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Economic growth in the context of demographic dividends

Ph.D. dissertation

Supervisor:

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professor

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Department of Macroeconomics

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Contents

1 Motivation and previous research

The ageing of the population, i. e. the demographic transition due to the low fertility and the increasing life expectancy, is becoming more important in the economic research. The ratio of the older citizens is growing in several countries, and according to the forecasts the tendency will not change in the next decades. The changing age structure of the population is leading to increasingly serious problems not just in the developed but in the developing countries also, because it makes the current social security system unsustainable after a certain period.

Four phases of the demographic transition are usually recognized in the literature. According to Van de Kaa (2010) the first phase is characterized by high birth rate with also high death rates, but altogether it shows a slowly growing or stagnating population. In the second phase the death rate starts to decline due to the developing health care and the improving living conditions, but the fertility is still high, hence the natural population change is positive, and the population growth is faster. It is followed by the third phase, when the moderation of the infant and child mortality lead people to have fewer children, therefore the population growth starts to slow down with the diminishing difference between the number of live births and the number of deaths. Finally, in the last phase after the further decline of the fertility rate the natural population change decreases such an extent, that the population size does not continue to rise, or natural population decrease can occur instead. Hungary and numerous developed countries are already in the fourth phase, and although most of the developing ones are still in the third phase, they will reach the last phase of the demographic transition soon because of the expected decline of the fertility.

The literature of the topic is diversified, but most studies draw attention to the growing pension and health-care expenditures, which put increasingly burden on the working age population, and raise the risk of poverty in old age due to unsustainability. There are different alternatives to reform the pension system, but their introduction is possible only step by step, mainly in the current pay-as-you-go system, and raising the retirement age is essential in all of them.

Another important issue is the possibility of increasing birth rates, especially in areas where the overall fertility rate is well below the replacement level. Nowadays the fertility rate does not reach the value needed to maintain the population, i. e. there are less than 2.1 births per woman on average, in any European country, and it is similar in other developed countries, as well. The articles in this research area deal mainly with proposals to family support systems and their effectiveness.

The dissertation approaches the problem of the ageing society from a third aspect, as it examines the impact of the ageing on growth in connection with the literature of economic growth. It is not clear whether aging will set the growth rate of GDP per capita back, because it depends on two – even opposite – effects due to demographic processes. One of the effects is caused by the changing share of the income-producing population and the other one is by their changing productivity. If relatively fewer people are able to work in the economy, then the value of per capita output can only be sustained or increased if the productivity of the economically active people is sufficiently developing.

We identify the expansion of the consumption per capita with the growth of welfare like Mason et al. (2016), which can be written according to the following components:

$$\frac{C}{N} = \frac{N^Y}{N} \cdot \frac{Y}{N^Y} \cdot \frac{C}{Y}, \tag{1}$$

where $\frac{N^Y}{N}$ is the share of the working age population in the total population, which can be interpreted as a kind of support ratio if the numerator shows the income-producers and the denominator is the number of consumers, i.e. the total population. Several other approaches of the support ratio are known or used as a measure of ageing. $\frac{Y}{N^Y}$ is the output per worker, which can be identified as the productivity of the workers, and $\frac{C}{Y}$ is the share of income spent on consumption, i.e. the consumption rate. According to equation (1) the growth rate of consumption per capita is the sum of the growth rates of these three factors. The first factor, the rate of growth of the support ratio, is called the first demographic dividend, and the rate of growth of the product of the second and third component – the share of income per worker spent on consumption – is the so-called second demographic dividend. The dissertation examines the impact of the population ageing on economic growth through these two demographic dividends.

Chapter 2 is the edited version of Berde – Kuncz (2014), in which we give a detailed description of the first demographic dividend and calculate it in Hungary. The first dividend is determined by the rate of growth of the support ratio, to which we apply an adjusted one based on national transfer accounts, weighting the number of age groups with age-specific coefficients reflecting relative levels of consumption and production. On the one hand, we draw attention to the role of these weights and the real meaning of the indicator with the available data. On the other hand, we show that apart from two shorter periods in Hungary – when the Ratkó-children or Ratkó-grandchildren reach the working age – the first dividend is negative, and further decline is expected until the 2030s.

Chapter 3 is the edited version of Berde – Kuncz (2017), in which one of the driving forces of the second demographic dividend, or the productivity growth comes to the fore, the human capital. We build an overlapping generations model based on Lee – Mason (2010), where the central element is the Beckerian quantity – quality trade-off. The latter briefly suggests that in the case of fewer children, parents can spend more on a child than those living in a larger family, thus providing them with more human capital. As a result, the decreasing number of the young generations can be offset by increasing their productivity, so, consequently, the decline in birth rates can have a positive effect on economic growth. We are using this model to simulate the potential paths of GDP per capita with exogenous fertility and survival rates, as well as different demographic processes. Based on the results, we conclude that the decrease in fertility rate generally has a positive effect on the per capita output, even if it falls below the replacement level, but we show that there is a critical level of fertility under which the growth of per capita output starts to decline.

Chapter 4 is an improved and expanded version of the Kuncz (2011) model applying to estimate demographic dividends. We build a stochastic overlapping generations model according to Baksa – Munkácsi (2016a), where household savings and physical capital accumulation appear as the other driving force of the second demographic dividend. We present theories linking demographic variables to household savings, and the three channels through which the size and the age composition of the population can have an impact on savings. After the latter and the description of the model, we calculate the first and the second demographic dividends with Hungarian fertility and mortality rates and estimate their value by 2060 using demographic forecasts. Although the interpretation of the support ratio differs from the one used in Chapter 2, we get a similar negative value for the first dividend over the forthcoming decades, and a low positive second dividend that can compensate the first one only with some level of technical progress.

The structure of the thesis is as follows: after the introduction, we first deal with the first demographic dividend and quantify it in Hungary based on age-specific data according to the national transfer accounts. Then we move on to the second dividend, which is first enforced through human capital and then through physical capital and savings. Finally, we estimate the value of the two dividends with an overlapping generations model in Hungary. In summary, the final chapter summarizes the results of the dissertation.

2 Applied methods

The first demographic dividend and its Hungarian trends

Using the notations of Mason (2005), we present the growth model that can be used to define the first demographic dividend. The model requires household income and consumption for the years considered. In this case the income is the labour income, which is quantified as the sum of net wages and taxes paid by the employee and the employer during the collection of statistical data. Consumptions of cohorts also play an important role in the model and are obtained from household statistics surveys. The value of public consumption in national statistics, in particular the cost of education and health care, is added to individually funded private consumption. However, the analysis of the statistical details of income and consumption goes beyond the scope of our present study. We mainly focus on modelling and determining the first demographic dividend.

In the model of the first demographic dividend, economic growth is measured by the output per an effective consumer. The definition of an effective consumer in the following equation (2) depends on both the demographic composition of the population and the relative consumption of each age group:

$$N(t) = \sum_{a=0}^{\omega} \alpha(a,t)P(a,t). \tag{2}$$

In equation (2) $N(t)$ is the effective number of the consumers at time t, ω is the maximum age, $P(a,t)$ is the population aged a at time t, and $\alpha(a,t) = \frac{c(a,t)}{c(b,t)}$ is the age-specific coefficient. In this coefficient $c(a,t)$ shows the average per capita consumption of population aged a, and $c(b,t)$ is the arithmetic average of average consumption by age of the 30–49-year-olds at time t. In the following, 30–49-year-olds will be referred as the base age group. This age group is used as a base for this type of model, because they are old enough to be able to work and are no longer students, but still young enough to be retired. In this way, equation (2) above expresses the total number of effective consumers of a given year in the society, considering that effective consumer is the hypothetical consumer whose consumption is the same as the average consumption of the base age group.

The growth of the economy is measured by the increase of the output per effective consumer defined by the equation (3)

$$y^n(t) = \frac{Y(t)}{N(t)}, \tag{3}$$

where $Y(t)$ is the total output at time t. Obviously, the economy grows if $y^n(t)$ is growing in t in the model. The output per effective consumer can be split into factors shown in equation (4).

$$\frac{Y(t)}{N(t)} = \frac{L(t)}{N(t)} \cdot \frac{Y(t)}{L(t)}, \tag{4}$$

where $L(t)$ is the number of effective producers (or workers) at time t. The number of effective workers indicates how many the average labor income of the base age group is in the total income earned by the population at time t.

$$L(t) = \sum_{a=0}^{\omega} \gamma(a,t)P(a,t), \tag{5}$$

where ω is the maximum age, $P(a,t)$ is the population aged a at time t, and $\gamma(a,t) = \frac{y(a,t)}{y(b,t)}$ is the age-specific income coefficient. In the latter, $y(a,t)$ is the average annual labor income per capita of population aged a, $y(b,t)$ is the arithmetic average of the per capita income of 30–49 year-olds, or as we mentioned earlier, the base age group at time t. The ratio of $\frac{L(t)}{N(t)}$ is an alternative interpretation of the support ratio in equation (4).

According to equation (4) the growth rate of output per effective consumer can be written as follows:

$$\hat{y}^n(t) = \hat{L}(t) - \hat{N}(t) + \hat{y}(t), \tag{6}$$

where $\hat{y}^n(t)$ is the growth rate of output per effective consumer, and $\hat{L}(t)$, $\hat{N}(t)$, $\hat{y}(t)$ are the growth rates of effective workers, effective consumers and output per effective worker. $\hat{L}(t) - \hat{N}(t)$ is called the first demographic dividend in equation (6). Its value is positive if the number of effective workers increases more (or decreases less) than the number of effective consumers. The last member of the right-hand side of the equation ($\hat{y}(t)$) is the second demographic dividend, discussed in more detail in Chapters 3 and 4. We estimate the first dividend defined in this way in Hungary using the National Transfer Accounts (NTA) Database and the Eurostat Population Projection Database, and draw attention to the role of age-specific weights.

Possible paths for GDP per capita – simulation with a demographic growth model

This chapter of the thesis was published in English in Financial and Economic Review (Berde – Kuncz 2017).

Estimation of the Hungarian demographic dividends in an overlapping generations model

In this chapter we focus on the first demographic dividend and on the certain part of the demographic dividend depending on savings and the physical capital investment. After the introduction, we discuss the relationship between savings and demographic trends, briefly summarizing the hypotheses and results of studies closely related to the topic. Then we build a model with overlapping generations to quantify the contribution of the two types of dividends to the economic growth in Hungary.

The main feature of overlapping generations models (OLG) is that it contains heterogeneous consumer groups. Allais (1947), Samuelson (1958) and Diamond (1965) were the first to deal with this type of model. It was assumed that in each period a new generation is born, which lives for a finite period, and at the end of each period, the old population exits the model when their lifetime ends. Thus, two different consumer groups live together, the young and old one.

There are several extensions of the base model. One method is the Auerbach – Kotlikoff approach, which counted consumers living for more than two periods, so the working age and the inactive period of life is longer than one period. In this case many generations are living next to each other in the economy. Auerbach – Kotlikoff (1987) considered individuals as children up to the age of 20 years old, and then they became adults at the age of 21 and died at the age of 75. These values are known also by the consumers in the model and are taken into account while maximizing their utility, so the model is deterministic. For example, Simonovits (2009) used this type of model to describe the sustainability of the pension system and the consumption of each generation, Major and Varga (2013) to examine the impact of parametric pension reforms on male life-cycle labor supply, and Varga (2014) to analyze the sustainability of the pension system and the paths of the macro aggregates with demographic processes in Hungary.

The other approach is the model with the so-called Blanchard–Yaari-type consumer, which, unlike the previous one, is stochastic. In Blanchard (1985), new individuals are born at any moment in time, who face a constant p probability of death in every period, so they do not know for sure when their lifetime ends. In this case, their life expectancy is $1/p$, so they are optimizing over a finite time horizon. Yaari (1965) was also concerned with the uncertainty of the length of lifetime, looking for an answer to how consumers make their decision if they are uncertain about how long they will live. Dynamic stochastic general equilibrium (DSGE) models with OLG-type households are also referred to as Blanchard–Yaari DSGE models after these two authors. We are using this type of overlapping generations models in our analysis.

The model we used is based on the Baksa – Munkácsi (2016a) model, transformed to a version which is able to answer the question of the study and to examine the paths of the demographic dividends. We also use Blanchard–Yaari-type households optimizing on a finite time horizon, but we are simplifying the production sector and the fiscal policy. The difference is that we distinguish three types of consumers: children, workers and the elderly. The childhood lasts for one period, and than the individuals become workers. The workers finance the consumption of children, so they have to take care of them. This generation may become pensioner with a certain probability, which they must take into account during the utility maximizing process. Retirement probability means that they can be economically active for several periods, but only this generation from the three consumer groups can enter the labor market. The elderly – i.e. pensioners – will die with a certain probability. It is possible, that they will be retired for several periods, but their lifetime will end once. In contrast with Kilponen – Ripatti (2006), they can not have labor income, so they can finance their consumption only from their savings and transfers given from the government.

In addition to households, there is a representative firm, a financial sector and a kind of asset manager in the model. The firm uses the workforce of the working age population and the accumulated capital during production, for which it pays wages and rents in each period. The fiscal policy levy three types of taxes: consumption tax, labor income tax and lump sum tax. Its income is spent on government spending or social benefits, and it can issue government bonds. The working age population and the elderly households also benefit from transfers from the government. In the latter case, this refers to the pension, and in the case of the former one, to transfers related to childcare, for example. As the asset market is an important part of a DSGE model with overlapping generations, there is also an asset manager in the model that collects savings from consumers and finances investments and public debt. Since the number of population may vary in the model, after writing and deriving the problem of the actors, the equations need to be standardized with the per capita variables from which we determine the steady state. In the contrary of Baksa – Munkácsi (2016a, 2016b), the model is calibrated to Hungarian data and used to estimate demographic dividends.

The first step of determining the steady state is to calculate the real interest rate in the equilibrium. In case of DSGE models that do not contain OLG households it can be solved relatively easily, because that is the reciprocal of the subjective discount factor. However, in a model extended to consumers with finite time horizons, this will no longer be true. Therefore, we have to find the interest rate, that balances the asset market in an iterative way. To do this, we used Matlab and the Newton algorithm.

3 Results of the thesis

The first demographic dividend and its Hungarian trends

- We have pointed out that quantification of the support ratio with this method is extremely costly, and therefore most of the countries involved in the NTA project have only published data for a few years. A commonly used method to solve this problem is to use the same income and consumption data in each year for weighting the current population numbers. In our study, however, we have shown that, in fact, they measure labor income growth per unit of aggregate consumption, also by considering household income and consumption data as constant.

- In Hungary the first demographic division is positive only between 1972 and 1983, that is, when the Ratkó-children became able to work, and between 1993 and 2009, when the Ratkó-grandchildren become economically active, while in the other years it is negative and is expected to remain there from the retirement of the Ratkó-children until the mid-2060s. It will expectedly touch the bottom at the end of the 2030s.

- We made a thought experiment where the support ratio calculated using the actual 2005 population, consumption and income data in Hungary was compared to an artificially constructed support ratio. The latter one was determined from the Hungarian population data of 2006 and the income and consumption values of six other European countries participating in the NTA project. Different support ratios were obtained from different weights, and thus the rate of growth of the ratio was very wide-ranging, including negative and positive values. We have shown, that although the comparison of income aggregates to consumption aggregates may be a useful tool for a large number of economic analyzes, but it may also lead to incorrect conclusions in the estimation of the first demographic dividend, even regarding the sign of contribution to economic growth.

- Examination of this first demographic dividend formula has led to the conclusion that the increase in average consumption of 30–49-year-olds, called the base age group, has a positive, and a negative effect on the growth of dividend, as well. The increase in the average labor income of the base age group has the opposite effect. However, the increase in labor income of the population outside the base age group, i.e. the younger and older generations, clearly increases, and the increase in consumption reduces the value of the support ratio.

Possible paths for GDP per capita – simulation with a demographic growth model

This chapter of the thesis was published in English in Financial and Economic Review (Berde – Kuncz 2017).

Estimation of the Hungarian demographic dividends in an overlapping generations model

- We have built a stochastic overlapping generations model with Blanchard–Yaari-type households, and we used it to estimate the demographic dividends in Hungary.

- We calculated the per capita values in steady state with the model calibrated with Hungarian data and using the Hungarian demographic indicators and their projections from 1980 to 2060. With our results, we came to the same conclusion as Prskawetz – Sambt (2014), and Gál – Radó (2018), according to which the second dividend is no longer able to offset the first demographic dividend, so the demographic transition will negatively affect the per capita consumption. But while the above authors made an empirical estimation with constant age-specific data based on national transfer accounts, the values from our model changed continuously each year. In addition, these articles count on 1.5 percent exogenous technical progress, while our model omits this in the first simulation.

- In the second case, with 1.5% of total factor productivity growth a year, the simulation was found that if this technical progress is exogenous, this kind of modification does not change the dynamics of the second dividend, but only its level, so it can lead to a positive dividend, offsetting the reduction in the support ratio. With the technical progress – in the contrary of the results of Prskawetz – Sambt (2014) and Gál – Radó (2018) – the sum of the first and second demographic dividends can be permanently positive.

- We found that the first demographic dividend has been negative in Hungary for years because of the changes in population age structure and is expected to remain there according to the population forecasts. This can be counterbalanced by the second demographic dividend, which is mainly due to labor productivity growth. By financing capital accumulation from increasing savings, the second dividend may be large enough to keep the sum of the two dividends positive, thereby supporting the increase in per capita consumption, i. e. the standard of living. Although our model predicts a positive second dividend for several years, it is unable to retract the negative impact of the first dividend without technical progress, and without this, demographic processes will negatively affect the growth after 2015. For this reason, policy-makers have an important role in reversing the process by adequate tools. It is more difficult to affect the first dividend, because it depends only on population structure. However, the second dividend is still positive, so it is proposed to try to boost it by stimulating savings and expanding capital stock – both physical and human – to increase productivity.

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