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Income inequality and Life expectancy: a panel data analysis on 13 OECD countries

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Abstract

Income inequality has been rising in the last two decades in most OECD countries, which might lead to various undesirable social and health consequences. Existing literature has examined the cross-sectional association between income inequality and life expectancy in the last century and significant negative relationship has found in most studies. Build on their approach, this study selected panel datasets from 13 OECD countries, investigate the association between income inequality and life expectancy in this century. All variables included shows time trend in some panels, therefore, the first difference of variables are taken to transform into stationary process. The relationship between them are interpreted as changes on changes. Both pooled cross-sectional and fixed effect regression reports strong evidence that short-run changes of income inequality does not significantly affect changes of life expectancy on average. Alternative specifications and measurements confirm the same result. However, the long-run relationship between inequality and life expectancy needs to be further investigated.

Table of Content

Introduction

Since the industrial revolution, the globally economy has been growing prosperously, due to drastic technological improvement and social changes, such as increase in population and the phenomenon of urbanization. As one of the common measurements of economic development, from 1960 until now globally real GDP increased by 7 times, from 11.434 Trillion to 80.25 Trillion. Undoubtedly, high economic growth benefits human being in various aspects, especially providing us with better living standard, more advanced public services, and rising employment rates. However, several studies also document that high economic growth widen the gap between the rich and poor, leading to more inequality of income, health and education. For example, a famous study by Kuznets (1955) concludes that as a country undergoing industrialization, the inequality gap between rural and urban area will first increases significantly due to the better-paying jobs in the cities. However, above a certain threshold, the inequality gap is expected to drop. He believes there is a U-shaped relationship between economic growth and income inequality. Indeed, the income inequality in developed countries is generally lower in developing countries. With rapid economic growth benefiting millions of poor people in China and India, the income inequality gap have even risen further. This has been a common phenomenon in emerging economies.[1]

A worldwide concern is high income inequality might lead to numerous social and health problems, even the instability of societies. For instance, one of major movements in the 21 centuries, the Arab Spring, is influenced by profound social inequalities in Middle Eastern countries (Ansani & Daniele, 2012). Besides, Alesina, Di Tellab & MacCulloch (2003) found individuals have lower tendency to report themselves happy with higher income inequality, controlling for individual characteristics, years and countries. Moreover, Kawachi & Kennedy (1999) investigate the relationship and mechanisms between societies' income distribution and individual's health status. They confirm the prediction that individual's health status is better

[1] http://www.oecd.org/social/inequality.htm

with more equal distribution of income. Furthermore, the effect of income inequality could be explained by the investment of social goods, disruption of social cohesion, and psychosocial effects of social comparison. Based on previous studies, I am interested in the effect of social income inequality on average life expectancy of OECD countries. As worse social conditions and citizen's overall health status is predicted by higher inequality of income distribution, does average life expectancy decreases correspondingly? Therefore, the central research question of this paper is:

To what extent does income inequality affect average life expectancy in one country?

The research question of this paper is closely concerned with government redistribution policies. The income inequality has increased since two decades ago in most OECD countries. The reason for this increase could be explained by unequally distributed market income, as well as fallen redistribution through taxes and transfers.[2] The major motivation for policy-induced reduction of redistribution for developing economies is to raise employment and economic efficiency by working incentives. However, if the rising income inequality leads to consequences of health such as decreasing life expectancy, government redistribution policies have to take this effect into account.

Besides, governments worldwide has been spending a large amount of resources on healthcare systems and technology, and one of the aims is to increase life expectancy. However, if the significant effect of income inequality on life expectancy is found, governments are provided with other efficient policies to rise life expectancy, such as policies to reduce absolute poverty by rising minimum wages and more progressive tax for the top wealthy.

Furthermore, life expectancy is chosen as an indicator for health status for several reasons. life expectancy is a utilized measurement across all socio-economic groups and readily comparable across countries. Small increase in life expectancy could lead to significant social challenges,

[2]https://oecdecoscope.blog/2019/02/14/income-redistribution-across-oecd-countries-main-findings-and-policy-implications/

such as fast rising population, aging population and pressure on health insurance. As an example, Acemoglu & Johnson (2007) instrumented changes in life expectancy and found a 1% increase in life expectancy leads to an increase in population of about 1.5%. Hence, investigating social factors associated with life expectancy is of great importance.

The rest of this paper is organized as follows. Existing literature on this topic is first examined. Following existing ideas, I select the panel datasets from OECD official website of 13 representative countries. As the data of Gini index is limited in many countries, those 13 countries are the most available publicly. The conceptualization and summary statistics of all variables will be discussed in Data. In Methodology, both pooled cross-sectional regression and fixed effect regression models will be performed including other potential time-varying confounders. Next, Main result will be presented and other alternative function forms and measurements of variables will be considered in Robustness Check. In the end, the summary of main findings, its limitations and policy implications will be discussed in Conclusion.

Existing literature

Income inequality has been rising since two decades ago, several research has been done to investigate the relationship between income inequality and life expectancy. In 1992, a famous study from the BMI produced strong and negative association between a society's income distribution and population life expectancy. Internationally comparable data on the distribution of income is very scare at that time, therefore this study only focus on nine western industrialized countries. Furthermore, this study proposed four possibilities that lead to the strong and negative relationship. The first explanation is country with more egalitarian income are likely to have better public services which benefits health. Secondly, ethnic minority communities may have poor health and widen the income gap due to low employment rate and discrimination. Based on empirical evidence, those two mechanism alone does not account for the strong correlation between income inequality and life expectancy. The third possibility is reverse causality, if sickness could lead to poor health and therefore widen the income distribution. The last

possibility is mortality rate is directly affected by income distribution, which is consistent with the curvilinear relationship between income and mortality found in Britain and Japan . It suggests that those four possible mechanisms might coexist and contribute to the strong negative relationship (Wilkinson, 1992).

However, a few years later, a critical appraisal published by BMI casts doubt on Wilkinson's finding that income inequality is strongly associated with average life expectancy among richest nations. This study first revised the dataset used by Wilkinson, as Wilkinson's study used family income data which are unadjusted for differences between family sizes between countries, creating potential bias of true individual income inequality. Moreover, it criticises that Wilkinson's significant result appears to be the consequence inappropriate measurement poverty estimate for Portugal and matching income inequality and life expectancy data for different years (Judge, 1995). This starts the debate whether there exists a negative influence on citizen's life expectancy from inequality of income distribution.

In 21st century, there are more studies concerning inequality and life expectancy with increasing availability of datasets and alternative measurements. It is found in Brazil, one of the developing countries, income disparities were negatively associated with life expectancy, based on cross-sectional dataset of 27 Brazilian states. However, by including illiteracy rates into multiple regression model, the effect of income inequality then is removed. Therefore, the study suggests education level is part of the pathway for the negative association. (Messias, 2003). In addition, Rasella, Aquino, & Barreto (2013) replicated this result by using panel dataset of 27 Brazilian states in the time period of 2000-2009. They also found significant negative relationship between income inequality and life expectancy even after adjusting all the socioeconomic and health-related covariates. It further concludes that social policies aiming at reducing absolute poverty and income inequality contributes to decreasing death rates in the population. In a high unequal developing country- Brazil, the pattern of negative association between income inequality and life expectancy is confirmed by both cross-sectional and panel studies. Besides, a cross-sectional analysis in Italy, which has a moderately high degree of income inequality

compared with other wealthy countries, found that income inequality had a strong negative correlation with life expectancy. Pearson correlation coefficients were calculated to study these relations and multivariate linear regression was used to measure the association, while controlling for both income per capita and education attainment. Furthermore, this study found income inequality has an independent and more powerful effect on life expectancy than per capita income education attainment, which suggests that psychosocial mechanisms such as social stress other than material deprivation is important at work. The significant result hence suggests government should focus more on policies minising income inequality, other than economic development and education attainment to improve population health (Vogli, 2005).

Based on comprehensive panel datasets of 43 European countries, Hu, Lenthe, & Mackenbach (2015) used both fixed effects and pooled cross-sectional models to investigate the relationship between income inequality and life expectancy between 1987 to 2008. The difference between cross-sectional and fixed effects model is that fixed effects model account for country-level time-invariant confonders. The strong negative relationship between income inequality and life expectancy is found in cross-sectional model and disappeared in the fixed effects model. They further investigate the association between income inequality and causal-specific mortality rates and obtain a similar result. Therefore, they suspect the previous found negative relationship in cross-sectional studies is due to the confounding effect of country-level cultural, historical, and social characteristics that remains unchanged over time. In conclusion, income inequality is not the main driver of reduced life expectancy and population health in a European context.

Existing literature seems to provide contradicting results, depending on background countries and regions. The true relationship between income inequality and life expectancy is still open up to debate. Especially among countries low to high level degrees of inequality distribution, income inequality is reported to have discrepant effect on life expectancy, implying there might exist a "threshold" effect. Building on Hu, Lenthe, & Mackenbach (2015)'s approach, this paper also use fixed effect model as the main Econometrics methodology and compares with pooled cross-sectional regression. To my best knowledge, this paper is the first to examine the

association between income inequality and life expectancy in both developed and developing countries from 21st century.

Data

In total, four potential time-varying omitted variables are included. Specifically, they are GDP per capita, education attainment, and health spending per capita, pharmacy spending per capita. The relationship between GDP per capita and income inequality is discussed in the Introduction, as there is a U-shaped curve between two variables. On the other hand, Preston curve indicates life expectancy rises with national income with diminishing returns. It further suggests that even 75 to 90 percent of growth in life expectancy during the 20th century for the whole world is attributed to other factors exogenous to a nation's increasing income, the cross-sectional relationship between income and life expectancy remains strong (Preston, 2007). Education attainment is another factor that both correlates with income inequality and life expectancy. Build on large set of panel data, Gregorio and Lee (2002) found that educational factors- higher education attainment and more equal distribution in education play a significant role in eliminating unequal distribution of income. Education is also found to significantly affect subjective life expectancy. One year of additional education increases the predicted subjective life expectancy by approximately 0.7 years (Mirowsky & Ross, 2000). A large proportion of health and pharmacy spending are both extracted from government tax revenue. Most of the developed economies have progressive tax system, aiming for a more equal income distribution. Therefore, health and pharmacy spending is expected to has an indirect influence income distribution though tax systems. Furthermore, studies found lower national healthcare spending is associated with a significant decrease in life expectancy in Canada (Crémieux, Ouellette, & Pilon, 1999). Indeed, by higher health and pharmacy spending, it is expected to advance the health technology and recruit professional medical staff, translating into significantly increase in average life expectancy.

All variables are conceptualized as follows. Income inequality is measured by Gini coefficient, as the most commonly used measurement of inequality. Gini coefficient is based on the comparison of cumulative proportions of population against cumulative proportions of income, ranging from 0 to 1. When the income is equally distributed among all citizens, the Gini coefficient is 0, which expressing perfect equality. On the contrary, maximum inequality is represented when Gini coefficient is 1. Other alternative measurements of income inequality, such as Interdecile P90/P10 ratio, S80/S20 quintile share ratio and Palma ratio, are also considered in Robustness Check. Life expectancy is measured as the average number of years that a person at birth can be expected to live in one certain country, assuming the current death rate does not change. The national income is conceptualized as real GDP per capita in constant 2010 US dollar, calculated as gross domestic product divided by midyear population. Education attainment is defined as the proportion of 25- 64 years-old population who completed tertiary education. Tertiary education is defined as types of education beyond high school level. Education attainment is conceptualized into tertiary education as post-secondary education plays distinguishable role for choosing healthier life choices, such as smoking behaviour and weekly exercise[3]. Furthermore, health spending is measured by the total consumption of health care goods and services, including personal health care and collective services. Pharmaceutical spending measures expenditure on medicines and self-medication annually. Both health spending and pharmaceutical spending are measured in US dollar and divided by the total population into spending per capita.

The dataset of real GDP per capita is extracted from World Bank website while all other dataset are from official OECD website. Due to the dataset limitation of Gini coefficient and life expectancy, the timespan is limited to 2004 to 2015 and 13 OECD countries are included. Those 13 countries are Belgium, Canada, Czech Republic, Finland, Greece, Iceland, Ireland, Italy, Latvia, Lithuania, Poland, Slovenia, and the UK.

[3] http://www.goodchoicesgoodlife.org/choices-for-young-people/the-benefits-of-higher-education/

The summary statistics of main variables are presented below and the summary statistics of time-varying omitted variables can be found in Appendix. Every variable is summarized by country, and its mean, standard deviation, minimum and maximum value are reported.

	Mean	Standard deviation	Min	Max
Belgium	80.092	0.654	79.000	81.100
Canada	80.933	0.722	79.800	81.900
Czech Republic	77.508	0.982	75.800	78.900
Finland	80.225	0.852	79.000	81.600
Greece	80.467	0.689	79.400	81.500
Iceland	81.983	0.619	81.100	83.000
Ireland	80.292	0.951	78.600	81.500
Italy	81.942	0.730	80.900	83.200
Latvia	72.583	1.568	70.600	74.600
Lithuania	72.858	1.383	70.900	74.700
Poland	76.233	0.987	74.900	77.700
Slovenia	79.350	1.318	77.200	81.200
United Kingdom	80.309	0.829	79.000	81.400

Table 1 Summary statistics of variable "life_expectancy"

From the summary statistics table, the country with the highest average life expectancy over years is Italy, in which a new-born can be expected to live approximately 82 years old. Following Italy, Iceland is ranked second country with the longest life expectancy. Comparatively, Eastern European countries generally have lower life expectancy on average, with Latvia being the lowest among 13 countries.

Graph 1 (Appendix) shows the trend of life expectancy for each country. In general, life expectancy has been increasing though time with some short-term fluctuation, except in Lithuania. There was a drop in life expectancy in Lithuania from 2004 to 2007, at which it

achieved the lowest point 70.9. However, after 2007, life expectancy has been continuously rising. Furthermore, the total increase years of life expectancy of each country are computed. Life expectancy in Slovenia increased by 3.700 years, which is the highest among all. The lowest increase is in Iceland, by only 1.400.

	Mean	Standard deviation	Min	Max
Belgium	0.271	0.007	0.265	0.287
Canada	0.316	0.002	0.313	0.321
Czech Republic	0.259	0.004	0.253	0.268
Finland	0.263	0.004	0.257	0.269
Greece	0.336	0.005	0.328	0.345
Iceland	0.265	0.020	0.241	0.305
Ireland	0.308	0.010	0.295	0.324
Italy	0.324	0.006	0.313	0.333
Latvia	0.358	0.014	0.346	0.392
Lithuania	0.350	0.018	0.322	0.381
Poland	0.311	0.023	0.292	0.376
Slovenia	0.244	0.006	0.234	0.254
United Kingdom	0.360	0.008	0.351	0.374

Table 2 Summary statistics of variable "gini"

From the summary statistics table of Gini coefficient, the United Kingdom has the highest value of Gini coefficient on average, representing it as the country with the most inequality of income distribution. Following the United Kingdom, Latvia ranked the second country in terms of high income inequality, with Gini coefficient 0.358. The country with the lowest average income inequality is Slovenia and its Gini coefficient is 0.116 lower than the United Kingdom. Though the whole timespan, the highest Gini coefficient is achieved by Latvia in 2005. The lowest Gini coefficient is achieved by Slovenia in 2008.

Unlike the variable “life_expectancy”, the most countries Gini coefficient shows no trend, but fluctuation around its mean over the years. (Appendix Graph 2). Indeed, existing theories regarding the causes of income inequality mainly tracks to the demand shifts of high-skilled workers and globalization , which are all long-term market structure changes(Dabla-Norris et al., 2015). The only exception is Poland, which Gini coefficient shows a decreasing trend from 0.376 to 0.292, also with the highest standard deviation.

The summary statistics and trends of four time-varying variables reports the information of their distribution. Ireland has the highest real GDP per capita on average, followed by Iceland. Latvia is the less wealthy country, in terms of real GDP capita. In general, western European countries has higher real GDP per capita on average than eastern and central European countries. (Appendix table1). Furthermore, expect for Poland whose real GDP per capita has been growing continuously, most countries’ real GDP per capita has been fluctuated around its mean (Appendix Graph 3). The average education attainment of percentage is highly unequal among countries, Czech Republic’s education attainment is ranked the first, more than doubled the lowest country-Ireland. Moreover, education attainment in post-communist countries are generally much higher (Appendix Table 2). This phenomena can be explained by fundamentally different education system that was redesigned during the communism eras, during which education was considered as collective goods to benefit society, especially the women tertiary education rate has been rising dramatically. The high education attainment rate sustained after the collapse of socialist regimes (Terama, Kõu, & Samir, 2014).

The descriptive statistics of variable “health spending” reports that Ireland has the top health spending per capita, followed by Canada. Latvia is the country last ranked, with only 1072.667 US dollars spending per capita on average (Appendix Table 3). Health spending shows a rising trend in most countries, except in Greece, in which health spending dropped from 2008(Graph 4). Lastly, Canada is the top-ranked country in terms of average pharmacy spending per capita and the country with the lowest average pharmacy spending is Latvia (Appendix Table 4). Pharmacy spending also shows an increasing trend in most countries, other than Greece

(Appendix Graph 5). The drop in health and pharmacy spending in Greece could be explained by 2008 global financial crisis, during which Greece was affected more than any other European countries. The economic burden of Greece government leads to insufficient support the public health sector and the hospital budgets are significantly disturbed. (Ifanti, Argyriou, Kalofonou, & Kalofonos, 2013).

Unfortunately, due to the limitation of official dataset, some data of controlled variables are omitted. The education attainment rate of Lithuania is unavailable. The pharmacy spending of Greece in 2008 and United Kingdom from 2004 to 2012 is unmeasured as well. The unavailability of these data is one of this paper's limitations.

Methodology

In Data, some variables such as life expectancy show time trends. Therefore, in the first step the stationarity of variables are tested. A series of data is said to be stationary when it has constant mean, variance and covariance. Testing for stationary is essential as non-stationary series can lead to many undesirable consequences, such as spurious regression. Spurious regression leads bias of the t-ratio statistics as well, which requires further transformation into stationary variables.

Specifically, three types of panel data unit root tests are performed - Levin–Lin–Chu test (LLC), Harris–Tzavalis test (HT) and Hadri Lagrange multiplier test (HLM), which are most commonly used tests for stationarity of balanced panel dataset. The null hypothesis of LLC and HT test is all panels contain a unit root while rejection implies some panel is stationary. On the contrary, the null hypothesis of LLM test is all panels are stationary and rejection implies some panels contain a unit root. Especially considering the relatively small sample size, three tests altogether increase the power of obtained results.

Corresponding to most previous studies using cross-section data, I explore pooled cross-section regression between income inequality and life expectancy. To account time-trend, I include year

dummies, and time-varying control variables are added subsequently. Robust standard error is to allow heteroscedasticity. Besides, to solve non-stationarity, all variables are taken the first difference to transform into stationary variables.

Mathematically, the pooled cross-sectional regression model can be written as:

$$\Delta Lifeexpectancy_{ij} = \alpha + \beta\ \Delta Gini_{ij} + T_j + \gamma C_{ij} + \varepsilon_{ij}$$

In this model, $\Delta Lifeexpectancy_{ij}$ is the change of life expectancy at birth for country i in year j from year j-1. α is the constant term. $Gini_{ij}$ is the change of Gini coefficient for country i in year j from j-1. T_j is a vector of year dummies to account for the time trend. C_{ij} is a vector of potential time-varying omitted variables, education attainment, health spending and pharmacy spending per capita, added into model subsequently. ε_{ij} represents robust standard error.

In the next step, I apply fixed effect model with four control time-varying variables discussed in Data. I include country and year fixed effect to allow different specific-means in each country and year. Fixed effect automatically controls for time-invariant omitted variables, including country-specifically social, culture, geographical, politically differences that remains constant over time. Clustered standard error in the country level is used to allow error terms to be correlated in a certain country.

Mathematically, the fixed effect regression model can be written as:

$$\Delta Lifeexpectancy_{ij} = \alpha + \beta\ \Delta Gini_{ij} + T_j + X_i + \gamma C_{ij} + \varepsilon_{ij}$$

X_i is a vector of country fixed effect and ε_{ij} is clustered standard error at the country-level.

By performing both models, the existing result based on cross-section data can be first tested. Moreover, if both models reporting significant result, a strong evidence of association between Gini index and life expectancy is confirmed. However, if the significant effect disappeared in

fixed effect model, the negative association found in previous cross-section studies can be contributed to the country-level confounders effect.

All regression analyses are performed in Stata 15.1 and statistical significance is at 5%.

Result

1.Stationarity

The result of stationary tests are reported in Table 4. The rejection of Levin–Lin–Chu (LLC) and Harris–Tzavalis(HT) indicates stationarity of some panels while rejection of Hadri Lagrange multiplier(HLM) test indicates some panels contains a unit root.

The rejection of three tests indicate there should be some panels but not all containing a unit root process. Therefore, both life expectancy and Gini coefficient is taken its first difference.

Variables	LLC	HT	HLM
life expectancy	-2.357***	-3.323***	3.257***
gini	-5.745***	-3.354***	8.778***

Table 4 Result of stationary tests

After transforming life expectancy and gini index, the same procedure is employed to test the stationarity of their first difference. For both variables, LLC and HT provides significant result, implying stationary process. The non-rejection of HLM test confirms the same conclusion. Therefore, by taking first differences, both life expectancy and Gini coefficient are transformed into stationary variables and the result in regression model is interpreted as short-run changes.

Variables	LLC	HT	HLM
D1. life expectancy	-2.897***	-6.892***	0.736

D1.gini	-7.841***	-6.523***	0.719

Table 5 Result of stationary tests of first difference variables

2. Regression Model

Table 5 reports the statistic results of both pooled cross-section and fixed effects regression models, including year dummies. For the purpose of concision, all yearly dummies are omitted in the table. They are all insignificantly different from 0, suggesting there is no overall time trends of life expectancy.

Both models report very similar result. In the short run, the change of income inequality represented by gini index have no significant association with the change of life expectancy. Besides, all other variables also does not show any significant effect.

Therefore, I found strong evidence that one of the most important indicators of citizens' health status does not affected all socio-economics factors in models.

	Model 1	Model 2
	Δ*Life expectancy*	Δ*Life expectancy*
Δ*gini*	2.718 (2.679)	3.540 (2.978)
Δ*gdp*	0.000 (0.000)	0.000 (0.633)
Δ*educationattainment*	-1.335 (3.740)	2.928 (0.425)
Δ*healthspending*	0.000 (0.000)	0.000 (0.500)

Δ*pharmacyspending*	0.000 (0.001)	0.000 (0.912)
constant	0.220*** (0.084)	0.240 *** (0.008)

Table 3 Result of pooled cross-section and fixed effect models

*p<.100. **p<.050 ***p<.010

Note: Model 1 reports the result from pooled cross-section regression. Model 2 reports the result from fixed effect regression.

The coefficients of yearly dummies are not presented for concision.

3. Robustness Check

In order to provide further support to the main findings, I alter the function form specification of fixed regression model and switch into alternative measurements of variables.

In the first model, the four time-varying potential confounders are excluded from the fixed effect regression model but year dummies are included. In the second model, the year dummies are removed to allow no time trend in a certain country, but time-varying confounders are included. Model 3 excludes both time-varying confounders and year dummies. Model 4 reports the result by using default standard error. In all four models, income inequality conceptualized by Gini coefficient does not significantly affect life expectancy, which confirms the main result of this paper (Table 5 Appendix).

Moreover, to allow the short-term lagged effect, the lagged terms of first difference Gini coefficients and GDP per capital are added into models. Due to the timespan of the dataset is rather limited (only 12 years for each panel), I only include one lagged terms of first difference of Gini coefficient in order not to lose too many observations. Model 5 adds lagged terms of Gini coefficients, without lagged terms of GDP per capita. Taking into account that the economic growth might also have a lagged effect on life expectancy, in Model 6, one lagged term of Gini

coefficient and GDP per capita are included. In both models, income inequality and its lagged terms are insignificant, therefore the main result remains unchanged (Table 6 Appendix).

Furthermore, the alternative measurements of variables are checked. Other than Gini coefficient, other common measurements of income inequality are Interdecile P90/P10 ratio, S80/S20 quintile share ratio and Palma ratio. All three alternative measurements are transformed into stationary variables by taking the first difference. In model 8, income inequality is conceptualized as Interdecile P90/P10 ratio, based on the upper bound value of the ninth decile disposal income (i.e. the 10% of people with highest income) to that of the first decile, implying the income inequality between top and bottom. In model 9, S80/S20 quintile share ratio is chosen as another alternative measurement of income. S80/20 ratio represents the average disposable income of the top 20% richest to 20% poorest households. Furthermore, Palma ratio is the share of top 10% highest disposable income divided by the share of income received by 40% poorest. Model 10 reports the result based on Palma ratio. All three models reports that the first difference of income inequality has no significant effect on that of life expectancy, confirming the main result of this paper (Table 7 Appendix).

In conclusion, the main result of this paper -In the short run, changes of income inequality has no significant effect on changes in life expectancy is a robust phenomenon to alternative regression specifications and measurements.

Conclusion

1.Summary of the study

Build on various existing literature of different social background documents that income inequality has a negative effect on social and health development, this paper further investigated the causal relationship between income inequality and life expectancy in 13 OECD countries, from 2004 to 2015. Most studies based on cross-sectional dataset found significant negative relationship between income inequality and life expectancy. However, potential omitted

variables at the region or country level cannot be ruled out. Therefore, this paper examine the association between variables using both pooled cross-section regression and fixed effect regression models. Four time-varying potential confounders - GDP per capita, education attainment, and health spending per capita, pharmacy spending per capita are added subsequently in both models. Due to the time trend in many panels of variables, first of all I test the stationarity of both life expectancy and gini coefficient by three panel data stationarity tests - Levin–Lin–Chu test (LLC), Harris–Tzavalis test (HT) and Hadri Lagrange multiplier test (HLM). Both variables test statistic can be rejected at 5%, which implies there should be some panels are stationary but not all. Non-stationarity could lead to many undesirable consequences, such as spurious regression which provides misleading statistical inference. Therefore, both variables are transformed into stationary variables by taking the first difference and the relationship is interpreted as changes of income inequality on changes of life expectancy. Furthermore, both pooled cross-sectional regression and fixed effect regression reported insignificant association. By changing the function form and measurements of inequality, still I found insignificant relationship between short-run changes of income inequality and life expectancy.

2. Policy Implications

Insignificant relationship between income inequality and life expectancy provides many policy implications. The fall in government transfers, which is considered as one of the policy drivers for increasing income inequality of OECD countries in the last two decades, does not significantly affect citizen's health status in perspective of life longevity, though the mechanism of more unequal income distribution. Besides, economic growth, reducing income inequality and spending in health and pharmacy are all insignificant factors to increasing life expectancy. It seems that in the short run life expectancy of a constant characteristics hard to be affected by economic policies. Nevertheless, the bright side of this insignificant relationship shows the

short-run economic fluctuation such as financial crisis would not harm citizens' life longevity on average.

3. Limitations and Further Suggestions

Certainly there are some limitations of this study. One of the major limitations is the shortage of dataset from official website. The unavailability of Gini coefficient even in this century of many OECD countries limit this study to relatively small numbers of observations. Whether the main result can applies to all OECD countries is a question remained for further studies with more comprehensive datasets. Moreover, as discussed in Data, some data of time-varying variables are not reported in official website, which might lead to bias of coefficient. In Robustness Check, even without controlling four potential time-varying confounders, the insignificant relationship between income inequality and life expectancy remains unchanged. Therefore, it is unlikely the omission of few time-varying confounders leading to the bias of main result.

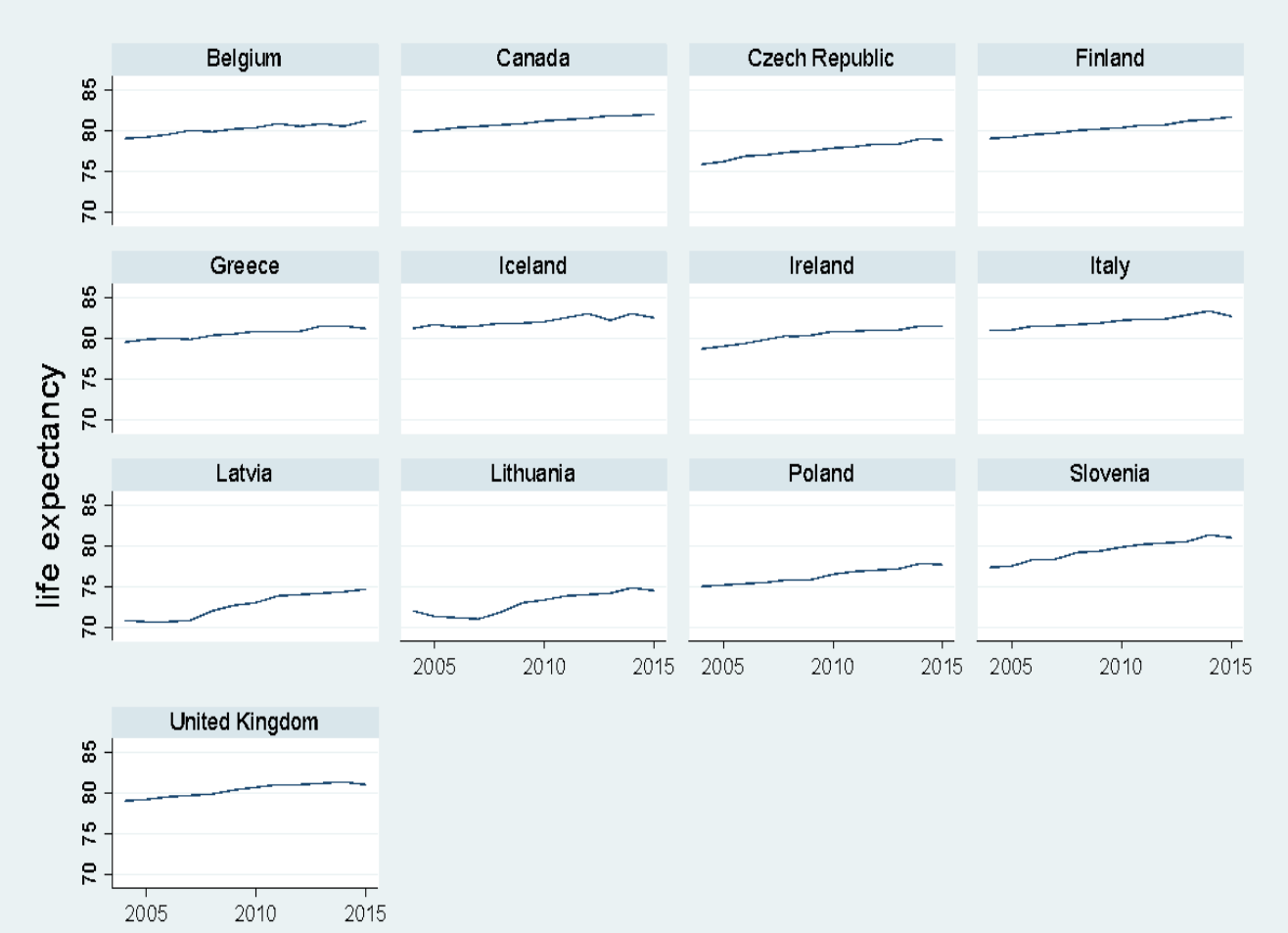
Another major limitation of this study is the simultaneous bias issue. In this setting, if a country's life expectancy also affect its income distribution, the main result could be bias. This possibility cannot be excluded since country with high life expectancy in need of more income taxes and transfers to support its welfare system, hence affect its income distribution. The causal mechanism between income inequality and life expectancy cannot be investigated by regression model. I can only draw the conclusion that income inequality does not have granger causal effect on life expectancy based on models with insignificant lagged term in Robustness Check. Further studies are suggested to investigate the causal mechanism between income inequality and life expectancy by more advanced Econometrics methodology.

Furthermore, this result of study can at most apply to country with relatively low income inequality and high or moderate economic development, as this is the main feature of selected 13 countries. Selected countries are all with high Human Development Index and well-developed welfare systems. There might exist a "threshold effect", above which the income inequality start to negative impact citizen's health status and life expectancy. Hence, policy makers of other less

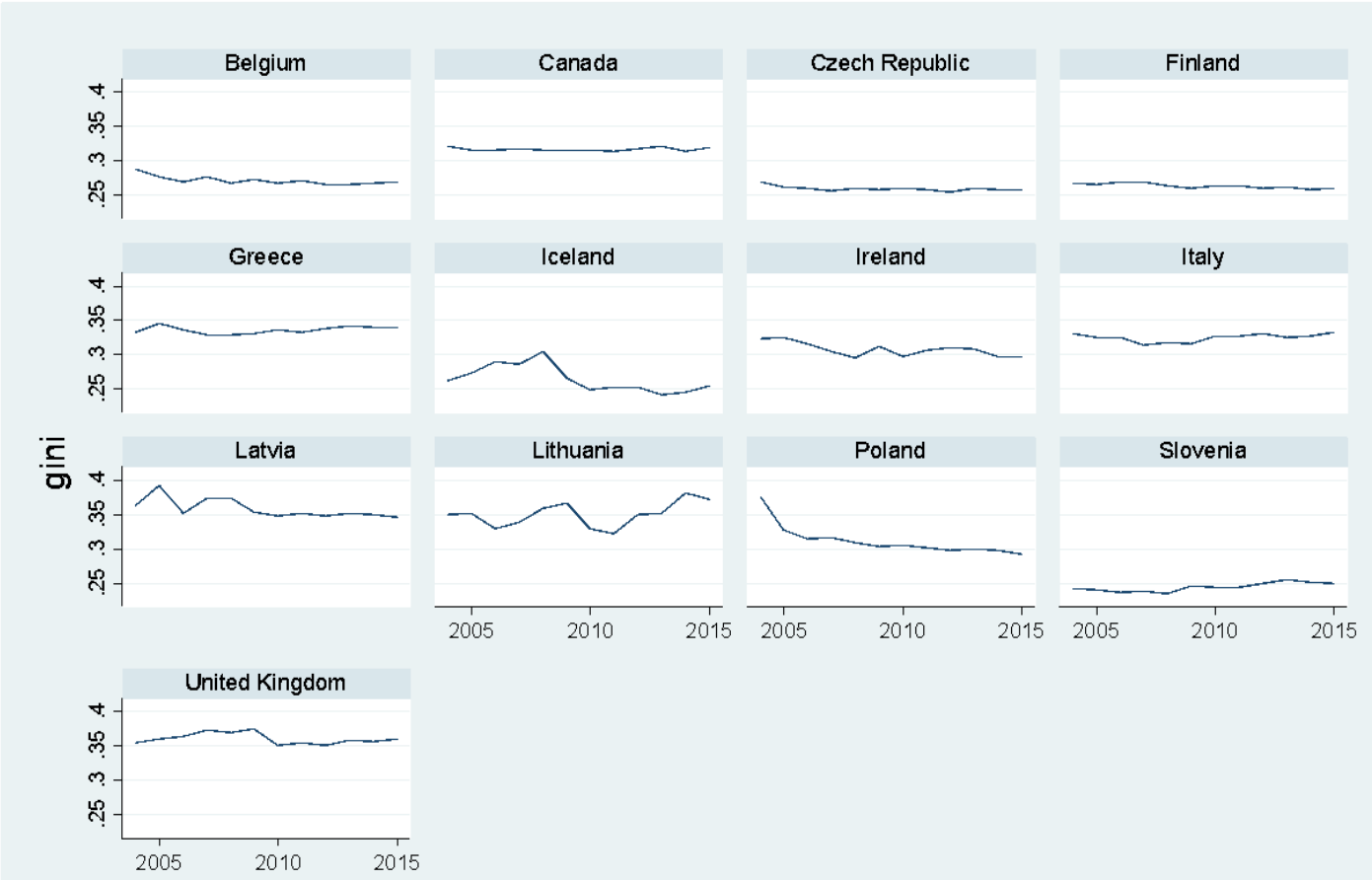
developed countries with more extreme income inequality should not simple apply this study's result.

Other than the suggestion to improve this paper's limitation, further studies could focus on the association between income inequality and other health problems related to life expectancy, such as smoking behaviour and alcohol consumption. This study only shows income inequality does not significantly affect life expectancy. However, if other general health problems are caused by income inequality, the overall citizen's quality of life quality might be reduced.

Appendix



Graph 1 Time trend of variable "life_expectancy" in 13 countries

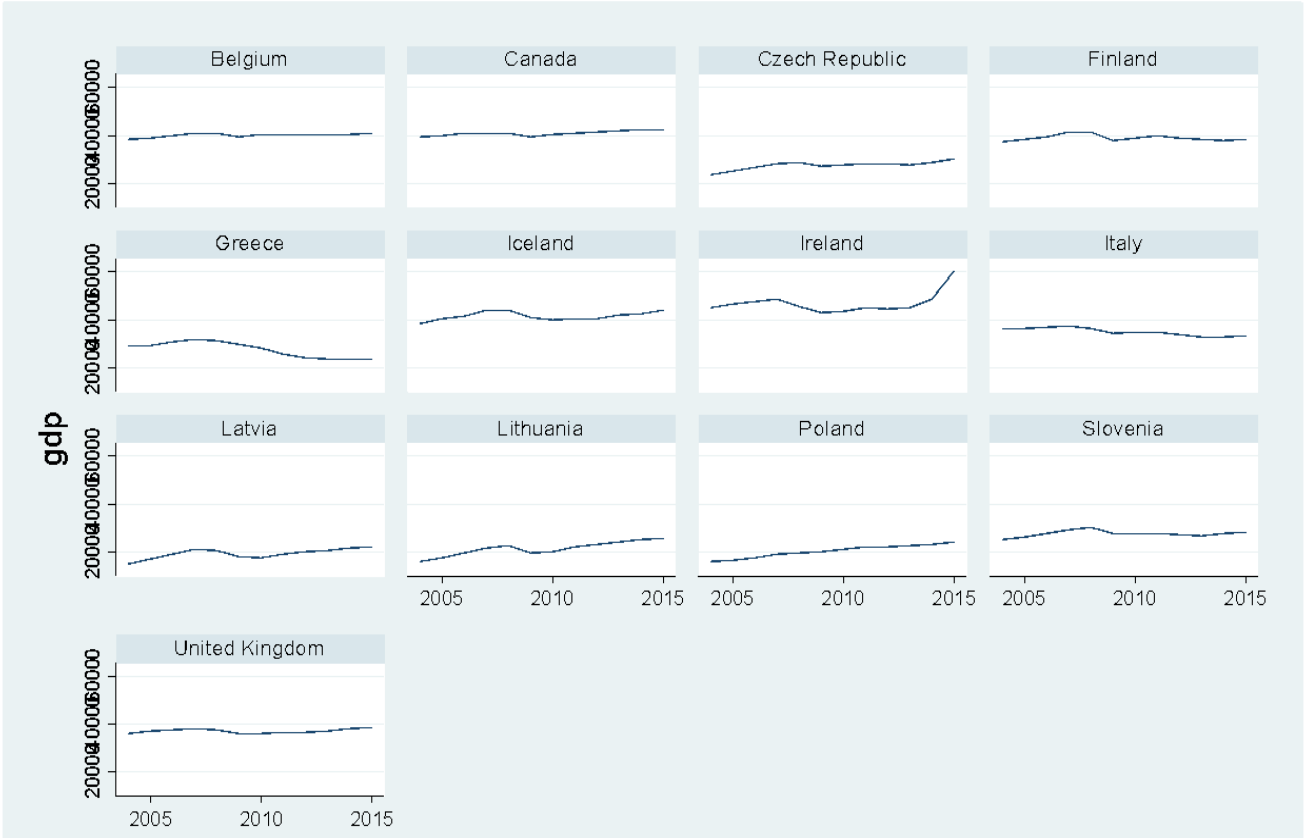


Graph 2 Time trend of variable "gini" in 13 countries

	Mean	Standard deviation	Min	Max
Belgium	39925.810	802.294	38215.500	40890.500
Canada	40804.130	1060.107	39074.530	42405.880
Czech Republic	27381.880	1647.069	23624.920	29874.270
Finland	38862.260	1343.553	37123.600	41387.920
Greece	27416.000	3203.681	23268.500	31428.760
Iceland	41361.320	1799.776	38282.010	44025.380
Ireland	46808.630	4626.436	42672.330	60263.860

Italy	34904.650	1587.432	32827.090	37117.720
Latvia	19280.780	2104.397	15064.840	22146.740
Lithuania	21348.880	2936.378	16133.130	25784.380
Poland	20315.440	2618.143	16055.820	24169.460
Slovenia	27532.760	1307.700	25109.560	30119.970
United Kingdom	36953.110	916.634	35694.180	38490.790

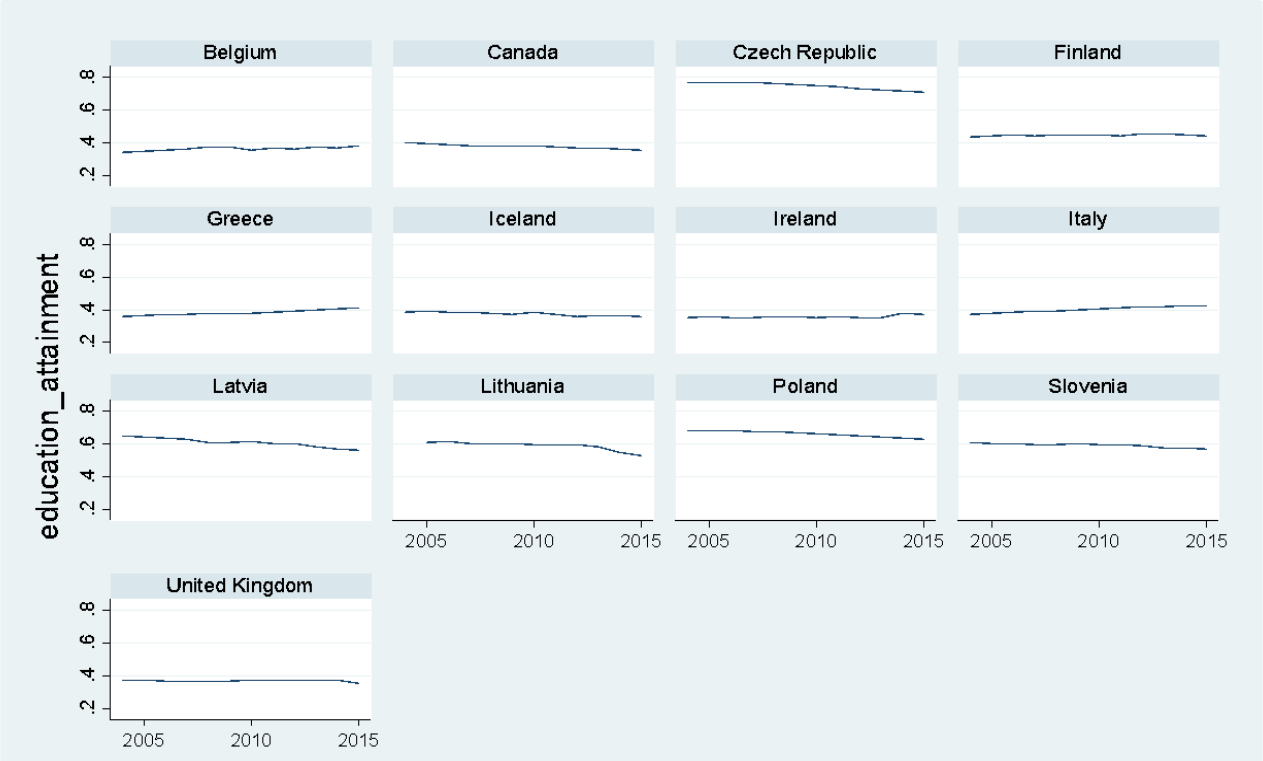
Table 1 Summary statistics of variable "gdp" in 13 countries



Graph 3 Time trend of variable "gdp" in 13 countries

	Mean	Standard deviation	Min	Max
Belgium	0.362	0.011	0.339	0.378
Canada	0.377	0.013	0.352	0.398
Czech Republic	0.747	0.022	0.710	0.769
Finland	0.445	0.005	0.434	0.454
Greece	0.381	0.017	0.354	0.412
Iceland	0.373	0.011	0.358	0.387
Ireland	0.356	0.009	0.349	0.379
Italy	0.400	0.018	0.370	0.424
Latvia	0.608	0.027	0.562	0.645
Lithuania	0.588	0.028	0.526	0.616
Poland	0.662	0.018	0.630	0.682
Slovenia	0.591	0.013	0.566	0.606
United Kingdom	0.368	0.005	0.354	0.374

Table 2 Summary statistics of variable "education_attainment" in 13 countries

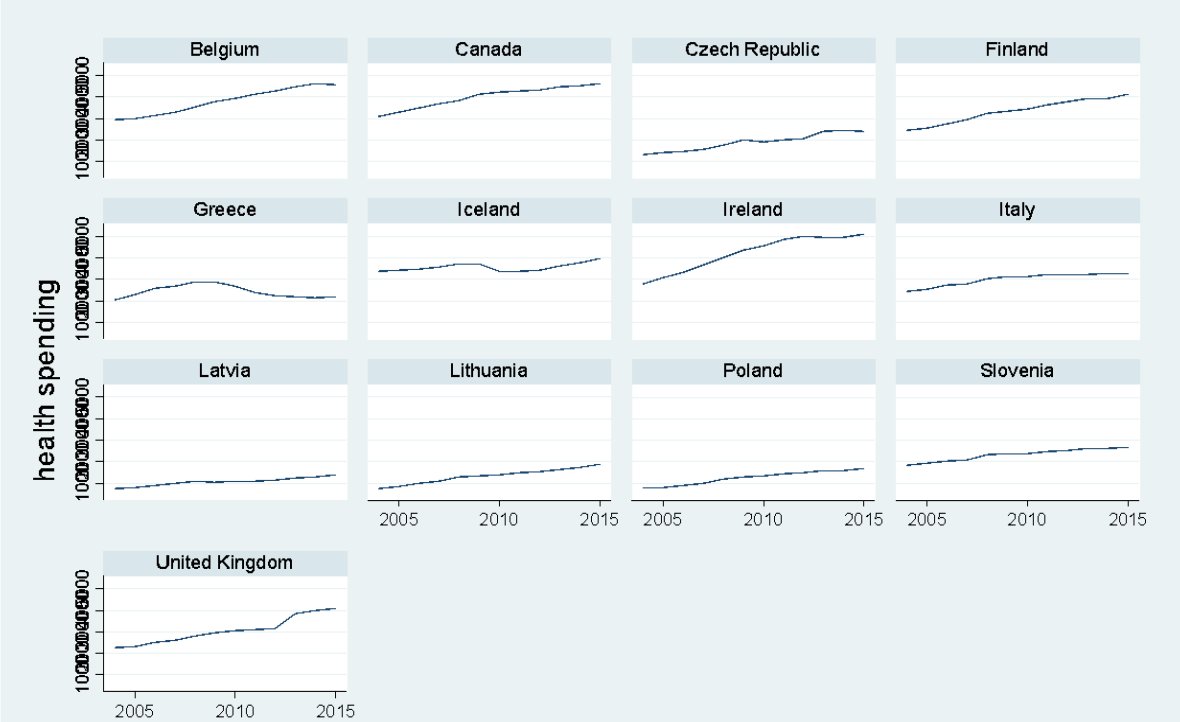


Graph 4 Time trend of variable "education_attainment" in 13 countries

	Mean	Standard deviation	Min	Max
Belgium	3808.500	627.115	2920.000	4612.000
Canada	3989.250	513.423	3076.000	4633.000
Czech Republic	1897.417	395.926	1329.000	2469.000
Finland	3339.667	564.790	2425.000	4099.000
Greece	2428.000	297.579	2018.000	2895.000
Iceland	3564.583	196.670	3364.000	3964.000
Ireland	4219.417	821.262	2795.000	5106.000
Italy	2994.667	307.488	2412.000	3292.000
Latvia	1072.667	188.118	761.000	1400.000

Lithuania	1324.250	363.105	718.000	1864.000
Poland	1250.500	322.214	783.000	1687.000
Slovenia	2314.667	297.719	1806.000	2675.000
United Kingdom	3049.250	619.224	2237.000	4072.000

Table 3 Summary statistics of variable "healthspending" in 13 countries

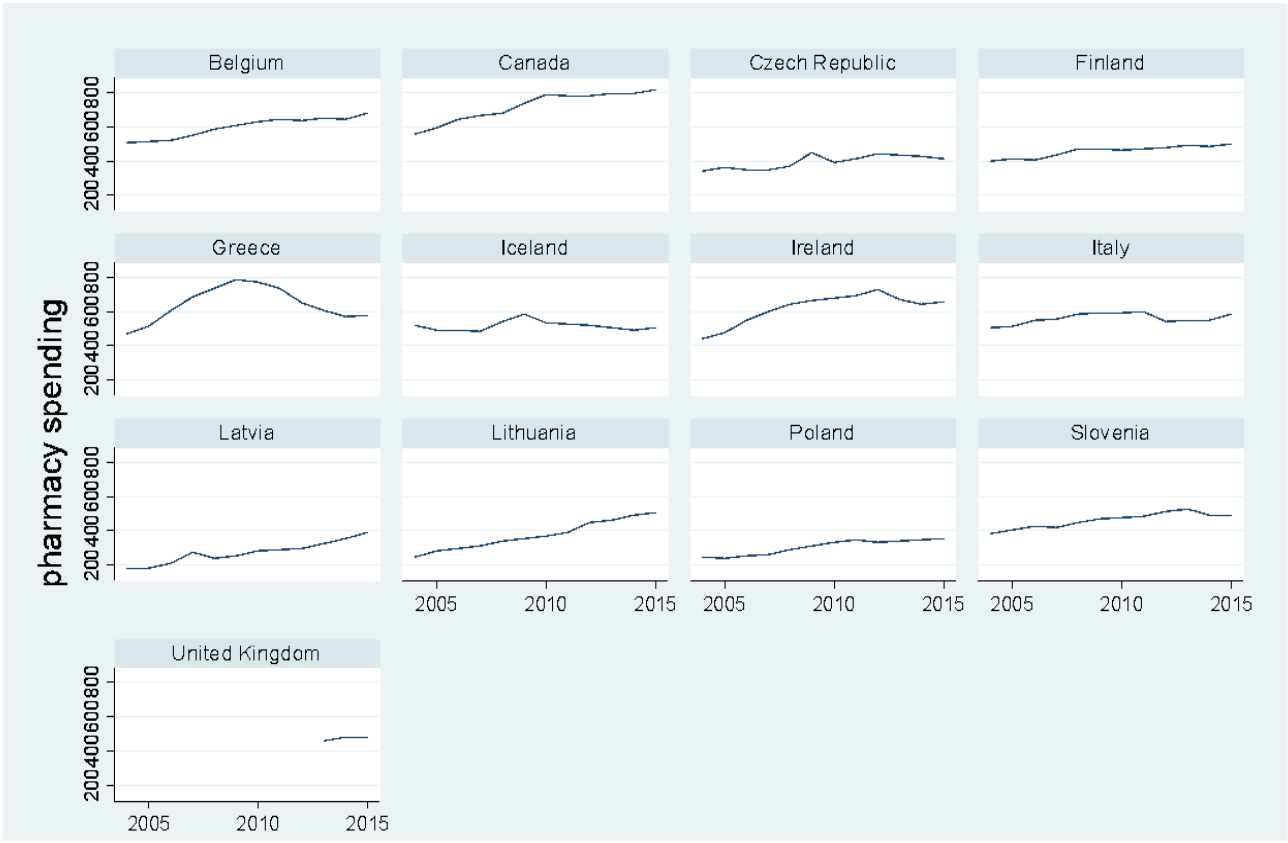


Graph 4 Time trend of variable "healthspending" in 13 countries

	Mean	Standard deviation	Min	Max
Belgium	594.242	59.166	502.200	676.100
Canada	715.408	87.377	553.500	811.900
Czech Republic	393.800	38.932	341.100	445.500
Finland	455.575	35.482	393.400	496.800

Greece	631.291	102.452	465.000	781.100
Iceland	514.625	28.544	479.800	582.000
Ireland	618.767	88.274	437.500	729.100
Italy	558.233	29.920	506.400	595.500
Latvia	271.458	63.769	180.200	387.000
Lithuania	373.517	84.500	243.400	500.900
Poland	303.125	43.530	240.200	353.700
Slovenia	458.758	44.063	383.500	526.500
United Kingdom	472.967	10.267	461.200	480.100

Table 4 Summary statistics of variable "pharmacyspending" in 13 countries



Graph 5 Time trend of variable "pharmacyspending" in 13 countries

	Model 1	Model 2	Model 3	Model4
	Δ*Life expectancy*	Δ*Life expectancy*	Δ*Life expectancy*	Δ*Life expectancy*
Δ*gini*	3.104 (2.224)	2.431 (3.111)	1.669 (2.372)	3.539 (2.550)
Δ*gdp*		0.000 (0.000)		0.000 (0.000)
Δ*educationattainment*		4.705 (3.435)		2.928 (4.457)
Δ*healthspending*		0.000 (0.000)		0.000 (0.000)
Δ*pharmacyspending*		0.000 (0.001)		0.000 (0.001)
constant	0.128 (0.096)	0.259*** (0.031)	0.226*** (0.002)	0.240 *** (0.103)

Table 5 Robustness check 1

- *p<.100. **p<.050 ***p<.010
- Note : Model 1 reports the result of fixed effect model excluding time-varying confounders.
- Model 2 reports the result of fixed effect model excluding year dummies
- Model 3 reports the result of fixed effect model excluding both time-varying confounders and year dummies
- Model 4 reports the result of fixed effect model by default standard error

	Model 5	Model 6
	$\Delta Life$ *expectancy*	$\Delta Life$ *expectancy*
$\Delta gini$	4.413	6.371
	(3.805)	(3.966)
L1. $\Delta gini$	3.699 *	2.912
	(1.956)	(1.984)
Δgdp	0.000	0.000
	(0.000)	(0.000)
*L*1.Δgdp		0.000
		(0.000)
Δ*educationattainment*	6.719*	4.171
	(3.441)	(3.943)
Δ*healthspending*	0.000	0.000
	(0.000)	(0.000)
Δ*pharmacyspending*	0.000	0.000
	(0.001)	(0.001)
constant	0.389***	0.396***
	(0.123)	(0.127)

Table 6 Robustness check 2

- *p<.100. **p<.050 ***p<.010
- Model 5 reports the result from fixed effect model adding two lagged terms of gini coefficient
- Model 6 reports the result from fixed effect model adding two lagged terms of gini coefficient and gdp

	Model 7	Model 8	Model 9

	Δ*Life expectancy*	Δ*Life expectancy*	Δ*Life expectancy*
Δ*Interdecile* 90/10	0.062 (0.180)		
Δ*S*80/20		0.077 （0.081）	
Δ*P alma*			0.387 (0.394)
Δ*gdp*	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)
Δ*educationattainment*	2.212 (3.389)	2.812 （3.588）	2.807 (3.682)
Δ*healthspending*	0.000 (0.000)	0.000 （0.000）	0.000 (0.000)
Δ*pharmacyspending*	0.000 (0.001)	0.000 （0.001）	0.000 (0.001)
constant	0.233** (0.081)	0.236*** （0.078）	0.234*** (0.073)

Table 7 Robustness check 3

- *p<.10. **p<.05 ***p<.01
- Model 7 reports the result with fixed effect model measuring income inequality by Interdecile90_10
- Model 8 reports the result with fixed effect model measuring income inequality by S80/S20
- Model 9 reports the result with fixed effect model measuring income inequality by Palma ratio

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