Netspar

Effects of increasing life expectancy on economic growth

Study on four OECD countries with focus on the Netherlands

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SERIES ACADEMIC NETSPAR

EFFECTS OF INCREASING LIFE EXPECTANCY ON ECONOMIC GROWTH

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Abstract

In the past decades, life expectancies in both developing as developed countries have increased tremendously and are expected to keep on increasing in the coming decades. How will this impact our economy? Using panel data and an endogenous growth model, I will investigate the relation between life expectancy and economic growth. I will focus on the Dutch economy but also use data on Sweden, Japan and the United states. In addition I will analyze the role of fertility rates in this process.

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1. **Introduction**

Institutions as National Institution on Aging and World Health Organization show that during the past decades the life expectancy of the population in both developing as developed countries has increased. Moreover, data from the OECD shows that it is expected to keep increasing during the coming decades (Health at a Glance, 2009). Although this might already influences economic growth right now Bloom, Canning and Fink (2010) even show that the most rapid increase in aging still has to occur. Therefore, the major changes will probably not be noticeable for another decade or two. For this reason, it is important that policy makers prepare for this change now they still have the time to do so. This is only possible when we carefully investigate how the increasing life expectancy of the population will influence the economy.

Using an exogenous growth model to investigate this relation, it turns out a higher life expectancy will lead to a lower economic growth. If this is truly the case, policy makers should prepare for a decline in GDP due to continuing increasing life expectancies. However, when analyzing this relation using an endogenous growth model, different results arise. Unlike the exogenous growth model predicting a negative relation between life expectancy and GDP, several endogenous growth models predict that life expectancy has a positive effect on the GDP. Further they all emphasize the role of human capital in this relation.

In my thesis I will investigate the relation between the increasing life expectancy and the GDP. I will use an endogenous growth model based on previous research done on this topic. I will start the second section by explaining my theoretical framework based on previous written papers. Then I will explain my endogenous growth model in the third section. In the fourth section, I will use panel data on four different countries for the years 1980 till 2012 to analyze the relation between the life expectancy and the GDP. I will conclude this section by interpreting these results and discuss some drawbacks on the model and data. As the aging population can be a result of both increased life expectancy as declining fertility rates I will dedicate the fifth section to the role of the declining fertility rates in the relation between increasing life expectancy and economic growth. I will end with a conclusion including a discussion on potential further research on this topic.

2. Theoretical framework

Where the exogenous model assumes growth to be a factor depending solely on the savings rate and technological development, which both cannot be explained within the model, an endogenous growth model takes growth as a factor depending on certain policy measures as well. For example on study grants, investment in research and developments, or other factors influencing human capital and innovation. As mentioned in the introduction, I will use an endogenous growth model to analyze the relation between an aging population and the economic growth of a country. I based my theoretical framework on several previous papers on this topic, and will briefly discuss these papers in this section. However, before I do that, I will shortly explain the Solow growth model as it is used as a base in many research done on this topic.

Following the Solow Growth model output is a function of labour, capital and technological progress. In this standard Solow growth model, the stock of labour, the stock of capital and the level of technology are in a positive relation to the output. So when one of these variables increase, the GDP will increase as can be seen in equation 1.

$$Y = T * K^{\propto} * L^{\beta} \qquad (1)$$

Equation 1

Where Y equals GDP, L equals Labour hours, C equals Capital and T equals Level of Technology and α+β=1. Capital is a function of the capital stock of the previous period, the investment done and the depreciation.

$$C_t = C_{t-1} - \delta_{t-1} + I_t \qquad (2)$$

Equation 2

Where C_t is the stock of physical capital in period t, I_t equals the investment in the stock of physical capital in period t, δ_{t-1} equals the depreciation of the stock of physical capital in period t-1 and C_{t-1} equals the physical capital stock of period t-1. Assuming that this country is a closed economy, investment equals savings and total savings equals the savings rate times the output of the concerning country.

$$I = S \tag{3}$$

Equation 3

$$S = s * Y \tag{4}$$

Equation 4

Where I equals investment, S equals savings and s equals the savings rate. So basically, when the savings rate for whatever reason would increase, investments in capital would increase, resulting in a higher stock of capital and eventually in a higher output.

The first paper I would like to discuss uses an exogenous growth model to investigate the relation between an aging population and the economic growth of countries. In their paper "Macroeconomic effects of pension reforms in the context of aging populations: overlapping generations model simulations for seven OECD countries" Hviding and Merette use an overlapping generations model, meaning the population of any country can be divided in three generations. The first group consists of the young ones, who consume much and do not save, the second group is the middle-aged group. This generation works and is able to save next to consuming, and the third group consists of the elderly. Those who are not able to save and only consume as they are retired. An aging population means a larger part of the population belongs to the elderly and do not save or work but only consume, which leads to lower national savings in any country and an upward pressure on wage income taxes (due to the relative smaller middle-aged group who finances the public expenditures on pension systems for the relative larger old-aged group). Using the Slow growth model for a closed economy, savings is equal to investment. Consequently, lower national savings will result in lower investment in the capital stock. An aging population therefore, leads to reduced growth in the capital stock of a country. On top of this, an aging population will also result in a falling labour force. Hviding and Merette assume that the labour force falls more than the capital stock, therefore the capital labour ratio increases as the population ages. Resulting in a lower return on capital. This will lead to a reduction in the capital income tax base. This again leads to an upward pressure to the wage income taxes. Therefore Hviding and Merette conclude that an aging population will lead to a lower economic growth.

However the assumption that growth is an exogenous variable, strongly affects the relation between economic growth and an aging population. Several studies have analyzed this relation using the endogenous growth model. I will discuss three of them and use them to construct an endogenous growth model to analyze this relation.

The first article "Implications of population ageing for economic growth", written by Bloom, Canning and Fink, it is argued that when using an exogenous growth model to analyze the relation between life expectancy and economic growth, it is indirectly assumed that no behavioral changes will occur with an increasing life expectancy. However, behavioral changes due to increased life expectancy do occur, following these authors, and also influence economic growth. In my thesis I would like to focus on one of the behavioral changes they mention in their paper, and that is how the changing age structure affects the population's investment in human capital. With the declines in fertility rates observed over the last decades, school enrolment and educational attainment have improved across countries as many parents now chose to invest more in fewer, but more highly educated children. In this way, large cohorts of less productive members are being replaced with small cohorts of more productive members. The more productive young cohorts will not only directly contribute to economic growth, but also as their higher average income levels lead to a reduced income tax pressure Therefore, Bloom, Canning and Fink indicate on a possible positive relation between an increasing life expectancy and output.

This increased investment in human capital also plays a big role in the second research I will discuss on population aging and economic growth. In the paper "Population aging and economic growth in seven OECD countries" Fougere and Merette use an endogenous growth model to analyze this relation.

They argue that an aging population is positively related to economic growth as well. Just as Bloom, Canning and Fink, they argue that aging could increase incentives for future generations to invest more in human capital and in turn increase economic growth. Although physical capital returns could drop due to a lower savings rate, human capital returns could rise. This would lead to a reallocation from investment in physical capital to investment in human capital and therefore a higher economic growth.

The third paper I would like to discuss is written by Futagami and Nakajima. They acknowledge this increased investment in human capital as well. In their paper "Population aging and economic growth" they focus on the relation between the savings rate and the

growth rate. Looking at the exogenous growth model in a closed economy, a lower savings rate leads lower investment in physical capital, which results in a reduced growth of the capital stock, which in turns leads to a lower growth rate of output. However the growth rate of the output also influences the savings rate. So it is a two way street. This effect is labeled as the growth effect meaning that a higher current income results in a lower ratio of the elder generation's consumption over current income ratio.

Futagami and Nakajima argue that there are two effects of the increasing life expectancy on the savings rate. First, as people know they have a longer retirement period as their life expectancy increases, they consume less at each moment in time and save more. Following the Solow growth model, this results in a higher output growth. Second, as life expectancy increases, the group of elderly increases and national savings decrease.

The authors argue, that the increase in the savings rate due to the first effect will lead to accelerated output growth rate. This effect counteracts the second effect that the increased group of elderly leads to lower national savings. The accelerated output growth again affects the savings rate through the growth effect, and so the savings rate increases even further. The savings rate will converge on a new steady state value, higher than the old one. At this new steady state, the economy grows faster than at the initial steady state. So Futagami and Nakajima conclude that increased life expectancy will lead to accelerated output growth.

So to summarize these studies, there are two ways to look at how an increasing life expectancy can influence economic growth. First, there is the exogenous growth model where increased life expectancy will lead to a lower savings rate resulting in lower investments in the capital stock and eventually a lower economic growth. On the other hand, there are the endogenous growth models that predict that an aging population leads to higher economic growth through increased human capital accumulation. In the next section I will explain the endogenous growth model I will use to investigate the relation between an increasing life expectancy and economic growth.

3. Endogenous growth model used in thesis

3.1 Endogenous growth model

To investigate the relation between life expectancy and GDP I will use a model based on the one of Fougere and Merette, but before I will explain the model it is imporant to recognize the distinction between physical and human capital.

Where physical capital is a function of the investment in the physical capital, the stock of previous period and the depreciation of the stock of the previous period, human capital is simply said human knowledge and is a function of the investment in human capital and the stock of human capital of the previous period.

$$C_{p,t} = C_{p,t-1} - \delta_{cp} + I_{cp} \tag{5}$$

Equation 5

Where $C_{p,t}$ is the stock of physical capital in period t, I_{cp} equals the investment in the stock of physical capital in period t, δ_{cp} equals the depreciation of the stock of physical capital in period t and $C_{p,t-1}$ equals the physical capital stock of period t-1.

$$C_{h,t} = C_{h,t-1} + I_h \tag{6}$$

Equation 6

Where $C_{h,t}$ is the stock of human capital in period t, I_{ch} equals the investment in the stock of human capital in period and $C_{h,t-1}$ equals the human capital stock of period t-1. I assume no depreciation at the human capital stock. Which implies that when a person accumulates knowledge, this will not depreciate over time. This is a simplifying assumption as gained knowledge can fade away over time, and regaining this knowledge will probably ask for some investment in the human capital stock. However, there is no data on this and it is therefore not possible to include this in the model.

Fougere and Merette use a Cobb-Douglas function to analyze the relation between an aging population and the output.

$$Y = AK_t^\varepsilon L_{e,t}^{1-\varepsilon} \tag{7}$$

Equation 7

Where Y is real output, A a scaling variable, K the stock of physical capital, L_e effective labour and ε the capital income share. They formulate effective labour hours as a function of the stock of human capital allocated to the labour market. As Fougere and Merette simplify the time allocation of people in their model, people can allocate time either to working or to human capital accumulation. Therefore effective labour hours becomes a function of the time allocated to working times the human capital stock times the population. As the population is divided in multiple generations, only the working generations contribute to the effective labour hours.

$$L_{e,t} = \sum_g h_t^g (1 - z_t^g) pop_t^g \qquad (8)$$

Equation 8

Where $L_{e,t}$ equals total efficient labour hours in time t, h_t^g equals the human capital stock from generation g at time t, z_t^g is the average time dedicated to working rather than accumulating human captial by generation g and pop_t^g is the amount of workers in generation g at period t.

I will use their idea of effective labour hours. However, unlike Fougere and Merette I will not attempt to calculate the absolute level of the human capital stock but use data on the investment in human capital. Just like Fougere and Merette I will start with a standard Solow growth model as given in equation 1. However, I will use GDP per capita rather than the absolute level of GDP. On top of this, all the independent variables will also be in the per capita form. L is formulated as:

$$L_{it} = Lh_{it} \times HC_{it} \qquad (9)$$

Equation 9

Where L_{it} equals the amount of efficient labour hours in country i for period t, Lh equals total labour hours and HC equals the stock of human capital. As higher life expectancy results in more investment in human capital, the amount of efficient labour hours will increase and this will lead to a higher GDP.

This relation will be estimated in first order differences or in other words, the growth rates. Then the GDP growth will become a function of the change in effective labour hours, the change in the technological level, or in other words technological progress and the change in the physical capital. Therefore economic growth can be approximated by equation 10.

$$\Delta Y / Cap_{it} = \Delta T / Cap_{it} + \Delta L / Cap_{it} + \Delta C / Cap_{it} \tag{10}$$

Equation 10

Where ΔL_{it} euquals the change in the effective labour hours. This is deducted from the equation 9.

$$\Delta L_{it} = \Delta (Lh * HC)_{it,} \tag{11}$$

Equation 11

As I only have data on the human capital investment, I will use data on total labour hours and data on the investment in human capital. Therefore, ΔL_{it} can be roughly estimated by equation 12.

$$\Delta L_{it} = Lh_{it} * \Delta HC_{it} \tag{12}$$

Equation 12

Where Lh = the total amount of labour hours, and ΔHC = the change in the human capital stock relative to the human capital stock of the previous period. As the investment in human capital might increases due to higher fertility rates rather than increased life expectancy, I will control for this possible effect by adding the change in fertility rates to the regression. On top of this, I will add country dummies to control for possible country specific effects. Therefore the final equation estimated becomes:

$$\begin{aligned} \Delta Y / Cap_{it} = \beta_0 + \beta_1 \Delta T / Cap_{it} + \beta_2 \Delta L / Cap_{it} + \beta_3 \Delta C / Cap_{it} \\ + \beta_4 \Delta F_{it} + \beta_5 Netherlands + \beta_6 Sweden + \beta_7 United\ States \\ + \varepsilon_{it} \end{aligned} \tag{13}$$

Equation 13

Where ΔF_{it} equals the change in the fertility rates and Netherlands, Sweden and United States are the dummy variables.

3.2 Justifying assumptions

Before I will run the regressions, I will check whether the data is in line with the assumptions made in the theoretical model. The first assumption made is that a higher life expectancy leads to more investment in human capital. This relation can be seen looking at the correlation betewen these two variables in figures 1, 2 and 3. Even though, the correlation says noghing about any causal relation it does show that the data is in line with the assumpion.
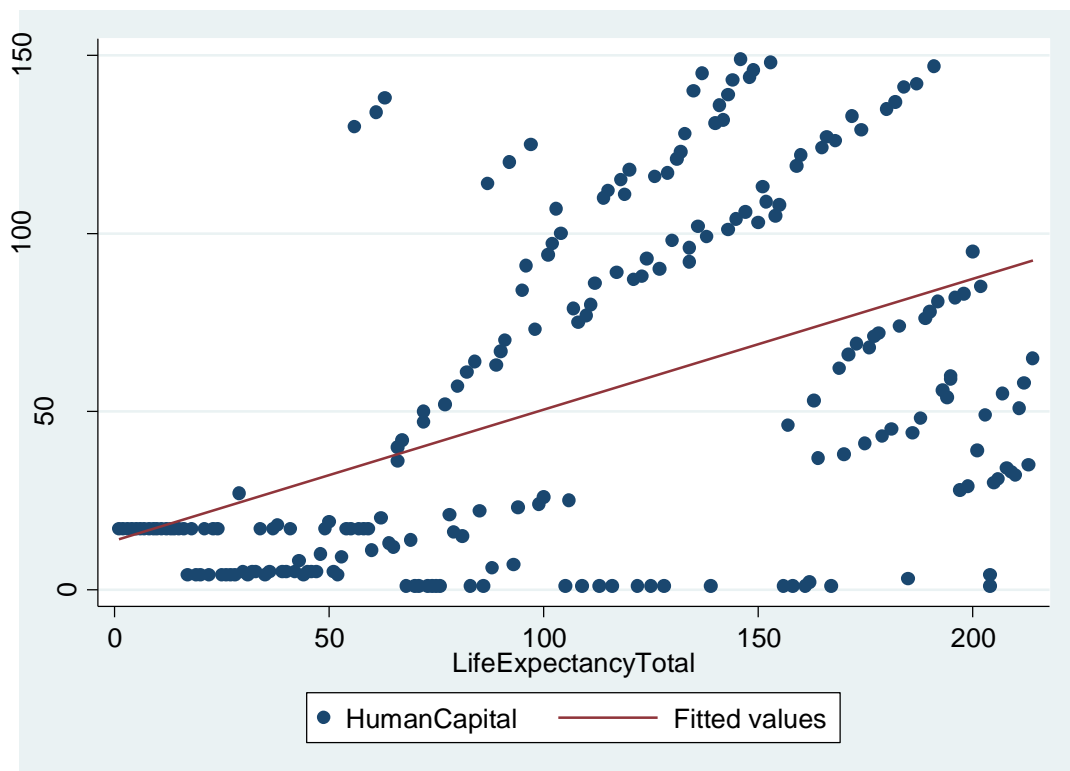

Figure 1: correlation investment in human capital and the total life expectancy.
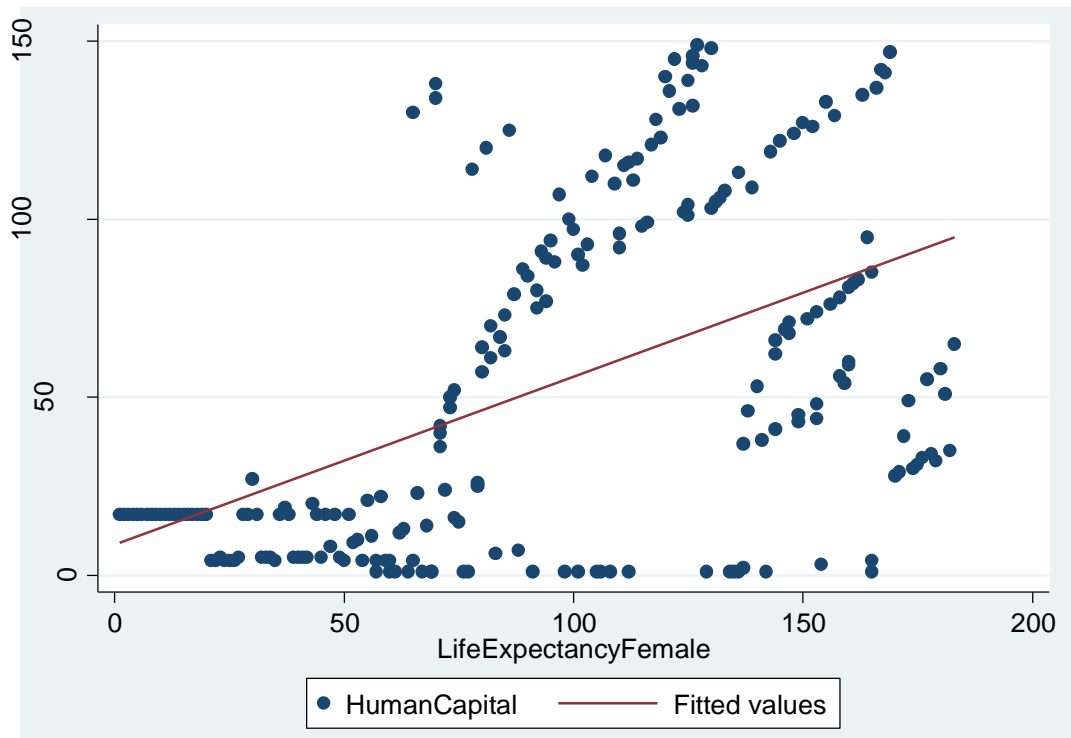
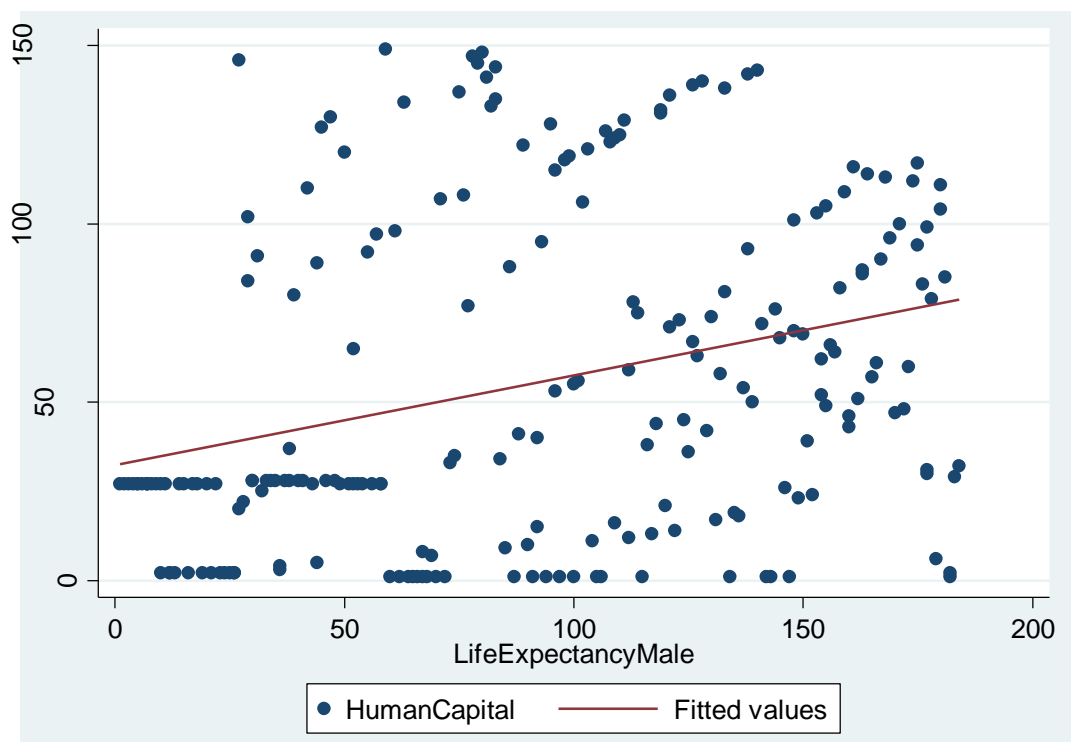Figure 2: correlation between investment in human capital and life expectancy of females.

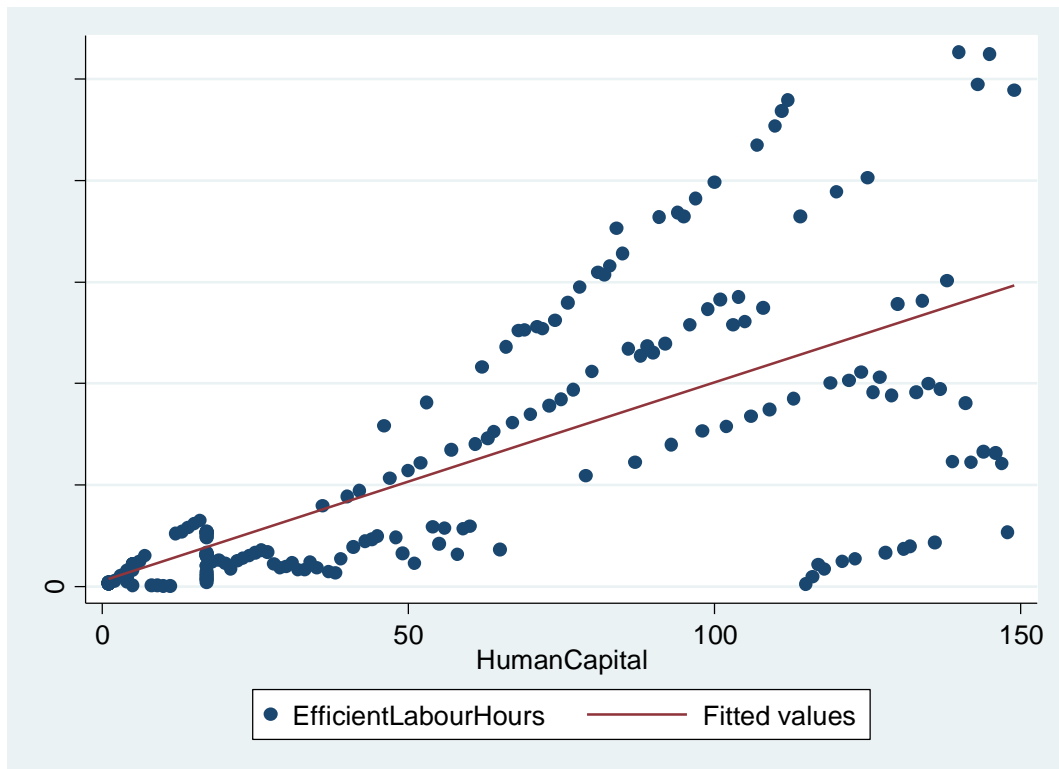Figure 3: correlation between investment in human capital and life expectancy of males.

Figure 4: correlation between investment in human capitaland efficient labour hours.
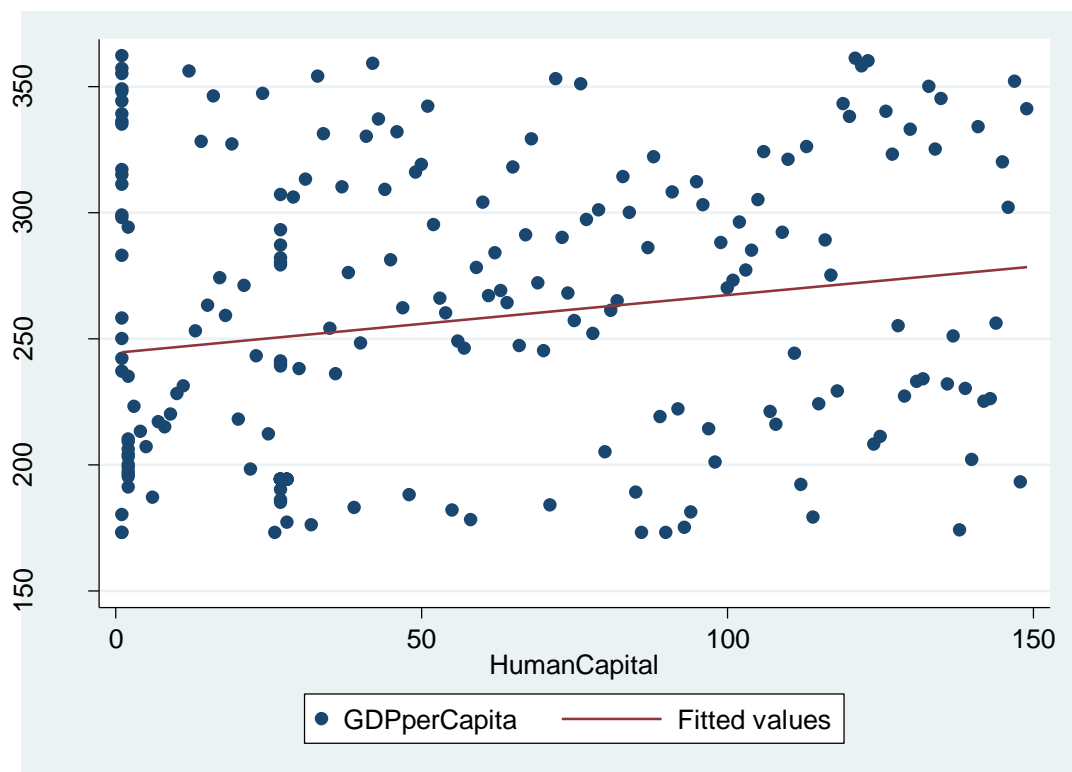

Figure 5: correlation between investment in human capital and GDP per capita.
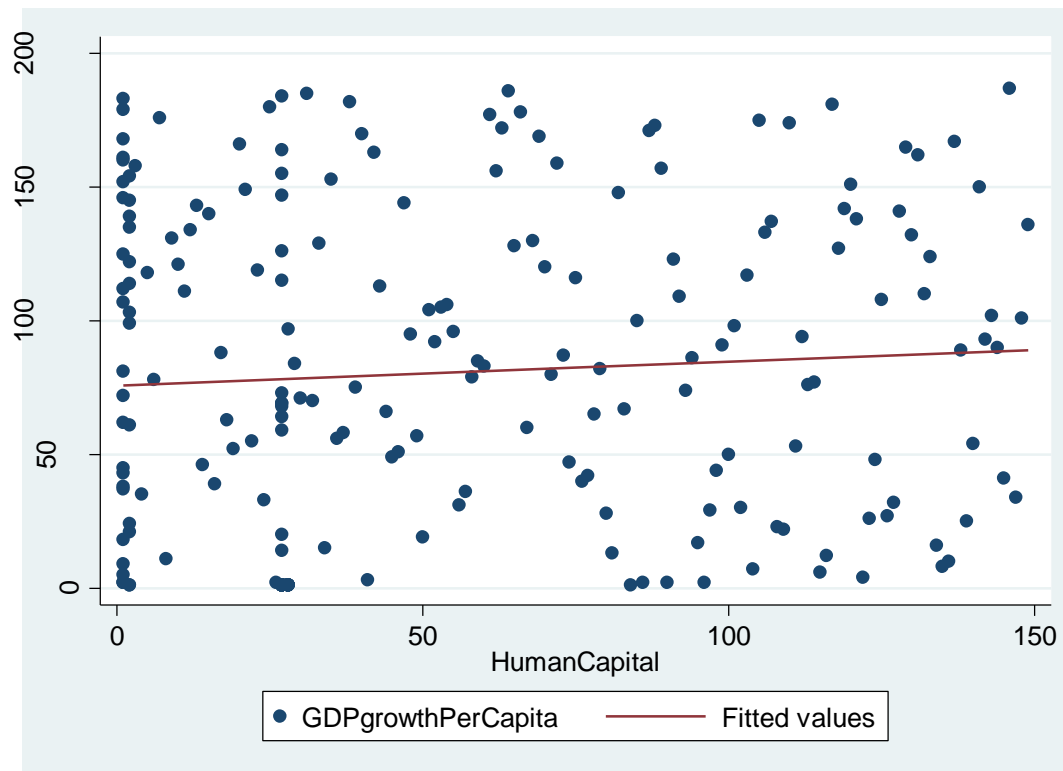
Figure 6: correlation between investment in human capital and GDP growth per capita.

The second assumption holds that more investment in human capital leads to more efficient labour hours and a higher GDP. Looking at figures 4, 5 and 6, it turns out that human capital is indeed positively correlated to efficient labour hours, GDP per capita and GDP growth per capita.

The correlation between GDP per capita and human captial seems to be very week but positive. However, this can be explained by the fact that the GDP also depends on many other factors.

Looking at these graphs there is reason to believe that higher life expectancy leads to more investment in human capital which results in more efficient labour hours which then again will lead to a higher GDP. The correlations between the life expectancy of both males and females with the GDP per capita in figure 7 and 8 are in line with this assumption.

In table 1 it can be seen that the correlations between life expectancy and both GDP per capita as GDP growth per capita are significant, just as the correlation between human capital and GDP per capita and the correlation between efficient labour hours and GDP per capita. However, the correlation between human capital and the GDP growth per capita and the one between the efficient labour hours and GDP growth per capita are not significant.This

indicates that there is a significant and positive relation between the life expectancy of the population and the GDP growth, but that the investment in human capital is not the link between these two variables. In the next section I will analyze the relation between these variables more carefully.
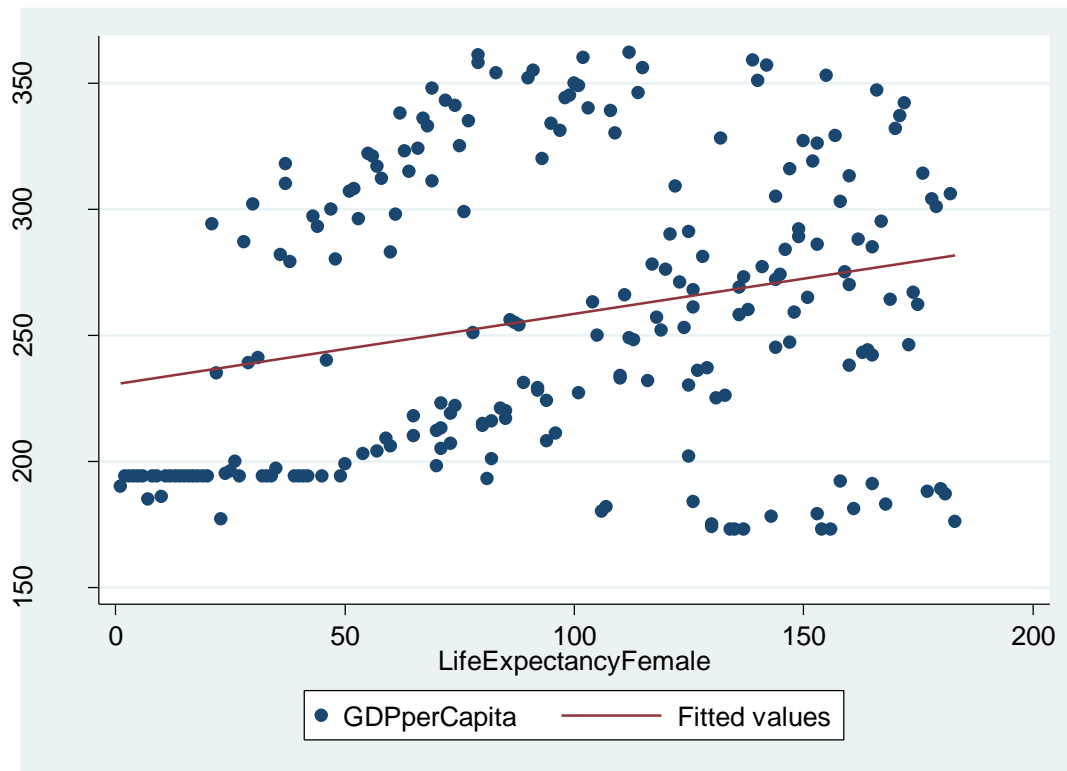

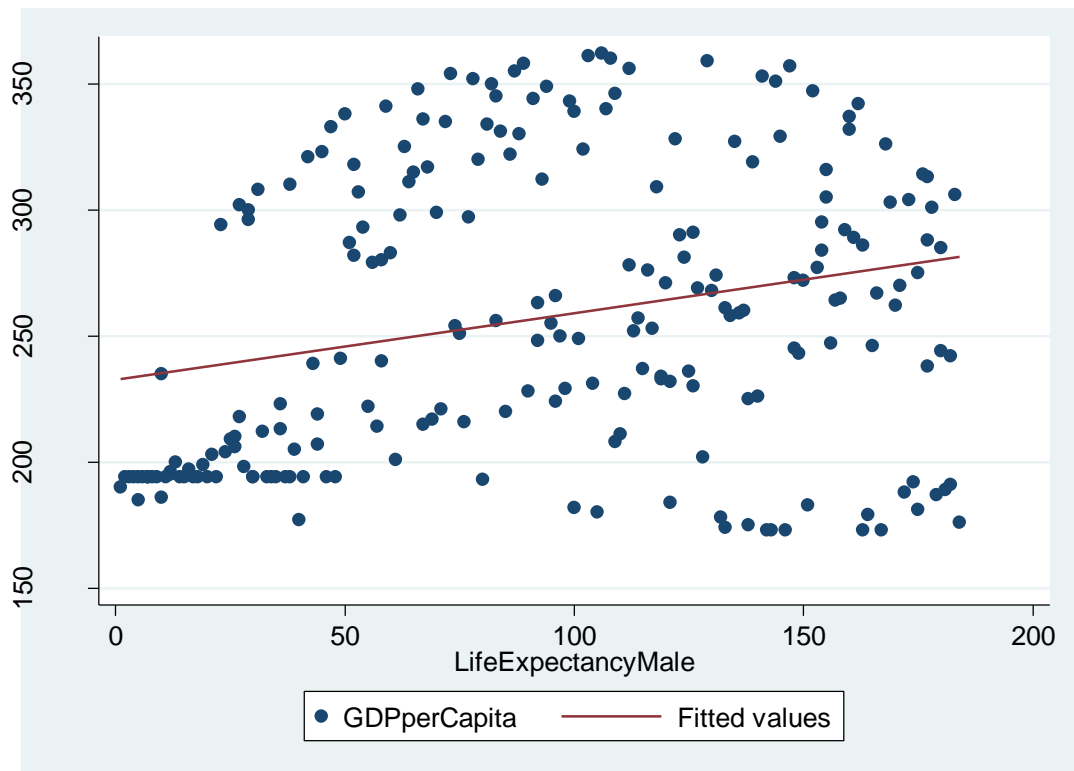Figure 7: correlation between life expectancy females and GDP per capita.

Figure 8: correlation between life expectancy males and GDP per capita.

	Human Capital	GDPperCapita	GDPgrowthPerCapita
LifeExpectancyMale	0,2984	0,2511	0,1728
	(0,0000)	(0,0002)	(0,0104)
LifeExpectancyFemale	0,2512	0,2468	0,1988
	(0,0002)	(0,0000)	(0,0031)
LifeExpectancyTotal	0,2817	0,2508	0,1843
	(0.0000)	(0,0002)	(0,0062)
HumanCapital	X	0,1821	0,0680
		(0,0068)	(0,3161)
EfficientLabourHours	0,8415	0,2470	0,0983
	(0,0000)	(0,0002)	(0,1463)

Table 1: correlations and attached significance

4. Results

4.1 Dataset description

The base sample consists out of 219 observations of panel data on four countries for the years 1960 till 2014. However, for investment in human capital there is only data for the

years 1980 till 2012. For the output growth I will use data on the GDP growth from the OECD. For the change in physical capital I will use data on the gross fixed capital formation from the Worldbank, which includes both investment as depreciation. For the investment in human capital I will use data on gross domestic spending on R&D from the OECD and educational spending from UNESCO. Data on the total hours worked comes from the Groningen Development Growth Centre database. For the technological progress I will use data on the amount of approved patent applications of both residents as nonresidents of a country from the Worldbank. As I will analyze these variables per capita, I will use data on population deducted from the Worldbank. Data on fertility rates is from the Worldbank. I will use data for the Netherlands, Japan, United States and Sweden. The National Institute on aging found that currently, Japan's population has the world's highest life expectancy. Many research done on this topic is based on United States data and Sweden has a high-quality individual-level population register available. Therefore, Japan, Sweden and United States are very suitable as reference countries for this thesis.

4.2 Empirical results

By adding a time and country index, the portion of the error that is due to country or time specific effects is taken into account in the regression. Then I regressed the level of gross capital investment, the technological progress and the effective labour hours on the GDP growth per capita. This can be seen in regression 1 in table 2. In the second regression in table 2 the change in fertility is added as well. However, as can be seen in table 2, the change in the fertility rates has no significant effect on the growth of the GDP per capita. Therefore, I will continue with regression 1.

To control for any possible time specific effects, I added year to te regression. The results can be found back in the regression " year". I could have chosen for the option year^2. However I have no reason to assume that years and GDP grwoth per capita are inverted related to each other so there would be a u-shaped relation between these variables.

	reg1 b/se	reg2 b/se	year b/se	uhat2 b/se	l.uhat b/se	l2.uhat b/se	prais b/se
technologycapita	0.082 (0.08)	0.084 (0.08)	0.082 (0.08)	2.621 (4.13)	0.018 (0.08)	0.021 (0.08)	0.069 (0.09)
capitalcapita	0.267** (0.08)	0.267** (0.08)	0.279* (0.11)	-1.220 (4.51)	-0.020 (0.09)	-0.019 (0.09)	0.262** (0.10)
hc	0.055 (0.09)	0.054 (0.09)	0.059 (0.10)	2.862 (5.00)	-0.006 (0.09)	-0.011 (0.09)	0.057 (0.10)
DeltaLabourHoursCa~a	0.005 (0.07)	0.002 (0.07)	0.005 (0.07)	6.971 (3.62)	-0.017 (0.07)	-0.020 (0.07)	0.038 (0.07)
_Icountry_2	-1.022 (13.56)	-0.825 (13.63)					-2.161 (16.00)
_Icountry_3	15.779 (12.14)	15.576 (12.21)					15.262 (14.47)
_Icountry_4	21.075 (13.47)	21.352 (13.57)					18.410 (15.84)
deltafertility		0.030 (0.15)					
country=Netherlands			-1.096 (13.60)	851.861 (719.58)	3.940 (13.80)	5.513 (14.31)	
country=Sweden			15.692 (12.18)	1086.750 (644.27)	1.101 (12.16)	1.540 (12.47)	
country=United st~s			21.956 (14.34)	748.821 (714.76)	-0.944 (13.80)	0.293 (14.52)	
year			-0.062 (0.34)				
l.Residuals					0.177* (0.07)	0.175* (0.07)	
l2.Residuals						0.008 (0.07)	
Constant	39.132 (19.89)	37.772 (21.01)	160.348 (665.23)	1494.133 (1055.22)	0.544 (20.40)	0.030 (21.78)	38.403 (21.90)

*, **, *** = significant on a five percent level.

Table2. GDP growth per capita as dependent variable

The variables are jointly significant as the overall F-value is significant. However, efficient labour hours and the change in fertility rate are not significant, while technological progress is significant on a ten percent level and investment in phsysical capital significant on a five percent level. In the next section I will test this regression on heteroskedasticity, autocorrelation, multicollinearity and stationarity.

4.3 Testing for heteroskedasticity and autocorrelation multicollinearity and stationarity

I will test on heteroskedasticity and autocorrelation by predicting the error therm. Then I will regress the squared predicted error therm on the independent variables to test for heteroskedasticity and predicted error therm on the the lagged predicted error therm and the independent variables in order to test for autocorrelation.

$$\hat{u}_{it}^2 = \gamma_0 + \gamma_1 \Delta T_{it} + \gamma_2 \Delta L_{it} + \gamma_3 \Delta C_{it} + t_{it} \qquad (14)$$

Equation 14

$$\hat{u}_{it} = \gamma_0 + \gamma_1 \hat{u}_{it-1} + \gamma_2 \Delta T_{it} + \gamma_3 \Delta L_{it} + \gamma_4 \Delta C_{it} + t_{it} \qquad (15)$$

Equation 15

As can be seen in table 2 the coefficients of equation 14 are not significant meaning there is no heteroskedasticity. Therefore the independent variables do not follow a random walk. The coefficient of $\hat{u}_{it-1}$ is significant meaning the regression suffers from first order autocorrelation. This means that the growth of the GDP per capita depends on the growth of the GDP per capita of the previous period. When adding $\hat{u}_{it-2}$ to the regression, it becomes clear the equation does not suffer from second order autocorrelation. Therefore, I can use the prais command to control for the first order autocorrelation. Results can be seen in table 2. When controlling for first order autocorrelation the only independent variable that has a significant effect on the GDP growth, is the investment in physical capital. A dollar increase in the investment in physical capital will lead to a 0,25 dollar increase in the GDP growth. The positive relation between these variables is in line with the theoretical framework. The fact that both technological progress as efficient labour hours are not significant, indicates neither of these variables significantly affects the GDP growth.

When testing for multicollinearity it turns out, the independent variables are not near perfect multicollinearity.

As the time frame for these countries is pretty small, the risk of non-stationarity is small. On top of this the regression is estimated in first differences and a time trend is added. Therefore the risk on non-stationarity influencing the coefficients in this regression is small enough to ignore it for now.

4.4 Empirical conclusion, drawbacks and discussion

Following the model, the only varaible that seems to have a significant effect on the GDP growth per capita is the investment in physical capital. It is very plausible that this specific model or dataset is not representative for real world relations. One of the major drawbacks of this research is that the time period per country is very limited. There is only data on educational investment from 1980 untill 2012 but with gaps for some years in between. On top of this, there is only data available for public investment in human capital while private investment undoubtedly plays a big role as well. Further it can be questioned whether I chose the right data to represent these independent variables in the model.

5   The role of dropping fertility rates

5.2 Theoretical background

The assumption that a higher life expectancy leads to more investment in human capital seems to be in line with the data, looking at the correlatoins. However, what I should take into account is that lower fertility rates play a role in this relation as well. In this section I will investigate the role of fertrility rates in the relation between life expectancy and GDP. First I will explain why investigating this is imporant and use previous literature on this to analyze this role. Then I will look at the correlation between fertility rates and life expectancy. I will end this section by looking at how the fertility rates affect this relation in the Netherlands and by making some concluding remarks on this.

In their paper "Life expectancy and economic growth: the role of the demographic transition" Cervellati and Sunde analzye how a specific demographic transition influences the effect that an increasing life expectancy has on economic growth. As mortalitity rates have dropped in the past years, the population growth has increased. However they argue that dropping fertility rates are often a consequence of these dropping mortality rates and thus can compensate for this, resulting in a reduction in the population growth. When fertility rates drop sufficiently to compensate for the dropping mortality rates, a country experiences a demographic transition. Now, as these authors argue, the effect of an increase in the life

expectancy depends for a great part on whether a country has experienced this demographic transition already. They specify a certain critical level that distinguishes between pre- and post-transitional demographic regimes. They give two reasons why lower mortality rates or increased life expectancy will lead to lower fertility rates. First, as mentioned before, when people have longer to live, they will tempted to invest more in human capital as the investements done in human capital will pay out over a longer life time. Logicwise, it will be more profitable to invest in human capital. On top of this Cervellati and Sunde argue that as life expectancy increases the opportunity costs of raising children instead of investing in your own human capital will raise as well. Therefore an increase in life expectancy will lead to an increase in education investments and to a decrease in fertility rates. A second possible reason given by Kalemli-Ozcan is that as the like hood on surviving until adulthood increases, the urge to have more children will decrease. So when mortality rates are high, the chance on a child surviving until adulthood is smaller and there is a bigger urge to have more children. When a country has already made the demographic transition, the fertility rates are dropping sufficienctly to compensate for the dropping mortality rates and so the population growth is declining. The increased investments in education will lead to a higher per capita per income. On the other hand, when a country is pre-transitional, the increase in life expectancy will lead to a higher population growth. And as the fertility rates do not drop suffiently, there is no increased incentive to invest more in human capital. This combination of growing population without increased investment in human capital, leads to a reduction in income per capita.

Just like previous research done on this topic by Acemoglu, Cervellati and Sunde focus their reseach on the period around 1940, when the international epidemiological transition took place. As during this period of time drugs for main killer deseases came on the market for the first time, mortality rates worldwide dropped significantly. They build on Acemoglu's findings that when fertility rates do not compensate a country's decreasing mortality rates, there will be no increased investment in human capital and therefore no increased GDP. They add the distinction between the pre- and post-demographic transition countries to be able to investigate the role of the fertility rates in the relation between life expectancy and GDP. They use three criterea to specify a country as pre- or post-transitional. First, they use a threshold for life expecancy (fifty years), second the fertility rates of a country should exhibit a sustained decline over five years, and last the fertility rates should be sufficiently low to compensate for the decreasing mortality rates. They use 30 births per

1000 inhibitants as a threshold for this last criterea. In the next part, I will use these criterea to analyze the role of fertiliy rates in the Netherlands.

5.3 Correlations and criterea in the Netherlands

Following previous literature, there should be a negative relation between the fertility rates and the human capital investment. To see if the data is in line with this, I have analyzed the correlation between fertility rates and human capital.
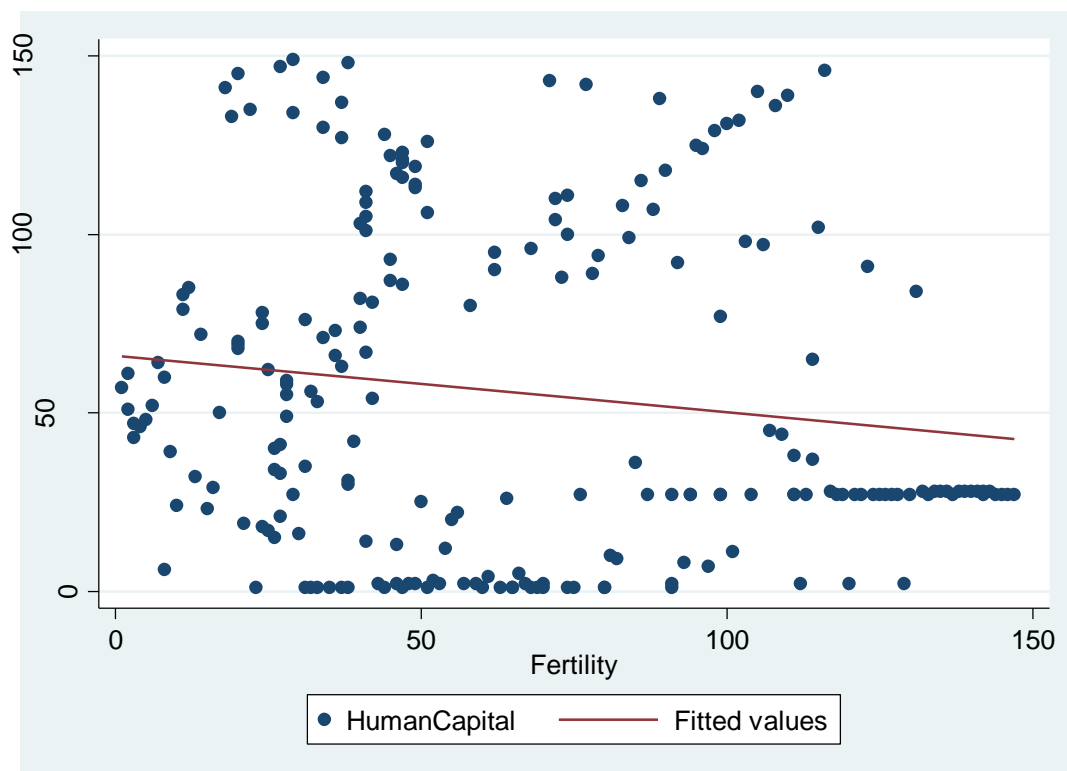

Figure 9: correlation between fertility rates and human capital.

Variable	Fertility
Human Capital	-0,1398
	(0,0382)

Table 3: correlation between fertility rates and human capital, plus significance.

The data seems to be in line with this, but as this is just a correlation, nothing can be said about any causal relation between the two variables. Moreover, this correlation turns out to be significant on a five percent level.

To be able to analzye the role of fertility rates in the Netherlands, it is important to know whether the Netherlands is a pre- or post- transitional country. The thresholds Cervellati

and Sunde have used are labeled as "typical thresholds". However the threshold for crude birth rates for example, is not representative for today. In the Figure 10, it becomes clear that birth rates have not been near 30 births per 1000 inhabitants since 1960. The same story applies for the for the life expectancy. Looking at Figures 11 an 12, it becomes clear that fifty years is not a very representative threshold for nowadays. However, the theory that fertility rates should decline enough to compensate for declining mortality rates in order to have a postive effect on the GDP, still applies.
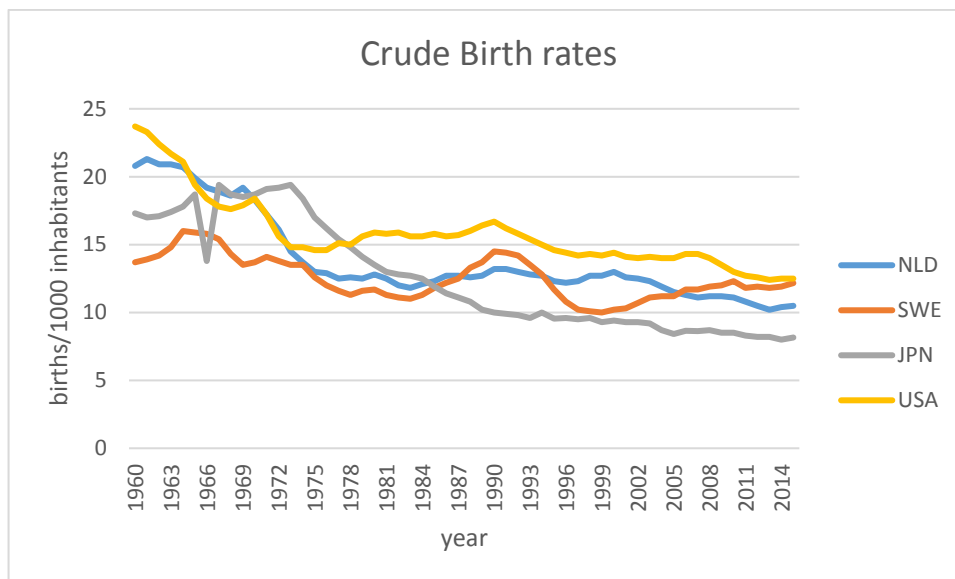
Figure 10: graph crude birth rates over time.
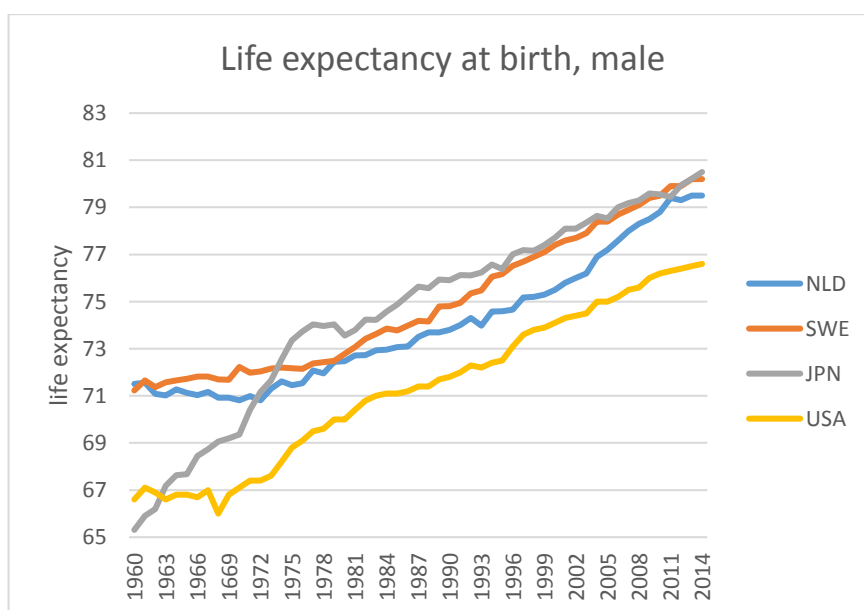
Figure 11: graph life expectancy male over time.
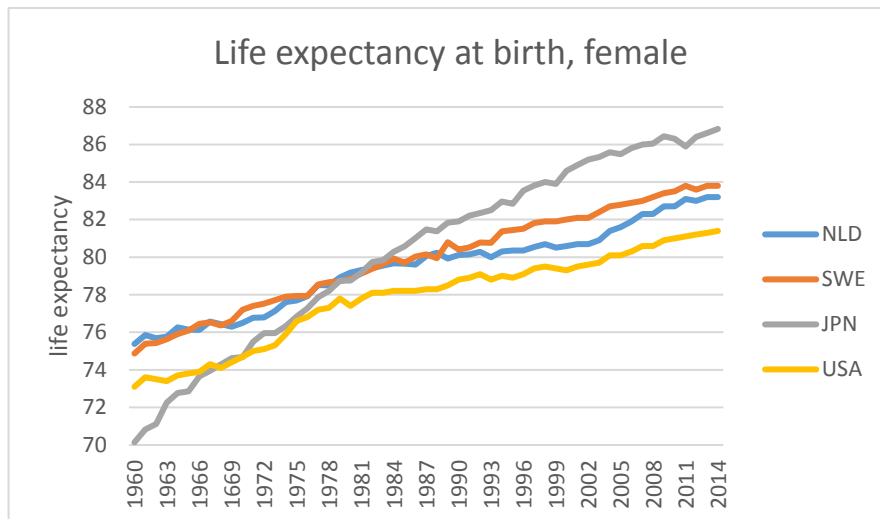
Figure 12: graph life expectancy female over time.

Follwing Cervellati and Sunde, I will look at the fertility and mortality rates and the population growth of the Netherlands, and attempt to estimate if and if so when the Netherlands experienced a demographic transition. Figures 10, 13, 14, 15, and 16 graph the crude birth rates, mortality rates, population growth and investment in human capital for the years 1960 till 2014.
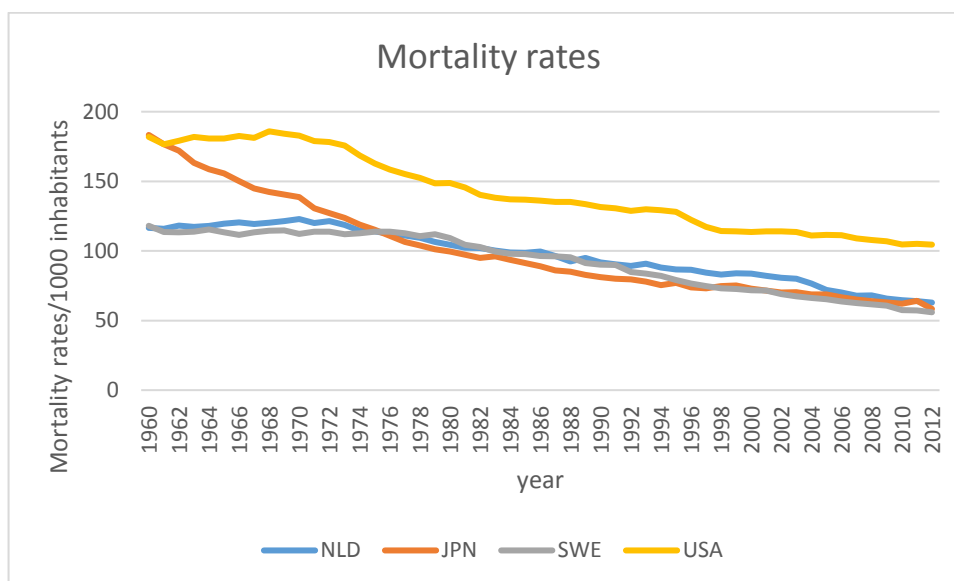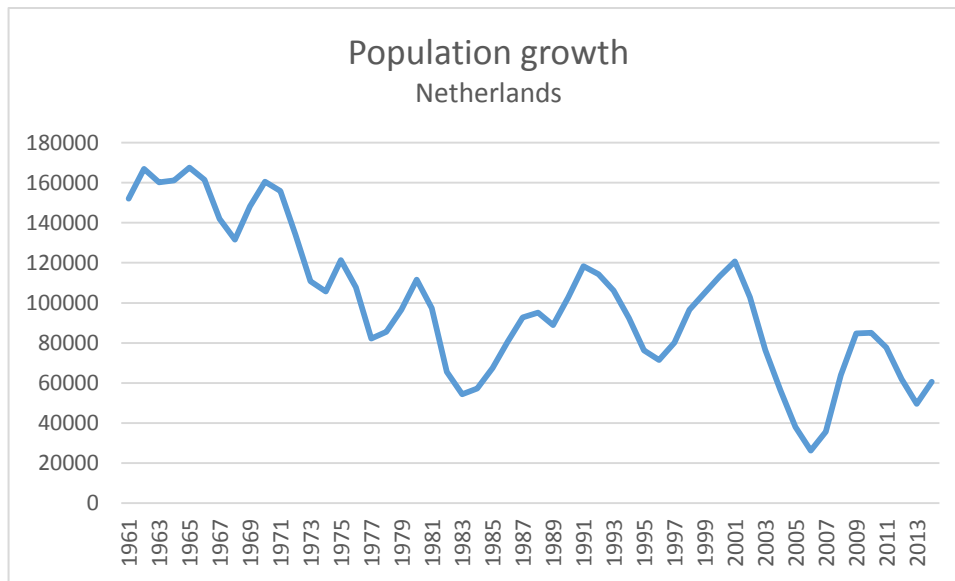

Figure 13: graph mortality rates over time.

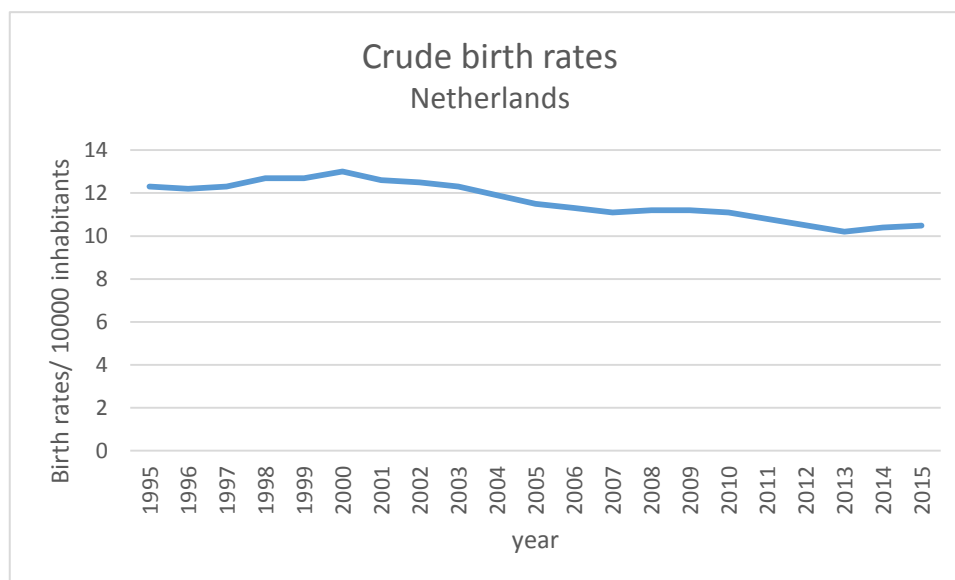Figure 14: graph population growth over time, the Netherlands.

Figure 15: graph crude birth rates between 1995 and 2015, the Netherlands.
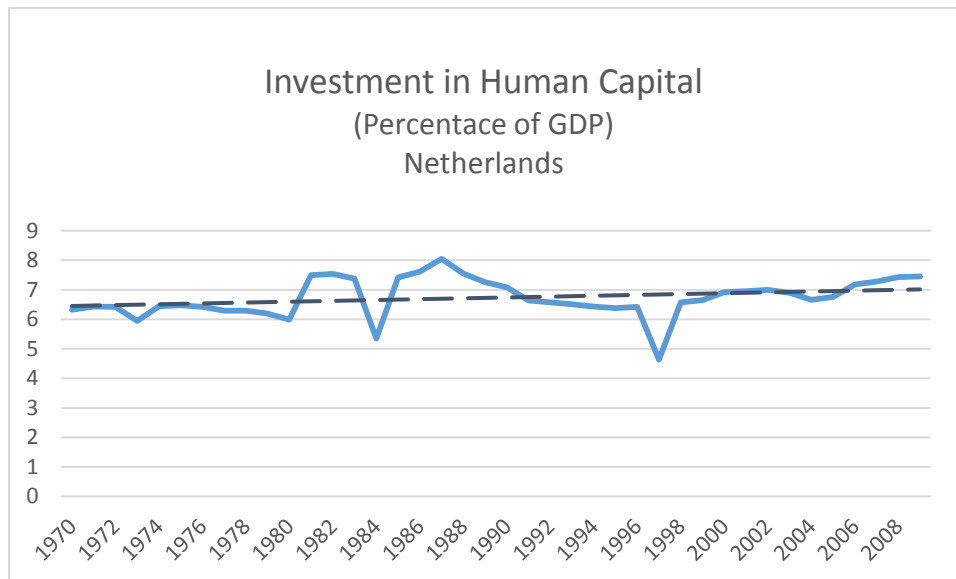
Figure 16: graph investment in human capital over time, the Netherlands.

Even though that based on these graphs, it is difficult to tell if and if so, when exactly this transition has taken place, I can make a rough estimation. Based on the three criteria established by Cervellati and Sunde, I assume that the graphs indicate a transition around 2000. One of their criteria states that the fertility rates, or in this case the birth rates should exhibit a sustained decline over at least five years. If you look Figures 10 and 15, it can be seen that from 2000 till 2007 there is a sustained decline of the birth rates. Another criteria states that the fertility rates should be sufficiently low to compensate for the decreasing mortality rates. As can be seen in Figure 14, from 2000 on there is a very deep decline in population growth, indicating fertility rates have dropped enough to compensate for the declining mortality rates. In the case of a demographic transition, the declining fertility rates should lead to higher investment in human capital. Looking at Figure 16, from 2000 on there is a steady increase. The fact that there is no sudden peak, can be explained by a time lag. When the population growth has experienced a sustained decline, the investment gradually increases. Therefore I assume the Netherlands has experienced a demographic transition around 2000. Then in this case, the increasing life experience should have a positive effect on the GDP per capita from then on.

I am going to compare the data I have on the Netherlands on population growth and GDP per capita with the distinction Cervellati and Sunde make between pre- and post-transitional countries. Characteristics of the post- transitional countries are the slightly concaved form of the log of the population as the growth declines and a fairly big increase in

the log of the GDP per capita, as can be seen in Figure 17. Both of these characteristics can be found back in the income and population dynamics graph of the Netherlands, Figure 18.

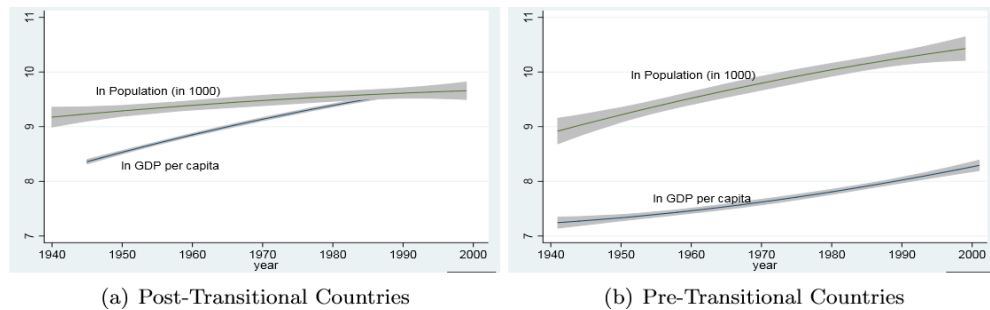(a) Post-Transitional Countries   (b) Pre-Transitional Countries

Figure 17: Income and population dynamics in pre-transitional and post-transitional countries. Source: Life expectancy and economic growth: the role of the demographic transition (2011), Cervellati and Sunde.
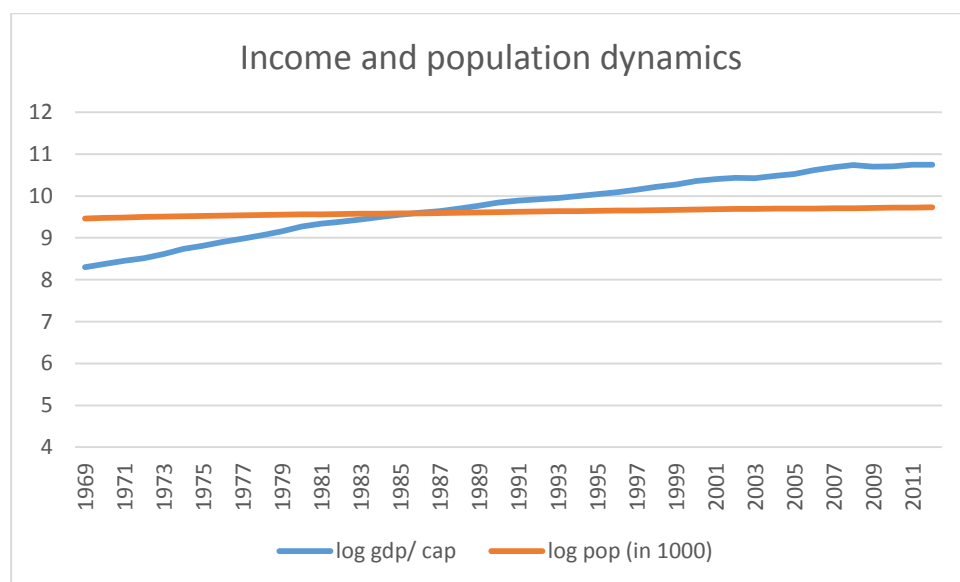

Figure 18: Income and population dynamics in the Netherlands

If the Netherlands experienced a demographic transition around 2000, this should be visible in Figure 18 as an increase in the slope of the log GDP/ cap and a decrease in the increase the slope of the population. Even though the log of the GDP/ cap indeed increases and it seems that the slope of the population is decreasingly increasing after 2000, there is no clear turning point in these graphs around 2000. Before 2000 these characteristics were also already visible in the graph. A possible explanation is a time lag. To test this, we would have to reanalyze this in the future. However, based on graphs of crude birth rates, population

growth, investment in human capital, and population dynamics, I conclude the Netherlands is a post-transitional country.
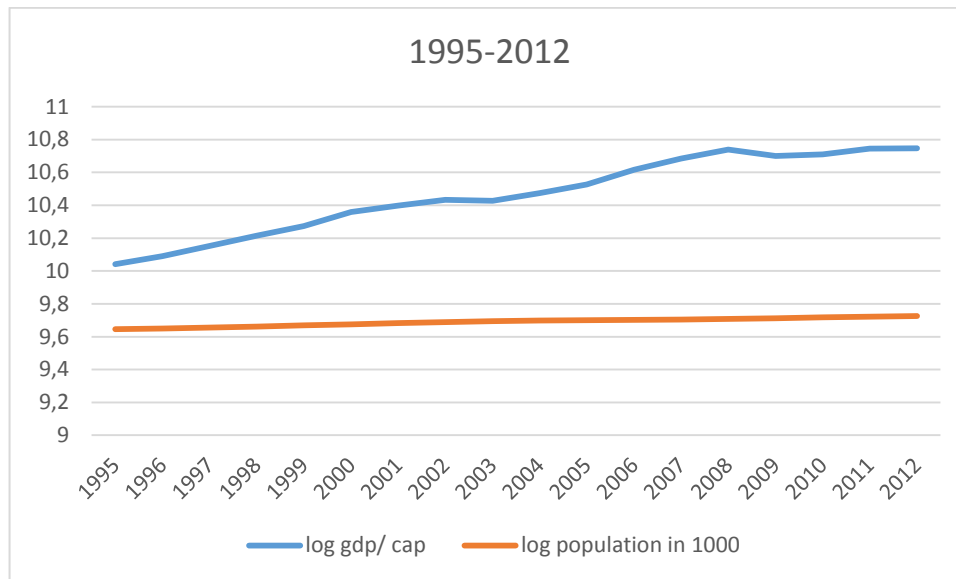

Figure 19: Income and population dynamics between 1995 and 2012 in the Netherlands

6. Conclusion

In this paper I attempted to investigate the relation between the life expectancy and the economic growth. Previous studies and correlations between the concerning variables point towards a positive relation. In addition I conclude that the Netherlands is a post-demographic transitional country which indicates a positive relation between life expectancy and economic growth as well. Graphs of crude birth rates, population growth and investment in human capital are in line with this believe. However, the model and dataset used in this thesis do not confirm this positive relation.

There are several major drawbacks of the dataset that can have influenced this conclusion but the results could also mean there is no important relation between a life expectancy and economic growth. As it is important to know whether politics should be preparing for possible effects on GDP due to increased life expectancy and this research does not give a very solid statement about this, it is important that further research on this topic is done. A major improvement in future research could be to construct a dataset over a longer period of time per country. In this way it would also be possible to compare the countries with one another and also investigate the role of pension systems in the relation between life expectancy and GDP. On top of this, it would be interesting to analyze this relation the other way around, so a possible effect of an increasing GDP on the life expectancy.

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