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The Social Value of Health: Amenable Deaths and Estimated the Gap with the Life Expectancy Frontier

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Abstract

We estimate the life expectancy gap that can be bridged by improving the quality of public health and health care policies at EU level. Our model calculates the net effect of amenable deaths on life expectancy after controlling for fixed effects (capturing time invariant country specific factors affecting the dependent variable independently from amenable deaths such as local environmental conditions and genetic factors) and time dummies (capturing global trends such as scientific and medical progress that "lift up" life expectancy independently from the quality of domestic health systems) in a model that accounts for more than 80 percent of the overall variability of life expectancy across years. We as well find evidence of beta convergence in amenable deaths across countries in our sample period. Based on our coefficients we estimate the life expectancy gap that countries with lower quality health systems can bridge if catching up and reaching the existing health quality frontier, computing the social value of that upside potential.

Keywords: life expectancy, amenable deaths, domestic health systems.

JEL numbers: I18, I12.

Declarations of interest: none'

1. Introduction

Life expectancy is undoubtedly a key factor in multidimensional wellbeing. A crucial question in health economics is how much the quality of health systems can contribute to it by adding on average life years to a given population. The progress of the humanity in this direction has been extraordinary in the last twenty centuries. The Dasgupta Review (2021) illustrates that the world population has moved from 230 million in the year zero to 7,8 billion in 2021, while average life expectancy at world level has progressed from 23 to 74 years in the same time interval. The progress in life expectancy is ongoing (even though the COVID-19 pandemics produced a sudden, and hopefully temporary, bounce back) and the investigation on its drivers and, more specifically, the role of health and education policies, is an issue of paramount importance.

Our research aims to provide an original contribution to this literature by calculating the net impact of amenable deaths as a proxy of the quality of health systems (intended in the different dimensions of medical care, prevention and healthy life style regulation and campaigns) on life expectancy at country level. More specifically, our empirical analysis calculates the life expectancy gap that, in each country having amenable deaths above the observed optimal frontier, can be bridged by improving domestic health systems, and the related social value of this investment in health quality.

Our work therefore provides a contribution to the ample literature studying the socio-economic determinants of life expectancy. Kabir (2008) shows that variables such as per capita income, education, health expenditure, access to drinking water and urbanisation ended up being statistically not significant in an econometric analysis on 91 developing countries. Guralnik et al. (1993) highlight the role of race showing that life expectancy of black men is lower even though their education attainments can significantly increase it.

Several studies have focused on the role of human capital which is expected to affect health, also directly beyond its indirect contribution via income, through different channels (healthier life styles, higher care and prevention of the more educated on painless diseases such as hypertension and diabetes) (Goldman and Lakdawalla, 2011 and 2005). Education has been recognized for its basic role in health status via its investment in human capital, which can induce changes in societies as well as promote the development in many countries (Chen and Li, 2009; Lange, 2011; Tenn et al., 2010). Bulled and Sosis (2010) study the relationship among life expectancy, reproduction, and educational attainment in 193 countries according to UNESCO world regions. Groot and Brink (2007) find that education measured in terms of schooling years has a positive association with health status. Ghez (1975) observes that education is helpful in increasing the efficiency of health production. Hill and King (1995) and Gulis (2000) find that education, and especially female education, play an important role in improving overall life expectancy. Williamson and Boehmer (1997) show a significant impact of education on life expectancy across 97 countries. Sen (1999) points out that education is an important determinant of life expectancy focusing on the case study of the Indian region of Kerala.

Cemieux et al. (1999) find a significant role of public expenditure on life expectancy in the case of Canada, concluding that lower health expenditure is associated with lower life expectancy and high infant mortality rate. Kalediene and Petrauskiene (2000) show that urbanisation is an important factor for life expectancy in both developed and developing nations since people living in urban areas have better medical care, better educational opportunities and better socio-economic infrastructure, all factors determining a positive impact on health. Macfarlane et al. (2000) find that safe drinking water is an important determinant of life expectancy in the case of developing nations.

It is reasonable to assume that income is an important determinant of health demand, especially when considering developing countries (World Bank, 1997). Residents of rich countries with high income and health expenditures have a higher quality of life than residents in poor countries. According to Kirkwood (2008), there is a strong positive correlation between life expectancy and income in developed countries, while Bulled and Sosis (2010) find a positive correlation between life expectancy and GDP globally. Anand and Anand (1993) find a positive and significant relationship between life expectancy and per capita GNP, working through national income and public expenditures on health.

Within this more general field of the literature several authors use amenable deaths as a proxy of performance of health systems. Jarčuška et al. (2017) find a significant divide in amenable mortality rates between Central and Eastern Europe, on the one side, and Western, Northern and Southern Europe, on the other side. Fantini et al. (2012) provide evidence of high variability in amenable mortality among Italian regions reflecting autonomy and high difference in quality of the regional health systems and find a negative and significant relationship of the variable with life expectancy and per capita GDP. Nolte and McKee (2008) study amenable mortality in nine OECD countries and provide evidence of a significant decline in amenable deaths over time, consistent with progress in medical knowledge and technology. Allel et al. (2021) observe a gain in life expectancy in the UK due to several factors reducing amenable deaths. These factors include a wide range of public health policies including smoking bans, traffic—light labelling on food, vaccination and cancer screening programs. Becchetti et al. (2019) show that self-assessed health is a leading indicator of diseases and mortality with causes that can be related to delays of both the health system in formulating the proper diagnosis and the patient in contacting doctors.

With our research we aim to provide an original contribution to this literature.

First, we use a fixed effect estimate including time dummies to capture the net effect of amenable deaths after controlling for time varying common factors and time invariant idiosyncratic country specific effects affecting life expectancy (finding that both groups of factors matter and are significant) extending our analysis to a wide range of countries and years. Second, we find evidence of beta convergence in amenable deaths across countries in the sample period. Third, we estimate the social value of improvement in health policies based on our estimate findings and value of life.

We find that amenable deaths contribute negatively and significantly as expected to domestic life expectancy and calculate for each country the life expectancy value at the "efficient" zero amenable death frontier and the life expectancy value would the country achieve the performance of the lowest amenable death (best performing) country in the sample. Based on standard literature findings and conventions on the value of life we calculate for each country the social value of bridging the gap with the frontier.

Our findings can be a reference for policymakers evaluating pros and cons of an increase in public expenditure aimed at improving the quality of domestic health systems.

2. Data construction and identification strategy

Our sample includes 33 countries observed in the 2011-2018 period.[1] We extract the amenable (treatable) death rate (number of amenable deaths per thousand inhabitants) measured at country level from Eurostat statistics. According to the Eurostat definition amenable (treatable) mortality is related to death causes that could be avoided with effective health care interventions, including interventions occurring after the onset of diseases to reduce case-fatality, secondary prevention and treatment.
The variable is calculated by an international task force of health care experts that create a list of diseases and age thresholds for which the illness is considered treatable. The conventional age threshold considered in the Eurostat amenable death taxonomy is 74. This implies that deaths of patients aged above 74 are not included among amenable deaths, even in case of pathologies that appear as definitely curable and therefore no death is considered amenable above that age. The final indicator is the sum of all deaths occurred under treatable conditions and diseases. Treatability of diseases obviously depends on medical knowledge and health technologies and therefore the methodology is periodically updated to keep into account progress in this direction.[2]

We estimate the impact of amenable deaths on life expectancy using the following specification

$$Life\ Expectancy_{jt} = \alpha_0 + \alpha_1 Amenable\ Death\ Rate_{jt} + \alpha_2 Tertiary\ Education\ Rate_{jt} + \sum_t \gamma_t DTime_t + \chi_j + e_{jt}$$

where the dependent variable is life expectancy of the j-th country at year t. Our main variable of interest is the rate of amenable deaths measured as explained above. Tertiary education rate is added as control by considering the positive relationship between education and health (see among others, Cutler and Lleras-Muney 2006; Becchetti et al. 2018). The model is estimated first with pooled data and in a second step with fixed country effects (Table 2, columns 1-6).

Based on the fully augmented fixed effect model (Table 2, section 4) our average time invariant frontier life expectancy level (FLEj) for country j in the model is

$$FLE_j = \alpha_0 + \chi_j$$

and its time contingent version (FLE_{jt})

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[1] Countries are: Austria, Belarus, Belgium, Switzerland; Cyprus, Czech Republic, Germany; Denmark, Estonia, Greece, Spain, Finland, France, Croatia, Hungary, Ireland; Iceland; Italy; Lithuania; Luxembourg; Latvia; Montenegro; Netherlands; Norway; Poland; Portugal, Romania; Serbia; Sweden; Slovenia; Slovakia; Turkey; United Kingdom.

[2] Different lists of amenable deaths exist in the literature. In this paper we use the standard OECD/Eurostat list instead of the alternative of Nolte and McKee (2011) and Statistics Canada (2012). We as well prefer to use amenable (treatable) deaths instead of the alternative indicator of preventable deaths since the latter include primary prevention intervention that go beyond the health system while our focus is on the health system performance.

$$FLE_{jt} = \alpha_0 + \chi_j + \gamma_t DTime_t$$

For any country it is as well possible to calculate the time contingent predicted effective life expectancy level conditional on its amenable death rate as

$$PLE_{jt} = \alpha_0 + \alpha_1 Amenable\ Death\ Rate_{jt} + \chi_j + \gamma_t DTime_t$$

and its gap with respect to the best country standard as $PLE(\min)_{jt} - PLE_{jt}$

where

$$PLE(\min)_{jt} = \alpha_0 + \alpha_1 Amenable\ Death\ Rate(\min)_{jt} + \chi_j + \gamma_t DTime_t$$

and $Amenable\ Death\ Rate(\min)_{jt}$is the minimum amenable death rate observed at time t in the sample.

As a consequence we have two ways of measuring distance from the frontier since $PLE(\min)_{jt} - PLE_{jt}$ is the distance from the first best in terms of experience of countries included in the sample, while $FLE_{jt} - PLE_{jt}$ is the distance from the zero amenable death frontier.

3. Empirical findings

The average number of yearly amenable deaths in our sample is 98.65 per 100,000 inhabitants. The lowest country-year value is 47.31, while the highest is 236.17 implying that the number of treatable deaths is four time larger in the region with the lowest vis-à-vis the highest quality health system in our sample (Table 1). The average life expectancy in the sample period is 79.53, with a gap between the highest/lowest country of almost 13 years (84.3 versus 71.75). As is well known, life expectancy is higher for females than males (the average distance is of more than 4 years). The highest/lowest life expectancy country gap is narrower for females (around 9.5 years) than for males life expectancy (around 14.4 years). The geographical distributions of our two key variables of interest show that Norway, Sweden, Iceland, Italy, France, Spain and Switzerland are the countries in the top longevity quartile, while all Eastern European countries (with the exception of Estonia) are in the bottom quartile (Figure 1). The ranking is practically reversed when looking at amenable deaths (Figure 2).

Country dynamics of amenable deaths across the sample period show a partial process of convergence of high amenable death Eastern European countries toward the lowest levels of the other sample countries (Figures 3.1-3.33).

We start our econometric analysis by estimating a pooled estimate. The benchmark specification captures 95 percent of the variability of the 255 country-year observations (Table 2, column 1). The amenable death variable is strongly significant and with the expected negative sign. The significant intercept value has a magnitude of 85.96 years representing the average life expectancy in the sample under the assumption of the highest possible quality of national health systems leading to zero amenable deaths (and no impact of tertiary education rate as well).

In order to allow estimation in the presence of heteroskedastic errors across panels, we re-estimate our benchmark specification with panel-data linear models by using feasible generalized least squares. The amenable death variable remains strongly significant with the same coefficient of pooled OLS estimates (Table 2, columns 3-4).

With the fixed effect estimate we capture time invariant country specific factors affecting our dependent variable (Table 2, column 5). Fixed effects are jointly significantly different from zero and we therefore use this as preferred benchmark to calculate distance from the efficient frontier. Amenable deaths are still negative and significant (with smaller magnitude coefficients) after controlling for them and the introduction of time dummies confirms the relevance of progress in medical science on life expectancy in the overall sample (Table, column 6).

Based on the empirical findings of our benchmark specification we calculate the life expectancy gap that could be bridged by an improvement in quality of domestic health systems. In order to understand implications of our findings we provide in Table 3 for each country in row the estimated highest possible life expectancy level in the sample period in case of zero amenable deaths in the first column, the highest possible life expectancy level in the sample period would the country have the highest observed health standard in the sample, the lowest life expectancy level in the sample period would the country have the lowest observed health standard in the sample. If the first (zero amenable deaths) predicted value is hardly achievable, the second is not and the gap between the second and the third predicted life expectancy value represents the maximum gap and the maximum gain attainable by the country with the lowest quality health system would it bridge the gap with the best performing health system.

Note that each country has a different frontier and different minimum and maximum achievable outcomes calculated as the estimate intercept plus the country specific fixed effect incorporating idiosyncratic time invariant factors affecting life expectancy of that given country and population. More formally and related to the methodological approach described in section 2, Table 3 reports evidence on frontier life expectancy (*FLE*), predicted life expectancy conditional to observed domestic amenable deaths (*PLE*), the minimum predicted life expectancy would the country have the health system of the best performer in the sample (*PLEmin*), plus distances from the *FLE* and *PLEmin* frontiers. Reported values refer to the last observation year of 2018 and therefore are adjusted for the estimated time effect of that year. We calculate the minimum and maximum values of predicted life expectancy using the best and worst health systems in the sample in terms of amenable deaths. By applying data of the best and worst health system (4.31 and 236.17 amenable deaths per thousand inhabitants) we find that the life expectancy gap between the top and bottom health system is around 10 years (83.88 against 73.26) (Table 3, column 1). The introduction of year dummies in the cross-sectional estimate does not change much the picture. The amenable death coefficient is remarkably stable and the estimated intercept life expectancy just slightly smaller. Year dummies are positive and significant capturing the positive effect of progress in medical science showing that these dummies increase life expectancy with respect to the omitted benchmark of 2011 (column 2). Differences in frontier life expectancy across countries (Table 3, column 1) depend on differences in country fixed effects proxying time invariant idiosyncratic factors affecting life expectancy (ie. genetic traits, geographical characteristics affecting life expectancy, components of dietary habits that are time invariant during the sample). These differences range up to a maximum of more than four and a half year difference between the maximum *FLE* of Italy (84.89) and the minimum of Bulgaria(79.36). The gap between the best predicted life expectancy level achievable with the best performer in terms of minimisation of amenable deaths in the sample and the effective predicted life expectancy level of a given country is up to a maximum of four years for several eastern European countries (3.95 years in Romania) (Table 3 column 4). The gap between the effective predicted life expectancy in a given country and the frontier life expectancy of that country with zero amenable deaths is up to almost 6 years in the case of the least performing health systems (5.22 years for Romania), while even the best performing country (Switzerland) has a distance from the zero amenable death frontier of 1.26 years (Table 3, column 5).

Note as well that the best performing country in terms of amenable deaths (Switzerland) has not the highest life expectancy level due to its slightly worse fixed effect with respect to the highest life expectancy country in the sample (Italy). The differences between values in column one can be interpreted in terms of country fixed effect differences.

To calculate the social value of such improvement we make reference to the literature on the value of life years. Empirical contributions from this literature produce a variety of values but a conventional benchmark also used by the legal profession is that of 50,000 US dollars per year of life (Neumann et al. 2000). If we take this legal benchmark as a reference and apply it to the Italian case we observe that Italy is 1.6 years below the frontier. The social value per capita of reaching the health quality frontier could be quantified in around 80,5 thousand dollars (Table 3, column 6). The country with the highest benefit in bridging the gap with the highest health performers is Romania where the social value of reaching the frontier per capita can be quantified in more than around 261 thousand dollars (Table 3, column 6). In aggregate terms what matters is a combination of distance from the frontier and the population size. As a consequence the highest aggregate benefit would be for Turkey (Table 3, column 7).

4. Robustness checks and convergence

We re-estimate our model separately for men and women even though unfortunately we do not have a gender decomposition of amenable deaths (we must therefore adopt the restrictive assumption of gender neutral amenable deaths). Our results show that, as expected, the intercept of life expectancy is higher for females (especially when we consider fixed effects) (Table 4). The magnitude of the amenable death coefficient is also much larger for males (three/fourth larger in cross-sectional, while one fourth larger in fixed effect estimates). Gender specific social values of bridging the gap with the efficient frontier are calculated in Tables 5 and 6. The lowest is 53 thousand dollar per capita as the social value of bringing Swiss females to the frontier, the highest is 296 thousand dollars for Romanian males.

In our robustness checks we perform estimates of the model under alternative specifications adding, in turn, disposable income and internet access and estimating the model with regional instead of national data. The amenable death coefficient is still negative and significant after this change (Table 7). We as well wonder whether our findings may be driven by an outlier country and therefore re-estimate the four specifications of the benchmark fixed effect model of Table 2 by omitting one country at a time. Table 8 shows the estimated amenable death coefficient with the omitted country in row. Our findings show that the coefficient remains significant in all estimates and therefore does not depend from a single country outlier. Descriptive evidence on domestic dynamic patterns of amenable deaths in our sample period shows that countries with the poorest amenable death performance tend to reduce their distance from average sample amenable deaths and the zero amenable death frontier over time (Figures 3.1-3.21). In order to test econometrically this phenomenon we estimate conditional and absolute beta convergence models with fixed effects and with/without time dummies. Our findings show that the hypothesis of absolute convergence is supported by empirical evidence (Table 9). Our rationale for this finding is that progress in medical knowledge circulates globally and poorest performing countries have enough absorptive and adoption capacity to move toward the frontier over time. This does not mean that the process is deterministic and does not need policy effort since it is highly reasonable that the speed of adjustment is far from being automatic while depending on the quality of domestic health policies.

5. Discussion

When discussing about causality in our estimates we should consider that causality from amenable deaths to life expectancy and from quality of health systems to amenable deaths (and therefore, by transitivity, from quality of health systems to life expectancy) is implied in some sense by variable construction and field expert evaluation. Amenable deaths are in fact deaths that could be avoided by domestic health systems according to the judgement of a task force of experts. This is evident if we consider some of the diseases included in the taxonomy such as appendicitis, sepsis, benign neoplasm.

One might wonder why we should not use a simple decomposition in evaluating the effect of amenable deaths on life expectancy. The rationale for following a non deterministic approach is that, as widely acknowledged in the literature, amenable deaths proxy the quality of public health and health care policies only imperfectly and therefore an econometric estimate allows to calculate their expected impact net of an error component and other concurring factors. There are several reasons why the amenable death proxy is imperfect. First, the conventional threshold for calculating the variable set at 74 years underestimates deaths that could be avoided for individuals aged 75 years and above. Second, as explained when introducing our fixed effects and time dummies, both time invariant idiosyncratic factors and time varying non country specific general components are likely to affect life expectancy net of the impact of domestic amenable deaths. Third, the same amenable death definition for given types of diseases and age classes varies over time according to the dynamics of medical knowledge and technology and as such it is measured imperfectly and not always timely updated.

By calculating the life expectancy efficient frontier we use our econometric findings to provide useful information for calculating the social return on investment in health quality. We in fact evaluate the maximum benefit achievable for each observed country by reaching the frontier in the sample period. We however cannot quantify the expenditure needed to achieve that frontier since we cannot predict with reasonable approximation the impact that additional expenditure on health systems could determine in terms of reduction of amenable deaths. We can however imagine that the social return is far higher than one. To take the case of the country with the highest life expectancy and next to lowest amenable death rate, Italy, the social gain amounts to more than 10 times the yearly health expenditure and it is hard to believe that so many financial resources would be needed to achieve that goal.

Another interesting issue to debate is what we mean for progress allowing countries to achieve the amenable death frontier. This progress does not only include direct investment in the health system infrastructure or in the number of health workers (ie. doctors, nurses, etc.), but it as well includes education campaigns for prevention and healthy life styles. This is because, when deaths that could be avoidable occur, the responsibility can be not only on the side of the doctors and the health structure but also on the side of patients for different reasons. Among them delays in acknowledging the health problem, unhealthy life styles leading to it and economic difficulties that delay the meeting of the patient with the health system and doctor diagnosis and prescription. In the latter case however part of the responsibility can again be placed on the health system since a well-functioning public health system could allow free access to health care to patients especially when they are in serious conditions. What on the contrary can happen when this principle is not met is that an effective private system allows timely access to patients that can pay, while those who cannot afford private health fares are in the waiting list of the public health. This is why poverty, income inequality and limited economic and human resources of the public system can be a combined factor reducing access, increasing health care time delays access and increasing amenable deaths.

A final problem on the side of patient is ideological aversion to cure, an issue that has become evident with the COVID-19 pandemics. In this case refusal of medical care (ie. vaccination, therapies) can produce amenable deaths that are entirely under the responsibility of the patient and not of the health system. As well, as shown by evidence during the COVID-19 pandemics, denial of cures can produce negative externalities on other patients by overcrowding intensive therapy beds and crowding out from therapies other patients.

These considerations help us to understand that policies addressing amenable deaths are quite complex and involve various dimensions including those related to health education, culture and communication.

We should as well consider that a maintained assumption of our analysis is that patients are constrained to access to their domestic health system while this is not always the case thanks to patient migration. Under the purely theoretical case of perfect patient arbitrage all citizens in our sample, irrespective of their country of birth, have access to medical care in the country with the highest quality health system and therefore do not suffer from the limits of their domestic system. The perfect arbitrage condition would therefore postulate that amenable deaths should converge to those of the country with the highest health quality. However our data displaying a high persisting variability of amenable death rates across countries, and our estimates showing that domestic life expectancy displays as well high variability and is affected by domestic amenable deaths, confirm that the perfect arbitrage hypothesis is far from reality. This is because initial conditions (factors affecting health until a patient eventually migrates) matter, cross-country patient migration has high costs and is often prevented by severe regulatory barriers and limited by patient economic conditions.

A final caveat of our analysis is that we use life expectancy as dependent variable while there is growing interest in understanding the dynamics of life expectancy in good health. We can however expect that factors driving amenable deaths, which we have shown as affecting life expectancy, can at the same time affect life expectancy in good health when not leading to death. Given the growing importance of the analysis of quality of life and the progress in health care making life longer but necessarily healthy in its last time spell, this extension of our research would be of great interest.

6. Conclusions

Life expectancy is one of the main, if not the most important, wellbeing target. In our paper we calculate the life expectancy gap that can be bridged by domestic health systems by estimating the impact that amenable death rates have on life expectancy.

Our empirical analysis estimates the negative contribution of amenable deaths, net of the impact of fixed effects and time dummies proxying the contribution of additional time invariant idiosyncratic and aggregate time varying effects to the dependent variable. Based on these estimates we calculate the existing gap for each country in terms of life years from the theoretical frontier (zero amenable deaths) and from the observed first best (sample country with lowest amenable death rate) and calculate on this basis the social value of improvement in the health systems.

As explained in the discussion section we consider that such improvement, in order to achieve the goal of a drastic reduction in amenable deaths, should involve not just an increase in health expenditure and an improvement in quality of medical structures and personnel, but also an improvement in public health access and an investment in health education, culture and communication since part of the responsibility for amenable deaths lies in patients' behaviour and beliefs.

We acknowledge the limits of our research such as lack of amenable deaths data at regional level that would be important given the autonomy of regional health systems in several countries, even though interregional heterogeneity in amenable deaths is more likely to be reduced than inter-country heterogeneity by patient migration.

Methodological limits in the definition of amenable deaths are as well discussed and justify our choice of estimating their impact on life expectancy instead of using a simple straightforward decomposition.

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Figure 1 Average life expectancy in the sample period

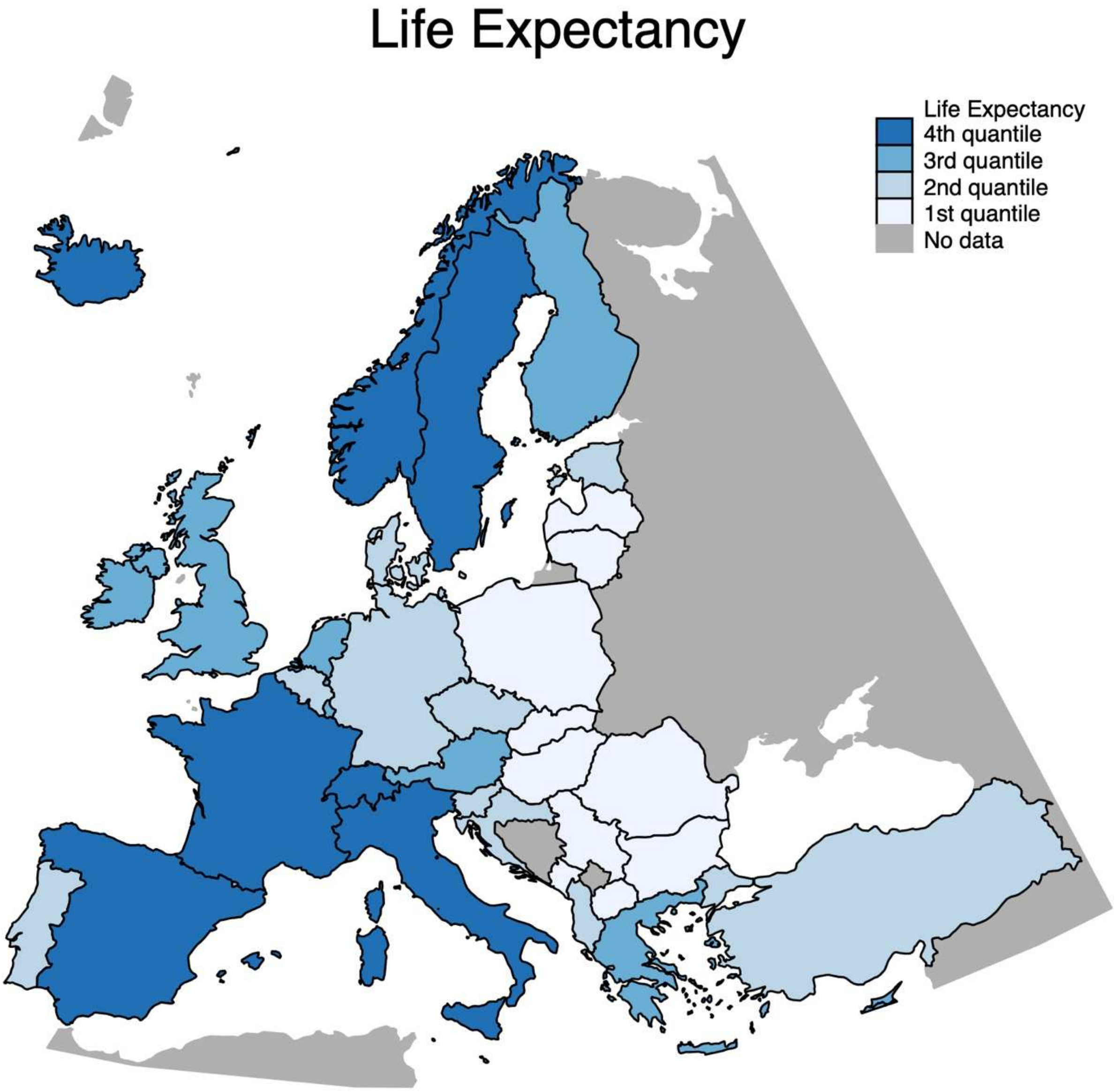
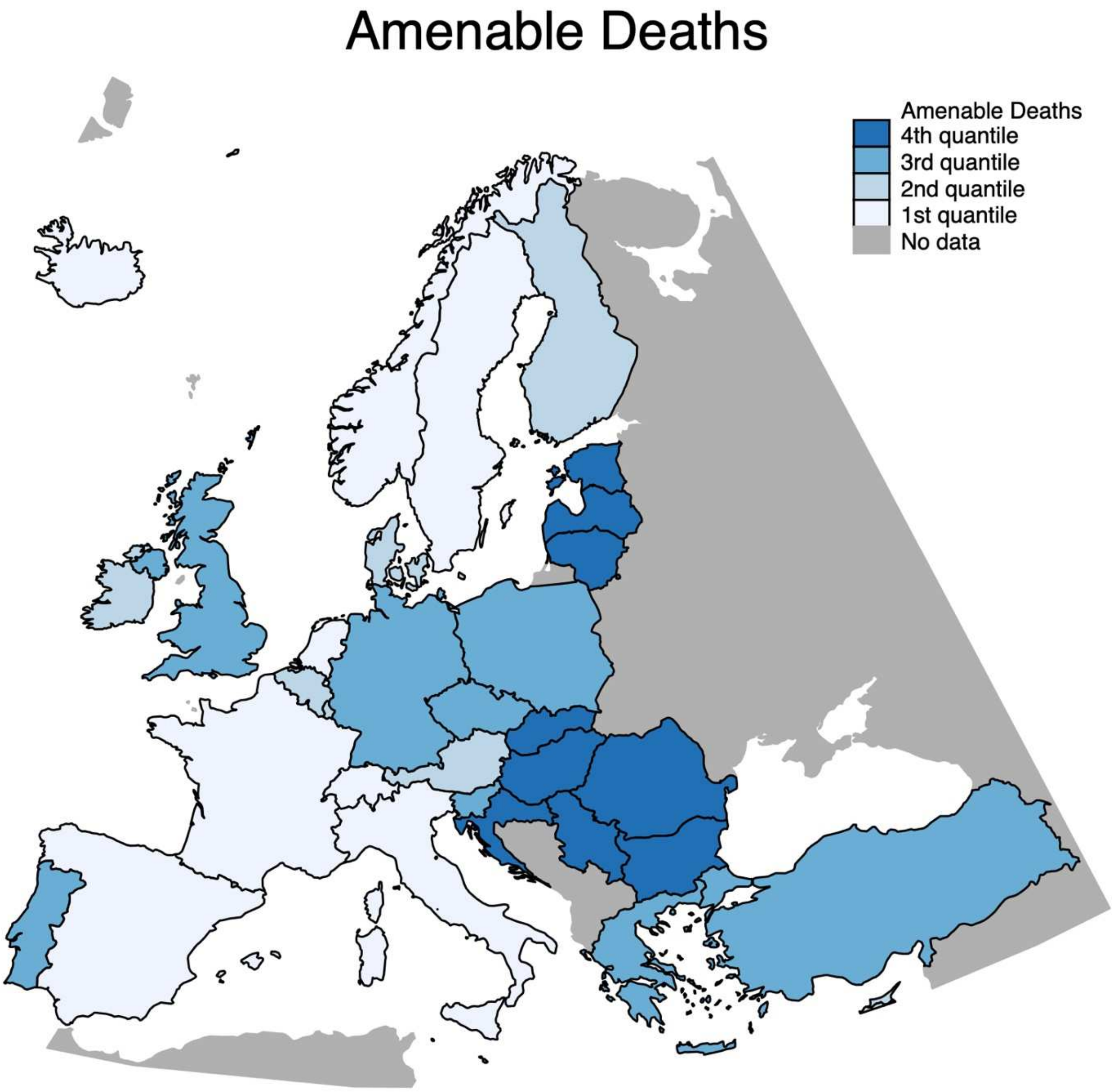
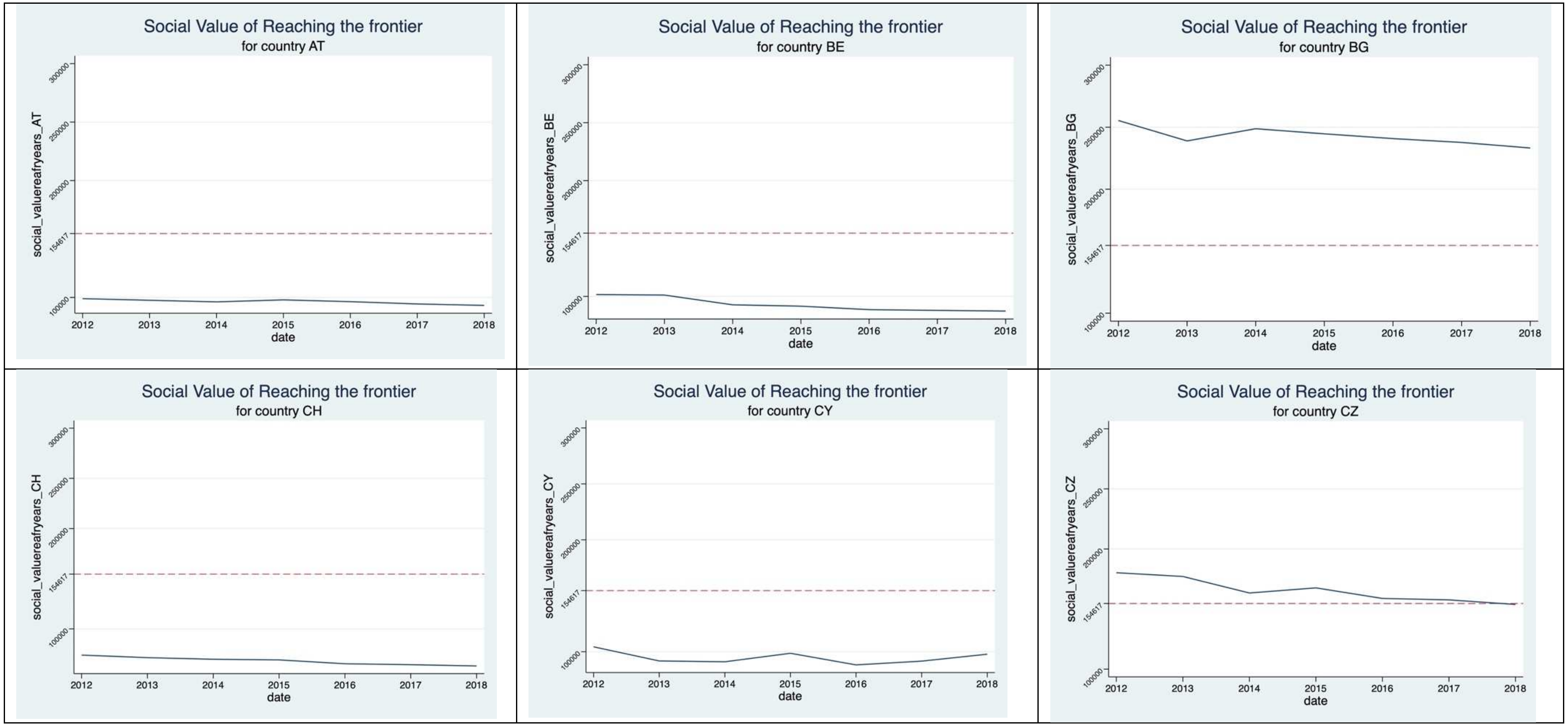
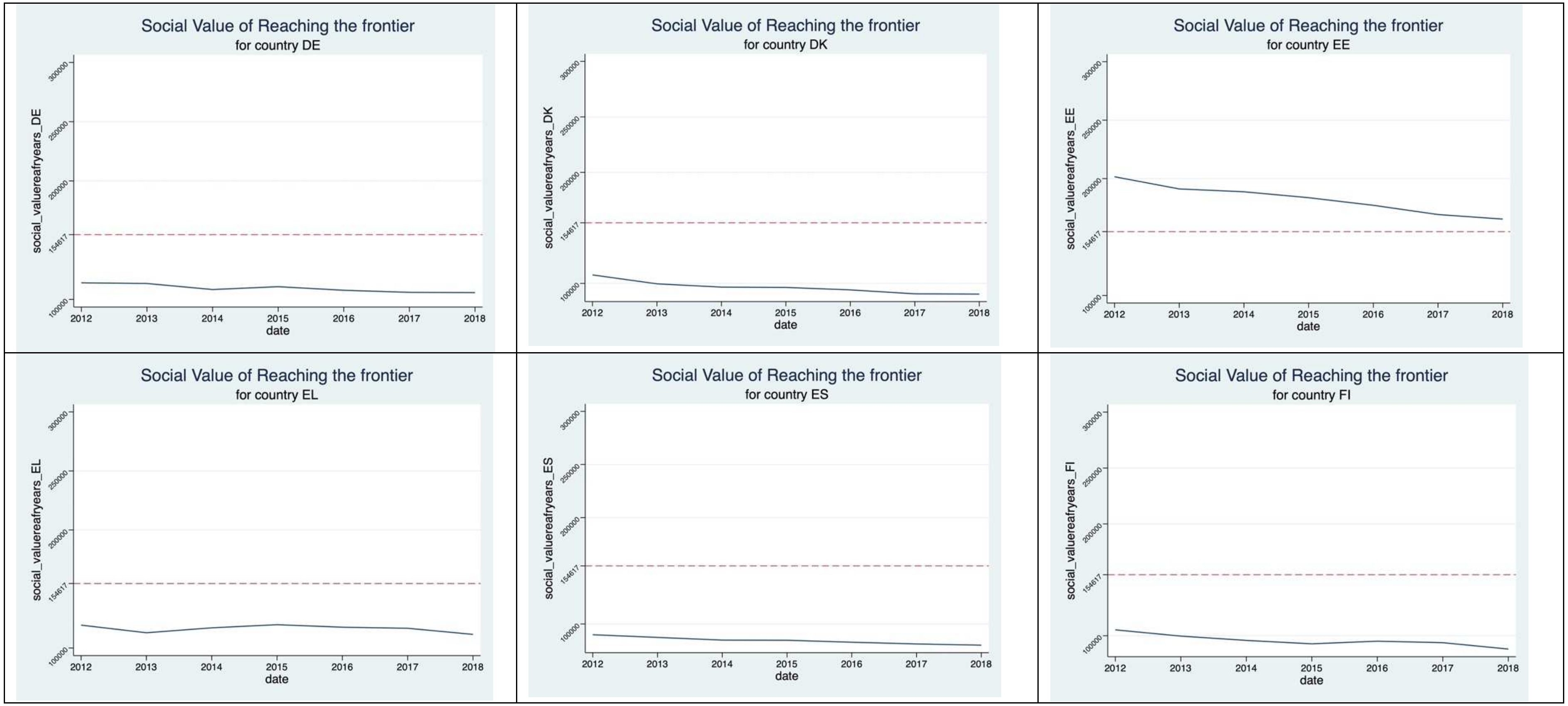


Figure 2 Average amenable deaths in the sample period



Figures 3.1-3.33 Country dynamics of the distance from the health frontier during the sample period

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200000
154617
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2012
2013
2014
2015
2016
2017
2018
date
Social Value of Reaching the frontier
for country DK
social_valuereafryears_DK
Social Value of Reaching the frontier
for country EE
social_valuereafryears_EE
Social Value of Reaching the frontier
for country EL
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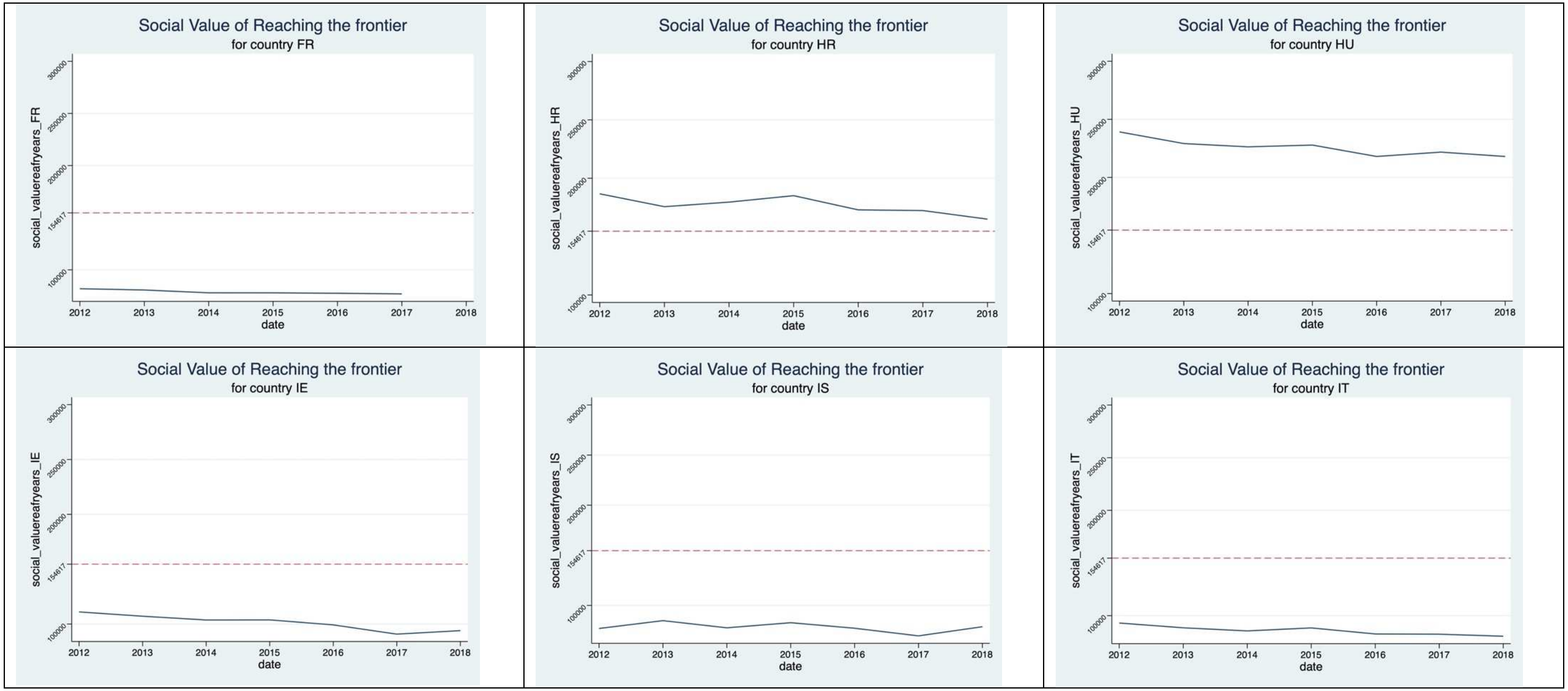
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for country HU
social_valuereafryears_HU
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Social Value of Reaching the frontier
for country IE
social_valuereafryears_IE
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Social Value of Reaching the frontier
for country IS
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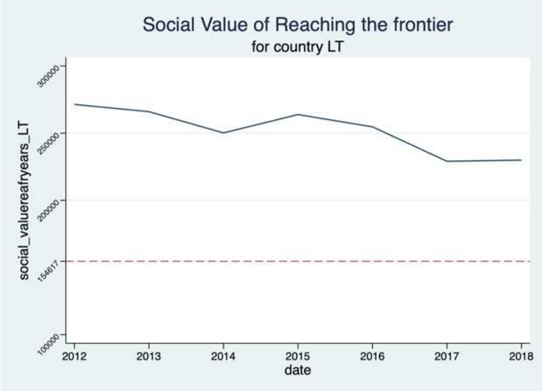
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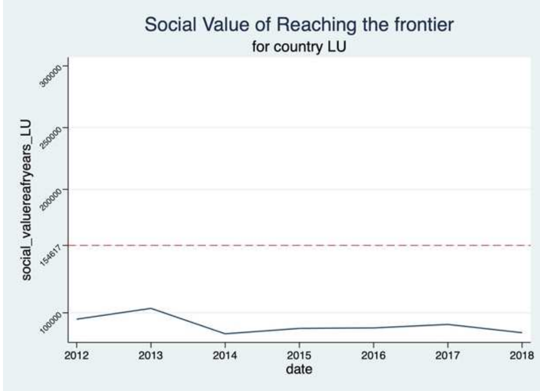
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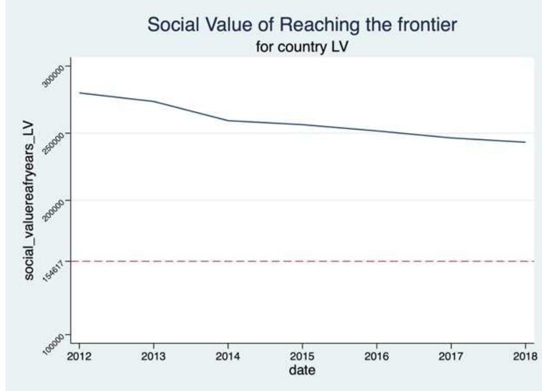
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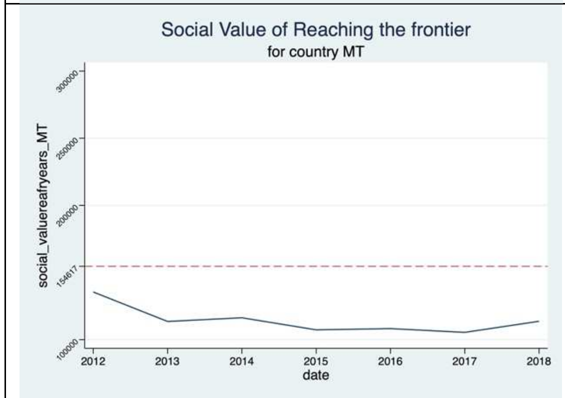
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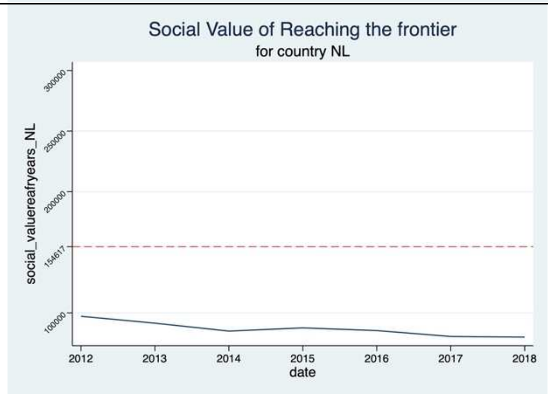
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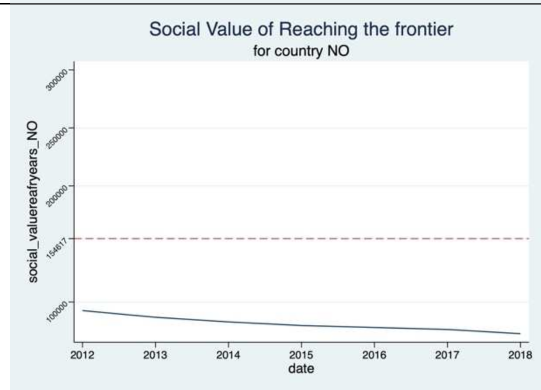
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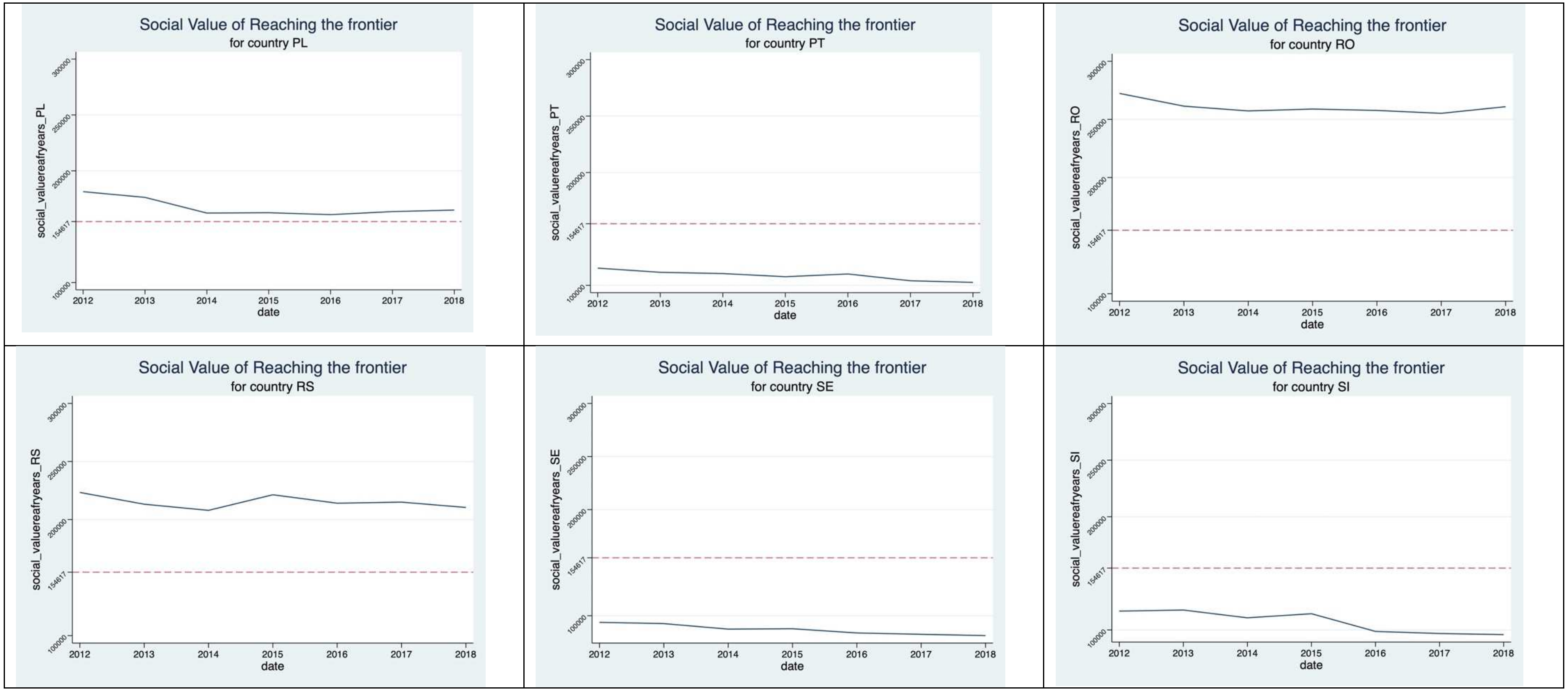
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2013
2014
2015
2016
2017
2018
date
Social Value of Reaching the frontier
for country PT
social_valuereafryears_PT
Social Value of Reaching the frontier
for country RO
social_valuereafryears_RO
Social Value of Reaching the frontier
for country RS
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Social Value of Reaching the frontier
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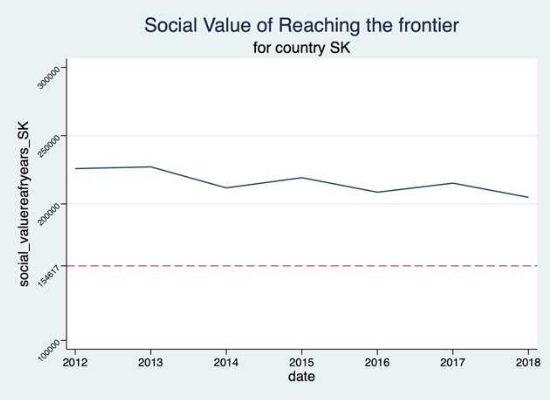
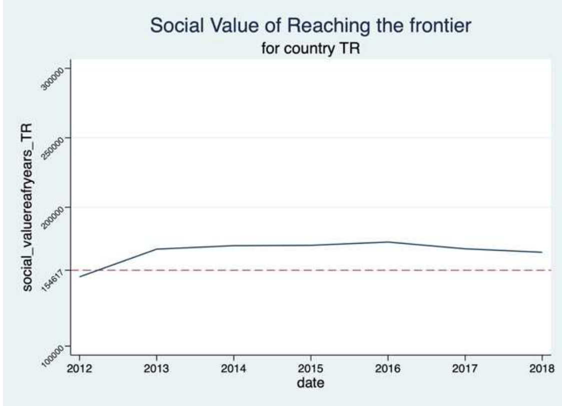
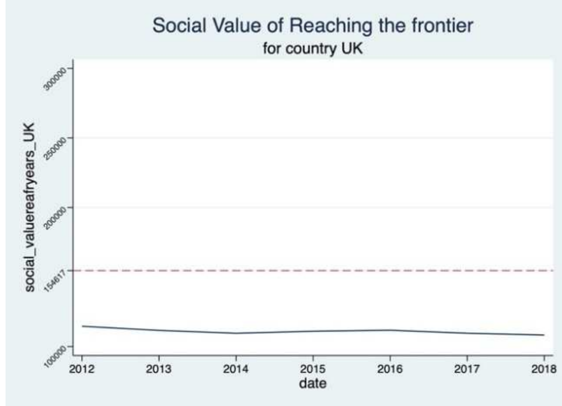
social_valuereafryears_SE
Social Value of Reaching the frontier
for country SI
social_valuereafryears_SI







Country legend: AT: Austria, BE: Belgium, BG: Bulgaria, CH: Switzerland; CY: Cyprus, CZ: Czech Republic, DE: Germany, DK: Denmark, EE: Estonia, EL: Greece, ES: Spain, FI: Finland, FR: France, HR: Croatia, HU: Hungary, IE: Ireland, IS: Iceland, IT: Italy, LT: Lithuania, LU: Luxembourg, LV: Latvia, MO: Montenegro, NL: Netherlands, NO: Norway, PO: Poland, PT: Portugal, RO: Romania, RS: Serbia, SE: Sweden, SI: Slovenia, SV: Slovakia, TU: Turkey, UK: United Kingdom.

Table 1 Descriptive statistics

Variable	*Obs*	*Mean*	*St. Dev.*	*Min*	*Max*
Life Expectancy	347	79.530	2.974	71.75	84. 3
Male Life Expectancy	316	77.014	3.569	68.2	82.6
Female Life Expectancy	316	82.582	2.338	76.9	86.453
Amenable Death Rate	271	110.355	49.937	47.31	236.17
Tertiary Education Rate	347	30.362	9.043	11.2	48.634
Disposable income	220	13884.04	4122.115	6083.333	26300
Access to Internet	287	82.345	11.496	42.5	100

Table 2. Amenable deaths and life expectancy: econometric findings (Pooled OLS - Feasible Generalized Least Squares – Panel Fixed-Effects)

VARIABLES Dependent Variable: Life Expectancy	(1) Pooled OLS	(2) Pooled OLS	(3) Feasible Generalized Least Squares	(4) Feasible Generalized Least Squares	(5) Panel Fixed- Effects	(6) Panel Fixed- Effects
Amenable Death Rate	-0.055***	-0.055***	-0.055***	-0.055***	-0.036***	-0.025***
	(0.002)	(0.002)	(0.001)	(0.001)	(0.009)	(0.009)
Tertiary Education Rate	-0.001	-0.004	-0.001	-0.004	0.071***	0.010
	(0.013)	(0.013)	(0.005)	(0.005)	(0.024)	(0.015)
Year=2012		-0.010		-0.010		0.027
		(0.046)		(0.154)		(0.048)
Year=2013		0.154*		0.154		0.270**
		(0.080)		(0.153)		(0.108)
Year=2014		0.265***		0.265*		0.476***
		(0.079)		(0.154)		(0.129)
Year=2015		0.178**		0.178		0.351**
		(0.085)		(0.154)		(0.138)
Year=2016		0.307***		0.307**		0.565***
		(0.094)		(0.154)		(0.159)
Year=2017		0.205*		0.205		0.539***
		(0.104)		(0.154)		(0.183)
Year=2018		0.322**		0.322**		0.668***
		(0.127)		(0.156)		(0.210)
Constant	85.962***	85.873***	85.962***	85.873***	81.742***	81.950***
	(0.588)	(0.583)	(0.202)	(0.217)	(1.673)	(1.143)
Observations	255	255	255	255	255	255
R-squared	0.951	0.953			0.717	0.785
Wald χ^2			21897.97	19512.69		
Number of Countries			33	33	33	33

Note: Columns (1) and (2) are Pooled OLS estimates, columns (3) and (4) are panel fixed-effect estimates, while column (5) IV estimates. In columns (2) and (4) year dummies are added with 2011 being the omitted benchmark. *** p<0.01, ** p<0.05, * p<0.1.

Table 3 Life expectancy gaps at country level

	FLE_{jt}	PLE_{jt}	$PLE(\min)_{jt}$	$PLE_{jt} - PLE(\min)_{jt}$	$FLE_{jt} - PLE_{jt}$	Social Value of Reaching Frontier per capita (US$)	Aggregate Social Value of Reaching Frontier (bln US$)
Austria	83.705	81.841	82.443	0.602	1.864	93185.805	822.110
Belgium	82.792	81.045	81.53	0.485	1.747	87350.086	995.667
Bulgaria	79.347	74.683	78.085	3.402	4.664	233218.391	1644.197
Switzerland	84.701	83.439	83.439	0	1.262	63102.34	535.368
Cyprus	83.871	81.915	82.609	0.694	1.956	97794.727	84.518
Czech Rep.	82.054	78.977	80.792	1.815	3.077	153835.297	1632.201
Germany	83.033	80.919	81.771	0.852	2.114	105724.336	8753.166
Danemark	82.496	80.688	81.234	0.546	1.808	90398.023	522.608
Estonia	81.232	77.925	79.97	2.045	3.307	165370.563	218.146
Greece	83.949	81.718	82.687	0.969	2.231	111535.641	1198.023
Spain	84.545	82.945	83.283	0.339	1.601	80039.977	3734.541
Finland	83.305	81.543	82.043	0.5	1.762	88105.773	485.739
Croatia	81.724	78.425	80.462	2.037	3.299	164949.031	677.197
Hungary	80.335	75.975	79.073	3.098	4.36	217991.25	2131.599
Ireland	83.383	81.503	82.121	0.619	1.881	94040.68	454.253
Iceland	84.046	82.471	82.784	0.313	1.575	78763.578	27.445
Italy	84.893	83.284	83.631	0.347	1.609	80461.117	4866.608
Lithuania	79.829	75.23	78.567	3.337	4.599	229972.078	645.969
Luxembourg	83.747	82.068	82.485	0.417	1.679	83930.586	50.527
Latvia	79.799	74.933	78.537	3.604	4.866	243279.266	470.594
Montenegro	84.33	82.056	83.068	1.012	2.274	113703.922	54.089
The Netherlands	83.263	81.663	82.001	0.338	1.6	79990.391	1374.322
Norway	83.636	82.183	82.374	0.191	1.453	72667.695	384.820

Poland	80.89	77.592	79.628	2.036	3.298	164912.031	6262.813
Portugal	82.433	80.38	81.171	0.791	2.054	102676.773	1056.649
Romania	80.421	75.202	79.159	3.957	5.219	260935.219	5096.973
Serbia	79.876	75.668	78.614	2.946	4.208	210395.813	1473.075
Sweden	83.704	82.078	82.442	0.364	1.626	81303.789	822.814
Slovenia	83.184	81.267	81.922	0.655	1.917	95849.609	198.110
Slovakia	81.486	77.389	80.224	2.835	4.097	204832.844	1114.930
Turkey	81.535	78.184	80.273	2.089	3.351	167563.25	13540.874
United Kingdom	83.385	81.219	82.123	0.904	2.166	108301.922	7177.556

Table 4. Amenable deaths and male/female life expectancy: econometric findings (Pooled OLS and Panel Fixed-Effects estimates)

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dependent Variable:		Male Life Expectancy				Female Life Expectancy		
Amenable Death Rate	-0.071***	-0.071***	-0.042***	-0.028**	-0.040***	-0.040***	-0.030***	-0.021**
	(0.003)	(0.003)	(0.010)	(0.010)	(0.003)	(0.003)	(0.008)	(0.008)
Tertiary Education Rate	-0.013	-0.018	0.095***	0.013	0.007	0.006	0.053**	0.011
	(0.020)	(0.021)	(0.025)	(0.021)	(0.016)	(0.017)	(0.023)	(0.017)
Year=2012		0.047		0.090		-0.066		-0.039
		(0.053)		(0.054)		(0.049)		(0.059)
Year=2013		0.213**		0.337***		0.112		0.208*
		(0.101)		(0.120)		(0.087)		(0.118)
Year=2014		0.287**		0.535***		0.259***		0.420***
		(0.112)		(0.148)		(0.080)		(0.124)
Year=2015		0.350***		0.536***		0.037		0.177
		(0.121)		(0.157)		(0.079)		(0.141)
Year=2016		0.396***		0.696***		0.247**		0.443**
		(0.135)		(0.182)		(0.092)		(0.164)
Year=2017		0.404***		0.754***		0.069		0.361*
		(0.142)		(0.203)		(0.123)		(0.195)
Year=2018		0.556***		0.879***		0.145		0.480**
		(0.176)		(0.235)		(0.147)		(0.220)
Constant	85.177***	85.047***	78.739***	79.224***	86.886***	86.830***	84.479***	84.436***
	(0.878)	(0.858)	(1.844)	(1.324)	(0.760)	(0.767)	(1.558)	(1.080)
Observations	255	255	255	255	255	255	255	255
R-squared	0.934	0.937	0.736	0.796	0.877	0.880	0.608	0.699
Number of Countries			33	33			33	33

Note: Columns (1) and (2) are Pooled OLS estimates, while columns (3) and (4) are panel fixed-effect estimates. In columns (2) and (4) year dummies are added. For columns (1)-(4) dependent variable is "Male Life Expectation", while for columns (5)-(8) dependent variable is "Female Life Expectation" *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Table 5 Male Life expectancy gaps at country level

	FLE_{jt}	PLE_{jt}	$PLE(\min)_{jt}$	$PLE_{jt} - PLE(\min)_{jt}$	$FLE_{jt} - PLE_{jt}$	Social Value of Reaching Frontier per capita (US$)	Aggregate Social Value of Reaching Frontier (bln US$)
Austria	81.466	79.351	80.034	0.683	2.114	105724.719	932.732
Belgium	80.46	78.478	79.028	0.55	1.982	99103.547	1129.641
Bulgaria	76.568	71.276	75.136	3.86	5.292	264599.219	1865.433
Switzerland	82.718	81.286	81.286	0	1.432	71593.477	607.408
Cyprus	82.046	79.827	80.614	0.787	2.219	110953.906	95.890
Czech Rep.	79.516	76.025	78.084	2.059	3.491	174534.609	1851.822
Germany	80.862	78.463	79.431	0.967	2.399	119950.484	9930.983
Danemark	80.774	78.722	79.342	0.619	2.051	102561.57	592.928
Estonia	76.878	73.126	75.446	2.321	3.752	187622.063	247.498
Greece	81.743	79.212	80.311	1.099	2.531	126543.43	1359.224
Spain	81.909	80.092	80.477	0.384	1.816	90809.633	4237.036
Finland	80.742	78.743	79.31	0.567	1.999	99961.094	551.099
Croatia	79.033	75.29	77.601	2.311	3.743	187144.094	768.319
Hungary	77.386	72.439	75.954	3.515	4.946	247322.844	2418.414
Ireland	81.65	79.516	80.218	0.702	2.134	106694.797	515.378
Iceland	82.694	80.906	81.262	0.355	1.787	89361.57	31.138
Italy	82.669	80.843	81.237	0.394	1.826	91287.992	5521.460
Lithuania	75.06	69.842	73.628	3.786	5.218	260916.516	732.889
Luxembourg	81.561	79.656	80.129	0.473	1.904	95224	57.325
Latvia	75.373	69.853	73.942	4.088	5.52	276013.938	533.916
Montenegro	82.486	79.906	81.054	1.148	2.58	129003.141	61.367

Netherlands	81.734	79.919	80.302	0.383	1.815	90753.555	1559.244
Norway	81.939	80.29	80.507	0.217	1.649	82445.523	436.600
Poland	77.265	73.523	75.833	2.31	3.742	187102.125	7105.519
Portugal	79.369	77.039	77.937	0.898	2.33	116492.461	1198.827
Romania	77.627	71.706	76.195	4.489	5.921	296045.688	5782.803
Serbia	77.913	73.139	76.482	3.342	4.774	238706.203	1671.288
Sweden	82.119	80.274	80.687	0.413	1.845	92243.578	933.527
Slovenia	80.388	78.213	78.956	0.743	2.175	108746.719	224.766
Slovakia	78.516	73.868	77.084	3.216	4.648	232394.406	1264.951
Turkey	79.291	75.489	77.86	2.37	3.802	190110.391	15362.921
United Kingdom	81.806	79.349	80.374	1.026	2.457	122874.453	8143.329

Table 6 Female Life expectancy gaps at country level

	FLE_{jt}	PLE_{jt}	$PLE(\min)_{jt}$	$PLE_{jt} - PLE(\min)_{jt}$	$FLE_{jt} - PLE_{jt}$	Social Value of Reaching Frontier per capita (US$)	Aggregate Social Value of Reaching Frontier (bln US$)
Austria	85.726	84.161	84.666	0.505	1.566	78284.836	690.650
Belgium	84.919	83.451	83.859	0.407	1.468	73382.188	836.453
Bulgaria	82.105	78.186	81.044	2.858	3.919	195925.516	1381.282
Switzerland	86.412	85.352	85.352	0	1.06	53012.086	449.761
Cyprus	85.563	83.92	84.503	0.583	1.643	82156.75	71.003
Czech Rep.	84.417	81.832	83.356	1.524	2.585	129236.219	1371.203
Germany	85.045	83.268	83.984	0.716	1.776	88818.742	7353.512
Denmark	84.076	82.557	83.016	0.459	1.519	75942.992	439.041
Estonia	84.926	82.148	83.866	1.718	2.779	138926.703	183.263
Greece	86.127	84.253	85.067	0.814	1.874	93700.031	1006.447
Spain	87.056	85.711	85.996	0.285	1.345	67241.289	3137.374
Finland	85.694	84.213	84.633	0.42	1.48	74017.336	408.067
Croatia	84.216	81.445	83.156	1.711	2.771	138572.688	568.909
Hungary	82.953	79.291	81.893	2.602	3.663	183133.313	1790.746
Ireland	85.008	83.428	83.948	0.52	1.58	79003.141	381.616
Iceland	85.292	83.969	84.232	0.263	1.323	66168.977	23.057
Italy	86.894	85.542	85.833	0.292	1.352	67595.289	4088.432
Lithuania	84.054	80.19	82.994	2.804	3.864	193198.391	542.675
Luxembourg	85.762	84.352	84.702	0.35	1.41	70509.336	42.447
Latvia	83.619	79.531	82.559	3.027	4.088	204377.359	395.343
Montenegro	85.958	84.047	84.897	0.85	1.91	95521.93	45.440

Netherlands	84.586	83.242	83.526	0.284	1.344	67199.703	1154.564
Norway	85.166	83.945	84.105	0.161	1.221	61047.746	323.286
Poland	84.339	81.568	83.279	1.711	2.771	138541.406	5261.344
Portugal	85.256	83.531	84.196	0.665	1.725	86258.313	887.687
Romania	83.159	78.774	82.098	3.324	4.384	219210.047	4281.935
Serbia	81.66	78.125	80.6	2.475	3.535	176752.469	1237.522
Sweden	85.149	83.783	84.089	0.306	1.366	68302.539	691.238
Slovenia	85.721	84.11	84.661	0.55	1.61	80522.539	166.430
Slovakia	84.138	80.697	83.078	2.381	3.442	172078.703	936.645
Turkey	83.704	80.888	82.643	1.755	2.815	140769.203	11375.633
United Kingdom	84.756	82.936	83.696	0.759	1.82	90983.578	6029.807

Table 7. Robustness checks

	(1)	(2)	(3)	(4)	(5)	(6)
Panel 6.1	Life Expectancy	Male Life Expectancy	Female Life Expectancy	Life Expectancy (using NUTS-2 data)	Male Life Expectancy (using NUTS-2 data)	Female Life Expectancy (using NUTS-2 data)
Pooled OLS						
Amenable Death Rate		-0.071***	-0.040***	-0.054***	-0.064***	-0.045***
		(0.003)	(0.003)	(0.002)	(0.002)	(0.002)
Panel 6.2						
Pooled OLS (with year dummies)						
Amenable Death Rate		-0.071***	-0.040***	-0.054***	-0.064***	-0.045***
		(0.003)	(0.003)	(0.002)	(0.002)	(0.002)
Panel 6.3						
Panel Fixed-Effects						
Amenable Death Rate		-0.042***	-0.030***	-0.027***	-0.035***	-0.020***
		(0.010)	(0.008)	(0.004)	(0.005)	(0.004)
Panel 6.4						
Panel Fixed-Effects (with year dummies)						
Amenable Death Rate		-0.028**	-0.021**	-0.007**	-0.011***	-0.003**
		(0.010)	(0.008)	(0.004)	(0.004)	(0.004)
Panel 6.5						
Pooled OLS						
(Adding Income as covariate)						

Amenable Death Rate	-0.052***	-0.067***	-0.039***
	(0.003)	(0.005)	(0.004)
Panel 6.6 ***Pooled OLS (with year dummies)*** ***(Adding Income as covariate)***			
Amenable Death Rate	-0.052***	-0.067***	-0.039***
	(0.003)	(0.005)	(0.004)
Panel 6.7 ***Panel Fixed-Effects*** ***(Adding Income as covariate)***			
Amenable Death Rate	-0.043***	-0.046***	-0.039***
	(0.006)	(0.008)	(0.005)
Panel 6.8 ***Panel Fixed-Effects (with year dummies)*** ***(Adding Income as covariate)***			
Amenable Death Rate	-0.032***	-0.034***	-0.029***
	(0.005)	(0.008)	(0.005)
Panel 6.9 ***Pooled IV*** ***(Adding Income as covariate)***			
Amenable Death Rate	-0.058***		
	(0.019)		
Panel 6.10 ***Pooled OLS*** ***(Adding Internet Access as covariate)***			

Amenable Death Rate	-0.054***	-0.068***	-0.040***
	(0.003)	(0.004)	(0.003)
Panel 6.11 ***Pooled OLS (with year dummies)*** ***(Adding Internet Access as covariate)***			
Amenable Death Rate	-0.054***	-0.069***	-0.041***
	(0.003)	(0.004)	(0.003)
Panel 6.12 ***Panel Fixed-Effects*** ***(Adding Internet Access as covariate)***			
Amenable Death Rate	-0.037***	-0.042***	-0.033***
	(0.006)	(0.008)	(0.005)
Panel 6.13 ***Panel Fixed-Effects (with year dummies)*** ***(Adding Internet Access as covariate)***			
Amenable Death Rate	-0.028***	-0.030***	-0.026***
	(0.007)	(0.010)	(0.005)
Panel 6.14 ***Pooled IV*** ***(Adding Internet Access as covariate)***			
Amenable Death Rate	-0.053***		
	(0.003)		

Table 7 Amenable deaths beta convergence

Dep. Var. One year changes in amenable death rate	Fixed effects (1)	Pooled (2)	Fixed effects (3)	Pooled (4)
Amenable death rate$_{t-1}$	0.400***	0.019***	0.656***	0.018***
	(0.051)	(0.005)	(0.063)	(0.005)
2013.date			2.783***	1.692
			(1.004)	(1.413)
2014.date			5.970***	2.728**
			(1.049)	(1.097)
2015.date			2.451**	-3.566***
			(1.164)	(1.154)
2016.date			6.708***	1.981**
			(1.104)	(0.963)
2017.date			7.450***	0.452
			(1.217)	(0.958)
2018.date			8.099***	-0.234
			(1.305)	(0.898)
Constant	-42.462***	-0.052	-75.704***	-0.363
	(5.649)	(0.480)	(7.528)	(0.750)
Observations	237	237	237	237
R-squared	0.235		0.450	
Number of countries	34	34	34	34

*** p<0.01, ** p<0.05, * p<0.1. Standard errors in round brackets

Table 8 Amenable death coefficient dropping one country

Omitted country	Coefficient of Amenable deaths using Pooled Estimates	Coefficient of Amenable deaths using Fixed Effects Estimates	Coefficient of Amenable deaths using Pooled Estimates (and controlling for year dummies)	Coefficient of Amenable deaths using Fixed Effects Estimates (and controlling for year dummies)
Austria	-0.055***	-0.055***	-0.033***	-0.024**
	(0.002)	(0.002)	(0.010)	(0.009)
Belgium	-0.055***	-0.055***	-0.036***	-0.025**
	(0.002)	(0.002)	(0.009)	(0.009)
Bulgaria	-0.054***	-0.054***	-0.037***	-0.025**
	(0.002)	(0.002)	(0.009)	(0.009)
Switzerland	-0.054***	-0.054***	-0.036***	-0.025**
	(0.002)	(0.002)	(0.009)	(0.009)
Cyprus	-0.055***	-0.055***	-0.036***	-0.025**
	(0.002)	(0.002)	(0.009)	(0.010)
Czech Republic	-0.055***	-0.055***	-0.036***	-0.025**
	(0.002)	(0.002)	(0.009)	(0.009)
Germany	-0.055***	-0.055***	-0.036***	-0.024**
	(0.002)	(0.002)	(0.009)	(0.009)
Danemark	-0.055***	-0.055***	-0.036***	-0.025**
	(0.002)	(0.002)	(0.009)	(0.009)
Estonia	-0.055***	-0.055***	-0.033***	-0.023**
	(0.002)	(0.002)	(0.009)	(0.009)
Greece	-0.054***	-0.054***	-0.037***	-0.025**
	(0.002)	(0.002)	(0.009)	(0.010)
Spain	-0.054***	-0.054***	-0.036***	-0.025**
	(0.002)	(0.002)	(0.009)	(0.009)
Finland	-0.055***	-0.055***	-0.035***	-0.025**
	(0.002)	(0.002)	(0.009)	(0.009)
France	-0.055***	-0.055***	-0.036***	-0.024**

	(0.002)	(0.002)	(0.009)	(0.009)
Croatia	-0.055***	-0.055***	-0.036***	-0.025**
	(0.002)	(0.002)	(0.009)	(0.009)
Hungary	-0.055***	-0.055***	-0.036***	-0.025***
	(0.002)	(0.002)	(0.009)	(0.009)
Ireland	-0.055***	-0.055***	-0.036***	-0.024**
	(0.002)	(0.002)	(0.009)	(0.009)
Iceland	-0.055***	-0.055***	-0.034***	-0.023**
	(0.002)	(0.002)	(0.009)	(0.009)
Italy	-0.054***	-0.054***	-0.036***	-0.025**
	(0.002)	(0.002)	(0.009)	(0.009)
Lithuania	-0.055***	-0.055***	-0.035***	-0.021**
	(0.003)	(0.003)	(0.010)	(0.009)
Luxembourg	-0.055***	-0.055***	-0.036***	-0.025**
	(0.002)	(0.002)	(0.009)	(0.009)
Latvia	-0.055***	-0.055***	-0.040***	-0.028***
	(0.002)	(0.002)	(0.010)	(0.010)
Montenegro	-0.054***	-0.054***	-0.036***	-0.024**
	(0.002)	(0.002)	(0.009)	(0.009)
Netherlands	-0.055***	-0.055***	-0.036***	-0.025***
	(0.002)	(0.002)	(0.009)	(0.009)
Norway	-0.055***	-0.055***	-0.036***	-0.025**
	(0.002)	(0.002)	(0.009)	(0.009)
Poland	-0.054***	-0.054***	-0.036***	-0.025**
	(0.002)	(0.002)	(0.009)	(0.009)
Portugal	-0.055***	-0.055***	-0.036***	-0.025**
	(0.002)	(0.002)	(0.009)	(0.009)
Romania	-0.056***	-0.056***	-0.036***	-0.025**
	(0.002)	(0.002)	(0.009)	(0.009)
Serbia	-0.055***	-0.055***	-0.036***	-0.025***
	(0.002)	(0.002)	(0.009)	(0.009)
Sweden	-0.055***	-0.055***	-0.036***	-0.025**

	(0.002)	(0.002)	(0.009)	(0.009)
Slovenia	-0.055***	-0.055***	-0.036***	-0.025**
	(0.002)	(0.002)	(0.009)	(0.009)
Slovakia	-0.055***	-0.055***	-0.036***	-0.025**
	(0.002)	(0.002)	(0.009)	(0.009)
Turkey	-0.055***	-0.055***	-0.044***	-0.034***
	(0.002)	(0.002)	(0.006)	(0.006)
United Kingdom	-0.055***	-0.055***	-0.036***	-0.024**
	(0.002)	(0.002)	(0.009)	(0.009)
Observations	247	247	247	247
Number of countries			32	32

Estimated models for each column are those of the corresponding column of Table 2.

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