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ABSTRACT

This paper re-examines the relationship between population aging and economic growth. We confirm previous research such as Cutler, Poterba, Sheiner, and Summers (1990) and Acemoglu and Restrepo (2017) that show positive correlation between measures of population aging and per-capita output growth. Our contribution is demonstrating that this relationship breaks down when the adjustment of interest rates is inhibited by an effective lower bound on nominal rates as took place during the Great Financial Crisis decade. Indeed, during the "secular stagnation regime" of 2008-2015 that prevailed in a number of countries, aging had a negative impact on living standards, consistent with the secular stagnation hypothesis.

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A data appendix is available at http://www.nber.org/data-appendix/w24902

1. Introduction

Over the last few decades a considerable literature has emerged focusing on the role of demographic change on growth. This is not surprising. An American woman reaching a childbearing age in 1960 would expect 3.6 children; an identical woman would expect 1.9 children in 1990. Today this number stands at 1.8. Moreover, this is not only a US phenomenon, but a worldwide one, and is tightly connected with growing pessimism about future potential growth rates. At the same time life expectancy has increased considerably. The population is aging.

Cutler, Poterba, Sheiner, and Summers (1990, hereafter CPSS) identify aging as having at least three effects on output per capita. 1) It reduces the fraction of active workers in the population thereby reducing output per capita, 2) it can increase capital per worker via capital deepening potentially offsetting the first effect, and 3) it can induce a positive technical change due to a relative labor force scarcity that triggers labor saving and technological innovation thus increasing total factor productivity (TFP) that also may offset 1).

At the most basic intuitive level, and this is prevalent in the popular discussion, one might think that the first force is of primary importance. Clearly, as the population ages, there are relatively fewer members of the population that are part of the active workforce. Hence, holding other factors of production fixed, and treating technology as exogenous, one should expect a decline in GDP growth per capita of a gradually aging economy.

As suggested by CPSS, however, one can make a theoretical argument supporting the opposite conclusion via 2) and 3), moreover CPSS present some empirical evidence in support of 2) and 3) being generally dominant. More recently, Acemoglu and Restrepo (2017, hereafter AR) present additional empirical evidence suggesting that aging across countries is indeed NOT associated with a decline in output growth per capita contrary to the popular perception. If anything the opposite applies under variety of empirical specifications. The evidence AR introduce is based upon a positive correlation between the increase of the ratio of old to young people and per-capita output growth post 1990. Their explanation of this phenomenon is 3).

AR and CPSS 3) basic argument dates back at least to Habakkuk (1962). He argued that incentives to innovate are strongest when labor is scarce relative to other factors of production, suggesting that industrialization proceeded faster in America than in England in the 19th century because attractive agricultural opportunities raised the price of labor in the US relative to in England. Later Clarke and Summers (1980) amplified and qualified this argument while Romer (1990) incorporated it into an endogenous growth model. AR provide an alternative model and connect this force with increasing atomization starting in 1990.

AR interpret their empirical evidence as contradicting the so-called secular stagnation hypothesis (see Summers (2013, 2014) or Eggertsson and Mehrotra (2014)) because the secular stagnation hypothesis is often tied to aging as one explanatory force, while the secular stagnation itself is a story about sub-par output growth. Here we revisit AR evidence and argue the opposite, i.e., we argue that the AR empirical evidence support the secular stagnation hypothesis rather than contradicting it.

Essentially, our argument boils down to two central points.

First, in order to explain that aging is correlated with higher output growth per capita one does not need to assume that labor scarcity leads to improvement in TFP as in 3). Instead, as stressed in CPSS, another natural explanation is that aging is coupled with capital deepening as in 2) associated with lower full employment real interest rates. Interest rates have been continuously declining since 1990 consistent with this explanation. Alone, we will see, this effect can theoretically be strong enough to explain the patterns observed in the data, and we use cross country empirical evidence to argue that this mechanism played an important role.

The second point, which is perhaps more interesting and novel to most readers, relates to the connection of the underlying empirical evidence to the secular stagnation hypothesis. Implicit in 2) is the assumption that the real interest rate can flexibly adjust downwards so as to accommodate capital deepening. The point of the secular stagnation hypothesis is that interest rates cannot always adjust downwards, for example, due to the zero lower bound (ZLB) on nominal interest rates. The main prediction of the secular stagnation hypothesis, thus, is that those countries that were aging faster in 2008, and experiencing low inflation, should have had larger "excessive savings", on average, and thus experience a deeper recession post 2008 *if they hit the ZLB*. We show that this prediction of the secular stagnation hypothesis is supported in cross country data and is statistically significant. We elaborate on this result by considering various estimation techniques beyond a basic regression.

The paper proceeds as follows. Section 2 shows the key empirical result looking at raw cross country correlations. The focus of this section is that aging has positive effect on output growth per capita prior to 2008 and reverses sign in the period after for those countries that hit the ZLB. The proposed mechanism operates via capital deepening and lower real interest rates. We show supportive evidence that aging has in fact triggered more accumulation of capital prior to 2008 using cross country evidence on capital accumulation, consistent with our hypothesis. Similarly, we show evidence that for countries that hit the ZLB the correlation switches sign, and aging start having negative effect on capital accumulation. Section 3 shows that our results are robust to introducing a variety of controls, such as regional dummies, and to implementing an IV regression approach suggested by AR. Section 4 presents a minimalistic and stripped down general equilibrium model that shows how the empirical findings can be interpreted in the context of the secular stagnation hypothesis. The model features two stark "regimes". The first is a "neoclassical regime" in which the economy operates according to the standard neoclassical logic and aging triggers capital deepening, i.e. real interest rate is able to flexibly adjust. The other is a "Keynesian regime" in which the neoclassical adjustment is prevented by the ZLB, predicting a reversal in the correlation between aging and output growth and capital deepening, consistent with the cross country evidence we show in section 2 and 3. A key contribution of this section is a minimalistic formalization of the secular stagnation hypothesis that is rich enough to speak to the new evidence. Section 5 concludes.

2. Main Empirical Results

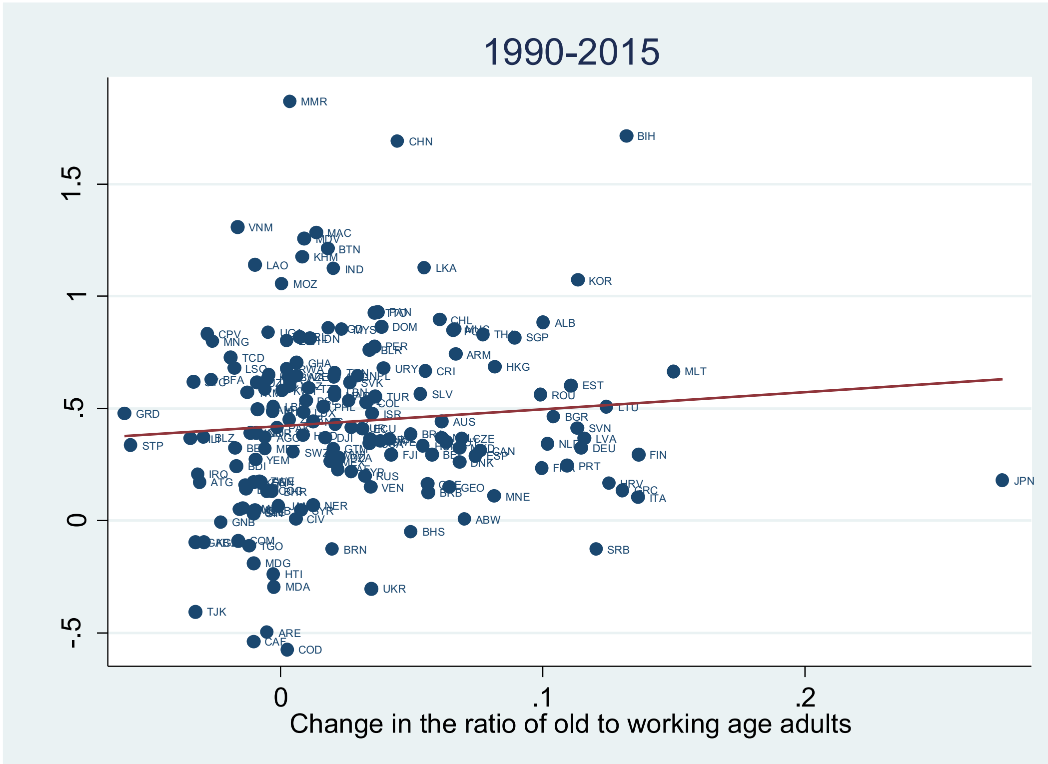

***Figure 1A**: Aging and annual GDP growth in the period 1990-2015*

Figure 1B and 1C: Panel B - *Growth and Aging pre ZLB episode (1990-2008), and Panel B - post crisis (2008-2015)*

In this section we show the key correlations before turning to various robustness checks and controls. The data we use is GDP and capital stock per capita from Penn World Table. Aging data is from the United Nations. Data on risk-free nominal interest rate was obtained from IMF International Financial Statistics Database (IFS).

Figure 1A shows a scatterplot of 168 countries plotting change in aging against GDP growth. The measure of aging is the change in the ratio of those above 65 to those between 20-65. The measure of growth is the change in (log) GDP per capital from 1990-2015. The figure plots an ordinary least square regression line. Table 1, column (1), shows that the slope is positive, suggesting a weakly positive relationship between aging and growth, as documented in Acemoglu and Restrepo (2017). We justify this aging measure, and consider alternatives, in the next sub-section along with several robustness tests.

Figure 1B and 1C show the same correlation but splitting the sample in half, before and after 2008. It shows aging from 1990-2008 relative to output growth during this period in 1B and from 2008-2015 in 1C. In 2008 several countries hit the zero lower bound. Table 1, Panel A, column (2) and (3) show respectively that the regression line becomes steeper in the period prior to 2008, and switches sign post 2008. In contrast to Figure 1A the regressions are now statistically significant.

Table 1: Estimates of the impact of aging on GDP and capital per capita: old > 65 years

Panel A: Estimates of the impact of aging on GDP per capita

	(1)	(2)	(3)	(4)	(5)
	1990-2015	1990-2008	2008-2015	≈ ZLB	≠ZLB
Change of the ratio of old to young	0.758	1.890*	-1.971***	-2.315**	-1.070
	(0.666)	(0.972)	(0.518)	(1.035)	(0.983)
Observations	168	168	168	44	126
R-squared	0.008	0.031	0.062	0.129	0.008

Panel B: Estimates of the impact of aging on Capital per working age adult (age 20-65)

	(1)	(2)	(3)	(4)	(5)
	1990-2015	1990-2008	2008-2015	≈ ZLB	≠ZLB
Change of the ratio of old to young	3.739***	4.980***	-0.373	-1.240	1.280
	(0.787)	(0.937)	(0.514)	(0.840)	(1.036)
Observations	168	168	168	44	126
R-squared	0.104	0.147	0.002	0.053	0.006

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 1, Panel A column (4), presents the same regression as in Figure 1C for those countries that were constrained by the ZLB during 2008-2015 in comparison with those that were not (column (5)). As the table makes clear, it is the ZLB countries that are driving the negative and statistically significant slope reported in Figure 1C. We define countries as having been constrained by the ZLB if the short-term nominal interest rate was below 1.5% at any point during this period. We consider alternative cut-off criteria in the next section.

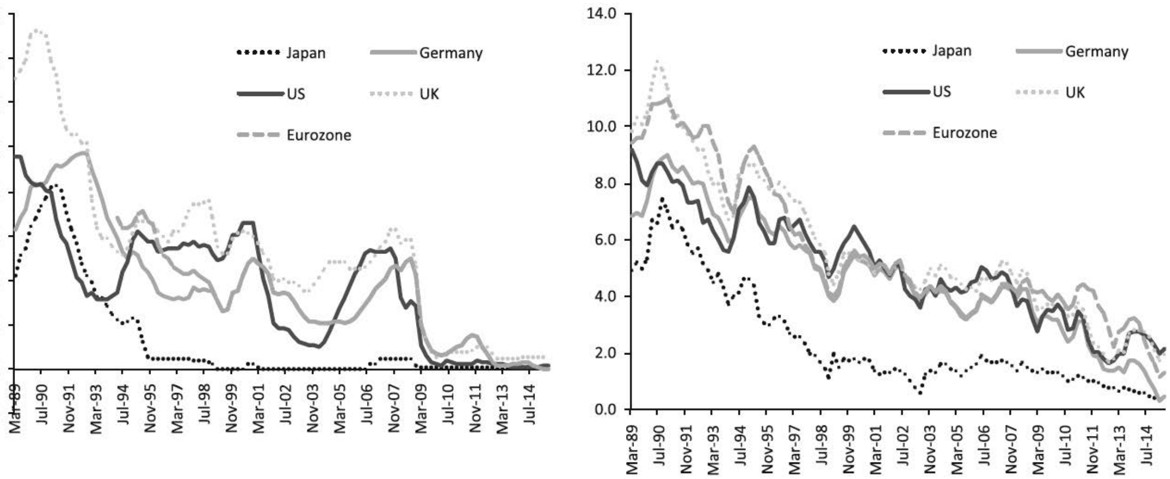

__Figure 2__: Short and long term interest rate since 1990

At the heart of the secular stagnation interpretation of this evidence is that aging triggers a reduction in real interest rate, which in turn lead to a capital depending (the precise mechanism is formalized in section 4). There is a growing literature that documents this mechanism in the context of quantitative overlapping generation models (OLG), we present a stylized example in section 4.[2] The idea, then, is that the ZLB prevents this adjustment from happening. Consistent with this view, Figure 2 shows that real interest rates have been falling throughout the industrial world over this period, but this is also a period in which the countries in question have been experiencing aging populations.[3]

The first part of our main hypothesis is that the reduction in the real interest rate, if unconstrained, should lead to capital deepening. Table 1, Panel B shows that aging is indeed associated with capital deepening during the sample period 1990-2015. The dependent variable is now the change in capital per working age adult rather than output per capita. Since our proposed mechanism works through lower real interest rate, the second part of the hypothesis predicts a breakdown in 2008 once the ZLB became binding in a number of countries. We once again split the sample between before 2008 and after. Again we see that this relationship is driven by the period *before* 2008 (column (2)) rather than the latter period (column (3)) where the coefficient on aging switches sign. As in our earlier exercise, the switch in sign is explained by those countries that were at the ZLB (column (4) and (5)).

3. Alternative Empirical Specifications, Controls and an IV Regression

We consider a variety of controls, and then move onto different measures of aging and also contemplate different measure of the dependent variable, most of the latter robustness checks is relegated to the Appendix. Statistical significance is strengthened under some specifications, weakened in others. Of most interest to us is the fact that the correlation between aging and

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[2] See e.g. Eggertsson and Mehortra (2014), Carvalho, Ferrero, and Nechio (2016), Eggertsson, Mehortra, and Robbins (2017), Gagnon, Johannsen, and Lopez-Salido (2016).

[3] A simple regression of our aging variable to a proxy of real interest rate suggest that these variables are negatively correlated across countries.

output growth becomes negative at the ZLB, and that this result survives with variety of controls and different aging and/or other choices of the dependent/independent variables.

Table 2: Estimates of the impact of aging on GDP per capita: old > 65 years

Panel A: from 1990 to 2014	SAMPLE OF ALL COUNTRIES					OECD COUNTRIES		
	(1 OLS)	(2 OLS)	(3 OLS)	(4 OLS)	(5 IV)	(6 OLS)	(7 OLS)	(8 IV)
Change in the ratio of old to young	0.758	1.830**	1.851**	1.191	4.244***	-1.124	-1.377	0.400
(from 2008 to 2015)	(0.666)	(0.779)	(0.887)	(0.836)	(1.440)	(0.976)	(0.938)	(1.483)
Initial GDP per worker		-0.0989***	-0.0794**	-0.128***	-0.147***		-0.206**	-0.168**
		(0.0334)	(0.0373)	(0.0437)	(0.0428)		(0.0783)	(0.0855)
First-stage F Statistic				12.65				7.32
Overidentification test p-value				0.14				0.16
Observations	168	168	168	168	168	35	35	35
Differential trends by:								
Population and initial age structure			✓	✓	✓		✓	✓
Regional dummies				✓	✓			
Panel B: from 1990 to 2008	SAMPLE OF ALL COUNTRIES					OECD COUNTRIES		
	(1 OLS)	(2 OLS)	(3 OLS)	(4 OLS)	(5 IV)	(6 OLS)	(7 OLS)	(8 IV)
Change in the ratio of old to young	1.890*	2.227**	2.079*	2.164*	6.941***	-0.420	-1.080	0.999
(from 2008 to 2015)	(0.972)	(1.073)	(1.166)	(1.176)	(2.097)	(1.103)	(0.961)	(1.264)
Initial GDP per worker		-0.0290	-0.0277	-0.0957**	-0.109***		-0.170***	-0.130*
		(0.0283)	(0.0328)	(0.0394)	(0.0380)		(0.0544)	(0.0612)
First-stage F Statistic				10.18				7.43
Overidentification test p-value				0.20				0.42
Observations	168	168	168	168	168	35	35	35
Differential trends by:								
Population and initial age structure			✓	✓	✓		✓	✓
Regional dummies				✓	✓			
Panel C: from 2008 to 2014	SAMPLE OF ALL COUNTRIES					OECD COUNTRIES		
	(1 OLS)	(2 OLS)	(3 OLS)	(4 OLS)	(5 IV)	(6 OLS)	(7 OLS)	(8 IV)
Change in the ratio of old to young	-1.971***	-0.477	-0.423	-0.991*	-0.743	-1.989**	-1.551**	-2.780*
(from 2008 to 2015)	(0.518)	(0.568)	(0.590)	(0.593)	(1.487)	(0.841)	(0.671)	(1.635)
Initial GDP per worker		-0.0535***	-0.0411***	-0.0267	-0.0276		-0.0310	-0.0334
		(0.0129)	(0.0145)	(0.0168)	(0.0175)		(0.0360)	(0.0334)
First-stage F Statistic				7.92				5.11
Overidentification test p-value				0.49				0.22
Observations	168	168	168	168	168	35	35	35
Differential trends by:								
Population and initial age structure			✓	✓	✓		✓	✓
Regional dummies				✓	✓			

Notes: The table presents long-differences estimates of the impact of aging on GDP per capita in constant dollars from the Penn World Tables for all countries (columns 1 to 5) and OECD countries (columns 6 to 8). Aging is defined as the change in the ratio of the population above 65 to the population between 20 and 64. Columns 5 and 8 present IV estimates in which we instrument aging using the birthrate in 1960, 1965, …, 1980. The bottom rows indicate additional controls included in the models but not reported: The population and age structure controls include the log of the population and the initial value of our aging measure. We report standard errors robust to heteroscedasticity in parentheses.

In Table 2, Panel A, we consider how the results are affected by introducing controls to the baseline regression. We follow AR closely in choice of controls. The first control (2) is an initial value for (log) GDP per capita in 1990 which makes the baseline regression 1990-2015 statistically significant, a result that still carries through once we introduce controls for population and age structure in 1990 (column (3)). Column (4) includes a set of dummies for World Bank "regions" (Latin America, East Asia, South Asia, Africa, North Africa, Middle East, Central Asia, and Developing countries). Column (5) estimates the same relationship using birthrates for the 1960, 1965, 1970, 1975 and 1980 as instrument for the demographic change variable. Columns (6) - (8) reports the same regression for only 35 OECD countries. Overall, Table A1, Panel A in the Appendix, is simply a verification of AR result for a variety of different controls. The bottom-line is unchanged. Contrary to commonly held perception, aging is not associated with lower growth for GDP. If anything, it is the other way around under various specifications as stressed by AR.

Table 2, Panel B and C illustrate our new evidence already reported in the basic correlations. The slope of the regression line changes in the latter half of the sample once we split the sample between 1990-2008 and 2008-2015, i.e., once we distinguish between the two “regimes” of neoclassical adjustment vs secular stagnation. This result also applies using the same controls as in AR. The most relevant bottom line, perhaps, is the first line column (4) in Table 2, Panel C. The negative correlation between aging and GDP growth in the period 2008-2015 is still there once all AR suggested controls are added, and the result is statistically significant, even if the coefficient goes down in absolute value. Moving to column (5) of Table 2, Panel C we use an instrumental variables approach using as instrument the birthrate in 1960, 1965, …, 1980 as AR. This approach still shows a switch in sign from statistically positive in Table A1, Panel B to a negative point estimate in Table A1, Panel C (which in turn is not statistically significant). While the main results are for all countries, we also report the OECD country subsample both with all controls (7) and using the instrumental variables (8). The result for the OECD subsample is consistent with the overall message under either specification in the period 2008-2015 when the ZLB was an issue in large parts of the world. We see a more negative correlation between output growth and aging as suggested by the secular stagnation hypothesis.

To explore robustness further we move to different measures of aging with results tabulated in the Appendix. AR use workers over 50 relative to those 20-50. In our context we prefer a 65 cut-off because the main mechanisms we are looking for has to do with retirement and life expectancy and how this changes the relative demand and supply for savings, as clarified further in the model of the next section. AR theoretical mechanism, instead, has to do with the ratio of older to younger workers and the implied effect on automation. Tables A1 replicates AR finding using their preferred age cut-off. The correlation between aging and output growth per capita is once again positive. Again, however, it is driven by the period 1990-2008, while the correlation switches sign and becomes statistically significant splitting the sample into the two regimes. Table A2 in the Appendix, shows that nothing changes when adding controls, using this alternative age cutoff.

As a third measure of aging, that is perhaps a little more direct, we replace our previous measure of aging with the *change in labor input*, defined as the change in the number of people 20-65 relative to all adults. Table A3 in the Appendix, reports the basic correlation. A drop-in labor input measured this way actually increases output per capita over the sample period, but once again it is driven by the capital deepening period 1990-2008. The sign is flipped post 2008. Table A4 in the Appendix, adds same controls as we have previously done.

We also consider as a measure of output, not output per capita, but instead output per member of the population above 20, which is a slightly more natural in the context of the model outlined in the next section, since children are not making meaningful economic savings decisions. Here, again, we use the labor input variable as an explanatory variable. Table A5 and A6 in the Appendix, show that the results are stronger with this specification. Nevertheless, we stick to our benchmark for the sake of comparison to the other literature and because the aging parameter in our main specification maps directly into the model we outline below.

We consider two additional robustness checks on the baseline correlations. Table A7 in the Appendix, considers evidence of secular stagnation outside of OECD. Out of the 168 countries in our baseline sample 133 are not in the OECD. Of those 133 then 14 experienced what we define as a secular stagnation, i.e. they were constrained by the ZLB. Table A7 shows that the same basic results apply if we only consider non-OECD countries. The basic correlation between aging and per-capita output growth is positive in the whole sample period but breaks down if we split it into the two sub-periods. Moreover, the breakdown is driven by the ZLB countries. Finally Table A8 in the Appendix considers if our results are sensitive to having picked 1.5% as a benchmark for what we define as a country that is constrained by the ZLB, using as alternative 0.5%, 1.0%, and 2.0%. As shown in the Table 8 the number of countries that fit the criteria is reduced from 42 to 37 and 34 respectively when reducing the cut-off point to 1% and 0.5%, while it is increased to 53 when it is increased to 2%. The negative correlation (i.e. the reversal from the positive baseline correlation) remains statistically significant when 1.0% is used as cut-off but loses statistical significance once 0.5% is used as then the number of countries shrinks in the ZLB sample. Meanwhile, statistical significance is maintained if the cut-off is increase to 2% but the absolute value of the correlation goes down.

While some general caution in interpreting cross country evidence is in order, the significance of the result is somewhat surprising, at least in the context of the secular stagnation hypothesis. The genesis of the secular stagnation hypothesis has never been that aging is the *only* driving force between imbalances between desired investment and saving. Instead, it has been proposed as one of several candidates, including an increase in inequality, debt deleveraging, fall in relative price of investment, fall in productivity to mention but a few candidates.[4] In theory aging can correlate with these other factors, complicating inference. We next turn to how the correlations we have just reported can be interpreted more explicitly in the context of a simple general equilibrium model of secular stagnation.

4. A Minimalistic Model to Interpret the Empirical Results

4.A 1990-2008: Modeling Capital Deepening

We first consider a simple model that rationalizes Figure 1A, i.e., aging leading to a decline in real interest rates and capital deepening that can be strong enough to explain an increase in GDP per capita even when the labor input is decreasing. Consider an overlapping generation model with two generations, young and old. The young earn labor income, the old do not. The young can invest in capital and sell in old age for retirement. A generation born at time t is of size N_t^y and has the utility function

$$U_t = \frac{1}{1-\sigma}(C_t^y)^{1-\sigma} + \beta\frac{1}{1-\sigma}(C_{t+1}^o)^{1-\sigma}$$

[4]See e.g. Eggertsson, Mehrotra, and Robbins (2017) for a quantitative evaluation.

and faces the budget constraint when young.

$$C_t^y = w_t \bar{l} \;\; - k_{t+1} - \tau_t$$

where w_t is the real wage rate, $\bar{l}$ is a fixed labor endowment and k_{t+1} is the capital saving of the young that can be used for production in the next period, and τ_t is tax. The budget constraint of the old is

$$C_{t+1}^o = R_{t+1}^k k_{t+1}$$

where R_{t+1}^k is the gross return on capital. For simplicity capital fully depreciates, even if this is not essential. The growth rate of the population is $1 + g_t$ and we denote the number of the old by N_t^o. Defining an aging parameter as the ratio of old versus young at time t we get

$$A_t \; = \frac{N_{t+1}^o}{N_{t+1}^y} = \frac{N_t^y}{N_{t+1}^y} = \frac{1}{1 + g_t}$$

We further assume $\sigma = 1$, specializing in log utility, but comment on how different values of σ matter and illustrate the relevant algebra in the Web Appendix. The young satisfy a consumption Euler Equation while the old consume all their income. Firms are perfectly competitive and have constant return to scale Cobb-Douglas production function $Y_t = K_t^\alpha L_t^{1-\alpha}$, thus satisfying standard neoclassical first order conditions. An equilibrium is now defined as when the demand and supply of capital are equated as detailed in the Web Appendix. As the model is of exponential form, it is linear in logs, and can be solved in closed form. Define $\tilde{k}_{t+1}^d \equiv log \frac{K_{t+1}^d}{N_{t+1}^y}$ and $\tilde{R}_{t+1}^k \equiv logR_{t+1}^k$ etc. The central logic is most easily seen by studying a steady state, denoting it by omitting time subscript, in which case we can write the demand and supply for capital as[5]

$$\tilde{k}^d \; = \frac{1}{1-\alpha} \log \alpha - \frac{1}{1-\alpha} \tilde{R}^k$$

and

$$\tilde{k}^s \; = \log \frac{\beta}{1+\beta} (1-\tau)(1-\alpha)\, \alpha^{\frac{\alpha}{1-\alpha}} - \frac{\alpha}{1-\alpha} \tilde{R}^k + \tilde{A}$$

that are plotted up in Figure 3A. The interpretation of the demand for savings is straight forward. The demand for capital is higher the lower is $\tilde{R}^k$ as shown in the figure, as capital becomes relatively cheaper for firms. The aggregate supply of capital is also downward sloping, but with a steeper slope.[6] An increase in aging will shift out the supply of capital, thus increasing the supply of capital available to any given young worker, and thus moving along the aggregate demand curve, increasing the demand for capital at lower real interest rate, moving from point A to point

[5] See Appendix for derivation of full dynamic system.

[6] The reason is that the young are earning more income, with the higher capital stock in the steady state, and thus supplying more savings in equilibrium. The strength of this effect does depend on $\sigma = 1$ (which determines the relative strength of the income and substitution effect). With high enough σ then the supply curve for capital can be upward sloping, and thus the effect is not as strong, albeit with the same sign.

A'. Accordingly aging leads to a reduction in the real interest rate via a capital deepening, and a higher capital labor ratio. The strength of this effect on the capital labor ratio depends on the capital share in the economy, and more generally on σ. Unambiguously, however, aging leads to higher output per worker. Intuitively, aging means that there is more savings floating around in form of capital *per young worker* entering the workforce due to the relative higher number of older people whose savings is in form of productive capital, hence the higher output per worker. What about output *per capita*? There are two offsetting forces at play. On the one hand output *per worker* increases as already shown. On the other hand, *labor force per capita* decreases. Denoting output per capital by $y^{pc}$and its log with $\tilde{y}^{pc}$, we can express the difference between two steady states (denoting the second by ') as

$$\tilde{y}_{\prime}^{pc} - \tilde{y}^{pc} = \alpha(\tilde{k}_{\prime} - \tilde{k}\ \ ) - \log\frac{1+A'}{1+A}$$

where the first term is positive and reflects higher capital per worker in the new steady state, while the second term reflects the reduction in labor input due to aging, which is negative. Substituting the solution for $\tilde{k}$ derived from the equilibrium depicted in Figure 3A we obtain[7]

$$\tilde{y}_{\prime}^{pc} - \tilde{y}^{pc} = \frac{\alpha}{1-\alpha}\left(\log\frac{A'}{A}\right) - \log\frac{1+A'}{1+A} \approx \left(\frac{\alpha}{1-\alpha} - \frac{A}{1+A}\right)\log\frac{A'}{A} > 0\ if\ \frac{\alpha}{1-\alpha} > \frac{N^o}{N^o+N^y}$$

A is the measure of aging $\frac{N^o}{N^y}$, so this condition is saying that the first effect is larger than the second as long as $\frac{\alpha}{1-\alpha} > \frac{N^o}{N^o+N^y}$. We report a more general formula in the Appendix illustrating that this condition is more likely to be satisfied the higher is σ. A higher value of this parameter will in general lead to further capital deepening.

The bottom-line, then, is that the empirical pattern observed in Figure 1, is predicted by a standard neoclassical OLG model under various parameter configurations, even if one can think of a parameter configuration in which it does not apply. We obtain a stronger prediction in the next subsection at the ZLB in which case aging always has negative effects on output growth. Here it can go either way.

The key observation, however, and regardless of which effect is dominating, is that the capital deepening requires the real interest rate to decline and the intensity of this effect depends on σ. In dynastic or representative agent models the real interest rate is fixed at β^{-1} in steady state while here it is pinned down by the relative supply and demand for capital which is governed, among other things, by aging. In principle, there is nothing that says that the real interest rate has to be positive (i.e. the gross rate R^k bigger than 1). This is precisely what the secular stagnation literature is all about. It says that *if* the real interest rate needed to make investment equal to savings is negative at full employment, and there are limits to which the interest rate can be adjusted, for example due to the zero-lower bound, the economy will experience a recession.

4.B 2008-2016: Secular Stagnation

[7] The last equality sign is approximated around A'=A.

The fundamental mechanism that generates secular stagnation is that the real interest rate cannot adjust to equate investment and savings at full employment. This is the sense in which it describes “excessive savings”. In order to capture this idea, we need some reasons that prevent the real interest rate to fall enough. The most straightforward way of doing so is to introduce the zero-lower bound on the nominal interest rate, together with some additional assumptions we clarify shortly.

The way monetary policy is typically introduced in this setting, and a tradition we follow, is to assume that the government can issue paper currency and through that the central bank controls the short-term nominal interest rate, i_t, via open market operations in risk-free government short-term bonds (see e.g. Woodford (2003)). The price of this bond satisfies on the Euler equation

$$\frac{1}{C_t^y} = (1+i_t)\beta E_t \frac{1}{C_{t+1}^o}\Pi_{t+1}^{-1}$$

where $\Pi_{t+1} \equiv \frac{P_{t+1}}{P_t}$ is inflation, and P_t the price of the consumption goods in terms of money. Similarly, there is an arbitrage equation between the one period risk-free bond and the return on capital given by

$$(1+i_t)E_t \frac{1}{C_{t+1}^o}\Pi_{t+1}^{-1} = \beta E_t \frac{1}{C_{t+1}^o} R_{t+1}^k$$

Adding these two pricing equations does not change the model we have already stated absent other assumption. It simply gives a theory of the price level once we add a more detailed description of monetary and fiscal policy[8]. The real interest rate R_{t+1}^k is the same as in the model analyzed in the last section, and so is output per capita and capital.

A theory of stagnation arises from the assumption that inflation cannot adjust freely. This allows monetary policy to directly affect the real interest rate, i.e. the return to capital, via the nominal interest rate and may prevent investment from matching savings at full employment. Recall that the reduction in the real interest rate was exactly the key mechanism by which capital deepening took place in response to aging in the previous section. But why can inflation not adjust freely? To illustrate the basic secular stagnation mechanism we *impose* that the *nominal wage is fixed* at some W_0 to start with, a case in which the firms may not employ the entire labor endowment and assume that labor is rationed equally across all workers.[9]

The major implication of fixing the nominal wage rate, relative to last section, is that output is now *demand determined*. Below we consider a constant solution in which $i = 0$, i.e. again, we abstract from transition dynamics, which are not central to the point, and focus on a stable secular stagnation equilibrium that can last for an arbitrary number of periods absent changes in the forcing variables. Output is determined by writing aggregate spending as

$$Y = C + I + G$$

---

[8] For expositional simplicity we assume that net government debt here is zero, the more general case is for example treated in Eggertsson and Mehrotra (2014).

[9] More flexible specifications for wage setting see Eggertsson and Mehrotra (2014).

It simplifies things to assume log utility, i.e., $\sigma = 1$. The consumption of the young and old can be derived to yield an aggregate consumption function

$$C = N^y C^y + N^o C^o = \frac{1}{1+\beta}(1-\alpha)Y \quad - \frac{1}{1+\beta} N^y \tau + \alpha Y \quad = \left(\frac{1-\alpha}{1+\beta} + \alpha\right) Y \quad - \frac{1}{1+\beta} N^y \tau$$

We can use the first order condition of the representative firm with respect to capital to derive the demand for investment, yielding an aggregate investment function

$$I = K = \frac{\alpha Y}{R^k}$$

At a superficial level the aggregate consumption function looks like an old fashion Keynesian consumption function in which aggregate demand depends upon a fraction of aggregate income net of the tax burden. Underlying it, however, is an intertemporal optimization problem, in which the labor income of the young is a fixed proportion $(1-\alpha)$ of total output[10]. Meanwhile the old consume all their income which is entirely derived from capital and thus in proportion α to total output Y. The investment function also looks old Keynesian. If the interest rate declines, i.e. the gross return on capital R^k, then the firms demand more capital for a given level of output Y. Putting the pieces together, and dividing by the total population, we arrive at aggregate demand in per capita terms given by

$$y^{AD} = \left(\frac{1-\alpha}{1+\beta} + \alpha\right) y^{pc} \quad + \frac{\alpha}{A}\frac{y^{pc}}{R^k} + \frac{\beta}{1+\beta} G^{pc}$$

where we have assumed that the budget is balanced in every period to substitute out for taxes. What we have written here is simply the spending for each agent in the economy, for a given level of production[11]. The consumer (young and old) will spend according to the first term, the firm capital expenditures are captured by the second, and each derived from the respective maximization problems of the underlying agents. Finally, government spending makes an appearance where balanced budget has been imposed for simplicity. Observe that the steps we have taken have not required us to make any assumptions, as of yet, about the wage setting[12]. The assumption of nominal frictions gives this equation a new life because it implies that the real interest rate cannot adjust to increase investment enough to match "desired savings". To be more specific, consider a secular stagnation equilibrium in which the nominal interest rate is zero, prices constant, so that $R^k = 1$ yielding to

$$y^{AD} = \left(\frac{1-\alpha}{1+\beta} + \alpha + \frac{\alpha}{A}\right) y^{pc} \quad + \frac{\beta}{1+\beta} G^{pc}$$

---

[10] This follows from the assumption of perfectly competitive firms and Cobb-Douglas production. This implies that output is split between output and capital in fixed shares.

[11] It is important here, that we assume that government spending, and thus taxes, is a fixed fraction of full employment output, see Web Appendix for details.

[12] The same equation applies in the model in the last section. If we replace each of the $y's$ with the flexible wage output derived in last section, this equation yields an expression for the implied real interest rate at flexible wages.

which is plotted up in Figure 3B[13].

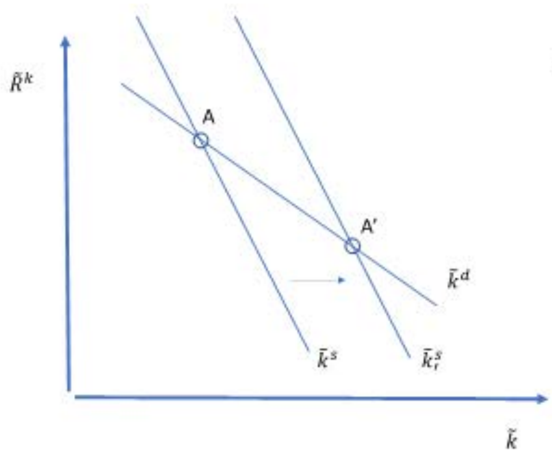

***Figure 3A**: Aging and capital per worker*

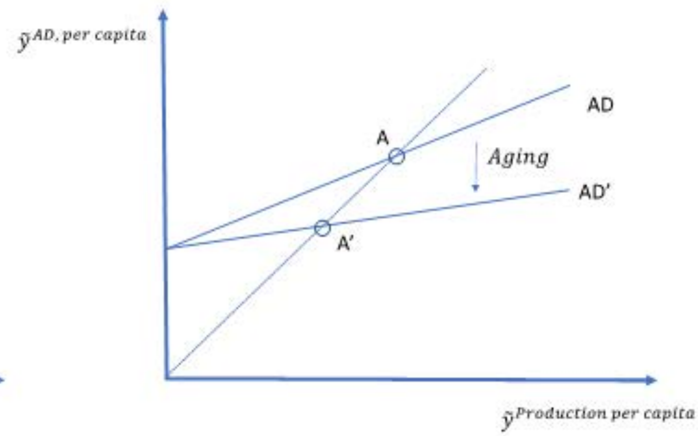

***Figure 3B**: Aging and secular stagnation*

Figure 3B plots aggregate demand, y^{AD}, using the latter equation as an aggregate demand *function* of any given level of production y^{pc}. The amount of output demanded of consumption by consumers, and of capital by firms, as we have just seen in last equation, can directly be related to the aggregate production level. The 45-degree line, then, is the observation that in equilibrium *it must be the case* that aggregate spending has to be equal to the production itself. This gives an equilibrium at point A.

This gives us a simple way of seeing the effect of aging in a secular stagnation. We can see the effect of aging by directly inspecting how it changes the AD demand function. An increase in aging from A to A 'makes the AD curve flatter, that is, there is now less demand for any given income level (production per capita).
What is the logic for this result? The key term in our characterization is how aging affects aggregate *investment demand*. We can express investment per capita, using the demand for capital by the firms, as

$$\frac{I}{N} = \frac{\alpha}{A}\frac{y^{pc}}{R^k}$$

Recall that before aggregate investment increased as *A* increased. This was because the increase in A was more than offset by a decline of R^k. The firms responded to the decline in the interest rate by demanding more capital which in turn led to capital deepening in equilibrium. This link is now broken. The real interest rate is fixed, due to nominal rigidities and the ZLB, so there is no offsetting effect on investment via the interest rate reduction. Accordingly, investment declines. The result is a fall in aggregate production as shown at point A' in Figure 3B. Observe that in a secular stagnation, therefore, the effect of aging on output per capita is *unambiguous*, i.e., it must

[13] The more general case that allows for movements in inflation is considered in the Appendix.

decline. Doing a log-linear approximation as in last section we can show that aging has a negative effect on output, given by the formula

$$\tilde{y}_{\prime}^{pc} - \tilde{y}^{pc} = -\frac{1}{\frac{\beta}{1+\beta}\frac{1-\alpha}{\alpha}A - 1}\log\frac{A'}{A} < 0$$

which is always negative, for the denominator is required to the positive for the secular stagnation equilibrium to exist.[14] This, then, explains the empirical patterns in Figures 1A-1C. Importantly the effect of aging on output per capital is unambiguous. It is always negative in a secular stagnation.

5. Conclusion

There has been an increasing attention lately about the effect of aging on GDP per capita. Researchers have noticed, however, a curious pattern. Looking over the last quarter of a century, it looks that in the cross section those countries experiencing aging have had higher GDP growth per capita relative to those with younger population. In this paper, we suggest that a natural explanation for this is capital deepening associated with the worldwide fall in the real interest rate during this period. A key prediction of this hypothesis, and the genesis of the secular stagnation hypothesis, is that the positive correlation is predicted to break down for those countries that hit the ZLB. The cross-country evidence we present is consistent with this prediction.

Broadly speaking the empirical evidence and the model suggest very different effect of aging if an economy finds itself in the regular neoclassical regime or in a secular stagnation. More generally, this caveat applies to any force that tends to increase the relative propensity to save or decrease the propensity to invest. Examples that may affect these margins include rise in inequality, debt-deleveraging cycles, the global savings glut, an increase in life expectancy, a fall in relative price of investment or lower productivity growth (see e.g. Summers (2014) and Eggertsson et al (2017) for discussion). In a regular neoclassical regime interest rates flexibly adjust to any changes in the desired capital-output ratio. In a secular stagnation regime, however, savings virtues become a vice, and have negative effect on growth. Of course, this is reminiscent of old Keynesian models, but both the data evidence and the model presented here highlight the key role low interest rates play in determining if the beneficial neoclassical force of savings is at play or the malignant one identified by Keynes.

It seems plausible that consideration related to excess savings at the ZLB will become increasingly relevant in future recessions. Kiley and Roberts (2017), for example, estimate the that the ZLB is likely to be a constraint 30-40 percent of the time going forward, and Summers (2018) reaches similar conclusion. Their analysis depends critically on the assessment that the long term neutral interest rate has declined permanently, a proposition that is consistent with the assessment of financial markets as of writing. More generally the assumption that monetary policy can stabilize the business cycle seems greatly attenuated going forward.

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[14] See Appendix for further discussion.

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Appendix

Table A1: Estimates of the impact of aging on GDP per capita from 1990 to 2014: old > 50 years

	(1) 1990-2014	(2) 1990-2008	(3) 2008-2014	(4) ≈ ZLB	(5) ≠ZLB
Change of the ratio of old to young	0.361* (0.208)	0.784*** (0.282)	-0.528** (0.205)	-0.267 (0.302)	-0.370 (0.305)
Observations	168	168	168	42	126
R-squared	0.019	0.052	0.038	0.015	0.012

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table A2: Estimates of the impact of aging on GDP per capita: old > 50 years

Panel A: from 1990 to 2014	SAMPLE OF ALL COUNTRIES					OECD COUNTRIES		
	(1 OLS)	(2 OLS)	(3 OLS)	(4 OLS)	(5 IV)	(6 OLS)	(7 OLS)	(8 IV)
Change in the ratio of old to young (from 2008 to 2015)	0.361* (0.208)	0.990*** (0.257)	1.067*** (0.265)	0.615** (0.290)	1.646*** (0.416)	-0.137 (0.415)	0.0909 (0.391)	1.042** (0.511)
Initial GDP per worker		-0.138*** (0.0362)	-0.118*** (0.0379)	-0.142*** (0.0447)	-0.180*** (0.0443)		-0.204*** (0.0733)	-0.244*** (0.0856)
First-stage F Statistic				18.96				13.72
Overidentification test p-value				0.65				0.31
Observations	168	168	168	168	168	35	35	35
Differential trends by:								
Population and initial age structure			✓	✓	✓		✓	✓
Regional dummies				✓	✓			
Panel B: from 1990 to 2008	SAMPLE OF ALL COUNTRIES					OECD COUNTRIES		
	(1 OLS)	(2 OLS)	(3 OLS)	(4 OLS)	(5 IV)	(6 OLS)	(7 OLS)	(8 IV)
Change in the ratio of old to young (from 2008 to 2015)	0.784*** (0.282)	1.150*** (0.368)	1.171*** (0.375)	0.870** (0.399)	1.947*** (0.624)	-0.255 (0.458)	0.0105 (0.490)	0.924 (0.673)
Initial GDP per worker		-0.0597* (0.0326)	-0.0530 (0.0350)	-0.108*** (0.0409)	-0.132*** (0.0414)		-0.163** (0.0625)	-0.205*** (0.0662)
First-stage F Statistic				13.86				11.96
Overidentification test p-value				0.11				0.32
Observations	168	168	168	168	168	35	35	35
Differential trends by:								
Population and initial age structure			✓	✓	✓		✓	✓
Regional dummies				✓	✓			
Panel C: from 2008 to 2014	SAMPLE OF ALL COUNTRIES					OECD COUNTRIES		
	(1 OLS)	(2 OLS)	(3 OLS)	(4 OLS)	(5 IV)	(6 OLS)	(7 OLS)	(8 IV)
Change in the ratio of old to young (from 2008 to 2015)	-0.528** (0.205)	0.138 (0.218)	0.236 (0.225)	-0.247 (0.232)	0.337 (0.349)	-0.350 (0.258)	-0.376* (0.201)	-0.259 (0.317)
Initial GDP per worker		-0.0615*** (0.0122)	-0.0502*** (0.0133)	-0.0268 (0.0171)	-0.0356** (0.0175)		-0.0395 (0.0302)	-0.0391 (0.0279)
First-stage F Statistic				17.38				3.40
Overidentification test p-value				0.58				0.03
Observations	168	168	168	168	168	35	35	35
Differential trends by:								
Population and initial age structure			✓	✓	✓		✓	✓
Regional dummies				✓	✓			

Notes: The table presents long-differences estimates of the impact of aging on GDP per capita in constant dollars from the Penn World Tables for all countries (columns 1 to 5) and OECD countries (columns 6 to 8). Aging is defined as the change in the ratio of the population above 65 to the population between 20 and 64. Columns 5 and 8 present IV estimates in which we instrument aging using the birthrate in 1960, 1965, … , 1980. The bottom rows indicate additional controls included in the models but not reported: The population and age structure controls include the log of the population and the initial value of our aging measure. We report standard errors robust to heteroscedasticity in parentheses.

Table A3: Estimates of the impact of Labor Input on GDP per capita: old > 65 years

	(1) 1990-2014	(2) 1990-2008	(3) 2008-2014	(4) ≈ ZLB	(5) ≠ZLB
Change in labor input	-1.827*	-3.297**	3.260***	4.249**	1.545
	(1.084)	(1.419)	(1.005)	(2.036)	(1.623)
Observations	168	168	168	44	126
R-squared	0.019	0.052	0.038	0.092	0.006

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table A4: Estimates of the impact of Labor Input on GDP per capita: old > 65 years

Panel A: from 1990 to 2014	SAMPLE OF ALL COUNTRIES					OECD COUNTRIES		
	(1 OLS)	(2 OLS)	(3 OLS)	(4 OLS)	(5 IV)	(6 OLS)	(7 OLS)	(8 IV)
Change in labor input	-1.827*	-3.458***	-3.357***	-2.280*	-6.531***	0.720	1.902	-1.197
(from 2008 to 2015)	(1.084)	(1.173)	(1.282)	(1.300)	(2.045)	(2.087)	(1.802)	(2.436)
Initial GDP per worker		-0.103***	-0.0859**	-0.129***	-0.147***		-0.197**	-0.154*
		(0.0323)	(0.0366)	(0.0433)	(0.0423)		(0.0857)	(0.0925)
First-stage F Statistic				12.17				7.88
Overidentification test p-value				0.21				0.18
Observations	168	168	168	168	168	35	35	35
Differential trends by:								
Population and initial age structure			✓	✓	✓		✓	✓
Regional dummies				✓	✓			
Panel B: from 1990 to 2008	SAMPLE OF ALL COUNTRIES					OECD COUNTRIES		
	(1 OLS)	(2 OLS)	(3 OLS)	(4 OLS)	(5 IV)	(6 OLS)	(7 OLS)	(8 IV)
Change in labor input	-3.297**	-3.791**	-3.563**	-3.720**	-9.914***	0.118	1.397	-1.934
(from 2008 to 2015)	(1.419)	(1.535)	(1.661)	(1.706)	(2.789)	(1.966)	(1.674)	(2.064)
Initial GDP per worker		-0.0312	-0.0312	-0.0948**	-0.107***		-0.163**	-0.119
		(0.0278)	(0.0322)	(0.0386)	(0.0372)		(0.0669)	(0.0750)
First-stage F Statistic				10.00				7.98
Overidentification test p-value				0.29				0.49
Observations	168	168	168	168	168	35	35	35
Differential trends by:								
Population and initial age structure			✓	✓	✓		✓	✓
Regional dummies				✓	✓			
Panel C: from 2008 to 2014	SAMPLE OF ALL COUNTRIES					OECD COUNTRIES		
	(1 OLS)	(2 OLS)	(3 OLS)	(4 OLS)	(5 IV)	(6 OLS)	(7 OLS)	(8 IV)
Change in labor input	3.260***	0.539	0.617	1.767	1.186	2.943*	2.322*	3.930
(from 2008 to 2015)	(1.005)	(1.088)	(1.103)	(1.108)	(2.511)	(1.621)	(1.172)	(2.713)
Initial GDP per worker		-0.0552***	-0.0432***	-0.0277	-0.0291*		-0.0280	-0.0291
		(0.0127)	(0.0144)	(0.0168)	(0.0175)		(0.0381)	(0.0348)
First-stage F Statistic				8.43				5.21
Overidentification test p-value				0.52				0.22
Observations	168	168	168	168	168	35	35	35
Differential trends by:								
Population and initial age structure			✓	✓	✓		✓	✓
Regional dummies				✓	✓			

Notes: The table presents long-differences estimates of the impact of aging on GDP per capita in constant dollars from the Penn World Tables for all countries (columns 1 to 5) and OECD countries (columns 6 to 8). Aging is defined as the change in the ratio of the population above 65 to the population between 20 and 64. Columns 5 and 8 present IV estimates in which we instrument aging using the birthrate in 1960, 1965, … , 1980. The bottom rows indicate additional controls included in the models but not reported: The population and age structure controls include the log of the population and the initial value of our aging measure. We report standard errors robust to heteroscedasticity in parentheses.

Table A5: Estimates of the impact of Labor Input Ratio on GDP per adult: old > 65 years

	(1) 1990-2014	(2) 1990-2008	(3) 2008-2014	(4) ≈ ZLB	(5) ≠ZLB
Change in labor input	-2.014*	-3.235**	2.681***	3.789**	1.330
	(1.031)	(1.365)	(1.018)	(1.813)	(1.675)
Observations	168	168	168	42	126
R-squared	0.019	0.052	0.038	0.087	0.005

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table A6: Estimates of the impact of Labor Input on GDP per adult: old > 65 years

Panel A: from 1990 to 2014	SAMPLE OF ALL COUNTRIES					OECD COUNTRIES		
	(1 OLS)	(2 OLS)	(3 OLS)	(4 OLS)	(5 IV)	(6 OLS)	(7 OLS)	(8 IV)
Change in labor input	-2.014*	-3.487***	-2.979**	-2.144*	-6.082***	0.970	1.995	-1.310
(from 2008 to 2015)	(1.031)	(1.042)	(1.169)	(1.232)	(1.887)	(1.821)	(1.770)	(2.516)
Initial GDP per worker		-0.132***	-0.128***	-0.149***	-0.159***		-0.161*	-0.0827
		(0.0348)	(0.0375)	(0.0442)	(0.0424)		(0.0922)	(0.105)
First-stage F Statistic				12.61				6.61
Overidentification test p-value				0.50				0.13
Observations	168	168	168	168	168	35	35	35
Differential trends by:								
Population and initial age structure			✓	✓	✓		✓	✓
Regional dummies				✓	✓			

Panel B: from 1990 to 2008	SAMPLE OF ALL COUNTRIES					OECD COUNTRIES		
	(1 OLS)	(2 OLS)	(3 OLS)	(4 OLS)	(5 IV)	(6 OLS)	(7 OLS)	(8 IV)
Change in labor input	-3.235**	-3.803***	-3.141**	-3.448**	-8.890***	0.454	1.386	-2.414
(from 2008 to 2015)	(1.365)	(1.406)	(1.532)	(1.623)	(2.598)	(1.622)	(1.541)	(2.095)
Initial GDP per worker		-0.0550*	-0.0685**	-0.117***	-0.120***		-0.124	-0.0396
		(0.0306)	(0.0330)	(0.0395)	(0.0371)		(0.0737)	(0.0878)
First-stage F Statistic				10.31				6.84
Overidentification test p-value				0.71				0.38
Observations	168	168	168	168	168	35	35	35
Differential trends by:								
Population and initial age structure			✓	✓	✓		✓	✓
Regional dummies				✓	✓			

Panel C: from 2008 to 2014	SAMPLE OF ALL COUNTRIES					OECD COUNTRIES		
	(1 OLS)	(2 OLS)	(3 OLS)	(4 OLS)	(5 IV)	(6 OLS)	(7 OLS)	(8 IV)
Change in labor input	2.681***	0.386	0.501	1.355	0.349	2.678*	2.242*	4.194
(from 2008 to 2015)	(1.018)	(1.077)	(1.101)	(1.089)	(2.406)	(1.498)	(1.155)	(2.684)
Initial GDP per worker		-0.0608***	-0.0498***	-0.0265	-0.0284		-0.0235	-0.0262
		(0.0143)	(0.0157)	(0.0181)	(0.0182)		(0.0401)	(0.0364)
First-stage F Statistic				8.85				5.06
Overidentification test p-value				0.59				0.25
Observations	168	168	168	168	168	35	35	35
Differential trends by:								
Population and initial age structure			✓	✓	✓		✓	✓
Regional dummies				✓	✓			

Notes: The table presents long-differences estimates of the impact of aging on GDP per capita in constant dollars from the Penn World Tables for all countries (columns 1 to 5) and OECD countries (columns 6 to 8). Aging is defined as the change in the ratio of the population above 65 to the population between 20 and 64. Columns 5 and 8 present IV estimates in which we instrument aging using the birthrate in 1960, 1965, … , 1980. The bottom rows indicate additional controls included in the models but not reported: The population and age structure controls include the log of the population and the initial value of our aging measure. We report standard errors robust to heteroscedasticity in parentheses.

Table A7: Estimates of the impact of aging on GDP per capita from 1990 to 2014 in non OECD countries: old > 65 years

	(1) 1990-2014	(2) 1990-2008	(3) 2008-2014	(4) ≈ ZLB	(5) ≠ZLB
Change of the ratio of old to young	2.365** (1.026)	3.208** (1.422)	-0.854 (0.862)	-3.188* (1.670)	-1.057 (1.204)
Observations	133	133	133	14	119
R-squared	0.045	0.056	0.006	0.102	0.006

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table A8: Estimates of the impact of aging on GDP per capita from 2008 to 2014 for different values of ZLB threshold: old > 65 years

ZLB Threshold	0.5%	0.5%	1.0%	1.0%	1.5%	1.5%	2.0%	2.0%
	(1) ≈ ZLB	(2) ≠ZLB	(3) ≈ ZLB	(4) ≠ZLB	(5) ≈ ZLB	(6) ≠ZLB	(7) ≈ ZLB	(8) ≠ZLB
Change of the ratio of old to young	-1.637 (1.082)	-1.418 (0.899)	-1.887* (1.079)	-1.134 (0.947)	-2.315** (1.035)	-1.070 (0.983)	-1.656** (0.798)	-1.535 (1.164)
Observations	34	134	37	131	42	126	53	115
R-squared	0.066	0.015	0.087	0.009	0.129	0.008	0.075	0.014

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1