013*	0.023**	0.024***
	(0.009)	(0.014)	(0.005)	(0.009)	(0.006)
Observations	507	507	1076	1076	1076
No. of countries	34	34	34	34	34
F-first satge	45.53	47.17	53.63	52.71	47.29
R^2	0.321	0.301	0.309	0.319	0.475

Notes: Innovation is 1 year lagged and instrumented by IP service charge receipt. 2SLS regressions with country and year fixed effects. Time span is 1980-2017. The lead between intrument and innovation is set to 3 years. Autocorrelation and hetero-sckedasticity robust standard errors are in parentheses, clustered at the country level. ***, ** and * indicate 0.01, 0.05 and 0.1 levels of significance, respectively.

Among controls in Table 4, GDP per capita shows significant effects on top income inequality across whole indicators. It shows negative but statistically significant effect at 1% level. That is, a 1% increase in GDP per capita decreases top 0.5% income share by 5.881%. The government expenditure and unemployment has powerful effects with expected signs. A 1% rise in government expenditure reduces top 0.1% and 1% income shares by 0.13% and 0.6% respectively. Similarly, 1% rise in unemployment leads to 0.03% and 0.01% increase in top 0.1% and 1% income share, respectively. This finding supports evidence that government expenditure and unemployment show significant impact on income inequality. This is not surprising considering that 24 out of 34 sample countries is European countries where unemployment is high and government spending is relatively higher than average of OECD countries. In Appendix Table 5 we use an alternative instrument of R&D intensity, which shows similar results with IP service charge instrument. 2SLS estimation used in Table 4 can be sliced into two stages. This is shown in Table 5 by country groups. In the first stage (Panel B) I run the regression of endogenous variable (patents) on instrument. Then, in the second stage (Panel A) I regress dependent (Top 0.1%) on fitted value of patents. Innovation shows positive and significant impacts on inequality in the whole country groups.

Table 5: 2SLS results by country groups (IV: IP service charge receipt)

	full sample	G7 countries	Europe
	(1)	(2)	(3)
Panel A: Two-Stage Least Squares (dependent : top 0.1% income share)			
Innovation	0.216***	0.213*	0.210***
	(0.031)	(0.116)	(0.051)
Controls	Yes	Yes	Yes
F-stat	45.53	10.41	37.16
Obsevations	507	224	337
No. of countries	34	7	24
Panel B: First Satge on innovation (patent application per worker)			
IP service charge (log)	0.205***	0.084*	0.221***
	(0.015)	(0.042)	(0.020)
Controls	Yes	Yes	Yes
R^2	0.321	0.113	0.382

Notes: Innovation is 1 year lagged and instrumented by IP service charge receipt. 2SLS regressions with country and year fixed effects. Time span is 1980-2017. The lead between intrument and innovation is set to 3 years. Robust standard errors are in parentheses, clustered at the country level. ***, ** and * indicate 0.01, 0.05 and 0.1 levels of significance, respectively.

Now I use both instruments (IP service charge receipt and R&D intensity) together to add power to our IV estimation as shown in Table 6. I obtain the results that innovation shows positive and powerful impacts on top income shares as in above case with single instrument. But the magnitude of coefficients has become smaller than the previous case. For example, column 1 reports that one unit rise in innovation results in 0.125% increase in top 0.1% income share, but the size of coefficient is larger (0.216%) when using single instrument as shown in Table 4. This trend continues across the whole indicators. Thus it has become evident that innovation has positive and statistically significant impact on top income shares in rich countries. I conclude that technology boosts up top income inequality among rich economies. The coefficient for Gini index shows negative and insignificant, implying that the Kutnetz Curve exists. The controls show similar signs and magnitude as in previous case.

Table 6: Innovation and top income shares using two IVs (service charge / R&D intensity)

Dependent variable (%)	Top 0.1%	Top 0.5%	Top 1%	Top 10%	Gini
Measure of innovation	Patents application per worker				
	(1)	(2)	(3)	(4)	(5)
Innovation	0.125***	0.071**	0.031*	0.030***	-0.008
	(0.023)	(0.033)	(0.015)	(0.010)	(0.005)
Human capital	0.029***	0.049***	0.024***	0.057***	0.035***
	(0.004)	(0.005)	(0.006)	(0.010)	(0.006)
Gdppc (log)	-0.290**	-0.615**	-2.274***	-4.682***	-2.911***
	(0.126)	(0.306)	(0.327)	(0.577)	(0.331)
Unemployment	0.025**	0.014**	0.018	0.049**	0.184***
	(0.010)	(0.007)	(0.021)	(0.023)	(0.037)
Globalization	0.002	0.027***	0.069***	0.038	0.016
	(0.005)	(0.006)	(0.012)	(0.020)	(0.012)
Government	-0.116***	-0.249***	-0.575***	-0.866***	-0.845***
	(0.015)	(0.020)	(0.047)	(0.084)	(0.047)
Finance	0.006***	0.006**	0.009**	0.015**	0.030***
	(0.002)	(0.003)	(0.004)	(0.006)	(0.004)
Observations	505	505	1074	1074	1074
No. of countries	34	34	34	34	34
F-first satge	23.47	27.13	30.85	25.53	24.71
Sargan-Hansen (p-value)	0.121	0.336	0.513	0.215	0.112
R^2	0.213	0.321	0.366	0.307	0.332

Notes: 2SLS regressions with country and year fixed effects. Time span is 1980-2017. Innovation is 1 year lagged and instrumented by R&D expenditure (% of GDP, 2 year lagged) and IP service charge receipts. Robust standard errors are in parentheses, clustered at the country level. ***, ** and * indicate 0.01, 0.05 and 0.1 levels of significance, respectively.

Table 7 presents empirical results on reduced form regressions. That is, the regressions represent the empirical analysis of our instruments on innovation proxied by the number of patent application and also the empirical results of our instruments on dependent variable measured by top 1% income share are provided. Column 1 and 2 use the instrument of IP service charge receipt while column 3 and 4 use R&D intensity as an instrument, and column 5 and 6 use both instruments. As shown in Table 7, both instruments have positive and significant effects on innovation (or endogenous variable), implying that the relevance condition of good instrument is satisfied. Column 1 and 3 report that a one percent increase in IP service charge receipts and R&D intensity leads to 0.205% and 0.025% rise in patent application, respectively. Also both instruments have positive and significant effects on dependent variable (or top 1% income share). Hence, the coefficients in reduced form regressions imply that IP service charge and R&D intensity increases top income share.

Table 7: First stage and reduced form regressions

Dependent variable	Patents	Top 1%	Patents	Top 1%	Patents	Top 1%
	(1)	(2)	(3)	(4)	(5)	(6)
IP Service charge (log)	0.205***	0.017**			0.192***	0.011***
	(0.015)	(0.008)			(0.007)	(0.003)
R&D intensity			0.025***	0.018**	0.017**	0.015**
			(0.007)	(0.09)	(0.008)	(0.006)
Human capital	-1.023	0.834**	-0.372	2.316***	0.432	2.214***
	(1.120)	(0.414)	(1.421)	(0.361)	(1.283)	(0.571)
Gdppc (log)	1.012***	0.103***	1.102***	0.051	1.042***	0.073
	(0.158)	(0.031)	(0.123)	(0.033)	(0.103)	(0.054)
Unemployment	0.031***	-0.025	0.075***	-0.003	0.076***	-0.005
	(0.015)	(0.014)	(0.020)	(0.004)	(0.017)	(0.004)
Globalization	0.026	-0.024***	0.017	-0.056***	0.005	-0.034***
	(0.017)	(0.006)	(0.012)	(0.009)	(0.010)	(0.011)
Government	-0.030	-0.091***	-0.006	-0.085***	0.025	-0.073***
	(0.053)	(0.032)	(0.051)	(0.023)	(0.045)	(0.022)
Finance	-0.314***	0.056**	-0.285***	0.134***	-0.542***	0.135***
	(0.115)	(0.023)	(0.118)	(0.031)	(0.120)	(0.031)
R^2	0.321	0.324	0.241	0.330	0.466	0.512
Observations	1077	1077	1074	1074	1074	1074

Notes: Panel data OLS regressions with country and year fixed effects. The dependent variables are innonovation proxied by the number of patent application and top income inequality measured by top 1% income share. Instrument variables are IP Service charge receipts and R&D expenditure (% of GDP, 2 year lagged). Time span is 1980-2017. Only IP service charge receipts are taken in log. Robust standard errors are presented in parentheses, clustered at the country level. ***, ** and * indicate 0.01, 0.05 and 0.1 levels of significance, respectively.

6.2 Robustness Check

Table 8 shows the robustness checks. For this, I use alternative variable for innovation: patent grant per worker rather than patent application. The results indicate that innovation shows positive and statistically powerful influence on all indicators of top income shares. This exactly complies with our main results. This also confirms the hypothesis that technology progress aggravates top income inequality and the Gini index as well. So, technical change benefits more for the top riches than for the rest of society. I find that technology plays a powerful role in boosting top income shares in rich countries. This finding is in line with IMF study, arguing that technological progress explains 0.45% rise in annual average of Gini across the world since the early 1980s. The introduction of new technology increased labor demand for skilled workers with reduced demand for the low-skilled (IMF, 2007). Moreover, I apply quality indicator of patents such as citations in the next. Especially I use citation data (Cit5) which received within 5 years after application.

Table 8: Robustness check-patent grant and top income share (2SLS)

Dependent variable (%)	Top 0.1%	Top 0.5%	Top 1%	Top 10%	Gini
Measure of innovation	Patents grant per worker				
	(1)	(2)	(3)	(4)	(5)
Innovation	0.251***	0.162***	0.041*	0.020*	0.018*
	(0.031)	(0.025)	(0.020)	(0.010)	(0.009)
Human capital	1.247**	1.282***	1.347***	1.328***	1.544***
	(0.522)	(0.413)	(0.305)	(0.125)	(0.270)
Gdppc (log)	-0.243**	-0.328***	-0.243***	-0.232***	-0.221***
	(0.116)	(0.072)	(0.035)	(0.021)	(0.016)
Unemployment	0.030***	0.020***	0.021***	0.004*	0.206***
	(0.006)	(0.004)	(0.003)	(0.002)	(0.041)
Globalization	0.011	0.045**	0.072***	0.045**	0.010
	(0.011)	(0.016)	(0.012)	(0.021)	(0.012)
Government	-0.136***	-0.287***	-0.602***	-0.915***	-0.823***
	(0.025)	(0.052)	(0.052)	(0.083)	(0.053)
Finance	0.025**	0.037***	0.012**	0.022**	0.025***
	(0.010)	(0.011)	(0.005)	(0.009)	(0.008)
Observations	506	506	1075	1075	1075
No. of countries	34	34	34	34	34
F-first satge	44.37	46.67	53.82	56.64	47.29
R^2	0.171	0.218	0.243	0.317	0.475

Notes: 2SLS regressions with country and year fixed effects. Time span is 1980-2017. Innovation is instrumented by IP service charge receipt. The lead between intrument and innovation is set to 3 years. Robust standard errors are presented in parentheses, clustered at the country level. ***, ** and * indicate 0.01, 0.05 and 0.1 levels of significance, respectively.

Table 9 shows another robustness checks. This time I use the qualitative indicators of patent such as citation, claims, and family size. The simple counting of the number of patent may be crude measure of innovation because each patent reflects different quality of technology. The USPTO website offers extensive database on patent citations, claims, and family size. Citation data refers to the sum of citations gained within 5 years from the year of patent application. Patent claims represent the breadth of patent while family size means number of public offices where the patent is protected. The high-quality patent is usually protected by many different patent offices. Table 8 reports the estimation results, similar to previous Table 4 and 7, implying that technological progress aggravates top income inequality when using qualitative data of patent. Column 2 reports that one unit rise in innovation results in 0.158% rise in top 0.1% income share. Also other indicators show the similar results, positive and significant effect on top income shares. The size of estimates is largest for family size indicator. These results confirm my findings and thus I conclude that technological development increases top income inequality.

Table 9: Robustness check-qualitative indicators of patent and inequality (2SLS)

Dependent variable (%)	Top 0.1% income share			
Measure of innovation	Patents	Cit5	Claims	Family
	(1)	(2)	(3)	(4)
Innovation	0.216***	0.158***	0.188***	0.263***
	(0.031)	(0.037)	(0.041)	(0.062)
Human capital	0.060***	0.044**	0.423*	0.311*
	(0.012)	(0.021)	(0.201)	(0.126)
Gdppc (log)	-3.085**	-0.242**	-0.203*	-0.260*
	(1.168)	(0.119)	(0.103)	(0.129)
Unemployment	0.029***	0.026***	0.031***	0.036***
	(0.007)	(0.007)	(0.007)	(0.008)
Globalization	0.011	0.001	0.003	0.006
	(0.011)	(0.002)	(0.002)	(0.004)
Government	-0.137***	-0.035***	-0.038***	-0.041***
	(0.035)	(0.005)	(0.005)	(0.006)
Finance	0.026**	0.002	0.008	0.005**
	(0.009)	(0.003)	(0.011)	(0.002)
Observations	507	504	504	504
No. of countries	34	34	34	34
F-first satge	45.53	24.88	45.23	38.26
R^2	0.321	0.191	0.224	0,254

Notes: 2SLS with country and year fixed effects. Time span is 1980-2017. Innovation is 1 year lagged and instrumented by IP service charge receipts (3 year lead). Patents are the number of patent application per worker. Robust standard errors are in parentheses, clustered at the country level. ***, ** and * indicate 0.01, 0.05 and 0.1 levels of significance, respectively.

6.3 Falsification Test

Table 10 shows falsification test. For this, I use the placebo dependent variable, that is, bottom 10% income share rather than top income shares. Due to data deficiency, I restrict the sample period into 1990-2017. I expect that the placebo dependent variable gives us the opposite estimation results compared to the main results. As seen in the first row of Table 10, I've obtained insignificant coefficients in OLS but negative and significant coefficients in 2SLS in the relationship between innovation and bottom 10% income share. Innovation is instrumented by IP service charge receipt. The results turned out to be completely opposite to what I have seen in the main results. For OLS, the size of coefficients has become smaller and the sign is reversed. For 2SLS, the signs are also reversed and the size of coefficients has become larger and added more statistical significance power.

Table 10: Falsification test-Innovation and bottom 10% income share

Dependent variable (%)	Bottom 10% income share			
Measure of innovation	Patents application		Patents grant	
	OLS	2SLS	OLS	2SLS
	(1)	(2)	(3)	(4)
Innovation	0.005	-0.043***	0.012	-0.051***
	(0.010)	(0.016)	(0.010)	(0.016)
Human capital	-1.026***	-1.245***	-1.114***	-1.421***
	(0.247)	(0.255)	(0.256)	(0.265)
Gdppc (log)	0.143***	0.228***	0.127***	0.250***
	(0.021)	(0.020)	(0.021)	(0.023)
Unemployment	-0.015***	-0.015***	-0.012***	-0.015***
	(0.003)	(0.004)	(0.002)	(0.003)
Globalization	0.010***	0.011***	0.009***	0.012***
	(0.003)	(0.002)	(0.002)	(0.003)
Government	0.032***	0.035***	0.031***	0.030***
	(0.002)	(0.002)	(0.004)	(0.003)
Finance	-0.003***	-0.004***	-0.003***	-0.005***
	(0.001)	(0.001)	(0.001)	(0.001)
Observations	761	758	761	758
No. of countries	34	34	34	34
F-first satge		45.74		43.63
R^2	0.516	0.532	0.517	0.524

Notes: 2SLS regressions with country and year fixed effects. Time span is 1990-2017. Innovation is instrumented by IP service charge receipt with t+3 lead values. Autocorrelation and hetero-sckedasticity robust standard errors are in parentheses, clustered at the country level. ***, ** and * indicate 0.01, 0.05 and 0.1 levels of significance, respectively.

7. DISCUSSION AND POLICY IMPLICATION

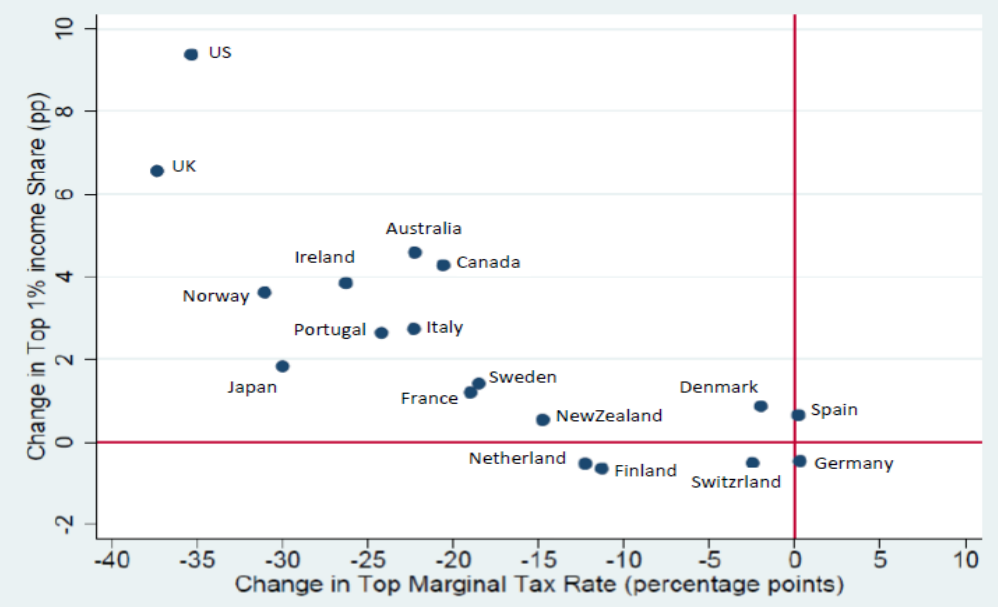
My analysis thus far has presented a snapshot on the causal links between innovation and top income shares in advanced economies. Now I will elaborate presumed mechanisms of the preceding empirical results and then propose several policy options to address rising top income inequality. My policy recommendations would not be purely new one, rather I will choose the approach to make practical comments on policy measures already argued by renowned scholars. I have found that technological progress has positive and significant effect on top income shares among advanced countries. Especially the impact is the strongest on top richest such as top 0.1% income share. As a mechanism for concentration of income for top earners, many studies pointed out tax policy of government (Chancel, 2019). In this respect, my policy suggestions to combat rising top income inequality are made, focusing on taxation. Policy tools can be summarized into three kinds; i) prevent tax loopholes used by the wealthy ii) enhance progressive taxation for the top riches including the wealth tax iii) strengthen education reform to promote moral values and thus reduce corruptions.

To recommend appropriate policy measures, we need start from our empirical results and underlying mechanisms of rising top income gaps in rich countries. Tax is one of the most critical factors in determining income distribution in many countries (PIIE, 2020). Numerous studies support this idea that taxation is one of the most critical drivers of rising income gaps (Moretti et al 2017; Akcigit et al. 2016). Lower taxes result in increased income gain among top earners and boost innovation through the migration of creative inventors. Hence I focus on tax policy. The marginal tax rate for top earners in rich countries such as the US and UK became regressive over the last 50 years, implying that tax rate for the richest has steadily decreased (Chancel, 2019; Piketty et al, 2011). In the US, average tax rate of bottom 99% in income distribution rose from 20.2% to 26.1% during the period 1950-2018. But average tax rate for richest top 1% fell from 57.3% to 28.8% in the same period. Especially, the average tax rate for the top 400 super-rich plunged from 70% to 23% in the same period.[23] This divergence of tax rate among income groups is one of the major candidates for yawning top income inequality. As a similar case, top marginal income tax rate remained higher (55%-

[23] The *Forbes* magazine releases the ranking of the richest Americans every year since 1982. Top 400 refers to the richest of the rich people in the US, including Jeff Bezos of Amazon, Elon Musk of Tesla, Bill Gates of Microsoft etc.

99%) in the period of 1940s-1980s in advanced countries (Appendix Figure 4). But, since the 1980s top marginal tax rate has begun to fall toward 40% - 60%, similar level to 1930s. This period of 1980s coincides with sharp rise in top 1% income share as already displayed in Figure 1. This suggests that drop in top marginal tax rate resulted in rising top 1% income share among advanced countries. The relationship between variance in top marginal tax rate and variance in top 1% income share is shown in below Figure 4. This picture illustrates historical trends of variation in top 1% income share against the variation in top marginal tax rate among rich economies between two periods (1970-74 vs. 2006-10). The correlation between these two periods is strong (negative) but significant at 1% significance level. The elasticity coefficient of OLS estimation for top 1% income share on top marginal tax rate is -0.18 (standard error 0.03). European countries show lower level of tax cut for top richest, and thus led to lower income inequality proxied by top 1% income share. Conversely, Anglo-Saxon economies show larger tax cut for the top richest and resulted in relatively higher level of income inequality. More detailed scatterplot in each period (1970-74, 2006-10) is shown in Appendix Figure 6. The correlation slope between top marginal tax rate and top 1% income share is steeper during the period of 2006-10 rather than 1970-74, suggesting that lower tax rate boosted top income shares in high-income countries.

Figure 3: Changes of top marginal tax rate and top 1% income share, 1970-74 vs. 2006-10



Source: data from www.wid.world and Piketty et al. (2014)

As such, changes of tax rate of the richest have become evident as a criminal of rising top income shares. Thus I can consider tax policy as an effective policy tool to combat rising top income inequality. Regarding tax policy, we can consider two kinds of policy options; ex ante and ex post. The former may be proactive policy measures to normalize (or increase) tax collection among the rich. It is well known that there are various loopholes to avoid and evade tax duty by the wealthy these days.[24] Therefore, drastic measures to reduce these tax loopholes used by the wealthy must be taken to promote equity and justice in tax collection (Saez et al. 2019). I can assert that the usual source of rising top income inequality is unfair tax schemes tilted toward the richest. The so-called 'tax heavens'[25] are widely used by the top riches to avoid tax. With the wide spread of globalization since the 1980s, tax dodging schemes have become popular globally among the rich. To plug these loopholes, however, international cooperation is essential. For instance, economic sanctions against tax heavens and establishment of minimum tax rate for multinationals are subject to formal coordination among countries. G20 summit (which includes world's largest economies) can be a useful international body to harmonize tax codes and discuss tax issues between countries.

As an ex post policy option, I propose the restoration of tax progressivity. Progressive tax refers to imposing higher tax rate for higher income earners. However, as mentioned above and shown in Figure 5, tax rate across income groups is unbalanced in the US, tilted toward for the riches. Total tax rate for top 400 richest Americans is relatively lower than the rest income groups in the US. To fix this distortion, it is necessary to impose a higher tax or wealth tax on the top earners (Piketty, 2014; Saez et al. 2019).[26] This argument can also be supported by my empirical results above that the impact size of innovation on inequality becomes larger and larger as income share goes up to the top such as top 0.1% income share.

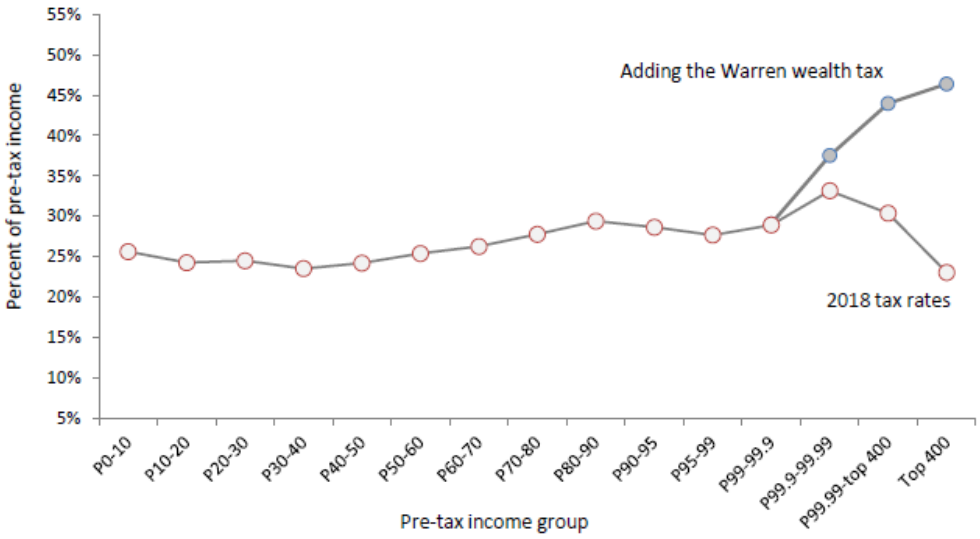
---

[24] There is some difference between tax avoidance and evasion. The former refers to legal way to minimize taxable income and thus reduce tax burden. On the other hand, the latter refers to illegal activity in which a person or a business willfully escapes paying tax duty. This activity is usually subject to criminal charges and legal penalties.

[25] This refers to a jurisdiction with effective low tax rate for foreign investors, including the Netherlands, Ireland, Singapore, Luxembourg, Cayman Islands, Bermuda, and so on. Firms move headquarters to this place to dodge the tax burden. This tax heaven is also used by the richest to hide their wealth and evade tax duty by using secretiveness practice in this area.

[26] In 2019, Senator Elizabeth Warren in the U.S. proposed the wealth tax for the top riches (2% tax rate for the wealth above U$50 million and 3% above U$1 billion). Also Senator Bernie Sanders proposed the wealth tax with rates 1, 2, 3, 4, 5, 6, 7, 8% applying above $32m, $50m, $250m, $500m, $1bn, $5bn, $10bn. In 2021 democratic lawmakers proposed a bill to adopt the wealth tax to cover the social-spending for the COVID-19. But Angus Deaton at Princeton University criticized this idea saying that this tax will discourage firm's investment and business activities as well as capital market development.

Figure 4: Total tax rate by income groups (the effect of wealth tax in the US)



Source: data from Saez and Zucman (2019)

According to a study by Saez and Zucman (2019), effective tax rate for top 400 richest Americans would be doubled from 23% to 46% when applying 'Warren wealth tax' (2% annual tax rate for the wealth above $50million and 3% for above $1billion). Figure 5 illustrates the effect of the wealth tax, showing that this idea can be powerful policy measure to restore progressive tax for top earners. It also shows that US tax schemes look like a flat tax at around 28% in 2018, except top 400 richest group in which they pay only 23%. To fill this gap, imposing heavier tax for them would be helpful to improve fairness and justice of taxation. But in reality this wealth tax idea confronts a lot of objections.

Imposing wealth tax is problematic from several reasons. First, it levies tax on unrealized income, contrary to general principle of taxation that it should be imposed on realized income or earnings. Second, another is double taxation problem. Regarding the first reason, we need think about various tax avoiding schemes used by super-riches. Let us take the example of Warren Buffett, the Oracle of Omaha, who owned U$65.3 billion in wealth in 2015. Most of his wealth consists of shares in his company Berkshire Hathaway, but the company does not pay dividends, which led to no tax base of individual income tax for him. His wealth has accumulated within his company every year without paying any income tax for decades. Other super-riches exploit similar way to avoid income tax. All of these super-riches belong to top 0.1% income share. If this is true, what can be done about it and what is ideal tax rate for super-riches? One possible answer can be obtained from the 'justice theory'

proposed by John Rawls (Saez et al. 2019). According to Rawls, economic and social inequalities can be acceptable if these inequalities increase the living standards of the poorest citizens in society (Rawls, 1971). To improve the living conditions of the poorest citizens, taxation must be designed to maximize revenues to spend on social welfare schemes. Therefore, theoretically optimal tax rate for the richest is the rate that makes revenues to be maximized. Academic debates on optimal tax rate for the richest are presented in Appendix Box 2. Empirical studies suggest that optimal top marginal tax rate for top 1% richest that maximizes revenues is around 75% in the US, implying the existence of large rooms to increase tax rate for the top richest considering current rate of around 40%.

Up to now we discussed tax policy as a weapon to combat rising top income inequality. But another important policy options fall on education reforms and government guidelines to boost so-called 'stakeholder' capitalism.[27] Education curricula must be renovated to respond properly to new technologies, and moreover education must focus on fostering moral values and community spirits, which will lead to reducing corruptions or rent-seeking activities. Corruptions include all kinds of undesirable collaborations between political elites and business elites as we've witnessed during global financial crisis 2008-2009. Hence, reforms in education could be useful to reduce corruptions and then mitigate income gaps in the long term. Also government's role in establishing laws and regulations to make a transition to 'stakeholder' capitalism would be vital to addressing inequality. This includes public rules to emphasize on improving benefits of all stakeholders, not only shareholders. The stakeholder capitalism may have smaller variance in executive salaries than the shareholder capitalism, implying that it can contribute to reducing top income gaps.

So far I've proposed 3 kinds of policy options to address rising income inequality. But the most important thing is that those options must be mixed together to draw out maximum effect. Also higher flexibility in labor market, easier access to education and health service would be highly conducive to reducing inequality (Blanchard et al. 2021). It is also important to recognize that distorted distribution of income is a sort of market failure. Thus government must intervene in this problem by using policy tools in order to make society more equal.

[27] 'Stakeholder' capitalism refers to a system in which firms focus on increasing the benefits of all stakeholders, including clients, employees, shareholders, and local community etc. Conversely, 'shareholder' capitalism focuses on raising the interests of shareholders only. Transition to stakeholder capitalism was proposed in Davos Forum 2020 to reduce inequality.

8. CONCLUSION

Using cross-country panel dataset covering 34 developed countries from 1980 to 2017, this essay tested the hypothesis that technology widens top income inequality in rich world. My findings imply that innovation has positive and significant impact on rising top income shares. Especially the size of impact becomes larger as income share goes up. This result is also robust by using other alternative variables such as patent citations. Thus, technology has shown two faces. It makes human life easier and more convenient by inventing new products and devices. But it also deepens income concentration at the top earners as shown in this essay. Rising income inequality has become major socio-economic challenges to which policymakers must respond urgently. To address this threat, I propose three kinds of policy alternatives. First, tax loopholes the wealthy usually use need to be blocked. International cooperation between countries to restrict various tax evading schemes by the rich would be useful to shrink top income gaps. Second, progressive taxation would be the most practical tool to reduce top income inequality. Especially some scholars propose imposing wealth tax on top richest. But this idea is controversial from several reasons economically and politically. The original intention of this idea is praiseworthy, but it is necessary to construct public consensus in advance of implementation to minimize side effects. Lastly, to combat rising top income inequality, education reforms would be highly useful. This may be the most important to achieve successful response to rising income inequality in the longer term. Education curricula focusing on moral values and community spirits would be conducive to reducing corruptions. Also government role in elevating transition to ‘stakeholder’ capitalism would be helpful to reduce inequality. But the most important is that the above options must be combined together to attack rising inequality more efficiently. If so, then rising inequality would take turns toward opposite direction for more equal and inclusive society.

According to Wooldridge (2021), rising income inequality is the most serious problem of capitalism which is now losing its luster. Income inequality is the DNA of capitalism since its system is based on meritocracy of individuals. The only way to cure this threat is through collective actions by government and civil society. Government has policy tools to readjust unequal distribution of income by using tax. Civil society and NGOs can alert the public by raising high voice against inequality and tilted distribution. This essay does not completely solve the puzzle of income inequality, but I view this study as a small contribution to existing literatures by sounding warning. More rigorous empirical studies on the relationship between technological progress and climate change would be an interesting topic in the future.

Appendix

Table A1: Country list of the sample

No.	Country	Code[1)]	Continent	top1%[2)]	Gini[3)]	R&D[4)]
1	Australia	AUS	Oceania	0.128	0.328	1.87
2	Austria	AUT	Europe	0.101	0.278	3.21
3	Belgium	BEL	Europe	0.086	0.260	3.17
4	Canada	CAN	America	0.148	0.301	1.69
5	Chile	CHL	America	0.264	0.458	0.35
6	Czech Republic	CZE	Europe	0.100	0.244	1.94
7	Denmark	DNK	Europe	0.127	0.266	2.91
8	Estonia	EST	Europe	0.116	0.307	1.61
9	Finland	FIN	Europe	0.103	0.260	2.79
10	France	FRA	Europe	0.098	0.299	2.19
11	Germany	DEU	Europe	0.129	0.293	3.19
12	Greece	GRC	Europe	0.107	0.313	1.27
13	Hungary	HUN	Europe	0.124	0.279	1.48
14	Iceland	ISL	Europe	0.088	0.247	2.32
15	Ireland	IRL	Europe	0.118	0.294	1.23
16	Israel	ISR	Middle East	0.165	0.349	4.93
17	Italy	ITA	Europe	0.089	0.338	1.47
18	Japan	JPN	Asia	0.131	0.320	3.20
19	Republic of Korea	KOR	Asia	0.147	0.340	4.64
20	Luxembourg	LUX	Europe	0.103	0.299	1.13
21	Mexico	MEX	America	0.261	0.428	0.28
22	Netherlands	NLD	Europe	0.069	0.265	2.18
23	Norway	NOR	Europe	0.093	0.258	2.15
24	New Zealand	NZL	Oceania	0.118	0.328	1.41
25	Poland	POL	Europe	0.148	0.285	1.32
26	Portugal	PRT	Europe	0.109	0.324	1.39
27	Slovakia	SVK	Europe	0.174	0.230	0.83
28	Slovenia	SVN	Europe	0.079	0.246	2.05
29	Spain	ESP	Europe	0.126	0.330	1.25
30	Sweden	SWE	Europe	0.095	0.263	3.38
31	Switzerland	CHE	Europe	0.115	0.299	3.37
32	Turkey	TUR	Asia	0.188	0.399	1.06
33	United Kingdom	GBR	Europe	0.126	0.338	1.76
34	United States	USA	America	0.187	0.386	3.06

Notes: 1) Country code is following the ISO 3166-1 Alpha-3

2) Top 1% income (pre-tax) share as of the latest data by WID (2019)

3) Gini coefficient (disposable income) as of the latest data by SWIID (2019)

4) R&D expenditure (percent of GDP) data by OECD (2019)

Table A2: Definition of variables and data source

Variables	Unit of measurement	Variable Definition	Data source
Income Inequality			
Top income shares	Percent (%)	Income share by top 0.1, 0.5, 1, 10%	WID
Gini (SWIID)	Percent (%)	Gini index of income inequality	SWIID
Innovation			
Patent applied/worker	Per 100,000 workers	Total patent applied per worker	WIPO
Patent granted/worker	Per 100,000 workers	Total patent granted per worker	WIPO
Citations	Per 100,000 workers	Total citation received per worker	OECD
Control variables			
Human capital	Percent	Enrollment Rate (tertiary)	World Bank
GDP per capita	US$ (log)	Real GDP per capita (2010 constant)	World Bank
Globalization	Index 1-100	Economic dimensions only	KOF
Financial development	Percent	Private sector credit to GDP	World Bank
Government size	Percent	Government expenditure (% of GDP)	World Bank
Unemployment	Percent	Total unemployment (% labor force)	World Bank
Instrument variables			
IP service charges receipts	Million US$ (log)	Charges for the use of intellectual property, receipts (BOP, current U$)	IMF
R&D intensity	Percent	Research & Development expenditure (% of GDP)	World Bank

Note) **WID**: world inequality database, **SWIID**: standardized world income inequality database, **WIPO**: World Intellectual Property Organization, **KOF**: Swiss Economic Institute, **IMF**: International Monetary Fund

Table A3: Four types of innovations

Type	Meaning	Example
Product innovation	• This refers to the introduction of new or improved products in the markets	• automobile • computer • iPhone
Process innovation	• This refers to the sequences and nature of production processes • This is often more difficult to detect but it is important especailly for production productivity	• automation
Incremental innovation	• This refers to improvement due to use/experience (progressive change of existing products or process) • This takes the form of design improvements, thru learn-by-doing or learn-by-using • This can be either product or processs innovation	• detergents for dark clothes • evolution of bicycle
Radical innovation	• This refers to the drastic change of existing products or processes, or the creation of new products to solve problems in society • This is discontinous events, which are the results of formal R&D activities • This can be either product or process innovation	• contact lenses • digital photos

Sorces: Dosi's (1988) and Damanpour et al. (1989)

Table A4: Innovation and top income inequality-OLS results (Innovation is not lagged)

Dependent variable (%)	Top 0.1%	Top 0.5%	Top 1%	Top 10%	Gini
Measure of innovation	Patent application per worker				
	(1)	(2)	(3)	(4)	(5)
Innovation	-0.008	-0.010	-0.012**	-0.011*	-0.015***
	(0.013)	(0.016)	(0.005)	(0.005)	(0.004)
Human capital	1.449***	1.318***	3.144***	2.506***	1.971***
	(0.452)	(0.430)	(0.400)	(0.226)	(0.157)
Gdppc (log)	0.323***	0.011	-0.176***	-0.162***	-0.136***
	(0.077)	(0.053)	(0.029)	(0.016)	(0.011)
Unemployment	0.022***	0.013**	0.003	0.001	0.005***
	(0.006)	(0.006)	(0.003)	(0.002)	(0.001)
Globalization	0.001	0.005***	0.006***	0.001*	0.001*
	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)
Government	-0.036***	-0.037***	-0.043***	-0.022***	-0.024***
	(0.004)	(0.003)	(0.003)	(0.002)	(0.001)
Finance	0.003***	0.004***	0.003**	0.002*	0.003***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Observations	510	510	1078	1078	1078
No. of countries	34	34	34	34	34
R^2	0.31	0.389	0.314	0.368	0.573

Notes: Panel data OLS regressions with country and year fixed effects. Time span is 1980-2017. Autocorrelation and heterosckedasticity robust standard errors are in parentheses, clustered at the country level. ***, ** and * indicate 0.01, 0.05 and 0.1 levels of significance, respectively.

Table A5: Top 1% income share and innovation with different lags-OLS

Dependent variable	Top 1% income share					
Measure of innovation	Patent application per worker					
Lag of innovation	2 years	3 years	4 years	5 years	6 years	all lags
	(1)	(2)	(3)	(4)	(5)	(6)
Innovation t-2	-0.022***					-0.010
	(0.008)					(0.021)
Innovation t-3		-0.020***				-0.005
		(0.006)				(0.024)
Innovation t-4			-0.018***			-0.011
			(0.006)			(0.023)
Innovation t-5				-0.017***		-0.006
				(0.005)		(0.022)
Innovation t-6					-0.015***	-0.017
					(0.005)	(0.018)
Human capital	1.138***	1.212***	1.070***	1.157***	1.032***	1.060***
	(0.242)	(0.192)	(0.261)	(0.220)	(0.299)	(0.242)
Gdppc (log)	-0.175***	-0.173***	-0.182***	-0.169***	-0.177***	-0.164***
	(0.027)	(0.028)	(0.025)	(0.022)	(0.031)	(0.022)
Unemployment	0.015**	0.011	0.013	0.022**	0.016**	0.013**
	(0.006)	(0.009)	(0.010)	(0.011)	(0.007)	(0.006)
Globalization	0.011***	0.006***	0.016***	0.012***	0.018***	0.011***
	(0.004)	(0.001)	(0.004)	(0.003)	(0.006)	(0.003)
Government	-0.045***	-0.034***	-0.032***	-0.024***	-0.054***	-0.034***
	(0.003)	(0.010)	(0.011)	(0.008)	(0.011)	(0.012)
Finance	0.004**	0.003**	0.002**	0.004**	0.003**	0.001**
	(0.002)	(0.001)	(0.001)	(0.002)	(0.001)	(0.000)
Observations	1077	1076	1075	1074	1073	1073
No. of countries	34	34	34	34	34	34
R^2	0.326	0.325	0.324	0.324	0.326	0.326

Notes: Panel data OLS regressions with country and year fixed effects. Time span is 1980-2017. The lag between dependent variable and innovation measures ranges from 2 to 6 years. Autocorrelation and heterosckedasticity robust standard errors are in parentheses, clustered at the country level. ***, ** and * indicate 0.01, 0.05 and 0.1 levels of significance, respectively.

Table A6: Innovation and top income inequality-IV results (R&D intensity)

Dependent variable	Top 0.1%	Top 0.5%	Top 1%	Top 10%	Gini
Measure of innovation	Patents application per worker				
	(1)	(2)	(3)	(4)	(5)
Innovation	0.079**	0.027**	0.035*	0.033***	-0.015*
	(0.029)	(0.011)	(0.014)	(0.008)	(0.006)
Human capital	0.386	1.100	2.962***	2.311***	2.019***
	(0.813)	(0.570)	(0.402)	(0.226)	(0.149)
Gdppc (log)	-0.164*	-0.019	-0.250***	-0.209***	-0.152***
	(0.082)	(0.057)	(0.032)	(0.019)	(0.013)
Unemployment	0.025***	0.013**	0.006*	0.001	0.005***
	(0.006)	(0.004)	(0.003)	(0.002)	(0.001)
Globalization	0.001	0.005***	0.006***	0.001	0.001
	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)
Government	-0.037***	-0.038***	-0.045***	-0.023***	-0.024***
	(0.004)	(0.003)	(0.003)	(0.002)	(0.001)
Finance	0.003***	0.004***	0.001	0.004*	0.005***
	(0.001)	(0.001)	(0.001)	(0.002)	(0.001)
Observations	508	508	1077	1077	1077
No. of countries	34	34	34	34	34
F-first satge	35.86	43.64	48.60	37.07	36.02
R^2	0.272	0.382	0.274	0,304	0.583

Notes: Innovation is 1 year lagged and instrumented by R&D expenditure (% of GDP, 2 year lagged). 2SLS regressions with country and year fixed effects. Time span is 1980-2017. Robust standard errors are presented in parentheses, clustered at the country level. ***, ** and * indicate 0.01, 0.05 and 0.1 levels of significance, respectively.

Annex A1: Skill-Biased Technological Change (supply and demand dynamics of labor)

SBTC can be theoretically and graphically explained by using demand and supply curve of labor developed by previous literatures (Acemoglu, 2002; Hicks, 1932; Katz et al. 1999). Suppose a production function has two kinds of factors: skilled (H) and unskilled (L) labor while capital is fixed. Production is carried out according to constant elasticity of substitution (CES) production function. Then, the function has the following form.[28]

$$Y_t = [\,(a_t H_t)^{\rho} + (b_t L_t)^{\rho}\,]^{1/\rho}$$

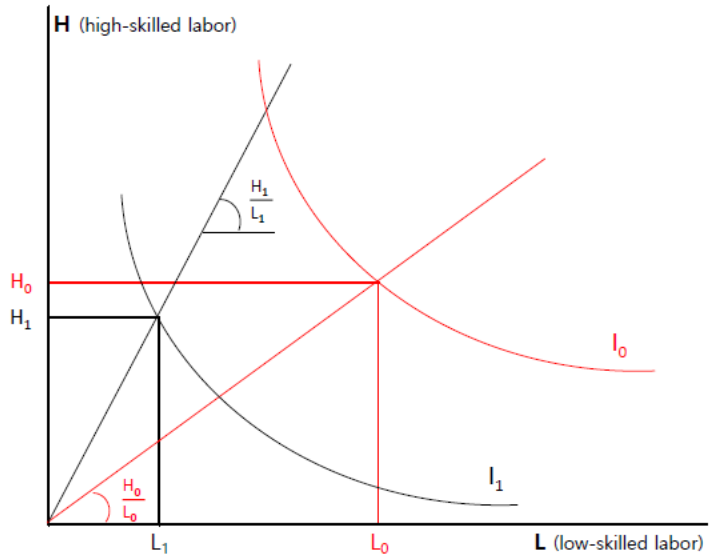
where Y_t represents output at time t while a_t and b_t are parameters that capture technical progress of skilled and unskilled respectively. This function depends on time t to capture technical change. In this function, $0 < \rho < 1$ and $1/(\rho-1)$ is elasticity of substitution between two factors (a_tH_t and b_tL_t). Then we can draw three types of technical change. First, technical change is skill-neutral when a_t and b_t change proportionately, which is called Hicks neutral. But, in case demand of skilled labor is greater than unskilled, parameter ratio (a_t / b_t) rises, which is called skill-biased. Lastly, if the ratio (a_t / b_t) decreases, technical change is biased toward unskilled labor, implying that demand for unskilled labor exceeds that of skilled. In addition, we can get relative wage between the two labor types using the production function and solving profit maximization problem of firms. The skill premium or the relative wage ratio (w_H/w_L) between skilled and unskilled labors in equilibrium will be obtained through partially differentiating production function by each labor. These results are as follows.

$$\omega_t = \frac{wH}{wL} = \left[\frac{at}{bt}\right]^{\rho} \left[\frac{Ht}{Lt}\right]^{\rho-1}$$

where the front part (a_t / b_t) shows the relative demand of labor while the rear part (H_t/L_t) represents factor ratio or relative supply of labor between skilled and unskilled. Hence the relative wage is determined by demand and supply of labor. We show skill-biased technical change when the relative wage is fixed (slope of budget line does not change) in Appendix Figure1. We also illustrate the traditional view (factor neutral technical change) in Appendix Figure 2. Furthermore the most intuitive case of SBTC is illustrated in the following Figure A.

[28] The general production function in aggregate economy has the following shape; Y(t) = F[K(t), H(t), L(t), t], where K is capital, H is high skill labor (high education), L is low skill labor (low education). Labor is inelastically supplied at time t.

Figure A: Illustration of skill-biased technological change (2 factor case)



Source: Based on authors imagination using method originally proposed by Hicks (1932)

In the above diagram which supposes two-factor economy (high- and low-skilled labor), technological progress will shift the isoquant curve toward the origin, from I_0 to I_1 because new technology may require less production factors to produce the same quantity of output. Factor employment intensity is biased for skilled labor after new technology adopted because H_1/L_1 is greater than H_0/L_0. As a result, tangent point moves in favor of skilled labor rather than unskilled under the assumption that relative wage ratio is fixed (budget line is parallel). Overall, the demand for low-skilled workers decreased even more than high-skilled workers, suggesting that technological change is biased toward high-skilled workers. But in reality the relative wage ratio changes according to development in technologies. This is more realistic situation, as depicted in Appendix Figure 3. During the last several decades, growing number of academic literatures on inequality largely focused on the effect of technical progress on worker's wage. As technology advances, high-skilled brain workers earn more compared to low-skilled hand workers, resulting in widening income gaps between them. Therefore current technological change is not factor-neutral, but biased to high-skilled workers such as college graduates or technological innovators. This widening gap is basically caused by different productivity between skilled and unskilled labor.

Annex A2: Academic discussions on the optimal tax rate for the top richest

Some scholars in the late 1990s conducted studies to explore the optimal tax rate for the rich when income tax rate is progressive (Diamond, 1998). They find that top income tax rate maximizing tax revenues is inversely proportional to the elasticity of taxable income[29]. Then, today income inequality level should be considered additionally in determining optimal tax rate for the richest (Saez, 2001). The higher the inequality, the larger the optimal tax rate for the rich. Empirical studies show that optimal top marginal tax rate for the top 1 % richest that maximizes revenues is around 75% in the US (Diamond et al. 2011; Kevin et al. 2014; Saez et al. 2012).[30] Considering this estimation, there are large rooms to increase marginal tax rate of top income earners in the US, equally applied to other rich countries as shown in Appendix Figure 4.

The best practice example of increased tax revenues can be found in the US. Top income tax rate of 90% for super-riches was adopted in the US in 1930s and it lasted for almost 50 years. These revenues were spent in building schools and funding public universities, which led to human capital accumulation and solid economic growth. But since 1980s, top income tax rate has begun to drop and income inequality rapidly rose. In fact, raising tax rate for the rich is not easy job for politicians economically and politically. Therefore, establishing public regulators to monitor and regulate tax-dodging by the wealthy can be practical way to prevent the rich from avoiding and evading tax. This watchdog contributes to crack down on tax crimes and mitigate the spread of tax dodging schemes among the richest.

To achieve the optimal tax rate of the rich, three kinds of tax schemes can be considered including progressive income tax, corporate tax, and wealth tax. The income tax plan alone is not sufficient to increase tax collection from the rich because they have various loopholes to avoid tax. For example, Amazon of Jeff Bezos, a giant online platform, does not make much profit today, but it is expected to be profitable in the future. Berkshire Hathaway, a holding company, does not pay dividends to shareholders, thus generating little taxable income. Even though top marginal income tax rate is raised, these company owners will not be affected much

[29] The idea of elasticity of taxable income comes from Frank Ramsey (1903-1930), a British economist. The '**Ramsey Rule**' says on optimal taxation, arguing that, under flat tax rate, revenue-maximizing tax rate is inversely proportional to elasticity of taxable income. When tax rate rises, reported income does not change much (inelastic income), in which government can collect more revenues by raising tax rate. The opposite is elastic income, in which increasing tax rate reduces tax revenues.

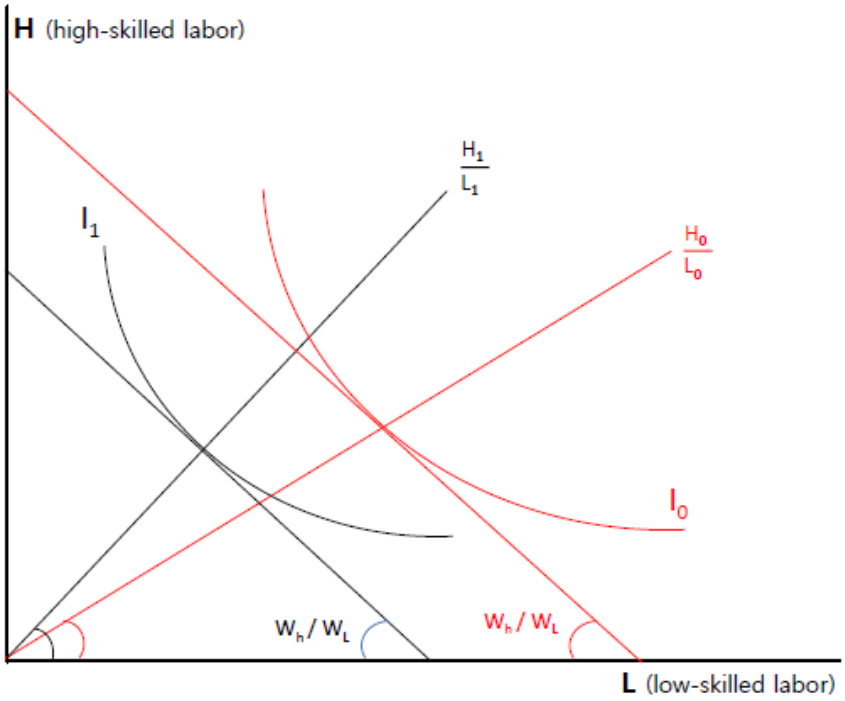
[30] The threshold of top 1% income earners in the US is U$500,000 in 2019. A **marginal** tax rate refers to the rate applied to the income above threshold. Hence **average** tax rate is smaller than marginal tax rate because income below the threshold is taxed less. Suppose that average tax rate for income below the threshold is 30%, then average tax rate for top 1% is 60% when their average income is U$1,500,000. [75% x (2/3) + 30% x (1/3) = 60%]

as the taxable income is tiny. Hence the other tax plans should be considered. Basically the corporate tax is not progressive, so it cannot be handsome way to increase tax collection from the richest. That's why the wealth tax can be a good alternative tax scheme as it is to impose tax on wealth itself. Most super-riches usually possess lots of wealth while taxable income is small. Therefore, wealth tax can be a practical tool to tax the richest because wealth can be clearly observed unlike income. The richest usually own huge wealth but not enough cash to pay tax, hence allowing them to pay tax with in-kind stocks or bonds would be wise way when adopting wealth tax. Despite many advantages of wealth tax idea, we also need to listen to pessimistic views on this tax. First, it may discourage firm investment activity and obstruct the development of capital market (Guvenen et al. 2019). Today's wealth is yesterday's income. Therefore, by imposing high tax on wealth, income generating activities, such as firm investment, will be depressed. Furthermore, wealth tax may encourage the rich to depend on tax loopholes in search of tax dodges. Also some argues that wealth tax will make capital market collapse as company founders do not like to list on stock exchange. Another critical weakness is that it has never been implemented and can be against constitution due to the double taxation problem.

Angus Deaton, a Nobel Prize economist at Princeton University, argues that wealth tax on super-riches would give them high incentives to avoid it and the current attempt to adopt it temporarily in the U.S. is bad idea in that it would be permanent tax if once adopted.[31] Regarding the wealth tax idea, Thomas Piketty, a French economist, has the boldest opinion of adopting this tax at the global level. He argues in his book *Capital in the 21st Century* that the rate of return on capital has been higher than average economic growth rate, making capitalists wealthier as time passes on (Piketty, 2014). To address this structural spiral of inequality, he proposed to impose heavy tax rate on the assets of the richest at the global level. But his aggressive idea has received fierce criticism from academics as well as policy makers. Judging from the above discussions, wealth tax could be an efficient method to revive tax progressivity among top riches, but it has some practical and legal problems for the full implementation.

[31] In 2021, democratic lawmakers including Elizabeth Warren proposed a bill to levy wealth tax on super-riches in the US. The purpose was to finance emergency spending for COVID-19 and reduce income inequality. But many jurists opposed this for practical and legal reasons. Angus Deaton also objected this bill. Historically income tax was first introduced temporarily in England in 1799 to finance war against France. But it has later become permanent tax, which spread to other countries.

Figure A1: Skill-Biased Technical Change (relative wage is fixed)



Source: Authors' work based on Sanders et al (2000)

Notes: ① The relative wage ratio is fixed (the slope of budget line is parallel)

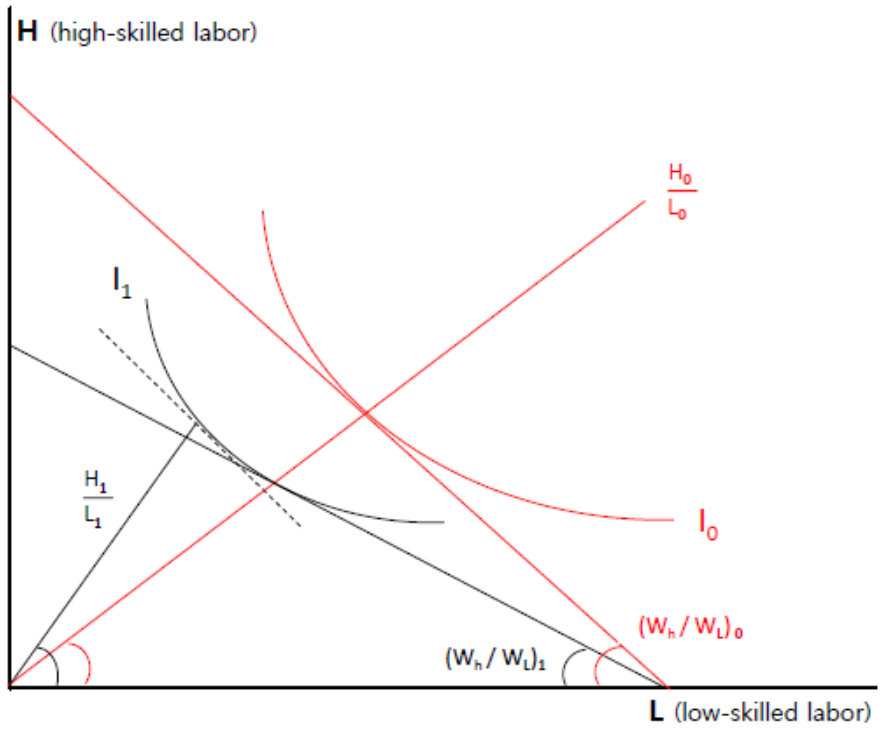
② Technical progress will move isoquant curve toward the origin ($I_0 \rightarrow I_1$)

③ Tangent point is not on original line any more (factor intensity changed in favor of high-skill labor)

④ Employment of high-skill labor is greater than that of low-skill labor (as a result of technical change)

⑤ In sum, technical change is biased toward high-skilled workers

Figure A2: Factor-Neutral Technical Change (traditional view)



Source: Authors' work based on Sanders et al (2000)

Notes: ① Factor intensity or factor employment ratio is constant

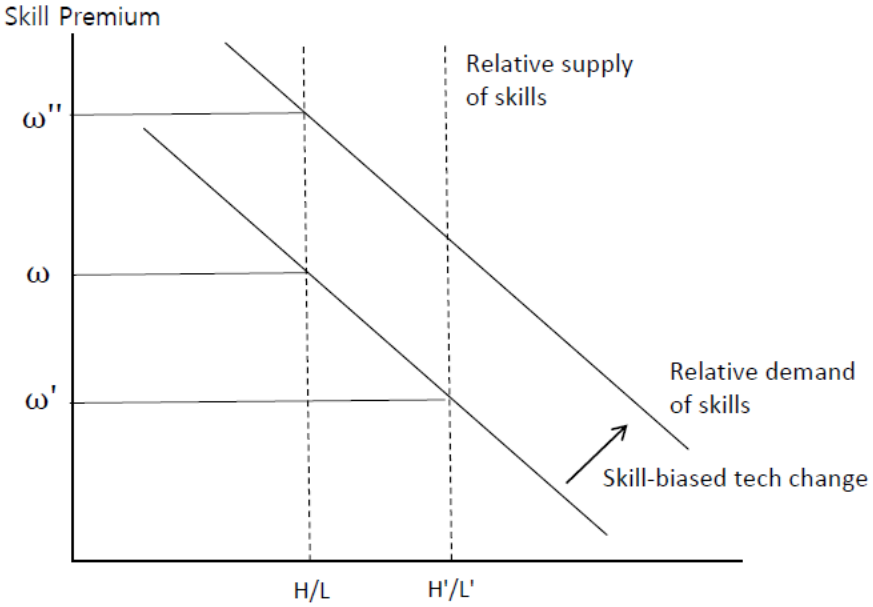
② Technical progress will move isoquant curve toward the origin ($I_0 \rightarrow I_1$)

③ Tangent point is on the same original line (no factor intensity changed from technical change)

④ But the relative wage ratio is adjusted to changes in the technical progress(wage ratio decreased)

⑤ In sum, no factor intensity (employment) changes as a result of technical progress

Figure A3: Skill premium and the relative demand and supply of skills

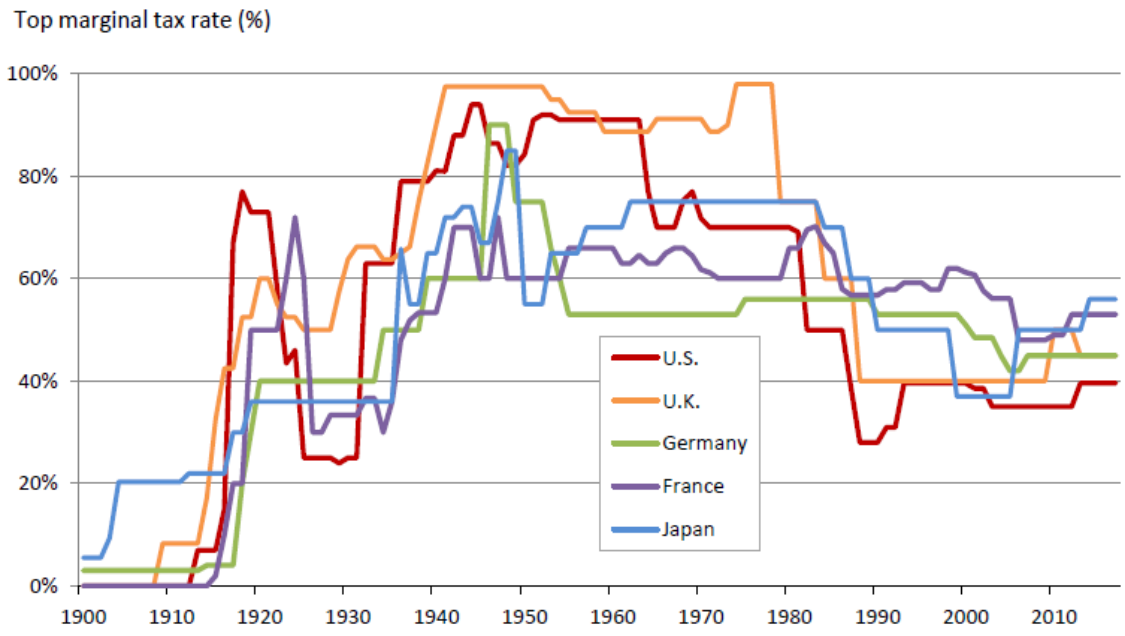


Notes: ① A rise in relative supply for skills, from H/L to H'/L', moves along downward sloping relative demand curve, and decreases skill premium from ω to ω'.

② But the falling tendency of skill premium would be counteracted by technological change

③ Skill complementary technical development increases skill premium as shown above from ω to ω'' which is caused by shift of the relative demand curve of skills

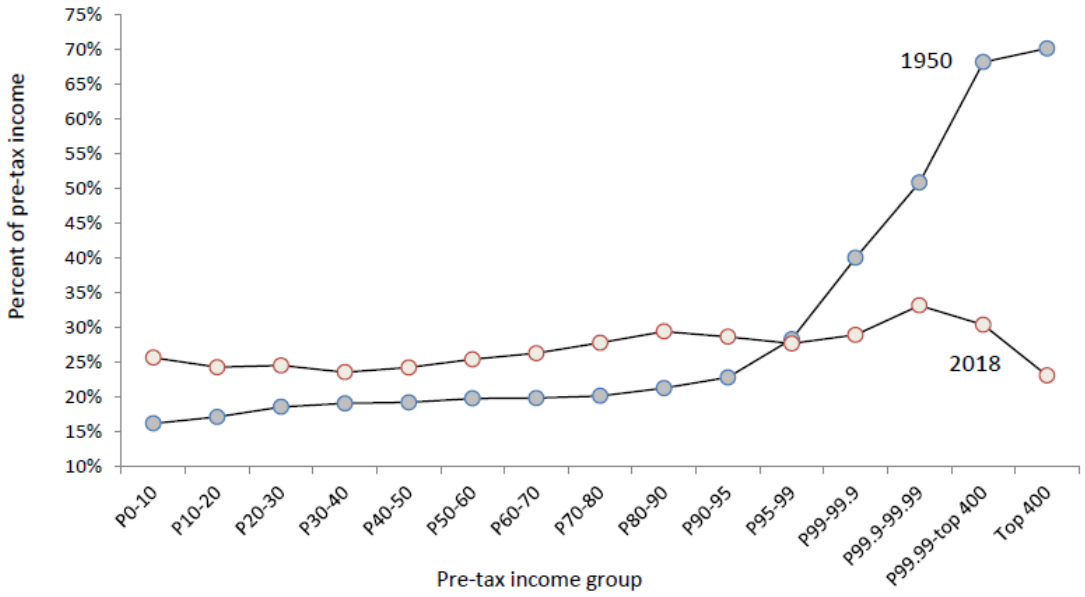
Figure A4: Top income tax rate in advanced countries, 1900-2017



Source: data from Piketty (2014) and World Inequality Report 2018

Notes: Top marginal tax rate in income tax (applying to top earners) in the United States decreseaed from 91% in 1963 to 40% in 2017

Figure A5: Average tax rate in the US, 1950 vs. 2018

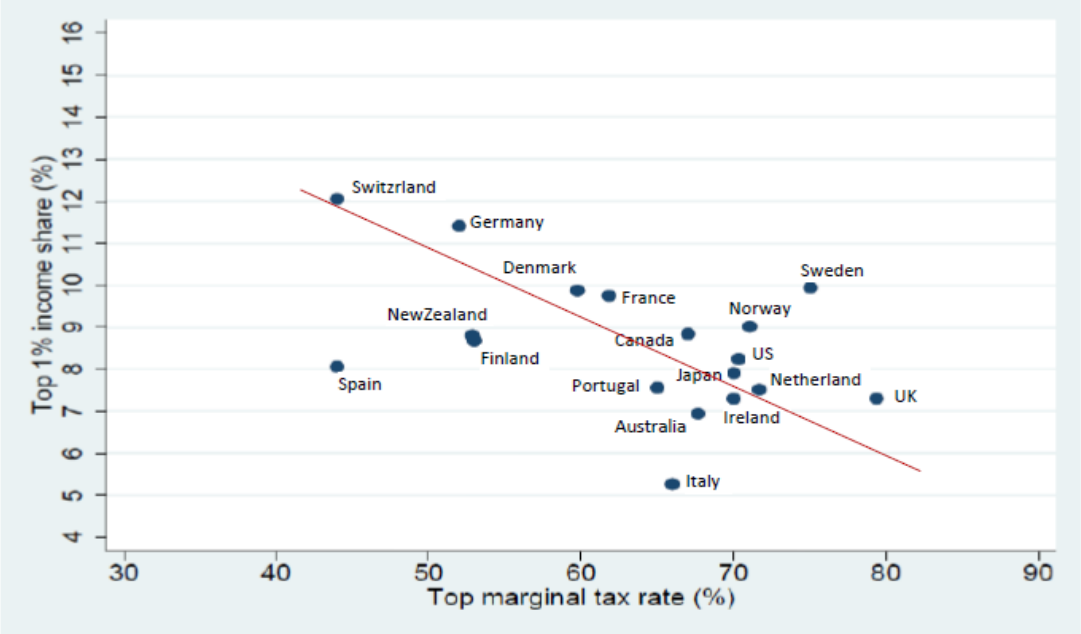


Source: data from Saez and Zucman (2019)

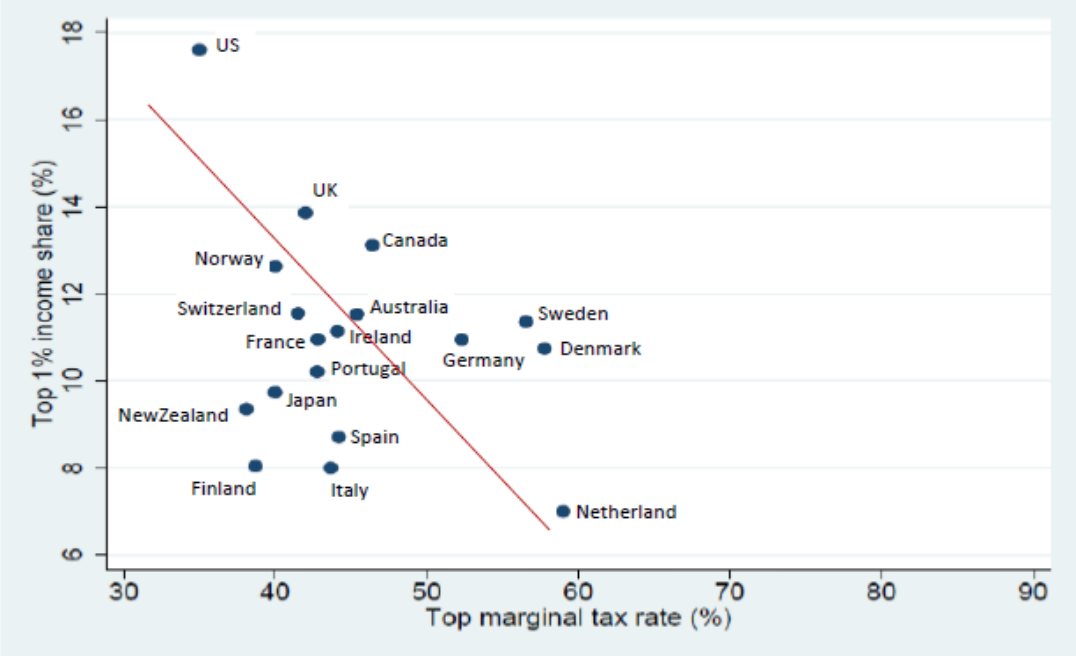
Notes: All taxes on federal, state, and local level in the US are included. Taxes are expressed as a fraction of per adult pre-tax income. Top 400 refers to the Forbes list of the 400 highest income earners in the US.

Figure A6: Top income shares and top marginal tax rate: historical change

A. Top 1% income share vs. Top marginal tax rate, 1970-74



B. Top 1% income share vs. Top marginal tax rate, 2006-10



Source: data from www.wid.world and Piketty et al. (2014)

References

Acemoglu, D., "Technical Change, Inequality, and the Labor Market" NBER Working Paper 7800 http://www.nber.org/papers/w7800, July 2000

Acemoglu, D., Restrepo, P., "Automation and New Tasks: How Technology Displaces and Reinstates Labor" Journal of Economic Perspectives, 33(2), 3-30, 2019

Adams, S., Klobodu, E.K.M., "Capital Flow and the Distribution of Income in Sub-Saharan Africa" Economic Analysis of Polcy, 55, 169-178, 2017

Aghion, P., Antonin, C., Bunel, S., *The Power of Creative Destruction: Economic Upheaval and the Wealth of Nations*, The Belknap Press of Harvard University Press, 2021

Aghion, P., Akcigit, U., Bergeaud, A., Blundell, R., Hemous, D., "Innovation and Top Income Inequality", Review of Economic Studies 86, 1-45, 2018

Aghion, P., Howitt P., and Prantel S., "Patent Rights, Product Market Reforms, and Innovation", Journal of Economic Growth, 20, 223-262, 2015

Akcigit U., Baslandze S., Stantcheva S., "Taxation and the International Mobility of Inventors", Americal Economic Review, 106(10) 2930-2981, 2016

Angrist, Joshua D., Jorn-Steffen Pischke, *Mostly Harmless Econometrics: An Empiricist's Companion*, Princeton University Press, 2009

Angrist, Joshua D., Jorn-Steffen Pischke, *Mastering 'Metrics: The Path from Cause to Effect*, Princeton University Press, 2015

Arrow, Kenneth, "The Economic Implications of Learning by Doing", Review of Economic Studies, Vol. 29, pp. 153-73, 1962

Asteriou D. Dimelis S. Moudatsou A. "Globalization and Income Inequality: A Panel Data Econometric Approach for the EU 27 Countries" Economic Modelling, 2014

Azman-Saini W., Baharumshah A.Z., Law S.H., "Foreign Direct Investment, Economic Freedom and Economic Growth: International Evidence" Economic Modeling, 27, 2010

Banerjee A.V., Newman A.F., "Occupational Choice and the Process of Development" Journal of Political Economy, 101, 274-298, 1993

Barro, R. J., "Economic Growth in a Cross-section of Countries", Quarterly Journal of Economics, 106(2), 407-443, 1991

Beladi H., Marjit S., Xu X., and Yang L., "Strategic Enforcement, Intellectual Property Right, and Contractual R&D", Economic Inquiry, Vol. 54, 1904-1917, 2016

Bell, A. M., Chetty, R., Jaravel, X., “Who Becomes an Inventor in America? The Importance of Exposure to Innovation,” NBER Working Paper 24062, 2017

Benos, N., Karagiannis S., “Inequality and Growth in the United States: Why Physical and Human Capital Matter?” Economic Inquiry Vol. 56 No. 1, 572-619, 2018

Benos, N., Tsiachtsiras, G., “Innovation and Income Inequality: World Evidence,” Munich Personal RePEc Archive Paper No. 92050, 2019

Bergh, A., Nilsson, T., “Do Liberalization and Globalization Increase Income Inequality?” European Journal of Political Economy 26(2), 488-505, 2010

Blanchard, Olivier, Rodrik, Dani, *Combating Inequality: Rethinking Government’s Role*, The MIT Press, Massachusetts, Cambridge, 2021

Bloom D.E., Sachs J.D., Collier P., Udry C., “Geography, Demography, and Economic Growth in Africa” Brookings Papers on Economic Activity 1998(2), 207-295, 1998

Boldrin M., Levine D K., “Does Intellectual Monopoly Help Innovation?” Review of Law and Economics, 2009

Bottazzi L., Parri G., “Innovation and Spillovers in Regions: Evidence from European Patent Data”, European Economic Review 47, 687-710, 2003

Card, D., John E. DiNardo, “Skill Biased Technological Change and Rising Wage Inequality; Some Problems and Puzzles,” NBER Working Paper 8769, 2002

Chancel, Lucas, “Ten Facts About Inequality in Advanced Economies” Event held at the Peterson Institute for International Economics, October 17, 2019

Cozzens, S. E., “Innovation and Inequality”, Technology Policy and Assessment Center, School of Public Policy, Georgia Institute of Technology, 2008

Diamond, Peter A., “Optimal Income Taxation: An Example with a U-shaped Pattern of Optimal Marginal Tax Rate.” *American Economic Review* 88, No.1, 83-95, 1998

Goldin, C. D., Katz, L.F., “The Race between Education and Technology” Harvard University Press, 2009

Griliches Z., *Patent Statistics as Economic Indicators: A Survey*, pp. 287-343, University of Chicago Press, 1998

Guvenen F., Kambourov G., Kuruscu B., Ocampo-Diaz S., Chen D., “Use It or Lose It: Efficiency Gains from Wealth Taxation” NBER Working Paper No. w26284, 2019

Gygli S., Haelg F., Potrafke N., Sturm J., “The KOF Globalization Index-Revisited” Review of International Organizations 14(3), 543-574, 2019

Hall B. H., Jaffe A. B., Trajtenberg M., "The NBER Patent Citation Data File: Lessons, Insights and Methodological Tools", NBER Working Paper 8498, 2001

Hall B. H., Lotti F., Mairesse J., "Employment, Innovation, and Productivity: Evidence from Italian Microdata," Industrial and Corporate Change 17(4), 813-839, 2008

Hicks, John R., *Theory of Wages*, 1st edition, London, Macmillan & Co. 1932

International Monetary Fund, World Economic Outlook: Globalization and Inequality, 2007

Jaumotte F., Lall S., Papageorgiou C., "Rising Income Inequality: Technology, or Trade and Financial Globalization?" IMF Economic Review, 61(2), 271-309, 2013

Jones C.I. and Kim J., "A Schumpeterian Model of Top Income Inequality," Journal of Political Economy, 2017

Katz L.F., Murphy K.M., "Changes in Relative Wages 1963-1987: Supply and Demand Factors" Quarterly Journal of Economics 107(1), 35-78, 1992

Kelly B., Papanikolaou D., Seru A., Taddy M., "Measuring Technological Innovation over the LongRun", NBER Working Paper, No.25266, 2018

Knight, J. B., Sabot, R. H., "Educational Expansion and the Kuznets Effect" *American Economic Review* 73 (5), 1132-36, 1983

Kortum S., Lerner J. "Stronger Protection or Technological Revolution: What is the behind the Surge in Patent?" Carnegie Conference Series on Public Policy 48(1), 247-304, 1998

Krugman, P., Venables, A. J., "Globalization and Inequality of Nations," *The Quarterly Journal of Economics*, 110(4), 857-880, 1995

Kuznets, S., "Economic Growth and Income Inequality," *American Economic Review* 45: 1-28, 1955

Law S.H., Naseem N.A.M., Lau W.T., Trinugroho I., "Can Innovation Improve Income Inequality? Evidence from Panel Data," Economic Systems 44(2020) 10085, 2020

Law S.H., Singh N., "Does Too Much Finance Harm Economic Growth?" Journal of Banking Finance, 41, 36-44, 2014

Lee, Neil and Clarke, Stephen, "Do Low-Skilled Workers Gain from High-Tech Employment Growth? High-Technology Multipliers, Employment and Wages in Britain," LSE, 2019

Lerner J., "The Importance of Patent Scope: An Empirical Analysis", RAND Journal of Economics, 25(2), 319-333, 1994

Lerner J., "The Empirical Impact of Intellectual Property Right on Innovation: Puzzles and Clues", American Economic Review, 2009

Lim, J. and Lee, K., "Employment Effect of Innovation under Different Market Structure: Findings from Korea" Technical Forecasting and Social Change, Elsevier vol. 146, 2019

Lucas, R. E., "On the Mechanics of Economic Development" Journal of Monetary Economics, 22, 3-42, 1988

Mah J.S., "Globalization, Decentralization and Income Inequality: The Case of China" Economic Modeling, 31, 653-658, 2013

Massa, Massimo, Si Cheng and Hong Zhang, "Financial Globalization and Income Inequality: The Surprising Role of Portfolio Flows in Taming Top 1%," CEPR Discussion Paper, 2021

Milanovic, B., "Can We Discern the Effect of Globalization on Income Distribution? Evidence from Household Surveys," The World Bank Economic Review 19, 21-44, 2005

Mokyr J., "Intellectual Property Right, the Industrial Revolution, and the Beginning of Modern Economic Growth", American Economic Review, 2009

Moretti, E., Steinwender, C., Van Reenen, J., "The Intellectual Spoils of War? Defense R&D, Productivity and Spillovers," London School of Economics, 2016

OECD, "Divided We Stand, Paris: Why Inequality Keeps Rising?', 2011

OECD, "Focus on Top Incomes and Taxation in OECD Countries: Was the Crisis a Game Changer?", 2014

PIIE(Peterson Institute for International Economics), How to Fix Economic Inequality? 2020

Piketty, T., *Capital in the Twenty-First Century*, Harvard University Press, 2014

Piketty, T., Saez E., Stantcheva S., "Optimal Taxation of Top Labor Incomes: A Tale of Three Elasticities" American Economic Journal: Economic Policy 6, no. 1, 230-271, 2014

Pareto, Vifredo, *Cours d'Economie Politique*, Geneva:Droz, 1896

Piketty, T., Saez E., Zucman, G., "Distributional National Accounts: Methods and Estimates for the United States." Quarterly Journal of Economics 133, no.1 553-609, 2018

Rawls, John, *A Theory of Justice*, Cambridge, MA, Harvard University Press, 1971

Ram, R., "Population Increase, Economic Growth, Educational Inequality, and Income Distribution: Some Recent Evidence" Journal of Development Economics 14, 419-28, 1984

Rodrik Dani, *One Economics, Many Recipes: Globalization, Institutions and Economic Growth*, Princeton University Press, 2009

Roine J., Vlachos J., Walenstrom D., "The Long-Run Determinats of Inequality: What can We Learn from Top Income Data?" Journal of Public Economics, Elsevier 93(7), 2009

Romer, Paul M. “Endogenous Technological Change,” *Journal of Political Economy*, vol. 98, pp.71-102, 1990

Saez E., Zucman G., *The Triumph of Injustice: How the Rich Dodge Taxes and How to Make Them Pay*, W.W. Norton & Company, Inc., 2019

Sanders, M., Bas ter Weel, “Skill-Biased Technical Change: Theoretical Concepts, Empirical Problems and a Survey of the Evidence”, Collections.unu.edu, 2000

Schumpeter, Joseph A., *Capitalism, Socialism, and Democracy*, New York, Harper and Brothers, 1942

Solow, R. M., “A Contribution to the Theory of Economic Growth,” *Quarterly Journal of Economics*, vol. 70, pp. 65-94, 1956

Solow, R. M., “Technical Change and the Aggregate Production Function” *The Review of Economics and Statistics* 39(3), 312-320, 1954

Squicciarini M., Dernis H., Criscuolo C., “Measuring Patent Quality: Indicators of Technological and Economic Value”, OECD Working Paper, 2013

Stiglitz, J., *Globalizaton and its Discontents*, New York: WW Norton, 2002

Stiglitz, J., “More Instruments and Broader Goals: Moving Toward the Post-Washington Consensus,” WIDER Annual Lecture 2, 1998

Tan H.B., Law S.H., “Nonlinear Dynamics of the Finance-Inequality Nexus in Developing Countries” Journal of Economic Inequality, 10, 551-563, 2012

Tebaldi E., Elmslie B., “Does Institutional Quality Impact Innovation? Evidence from Cross-Country Patent Grant Data” Applied Economics Vol. 45, 887-900, 2013

Uslaner, Eric and Bo Rothstein, “The Historical Roots of Corruption: State Building, Economic Inequality, and Mass Education.*” Comparative Politics* 48: 227-248, 2016

Wang C., “Can Institutions Explain Cross Country Differences in Innovation Activity? *Journal of Macroeconomics*, 37, 128-145, 2013

Wooldridge, A., *The Aristocracy of Talent: How Meritocracy Made the Modern World*, Skyhorse Publishing, New York, 2021

Zhou, L., Biswas, B., Bowles, T., Saunders, P. I., “Impact of globalization on Income Distribution Inequality in 60 Countries,” *Global Economy Journal*, 11(1), 1-18, 2011

Chapter 2

Financial Innovation, Financial Inclusion, and Poverty: Evidence from 103 Developing Countries

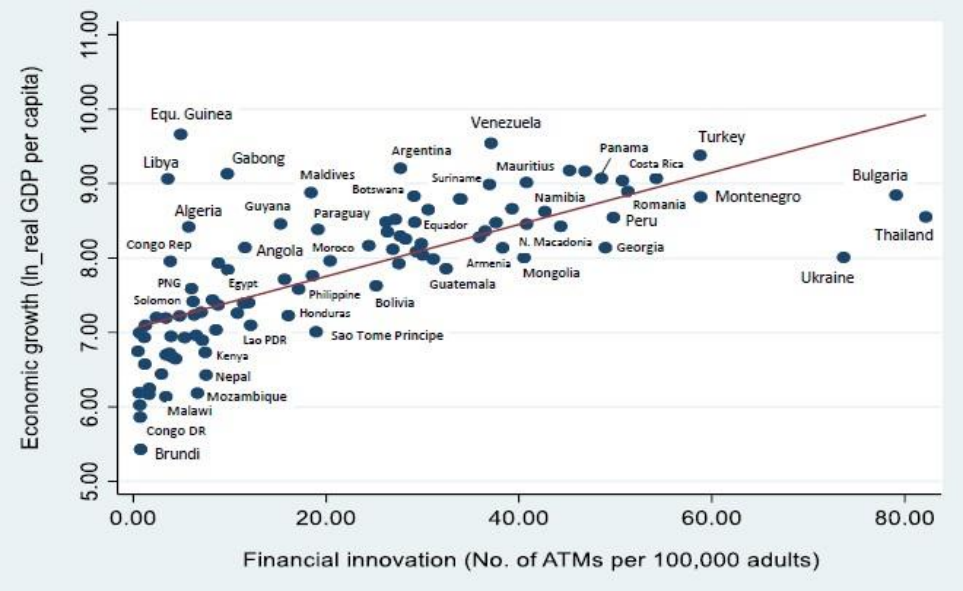
1. INTRODUCTION

Recently financial innovation has become one of the most popular words in the financial market since it has become a powerful engine driving financial development by improving access to financial services. Most evidences indicate that financial innovation plays a vital part in elevating financial depth and economic development (Beck et al. 2004; Levine, 2005; Loukoianova et al. 2018; Sahay, 2015)[1]. Hence financial innovation enhances financial inclusion through easier access to financial services including payment, deposit, loans, and insurance. (Galor et al. 1993; Honohan, 2004; Sarma, 2008). Financial innovation includes various definitions, such as creating new financial services or enhancing financial inclusion by lowering barriers to market (Ozili, 2020). Mobile banking and peer-to-peer (P2P) lending are good examples. Financial inclusion describes the process of encouraging accessibility and usage of formal financial services among people, especially vulnerable people such as low-income citizens (Sarma, 2012). This is why financial innovation is usually stated as a game changer to address poverty problem in developing countries.

Traditionally, financial innovation is led by financial institutions such as banks. Bank of America (BOA) issued 'credit card' in 1958 for the first time, which has dramatically changed the patterns of consumer's daily lives. ATM (automated teller machine) was first installed in London in 1967 by Barclays Bank. Customers could withdraw money whenever they want without visiting banks. But these days most financial innovation is usually led by IT (information technology) firms. Thanks to the wide penetration of mobile phones and the internet, people can use financial services online regardless of time and space. If this is the case, is financial innovation conducive to reducing poverty in developing world? To answer the question is the goal of this essay. There are still 1.7 billion unbanked in the world who are marginalized from formal financial services (World Bank, 2018). They cannot access to formal financial services, which blocks them from escaping poverty. Recently there are growing interests that financial innovation can be a solution for poverty. This essay is based on this idea. Thus I focus on developing countries where poverty is still serious problem.

[1] In this essay, I presume that **financial innovation** enhances **financial inclusion** as financial inclusion means essentially higher access to financial services by general people, especially by financially marginalized poor people. This is why I use **financial inclusion index** as proxy of financial innovation. Financial inclusion index was developed by many scholars to capture financial inclusion level. Usually the index consists of two pillars: access and usage. The former includes number of ATMs or bank branches. The latter includes the ownership ratio of bank accounts, savings, or deposits etc.

Figure 1: Scatterplot between financial innovation and economic growth, 2004-2018



Source: data from World Bank WDI

The growth of financial technology or fin-tech has changed the way people pay, send money, borrow and lend, which expanded customer base to the poor or financially excluded people who could not use those services before. Thus financial innovation can contribute to poverty reduction and growth as shown in Figure 1. Also it enhances financial inclusion as displayed in Appendix Figure 1. The economic impact of fin-tech can be viewed in two ways (Smith et al. 2009). One is 'disruptive' innovation. As information technology (IT) firms enter into financial sector, market competition would be more intensifying. The incumbent financial institutions must respond to new entrants by developing new services and destroying existing business models. Another view is 'creative' destruction. New entrants unbundle existing financial products into more complex and effective ones. New financial products such as crowd funding or P2P loans are good examples.

In this essay I primarily focus on financial inclusion to identify causality from financial innovation to poverty in developing economies. Financial innovation is represented by 'financial inclusion index' computed by Gutierrez-Romero et al. (2021) based on IMF Financial Access Survey data.[2] To draw out causal links between financial inclusion and poverty I use several empirical methods such as panel fixed effects and instrument variable strategy. As exogenous instruments, I use latitude of capital city and legal origin dummy of European ex-colonies. Through this analysis, I test the hypothesis that financial innovation (financial inclusion) has positive influences on poverty reduction in developing countries.

[2] This aims to help policy makers and scholars to measure financial inclusion. It was launched by IMF in 2008, focusing on financial usage and access. This data cover 189 countries and spanning more than 15 years. To facilitate cross-country comparison, indicators are normalized by adult population, land size, and GDP. More details are in Appendix Table 2.

Many evidences exist that fin-tech has positive effects on financial inclusion (Akhter et al. 2017; Demombyne et al. 2012; Mbiti and Weil, 2016). Fin-tech, combined term of finance with technology, has dramatically changed the landscape of financial market. Financially excluded people can now enjoy various financial services thanks to new technologies. Fin-tech is financial market version of digital transformation (DT), providing three kinds of expected welfare gains to consumers: lower transaction cost, reduce information asymmetry between borrowers and lenders, and extend financial inclusion (Cho, 2021). Thus financial innovation is critical in mitigating poverty in developing countries (World Bank, 2018). Improved access to finance may enhance investment chances, making people richer than before. The concern of this essay is to explore the relationship between financial inclusion and poverty in developing economies. So this work examines the bright side of technology. For this, I set up a panel for 103 developing economies during the years 2004-2018. The reason why we focus on developing countries is that poverty is still serious problem in these countries. Today almost 10% of world people lives in extreme poverty of $1.90 a day mostly in sub-Saharan Africa and South Asia.[3] Thus, poverty reduction is one of the most urgent issues in developing economies. Moreover, as noted, 1.7 billion people are unbanked globally, representing 40% of adults. If this is true, then financial technology can help them escape from poverty? And what determines financial inclusiveness in the age of fin-tech revolution? These are research questions that we would like to answer in this essay.

Many empirical studies have shown that there exist positive links between financial development and growth (Guillaumont-Jeanneney et al. 2011; Hassen et al. 2011; Khan et al. 2003; Levine, 1997; Patrick, 1966). Hence scholars and policy makers have high interests in exploring the effect of financial technology on socio-economic outcomes such as poverty or inequality in developing countries. According to evidences, technologies make contribution to elevating financial inclusion by boosting accessibility and usage of various financial instruments. Therefore, financial inclusion became a critical policy goal enabling to achieve sustainable economic and financial development in many countries. In fact, higher financial inclusion can have positive impact on the real economy as well as financial sector. Many empirical studies have already proved that financial inclusion can reduce rural poverty, increase employment and consumer savings (Burgess et al. 2005; Bruhn et al. 2014; Brune et al. 2016; Dev 2006; Grohmann et al. 2018).

[3] According to World Bank data, there are 729 million people (10% of world population) who suffer from extreme poverty in 2015, reduced from 1.9 billion (36% of world population) in 1990. The dramatic drop in poverty is mainly due to the fast economic growth in Asia, particularly in China and India. However, in Africa, poverty is still rising due to fast population growth. People who live below extreme poverty rose from 290 million (1990) to 422 million (2015) in sub-Sahara Africa.

Before fin-tech has emerged, we had to visit bank branches to use financial services. But fin-tech innovation has made it possible for people to handle financial services faster and more conveniently using mobile devices. Fin-tech lenders in the U.S. process mortgage application 20% quicker than traditional lending firms (Fuster et al. 2018). Moreover, thanks to financial technology, those who could not approach to formal financial institutions before are now available to use various services (World Bank, 2018). This is the main reason why financial innovation is cited as a game changer to address poverty in developing countries. Microfinance was once prevalent as a potential tool to elevate financial depth and reduce poverty in developing world. But nowadays various studies show skeptical view on the effect of microfinance on poverty (Coleman, 2004; Hickel, 2015). Of course, there are some caveats regarding fin-tech innovations. Economic benefits that fin-tech produces are heterogeneous across countries and regions. Our findings in this study also provide some different influence of financial inclusion on poverty among income groups. More specifically, financial inclusion shows significant effect on poverty reduction in middle-income group, but the impact does not show significance in high-income and low-income groups.[4] This suggests that financial inclusion is not sufficient condition for poverty reduction in these countries. Rather, other factors such as institutional quality or financial literacy would be essential.

This essay may contribute to existing studies in two ways. First, my empirical work provides validating the empirical results of previous works in this field. Second, this essay gives robust results on the effect of financial inclusion on poverty in developing economies. In fact, most empirical studies focused on the effect of financial development on growth or inequality. The correlation between financial inclusion and socio-economic consequences has received less attention from academic researchers. In this respect, my work is meaningful and contributes to the existing literatures. Poverty reduction is the foremost policy goal in many developing countries. Thus I use various poverty indicators in this study including headcount, poverty gap, squared poverty gap and the Watts index. Financial innovation is measured by 'financial inclusion index' constructed by Gutierrez-Romero et al. (2021). To estimate the model I've used panel fixed effects and instrumental variable approaches. My findings indicate that financial innovation (or inclusion) shows powerful impacts on poverty in developing economies. This study consists of the following. In the next part, I provide literature reviews and data explanations are presented in section 3. Section 4 elaborates identification strategy and empirical techniques. Section 5 provides the main results while section 6 makes policy suggestions. Section 7 is conclusions.

[4] My findings, that middle-income countries are the only beneficiaries of financial inclusion, would not always hold good. That is, one caveat is that different results would be possible when using different sample countries and different time periods, even different control variables.

2. LITERATURE REVIEW

In this part, I examine a strand of literatures dealing with the links between financial innovation and poverty. First, I examine some theoretical literatures and then look at the literatures exploring finance-poverty nexus, and lastly I review literatures exploring the influence of fin-tech on poverty, particularly in perspective of digital financial inclusion.

2.1 Theoretical Literatures

Among theoretical literatures, the most famous studies would be the following ones: Mckinnon (1973), Shaw (1973), and Aghion et al. (2005). The first one elaborates the so-called Mckinnon's 'conduit effect'[5], implying the direct influence of financial development on poverty through increased accessibility to finance. That is, advanced financial system functions as a 'conduit' to promote fund raising and investment chances. Mckinnon (1973) argues that financial system is under-developed in most poor countries, thus there is no clear distinction between savings and investments. Investment is financed by cash holdings within an economy (complementarity hypothesis). In this economy people prefer to maintain cash holding rather than savings. But financial development provides more saving opportunities as diverse financing tools even for the poor, prompting to accumulate assets and reduce poverty. Shaw (1973) proposed the 'intermediation effect', arguing that increased interest rate of deposits boosts savings and thus banks have enough resources to extend credits to investors including the poor and small firms. So the total volume of investment increases in an economy.[6] Aghion et al. (2005) claims the 'threshold effect' regarding the links between finance and poverty, arguing that: "As financial sector develops, it expands its services to poor people". They assert that financial system should reach at certain threshold of development for the poor people to benefit from it. In many less-developed countries, poor people depend more on informal finances rather than formal financial institutions. This hinders financial development in those countries. According to them, there are three major constraints for the poor in developing country: lack of guarantees, physical obstacles, and the absence of banks for the poor. To reach the threshold, these obstacles must be eliminated.

[5] Financial development is pro-poor. That is, financial development contributes to reducing poverty by two channels. One is economic growth channel which is indirect influence of financial development on poverty through distributional effect. The other is 'conduit effect', in which poor people can expand access to finance and thus raise income (Mckinnon, 1973).

[6] To test finance-poverty model, Fry (1980) conducted a study using data for seven least-developed countries in Asia over the period of 1962-1972 (Burma, India, Korea, Malaysia, Philippines, Singapore, Taiwan). He finds that high real rate of interest boosted savings and growth, but no evidence for complementarity hypothesis. That is, his finding does not support the complementarity assumption that investment is self-financed and cash holding is predominant form of savings.

2.2 Empirical Literatures

2.2.1 Financial development and poverty

There are lots of empirical literatures examining the causal relationship between financial development and poverty. Those literatures basically explore direct influence of financial development on poverty, focusing on increased accessibility to financial services. Among these, most remarkable work would be Beck et al. (2004). They explored the impact of financial development on poverty and inequality using panel data for 81 economies during the years of 1960-2000. Financial development is proxied by the credit-to-GDP ratio of each country. As proxy of poverty, they used headcount, poverty gap, and average income of poorest quintile. To address potential endogeneity, they used instrumental variable approach such as legal origins and latitude of capital city of each country. Their findings imply that financial development has significant impacts on reducing poverty and income disparity. That is, financial development boosts income of poorest quintiles through improved access to finance. Kaidi et al. (2020) has obtained the similar results. They explored the causality relationship among financial development, inequality and poverty by analyzing two different panels for 93 democratic countries and 31 autocracies. Their findings show that financial development decreases inequality through reducing poverty in democratic countries. But in autocracy, only when financial development is combined with political institutions, financial development reduces poverty and inequality. Democratic nations show heterogeneous impact by income levels. Low- and middle-income ones show that interaction between finance and political institutions reduces poverty and inequality but no effect in high-income group.

Seven et al. (2016) also conducted cross-country analysis on the correlation among finance, inequality and poverty. They focused on forty-five developing economies over the years 1987-2011, using banking sector and stock market indicator to examine finance-inequality-poverty nexus. Gini index is used to measure income inequality while headcount and average income of poorest quintiles are used to measure poverty. Several control variables are used such as government consumption (percent of GDP), inflation (annual GDP deflator), trade openness (export plus import, percent of GDP), and school enrollment rate (secondary, gross). But they obtained unexpected results. Neither banks nor stock market development shows significant effect on poverty alleviation. Moreover, economic growth arising from financial development does not necessarily benefit the poorest in their sample countries. They argued that the results are due to high income inequality in those countries.

Boukhatem (2016) conducted similar study using panel data for 67 low-income economies during the years of 1986-2012. He aims to make clear the channels through which financial development impacts on poverty. His finding shows that financial development directly influences poverty reduction by way of elevating accessibility to financial instruments and services. Also, financial development improves financial inclusion by providing more opportunities to save money and smooth consumptions. These results are in steps with previous literatures (McKinnon, 1973; Beck et al. 2007). But there is also the cost of financial development including market instability such as banking crisis or credit crunch, which is more harmful to poor people and downgrade positive influence of financial development on poverty. In the same context, Chaouachi et al. (2021) provides similar empirical findings in African countries. They explored the impact of financial development on poverty among six economies in West Africa (Ivory Coast, Gambia, Ghana, Senegal, Mali and Benin) over the years of 1996-2015. Poverty is proxied by headcount ratio and poverty gap whilest financial development is represented by money supply (M3) and private credit to GDP. Their findings show similar results with above literatures that financial development shows direct influence on poverty alleviation by extending financial service to poor people. Financial development makes transactions cheaper and more convenient, and offers opportunities to smooth consumption and savings. Furthermore, it allows the poor to respond economic shocks more efficiently and thus help cut off the vicious circle of poverty.

However, though numerous studies were conducted on this topic, theoretically no conclusive consensus exists on the correlation among financial development and poverty, so their relationship is ongoing research topic. Until now, I have examined cross-country empirical literatures, but there are many studies focusing on specific country to explore the influence of financial development on poverty. Ho et al. (2018) chooses Ghana to explore finance-growth-poverty links during the years 1960-2015. They concluded that financial development reinforces growth and thus lowers poverty. This finding is similar to the literature by Ravallion et al. (2002) or Dollar et al. (2002), in which they asserted trickle-down hypothesis[7]. Especially they used non-monetary poverty indicators such as infant mortality or life expectancy. Financial development is represented by the ratios of private credit to GDP and broad money to GDP. Other examples for specific country-level studies would be Sehrawat et al. (2016) for India, Uddin et al. (2014) for Bangladesh, and Zhang et al. (2012) for China. These studies also present similar result to previous cross-country ones.

[7] This originally refers to the idea that tax cut for the wealthy or firms is good for the average citizens. Dollar and Kraay (2002) argued that economic growth reduces poverty based on empirical evidence from 92 countries that the income of the poorest people rises proportionately with the average income growth of the country.

2.2.2 Fin-tech and poverty

Recently the role of financial technology (fin-tech) is attracting attention of academics as well as policy makers, especially on developing countries. A lot of empirical works explore the effect of fin-tech on socio-economic outcomes such as poverty or income inequality. Among developing countries, Bangladesh and Kenya is the most popular target countries for these empirical studies. Akhter et al. (2017) explored the effect of mobile banking platform on financial inclusion in Bangladesh. The platform is called 'bKash'[8], a mobile financial service provider. By analyzing survey data, they find that the platform has positive impact on expanding financial inclusion. Lee et al. (2016) also conducted RCT to examine the effect of 'bKash' on financial inclusion and poverty. They also find that bKash has positive impact on reducing poverty and enhancing financial inclusion in Bangladesh.

Another good example of successful mobile banking is found in Kenya. The platform is called 'M-Pesa', which is launched in 2007 and provides mobile phone-based money transfer, payments, and microfinance services. Many studies were conducted to examine the effect of M-Pesa on financial inclusion and poverty (Demombyne et al. 2012; Jack et al. 2014; Mbiti et al. 2016). The platform was successful in Kenya and then expanded its business to other countries including Tanzania, Mozambique, Ghana, Egypt, and South Africa etc. Extensive evidences show that M-Pesa has contributed to expanding financial inclusion to the poor and thus significant effects on poverty reduction among developing economies.

Khera et al. (2021a) proved the strong relationships among digital financial inclusion and growth. Digital finance is provided via digital platforms such as mobile devices, the internet, and personal computers. Digital financial inclusion means igital approach to and use of financial services by financially marginalized people (Ozilli, 2018). Their results report that digital financial inclusion has positive and powerful effects on growth, using a panel for 52 developing economies during the years 2011-2018. Digital finance is proxied by 'financial inclusion index'[9] newly constructed by Khera et al. (2021b) and instrument variable method is used to address potential endogeneity. As instrument variables, the ratio of internet users and number of mobile money agents are used.

---

[8] It is established by BRAC Bank (microfinance bank) in 2010 with alliance with US fin-tech firm (Money in Motion). After opening account in local agent office, customers can deposit or draw money at any time. The local agents must have enough liquidity to respond to customer's demand. It is holding about 28 million clients as of 2019.

[9] The index are created by Sarma (2012) to provide comprehensive indicator to capture financial inclusion level across the countries. This index ranges from 0 to 1 (0 shows perfect financial exclusion and 1 means perfect financial inclusion). Methodology of calculating index varies across scholars. More details are in Appendix Table 3.

2.2.3 Financial inclusion and poverty

Many literatures observed financial inclusion as a useful tool for reducing poverty. Most of them use financial inclusion index to capture degree of financial development in an economy. This index is first developed by Sarma(2008) using IMF Financial Access Survey database, focusing on three pillars: financial access, availability and usage. Since then, many scholars followed suits. But there is no standard measure to construct this index and hence it varies across studies and scholars. The list of financial inclusion index across scholars is presented in Appendix Table4. The work by Sarma (2008), forerunner of financial inclusion index, provides composite indicator to capture degree of financial inclusion at the country level. She computed this index by using weighted geometric mean method for 94 countries. OECD countries show higher scores while low-income countries relatively lower scores, implying the positive connection between financial inclusion and growth.

Recently Khera et al. (2021b) developed new comprehensive index including traditional and digital financial inclusion[10]. Especially digital financial inclusion index is a new effort to include fin-tech activities such as online payments data for 52 emerging economies. They find that fin-tech is key driving factor for financial inclusion, but wide variations exist among countries. Gutierrez-Romero et al. (2021) also constructed financial inclusion index using IMF survey data by applying principal component analysis. Using this, they explored to what extent financial inclusion reduces poverty among 79 developing countries, finding that financial inclusion (especially access dimension) is key driving force for reducing poverty in developing economies. Park et al. (2015) also set up financial inclusion index to estimate the impact of financial inclusion on poverty for 37 developing countries in Asia. They conclude that financial inclusion shows powerful impacts on reducing poverty. Park et al. (2018) also constructed new financial inclusion index for 151 countries across the world. Their findings show that the impact of financial inclusion on poverty is strong but heterogeneous across income groups. Bernerjee et al. (2020) estimated the effect of financial inclusion on growth outcomes among 20 Asian countries over the years 2004-2015. Their analyses imply that financial inclusion significantly boosts development indicators including growth, health, education, and income inequality. But impact power accelerates when country has high political stability. Also there are other studies to explore significant impacts of financial inclusion on poverty by applying the index (Omar, 2020; Park et al, 2021; Sahay et al. 2015).

[10] Digital financial inclusion as financial revolution poses 4th stage after microcredit, microfinance, and financial inclusion. Digital financial inclusion put heavy weights on technology to broaden accessibility to financial services. Microcredit means small loans offered by banks to firms or individuals. In the 1990s, microcredit was replaced by microfinance.

3. DATA AND VARIABLES

3.1 Data sources

In this analysis, several data sources are used. Financial inclusion index comes from Gutierrez-Romero et al. (2021). They constructed the index for 145 countries based on IMF Financial Access Survey. Among those, my sample includes only 103 developing countries. Also I include 34 advanced countries in additional analysis. Poverty indicators are obtained from World Bank PovcalNet. The controls such as education, trade, and GDP per capita etc. come from World Bank WDI. The definition and data source are shown in Appendix Table 4.

3.2 Variables

3.2.1 **Poverty**. Four kinds of poverty indicators are used: headcount, poverty gap, squared poverty gap, and the Watts index. These data are obtained from the World Bank PovcalNet, which offers comprehensive poverty data at the country level based on household survey since the 1980s. I restricted time period into 2004-2018 to adjust data availability of financial inclusion index. 'Headcount' is the ratio of people who live below the poverty line. It is widely used to show the absolute poverty of a country, calculated by the number of people whose income is below the poverty line over total population. 'Poverty gap' captures average distance of poor people's income from the poverty line. This indicates the depth of poverty, implying total amount of money per day needed to move all the poor of a country above poverty line, calculated by summing up the distance between poverty line and the income of poor people. 'Squared poverty gap' represents the severity of poverty, showing the most comprehensive poverty index. The Watts index is sensitive measure to variations in the lowest part of income distribution[11]. In more detail, public subsidies to the poorest of the poor give higher weights when calculating index than the relatively wealthier among the poor.

3.2.2 **Financial Innovation**. The independent variable of interest, financial innovation, is measured by financial inclusion index constructed by Gutierrez-Romero et al. (2021). This composite index is composed of two pillars: financial outreach (access) and usage. The usage is expressed by the number of bank accounts per capita to capture degree of financial usage. The outreach (access) captures the physical penetration of financial services to customers,

[11] It is the first distribution-sensitive poverty index, developed by Harold Watts in 1964. Calculation is simple. First, divide poverty line by the income of the poor, taking natural logs, and then summing up over the poor. Finally, divide by total population to get the Watts index. The calculation formula is as follows: $W = \frac{1}{N}\sum \ln(\frac{z}{y_i})$, where N is population size, z is the poverty line, y_i is income level of the poor individuals who are under the poverty line.

including the number of bank branches and ATMs per capita[12], the number of bank branches and ATMs per square kilometers. Thus, financial outreach captures physical distance to the point of financial institutions. Long distance to the bank is big obstacle to financial inclusion in developing countries. The index ranges from 0 to 1, showing high score high inclusion.

3.2.3 **Controls**. Six controls are included in estimation model including education, inflation, government expense, trade openness, institutions and GDP per capita. Education is measured by secondary school enrollment rate while government expenditure is expressed by the ratio of public expenditure over GDP. Inflation is CPI index, widely known to be more harmful to the poor than the wealthy as the rich tend to evade inflation risks through inflation hedging products (Easterly et al. 2001). Trade openness is obtained by summing up exports and imports volume to capture the degree of globalization. Credit-to-GDP ratio captures degree of financial development (Beck et al. 2004). The rule of law captures institutional quality while GDP per capita shows income level of each country.

3.2.4 **Instrument Variables**. My first estimation approach, OLS with fixed effects, may help to mitigate the potential problems with endogeneity bias arousing from omitted time-invariant variables that would be related with error term. Also we worry about the reverse causality from poverty to financial inclusion. Poverty can have negative influence on financial development including financial inclusion, which may lead to misleading estimates in the regressions. I use instrumental variable (IV) strategy to address potential endogeneity bias. For this, I borrowed ideas from previous works by Beck et al. (2004) and Gutierrez-Romero et al (2021). The former study used legal origins of ex-colony countries and latitude of capital city as exogenous instruments of financial development. The latter used legal origins and the number of mobile phone subscription as instrument for financial inclusion. Among these, I use legal origins and latitude as instruments. There are two theories on what determines financial development: law and finance theory and endowment theory. The former focuses on legal origins while the latter emphasizes geographical endowments such as climate. Theoretically a good and valid instrument variable must be correlated with endogenous variable (or financial inclusion; this is relevance condition), but should not affect directly on dependent variable (or poverty indicators; this is exclusion restriction). Legal origins and latitude of capital city are already observed in the similar studies to be positively related with current institutions as well as financial development.

[12] The count of bank branch and ATMs per 100,000 adults is also included in UN's SDG Target 8.10 which aims to enhance capacity of banks to improve access to financial service. It is also included in G20 financial inclusion indicators.

3.3 Summary statistics

Table 1 shows descriptive statistics with maximum 1,545 observations. A panel for 103 developing countries over the years 2004-2018 was set up for this analysis. Only developing countries are sorted out from all samples by Gutierrez-Romero et al (2021).[13] Table 1 reports that 19.3% of population of sample countries lives below poverty line of $1.90 per day on average during the sample period. For poverty, standard deviations are bigger than mean values, implying that high variations exist across countries. However, for financial inclusion index, standard deviations are smaller than mean values suggesting that relatively smaller variations exist across countries. Six control variables are also included such as education, inflation, government expenditure, trade openness, institutions and GDP per capita. In the robustness checks, I apply instrumental variable approach.

Table 1: Descriptive statistics of variables

Variables	Obs	Mean	Std.Dev.	Min	Max
Financial Innovation					
Financial inclusion Index	1,545	0.176	0.150	0.012	0.681
Financial outreach	1,545	0.162	0.124	0.001	0.653
Financial usage	1,545	0.227	0.186	0.003	0.862
Poverty Indicators					
Headcount	1,545	19.330	22.072	0.002	94.605
Poverty gap	1,545	7.460	10.543	0.001	64.836
Poverty gap squared	1,545	4.048	6.442	0.001	48.277
Watts	1,545	11.151	17.105	0.001	98.441
Gini index	1,545	0.422	0.073	0.267	0.667
Controls					
GDP per capita	1,530	3920.43	3471.13	210.80	20532.98
Inflation (%)	1,530	6.21	5.87	0.36	54.94
Trade openness (%)	1,530	83.50	41.89	11.86	246.99
Rule of law	1,530	1.960	0.583	0.177	3.558
Secondary school enrollment	1,455	68.39	26.46	3.60	132.80
Government expenditure (%GDP)	1,470	15.54	8.02	2.04	72.61
Instruments					
Lattitude	840	0.159	0.105	0.011	0.388
legal origin (dummy)	840	0.541	0.462	0.000	1.000

Notes : Summary statistics is over the period 2004-2018. Instruments are used for robustness checks for ex-colonies. Lattitude is absolute value for distance from the equator scaled 0 to 1 (equator is 0). Lattidude is positively related with economic performance (Hall and Jones 1999). Legal origin is dummy varibale for a value of one for British legal system and zero otherwise.

[13] They construct financial inclusion index for 145 countries including developed and developing countries across the world using IMF Financial Access Survey (FAS), over years 2004-2018. Among this sample, I use 103 developing countries in this analysis to explore the influence of financial inclusion on poverty. They construct composite index of financial inclusion, including two sub-index such as financial outreach (or access) and financial usage.

4. EMPIRICAL STRATEGY

In this section, I will explain the identification strategy and estimation methods. Basically I use a couple of estimation techniques including Ordinary Least Squares (OLS) with fixed effects, and instrumental variable (IV) approach.

4.1 Model Specification and

Following the previous studies by Khera et al. (2021a) and Gutierrez-Romero et al. (2021), I estimate the effect of financial innovation on poverty using following model.

$$Povt_{it} = \alpha + \beta_1 (FII_{it}) + \beta_2 X'_{it} + \mu_i + year_t + \varepsilon_{it}$$

where $Povt_{it}$ is poverty indicators including headcount, poverty gap, squared poverty gap, and the Watts index of country *i* and year *t*. FII_{it} refers to financial inclusion index calculated by Gutierrez-Romero et al. (2021) based on IMF Financial Access Survey over the period 2004-2018. X' represents control variables that may affect poverty, including education, inflation, government spending, trade, institutions and GDP per capita. These variables are widely used in previous empirical studies. Most controls are indicated in percentage value except GDP per capita and rule of law. μ_i and $year_t$ represents country-fixed effect and time- fixed effect, respectively. Country-fixed effects may eliminate time-invariant heterogeneity across countries, and year-fixed effects may control for time-varying heterogeneity across the years. Thus we examine the links between differential changes of financial inclusion and differential changes of poverty across the country. E_{it} is error term. I use robust standard errors clustered at country level in all estimations to prevent potential Type I error.

4.2 Estimation Methodology

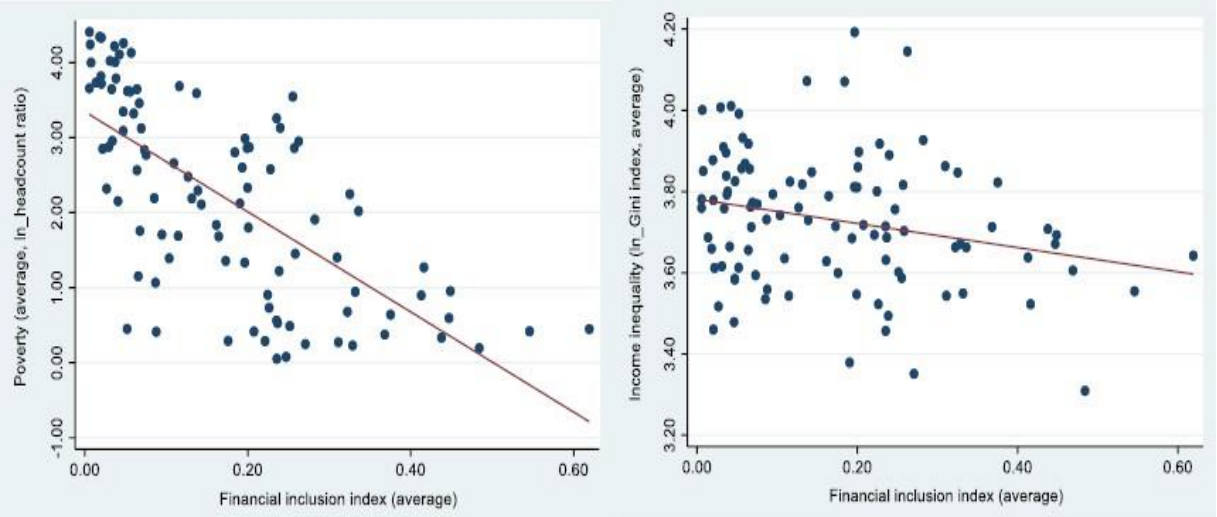
I assume that correlation between financial innovation and poverty may arouse potential endogeneity issue. That is, reverse causality and simultaneity bias. To address this bias arousing from endogeneity, I apply several methods including OLS with fixed effects and clustered standard errors at country level. I also use instrumental variable method in the robustness checks. As external instruments, geographic latitude and legal origins dummy are used. Extensive studies proved that British common law countries do better job than French, German, Scandinavian civil law countries at protecting property rights, fostering private contracts, and thus promote financial development (La Porta et al. 1997; Beck and Levine, 2004). Latitude of each capital city is an important determinant of current national institutions of European ex-colonies (Acemoglu et al. 2001). Both legal origins and latitude can explain the difference in financial development among European ex-colonies.

5. EMPIRICAL RESULTS

5.1 Main Results

In this part, I provide main empirical results. As preliminary information, I display the scatterplot of main variables such as financial inclusion, poverty and income inequality to overview the correlation between them using average values during the sample years. Figure 2 shows the result of scatterplot. Left panel implicates negative correlations among financial inclusion and poverty represented by headcount. Right panel shows the correlations among financial inclusion and inequality proxied by Gini index, showing negative trends as well. But the slope of fitted values in the first panel is steeper than that of second panel, implying that financial inclusion has stronger contribution to poverty than income inequality. One possible reason for this would be the fact that poverty rate is in general higher in developing countries, which may lead to sharper drop in poverty when capital injection to the economy increases. But income inequality (Gini) is also relatively higher in developing countries, but the tone-down speed is slower than poverty ratio. Thus both panels clearly show negative relationship among financial inclusion, poverty, and inequality. I assume that higher financial inclusion is related with lower level of poverty (headcount using $1.90 poverty line) and lower income inequality. Keeping this picture in mind, next I run the OLS regressions to test these trends using our empirical model. Simple OLS estimation is presented in Appendix Table 5, showing negative and significant effect of financial inclusion on poverty across all poverty indicators.

Figure 2: Scatterplot between financial inclusion, poverty, and inequality (2004-2018)



Source: data from Gutierrez-Romero et al. (2021) and World Bank WDI

Table 3 provides OLS estimation with fixed effects and clustered standard errors at the country level. All regressors are lagged by one-year to address endogeneity problem. The magnitude of main coefficients is smaller than baseline OLS. For instance, column 1 reports that one unit increase of financial inclusion index results in reducing headcount by 0.15% on average (0.51% in the OLS). Other poverty indicators such as poverty gap, squared poverty gap, and Watts index show similar trends with headcount. Column 2 and 3 reports that one unit rise of financial inclusion index is associated with 0.17% decrease in poverty gap and 0.18% decrease in poverty gap squared, respectively. The Watts index displays the similar pattern as in column 4. The Gini index also shows negative and significant effect, but the size of coefficient is smaller. Among control variables, education level, GDP per capita, and institutional indicator show significant impact on poverty while inflation rate, trade openness, and government size shows relatively weaker impact on poverty. Overall, OLS with fixed effect confirms negative links between financial inclusion and poverty.

Table 2: Financial inclusion index and poverty (OLS with fixed effect)

Dependent variable	Headcount	Povty gap	Povty gap sq.	Watts	Gini
Measure of innovation	Financial Inclusion Index (FII)				
	(1)	(2)	(3)	(4)	(5)
FII	-0.149***	-0.166***	-0.172**	-0.153**	-0.012***
	(0.016)	(0.026)	(0.040)	(0.054)	(0.004)
Education	-0.286**	-0.192*	-0.262**	-0.211*	0.012*
	(0.122)	(0.101)	(0.121)	(0.101)	(0.006)
Gdppc (log)	-2.703***	-3.246***	-3.361***	-3.366***	-0.032***
	(0.152)	(0.186)	(0.214)	(0.176)	(0.006)
Inflation	-0.008	-0.021	-0.053	-0.033	0.002
	(0.024)	(0.028)	(0.033)	(0.027)	(0.004)
Trade openness	0.187	0.400**	0.214	0.315*	0.012**
	(0.113)	(0.138)	(0.159)	(0.131)	(0.004)
Government exp	-0.206	-0.332*	-0.365*	-0.348**	-0.005
	(0.115)	(0.140)	(0.161)	(0.132)	(0.004)
Rule of law	-0.246**	-0.257**	-0.376**	-0.265**	-0.121***
	(0.115)	(0.101)	(0.153)	(0.123)	(0.014)
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes
Country Fixed Effects	Yes	Yes	Yes	Yes	Yes
Observations	1271	1226	1226	1226	1301
No. of countries	103	103	103	103	103
R^2	0.324	0.322	0.287	0.369	0.128

Notes: OLS regressions with fixed effects. Dependents are poverty indicators. Time span is 2004-2018. All regressors are lagged by one period to address endogeneity. Clustered standar errors at the country level are presented in parentheses. ***, ** and * indicate 0.01, 0.05 and 0.1 levels of significance, respectively.

Now I consider heterogeneous influence of financial inclusion on poverty across different income groups including rich economies. For this, I rearrange original sample into 4 groups: high-income, upper-middle, lower-middle and low-income group. This result is presented in Table 4. It reports that financial inclusion lowers poverty significantly in middle-income countries, but insignificant among rich and low-income groups. Column 1 shows the results for all samples. Column 2 tells that financial inclusion has insignificant effects on poverty among rich economies. This is similar result with Park et al. (2021). The potential reason for this would be financial crisis or cyclical economic downturn in advanced countries, which will drive households into poverty despite elevated financial inclusion. Column 3 and 4 reports that one unit rise of financial inclusion results in 0.32% and 0.24% reduction of headcount in upper-middle and lower-middle groups, respectively. But, in low-income group, financial inclusion has insignificant impact on poverty as shown in column 5, implying that there are other factors to impede the positive effect of financial inclusion on poverty. Those factors would be inefficient financial system and poor institutions in low-income economies (Park et al. 2018). Also the size of impact of financial development will depend on other factors such as land title, social class, or social trust etc. Thus I assume that financial inclusion itself is not sufficient for lowering poverty in low-income economies. This is in line with Beck et al. (2009) and Park et al. (2018). This suggests that 'indirect effect' (higher wage through formal businesses) of financial inclusion matters much more than 'direct effect' (accessibility to finance by poor people) in low-income economies.

Table 3: Impact of financial inclusion on poverty (by income group)

Dependent variable	Headcount poverty ($5.5 a day)				
	(1)	(2)	(3)	(4)	(5)
Income group	All samples	high-income	upper-middle	lower-middle	low income
Financial inclusion	-0.146**	0.102	-0.318**	-0.236*	-0.025
	(0.045)	(0.094)	(0.138)	(0.112)	(0.106)
Human capital	-0.265**	-0.281*	-0.324**	-0.326**	0.184*
	(0.113)	(0.145)	(0.129)	(0.153)	(0.101)
Gdppc (log)	-1.673**	-1.024*	-1.932**	-3.293***	-1.125*
	(0.392)	(0.512)	(0.695)	(0.619)	(0.505)
Inflation	0.004	0.013	0.042	0.023	0.015
	(0.023)	(0.045)	(0.087)	(0.034)	(0.029)
Trade openness	0.175	0.153	0.431	-0.214	-0.318
	(0.113)	(0.201)	(0.230)	(0.226)	(0.192)
Government exp	-0.225*	-0.113*	-0.225*	-0.090	-0.236*
	(0.115)	(0.054)	(0.110)	(0.199)	(0.115)
Rule of law	-0.236**	-0.187*	-0.382*	-0.296*	-0.265*
	(0.115)	(0.086)	(0.217)	(0.143)	(0.121)
Year fixed effect	Yes	Yes	Yes	Yes	Yes
Country fixed effect	Yes	Yes	Yes	Yes	Yes
Observations	1781	510	630	630	285
No. of countries	137	34	42	42	19
R^2	0.324	0.287	0.292	0.276	0.286

Notes: OLS with fixed effect. Dependent is headcount poverty. Time span is 2004-2018. 34 advanced countries are included to original sample. All regressors are lagged by one period to address endogeneity. Clustered standar errors at the country level are presented in parentheses. ***, ** and * indicate 0.01, 0.05 and 0.1 levels of significance, respectively.

As mentioned, OLS with fixed effects cannot solve completely endogeneity problem. To address this, I apply instrumental variable method. As exogenous instruments, I use latitude of capital city and legal origin dummy. For this, I restrict the sample into only European ex-colonies to draw out causal inference. There are 64 ex-colonies in the new sub-sample. Latitude and legal origins are used as instruments of financial development to examine cross-country evidence among financial development, growth and inequality (Beck et al. 2004; Clarke et al 2006; Kappel, 2010). Latitude is absolute value of capital city's distance from equator. Past studies proved that legal origins of ex-colonies explain variations of financial development between countries (La Porta et al. 1997; Beck et al. 2000). Legal traditions are transplanted from colonizers to the rest of the world through colonialism or occupation (Beck et al. 2000).[14] Hence legal origins could be used as exogenous endowments that up to now influence financial development. I use legal origin dummy that equals one for British common law and zero for otherwise. Table 5 shows the results. As expected, it reports that financial inclusion shows strong impacts on poverty. The first stage between instruments and endogenous variable is also strong as in Panel B. That is, higher latitude or British legal origin is associated with higher level of financial inclusion. Panel A reports 2SLS estimates, showing larger coefficients than OLS or panel fixed effects. Thus I can assume that OLS analysis gives us relatively conservative estimates.

Table 4: Impact of financial inclusion on poverty (2SLS)

Poverty lines	**$1.9 per day**			**$5.5 per day**		
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Two-Stage Least Squares						
Dependent	Hcount			Hcount		
Financial inclusion	-0.624***			-0.255**		
	(0.176)			(0.094)		
FII_use		-0.611*			-0.132*	
		(0.287)			(0.054)	
FII_out			-0.931**			-0.334**
			(0.311)			(0.136)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
No. of countries	64	64	64	64	64	64
Sargan-Hansen (p-value)	0.113	0.126	0.115	0.103	0.117	0.102
Panel B: First Satge						
Dependent	FII	FII_use	FII_out	FII	FII_use	FII_out
Latitude	1.311***	2.046***	7.455***	1.312***	2.046***	7.144***
	(0.318)	(0.607)	(0.937)	(0.326)	(0.607)	(0.927)
Legal origin (dummy)	0.604***	0.506***	0.621***	0.604***	0.505***	0.611***
	(0.056)	(0.113)	(0.154)	(0.056)	(0.114)	(0.147)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.531	0.556	0.564	0.506	0.516	0.521

Notes: 2SLS estimates with country and year fixed effects. Dependents are headcount ($1.9/$5.5 poverty line). Financial inclusion is instrumented by latitude and legal origin dummy. Time span is 2004-2018. Clustered standard errors at country level are in parentheses. ***, ** and * indicate 0.01, 0.05, 0.1 levels of significance, respectively.

[14] Legal origins are divided by two: English common law and French civil law tradition. British colonies appear to be better institutions than other colonies. English common law colonies show stronger legal protection of investors while French civil law colonies show weaker legal protection for investors (La Porta, 1998; Reynolds et al. 1996; von Hayek, 1960).

5.2 Robustness Checks

To assess the robustness of our estimates, Financial Development Index[15] are employed instead of Financial Inclusion Index. Financial Development Index was launched by IMF in 1980 to fill out data gaps by providing more comprehensive measures of financial development. Before then, most empirical works have typically used the ratio of private credit to GDP or stock market capitalization as a proxy of financial development. But there was criticism that those indicators did not fully represent complex multi-dimensional property of financial development. Basically the index measures degree of financial development in an economy based on 3 pillars: financial depth, access, and efficiency. Compared to Financial Inclusion Index, IMF's index includes more extensive categories to fathom level of financial development. Table 6 provides this result, showing similar patterns to the previous financial inclusion index. But overall estimates and significance level are smaller and weaker than those of main results. Column 1 to 3 is regressed by OLS while column 4 to 6 is estimated by 2SLS, showing different impact in size and significance. 2SLS estimates show more powerful impact on poverty. Column 4 reports that a one unit rise of financial development index is associated with 0.83% decrease in headcount.

Table 5: Robustness checks by using Financial Development Index

	OLS (fixed effect)			2SLS		
	(1)	(2)	(3)	(4)	(5)	(6)
Dependent	Hcount	Povgap	Watts	Hcount	Povgap	Watts
Financial development index	-0.112*	-0.107*	-0.109*	-0.839***	-1.411***	-1.521***
	(0.053)	(0.054)	(0.056)	(0.202)	(0.250)	(0.261)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Obsevations	1229	1199	1228	665	652	663
No. of countries	103	103	103	64	64	64
R^2	0.081	0.071	0.62	0.531	0.542	0.512

Notes: Dependents are poverty indicators such as headcount (1.9$ per day), poverty gap, and Watts. Main regressor is IMF's Financial Development Index. Clustered standard errors at the country level are in parentheses. In OLS fixed effects, regressors are lagged by one year. In 2SLS, instruments are latitude and legal origin dummy of each country. ***, ** and * indicate 0.01, 0.05, 0.1 levels of significance, respectively.

[15] The index was developed by IMF to provide more appropriate measure of financial development. The index represents how well financial institutions or financial markets of each country are in progress for 3 categories; depth (size and liquidity), access (ability to approach to financial service), efficiency (provide service with low cost). The index ranges from zero to one, showing higher value higher financial development. Data are available for over 180 countries by year since 1980.

5.3 Falsification Test

For the falsification test, I've used a couple of placebo dependent variables such as total fertility rate and greenhouse gas (CO2) emission per capita of each country. Through this placebo analysis, I expect different signs or statistical significance level from our main results. The same control variables are also included. Table 7 shows this result. Column 1 through 2 reports the effects of financial inclusion index on total fertility rate (births per woman), showing the opposite signs from our main results. More specifically, it shows positive and significant coefficients in simple OLS without fixed effects, but insignificant results in OLS with fixed effects. Column 1 reports that one unit rise of financial inclusion index results in 0.08% increase of total fertility rate. Column 3 through 4 represents the impact of financial inclusion on greenhouse gas emissions. All columns show insignificant influence on CO_2 emissions. This result is quite different from our previous main results. Overall, by using placebo dependent variables such as fertility and greenhouse gas emissions, our falsification test indicates that financial inclusion index shows no significant effect on CO2 emissions, but it shows opposite signs for the placebo fertility rate. This implies that our placebo tests are successful.

Table 6: Placebo test using false dependent variables

Dependent variable	Fertilty Rate (birth per woman)		CO2 emmissions (metric ton)	
	OLS	OLS_FE	OLS	OLS_FE
	(1)	(2)	(3)	(4)
Financial inclusion index	0.085***	0.303***	-0.061	-0.031
	(0.016)	(0.048)	(0.040)	(0.072)
Contols	Yes	Yes	Yes	Yes
Year Fixed Effect	No	Yes	No	Yes
Country Fixed Effect	No	Yes	No	Yes
Observations	1271	662	1301	1301
No. of countries	103	64	103	103
R^2	0.621	0.513	0.273	0.073

Notes: Placebo dependent variables are total ferti;ity rate and CO2 emmissins per capita. Time span is 2004-2018. Clustered standard errors at the country level are in parentheses. In OLS fixed effects, regressors are lagged by one year. In 2SLS, instruments are used such as legal origin dummy and latitude of capital city. ***, ** and * indicate 0.01, 0.05, 0.1 levels of significance respectively.

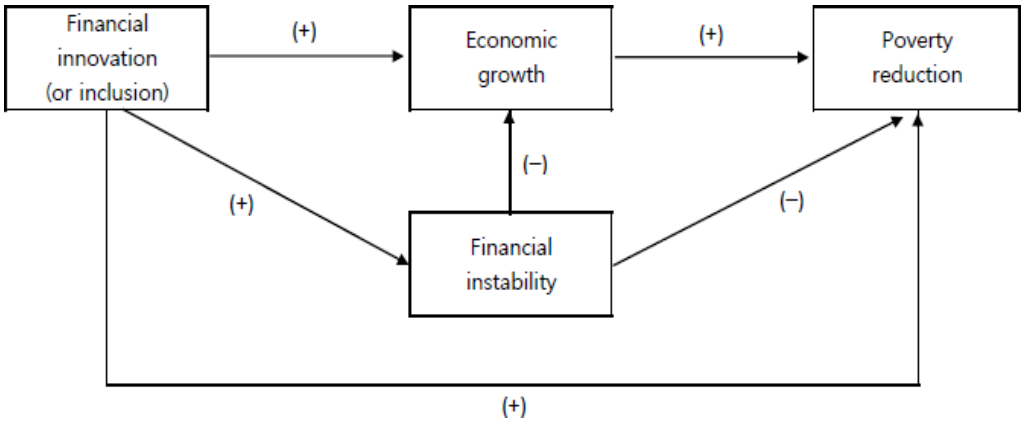
6. DISCUSSION AND POLICY IMPLICATION

In this part, I discuss about underlying mechanisms through which financial innovation (or inclusion) influences growth and poverty reduction. I also discuss the driving forces of current financial innovation and then make several policy proposals to promote financial inclusion through technological progress. Especially policy recommendations will be made in the perspective of the role of government in three categories: i) the construction of digital infrastructure ii) education programs to enhance financial literacy iii) rigorous and balanced regulation frameworks. As noted above, financial innovation has broad definition, including creating new products to satisfy new market demands as well as establishing new financial firms through combining ICT technology with finance. But financial innovation has both bright and dark sides. The bright side is represented by the financial innovation-growth hypothesis, which asserts that financial innovation reduces transaction costs, promotes risk sharing, helps allocate credits efficiently, and thus bring about economic growth. Conversely, the dark side is represented by financial innovation-fragility hypothesis, which argues that financial innovation entails certain costs such as financial crisis or market instability. For example, financial engineering in the mortgage market in the US boosted credit bubble and triggered financial crisis. In this essay, however, I primarily focus on the bright side of financial innovation to identify positive influence of financial inclusion on poverty alleviation among developing economies.

As shown in the main results, financial innovation enhances financial inclusion that has powerful impacts on poverty reduction in developing economies. If it is true, what is the transmission mechanism that financial development boosts growth and reduces poverty. We consider two major channels through which financial inclusion has impacts on poverty and growth (Guillaumont-Jeanney et al. 2011). Figure 2 illustrates the process that financial development (or inclusion) influences on growth and poverty. First, financial inclusion tends to boost economic growth, and then this leads to poverty reduction through distributional policies (indirect effect). Second, financial inclusion has direct and positive impact on income growth of poor people through improved accessibility to finance (direct effect). Third, financial innovation can cause financial instability such as global financial crisis 2008- 2009. Financial crisis does harm more to the poor people than the wealthy (Chaouachi. 2021; Jeanneney et al. 2006). Thus the financial crisis has negative impacts on growth and poverty

reduction as shown in Figure 2. But this kind of dark side of financial innovation is not our main point in this work, rather we mainly concern both direct and indirect effect of financial innovation on poverty such like plus signs in Figure 2.

Figure 3: Channels that financial innovation affects poverty



Source: Adapted from Guillaumont-Jeanneney et al. (2011)

Now I would like to discuss the determinants of financial inclusion based on recent empirical studies. Numerous empirical works identified the drivers of traditional financial inclusion including institutions, borrowing costs, macroeconomic stability, proximity to the banks, and strong legal rights, and so on (Allen at al. 2016; Blancher et al. 2019; Rojas-Suarez et al. 2016). However, empirical works to identify driving forces of current digital financial inclusion at cross-country level are adoption using cross-country panel for seven economies in Africa over the period 2013-17. He found that factors to affect mobile money adoption are the number of mobile money agents, government laws, banking penetration, and education level of customers etc. Staschen et al. (2018) explores the drivers of digital financial inclusion in viewpoint of government regulation using cross-country panel for ten countries in Africa and Asia. Their findings indicate that there are four basic drivers of digital finance, including e-money publishing, mobile money agents, customer due diligence, and customer protections. Khera et al. (2021b) also conducted empirical study to identify what determines current financial inclusion by analyzing a panel of 52 developing economies over the two years of 2014 and 2017. They employ the usage of digital payment as dependent variable to explore the determinants of digital payment. Traditional access to finance has shown negative effect on digital financial inclusion while traditional usage of finance showed

positive and significant effect on digital payment. This means that financial usage is more important than financial access in promoting digital finance. That is, customers must be accustomed to using traditional financial services in order to maximize financial inclusion through digital finance.

Now we discuss policy implications. Standing on the basis of our results and above discussions, I make several policy suggestions to enhance financial inclusion in developing countries. More specifically, I propose policy alternative, focusing on digital infrastructure and importance of financial education and government regulations. First, we need review my empirical findings that financial inclusion has insignificant effects on poverty in low- income economies while showing powerful impact in middle-income groups. This indicates that financial inclusion is not working well among low-income countries. Hence, we can assume that there are other factors for more efficient function of financial inclusion in these countries. Those factors would be ICT infrastructure such as internet and institutional quality such as efficient service delivery or rule of law (Park et al. 2018). Institution quality such as the rule of law, regulatory frameworks, government effectiveness, control of corruption, and political stability significantly influence financial development or financial deepening. Among these indicators, government effectiveness shows stronger effects on middle- and high-income countries while other indicators show significant effects in low-income group (Sanga et al. 2022).[16] Therefore, corrupted work practices must be removed to enhance the efficiency of service delivery because corruption is seen as the most prevalent hurdles for development in low-income economies. Political reform is also essential to establish the rule of law and legal protection for individual wealth, which may boost economic activities. Therefore, in low-income countries, governments should make efforts to strengthen political and economic institutions to maximize the positive effect of financial inclusion.

Second, I emphasize the importance of digital infrastructure. To facilitate access to mobile services, digital infrastructure such as the internet networks and mobile devices is essential. Government policy should prioritize the expansion of financial inclusion that guarantees easier accessibility of financial services by vulnerable such as the poor, women, and rural population. Internet penetration is critical for higher financial inclusion and positive economic outcomes. For instance, Hjort et al. (2019) proved that the advent of fast internet in Africa in 2000s resulted in positive and significant effect on employment and firm activity. Another research also proved that the internet use and ICT infrastructure have positive influence on economic boosting in developing and developed economies

[16] They studied the effect of institutions on financial depth in 50 African economies over the years 2000-2019. As proxy of institutions, they used World Bank WGI (World Governance Indicator). They found that most WGI indicators except government effectiveness are critical to improving financial depth in low-income economies.

(Billon et al. 2017; Donou- Adonson et al. 2016). The use of mobile phones contributed to increasing income and information exchange in many developing countries (Duncombe, 2014; Labonne et al. 2009; Mittal et al. 2010). Considering this, I propose governments in developing countries and international donors to put top priority in connecting internet and providing mobile devices to facilitate financial transactions. According to OECD CRS database,[17] advanced donors provided aid funds to ICT sector of recipients with only 0.68% of total aid money in 2018, compared to 13% in healthcare and 7.2% in education. The allocation of aid to ICT infrastructure must be elevated to meet high demand of internet in developing countries. Well-established infrastructure may have infinite potential to create new chances for the poor to escape poverty and manage better life (Vora et al. 2022).

Third, financial education is essential to improve access to finance by the financially marginalized people. Financial literacy[17] is becoming more important for financial inclusion in the age of digital finance. ICT infrastructure is just necessary condition to expand financial inclusion, but it is useless without appropriate skills and financial knowledge. Promoting financial literacy makes it possible for people to understand what products and services are most suitable for them to improve their financial status (Braunstein et al. 2002). Recently financial literacy on digital devices and new services has become critical to boost financial usage and thus improve financial inclusion, especially among the poor (Lyons et al. 2021). Establishing education institutes or providing information on core services such as retire pension plans would be highly recommended to promote financial knowledge. Singapore is a good example. The government established Financial Literacy Hub for Teachers in 2007 to encourage teachers to transfer financial knowledge to students in regular classes. Also Singapore government set up Financial Literacy Institute in 2012 to provide free financial education to workers as well as general citizens. Numerous studies have proved that financial literacy improves inclusive finance and thus alleviates poverty in less-developed economies (Atkinson et al. 2011; Shen et al. 2018). Lastly, rigorous but flexible regulatory frameworks are necessary. Higher consumer protection leads to higher usage of fintech services (Gutierrez et al. 2013). Data security is also important to reduce voluntary financial exclusions. But the biggest challenge regarding regulatory frameworks would be maintaining the balance between promoting innovation and ensuring stability or protecting consumers.

[17] OECD CRS(Credit Reporting System) provides unique data for official and standard statistics on ODA among advanced donors, including information on where aid goes, what purposes it serves, and what policies it aims to implement.

[18] Financial literacy is first introduced by JumpStart Coalition for Financial Literacy, a NGO in the US, in 1997. **Financial literacy** refers to individual capability to manage financial knowledge to use financial services efficiently. **Digital literacy** is the capacity to deal with data and technology using digital devices. This is highly critical as recently most people depend on the internet and mobile phones as key sources of information.

7. CONCLUSION

The historical development of financial innovation has dramatically changed the daily life of consumers in payment and cash use practices since the 1970s. Currently the wide use of the internet and mobile devices has also drastically changed the landscape of financial market through ensuring easier accessibility to financial products. Especially the COVID-19 pandemic intensified mobile financial transactions and accelerated the spread of fin-tech or financial technology (Sahay et al. 2020). Fin-tech has emerged as a game changer for addressing poverty in developing world, enabling poor people to get easier access to finance. The poor can have more chances to accumulate assets by using savings account, and thus cut the vicious circle of poverty. Thus, it became evident that financial innovation is a useful tool to address poverty in developing economies. Mckinnon(1973) described this process as 'conduit effect', that is, direct effect of financial development on poverty. In this essay I proved that financial inclusion shows positive and powerful impact on poverty reduction. I also found that institutions and ICT infrastructure must be strengthened to maximize positive influence of financial inclusion on poverty among low-income economies.

Based on my empirical findings, I've proposed several policy options to improve financial inclusion in developing economies. First, governments in developing countries and advanced donors should focus on establishing digital infrastructure among less-developed economies to maximize accessibility to finance and mitigate poverty. There are various evidences that the arrival of fast internet has positive impact on financial inclusion and socio-economic outcomes (Hjort et al. 2019). Especially, in low-income countries, institutional quality must be strengthened to improve effectiveness of financial inclusion. Second, education programs to enhance financial literacy must be prepared particularly for the financially marginalized people to improve accessibility to financial services using the internet and mobile devices. Third, rigorous and flexible regulatory frameworks must be set up to protect consumers and promote financial innovation as well. Overall, the message of this essay is clear. Financial innovation reinforces financial inclusion and thus brings about growth and reduces poverty in developing countries through direct and indirect channels. Though my findings in this essay are not entirely new, but it offers validating the results gained in previous studies. In the future, empirical studies about the links between financial innovation and financial instability in developed and developing economies would be an interesting research topic.

Appendix

Table 1: Country list of the sample

No.	Country	Income group[1)]	FII[2)]	No.	Country	Income group[1)]	FII[2)]
1	Afghanistan	low	0.028	53	Lebanon	upper middle	0.507
2	Albania	upper middle	0.296	54	Lesotho	lower middle	0.088
3	Algeria	upper middle	0.090	55	Liberia	low	0.052
4	Angola	lower middle	0.049	56	Libya	upper middle	0.048
5	Argentina	upper middle	0.378	57	Madagascar	low	0.029
6	Armenia	lower middle	0.426	58	Malawi	low	0.058
7	Azerbaijan	upper middle	0.35	59	Malaysia	upper middle	0.445
8	Bangladesh	lower middle	0.292	60	Maldives	upper middle	0.527
9	Belize	upper middle	0.205	61	Mauritania	lower middle	0.066
10	Bhutan	lower middle	0.274	62	Mauritius	upper middle	0.611
11	Bolivia	lower middle	0.244	63	Mexico	upper middle	0.231
12	Bosnia and herz	upper middle	0.371	64	Micronesia	lower middle	0.123
13	Botswana	upper middle	0.219	65	Moldova	lower middle	0.327
14	Brazil	upper middle	0.597	66	Mongolia	lower middle	0.463
15	Bulgaria	upper middle	0.542	67	Montenegro	upper middle	0.489
16	Brundi	low	0.026	68	Moroco	lower middle	0.291
17	Cambidia	lower middle	0.101	69	Mozambique	low	0.058
18	Cameroon	lower middle	0.101	70	Myanmar	lower middle	0.057
19	Central Africa Rep	low	0.011	71	Namibia	upper middle	0.306
20	Chad	low	0.008	72	Nepal	low	0.209
21	China	upper middle	0.205	73	Nicaragua	lower middle	0.125
22	Colombia	upper middle	0.361	74	North Macadonia	upper middle	0.499
23	Comoros	low	0.048	75	Pakistan	lower middle	0.119
24	Congo Dem Rep	low	0.009	76	Panama	upper middle	0.388
25	Congo Rep	lower middle	0.040	77	Papua New Guinea	lower middle	0.069
26	Costa Rica	upper middle	0.517	78	Paraguay	upper middle	0.152
27	Croatia	upper middle	0.357	79	Peru	upper middle	0.342
28	Djibouti	lower middle	0.067	80	Philippines	lower middle	0.192
29	Dominican Republic	upper middle	0.281	81	Romania	upper middle	0.224
30	Ecuador	upper middle	0.192	82	Rwanda	low	0.099
31	Egypt	lower middle	0.138	83	Samoa	upper middle	0.367
32	El Salvador	lower middle	0.321	84	Sao Tome Principe	lower middle	0.257
33	Equatorial Guinea	upper middle	0.072	85	Serbia	upper middle	0.246
34	Eswatini	lower middle	0.164	86	Solomon Islands	lower middle	0.085
35	Fiji	upper middle	0.314	87	South Africa	upper middle	0.313
36	Gabon	upper middle	0.107	88	South Sudan	low	0.013
37	Gambia	low	0.091	89	Suriname	upper middle	0.298
38	Georgia	lower middle	0.577	90	Syrian Arab Rep	lower middle	0.058
39	Ghana	lower middle	0.137	91	Tanzania	low	0.047
40	Guatemala	lower middle	0.341	92	Thailand	upper middle	0.474
41	Guinea	low	0.026	93	Tonga	upper middle	0.354
42	Guyana	upper middle	0.152	94	Turkey	upper middle	0.624
43	Haiti	low	0.056	95	Uganda	low	0.075
44	Honduras	lower middle	0.241	96	Ukraine	lower middle	0.410
45	India	lower middle	0.402	97	Uzbekistan	lower middle	0.320
46	Indonesia	lower middle	0.352	98	Vanuatu	lower middle	0.215
47	Jamaica	upper middle	0.301	99	Venezuela	upper middle	0.225
48	Jordan	lower middle	0.174	100	Vietnam	lower middle	0.201
49	Kenya	lower middle	0.250	101	Yemen	lower middle	0.025
50	Kiribati	lower middle	0.071	102	Zambia	lower middle	0.057
51	Kosovo	upper middle	0.265	103	Zimbabwe	low	0.109
52	Lao Republic	lower middle	0.114				

Notes: 1) Income group classification by World Bank (2021)

2) Financial inclusion index constructed by Gutierrez_Romero et al (2021)

Table 2: Overview of financial inclusion indicators

name	starting year	data source	description
WB Glabl Findex Database	2011 (triennial)	adult survey	• World Bank global financial inclusion indicator (partnership with Gallup) • Most comprehensive data on financial inclusion, published every 3 years and funded by Bill Gates Foundation • It provides almost 300 indicators on topics such as account ownership, payment, saving, credit, and financial resilence by country, region, and income groups. • In 2021, surveys were done for about 128,000 adults in 123 countries. • Currently the data are available for 4 waves (2011, 2014, 2017, 2021)
G20 Financial Inculsion Indicators	2012 (annual but some catogory is triennial)	WB Global Findex; IMF FAS Gallup World Poll OECD survey etc.	• G20 agreed to Global Partnership for Financial Inclusion (GPFI) in 2011 • Financial inclusion is a key tool to fight poverty and gain growth • G20 endorsed Basic Set of financial inclusion indicator in 2012 • It includes 3 dimensions : access to financial services, usage of financial services, quality of products and service delivery • It also has 15 catagories : access (10), usage (5) • New indicators were endorsed in 2016 to capture current digital payment and digital infrastruture.
IMF financial development index	1980 (annual)	IMF FinStats IMF FAS BIS debt data etc.	• This index considers multidimensional nature of financial development • This index captures the degree of development of financial institutions and financial markets of each country in the perspective of depth (size and liquidity), access (access to financial services), and efficiency (provides services at low costs) • This index is composed of total 9 indices for over 180 countries
IMF financial access survey	2004 (annual)	survey	• This is supply-side dataset on access to and use of financial services, launched in 2009 by IMF to support policymakers to measure and monitor financial inclusion.[1)] • This survey covers 189 countries with annual frequency • This provides 70 indicators that are normalized relative to audult population, land size, GDP to make easier comparison between countries
Traditional financial inclusion index	2008 onwards	IMF FAS WB FinDex etc.	• Methodology varies across scholars using various survey data and Sarma (2008) is the forerunner of this work as in Appendix Table 2 • Later, most scholars followed suits covering access to and use of financial services based on various financial survey data[2)]

Notes: 1) The data in the website are available since 2004
2) Currently digital fianncial inclusion index is developed by IMF and other scholars, focusing on digital banking services

Table 3: List of financial inclusion index literatures

Literature	Sample	Methodology	Data	**Access**	**Usage**
Sarma (2012)	94 country (2004-2010)	UNDP approach: geometric average using weighted dimension index	FAS[1)]	• Bank branch/100,000 people • ATMs/1,000,000 people	• Bank account/1000 people
World Bank (2013)	2011	Equally weighted index	Findex;[2)] others	• Bank branch/100,000 adults • % of market capitalization (outside of top10 firms) • government bond yields • private/total debt security(%) • corporate bond issue/GDP(%)	• Bank account/1000 people • % of firms with line of credit • Account holders (%, age15+)
Camara et al (2014)	82 country (2011)	Two-satge PCA[3)]	Findex; FAS	• Bank branch/100,000 people • ATMs/1,000,000 people • ATMs/1,000 sq km • Bank branch/1,000 sq km	• Financial product hold(% adult) • Bank savings last year (%, 15+) • Bank loans last year (%, 15+)
Sahay et al (2015) Svirydzenka (2016)	176 country (1980-2013)	PCA	FAS; others	• Bank branch/100,000 adults • % of market capitalization (outside of top10 firms) • number of debt issuers	
Mialou et al. (2017)	31 country (2009-2012)	Weighted geometric average; weights derived from factor analysis	FAS	• ATMs/1,000 sq km • Bank branch/1,000 sq km	• number of resident household depositors/1000 adults • number of resident household borrowers/1000 adults
Loukoianova et al. (2018)	88 country	Weighted geometric average; weights derived from factor analysis	FAS	• ATMs/1,000,000 people • Bank branch/100,000 people • ATMs/1,000 sq km • Bank branch/1,000 sq km	• Bank depositors/1,000 adults • Bank borrowers/1,000 adults
Blancher et al. (2019)	Household	PCA	Findex; FAS	• Bank branch/100,000 people • ATMs/1,000,000 people	• Account at banks (%, 15+) • bank saving last year (%, 15+) • Bank Loan last year (%, 15+) • Any saving last year (%, 15+) • Own credit/debit card (%, 15+)
Park and Mercado (2021)	153 country (2011-2019)	Two-satge PCA	Findex; FAS	• Bank branch/100,000 adults • ATMs/1,000,000 adults Bank account holder(%, 15+) • Credit card holder(%, 15+)	• Borrowing from bank (%, 15+) • saving at bank (%, 15+) • depositors at bank/1000 adult
Khera et al. (2021)	52 country (2014, 2017)	Weighted geometric average; weights derived from factor analysis	Findex; FAS	• Bank branch/100,000 adults • ATMs/100,000 adults	• Bank account holder(%, adult) • Bank saving holder(%, adult) • Debit card holder(%, adult) • get wage thru bank (%, adult)
Gutierrez-Romero et al. (2021)	135 country (2004-2018)	PCA	Findex; FAS	• Bank branch/100,000 people • ATMs/100,000 people • ATMs/1,000 sq km • Bank branch/1,000 sq km	• Bank account/1,000 people • Bank borrowers/1,000 adults

Notes: 1) Financial Access Survey conducted by IMF
2) Global Findex database realeased by World Bank since 2011 (indicators on access to and use of formal and informal financial services)
3) Principal compenent analysis

Table 4: definition of variables and data sources

Variables	Measurement Unit	Definition	Source
Poverty Indicator			
Headcount ratio	Percent	Ratio of total population who live less than $1.90 per day	PovcalNet [1)]
Poverty gap	Percent	Summing up the distance between poverty line and income of the poor	PovcalNet
Poverty gap squared	Percent	Sum of squared poverty deficits	PovcalNet
Watts index	Percent	Poverty line divided by income of the poor, taking logs, and sum up (% population)	PovcalNet
Gini index	Percent	Gini coefficient for income after deducting taxes and transfers	SWIID [2)]
Financial Innovation			
Financial Inclusion Index (FII)	Index (0 - 1)	Composite index	Gutierrez-Romero et al. (2021)
FII_usage	Index (0 - 1)	Sub-index of FII for financial usage	Gutierrez-Romero et al. (2021)
FII_outreach	Index (0 - 1)	Sub-index of FII for financial outreach	Gutierrez-Romero et al. (2021)
Control variables			
Education	Percent	Gross secondary school enrollment ratio (% population)	World Bank WDI [3)]
Inflation rate	Percent	Annual % change of CPI	World Bank WDI
Trade openness	Percent	Export plus import volume of goods and services (% GDP)	World Bank WDI
Government size	Per cent	Government expenditure (% GDP)	World Bank WDI
GDP per capita	Million US$ (log)	Per capita real GDP at constant 2010 US dollars	World Bank WDI
Instrument variables			
Latitude	Value (0 - 1)	Absolute value of latitude of capital city (scaled to have value 0-1)	AJR (2001) [4)]
Legal origin	Dummy	Equals one for British common law and zero otherwise	LLSV (1997) [5)]

Note: 1) **PovcalNet** : World Bank poverty database

2) **SWIID** : standardized world income inequality database

3) **WDI** : World Development Indicators

4) Acemoglu, Johnson, and Robinson (2001) "Colonial Origins of Comparative Development"

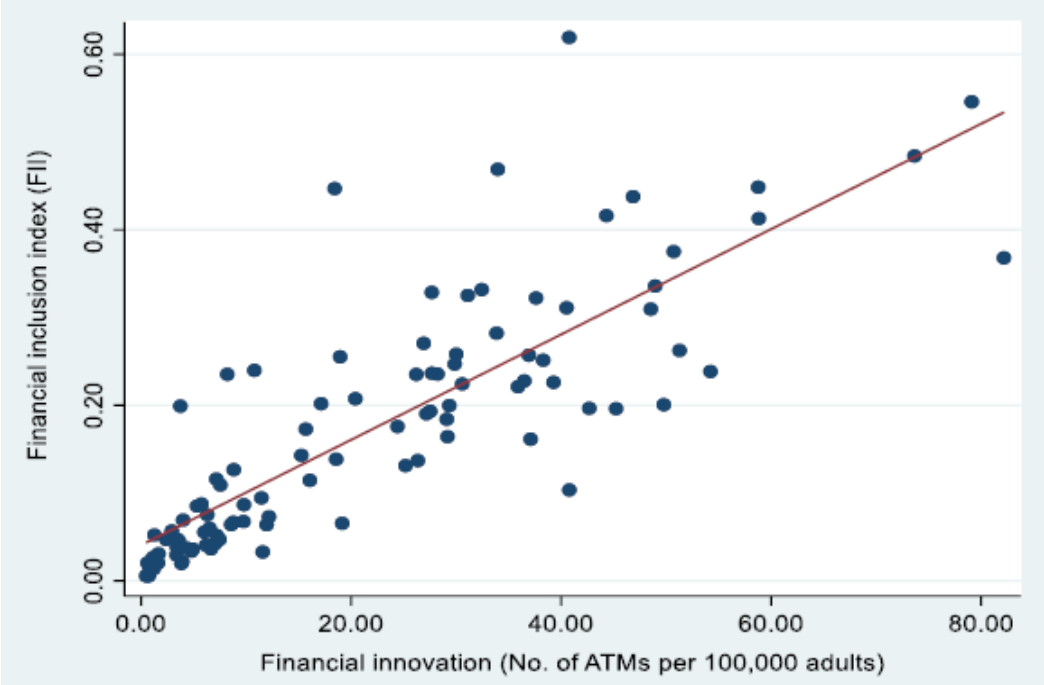
5) La Porta, Lopez-de-Silanes, Shleifer, Vishny (1997) "Legal Determinants of External Finance"

Table 5: financial inclusion index and poverty (OLS)

Dependent variable	Headcount	Povty gap	Povty gap sq.	Watts	Gini
Measure of innovation	Financial Inclusion Index (FII)				
	(1)	(2)	(3)	(4)	(5)
FII	-0.511***	-0.582***	-0.653***	-0.593***	-0.066***
	(0.078)	(0.089)	(0.096)	(0.088)	(0.008)
Education	-0.275**	-0.439***	-0.487***	-0.438***	-0.094***
	(0.101)	(0.126)	(0.142)	(0.129)	(0.013)
Gdppc (log)	-0.503***	-0.387***	-0.265***	-0.489***	0.058***
	(0.054)	(0.067)	(0.077)	(0.066)	(0.006)
Inflation	0.098*	0.108	0.106	0.086	0.010*
	(0.043)	(0.057)	(0.059)	(0.050)	(0.004)
Trade openness	-0.120	-0.487***	-0.474***	-0.396***	-0.055***
	(0.078)	(0.100)	(0.115)	(0.102)	(0.009)
Government exp	0.096	0.225	0.226*	0.411**	0.043*
	(0.076)	(0.132)	(0.103)	(0.132)	(0.021)
Rule of law	-0.259**	-0.251**	-0.469**	-0.254**	-0.126***
	(0.117)	(0.103)	(0.162)	(0.116)	(0.016)
Observations	1271	1226	1226	1226	1301
No. of countries	103	103	103	103	103
R^2	0.505	0.471	0.439	0.493	0.284

Notes: Baseline OLS regressions. Dependent varibale is poverty indicators and Gini index. Time span is 2004-2018. Robust standard errors are presented in parentheses. ***, ** and * indicate 0.01, 0.05 and 0.1 levels of significance, respectively.

Figure 1: Scatterplot between financial innovation and financial inclusion, 2004-18



Source: data from World Bank WDI and Gutierrez-Romero et al. (2021)

Notes: Each variable shows the average value for 103 sample countries over the period 2004-18

References

Acemoglu, Daron, Simon Johnson, James Robinson, "The Colonial Origins of Comparative Development: Empirical Investigation" *American Economic Review* 91, 1369-1401, 2001

Aghion P., Howitt P., Mayer-Foulkes D., "The Effect of Financial Development on Covergence: Theory and Evidence," *Quarterly Journal of Economics* 120(1), 2005

Akhter N., Khalily B., "Impact of Mobile Financial Services on Financial Inclusion," Institute for Inclusive Finance and Development working paper No. 52, 2017

Asia Development Bank, *Key Indicators for Asia and the Pacific 2021: 52nd Edition*, 2021

Banerjee A., Newman A., "Occupational Choice and the Process of Development," *Journal of Political Economy*, 101(2), pp. 274-298, 1993

Banerjee R., Donato R., Maruta A., "The Effects of Financial Inclusion on Development Outcomes: New Insights from ASEAN and East Asian Countries," ERIA Paper, 2020

Beck T., Demirguc-Kunt A., Levine R., "Finance, Inequality, and Poverty," National Bureau of Economic Research working paper 10979, December 2004

Beck T., Demirguc-Kunt, A., Levine R., "Finance, Inequality and the Poor," *Journal of Economic Growth* 12(1) 27-49, 2007

Beck T., Levine R., "Stock Market, Banks and Growth: Panel Evidence," Journal of Banking and Finance 28(3), pp. 423-442, 2004

Billon M., Crespo J., Lere-Lopez F., "Internet, Educational Disparities, and Economic Growth: Differences Between Low-Middle and High-Income Countries," 2017

Boukhatem J., "Assessing the Effect of Financial Development on Poverty Reduction in Low and Middle-Income Countries," *Research in International Business and Finance*, 2016

Chaouachi M., Chaouachi S., "Financial Development and Poverty Reduction in Crisis Periods: Panel Data Evidence from Six Countries of ECOWAS," STATISTIKA, 2021

Cho, M., "FinTech Megatrends: What Welfare Implications Can We Draw for Financial Consumers?" The International Review of Financial Consumers, Vol.6 29-45, 2021

Christopoulos D K., Tsionas E G., "Financial Development and Economic Growth: Evidence from Panel Unit Root Tests," *Journal of Development Economics* vol. 73, 2004

Coleman B. E., "Microfinance in Northeast Thailand: Who Benefits and Who Much?," *World Development*, 2004

Donou-Adonson F., Lim S., Mathy S. A., "Technological Progress and Economic Growth in Sub-Saharan Africa: Evidence from Telecommunication Infrastructure," 2016

Easterly W., "How Much Do Distortions After Growth," *Journal of Monetary Economics,* vol. 32, pp. 187-212, 1993

Fuster, A., Matthew Plosser, Philipp Schnabl, James Vickery, "The Role of Technology in Mortgage Lending," NBER Working Paper 24500, 2018

Guillaumont-Jeanneney, S., Kpodar, K. R., "Financial Development and Poverty Reduction: Can There be a Benefit Without a Cost?," *Journal of development Studies* 47(1), 2011

Grohmann A., Kluhs T., Menkhoff L., "Does Financial Literacy Improve Financial Inclusion?" World Development 111, 84-96, 2018

Hickel, J., "The Microfinance Delusion: Who Really Wins," *The Guardian,* 2015

Hjort J., Poulsen J., "The Arrival of Fast Internet and Employment in Africa," *American Economic Review*, 109(3), 1032-79, 2019

Ho, Sin-Yu, Njindan Iyke, B., "Financial Development, Growth, and Poverty Reduction: Evidence from Ghana," MPRA Paper No. 87121, 2018

International Monetary Fund, Financial Access Survey 2019 Trends and Developments, 2019

Jack, W., Suri T., "mobile Money: Economics of M-Pesa" NBER working paper 16721, 2011

Jeanneney, S. G., Kpodar K., "Financial Development, Financial Instability and Poverty," CERDI, Etudes et Documents, 2006

Kaidi N., Mensi S., "Financial Development, Income Inequality, and Poverty Reduction: Democratic vs. Autocratic Countries," *Journal of Knowledge Economy* 11, 2020

Khera P., Ng S., Ogawa S., Sahay R., "Is Digital Financial Inclusion Unlocking Growth?" IMF Working Paper No.167, 2021a

Khera P., Ng S., Ogawa S., Sahay R., "Measuring Digital Financial Inclusion in Emerging Market and Developing Economies: A New Index," IMF Working Paper No. 21, 2021b

King, R., Levine, R., "Finance, Entrepreneurship and Growth: Theory and Evidence," *Journal of Monetary Economics*, 32(3), pp. 513-542, 1993

Kharas, H., Dooley, M., "The Evolution of Global Poverty, 1990-2030" Brookings Global Working Paper 166, February 2022

La Porta, Rafael, Florencio Lopez-de-Silanes, Andrei Shlefer, and Robert Vishny, " Legal Determinants of External Finance" Journal of Finance 52, 1131-1150, 1997

Levine, R., "Finance and Growth: Theory and Evidence," NBER Working paper 10766, 2004

Levine, R., "Financial Development and Economic Growth: Views and Agenda," *Journal of Economic Literature*, vol.35, pp. 688-726, 1997

Levine, R., Zervos, D. A., "Stock Markets, Banks and Economic Growth," *American Economic Review* 88(3), pp. 537-558, 1998

Levine, R., Loayza N., Beck T., "Financial Intermediation and Growth: Causality and Causes," *Journal of Monetary Economics* 46(1), pp. 31-77, 2000

Lyons A., Kass-Hanna J., "A Multidimensional Approach to Defining and Measuring Financial Literacy in the Digital Age," *Handbook on Financial Literacy Research*, 2021

Morgan P., Huang B., Trinh L., "The Need to Promote Digital Financial Literacy for the Digital Age," 2019

Mckinnon I., "*Money and Capital in Economic Development*," Brookings Institutions, 1973

Park, C. Y., Mercado R. J. V., "Financial Inclusion: New Measurement and Cross-country Impact Assessment," ADB Economics working paper series, 2018

Ravallion M., datt G., "Why Has Economic Growth Been More pro-Poor in some States of India than Others?" *Journal of Development Economics* 68(2), 381-400, 2002

Restoy, F., "Rgulating Fintech: What is Going on, And What Are the Challenges?" The European Money and Finance Forum, Policy Note No. 134, 2020

Sahay, R., Allmen UE., Lahreche A., Khera P., Ogawa S., Barzabash M., "The Promise of Fin-tech: Financial Inclusion in the Post COVID-19 Era," IMF, 2020

Sahay, R., Cihak P., N"Diaye A., Barajas S., Mitra A., "Financial Inclusion: Can It Meet Multiple macroeconomic Goals?" IMF discussion note 15/17, 2015

Sarma, M., "Index of Financial Inclusion: A Measure of Financial Sector Inclusiveness," Berlin Working Papers on Money, Finance, Trade and Development, No. 07, 2012

Shaw E. S., *Financial Deepening in Economic Development*, Oxford University Press, 1973

Sehrawat M., Giri A., "Financial Development and Poverty Reduction in India: an Empirical Investigation," *International Journal of Social Economics*, 43(2), 106-122, 2016

Seven U., Coskun Y., " Does the Financial Development Reduce Income Inequality and Poverty? Evidence from Emerging Countries," *Emerging Market Review* 26, 34-63, 2016

Shaw, E S, "Financial Deepening in Economic Development," Oxford University Press, 1973

World Bank, The Global Findex Database 2017: Measuring Financial Inclusion and the Fintech Revolution, 2018

Zhang J., Wang L., Wang S., "Financial Development and Economic Growth: Evidence from China," *Journal of Comparative Economics* 40(3), 393-412, 2012

Chapter 3

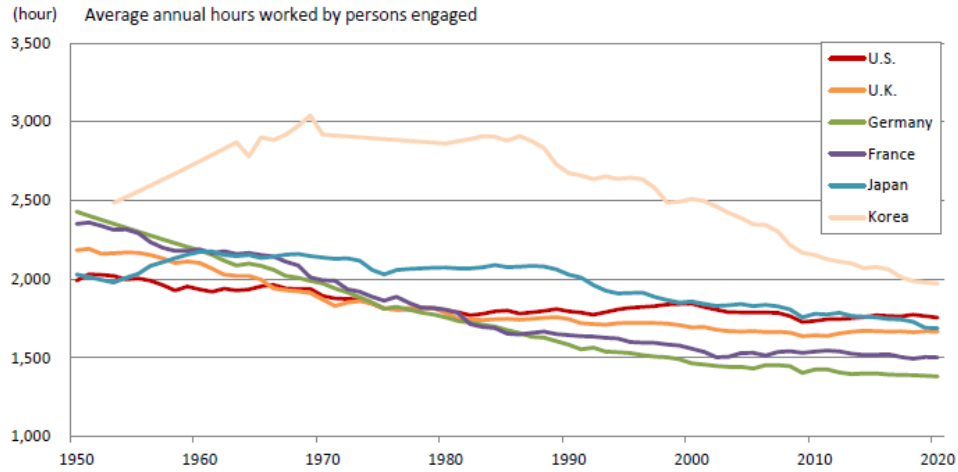
The Effect of Work Hour Reduction on Employee Satisfaction: The Case of Work Hour Reduction Policy in Korea

1. INTRODUCTION

Work hour is usually regarded as one of the most important work conditions that are of big concern for workers, employers, and the whole society. This concern is mirrored by various laws for standard work hours in many countries. In fact, after ILO[1] established the principle of work hours in 1935, the 40-hour workweek has become international work standards (Lee et al. 2007). Despite various efforts to reduce working time, however, long-hour work which means more than 50-hour work per week is common even in advanced countries (OECD, 2013; Wooden et al. 2007). In this respect, 'work time mismatch' between actual and preferred work hours is easily found, hurting the well-being of workers. Lots of studies have explored harmful impact of long-hour labor on worker's satisfaction (Bunting, 2004; Burke and Cooper, 2008; Thompson, 2013).

Historically, the annual average working hours have been steadily decreasing among rich countries as shown in Figure 1 (Huberman, 2004; Oh et al. 2012). European countries such as France, Germany, and the UK show relatively smaller hours compared to other rich countries. Korea's working hours are still remarkably higher, showing 1,972 hours in 2020 with 42.6% higher than Germany. But the working hours are steadily reducing fast.

Figure 1: Annual work hours of major advanced countries plus Korea, 1950-2020



Source: Groningen Growth and Development Center and Penn World Table (Ver. 10.0)

[1] International Labor Organization was created in 1919, aiming to improve working conditions which were aggravated steadily since the Industrial Revolution. Factory workers have worked for tremendous 14-16 hours a day until the early 20th century. ILO chose the principle for 8-hour a day and 48-hour a week in 1919. It was reduced to 40-hour a week in 1935.

This empirical work deals with Korea's innovative labor policy implemented in 2004. Korea has been famous for long-hour work culture, which has formed during the process of compressed rapid growth since the 1960s. Excessive and extra work was common in Korea. But long-hour working is detrimental to health of workers, which then reduces productivity and well-being (Artazcoz et al. 2009; Lee et al. 2016; Virtanen et al. 2012). This is rational considering that workers will experience fatigue, stress, and less attention from long working (Rogers et al. 2004). In 1953, Labor Standard Act was set up in Korea to secure and improve the living standards of workers, mandating 8-hour a day and 48-hour a week. The weekly work standards reduced from 48 to 46 hours in 1989 and 44 hours in 1991. Then, the Asian financial crisis (1997-1998) hit Korean economy and its labor market has experienced unprecedented high unemployment rate. This shock led to public debate on the revision of labor law to reduce work hour and boost employment through job sharing (Lee et al. 2016). Special committee was formed to discuss the revision of labor law, which led to submission of revised bill in 2002. The Congress passed the bill in August 2003, mandating 40-hour workweek from 2004 through 2011 as shown in Table 1. Thus, Korea adopted a new labor policy to reduce work hours from 44 to 40 in July 1, 2004 to enhance worker's well-being.[2]

This policy was adopted in time order by industry and firm size. This makes a great chance to explore causal impact of the policy using difference-in-difference (DID) method. The DID will address the concern of potential endogeneity in this quasi-experimental case study. This essay aims to test the hypothesis that standard 40-hour workweek policy leads to increased satisfaction of workers in Korea. So, this study estimates causal links between work hours and satisfaction. From this analysis, I find that the policy has positive effects on life satisfaction with leisure and family income, but negative impacts on job satisfactions.

Table 1: Adoption process of standard 40-hour workweek in Korea

Starting date	Establishment size and industry
July 1, 2004	Financial sector, Public sector, Establishments with 1000+ employees
July 1, 2005	Establishments with 300 to 999 employees
July 1, 2006	Establishments with 100 to 299 employees
July 1, 2007	Establishments with 50 to 99 employees
July 1, 2008	Establishments with 20 to 49 employees
July 1, 2011	Establishments with 5 to 19 employees

Source: Ministry of Employment and Labor of Korea

[2] The wide use of automation technology in Korea has also contributed to reducing work hours of employees. Korea shows the highest industrial robot density of 932 per 10,000 employees in 2020, followed by Singapore (605) and Japan (390). The stock of robots has begun to rise steadily since 2000 in Korea, but labor hours decreased as in Appendix Figure 1.

Thus, the dependent variables in this study are employee's satisfaction level, which is measured by self-reported life and job satisfaction scaling from 1 to 5. Life satisfaction measures workers' self-reported well-being on their daily lives. Respondents are asked in face-to-face interview, 'All things considered, how satisfied or dissatisfied are you with your life?' Answers are on a scale where 1 ('very satisfied') and 5 ('very dissatisfied') in original survey data. But, for analysis convenience, we recode this scale reversely, showing 1 ('very dissatisfied') and 5 ('very satisfied'). The distribution histogram of answers is shown in Appendix Figure 2. Life satisfaction is skewed to left-side, suggesting that more workers feel satisfied with their lives. Job satisfaction takes similar form and scales to life satisfaction, but, unlike life satisfaction, it is skewed to right-side, suggesting that more workers have negative feelings on their jobs. The histogram suggests that overall life satisfaction has improved since the start of standard 40-hour workweek policy, but overall job satisfaction has decreased after the policy adoption. Unlike previous literatures which use overall satisfaction and cross-section data, we apply life and job satisfaction together across panel data. Unlike cross-section analysis, we can control for unobserved individual heterogeneity using panel fixed effect. Also we include not only overall satisfaction but also several sub-factors including leisure, family income, social friendship, and job satisfaction with work hour etc.

Historically, fixed work time was triggered by technology progress, especially during 1st Industrial Revolution. There was no fixed working time in the days of hunter-gathering and early settled farming. With the advent of steam engine and spinning machines in the late 18th century, mass production was possible in factories using machines and labor workers. However, factory workers suffered from long and hard working as factory owners wanted to maximize production and profits. Therefore, workers organized unions and demand better working conditions including shorter work hours. The Factory Act was passed in Britain to limit work day in 8-hour for children in 1833, and there was nationwide strike for demanding 8-hour work a day in the US in 1886. Spain was the first country to establish a law to restrict work day into maximum 8-hour for all in 1919. The 5-day, 40-hour work week was officially adopted in the US by the Ford Motor Company in 1926.[3] As such, the standard 40-hour workweek system has the origins of technological development and labor reforms.

This essay is configured in following order. Section 2 explains conceptual frameworks and section 3 provides literature reviews. Section 4 elaborates data sources and main variables while section 5 discusses identification strategies. Section 6 provides main results and robustness checks while we discuss policy implications in section 7. Section 8 concludes.

[3] Henry Ford decided to turn off all factory machines on Saturday and Sunday to provide employees 2-day holidays, arguing that consumers are expected to purchase more cars when they have more holidays and more leisure time.

2. CONCEPTUAL FRAMEWORK

In this part, we discuss two basic concepts to capture the links between working hour and employee satisfaction to construct theoretical frameworks for the following analysis. The two concepts are 'work time mismatch' and 'person-environment fit' theory.

2.1 Working time mismatch

These days most people are keen to balance between work and life for happier living. The term 'work-life balance'[4] has become popular among workers, describing situation in which workers have sufficient control over where, when, and how they work to maximize their satisfactions (Visser et al. 2006). Thus, work-life balance of workers has become one of the most pressing policy goals in many countries (Abendroth et al. 2011; Kelly et al. 2014). Basically work time mismatch refers to discrepancies between actual and preferred working hours, and this is common and hinders job-related satisfaction among workers (Bell et al. 2001; Clark, 2005; Holly et al. 2012; Reynolds, 2004). This mismatch is caused by various characteristics of individuals as well as environments or workplaces (Kalleberg, 2008). More specifically, the mismatch can be caused by various factors such as long-term labor contracts, unstable job security, public regulations, information asymmetry, and income inequality and so on (Kahn et al. 1996; Stewart et al. 1997; Rottenberg, 1995; Bell et al. 2001). There are two types of work time mismatch such as overemployment and underemployment. The former implies that actual work hours are higher than preferred work time while the latter indicates the opposite. The empirical study about which one is more detrimental to subjective well-being of workers shows mixed results so far (Holly et al. 2012). Both overwork and underwork are not desirable situations in the perspective of the work-life balance, therefore, we can assume the hypothesis that work hour mismatch is associated with lowering satisfaction of workers. This mismatch can be theoretically explained by using simple labor supply model. Workers usually choose job packages such as fixed wage-hour combination provided by employers though he or she prefers different work conditions. This mismatch will continue when workers have limited information about new jobs or when mobility cost is extremely high. If utility gains are larger than mobility cost, workers change jobs to solve mismatch. But, to examine more closely the links between individual characteristics and job performance, we need to consider a theory of person-environment fit (P-E fit) as follows.

[4] In 1970s, the concepts of 'work-family balance' emerged as more female workers entered labor market and firm owners got to know the challenges of working mothers (Lewis, 1997). In 1980s-90s, the concepts extended to fragile workers such as disabled workers. Then, in the early 2000s, more inclusive concepts of 'work-life balance' have become popular.

2.2 Person-Environment Fit Model[5]

The theory of person-environment fit (P-E fit) provides useful theoretical frameworks to capture the impact of working hour mismatch regarding job-related satisfactions of workers (French et al. 1974; Edwards, 1991; Kristof, 1996). 'P-E fit' refers to the balance between individuals and their environment that occurs when personal characteristics go well with environment (Kristof-Brown et al. 2005). This focuses on interaction between the characteristics of workers and the environment. The basic idea is that individuals not only influence environment and the environment also affect the individuals. Good fit between a person and the environment leads to positive outcome and overall satisfaction including high motivations, desirable behaviors, and mental and physical health. But if the fit is unsuitable, individuals experience high levels of stress, poor health, and ill-being. Thus, the relationship between worker preference and actual work hour is determined by the fit between worker preferences and work characteristics (Angrave et al. 2015). This theory is essential to capture the links between working time and satisfaction of workers. The theory argues that job outcomes and employee satisfaction is higher when P-E fit is good. But the opposite, the poor fit between preference and work characteristics may hinder well-being. When the misfit exists, un-met needs (needs for smaller work hours) become a source of stress, leading to lower satisfaction. Thus, optimal fit facilitates individual performance in the workplace, such as improved attitude and performance, but poor fit worsens individual outcomes. For instance, people with excellent knowledge, skills, and abilities but no interest in research is not a good fit for scholars. Empirical study also proves that the degree to which actual work time stands with preferences is more important to job-related satisfactions than absolute number of work hour (Wooden et al. 2009). There are several types of P-E fit, such as person-group fit, person-job fit, person-vocation fit, and person-organization fit. Among these, person-job fit explains good match between individuals and jobs. Edwards (1991) argued that there are two conceptualizations of this fit. 'Demand-ability fit' describes the situation that demand of the job complies with worker's knowledge, skills, and ability. But 'needs-supply fit' implies that worker's needs and preferences are compatible with rewards from the jobs (Kaplan, 1987). However, the misfit between person and job will lead to psychological, physiological, and behavioral stress (Edwards et al. 1998).

[5] This theory goes back to 1909 when Frank Parsons (social reformer) stressed importance of both person and environment in job choice. Then, many scholars developed the model to capture how interaction between person and environment works each other. The idea of P-E came from the maxim of Kurt Lewin (1890-1947, American psychologist); the human behavior is the function of person and environment. He is known as one of modern pioneers of social psychology.

3. LITERATURE REVIEW

There are lots of empirical studies exploring the effect of standard work hour reduction on socio-economic outcomes. Among them, the most remarkable study is done by Hunt (1999). She examined the effect of mandatory reduction of workweek on actual work hours, wage and work-sharing[6] in Germany. She used industrial level changes in work hours to explore the impact on employment using panel survey data at the individual and industry level for firms with 20 or more employees. Working hour reduction policy was adopted in Germany from 1985 to 1996, mandating 40 to 35 hours per week. She applied panel fixed effect regression model, finding that 1-hour reduction in standard workweek decreases actual work hours by 0.8 to 1 hour, but monthly wage did not affected by reduced hours, implying the rise in wage per hour. She also finds that no work-sharing effect exists due to the increased real wages caused by fall in actual work hours. Lee et al. (2012) conducted comparative study on non-market outcomes from standard 40-hour workweek policy in Korea and Japan. Standard 40-hour workweek policy was adopted in April 1, 1998 in Japan and July 1, 2004 in Korea. They used time-diary survey data of each country to examine the changes in free time allocation in these countries. Comparing 1999 and 2009 wave in Korea and 1991 to 2006 wave in Japan, they find that average daily working time was reduced in both countries by 11 percent in Korea and 6 percent in Japan. Moreover, they find that a third of time gift was spent on leisure activities in Japan while half of time gift was spent on personal cares such as day sleeping in Korea.

Another study to analyze Korea's case is done by Rudolf (2014). He explored the impact of standard 40-hour workweek on worker happiness and their families. He used longitudinal data taken from Korea Labor and Income Panel Study ("KLIPS") for the years of 1998-2008 by applying panel fixed effects ordered logit regressions. He found that work hour reduction in Korea has no impact on job and life satisfaction, implying that workers' actual work hours did not reduced substantially and long work hours might not be negative to worker's well-being in Korea unlike existing theories. Another noteworthy study on the effect of work hour reduction policy in Korea is done by Lee et al. (2016). They analyzed the impact of standard 40-hour workweek policy on industrial injuries using quasi-experimental policy setting. They

[6] Traditionally the purpose of work hour reduction was to boost employment and improve quality of lives. Job-sharing was one of the important goals of work hour reduction. This is based on the following idea. When labor is fixed in short term and each worker works fewer hours, then this means creating more opportunity to work. But theoretically it is not clear whether work hour reduction boosts employment or not. Due to increased real wage after the policy, firms reduce output and then employment (scale effect). Firms substitute labor with capital (substitution effect). Net effects depend on the relative size.

found that there are significant correlations between working time and industry accident occurrences, showing that one hour reduction of actual work hour leads to 8% decrease of workplace accidents. Kawaguchi et al. (2008) analyzed the similar case in Japan, where legal working hour per week decreased in steps from 48 to 40 hours during years of 1987-1997. They estimated the effect of legal work hour reduction on labor market outcomes such as actual working hour, wage and employment. They applied the same regression model used by Hunt (1999). Their findings report that one hour reduction of legal working time is associated with 0.14 hours reduction in actual work hour, but it does not lead to reduction in monthly wages. Also they found that new recruitment of college graduates is suppressed by increased real wages caused by reduced actual working hours.

Crepon et al. (2002) studied French case of 1982 that reduced standard work week from 40 to 39 hours with no reduction in weekly wages. They used longitudinal individual survey data to estimate the impact of work hour reduction policy on employment by comparing two groups: treated group working 40 hours in 1981 and control group working between 36 and 39 hours in 1981. They found that one hour reduction in weekly work hour leads to decrease in employment from 2 to 4 percent. This policy was unexpectedly adopted faster than preceding government announcements, therefore many firms have no time to revise negotiations with 40-hour working employees, leading to dismissing them to find new jobs with new contracts. Additional policy to reduce work hours from 39 to 35 in France during the period of 2000-2002 was studied by several scholars (Fagnani et al. 2004; Estevao et al. 2008). The former study found that this policy reduced actual work hours but increased wage per hour and employee turnover. The latter focused on work-family life balance, finding that 60 percent of parents responded positive impacts of 35-hour workweek on work-life balance.

Raposo et al. (2010) explored Portugal case where weekly work hour decreased from 44 to 40 in 1996. They find that work hour reduction increased hourly wage of affected workers (40-42 hour workers) and had no impact on job loss of affected workers, but reduced employment for people working less than 40 hours. Skuterud (2007) analyzed Canada case where standard workweek was reduced from 44 to 40 during years 1997-2000. He found that this policy reduced actual work hours but no effect on employment. Also there exist lots of literatures to explore the links between work hour and output or productivity. Pencavel (2014) finds that output increases by adding more working hours, but it increases at a decreasing rate. This means that there exist diminishing returns between work hours and production.

The causal links between work time mismatch and employee satisfaction has been popular research topic among scholars. There are lots of studies dealing with working time mismatch. Angrave et al (2015) finds that the absolute number of work hour is not the direct cause of lower well-being of workers, but work hour mismatch is the root cause of lower satisfaction. But empirical studies have shown mixed results so far about whether over- or under-employment is more detrimental to satisfaction. Wooden et al (2009), using Australian household panel data, finds that overemployment is more detrimental to worker's well-being rather than underemployment. They argue that working time mismatch is more critical factor in determining worker's satisfaction rather than absolute number of work time. They also find that overtime work does not show overall negative effect on satisfactions because it is largely voluntary choice and financially compensated enough. But Wunder et al. (2012) found different results using German data, arguing that underemployment is more harmful to worker's well-being mainly due to deprived utility gains such as up-skilling training chances or expanding social networks, particularly among male workers. They also find that self-reported satisfaction is contagious within couples. Clark (2005) shows similar results that work hour is important for life and job satisfaction level only when actual and preferred work hours are different. Valcour (2007) analyzed call center workers in the US to explore impact of work hours on life and job satisfaction. He finds that number of work hours has negative effects on satisfaction. Gash et al. (2010) examined the effect of changing work hours from full-time to part-time on overall life satisfaction among female workers in the UK and Germany. They found that decreased work hours have positive impact on life satisfactions. Pagan (2017) explores impact of work time mismatch on job satisfaction among disabled workers in Germany, finding that workers experiencing work hour mismatch tend to have low level of job satisfaction compared to those who actually work their desired hours. He also argues that overemployment is more harmful to job satisfaction rather than underemployment, and its effect is much higher for females with disability compared to non-disabled females. He concludes that public policy to reduce work hour mismatch is vital to improve job satisfaction of employees. Frei et al. (2022) analyzed longitudinal survey data for 1,949 doctoral students and postdocs in Germany to explore the impact of work time mismatch on academic job satisfaction. They find that work time mismatch is common in academics and is related with low job satisfaction, and overemployment (work more than desired hours) shows more harsh impact on job satisfaction than underemployment.

4. DATA AND VARIABLES

The primary source of data is Korea Labor and Income Panel Study ("KLIPS"), which is extensive labor-related survey data in Korea and includes cross-sectional and time-series data on households and individuals. KLIPS is created based on National Longitudinal Survey (NLS) and Panel Study of Income Dynamics (PSID) in the US. This dataset is most widely used in Korea for academic researches on the labor and income related studies. Korea Labor Institute, a public research organization, conducts annual survey for the samples of households and its members located in urban area. The 1st wave survey was conducted in 1998 for 5,000 households and 13,783 individuals aged 15 or older, and accumulated 1st to 23rd waves to date. The survey questionnaire includes a broad set of socio-demographic questions such as job and life satisfactions, wages, education, family and employment and so on. To explore the impact of standard working hour reduction on worker satisfaction, I used three wave dataset (2003, 2005, and 2006) and restricted the samples into full-time wage workers who did not change workplace during sample periods to exclude confounding factors from job mobility and thus draw out pure causal effect of the policy. Usually wage workers have little control over work hours and the intensity of labor seems to be uniform compared to self-employed and unpaid family workers. This makes it possible for us to compare changes in satisfaction between before and after policy adoption as well as between treated and control groups. Basically this study aims to identify the impact of standard 40-hour workweek policy on life and job satisfaction of workers in Korea. For this, I first pick up the samples for full-time wage workers who maintained same workplace as noted, and then split this sample into two groups: beneficiary (treatment) and non-beneficiary (control) group.

As explained above, the standard 40-hour workweek policy in Korea was implemented gradually by industry and firm size during seven years from 2004 to 2011. I use 2003 wave data for pre-event and 2005 and 2006 wave for after-event in DID analysis. Table 2 shows summary statistics. Dependent variables are satisfaction with life and job and its related sub-factors which are measured by 5 ordered categories. The original scales for satisfaction range from 1 to 5, showing 1 is most satisfied while 5 are most dissatisfied. I recoded this score so that higher score indicates higher well-being. The values are concentrated on category 2 (dissatisfied), 3 (neutral), and 4 (satisfied) while boundary scores 1 (very dissatisfied) and 5 (very satisfied) are relatively rare as in Appendix Figure 1. In 2003, for job satisfaction, 96.9% answered for three categories 2, 3, and 4 while boundary category 1 and 5 explain only 3.1%.

Thus, I've used continuous (ordinal) values for dependents in main analysis. Then, in the robustness, we rearrange the scales into binary indicator (satisfy or not satisfy) which equals 1 for categories 4 and 5 and 0 for categories 1, 2, and 3. I apply LPM and logit model as dependents are binary. Table 2 reports that life satisfaction is higher than job satisfaction on average. The mean value of overall satisfaction for life and job is 3.3 and 2.7, respectively. Independent variables are listed. Mean age is 40. There is gender gap, showing 65% for men and 35% for women. Mean wage is 1.8 million won (U$1,774), showing large income gaps among workers. Most are married (79.4%) and 46.5% lives in Seoul and Kyung-gi province. 33% finished high school. 27% for above university degrees and 21% for below high school.

Table 2: Descriptive statistics

Variables	Obs	Mean	Std.Dev.	Min	Max
Dependent Variabes					
Job satisfaction (overall)	9,752	2.798	0.653	1	5
Job satisfaction (workhour)	9,789	2.827	0.789	1	5
Job satisfaction (wage)	9,788	2.789	0.713	1	5
Life satisfaction (overall)	9,797	3.344	0.609	1	5
Life satisfaction (leisure activity)	9,792	3.012	0.753	1	5
Life satisfaction (family relation)	9,792	3.704	0.613	1	5
Actual work hour (week average)	8,444	49.691	11.773	2	88
Treated	7,576	0.433	0.495	0	1
Post	9,841	0.724	0.446	0	1
Control Variabes					
Gender					
Male	9,841	0.649	0.477	0	1
Female	9,841	0.351	0.477	0	1
Age	9,841	40.483	11.037	19	83
Wage (monthly)	9,812	183.640	118.900	5	3300
Wage (monthly)_ln	9,812	5.033	0.621	1.609	8.102
Marital staus					
Not married	9,841	0.206	0.404	0	1
Married with spouse	9,841	0.731	0.444	0	1
Married but no spouse	9,841	0.063	0.243	0	1
Education level					
Below high school	9,841	0.217	0.412	0	1
High school	9,841	0.330	0.470	0	1
College (2-year)	9,841	0.177	0.381	0	1
Above university (4-year)	9,841	0.277	0.448	0	1
Place of residence					
Seoul	9,841	0.241	0.428	0	1
Kyung-gi province	9,841	0.224	0.417	0	1
Other provinces	9,841	0.535	0.481	0	1

Notes : The depedent variables are measured by 5 category Likert scales for the questions: how satisfied or dissatisfied with your job or life? The respondents are required to choose among 5 scales (1 very satisfied, 2 satisfied 3 neutral 4 dissatisfied 5 very dissatisfied). For convenience, I recode this scale so that the higher value shows higher satisfaction. Most answers are concentrated on 2, 3, and 4, therefore I use continous variables for dependents. However, I use logit regression in robustness checks using three categories such as dissatisfied(1-2), neutral(3), and satisfied(4-5).

5. EMPIRICAL STRATEGY

5.1 Estimation model

I explore the effect of work hour reduction on life and job satisfaction among Korean workers by using difference-in-difference (DID) estimation strategy. I compare the changes in self-reported satisfaction level between policy-affected workers and non-affected workers. I estimate the following equation model:

$$Y_{it} = \beta_0 + \beta_1 Post_t + \beta_2 Treatment_i + \beta_3 (Post_t * Treatment_i) + X'_{it}\alpha + \varepsilon_{it}$$

where Y_{it} represents the outcome variables such as life and job satisfaction of individual worker i at year t. Job satisfaction includes several sub-factors such as overall, work hour, wage, and welfare. Life satisfaction also includes sub-factors with overall, leisure activity, family relations, and social friendship. $Post_t$ is year dummy variable which equals one for the year 2005 and 2006 and equals zero for the year of 2003. $Treatment_i$ is the binary indicator that indicates one for policy affected workers (those who work for public and financial sector, or firms with over 1,000 employees) and zero denotes for non-affected workers. $Treatment_i$* $Post_t$ is the interaction term of treatment and post. β_3 measures the treatment effect of the policy. X'_{it} shows control variables such as age, gender, wage (monthly earnings), education, marital status, and place of residence. ε_{it} is the error term.

5.2 Estimation Methodology

In analyzing the causal relationship between work hour reduction and workers' self-rated satisfaction with job and life, we need to be careful about simultaneity problem, which leads to misleading estimates due to endogeneity issue. That is, workers usually choose their occupations and work conditions such as work hours simultaneously. Moreover, those who are satisfied with their work and life could be more productive and passionate at their workplace (Zelenski et al. 2008). To address this kind of problem I apply difference-in-difference estimation technique to draw out causal relationship. As mentioned above, Korea's standard 40-hour workweek policy was implemented in time order by industry and firm size during the years of 2004-2011, initially applying to workplace with 1000 or more workers and public plus financial sector. Almost all establishments except the smallest ones were applied by the mid-2008. This gradual adoption of the policy gives us an ideal chance to examine the policy impact using exogenous changes in working time across groups based on different time, industry, and firm size (Hunt, 1999; Kawaguchi et al. 2008). This policy setting makes it possible for us to apply the DID analysis (before and after the policy and

differences between treated and control groups) to capture causal impact of the policy. I restricted the sample individuals into full-time wage workers who did not change jobs during the sample period to minimize confounding factors and improve the accuracy of estimation. Basically the DID method is comparing two differences: differences between before and after the policy, and differences between treated and control groups. The treated individuals are those who work for public and financial sector as well as firms with 1,000 over employees. The research design is illustrated in Appendix Figure 2. The validity of our estimates depends on whether the outcome variables show the similar trends between treated and control groups before policy is implemented. This is called 'parallel trends assumption', which is shown in Figure 2. In DID analysis, the most important precondition is the parallel trends. Figure 2 shows that the parallel trends exist between treated and control groups. The left panel indicates that life satisfaction has similar trends among treated and control groups. Right panel shows trends of job satisfaction, suggesting parallel movement between treated and control groups. One unique point in this graph is that life satisfaction has turned toward upward direction after the adoption of work hour reduction policy. On the other hand, job satisfaction shows the completely opposite trends, showing downward after the policy adoption. We also conducted balance test for covariates to check the correlation of control variables between treated and control groups. The result is shown in Appendix Table 1, implying that insignificant mean differences exist between treated and control groups except income variable (thus, two groups are balanced). In other words, most covariates are below the acceptable threshold of 5 percent, meaning that our baseline covariates are balanced and thus this may support the parallel path assumption of covariates.

Figure 2: Parallel trends between treated and control groups

Source: KLIPS (Korea Labor and Income Panel Study) 5-9th Wave

6. ESTIMATION RESULTS

6.1 Main Results

I estimate the impact of standard 40-hour workweek policy on worker's satisfaction with various parts in life and job. Table 3 provides results of life satisfaction. Overall policy influence on life satisfaction in column 1 is trivial and insignificant. Only column 2 and 4 shows significant effects on life satisfaction with leisure and family income. But column 3 and 5 report that standard 40-hour workweek has no significant effect on life satisfaction with family relation and social friendship. Column 2 and 4 reports that the policy increases leisure satisfaction and income satisfaction by 0.05 and 0.08 points. Both are statistically significant at 10% level. This is consistent with previous studies by Park (2014) and Yang et al. (2009). Significant leisure satisfaction in column 2 implies that workers increased leisure activities thanks to reduction in working hours. Also significant income satisfaction in column 4 suggests that workers increase overtime work and thus earn more wages due to higher rewards on overtime work. Considering the ordinality of satisfaction scores, I also estimate ordered logit model as in Appendix Table 2, showing similar results to OLS.

Table 3: Effects of the policy on life satisfactions (OLS)

Variables	Life satisfaction				
	Overall	leisure activity	family relation	family income	social friendship
	(1)	(2)	(3)	(4)	(5)
Treated	0.062	0.029	0.053	0.028	0.019
	(0.046)	(0.066)	(0.053)	(0.056)	(0.051)
Post	0.060*	0.042*	0.071**	0.087**	-0.079**
	(0.024)	(0.031)	(0.025)	(0.028)	(0.025)
Treated*Post	0.014	0.047*	0.035	0.083*	0.005
	(0.029)	(0.024)	(0.026)	(0.033)	(0.029)
Age	0.023**	0.016	0.028**	0.006	0.025**
	(0.009)	(0.012)	(0.009)	(0.010)	(0.009)
Married (=1)	0.089	0.206**	0.084*	0.053	-0.109
	(0.070)	(0.067)	(0.041)	(0.052)	(0.066)
Edu (above college=1)	-0.178	-0.143	-0.059	-0.046	-0.174
	(0.159)	(0.135)	(0.145)	(0.125)	(0.124)
Residence (Seoul=1)	-0.170*	-0.392*	-0.077	-0.197	-0.055
	(0.067)	(0.154)	(0.121)	(0.152)	(0.107)
Year FE	Yes	Yes	Yes	Yes	Yes
Individual FE	Yes	Yes	Yes	Yes	Yes
Observations	7,515	7,510	7,510	7,511	7,509
R-squared	0.109	0.113	0.127	0.121	0.104

Notes: Panel fixed effect (OLS). Standard errors (clustered in individual level) in parentheses. ****p<0.01, **p<0.05, *p<0.10.* Dependent variables are life satisfaction sub-factors including leisure, family relation, family income, and social friendship. They are continous variables ranging from 1 to 5, showing that 1 is most dissatisfied and 5 is most satisfied score. The survey question for life satisfaction is as follows; "Are you satisfied or dissatisfied for your life?" The answers are among 5 choices ranging from 1 (most satisfied) to 5 (most dissatisfied). For convenience we recode the scale for 5 showing most satisfied and 1 is most dissatisfied. The controls include age, marriage, education and place of residence.

Now I consider the effect of the policy on job-related satisfaction as shown in Table 4. Overall results indicate that the policy has negative effects on job satisfaction. This result is much contrary to our usual expectation considering that the policy aimed to enhance workers' subjective well-being through ensuring work-life balance. Column 1 and 4 reports that the policy adoption reduced job satisfaction with overall and workplace welfare by 0.07 and 0.10, respectively. Both coefficients are significant at 10 percent and 5 percent level, respectively. Column 2 and 3 shows negative and insignificant effect on satisfaction with work hour and wage. Column 5 reports the impact on actual working hours per week, indicating 1.3 hours reduction on average. This suggests that actual work hours diminished much less than our expectation considering 4-hour falls in standard working hours per week. We can presume several reasons for this, including the increase in overtime work due to higher premium on overtime wage. Thus, I assume that, to obtain more powerful and positive effects on job satisfaction, actual work hours must be declined even more. We also get the similar results by using ordered logit regressions as shown in Appendix Table 3

Table 4: Effects of the policy on job satisfactions and work hours (OLS)

Variables	Job satisfaction				Work hours
	Overall	work hour	wage	welfare	(weekly)
	(1)	(2)	(3)	(4)	(5)
Treated	-0.046	-0.143*	0.005	0.040	-0.009
	(0.055)	(0.067)	(0.067)	(0.065)	(0.865)
Post	0.117***	0.010	0.088**	0.050	1.166**
	(0.025)	(0.030)	(0.029)	(0.031)	(0.421)
Treated*Post	-0.070*	-0.011	-0.053	-0.103**	-1.300**
	(0.030)	(0.037)	(0.035)	(0.038)	(0.469)
Age	-0.029**	-0.034**	-0.023*	-0.022*	-1.238***
	(0.009)	(0.011)	(0.011)	(0.011)	(0.153)
Married (=1)	0.020	-0.029	0.038	-0.002	0.124
	(0.067)	(0.091)	(0.091)	(0.080)	(0.967)
Edu (above college=1)	-0.062	-0.128	0.087	-0.130	-0.313
	(0.180)	(0.174)	(0.157)	(0.134)	(1.048)
Residence (Seoul=1)	0.022	0.275	0.208	0.025	2.081
	(0.084)	(0.166)	(0.141)	(0.120)	(2.516)
Year FE	Yes	Yes	Yes	Yes	Yes
Individual FE	Yes	Yes	Yes	Yes	Yes
Observations	7,478	7,509	7,508	7,466	6,681
R-squared	0.124	0.119	0.118	0.116	0.128

Notes: Panel fixed effect (OLS). Robust standard errors (clustered in individual level) in parentheses. ****p<0.01, **p<0.05, *p<0.10.* Dependent variables are job satisfaction and actual work hours per week. They are continous variables ranging from 1 to 5, showing that 1 is most dissatisfied and 5 is most satisfied score. Actual work hours refer to actual average work hours per week including regular and overtime work. The survey question for job satisfaction is as follows; "Are you satisfied or dissatisfied for your job?" The answers are among 5 choices ranging from 1 (most satisfied) to 5 (most dissatisfied). For convenience of analysis we recoded the scale for 5 showing most satisfied and 1 is most dissatisfied. The control variables include age, marital status, education level and place of residence.

Now I check heterogeneous effect by gender. We assume that the policy effect on life satisfactions varies by gender. For example, study by Park (2014) shows that the policy of standard 40-hour workweek in Korea increased life satisfaction slightly among male workers, but insignificant effect on females. Rudolf (2014) also finds that there is gender gap in distribution of work hour in Korea, showing differential well-being by gender. His finding indicates that the impact of the policy on satisfaction for work hours is much stronger for female, showing the existence of work-life conflicts for women in Korea. In the same vein, I explore heterogeneous effect on life satisfaction by gender as shown in Table 5, showing that there are some differential effects between male and female workers regarding self-reported life satisfactions. As shown in Table 5, the standard 40-hour workweek policy has relatively stronger impacts on males than females regarding life satisfaction. Column 1 reports that the policy has no significant effect on overall life satisfaction for male workers. Column 2 and 3 reports that the policy significantly increased life satisfaction with leisure activities and family income by 0.06 and 0.11 points, respectively. However, for females, the effects are not significant for all dependent variables. This result is in line with the study by Park (2014), which found that the policy has stronger impact on men than women in Korea. The impact on job satisfaction by gender is also presented in Appendix Table 4, which shows similar trends to effects on life satisfaction between men and women. The heterogeneous effect by industry (service, manufacturing) is also shown in Appendix Table 5.

Table 5: Impacts of the policy on life satisfaction by gender (OLS)

	Male			Female		
Dependent : Life satisfaction	overall	leisure activities	family income	overall	leisure activities	family income
	(1)	(2)	(3)	(4)	(5)	
Treated	0.062	0.068	0.021	0.061	-0.025	-0.065
	(0.061)	(0.088)	(0.074)	(0.070)	(0.100)	(0.087)
Post	0.057	0.062	0.104**	-0.077	-0.047	-0.055
	(0.030)	(0.038)	(0.036)	(0.041)	(0.052)	(0.046)
Treated*Post	0.016	0.061*	0.108**	0.019	0.016	0.035
	(0.036)	(0.029)	(0.040)	(0.052)	(0.067)	(0.059)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Individual FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	4,809	4,806	4,806	2,706	2,704	2,705
R-squared	0.019	0.102	0.105	0.113	0.101	0.106

Notes: Panel fixed effect (OLS). Standard errors (clustered in individual level) in parentheses. ***$p<0.01$, **$p<0.05$, *$p<0.10$. Dependents are life satisfaction sub-factors including overall, leisure activities, and family income. They are ordinal variables ranging from 1 to 5, showing that 1 is most dissatisfied and 5 is most satisfied. The survey question for life satisfaction is as follows; "Are you satisfied or dissatisfied for your life?" The answers are 5 choices ranging from 1 (most satisfied) to 5 (most dissatisfied). For convenience we recode the scale for 5 showing most satisfied and 1 is most dissatisfied. The controls include age, marrital status, education level and place of residence.

6.2 Robustness Check

For robustness check, I transform satisfaction scores into binary indicator which equals one if scores are '4' or '5' while zero if scores are '1', '2', or '3'. Simply this means one is satisfaction and zero is non-satisfaction. I classify 'neutral' scores into non-satisfaction category considering the distribution of scores as shown in Appendix Figure 1. It shows that most answers are concentrated on '2' (dissatisfied), '3' (neutral), or '4' (satisfied), with relatively scanty answers for '1' (very dissatisfied) or '5' (very satisfied). 98.9% of scores are for '2', '3', or '4', with only 1.1% for '1' or '5' in 2003. Other years show similar trends. The distribution is skewed to the left, meaning more workers feel satisfied on life. However, the case of job satisfaction is a little different. The general shape of distribution is similar, but it is skewed to the right, implying more people feel dissatisfied on job. Thus, in this case, I classify 'neutral' scores into satisfaction category to strike a balance. LPM and logit regressions are used as dependents are binary. Table 6 shows the result. The overall results are similar to the baseline, showing significant effects on life satisfaction with leisure and family income. Column 2 and 4 in Panel A shows that the policy significantly raises satisfaction by 7.3% and 6.6% for leisure and family income. Similarly in Panel B, column 2 and 4 shows similar effects.[7] Results for job satisfaction are shown in Appendix Table 5.

Table 6: Robustness check using binary dependent variables

Variables	Life satisfaction_binary outcome				
	Overall	leisure activity	family relation	family income	social friendship
	(1)	(2)	(3)	(4)	(5)
	Panel A: Linear Probability Models				
Treated	0.018	-0.031	0.007	-0.018	0.005
	(0.018)	(0.049)	(0.015)	(0.039)	(0.013)
Post	0.011	-0.040	-0.003	-0.052*	-0.010
	(0.019)	(0.027)	(0.008)	(0.020)	(0.009)
Treated*Post	-0.012	0.073*	-0.008	0.066*	0.017
	(0.020)	(0.034)	(0.008)	(0.026)	(0.010)
	Panel B: Logit regressions				
Treated	0.081**	0.058**	0.087***	0.031	0.091***
	(0.031)	(0.020)	(0.021)	(0.017)	(0.022)
Post	-0.149	0.003	-0.043**	-0.042**	-0.027
	(0.015)	(0.015)	(0.013)	(0.013)	(0.015)
Treated*Post	0.006	0.042*	-0.017	0.057**	-0.017
	(0.022)	(0.021)	(0.022)	(0.017)	(0.023)
Contols	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
Individual FE	Yes	Yes	Yes	Yes	Yes
Observations	7,551	7,551	7,551	7,551	7,551

Notes: Panel A reports linear probability model estimates and Panel B reports logit regression estimates (Panel B is transformed to marginal effect coefficients). Standard errors in parentheses. ***p<0.01, **p<0.05, *p<0.10. Dependent variables are binary outcome variables that equal one for satisfaction categories '4' and '5', and zero for dissatisfaction categories '1' '2' and '3'. The control variables include age, marital status, education level and place of residence.

[7] Unlike LPM models, we need to be careful in interpreting estimates in logistic models. We have to convert them into marginal effect coefficients by using Stata command after running original logistic regressions: margins, dydx(*)

7. DISCUSSION AND POLICY IMPLICATION

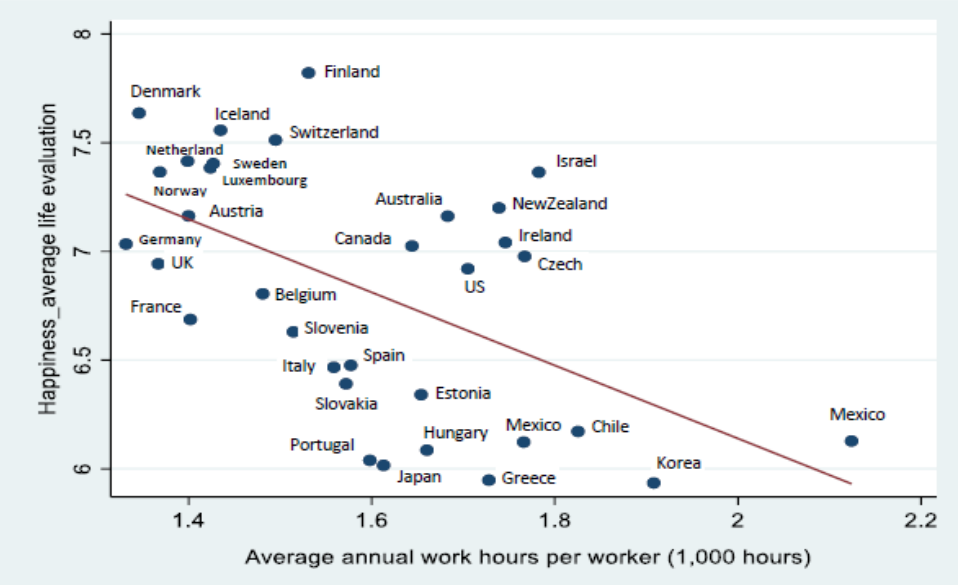
In this part we discuss policy implications of my empirical findings. I also touch on the links between work time and work performance based on empirical study by Pencavel (2014) to point out the importance of productivity. Lastly I will examine the historical development of standard work hours in the perspective of optimal work hours. As noted, policy goal of standard 40-hour workweek in Korea was to improve workers' welfare as well as promote employment. This essay focuses on the former objective: employee's subjective well-being. But my empirical analysis indicates that the policy effects on life and job satisfaction of workers are trivial and much weaker than our expectation.[8] This will reflect that current working conditions in Korea are still tough.

In fact, there are lots of problems in Korea's labor market. First of all, polarization is widely stated, including income gaps between regular and non-regular workers, gender gaps in wage, careers, promotion chances, and generation conflicts on employment etc. Second, the rigidity of labor market makes mobility difficult, which decreases labor productivity and erodes competitiveness of firms. Furthermore, the deepest problem may be non-existence of consistent and long-term reforming plans to address the above problems. More elaborate and longer-term reform programs must be established to respond properly to rapid changes in current labor market. Though Korean government has made some efforts to push for labor market reforms to address these problems, but results show limited outcomes so far.

Working hour arrangement may be the most important work conditions to determine worker's subjective well-being as long-hour work culture was prevalent in Korea. In this respect, the theme of this essay, the impact of work hour reduction on employee satisfaction is important in that it may directly impact on worker's satisfaction through reducing actual work hours and thus increase family and leisure activity. We can imagine a few reasons why work hour reduction has limited impact on employee subjective well-being in Korea. One of the most likely reasons may be mismatch between actual and preferred working hours among workers. One local survey data also prove this assumption. According to Korea Working Conditions Survey[9], the mismatch exists among Korean workers. In 2011, Korean workers actually worked 46.54 hours per week but their preferred work hours were 44.98 on average, implying the mismatch of 1.56 hours toward over-working. This trend continues until now. Actual working hours were 40.2 hours in 2021, but preferred working hours were 39.3 with mismatch of 0.9 hours toward over-working.

[8] If we categorize workers differently according to their work hours and income change, empirical results would be different. That is, the relative composition of different types of workers will have different welfare implications of the policy adoption.
[9] This data are released by Korea Occupational Safety and Health Agency every 3 years. It started in 2006. The data include extensive working conditions such as work hours, wage, job type, job security etc. for 50,000 workers across the country.

Figure 3: Relationship between work time and happiness among OECD countries



Source: World Happiness Report 2022, OECD statistics

Definitely, long-hour work reduces employee's subjective well-being as shown in Figure 3. Among OECD countries, average annual work hours show negative correlations with happiness measured by subjective life evaluation. This relationship is significant at 1 percent level. Korea is located in right-bottom side in Figure 3, suggesting that lower happiness and longer work hours compared to other rich countries. This suggests that the efforts to reduce longer working hours in Korea are still necessary to enhance worker's happiness. Standard 40-hour workweek policy can be understood as one of these efforts. Moreover, regarding work time mismatch which can be one of the root causes for lower level of satisfaction in Korea, then what should be done about it? As noted, policies to reduce standard work hours can be helpful to narrow the gaps between actual and preferred work hour, but more effective tools can be found in boosting worker's self-control or discretion over their working time such as flexible work plans[10]. Government should induce employers to increase negotiating non-standard work hours with employees. Thus workers can work only part of the year or part of the week, and enter or leave the workplace at different time of the day. Allowing employees to decide their work time will boost worker's morale and reduce stress levels. Furthermore, 'work-life balance' promotes loyalty to firms, which boosts productivity. For instance, in Denmark and Finland, based on trust between management and unions, flexible work was established, leading to high happiness and productivity as shown in Figure 3 and 4.

[10] The types of flexible work can vary. Time difference commuting: workers can decide their start (ending) time of the day rather than 9 to 6. Home working: work using e-mail and internet at home based on telecommunication device. Flexible work time: some days work longer while some days shorter, but average hours must be observed by legal working hours.

Recently new technologies, by lowering transaction cost of providing services, plays an important role in promoting work flexibility. Uber[11], ride-sharing company, is good example. Empirical study proves that Uber drivers significantly benefit from work flexibility and earn more than twice before (Chen et al. 2017).

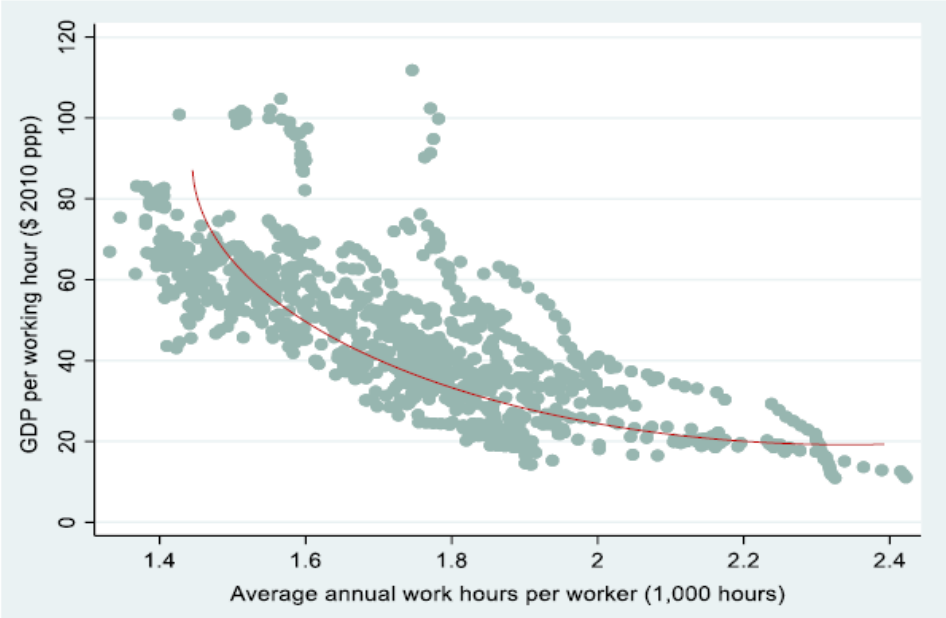
From now on, we will discuss about the links between working time and productivity. Productivity increase is an essential precondition for the success of work hour reduction policy. Without productivity rise, work hour reduction may be detrimental to firms as well as employees. In fact, studies prove that work hour reduction policy does not lead to boosting employment in many countries (Crepon et al. 2002; Hunt, 1999; Kim et al. 2012). In this vein, to achieve the policy goal of boosting employment, work hour reduction should be pushed ahead in a way that builds up productivity and competitiveness (Park et al. 2015). For this, unnecessary works and inefficient work practices must be eliminated and the existing workforce should be reallocated more efficiently to enhance competitiveness. Also wage should be determined by performance, not by input, to expand more efficient work practices. By eliminating inefficiencies under the long-hour working, the policy may improve firm's efficiency and productivity. In this vein, to improve productivity we propose two policy options: i) support accumulation of human capital especially skilled workers, ii) support technology progress by expanding R&D funds to core sectors such as ICT. For the former intervention, governments must cooperate with industries and academics to develop various vocational training courses or up-skilling programs to help workers' adaption to new technologies. R&D funds should be allocated with top priority into the core sectors that have powerful spillovers on the economy.

Also extensive tax deduction for corporate investments can help increase productivity of firms by reducing cost. In fact, the relationship between work hours and output performance has always been one of the major issues to firm owners and policy makers. A study on this link was done by Pencavel (2014). He analyzed observational data collected in a Britain factory during World War I.[12] Unexpectedly, he found that there exists non-linear link among labor supply and output. Below 49 work hour a week, there is positive link between work time and output, but when people work more than 50-hour, output rose at a decreasing rate (output per hour is decreasing). That is, marginal product of work hours is constant until 50 hours a week, but after that it declines.

[11] This is a ride-sharing platform, on which drivers can use their own cars to provide riding service to applicant customers. As requests arrive, the platform allocates the requests to nearest drivers. When the trip is completed, the riders pay rates. There are no minimum work hours for drivers but modest limits on maximum work hours.

[12] During the 1st World War, nationwide mobilization of labor was planned to maximize production. British government conducted a research to maximize output in munitions factory by establishing special committee (British health of Munitions Workers Committee) for data collection and investigating the links between work hour and work performance.

Figure 4: Working hours and productivity in advanced countries, 1990-2020



Source: data from OECD statistics

Thus, weekly work hour reduction from 55 to 50 would have a negligible effect on output. The point of this study is that work hour reduction does not always lead to higher output per hour. Hicks (1932) already reasoned this idea by arguing that output per hour will decrease with longer working hours (*Economist*, 2014).[13] As workers work longer and longer, they will lose energy and concentration, making them less productive. Figure 4 shows this idea at cross-country level, illustrating relationship between average annual working time and productivity among advanced economies during years of 1990-2020. The shorter work hour is, the higher productivity in OECD countries. Korea is located in lower right position, implying longer working hours and lower productivity. This suggests that Korea has large rooms to strengthen productivity in the process of reducing working hours. These days most countries stipulate standard 40-hour workweek in the law, and this has become global norms as noted. But labor environment including the optimal work hours is changing dramatically these days mainly due to fast technological progress. The concept of standard work hours has become obsolete in that 'gig economy' and part-time work has become popular these days. Some companies are in practice for four day workweek and new business models by using temporary workers is prospering especially among venture startups and platform companies. Businesses are fast moving online and traditional jobs are automated using new technologies and remote work is common. The catch here is that these revolutionary changes are driven by markets, not by government. As a result, the optimal work hours would be determined by market demands and thus government's role should also keep step with these trends.

[13] *The Economist*, Dec 9, 2014, "Working hours: proof that you would get a life"

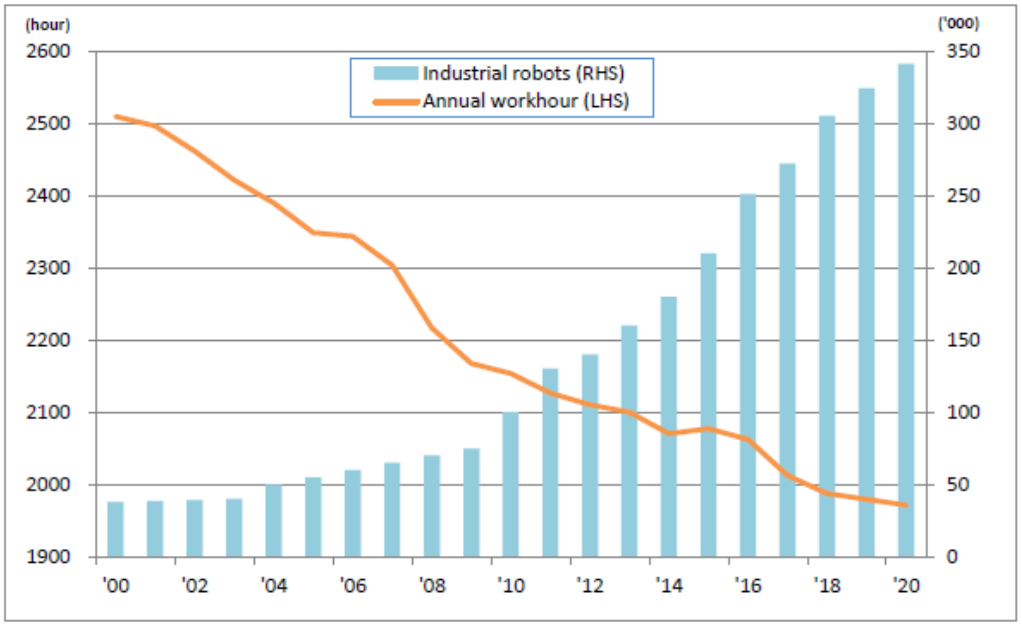
8. CONCLUSION

This essay analyzed an innovative labor policy that reduced standard work hours from 44 to 40 per week in Korea. I've conducted empirical analysis to explore causal impact of the policy on employee satisfaction. Korean government launched this policy in 2004 to increase worker's well-being and boost employment. This policy was adopted gradually in time order by industry and the size of establishments from 2004 through 2011. This step-by-step adoption provides us an ideal chance to explore the policy effect by using difference-in-difference (DID) method in a quasi-experimental setting. This policy aimed to improve employee's subjective well-being through ensuring work-life balance. Thus, this study tried to check causal effect of the policy on employee satisfaction. But my findings show trivial and relatively small effects on satisfaction. This result may come from several reasons including mismatch between actual and preferred work time among workers. Another reason is probably increased intensity of work after the adoption of the policy because the absolute amount of work was not changed (Rudolf, 2014).

Based on the above assumptions, I proposed some policy suggestions to elevate workers' subjective well-being in the perspective of work hour reduction policy. First, it is necessary to enhance workers' self-control over their work time to maximize well-being effect of the policy. Government needs to induce employers to expand flexible working plans such as time difference commuting, flexible work time, or home working to allow employees to have more discretion over their work hours in accordance with their own personal situations. The measures to improve work flexibility may lead to increased morale at workplace and loyalty to firms, which may also contribute to enhancing productivity and subjective well-being of workers. Second, together with standard work hour reduction, various policies to support labor productivity increase are essential. For these purposes, government should provide various vocational trainings or up-skilling programs to enhance workers' knowledge and skills. These re-education programs can enable workers to respond to new technologies and production skills. Moreover, inefficiencies and absurd practices under the longer working hours should be eliminated during the adoption process of work hour reduction to enhance productivity and competitiveness. Lastly, one of the current remarkable characteristics in the labor market is the destruction of traditional fixed work hours. The optimal work hours are driven by market demand and new business models of tech firms. As such, the role of government should be realigned to provide appropriate institutions to protect workers' basic rights and boost entrepreneur's innovation.

Appendix

Figure A1: Automation and work hours in Korea



Source: IFR for robots, OECD stats for work hour

Notes: Operational stock of industrial robots, Average annual hours actually worked per worker

Figure A2: Distribution of life and job satisfaction

A. Histogram of life satisfaction by year

B. Histogram of job satisfaction by year

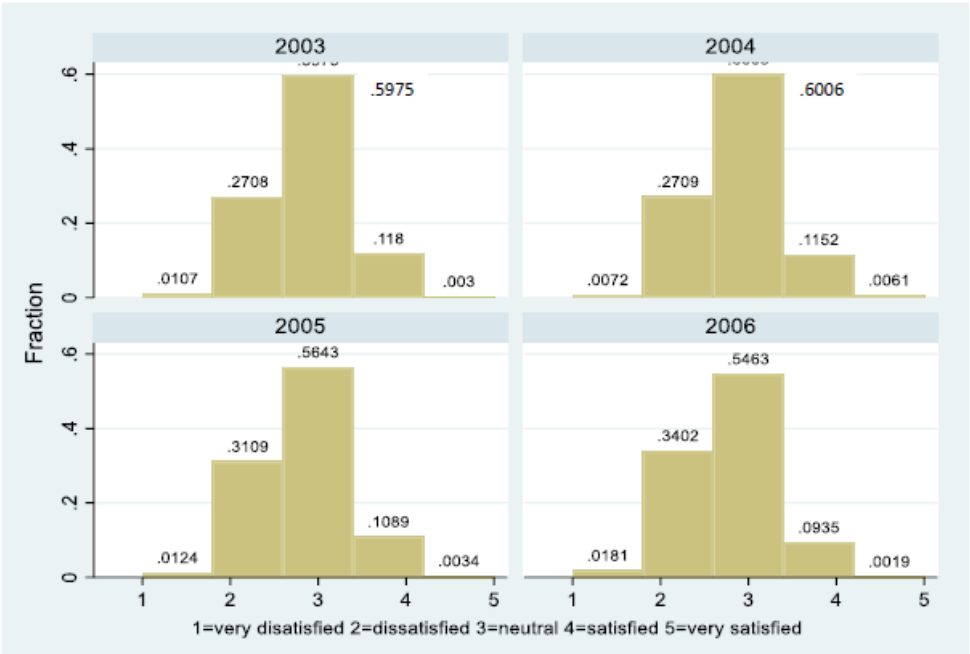


Figure A3: Illustration of empirical design

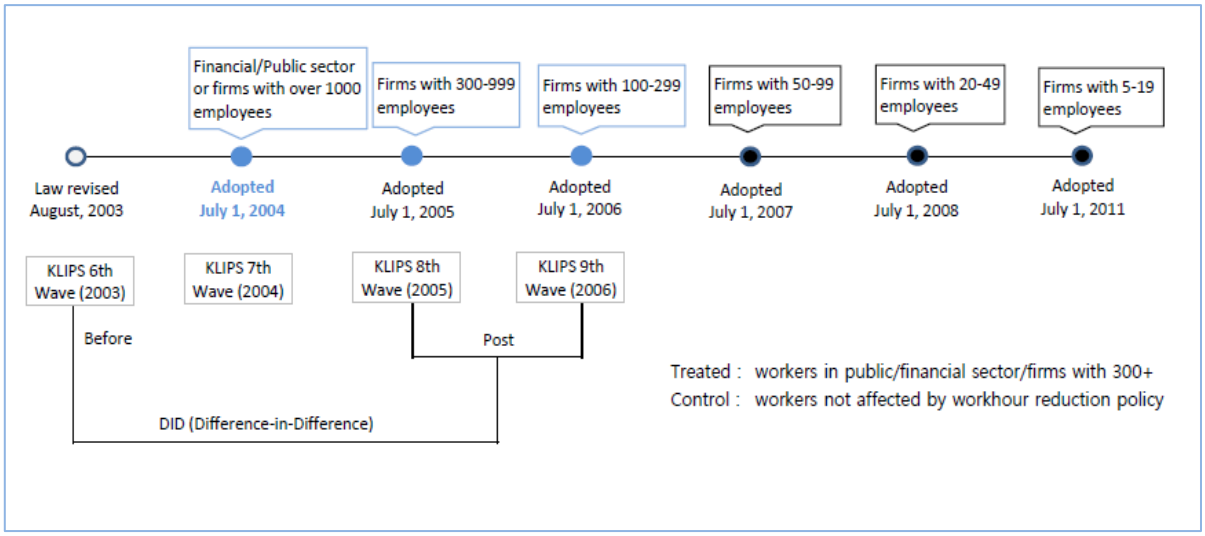


Table A1: Balance test for covariates

(baseline = 2003)

Variables	Mean Control	Mean Treated	Diff.	| t |	Pr(T>t)
Gender (Male==1)	0.653	0.662	-0.009	0.162	0.357
Age	40.683	40.564	0.119	0.351	0.818
Monthly income (log)	5.032	6.125	-1.093	2.571	0.003**
Marriage status (Not married==1)	0.227	0.214	0.013	0.338	0.943
Education level (below highschool==1)	0.246	0.225	0.021	0.583	0.697
Place of residence (Seoul==1)	0.235	0.253	-0.018	0.446	0.894

Notes: Difference = Mean (not affected) - Mean (affected). *** p<0.01, ** p<0.05, * p<0.10

Table A2: Effects of the policy on life satisfaction (Ordered Logit Model)

Variables	Life satisfaction				
	Overall	leisure activity	family relation	family income	social friendship
	(1)	(2)	(3)	(4)	(5)
Treated	0.471***	0.406***	0.476***	0.341**	0.496***
	(0.125)	(0.112)	(0.120)	(0.126)	(0.118)
Post	-0.108	0.108	0.143	-0.318***	-0.161
	(0.085)	(0.073)	(0.083)	(0.081)	(0.083)
Treated*Post	-0.006	0.198*	0.080	0.322*	-0.095
	(0.130)	(0.102)	(0.128)	(0.125)	(0.123)
Age	-0.019***	-0.016**	-0.028***	-0.007	-0.021***
	(0.004)	(0.004)	(0.004)	(0.005)	(0.004)
Married (=1)	-0.437***	0.367***	-0.839***	0.208	-0.505***
	(0.108)	(0.098)	(0.111)	(0.114)	(0.103)
Edu (above college=1)	0.808***	0.628***	0.438***	0.653***	0.530***
	(0.099)	(0.087)	(0.095)	(0.099)	(0.090)
Residence (Seoul=1)	-0.517***	-0.685***	-0.546***	-0.807***	-0.203**
	(0.078)	(0.070)	(0.079)	(0.083)	(0.075)
Year FE	Yes	Yes	Yes	Yes	Yes
Individual FE	Yes	Yes	Yes	Yes	Yes
Observations	7,515	7,510	7,510	7,511	7,509

Notes: Ordered Logit models. Standard errors (clustered in individual level) in parentheses. ****p<0.01, **p<0.05, *p<0.10.* Dependent variables are life satisfaction sub-factors including leisure, family relation, family income, and social friendship. They are ordinal variables ranging from 1 to 5, showing that 1 is most dissatisfied and 5 is most satisfied score. The survey question for life satisfaction is as follows; "Are you satisfied or dissatisfied for your life?" The answers are among 5 choices ranging from 1 (most satisfied) to 5 (most dissatisfied). For convenience we recode the scale for 5 showing most satisfied and 1 is most dissatisfied. The controls include age, marriage, education and place of residence.

Table A3: Effects of the policy on job satisfaction (Ordered Logit Models)

Variables	Job satisfaction				Work hours
	Overall	work hour	wage	welfare	(weekly)
	(1)	(2)	(3)	(4)	(5)
Treated	-0.775***	-0.987***	-0.423***	-0.833***	-0.770***
	(0.124)	(0.118)	(0.118)	(0.116)	(0.121)
Post	0.277***	-0.140*	0.162*	0.272***	-0.273***
	(0.082)	(0.071)	(0.076)	(0.074)	(0.074)
Treated*Post	-0.250*	-0.027	-0.127	-0.345**	-0.400***
	(0.126)	(0.117)	(0.118)	(0.117)	(0.106)
Age	-0.001	-0.005	0.007	0.000	0.003
	(0.004)	(0.004)	(0.004)	(0.004)	(0.006)
Married	-0.125	-0.139	-0.084	-0.145	-0.025
	(0.110)	(0.106)	(0.108)	(0.103)	(0.128)
Edu (above college)	-0.761***	-0.769***	-0.830***	-0.503***	-0.879***
	(0.101)	(0.096)	(0.098)	(0.093)	(0.108)
Residence (Seoul)	0.380***	0.617***	0.150*	0.497***	-0.088
	(0.078)	(0.076)	(0.073)	(0.072)	(0.100)
Year FE	Yes	Yes	Yes	Yes	Yes
Individual FE	Yes	Yes	Yes	Yes	Yes
Observations	7,478	7,509	7,508	7,466	6,681

Notes: Ordered logit models. Robust standard errors in parentheses. ****p<0.01, **p<0.05, *p<0.10.* Dependent variables are job satisfaction and actual work hours per week. They are ordinal variables ranging from 1 to 5, showing that 1 is most dissatisfied and 5 is most satisfied score. Actual work hours refer to actual average work hours per week including regular and overtime work. The survey question for job satisfaction is as follows; "Are you satisfied or dissatisfied for your job?" The answers are among 5 choices ranging from 1 (most satisfied) to 5 (most dissatisfied). For convenience of analysis we recoded the scale for 5 showing most satisfied and 1 is most dissatisfied. The control variables include age, marital status, education level and place of residence.

Table A4: Impacts of the policy on job satisfaction by gender (OLS)

Variables	Male			Female		
	Job_overall	Job_workhour	Job_welafre	Job_overall	Job_workhour	Job_welafare
	(1)	(2)	(3)	(4)	(5)	
Treated	-0.079	-0.174*	0.000	0.001	-0.108	0.086
	(0.066)	(0.083)	(0.084)	(0.094)	(0.112)	(0.103)
Post	0.104**	-0.008	0.093*	0.145***	0.036	-0.020
	(0.032)	(0.039)	(0.039)	(0.041)	(0.048)	(0.051)
Treated*Post	-0.064*	-0.040	-0.138**	-0.072	0.056	-0.047
	(0.031)	(0.047)	(0.046)	(0.052)	(0.061)	(0.068)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Individual FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	4,786	4,805	4,778	2,692	2,704	2,688
R-squared	0.121	0.112	0.107	0.135	0.101	0.122

Notes: Panel fixed effect regression (OLS). Standard errors (clustered in individual level) in parentheses. ****p<0.01, **p<0.05, *p<0.10.* Dependent variables are job satisfaction sub-factors including overall, work hours, and welfare. They are continous variables ranging from 1 to 5, showing that 1 is most dissatisfied and 5 is most satisfied score. The survey question for life satisfaction is as follows; "Are you satisfied or dissatisfied for your job?" The answers are 5 choices ranging from 1 (most satisfied) to 5 (most dissatisfied). For convenience we recode the scale for 5 showing most satisfied and 1 is most dissatisfied. The controls include age, marrital status, education level and place of residence.

Table A5: Effect of the policy on life/job satisfaction by industry

(Life satisfaction)

Dependent : Life satisfaction	Service			Manufacturing		
	overall	leisure activities	family income	overall	leisure activities	family income
	(1)	(2)	(3)	(4)	(5)	
Treated	0.073	0.071	0.042	0.051	-0.027	-0.067
	(0.065)	(0.089)	(0.071)	(0.071)	(0.100)	(0.089)
Post	0.067	0.073	0.089**	-0.073	-0.049	-0.056
	(0.035)	(0.039)	(0.042)	(0.043)	(0.053)	(0.047)
Treated*Post	0.021	0.083*	0.086**	0.020	0.017	0.037
	(0.035)	(0.041)	(0.039)	(0.051)	(0.068)	(0.054)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Individual FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	4,210	4,205	4,206	3,305	3,205	3,205
R-squared	0.022	0.118	0.106	0.102	0.114	0.104

Notes: Panel fixed effect (OLS). Standard errors (clustered in individual level) in parentheses. ****p<0.01, **p<0.05, *p<0.10. Service sector includes public entities.* Dependents are life satisfaction sub-factors including overall, leisure activities, and family income. They are ordinal variables ranging from 1 to 5, showing that 1 is most dissatisfied and 5 is most satisfied. The survey question for life satisfaction is as follows; "Are you satisfied or dissatisfied for your life?" The answers are 5 choices ranging from 1 (most satisfied) to 5 (most dissatisfied). For convenience we recode the scale for 5 showing most satisfied and 1 is most dissatisfied. The controls include age, marrital status, education level and place of residence.

(Job satisfaction)

Variables	Service			Manufacturing		
	Job_overall	Job_workhour	Job_welafre	Job_overall	Job_workhour	Job_welafare
	(1)	(2)	(3)	(4)	(5)	
Treated	-0.065	-0.064	0.011	0.003	-0.109	0.076
	(0.067)	(0.063)	(0.085)	(0.092)	(0.114)	(0.112)
Post	0.103*	-0.005	0.091*	0.115*	0.031	-0.021
	(0.052)	(0.031)	(0.045)	(0.053)	(0.043)	(0.050)
Treated*Post	-0.061*	-0.043	-0.122**	-0.071	0.051	-0.048
	(0.030)	(0.045)	(0.045)	(0.055)	(0.065)	(0.066)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Individual FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	4,210	4,205	4,206	3,305	3,205	3,205
R-squared	0.125	0.102	0.115	0.124	0.113	0.104

Notes: Panel fixed effect regression (OLS). Standard errors (clustered in individual level) in parentheses. Service sector includes public sector. ****p<0.01, **p<0.05, *p<0.10.* Dependent variables are job satisfaction sub-factors including overall, work hours, and welfare. They are continous variables ranging from 1 to 5, showing that 1 is most dissatisfied and 5 is most satisfied score. The survey question for job satisfaction is as follows; "Are you satisfied or dissatisfied for your job?" The answers are 5 choices ranging from 1 (most satisfied) to 5 (most dissatisfied). For convenience we recode the scale for 5 showing most satisfied and 1 is most dissatisfied. The controls include age, marrital status, education level and place of residence.

Table A6: Robustness checks / Effects of the policy on job satisfaction (binary)

Variables	Job satisfaction_binary outcome			
	Overall	work hour	wage	welfare
	(1)	(2)	(3)	(4)
	Panel A: Linear Probability Models			
Treated	-0.023	-0.079	-0.008	0.019
	(0.042)	(0.043)	(0.042)	(0.037)
Post	0.053**	0.004	0.060***	0.046**
	(0.018)	(0.019)	(0.017)	(0.015)
Treated*Post	-0.047*	-0.003	-0.030	-0.056**
	(0.022)	(0.024)	(0.023)	(0.021)
	Panel B: Logit regressions			
Treated	-0.117***	-0.187**	-0.075***	-0.118***
	(0.019)	(0.020)	(0.018)	(0.017)
Post	0.028	-0.020	0.029	0.011
	(0.015)	(0.015)	(0.014)	(0.015)
Treated*Post	-0.041*	0.001	-0.022	-0.038*
	(0.020)	(0.021)	(0.019)	(0.018)
Controls	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Individual FE	Yes	Yes	Yes	Yes
Observations	7,551	7,551	7,551	7,551

Notes: Panel A reports linear probability model estimates and Panel B logit regression estimates (Panel B is transformed to marginal effect coefficients). Standard errors in parentheses. ****p<0.01, **p<0.05, *p<0.10.* Dependent variables are binary outcomes that equal one for satisfaction categories '3', '4' and '5', and zero for satisfaction categories '1' and '2'. The control variables include age, marital status, education level and place of residence.

References

Abendroth AK, Den Dulk L, "Support for Work-Life Balance in Europe: the Impact of State, Workplace and Family Support on Life Satisfaction" *Work, Employment, and Society*, 2011

Acemoglu, D. and Restrepo, P., "Low-skill and High-skill Automation," NBER Working Paper Series No. 24119, December 2017

Angrave, D. and Charlwood, A., "What Is Relationship Between Long Work Hours, Over-Employment, Under-Employment and SWB of Workers in UK? *Human Relations*, 2015

Ahn, T. H., "Reduction of Working Time: Does It Lead to a Happy Lifestyle?" *Health Economics*, May 2015

Angrist, Joshua D. and Jorn-Steffen Pischke, *Mostly Harmless Econometrics: An Empiricist's Companion*, Princeton University Press, 2009

Artazcoz, L., Cascant, L., Villegas, R., "Understanding the Relationship of Long Working Hours with Health Status and Health-related Behaviors," *Epidemiol Community Health*, 2009

Bell, L. A., Freeman, R. B, "The Incentive for Working Hard: Explaining Hours Worked Differences in the US and Germany" *Labor Economics* 8(2), 181-202, 2001

Burtle, J., "Automation, the Guaranteed Wage and Hours of Work," HeinOnline, International Laboratory Rev. 495, 1957

Chemin, M., Wasmer, E., "Using Alsace-Moselle Laws to Build DID Estimation Strategy of Employment Effect of 35-hour Workweek in France," *Journal of Labor Economics*, 2009

Clark A., "What Makes a Good Job? Evidence from OECD Countries" *Job Quality and Employer Behavior*, pp. 11-30, 2005

Clark A., Georgellis Y., "Back to the Baseline in Britain: Adaptation in the British Household Panel Survey," *Economica* 80(319): 496-521, 2013

Crepon, B., Kramarz, F., "Employed 40 Hours or Not Employed 39: Lessons from the 1982 Mandatory Reduction of the Workweek," *Journal of Political Economy* 110(6), 2002

Crepon, B., Leclair, M., Roux, S., "The Shorter Working Week, Productivity and Employment: New Estimates Based on Business Data," *Economy and Statistique*, 2005

Fagnani, J., Letablier, M. T., "Work and Family Life Balance: The Impact of the 35-Hour Laws in France," *Work, Employment and Society*, 18(3), 551-572, 2004

Ford M. T., Heinen B. A., Langkamer K. L., "Work and Family Satisfaction and Conflicts: A Meta-Analysis of Cross-Domain Relations," *Journal of Applied Psychology* 92(1), 2007

Frei I., Grund C., "Working-time Mismatch and Job Satisfaction of Junior Academics" *Journal of Business Economics*, 2022

Gash V., Mertens A., Romeu Gordo L., "Women between Par-time and Full-time Work: The Influence of Changing Work Hours on Happiness and Life-Satisfaction, SOEP 268, 2010

Hicks, John R., *Theory of Wages*, 1st edition, London, Macmillan & Co. 1932

Holly S., Mohnen A., "Impact of Working Hours on Work-Life Balance" SOEP Papers No. 471, DIW Berlin, 2012

Huberman, M., "Working Hours of the World Unite? New International Evidence of Work Time," *Journal of Economic History* 64, 964-1001, 2004

Hunt, Jennifer, "Has Work-Sharing Worked in Germany?" *Quarterly Journal of Economics* 114(1) pp. 117-148, 1999

Kahn S., Lang K., "Hours Constraints and the Wage/Hours Locus" *Canadian Journal of Economics*, 29, pp. 71-75, 1996

Kawaguchi D., Naito H., Yokoyama I., "Labor Market Responses to Legal Work Hour Reduction: Evidence from Japan," ESRI Discussion Paper Series No. 202, 2008

Kelly EL, Moen P, Oakes JM, Fan W et al. "Changing Work and Work-Family Conflicts: Evidence from Work, Family, and Health Network" *American Sociology Review*, 2014

Kim, H. R., Lee, J., "The Impact of the 40-Hour Workweek Standard on Actual Working Hours, Wages, and Employment," *Korea Journal of Labor Economics*, 35(3), 2012 (Korean)

Klein, F., Drews, S., Savin, I., Bergh, J., "How Work Patterns Affect Leisure Activities and Energy Consumption: A Time-Use Analysis for Finland and France," *Energy Research*, 2021

Lee J. M., Kawaguchi D., Hamermesh D. S., "Aggregate Impacts of a Gift of Time," *American Economic Review* 102(3) pp.612-616, 2012

Lewis S., "Family-Friendly Employment Policies: Route to Changing Organizational Culture or Playing About at the Margins?" *Gender, Work, and Organizations* 4(1):13-23, 1997

Skuterud, M., "Identifying the Potential of Work-Sharing as a Job Creation Strategy," *Journal of Labor Economics*, 25(2), 265-287, 2007

OECD (Organization for Economic Cooperation and Development), OECD Better Life Index, Available at: http://www.oecdbetterlifeindex.org/. 2013

Oh, S., Park, Y., Bowles, S., "Veblen Effects, Political representation, and the Reduction in Working Time Over the 20th Century," *Journal Economic Behavior and Organization*, 2012

Otterbach S., "Mismatch Between Actual and Preferred Work Time: Empirical Evidence of Hours Constraints in 21 Countries" *Journal of Consumer Policy* 33(2), 143-161, 2010

Park, C., "A Study of the Non-Market Effects of Five-Day Workweek," *Korea Journal of Labor Economics*, 37(4), pp. 59-88, 2014 (Korean)

Park, W. R., Park Y. S., “Effect of Working Time on Labor Productivity: Evidence from Korean Manufacturing Sector,” KDI Policy Research Series, 2015

Pencavel, J. H., “The Productivity of Working Hours,” IZA Discussion Papers No. 8129, Institute of the Study of Labor, 2014

Raposo, P. S., van Ours J. C., “How Working Time Reduction Affects Jobs and Wages,” Economics Letters 106(1): 61-63, 2010

Reynolds, J., “When Too Much Is Not Enough: Actual and Preferred Work Hours in the US and Abroad” *Sociological Forum* 19(1), 89-120, 2004

Rudolf, R., “Work Shorter, Be Happier? Longitudinal Evidence from the Korean Five-Day Working Policy,” *Journal of Happiness Studies* 15(5), pp. 1139-1163, 2014

Skuterud, M., “Identifying the Potential of Work-Sharing As a Job Creation Strategy,” *Journal of Labor Economics* 25(2): 265-287, 2007

Sparks K., Cooper C., Fried Y., Shirom A., “Effects of Hours of Work on Health: A Meta-Analytic Review,” *Journal of Occupational and Organizational Psychology* 70(4), 1997

Stewart M. B., Swaffield J. K., “Constraints on the Desired Hours of Work of British Men.” Economic Journal, 107(441), pp. 520-535, 1997

The Economist, “Working Hours: Proof That You Should Get a Life,” December 9, 2014

Virtanen M., Stansfeld, S., Fuhrer R., Kivimaki M., “Overtime Work as a Predictor or Major Depressive Episode: A 5-Year Follow-up of the Whitehall II Study,” *PLoS One*, 2012

Visser F., Williams L., *Work-Life Balance, Rhetoric versus Reality?: An Independent Report Commissioned by UNISON*, London: The Foundation, 1-60, 2006

Wilkinson C., Tomlinson J., Gardiner J., “Exploring Work-Life Challenges and Dilemmas Faced by Managers and Professionals Who Live Alone,” *Work, Employment, Society*, 2017

Wooden M., Drago R., “The Changing Distribution of Working Hours in Australia,” Melbourne Institute Working Paper No. 19/7, 2007

Wooden M., Warren D., Drago R., “Working Time Mismatch and Subjective Well-Being,” *British Journal of Industrial Relations* 47(1): 147-179, 2009

Wunder C., Heineck G., “Working Time Preferences, Hours Mismatch and Well-Being of Couples: Are There Spillovers?” *Labor Economics* 24© : 244-252, 2013

Zelenski, J. M., Murphy, S. A., Jenkins, D. A., “The happy-Productive Worker Thesis Revisited,” *Journal of Happiness Studies*, 9, 521-537, 2008