Population Aging and Innovation
Do Old Societies Think New Ideas?

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Abstract

This research advances the hypothesis that at the individual level "old people think old ideas" whereas at the aggregate level "old societies think new ideas." More precisely, we empirically establish the following three hypotheses: i) population aging has a hump-shaped effect on innovation, ii) old societies think new ideas, and iii) the effect of population aging on innovation operates partly through a favorable attitude towards new ideas and creativity. Our results falsify the often encountered vision according to which old societies think old ideas. Moreover they emphasize that innovation activity in aging societies is in part driven by cultural attitudes.

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1 Introduction

Following the demographic transition and the associated economic boost driven by a growing population, population aging has become an unavoidable fate for most developed countries. Multiple facets of this phenomenon have been explored with one of the dominating issues being the effect of population aging on economic growth. In due course other crucial issues emerged, such as the potential impact of an aging population on social security, pension schemes and productivity. Crucially though, the profound effect of aging on cultural attitudes has been ignored.

The present paper provides a first step in this direction. The focus of our research is on the relationship between population aging and innovation. Do older societies innovate more? Do they think new ideas? Interestingly, our findings suggest that at the individual level "old people think old ideas" whereas at the aggregate level "old societies think new ideas." More precisely, we empirically establish the following three hypotheses: i) population aging has a hump-shaped effect on innovation, ii) old societies think new ideas, and iii) the effect of population aging on innovation operates partly through a favorable attitude towards new ideas and creativity. Our results falsify the often encountered vision according to which old societies think old ideas.[1] Moreover we emphasize that innovation activity in aging societies is in part driven by cultural attitudes.

Our empirical analysis employs the fraction of old people in the total population in 18 OECD countries as the main explanatory variable of innovation in the respective countries. All countries in the sample left the demographic transition behind. Therefore population aging is an imminent reality for all of them. The intriguing part of our approach is that we are not after a production function of innovation that possibly depends upon the age distribution within the workforce. Rather our focus is on the size of the old and retired workforce as a fraction of the total population. This suggests to us that the hump-shaped effect of an aging population on innovation, that we establish as our first hypothesis, must be driven by considerations that are beyond the production process of innovation.[2]

The next logical step is to explain this hump-shaped relationship and to explore potential channels through which the fraction of the old in a society can affect innovation. Our analysis emphasizes the as yet unexplored cultural channel. Living in an aging society raises all sorts of concerns as to the viability of the pension scheme, the health care system, the sustainability of public finances and of economic growth in general. These concerns are

[1] The pessimistic view of Sauvy (1948) is representative of the vision on the adverse effect of ageing. *"In countries suffering from ageing, the spirit of enterprise, and hence the willingness to take risks without capitalism cannot function, gradually atrophies and is replaced by a new feeling: The desire for security"*

[2] It could be argued that in several countries where retirement is not obligatory at some specific age, the old could still participate in the production process. Nevertheless even if this is the case, it could be hardly debated that this channel could have a profound effect on innovation.

part of most public debates on how policy makers should respond to the aging problem. More importantly, through public discourse, it has become part of the culture of individuals and of societies as a whole. The aging problem of Japan as well as the imminent aging of the German population, to mention only some of the most prominent examples, are issues that concern not only local policy makers, but in the context of a globalized world, they also concern international politics as these countries are drivers of growth both at a regional and at a global level. Policy-wise, favorable policies towards large scale immigration that can mitigate the challenges of an aging population, as well as increases in female labor participation, are only a few prominent examples of the types of policies that have naturally emerged partly as a consequence of an aging population.

We therefore aim to capture a cultural elements of an aging population, namely the propensity of societies towards favoring novel ideas and fostering creativity. The results are quite astonishing as they suggest that whereas individual age goes hand in hand with old ideas, as would be anticipated, nevertheless aging societies foster new ideas and creativity. The result at first sight is rather unexpected, however it is quite intuitive if we account for the fact that the presence of old generates pressure to the society to accommodate their needs while at the same time the labor force supporting them diminishes. Therefore, this pressure generates an imminent need for innovations that can compensate for the reduction in resources. This urgency is not only reflected not only in the final economic outcomes, e.g. at the levels of innovation, but also in the cultural attitudes of aging societies.

The literature on population growth and aging has evolved in several directions during the last years. Initially the debate was centered around population growth and its effect on economic growth. During the 20th century a large number of developing and developed countries experienced reduced mortality rates which were later reflected in lower fertility rates. This led to the emergence of a "boom" generation which in some countries it is still active and in some other countries it has already retired and become part of the old population . The main issue at stake was how to best take advantage of this population growth so as to boost economic growth. Three mains hypotheses have been advanced. The first one is that population growth hinders economic growth (Malthus, 1798; Ehrlich, 1970; Sachs et al., 2001). The main argument is that this size of population is not sustainable and the geographic regions that experience faster population growth (usually developing countries), are too fragile to sustain economic growth. The second view argues that population growth is conducive to economic growth particularly the ones that managed to capitalize a growing productive population (Sen, 1999; Bloom et al., 2001). More people imply more ideas, a larger labor force and if this labor force is educates, it also implies higher productivity. All that is needed is to undertake the right set of policies. Last but not least, the "neutralists" advance the hypothesis that the role of population growth in boosting economic growth would be limited and non-systematic (Bloom and Freeman, 1986).

The effect of aging on growth has become more clear once the concept of aging has been disentangles into its main two elements, i.e. reduced mortality and longer life expectancy. The vast majority of the researchers argues that increased longevity fosters human capital, factor productivity and ultimately economic growth (Cervellati and Sunde, 2005; Li et al., 2007; Lorentzen et al., 2008; Cervellati and Sunde, 2011), whereas a number of studies argue that there is no significant or systematic effect of life expectancy or an aging population on economic outcomes (Hazan, 2009; Acemoglu and Johnson, 2007; Irmen, 2013).[3]

Several countries succeeded in capitalizing a growing population whereas others where somewhat less successful. Currently though, a crucial issue for all countries is how to address the future challenges the boom generation would pose, i.e. the challenges of the emergence of an aging population that will be supported by a smaller fraction of the working age population. This ultimately led to a new strand of research that abstracted from population growth itself and focused more on the age structure of the population. (Kogel, 2005; Bloom et al., 2007; Feyrer, 2007; Irmen and Tabakovic, 2014).

Surprisingly, whereas a vast array of potential effects of aging have been explored, its impact on innovation and on culture has been largely unexplored. Recently, a number of papers explore the impact of several aspects of culture on the economy as well as the determinants of culture.[4] Nevertheless there is no paper that systematically explores the effect of an aging population on innovation and more importantly an exploration of the cultural impact of an aging population. Our analysis aspires to fill this gap by correlating the fraction of old people in the society with innovation and empirically establishing that this effect operates via the effect of an aging population on individual attitudes favorable towards new ideas and higher creativity.

The advance our hypothesis we employ a panel dataset of 18 OECD countries for the period 1972-2010. We estimate the reduced form model and we establish that i) population aging has a hump shaped effect on the number of patent applications filed by residents. Our analysis controls for a wide range of time varying controls, such as income per capita, life expectancy, fertility, mortality, education, institutions, unemployment and general private and public spending, all of which could be plausible determinants of the level of innovation. Moreover we control for country and time fixed effects so as to capture time invariant char-

[3] A systematic approach as to the long-run determinants of the demographic transition and life expectancy has been undertaken by (Galor and Weil, 2000; Galor and Moav, 2007; Galor, 2012).

[4] See e.g. Guiso et al. (2004) for the effect of social capital on financial markets, Guiso et al. (2006) for the effect of social capital on economic outcomes, Giuliano and Spilimbergo (2009) on the impact of macroeconomic shocks on the attitudes of individuals towards government redistribution, Alesina et al. (2010) establish the effect of family ties on labor market regulation, Algan and Cahuc (2010) for the effect of trust on growth.

Ashraf and Galor (2011b, 2013) have explored the persistent effect of geography and of genetic diversity on culture and ultimately on long run development. As to the determinants of culture see Fernández and Fogli (2009) on the transmission of fertility attitudes of second generation migrant in the US, Luttmer and Singhal (2011) on the persistence of preferences for redistribution and Litina et al. (2014) for the transmission of environmental preferences.

acteristics at the country level as well as potential shocks. Nevertheless, as omitted variable bias can always be a concern, we adopt an IV strategy. To instrument for the fraction of old in the society we employ the fraction of children that are immunized every year against measles, under the identifying assumption that innovation and immunization against measles are not correlated via channels that have not already been accounted for at the first stage of the analysis. Moreover, we argue that better protection against measles can positively affect the fraction of old in the society via affecting the overall health status of the population. Our results remain unaffected under both estimation strategies.

Intrigued by the plausible observation that people above the age of 65 do no longer participate in the production process and yet confer a statistically significant effect on innovation, we explore the channels via which the presence of an aging population affects innovation. In particular we explore the role of culture. Analytically, we conduct a multi-level analysis by combining data on individuals attitudes from the European Social Survey and the same set of aggregate (at the country level) controls used in the first stage of the analysis, derived from the World Bank. In this part of the analysis we establish the remaining two hypotheses: ii) population aging has a hump shaped effect on individual attitudes towards new ideas and creativity, and iii) population aging affects innovation partly via triggering individual attitudes favorable to innovation and creativity. Interestingly our results suggest that whereas old individuals think old ideas, nevertheless old societies foster new ideas and ultimately innovation.

The structure of the paper is the following. Section 2 describes the empirical strategy and the data used in our paper. Section 3 presents the empirical results for all three hypothesis using both samples, i.e. the World Bank panel dataset and the ESS dataset. Section 4 conducts some robustness tests whereas Section 5 concludes.

2 Empirical Strategy and Data

The empirical analysis of the paper is conducted in two stages. At the first stage of the analysis, we estimate the reduced form equation capturing the effect of aging on innovation. Interestingly, our results suggest that a higher fraction of old individuals in the society is associated with a larger number of patent applications. At the second stage we explore the channel of culture. Here, our analysis suggests that aging societies tend to favor more novel ideas that lead to higher levels of innovation.

2.1 The Impact of Population Aging on Innovation

2.1.1 The Data

The main hypothesis of the paper is that a higher fraction of old people in the society is positively correlated with the number of patent applications filed by residents , i.e., a higher level of innovation. To establish this our analysis uses a panel dataset of 18 OECD countries for which the full set of controls is available.[5] The countries in the sample are Belgium, Denmark, Spain, Estonia, France, the UK, Greece, Hungary, Ireland, Israel, Luxembourg, the Netherlands, Norway, Poland, Portugal, Slovenia, Sweden, and Turkey. The period under examination in the panel dataset is the interval between 1972-2010 and the data are employed on a yearly basis.[6]

The scope of limiting the analysis to a sample of OECD countries is to ensure that all the countries under examination have already experienced the demographic transition and thus aging is not only a plausible concern but also part of the policy makers agenda. A number of studies suggest that in countries that are on the onset of the demographic transition, aging is not yet a concern since the "boom" generation is still active. In these countries, the structure of the population is not yet as a central issue as the growth rate of the population (Bloom et al., 2007).

The use of the World Bank dataset allows us to have a full range of controls on a yearly basis such as income per capita, life expectancy, fertility and mortality rates, population growth, institutional quality, school enrollment, unemployment rates and gross national expenditure, all of which are plausible determinants of innovation.

2.1.2 Empirical Strategy

We estimate the reduced form model given by

$$I_{it} = \alpha_0 + \alpha_1 O_{it} + \alpha_2 O_{it}^2 + \alpha_3 \mathbf{X}_{it} + \alpha_4 \mathbf{I}_i + \alpha_5 \mathbf{T}_t + \varepsilon_{it} \tag{1}$$

where I is the number of patent applications (per 1000 inhabitants) filed by residents of country i at time t. O_{it} is the number of individuals above the age of 65, expressed as a fraction of the total population. O_{it}^2 is the squared term of the fraction of old individuals. This suggests a non-linear effect of aging on innovation, a rather intuitive assumption strongly supported by the data. $\mathbf{X}_{it}$ is a vector of controls that includes a large number of time varying controls that can have an effect on innovation such as income per capita, life expectancy, fertility and mor-

[5] The results are robust to the use of a larger sample of OECD countries. However, the sample of countries is not constant across the aggregate and the individual datasets. Therefore, in the baseline analysis we use only the sample of 18 countries for which both the individual and the aggregate controls are available.

[6] The results remain largely intact if instead we aggregate data in 5 year intervals to absorb the potential effect of cyclical fluctuations.

tality rates, population growth, institutional quality, school enrollment, unemployment rates and gross national expenditure reflecting all sources of private and government expenditure. $\mathbf{I}_i$ is a vector of country fixed effects that captures unobserved heterogeneity at the country level, at least for time invariant characteristics such as geography or climate. $\mathbf{T}_t$ is a vector of year fixed effects aimed at capturing time specific shocks. ε_{it} is a country and time specific error term.

The analysis indicates that $\alpha_1 > 0 > \alpha_2$ so that aging has a hump-shaped on innovation.

Endogeneity Omitted variable bias and reverse causality may conflate our estimations even though we control for many sources of unobserved heterogeneity via time varying controls, country and time fixed effects.[7] To further address potential endogeneity concerns the analysis adopts two alternative strategies: i) the use of lagged values of aging to mitigate the concern of reverse causality, and ii) an IV approach.

Whereas case (i) is straightforward, case (ii) merits some discussion.

We use rates of "immunization against measles" as an instrument to address the concern of omitted variable bias. Measles is an infection of the respiratory system, immune system and skin caused by a virus (Griffin, 2007). It is a particularly contagious disease that affects primarily children but can be contaminated to anyone who has not been immunized against the disease. Interestingly, the fight against the disease is quite advanced, it can nevertheless create complications and lead to death. Crucially, the symptoms of the disease become more severe with age. The numbers are stunning. For 2011, the World Health Organization estimated that approximately 158.000 people died worldwide because of measles, whereas in 1990 this number was as high as 630.000. In developed countries 1% of people infected with measles can die because of complications of the disease whereas in developing countries the rate might become as high as 10%.[8] Treatments against measles are available, however, the best protection is immunization.

Our instrument of child immunization measures the percentage of children aged 12-23 months who received vaccinations before 12 months or at any time before the survey. A child is considered adequately immunized against measles after receiving one dose of vaccine. The data is part of the World Bank statistics. A mechanism via which our instrument affects the endogenous regressor, i.e., the effect of immunization on aging, can operate via the positive spill-overs of immunization to the overall health status of the population. If this status improves then the fraction of the old in the population, who are on average more vulnerable, tends to increase.[9] Surprisingly whereas vaccination is the best way to be protected from the

[7] The robustness section corroborates our results in a model with first-differences and in a dynamic panel analysis.

[8] WHO Factsheet: http://www.who.int/mediacentre/factsheets/fs286/en/

[9] One could think of weakening effects, however the unconditional and conditional correlation coefficients are positive.

disease, not all OECD countries impose mandatory vaccination. We build our IV strategy exploiting this variation in vaccination rates. [10]

The identifying assumption employed in our analysis is that immunization against measles, in the context of the 18 considered OECD countries between 1972-2010, is not correlated with the number of patents filed each year by residents of the respective countries. This is plausible since existing vaccination strategies are sufficiently advanced, since the 1960's, to potentially protect the total population, provided that all individuals are vaccinated. Therefore, it is very unlikely that further innovation efforts will be targeted towards improvements of measles vaccination. This argument excludes a causality running from patent to vaccination rates.

To address the concern that measles affect innovation via other indirect channels we introduce a number of time varying controls that are meant to capture this. In particular, we use life expectancy and mortality rates to control for the fact that immunization against measles could have an effect on the overall health capital of individuals and thus improve their overall records towards innovation. Moreover, we control for education to capture a potential effect of vaccination on the incentives to build human capital. Finally, we use gross national expenditure, a measure of all types of individual and government expenditure including health and education, to control for time varying resources that could absorb funds from innovation. It is hard to argue that immunization against measles is systematically correlated with any of the above factors, nevertheless controlling for them further supports the view that our IV strategy satisfies the exclusion restriction.

Therefore, we instrument for the fraction of old people using the fraction of children immunized against measles. Since the second stage is quadratic in the endogenous regressor, it is necessary for the 2SLS regressions to instrument for both the fraction of old individuals as well as its squared term. This allows the system of equations to be exactly identified. To accomplish this task we follow the two step procedure suggested by Wooldridge (2010). First, the fraction of old is regressed on the fraction of children immunized against the measles, while including all the second-stage controls. This delivers predicted (i. e., fitted) values of the fraction of the old. The predicted fraction of old individuals from the first stage is squared, and this squared term is then used as an excluded instrument in the second stage along with the instrument of rates of immunization against measles.

[10] Data on recent outbreaks of measles are quite revealing as to the negative externality of low rates of immunization. The outbreak of measles in Japan in 2007 prompted a closing of universities and other public institutions in an attempt to contain the spread of the disease. In 2008, measle epidemics have been reported in Austria, Italy, Switzerland and the UK (in the UK there were more than 1200 reported cases). Similarly in 2009, two schools in Wales were closed after an outbreak of the disease. France had 17.000 reported cases of measles between 2008 and 2011, out of which 8 cases led to death. In the US, more than 500 people die of measles every year during the last decade.

2.2 Aging and Innovation: The Channel of Culture

2.2.1 The Data

To account for the intriguing hypothesis of the previous section of the positive effect of aging on innovation, this section suggests a channel for this hypothesis. More precisely our analysis suggests that a higher fraction of the old in the society is associated with a tendency of individuals to favor new ideas. Interestingly, whereas individual age is negatively correlated with favoring new ideas, at the aggregate older societies are more willing to embrace new ideas. If this is true aging induces innovation through fostering new ideas.

To establish the results of this section we employ data from five waves of the European Social Survey (2000-2010), a cross sectional survey conducted in a number of European countries.[11] We employ the same sample of 18 OECD countries as above. We conduct a multilevel analysis where we combine aggregate and individual controls. The aggregate controls are the same as the ones used to test the first hypothesis and are taken from the World Bank. Moreover aggregated over 2-year intervals to match the intervals of the ESS dataset.

We are particularly interested in the proxies of culture towards new ideas that are available in the ESS. Respondents are given the following two statements describing some fictitious personality: i) Thinking up new ideas and being creative is important to her/him. She/he likes to do things in her/his own original way, and ii) She/he likes surprises and is always looking for new things to do. She/he thinks it is important to do lots of different things in life. Then respondents are asked to state the extend to which they feel close to either personality. To do this they have six alternatives, i.e., the person is "not like me at all", "not like me", "a little like me", "somewhat like me", "like me" and "very much like me". Then these choices are mapped into a binary variable taking the value of 0 if the response is "not like me" or "not like me at all", and the value of 1 if the response is "very much like me", "like me", "somewhat like me", "a little like me".

Moreover the ESS data provides a wide array of individual controls such as age, gender, education, employment status as well as paternal and maternal education.

2.2.2 Empirical Strategy

Then we proceed with the following sequence of estimations.

First we establish the effect of aging on cultural attitudes using the following equation:

[11] The analysis of the first section is replicated for the same period as well, i.e., 2000-2010 to match the ESS data coverage. Our results remain highly significant even after reducing the size of the sample. In the baseline analysis we report the full span of years, i.e., 1972-2010 to increase the power of our tests and to be able to employ a dynamic panel approach in the robustness section.

$$C_{jit} = \alpha_0 + \alpha_1 O_{it} + \alpha_2 O_{it}^2 + \alpha_3 \mathbf{Z}_{jit} + \alpha_4 \mathbf{X}_{it} + \alpha_5 \mathbf{I}_i + \alpha_6 \mathbf{T}_t + \varepsilon_{jit} \tag{2}$$

where C is the proxy for culture. We employ two proxies for culture, i) attitudes towards new ideas and creativity and ii) attitudes towards trying new things. These proxies reflect the properties of the fictitious personalities described in the previous paragraph. The index j denotes an individual, i its country of residence and t is an indicator of the ESS round. As before, $\mathbf{O}_{it}$ is the number of individuals above the age of 65 expressed as a fraction of the total population. $\mathbf{O}_{it}^2$ is the squared term of this fraction. $\mathbf{Z}_{jit}$ is a vector of individual characteristics such as individual age, age square, gender, education, unemployment and parental education. $\mathbf{X}_{it}$ is the same vector of aggregate (at the country level) controls that were used to estimate equation (1). $\mathbf{I}_i$ is a vector of country fixed effects that captures unobserved heterogeneity at the country level whereas $\mathbf{T}_t$ is a vector of year fixed effects aimed to capture time specific shocks. ε_{jit} is an individual, country and time specific error term.

The analysis establishes that $\alpha_1 > 0 > \alpha_2$ thereby implying that aging at the societal level fosters new ideas and more creativity.

Second, we explore whether the effect of aging on innovation operates partly via fostering new ideas. To establish this channel we employ interactive terms between individual attitudes towards culture and (aggregate) aging, i.e.

$$I_{it} = \alpha_0 + \alpha_1 O_{it} + \alpha_2 O_{it}^2 + \alpha_3 C_{jit} + \alpha_4 O_{it} * C_{jit} + \alpha_5 O_{it}^2 * C_{jit} + \alpha_6 \mathbf{Z}_{jit} + \alpha_7 \mathbf{X}_{it} + \alpha_8 \mathbf{I}_i + \alpha_9 \mathbf{T}_t + \varepsilon_{jit} \tag{3}$$

where again all elements of the equations are as described above. Interestingly, the results also indicate that $\alpha_5 > 0 > \alpha_4$. Hence, the positive effect of aging on innovation, that we established in eq. (**??**) is diminished by the presence of culture. In other words the effect of ageing on innovation operates partly through culture.

3 Empirical Results

The analysis in the preceding section suggested that population aging has a persistent positive effect on innovation, partly operating via culture. While old people produce old ideas, interestingly old societies produce novel ideas in an attempt to mitigate the adverse effect of an aging population.

In particular we advance the following three hypotheses: i) Population aging has a positive, causal effect on the number of patent applications, ii) old societies foster novel ideas, and iii) population aging affects innovation via fostering individual attitudes favorable to innovation.

3.0.3 Hypothesis I: The Impact of Aging on Innovation

This section establishes the first hypothesis, i.e. that population aging has a positive, causal effect on the number of patent applications, via exploiting variation within 18 OECD countries for the period 1971-2010. The dependent variable is the log of the number of patent applications, filed by residents, expressed in per 1000 residents terms. Column (1) explores the effect of aging while controlling for country and year fixed effects. As already discussed in the empirical implementation section, the data strongly support a non-linear effect of aging on the number of innovations, a result that is further confirmed by our empirical analysis. The estimated linear and quadratic coefficients are significant at the 1% level with the effect of aging being positive but exhibiting diminishing effects as the fraction of old increases in the society, a result that is rather plausible, suggesting that there is an upper fraction of elderly in the society, after which an older population becomes a liability and hinders innovation.

Column (2) introduces a control for income per capita, so as to capture the stage of development of the country. Despite the fact that all countries are OECD members, nevertheless they manifest significant variations in income per capita. Column (3) introduces three controls that can have a long lasting effect on the incentives of individual to invest in education and thus ultimately on their ability to innovate. These controls are mortality rate, life expectancy and fertility rates. The effect of mortality comes with the expected coefficient, i.e. high mortality rates are associated with lower innovation.

Column (4) augments the analysis with a control for population growth rate so as to capture the effects of a growing population. As already described in the introduction, population growth which has long been debated in the aging literature as one of the drivers of growth, at least for the societies that managed to properly utilize the abundant labor supply. Column (5) presents the results obtained from exploiting the combined explanatory power of the channels of institutional quality and secondary school enrollment. Whereas school enrollment has no significant effect, better institutional quality is associated with more innovation, in line with the theory suggested by Aghion et al. (2007). Finally, the results reported in Column (6), enrich the analysis with a control for gross national expenditure and unemployment. The control on expenditure captures all types of private and public consumption and expenditure as a % of GDP, including expenditure on health and education, thereby implicitly controlling for the public and private level of investment in health and education infrastructure. The control of unemployment is aimed to capture the fact that aging societies quite often trigger the participation of women in the labor force in an attempt to mitigate the lack of resources.

Reassuringly all our results suggest a significant effect of aging on innovation, whereas our coefficients increase in magnitude with the addition of new controls and remain relatively stable in Columns (5) and (6). The coefficients on the linear and quadratic terms of aging in

Column (6), which employs the full set of controls, suggest that an 1% increase in the fraction of old in the population is associated with an 20% increase in the number of patents per 1000 residents.

IV Estimates The findings in Table 2, after controlling for a large number of time varying controls as well as time and country invariant characteristics, indicate that the results are not merely reflecting the possible influence of some unobserved country-specific attributes. The finding that aging possess a significant hump-shaped relationship with innovation appears to be quite robust. Nevertheless, to further mitigate potential concerns about endogeneity, this section employs an IV approach. As already described in the empirical implementation section , the instrument employed is the fraction of the children aged 1-3 immunized against measles, as well as the predicted value of the fraction of old, as it emerges from the zeroth stage.

Column (1) reports against the OLS results to facilitate comparability. Columns (2) and (3) present the results from the first stage regression (reported in the upper part of the table) which suggest that immunization against measles has a positive and statistically significant effect on the log of the fraction of old people, for both the linear and the quadratic terms.

Column (4) presents the results of the second stage of the 2SLS. The dependent variable of the baseline analysis, i.e. the log of the fraction of the number of patents per 1000 inhabitants, is regressed on the linear and the quadratic term of the log of the fraction of old and the full set of controls that have been employed in the baseline analysis. Reassuringly the effect of both the linear and the quadratic coefficients of aging on patents remains hump-shaped and statistically significant at the 1% level whereas the coefficients remain similar in magnitude. Reassuringly, the weak identification test suggests that we can reject the null of weak identification.

To summarize, the results presented in Tables 1 and 2 demonstrate that the log of the fraction of old in the society has a hump-shaped relationship with the log of the number of patents filed by residents. This non-monotonic relationship prevails even after controlling for a large number of time varying controls that confer a statistically significant effect on innovation as well as after controlling for time and country fixed effects. Moreover when addressing the issue of potential endogeneity employing an IV approach the results become stronger, which is reassuring as to the validity of the inference made in the main body of the empirical analysis. The following sections attempt to explore the channels via which aging generates this intriguing effect on innovation.

Table 1: Hypothesis I: The Effect of Aging on Innovation

	(1)	(2)	(3)	(4)	(5)	(6)
			Dep. Var.: Log Patents per 1000 Residents			
Log % of Old Above 65	31.490***	31.402***	32.314***	31.782***	31.683***	29.141***
	(8.550)	(8.654)	(8.835)	(8.959)	(9.102)	(7.903)
Log % of Old Above 65 Square	-5.538***	-5.528***	-5.579***	-5.490***	-5.470***	-5.119***
	(1.620)	(1.631)	(1.626)	(1.649)	(1.686)	(1.543)
Log Income per Capita		0.158	-0.259	-0.171	-0.387	-0.367
		(1.266)	(0.784)	(0.785)	(0.799)	(0.782)
Mortality Rate			-0.029***	-0.029***	-0.028***	-0.029***
			(0.009)	(0.009)	(0.009)	(0.008)
Life Expectancy			-0.292*	-0.286*	-0.341**	-0.283**
			(0.151)	(0.146)	(0.152)	(0.122)
Fertility Rate			0.077	0.109	0.266	0.164
			(0.222)	(0.208)	(0.250)	(0.244)
Population Growth Rate				-0.069	-0.041	-0.064
				(0.152)	(0.141)	(0.145)
School Enrollment					0.035	0.041
					(0.099)	(0.092)
Institutional Quality					0.017*	0.014
					(0.009)	(0.010)
Gross National Expenditure						-0.009
						(0.018)
Unemployment Rate						0.020
						(0.015)
Country Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
No of Countries	18	18	18	18	18	18
R-squared	0.279	0.280	0.374	0.375	0.392	0.418

Summary: This table establishes that population aging is positively correlated with innovation. The analysis controls for log income per capita, life expectancy, fertility and mortality rates, population growth, institutional quality, school enrollment, unemployment rates, gross national expenditure. as well as unobserved time and country fixed effects.

Notes: (i) Ageing is captured by the fraction of individuals above the age of 65; (ii) innovations are measured as the number of patent applications filed by residents per 1000 residents; (iii) standard errors are clustered at the country level and robust and clustered estimates are reported in parentheses; (iv) *** denotes statistical significance at the 1 percent level, ** at the 5 percent level, and * at the 10 percent level, all for two-sided hypothesis tests.

Table 2: Hypothesis I: The Effect of Aging on Innovation-IV Estimates

	(1)	(2)	(3)	(4)
	OLS	First Stage		2SLS
		Dependent Variable is:		
	Log Patents	Log % Old Ab 65	Log % Old Ab. 65 Sq.	Log Patents
Immun. Measles		0.001***	0.010***	
		(0.001)	(0.003)	
Log % Old Ab. 65 Sq. Pr		0.019	1.089*	
		(0.118)	(0.593)	
Log % Old Ab. 65	29.141***			30.787***
	(7.903)			(6.466)
Log % Old Ab. 65 Sq.	-5.119***			-5.482***
	(1.543)			(1.092)
Country-Year FE	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes
No of Countries	18	18	18	18
R-squared	0.418	0.626	0.617	0.419

Summary: This table establishes a causal effect from population ageing to higher levels of innovation, after conducting an IV analysis. The fraction of children aged 1-3 which are immunized against measles is used to instrument for the fraction of old. The first and second stage analysis controls for log income per capita, life expectancy, fertility and mortality rates, population growth, institutional quality, school enrollment, unemployment rates, gross national expenditure. as well as unobserved time and country fixed effects.

Notes: (i) Aging is captured by the fraction of individuals above the age of 65; (ii) innovations are measured as the number of patent applications filed by residents per 1000 residents; (iii) standard errors are clustered at the country level and robust and clustered estimates are reported in parentheses; (iv) *** denotes statistical significance at the 1 percent level, ** at the 5 percent level, and * at the 10 percent level, all for two-sided hypothesis tests.

3.0.4 The Channel of Culture

The empirical findings of the previous section were rather unexpected and at first sigh counter intuitive. What one would anticipate to be the dominating force in an aging society would be less innovation. Interestingly though our empirical findings which are robust to a number of alternative specifications suggest the opposite. This section attempts to provide one potential interpretation for this interesting result and argues that the effect of aging on innovation operates partly via affecting cultural attitudes towards innovation.

Hypothesis II: Do Old Societies Trigger Novel Ideas? Before explicitly exploring the channel of culture one needs to illustrate that an aging population indeed fosters new ideas. In this part of the analysis we employ the ESS sample of 118.307 individuals residing in the same 18 countries that we employ in the macro part of the analysis. Table 3 illustrates that whereas individual age is negatively correlated with attitudes conducive to new ideas and creativity, nevertheless the fraction of the old in the society manifests a hump-shaped correlation with propensity towards new ideas and creativity, potentially reflecting a general equilibrium effect.

Analytically, Column (1) of Table 3 employs as the dependent variable individual attitudes toward new ideas and creativity. This is a binary variable with 0 denoting negative attitudes towards new ideas and 1 denoting positive attitudes towards new ideas. The analysis controls only for country and ESS round fixed effects. The coefficient of the linear and the quadratic term are both highly significant thereby suggesting the presence of the hump-shaped effect. Column (2) introduces individual controls such as individual age, age squared, gender, educational level, employment status and parental educational level. Interestingly the linear and quadratic coefficient on individual age are highly significant and come with the opposite coefficient, thereby implying a U shaped effect of individual age on economic outcomes. This results is rather interesting and confirm that whereas old people come up with old ideas, on the contrary aging societies come up with novel ideas, perhaps as a survival strategy in order to mitigate the externality imposed by the presence of the old.

Column (3) introduces the full set of country controls that were use in the reduced form equation. Due to space limitation we report only the coefficients for the linear and quafratic aging terms. In line with out hypothesized effect of population aging, whereas individual age retains its significance and exerting a negative effect on innovation attitudes, nevertheless population aging has a hump-shaped effect on innovation and creativity attitudes. Finally Column (4) replicates the analysis using an alternative proxy for individual attitudes conducive to innovation, e.g. attitudes towards trying new and different things, while controlling for the full set of individual and aggregate controls. The results remain very similar.[12]

[12] Since the cultural variables are binary we conducted as robustness a probit estimation. The results remain quite similar.

To sum up, the main intuition learned from Table 3 is that whereas old people come up with old ideas, on the contrary aging societies can trigger novel ideas. This finding is rather interesting and paves the way for a channel via which aging and in particular a large fraction of people who do not actively participate in the production process can confer a significant hump-shaped effect on innovation.

Hypothesis III: Does Aging Affect Innovation via Culture? Table 4 establishes the last hypothesis of the paper, i.e. that the effect of an aging population on innovation operates partly via culture. To capture this channel we interact both the linear and the quadratic term with the binary variable that captures individual attitudes towards innovation. Column (1) regresses log patents per 1000 residents on the linear and the quadratic terms of the fraction of old, on the individual attitudes towards new ideas and creativity, as well as the interaction of the culture variable with both the linear and the quadratic term of aging. The results suggest that aging always manifests a hump-shaped correlation with the number of patents. The coefficients of the linear and the quadratic interaction terms are respectively negative and significant. The way to interpret this result is that the positive effect of aging on innovation is suppressed by the presence of cultural attitudes that are conducive to innovation, due to the fact that part of the effect of aging operates through culture. The coefficient on cultural attitudes become negative once we include the interactive term however this should not be interpreted as a negative effect of culture on innovation, since this is the partial effect only in the case where the fraction of the old in the society is equal to zero. To learn about the true partial effect of culture on innovation we should run the regressions without the interactive terms.

Similarly, Column (2) uses the alternative proxy for innovation, i.e. individual attitudes towards trying new and different things and the results remain quite similar.

The analysis in Table 4 completes and empirically establishes the line of thinking that was advanced throughout the sections of the paper. More analytically, it re-establishes , using a micro data sample, that a higher fraction of an again population is associated with higher levels of innovation. One could think many channels via which this operates. In our analysis we focus on the cultural channel and we show that a higher fraction of old people is associated with the emergence of ideas variable towards innovation which in turn fosters innovation itself. Consequently, one we explore the interactive terms we find that the hump-shaped effect of the old on innovation is mitigated by the effect of culture on innovation, since aging partly operates through culture. This interpretation is rather intuitive and can plausibly explain

Table 3: Hypothesis II: The Effect of Population Aging on Individual Attitudes towards Innovation

	(1)	(2)	(3)	(4)
	New Ideas and Creativity			New and Diff. Things
Log % of Old Above 65	61.203***	65.664***	52.166***	48.570***
	(6.745)	(6.483)	(11.856)	(14.416)
Log % of Old Above 65 Square	-30.698***	-32.919***	-26.188***	-24.449***
	(3.372)	(3.241)	(5.936)	(7.243)
Individual Age		-0.002***	-0.002***	-0.004***
		(0.000)	(0.000)	(0.000)
Individual Age Sq.		0.000***	0.000***	0.000***
		(0.000)	(0.000)	(0.000)
Country-Year Fixed Effects	Yes	Yes	Yes	Yes
Gender	No	Yes	Yes	Yes
Education	No	Yes	Yes	Yes
Employment	No	Yes	Yes	Yes
Parental Education	No	Yes	Yes	Yes
Country Controls	No	No	Yes	Yes
No of Countries	18	18	18	18
Observations	118307	118307	118307	118307
R-squared	0.011	0.041	0.041	0.058

Summary: This table establishes that whereas old individuals tend to favor old ideas, nevertheless "old" societies foster novel ideas and higher creativity. The analysis controls for the full set of individual controls such as age, age square, gender, education, unemployment and parental education as well as for the aggregate (country level) controls, i.e. log income per capita, life expectancy, fertility and mortality rates, population growth, institutional quality, school enrollment, unemployment rates, gross national expenditure. It also controls for unobserved ESS round and country fixed effects.

Notes: (i) Aging is captured by the fraction of individuals above the age of 65; (ii) innovations are measured as the number of patent applications filed by residents per 1000 residents; (iii) New Ideas refers to the statement "Thinking up new ideas and being creative is important to her/him." The variable takes the value 0 if the individual disagrees with the statement and 1 otherwise; (iv) New and Diff things refers to the statement " She/he likes surprises and is always looking for new things to do. She/he thinks it is important to do lots of different things in life". The variable takes the value 0 if the individual disagrees with the statement and 1 otherwise; (v) standard errors are clustered at the country level and robust and clustered estimates are reported in parentheses; (vi) *** denotes statistical significance at the 1 percent level, ** at the 5 percent level, and * at the 10 percent level, all for two-sided hypothesis tests.

Table 4: Hypothesis III: The Effect of Population Aging on Innovation-The Channel of Culture

	(1)	(2)
	Dep. Var.: Log Patents per 1000 Res.	
Log % of Old Above 65	689.729***	686.920***
	(160.548)	(160.948)
Log % of Old Above 65 SQ	-345.704***	-344.279***
	(80.571)	(80.773)
New Ideas and Creativity	-0.291***	
	(0 .085)	
New and Different Things		-0.1647
		(0.059)
Log % of Old Ab 65 x New Ideas/Creat.	-9.188	
	(3.822)	
Log % of Old Ab. 65 Sq x New Ideas/Creat.	4.643	
	(1.923)	
Log % of Old Ab. 65 x New/Diff. Things		-5.007
		(2.175)
Log % of Old Ab. 65 Sqx New/Diff. Things		2.532
		(1.096)
Country-Year Fixed Effects	Yes	Yes
Country Controls	Yes	Yes
Age	Yes	Yes
Age Square	Yes	Yes
Gender	Yes	Yes
Education	Yes	Yes
Employment	Yes	Yes
Parental Education	Yes	Yes
No of Countries	21	21
Observations	118307	118307
R-squared	0.973	0.975

Summary: This table establishes that the effect of population ageing on innovation operates partly via culture. The analysis controls for the full set of individual controls such as age, age square, gender, education, unemployment and parental education as well as for the aggregate (country level) controls, i.e. log income per capita, life expectancy, fertility and mortality rates, population growth, institutional quality, school enrollment, unemployment rates, gross national expenditure. It also controls for unobserved ESS round and country fixed effects.

Notes: (i) Ageing is captured by the fraction of individuals above the age of 65; (ii) innovations are measured as the number of patent applications filed by residents per 1000 residents; (iii) New Ideas refers to the statement "Thinking up new ideas and being creative is important to her/him." The variable takes the value 0 if the individual disagrees with the statement and 1 otherwise; (iv) New and Diff things refers to the statement " She/he likes surprises and is always looking for new things to do. She/he thinks it is important to do lots of different things in life". The variable takes the value 0 if the individual disagrees with the statement and 1 otherwise; (v) standard errors are clustered at the country level and robust and clustered estimates are reported in parentheses; (vi) *** denotes statistical significance at the 1 percent level, ** at the 5 percent level, and * at the 10 percent level, all for two-sided hypothesis tests.

how a group that does not participate in the production process can have such a strong effect on innovation.

4 Robustness

4.0.5 Hypothesis I: The Impact of Aging on Innovation

This section establishes the robustness of the reduced form hypothesis, i.e. to the effect of aging on innovation, to a number of alernative specifications.

4.0.6 First Differences Model

Column (1) of Table 5 replicates the results of Column (1) in Table 2 simply to facilitate the illustration. Column (2) uses a first differences model instead of a fixed effects model. The results remain largely intact with the coefficient reducing somewhat in magnitude. Column (3) uses an alternative measure of aging, i.e. the old-age dependency ratio, i.e. the number of people above 65 as a fraction of the working age population. The analysis yields different magnitudes of coefficients, which however are comparable to the previous results once quadratic terms are accoutned for, and importantly the old-age dependency ratio has a hump-shaped correlation with hte number of patents. Column (4) replicates the analysis in Column (3) using a first differences model, whereas Column (5) adopts an IV apporach and uses the same instruments as in Table 2. The results are robust to all robustness checks.

4.0.7 Dynamic Panel

Table 6 estimates a dynamic panel model. Whereas the coexistence of country effects and of lagged values of the dependent variable may yield inconsistent estimates, nevertheless the bias reduces in magnitude and ultimately becomes negligible as the time dimension reaches infinity (Nickell, 1981). Moreover (Judson and Owen, 1999) estimations suggest that when $t = 20$ the bias on the lagged dependent variable is aroung 2-3 % and this number and it drops to 1-2% for $t = 30$.

that the bias on the lagged dependent variable is around 1 to 2 percent of the true coefficient value.

In Column (1) we estimate an autoregressive specification while controlling for the full set of controls including year and country fixed effects. Column (2) replicates the analysis of Column (1) estimating a first differences model. The estimated coefficients on the linear and quadratic terms of aging retain their significance at the 1% level and confirm the presence

Table 5: Hypothesis I: Robustness Checks-First Differences

	(1)	(2)	(3)	(4)	(5)
	Dep. Var.: Log Patents per 1000 Residents				
Log % of Old Above 65	29.141***				
	(7.903)				
Log % of Old Ab. 65 Square	-5.119***				
	(1.543)				
Diff. Log % of Old Above 65		22.347***			
		(5.336)			
Diff. Log % of Old Ab.65 Sq.		-4.136***			
		(1.159)			
Log % of Old Age Dep,			9065.936***		10075.4***
			(2066.727)		(2330.512)
Log % of Old Age Dep.			-4533.687***		-5038.448***
			(1033.917)		(1165.343)
Diff. Log % of Old Age Dep.				8555.936***	
				(2083.634)	
Diff. Log % of Old Age Dep.				(-4278.251)***	
				(1042.62)	
Country Fixed Effects	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes
No of Countries	18	18	18	18	18
R-squared	0.421	0.032	0.419	0.035	0.482

Summary: This table establishes that the first hypothesis, i.e. that population ageing is positively correlated with innovation is robust to alternative specifications, i.e. to the use of alternative ageing measures and to the use of a first differences model. The analysis controls for the full set of controls as well as time and country specific fixed effects.

Notes: (i) Ageing in Columns (1) and (2) is captured by the fraction of individuals above the age of 65 ; (ii) ageing in Columns (3)-(6) is captured by the old age dependeny ratio, i.e. the number of individuals above 65 as a fraction of the working age population ; (iii) innovations are measured as the number of patent applications filed by residents per 1000 residents; (iv) standard errors are clustered at the country level and robust and clustered estimates are reported in parentheses; (v) *** denotes statistical significance at the 1 percent level, ** at the 5 percent level, and * at the 10 percent level, all for two-sided hypothesis tests.

Table 6: Hypothesis I: Robustness Checks-Dynamic Panel

	(1)	(2)	(3)	(4)
		Dep. Var.: Log Patents per 1000 Residents		
Log % of Old Above 65	21.085***			
	(4.235)			
Log % of Old Above 65 Sq.	-3.727***			
	(0.865)			
Diff. Log % of Old Above 65		22.552***		
		(5.386)		
Diff. Log % of Old Ab. 65 Sq.		-4.144***		
		(1.148)		
Log % of Old Age Dep.			8910.98***	
			(1622.693)	
Log % of Old Age Dep.			(-4456.125)***	
			(811.718)	
Diff. Log % of Old Age Dep.				8113.132***
				(2069.564)
Diff. Log % of Old Age Dep.				-4057.328***
				(1035.365)
Country Fixed Effects	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes
No of Countries	18	18	18	18
R-squared	0.596	0.039	0.591	0.035

Summary: This table establishes that the first hypothesis, i.e. that population ageing is positively correlated with innovation is robust to alternative specifications, i.e. to the use of dynamic panel data analysis and first differences model. The analysis controls for the full set of controls as well as time and country specific fixed effects.

Notes: (i) Aging in Columns (1) and (2) is captured by the fraction of individuals above the age of 65 ; (ii) ageing in Columns (3) and (4) is captured by the old age dependeny ratio, i.e. the number of individuals above 65 as a fraction of the working age population ; (iii) innovations are measured as the number of patent applications filed by residents per 1000 residents; (iv) standard errors are clustered at the country level and robust and clustered estimates are reported in parentheses; (v) *** denotes statistical significance at the 1 percent level, ** at the 5 percent level, and * at the 10 percent level, all for two-sided hypothesis tests.

of a hump-shaped effect. Columns (3) and (4) replicate the results in Columns (1) and (2) respectively using the old age dependency ratio instead.

4.0.8 Reverse Causality

Table 7 further addresses the issue of reverse causality by using lagged values of aging. Column (1) employs as the explanatory variable the fraction of old in the society, whereas Column (2) uses the old age dependency ratio. Our findings strongly confirm the presence of a hump-shaped effect.

Table 7: Hypothesis I: Robustness Checks-Reverse Causality

	(1)	(2)
	Dep. Var.: Log Patents per 1000 Residents	
Lagged Log % of Old Above 65	18.950***	
	(4.724)	
Lagged Log % of Old Above 65 Square	-3.307***	
	(1.012)	
Lagged Log % of Old Age Dependency		777.582***
		(182.976)
Lagged Log % of Old Age Dependency		-389.222***
		92.034
Country Fixed Effects	Yes	Yes
Year Fixed Effects	Yes	Yes
Controls	Yes	Yes
No of Countries	18	18
R-squared	0.433	0.458

Summary: This table establishes that the first hypothesis, i.e. that population ageing is positively correlated with innovation is robust to further mitigating reverse causality concerns, i.e., to the use of lagged values of the aging variables. The analysis controls for the full set of controls as well as time and country specific fixed effects.

Notes: (i) Aging in Column (1) is captured by the fraction of individuals above the age of 65 ; (ii) ageing in Column (2) is captured by the old age dependeny ratio, i.e. the number of individuals above 65 as a fraction of the working age population ; (iii) innovations are measured as the number of patent applications filed by residents per 1000 residents; (iv) standard errors are clustered at the country level and robust and clustered estimates are reported in parentheses; (v) *** denotes statistical significance at the 1 percent level, ** at the 5 percent level, and * at the 10 percent level, all for two-sided hypothesis tests.

Table 8: Hypothesis I: Robustness Checks-Full Sample

	(1)	(2)	(3)
	Dep. Var.: Log Patents per 1000 Residents		
Lagged Log % of Old Above 65	8.481**	18.444***	11.3586***
	(3.979)	(6.652)	(4.288)
Lagged Log % of Old Above 65 Sq.	-1.510*	-2.977***	-2.210***
	(0.793)	(1.034)	(0.889)
Country Fixed Effects	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes
Controls	Yes	Yes	Yes
No of Countries	29	29	29
R-squared	0.339	0.239	0.046

Summary: This table establishes that the first hypothesis, i.e. that population ageing is positively correlated with innovation is robust to the use of the full sample of OECD countries, i.e., 29 countries for the period 1972-2010. The analysis controls for the full set of controls as well as time and country specific fixed effects.

Notes: (i) Aging is captured by the fraction of individuals above the age of 65 ; (ii) innovations are measured as the number of patent applications filed by residents per 1000 residents; (iii) standard errors are clustered at the country level and robust and clustered estimates are reported in parentheses; (iv) *** denotes statistical significance at the 1 percent level, ** at the 5 percent level, and * at the 10 percent level, all for two-sided hypothesis tests.

4.0.9 Full Sample of OECD Countries

Table 8 illustrates the results for the full sample of OECD countries for which all controls are available. Overall, the full sample coprises 29 OECD countries for the period 1982-2010. Column (1) replicates the OLS results, Column (2) reports the IV estimates, using the same instrument as in the baseline analysis, whereas Column (3) reports the coefficients from estimating a first differences model. Our findings strongly confirm the presence of a hump-shaped effect of aging on innovations.

5 Concluding Remarks

This paper empirically establishes the hypothesis that older societies tend to innovate more. We account for this intriguing finding by highlighting the cultural aspects of an aging society. We establish that whereas individuals tend to favor old ideas as they grow older, nevertheless aging societies tend to favor novel ideas and foster creativity. This result highlights an aspect of aging that has been largely ignored so far, i.e. the cultural dimensions of aging societies. More importantly we show that this effect on individual attitudes ultimately results to larger innovation thereby suggesting that the effect of aging on innovation partly operates through culture.

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Appendices

A Variable Definitions and Sources

World Bank Data

Patent Applications. Patent applications are worldwide patent applications filed through the Patent Cooperation Treaty procedure or with a national patent office for exclusive rights for an invention–a product or process that provides a new way of doing something or offers a new technical solution to a problem. A patent provides protection for the invention to the owner of the patent for a limited period, generally 20 years.

Fraction of Old above 65. Fraction of old is measured as the number of people above the age of 65 as a fraction of the total population. The quadratic term is the squared term of the fractino of old.

GDP per Capita. GDP at purchaser's prices is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products. It is calculated without making deductions for depreciation of fabricated assets or for depletion and degradation of natural resources. Data are in constant 2005 U.S. dollars. Dollar figures for GDP are converted from domestic currencies using 2000 official exchange rates.

Fertility Rates. Total fertility rate represents the number of children that would be born to a woman if she were to live to the end of her childbearing years and bear children in accordance with current age-specific fertility rates.

Life Expectancy. Life expectancy at birth indicates the number of years a newborn infant would live if prevailing patterns of mortality at the time of its birth were to stay the same throughout its life.

Mortality Rate. Adult mortality rate is the probability of dying between the ages of 15 and 60–that is, the probability of a 15-year-old dying before reaching age 60, if subject to current age-specific mortality rates between those ages. The reported values is the mean mortality rate for men and women.

Population Growth. Population growth (annual %) is the exponential rate of growth of midyear population from year t-1 to t, expressed as a percentage.

School Enrolment. Gross enrolment ratio. Secondary. All programmes. Total is the total enrollment in secondary education, regardless of age, expressed as a percentage of the population of official secondary education age. GER can exceed 100% due to the inclusion of over-aged and under-aged students because of early or late school entrance and grade repetition.

Gross National Expenditure. Gross national expenditure (formerly domestic absorption) is the sum of household final consumption expenditure (formerly private consumption), general government final consumption expenditure (formerly general government consumption), and gross capital formation (formerly gross domestic investment). Data are expressed as a % of GDP.

Unemployment. Unemployment refers to the share of the labor force that is without work but available for and seeking employment. Definitions of labor force and unemployment differ by country.

Measles Immunization. Child immunization measures the percentage of children ages 12-23 months who received vaccinations before 12 months or at any time before the survey. A child is considered adequately immunized against measles after receiving one dose of vaccine.

ESS Data

New Ideas and Creativity. Respondents are given the following statement describing some ficticious personality: "Thinking up new ideas and being creative is important to her/him. She/he likes to do things in her/his own original way". Then respondents are asked to state the extend to which they feel close to either personality. To do this they have six alternatives, i.e., the person is "not like me at all", "not like me", "a little like me", "somewhat like me", "like me" and "very much like me". Then these choices are mapped into a binary variable taking the value of 0 if the response is "not like me" or "not like me at all", and the value of 1 if the response is "very much like me", "like me", "somewhat like me", "a little like me".

New Things/ Own Way. Respondents are given the following statement describing some ficticious personality: "TShe/he likes surprises and is always looking for new things to do. She/he thinks it is important to do lots of different things in life.". Then respondents are asked to state the extend to which they feel close to either personality. To do this they have six alternatives, i.e., the person is "not like me at all", "not like me", "a little like me", "somewhat like me", "like me" and "very much like me". Then these choices are mapped into a binary variable taking the value of 0 if the response is "not like me" or "not like me at all", and the value of 1 if the response is "very much like me", "like me", "somewhat like me", "a little like me".

Age. The age of the respondent.

Gender. The gender of the respondent.

Employment Status. A binary variable taking the value 1 if the individual is employed and 0 otherwise.

Level of Education. The higher level of education attained by the respondent. The questionnaire distinguishes seven different levels of education (less than lower secondary, lower secondary, lower tier upper secondary, upper tier upper secondary, advanced vocational, lower tertiary BA level, higher tertiary > MA level).

Paternal and Maternal Educational Level. The higher level of education attained by the respondents' father and mother. The questionnaire distinguishes seven different levels of education (less than lower secondary, lower secondary, lower tier upper secondary, upper tier upper secondary, advanced vocational, lower tertiary BA level, higher tertiary > MA level).