Productive Population and Czech Economy by 2060

Jaroslav Sixta [1] | *Prague University of Economics and Business, Prague, Czech Republic*
Karel Šafr [2] | *Prague University of Economics and Business, Prague, Czech Republic*

Abstract

The paper brings a deeper outlook at the development of productive population by 2060 in the Czech Republic. The Czech Republic will be strongly confronted with population ageing and suitable mix of different policies will be needed. The crucial issue is, how much the development of labour productivity as well as technical progress can prevent radical increases in statutory retirement age. Capping this fundamental economic parameter at the age of 65 years will shift economic burden on productive population that will have to respond. We bring a deeper view on the structure of current labour force and its possible development by 2060. This comes from the combination of official demographic projection and computable general equilibrium model based on Leontief input-output principles. We prove that economic sustainability of such parameters is more than uncertain since the estimates of the potential burden incurred by population ageing is significant despite the compensation by the changes in labour productivity and technological growth.

Keywords	***DOI***	***JEL code***
Demographic ageing, labour force, productivity, CGE	*https://doi.org/10.54694/stat.2021.29*	*J11, C68*

INTRODUCTION

Population ageing and its consequences affect lots of areas of human society. The most discussed issues include retirement pensions, health and social care system. Economic impacts are often discussed from the perspectives of resources for retirement pensions. Besides, we should also consider the impact of ageing on the potential capacities to produce goods and services that will always be needed for satisfying population needs. It is very difficult to predict any development in a long perspective and current pandemic situation with coronavirus emphasises that. However, that does not mean that these thoughts and concerns are not justified. Sober look on the demographic projection by 2100 prepared by the Czech Statistical Office (CZSO) should not leave us calm (CZSO, 2018). We raise the question of how to secure resources for ageing population. We think that all extremes are counterproductive such as no changes in statutory retirement age or completely voluntarily based pension systems. Our question is simple,

[1] Department of Economic Statistics, Faculty of Informatics and Statistics, Prague University of Economics and Business, W. Churchill Sq. 4, 130 67 Prague 3, Czech Republic. Also the Czech Statistical Office, Na Padesátém 81, 100 82 Prague 10, Czech Republic. Corresponding author: email: sixta@vse.cz.
[2] Department of Demography, Faculty of Informatics and Statistics, Prague University of Economics and Business, W. Churchill Sq. 4, 130 67 Prague 3, Czech Republic. Also the Czech Statistical Office, Na Padesátém 81, 100 82 Prague 10, Czech Republic.

what is the necessary development of productivity for ensuring enough resources for the population. Of course, the question is partly theoretical since the Czech Republic is not an isolated island and financial transaction may solve lots of shortages in both material and human capacities. The ageing problem of the Czech Republic and its regions is also mentioned in Šimková (2021).

When studying the structure of labour supply, we still consider capital assets, as well. We do not want to tackle futuristic scenarios in terms of significant substitute of labour by robots or computer since it seems that in many areas of human life the labour is irreplaceable. At least for now. Ongoing progress will reduce the necessity of labour in many industries of the economy but in some others the labour will still be needed. To date we cannot imagine many of human related services (health, education) without active participation or presence of a human being. The discussion about productive population and its future is not without context with demographic ageing. IMF estimates of total productivity growth, loss and estimated development of a share of prime age workers do not provide an optimistic view, see Aiyar et al. (2016).

Our paper focuses on the expected changes in the size and structure of labour supply that will result in changes of the Czech economy. The size and structure of employment (labour supply) is not steady in time. Since the radical changes at the beginning of 1990s, labour supply changed significantly and it was not only due to the changes connected with economic transformation. Availability of computers and technological progress boosted labour productivity but should we expect the same development in next 40 years? Currently, the demographic process of ageing is starting to influence the Czech labour market. Ageing influences both labour supply (the possibility to find suitable worker) and labour demand (older patients require more health and social services).

All changes connected with labour supply and ageing can be expressed by the development of productive population. For our purposes, productive population is hypothetical labour supply affected by structure, health status, education, productivity and rate of economic activity. These parameters are separately estimated and used as an input for computable general equilibrium (CGE) model, see Johansen (1963). The Johansen system of equations is based on the same framework as IOA, on Keynes theory, see Goga (2009), or Taylor (2016). We put the emphasis on the input-output approach (CGE based on input-output framework) as described in Ronson (1991). In our estimates, we combine Ronsons´ works and standard CGE model, see Hosoe et al. (2010) and Sue Wing (2004). Alternatively, Gawthorpe uses input-output DSGE (Gawthorpe, 2019) and Gawthorpe and Šafr (2019) for estimation of a well-being of ageing population.

We present the outcomes from our CGE in relative terms, by indices comparing current and potential state of art in 2060. Under classic CGE condition, we are able to estimate different scenarios with necessary requirement of labour productivity growth. The main aim of CGE model consists in the evaluation of the exogenous effect of parameters of model (Mardones, 2015). An example of the combination of the input-output approach and CGE can be found in Kim and Hewings (2009).

1 METHODOLOGY AND DATA

Our model of productive population is based on both official statistical data and research data from our models. Official statistical data comes from the Czech Statistical Office, namely Labour Force Survey (LFS) used for the expression of labour supply and data on population and demographic projection. With respect to the specifics of the data, we successfully combine macroeconomic data (CZSO, 2021), social statistics data and demographic data. Macro-aggregates come from Czech national accounts.

Research data comes from own-designed Computable General Equilibrium model programmed in R. Within the Section 5, we use only fragments of our CGE model since this paper is focused on productive population and its ageing consequences only and it is not devoted to the description

of specifically built CGE.[3] Generally, CGE models use lots of data as well as other sophisticated models. Among the most important data inputs, we defined estimates of labour productivity, development of the population and its consumption structures, inter-industry mobility of workers, estimates of the development of health condition of population, estimates of activity rates and development of the technology. For those who are interested in CGE modelling, the list of main assumptions is presented in the Annex I.

The specifics of our CGE model lie in the use of Leontief production function (Šafr, 2017) and corresponding limits consisting of fixed structure of production. The model is prepared on the level of 21 industries (sections) of CZ-NACE. The idea of the model lies in the maximisation of fictitious following utility function (U) and computation of Cobb-Douglas (C-D) production function (x):

$$U = \sum y_h^{\alpha_i}, \tag{1}$$

$$x = f\left(y, A\right), \tag{2}$$

where:

- U utility,
- α_i input coefficients,
- y_h final use – household consumption expenditures,
- x output,
- A matrix of input coefficients from input-output tables.

Utility comes endogenously from the CGE computation respecting both the level and the structure of household consumption. As consumption and structure varies during the time, utility changes, in fact Formula (1) expresses weighted consumption according to the input coefficients and therefore it also reflects consumption non-linearly by products. Output (x) endogenously affects utility under the condition of maximisation. All the inputs described above (population estimates, health status, development of the productivity,...) come as exogenous variables under our control. In other words, under a give set of parameters, we receive maximisation task –> max U.

With reference to the above, we define productive population (*pp*) as:

$$pp_{t,s} = p_{t,s} h_{t,s} e_{t,s} q_{t,s}, \tag{3}$$

where:

- pp productive population,
- p total population,
- h health condition index,
- e education status index,
- q labour productivity index,
- t index for time,
- s index for specific group (age and education).

Computation is done on the level of three age groups (15–49, 50–64, over 65) for three educational levels (elementary and lower, secondary and higher than secondary). Detailed description of these inputs goes far beyond the purpose of this paper and therefore we use just some model outcomes. For the consequences of ageing and its mutual linkage to productive population this brief description is sufficient.

[3] We intend to prepare a special paper devoted to the methodology of construction CGE model describing population ageing in a detail.

With respect to the definition of standard demographic indicators such as economic dependency ratio, we use our own computations since we focus on economic side of the changes on labour supply and we must consider the rate of activity in different age groups. In Section 3, we present our estimates of these rates that reflect future participation of older people in the labour market, estimated population structure, estimated development of educational status and gradual growth of statutory retirement age to 70 years in 2060.

Mainly, we focus on the quantitative side of labour. Qualitative issues must be considered, as well. It would be ridiculous to say that the nature and the qualitative aspects of labour remain steady. The evidence from the comparison of Czech society and economy when comparing 2019 and 1990 is obvious. But, on the other side, some works (jobs) can be hardly handled without human beings. We do not have consider only nurses, doctors etc. It means that the most serious reflection of our study is indicative impact on the quantity of work (labour supply) that will definitively affects our population.

2 LABOUR SUPPLY AND EMPLOYMENT IN THE CZECH REPUBLIC

Currently, the structure of labour supply in the Czech Republic is going to be at the beginning of a serious ageing problem. The lack of different (and human demanded) professions such as doctors, dentists, nurses, masons, plumbers etc. is observable everywhere. Anyway, the situation is at the stage of exhaustion demographic dividend, the issue described by Der Gaag and De Beer (2014). The structure of the Czech population has been continuously changing from the beginning of 1990s. The growth of the population from 10.3 million to 10.7 million in 2019 was due to the migration increments and prolongation of life expectancy, which moderated population decrease by natural change. In economic words, it means that while the population is growing, the number of economically active is not increasing adequately, see Table 1.

Table 1 Structure of the population in the Czech Republic, 1990–2019 (persons, in %)

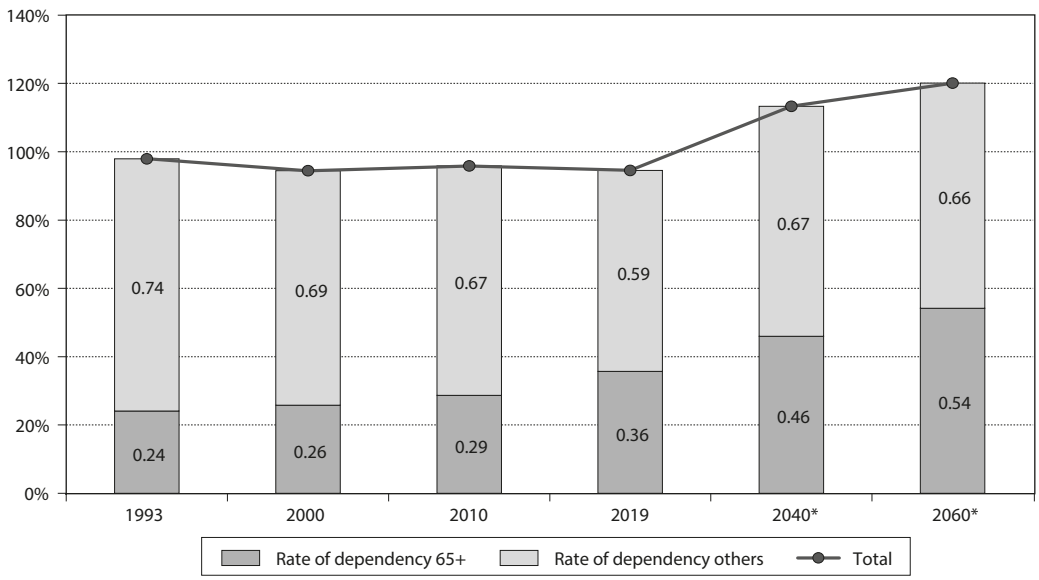
Year	1990	1995	2000	2005	2010	2015	2019
Total population	10 362 257	10 330 759	10 272 503	10 234 092	10 517 247	10 542 942	10 669 324
Economically active population	5 418 006	5 253 753	5 283 581	5 266 713	5 370 318	5 435 384	5 483 945
Total employment – national concept	5 378 627	5 045 702	4 829 069	4 856 559	4 986 668	5 167 112	5 374 873
of which employees	5 265 870	4 443 909	4 124 640	4 114 220	4 180 829	4 403 571	4 617 438
of which self-employed	112 757	601 793	704 429	742 339	805 839	763 541	757 435
Rate of economic activity	51.9%	48.8%	47.0%	47.5%	47.4%	49.0%	50.4%

Source: Own computations based on the CZSO figures

The number of both employees and self-employed is around 5.4 million people and this figure together with unemployed people form economically active population. The rate of economic activity (economically active divided by total population) decreases from 52% to 50% between 1990 and 2019. It means that the increase of the population does not result in the support of economically active people and labour supply.

The substance of the problem lies in the growth of dependency ratio in following years. Demographers usually compute the economic dependency ratio as the ratio of population of selected age groups (0–19, over 65) on productive category, e.g. 20–64 years. It represents the number of people dependent on one economically active person. In other words, how many people one economically active person has to provide. But we compute the rate of dependency in a slightly different way[4] since the life expectancy is changing as well as economic life. Currently, we can easily find people working (that means economically active) at the age of 70 or 80. That was very scarce in 1990s. In our approach, we reflect only economically active population (irrespective of their age) and dependent (inactive) people. Overall dependency ratio indicates possible negative development in the future even if it is still below the value 1.00 by 2020. But when we split it between the elderly and others (children + all other reasons for inactivity), we get more serious information, see Figure 1. The rate of dependency of the elderly increased from 0.24 to 0.36, correspondingly the rate of dependency of others (young and medium age disabled people) declined from 0.74 to 0.59. When we add figures from demographic projection (more in Section 4), we estimate that the overall rate will rise to 1.13 in 2040 and 1.20 in 2060. Negative trend will be observable in the structure since the share of dependent elderly will form 45% in 2060 while 38% in 2019. The 20% increased burden imposed on active population will require adequate resources and it will boost concerns about future development.

Figure 1 Estimates of dependency ratio in the Czech Republic, 1993–2060 (in %)



Source: CZSO, own computations based on the CZSO figures

[4] We consider only economically active people. These people are working or they are unemployed. Inactive group contains students, maternity leaves and people excluded from the labour market for all reasons.

Economic activity is highly connected with the structure of the workforce that lies behind, see Table 2. In line with modern trends, people tend to spend more years in schools and the increase of the qualification of the population is one of the most positive factors (investment into the future). On the contrary, it means that more people depend on the parents for longer time. In the beginning of the 1990s, about 6% of the population were employed by the age of 20. In 2019, this group makes about 0.5%.

Table 2 Employment structure in the Czech Republic, 1993–2019 (in %)

Year	1993	1995	2000	2005	2010	2015	2019
Age group	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
15–19	5.8%	4.5%	1.4%	0.7%	0.5%	0.4%	0.5%
20–24	10.1%	11.6%	11.2%	7.1%	6.2%	5.6%	4.6%
25–29	10.9%	10.6%	13.0%	13.4%	11.2%	10.3%	9.8%
30–34	11.2%	11.6%	11.5%	14.1%	14.3%	11.3%	10.7%
35–39	14.1%	12.7%	12.3%	12.3%	15.0%	15.1%	12.7%
40–44	15.4%	14.9%	12.8%	12.5%	12.7%	15.3%	16.1%
45–49	14.5%	14.9%	14.6%	12.6%	12.5%	12.5%	14.3%
50–54	9.8%	10.8%	13.6%	13.5%	11.9%	11.9%	12.0%
55–59	4.6%	5.0%	6.7%	10.0%	10.4%	10.4%	10.5%
60–64	1.9%	1.9%	1.7%	2.8%	3.8%	4.9%	5.9%
65+	1.5%	1.5%	1.2%	1.1%	1.5%	2.1%	2.9%

Source: Own computations based on the CZSO figures

The rate of economic activity for the group 15–19 declined from 35.5% in 1993 to only 6.3%, see Table 3. Significant decrease is also observed in the group 20–24. The lowest changes are observed for the people between 25 and 49 years but after 50 the rates changed dramatically. In line with the changes in the statutory retirement age, rate of activity increased in the group 60–64. It is very interesting that activity rates and number of people over 65 show that such group counts about 7.3% of the workforce in 2019 while just about 4.8% in 2010. The ageing of the workforce is clearly evident from these data. We have to consider that the absolute number of people in the age group 15–19 declined by 48%, from 909 thousands to 473 thousands only. Such decrease in line with increase of total population caused the decline of the share of this group from 9% to 4%. In relative terms, lower activity rate is addressed to lower number of potential workers and direct economic contribution (from the labour) of this group is negligible.

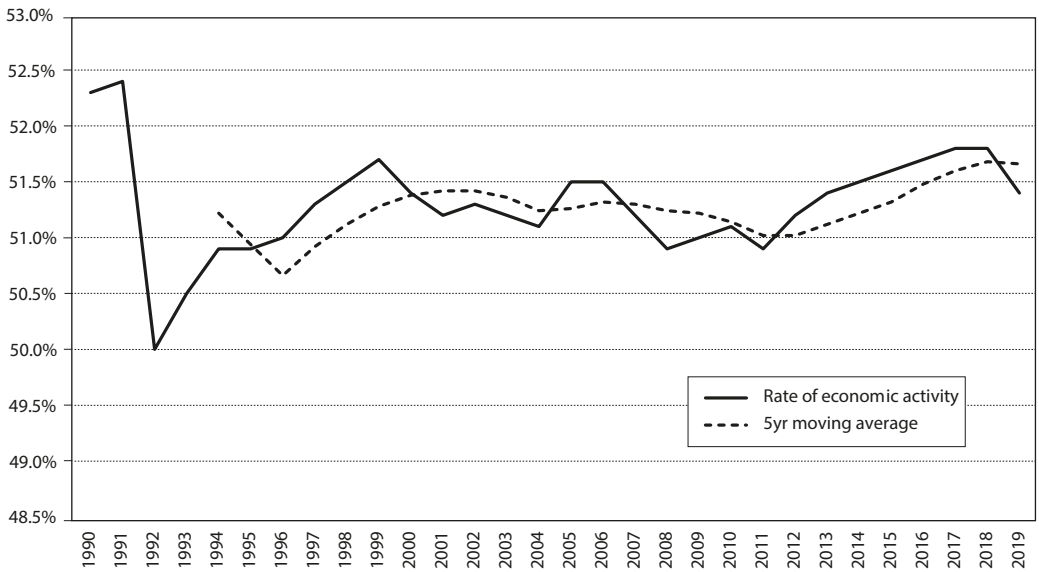
Table 3 Estimates of the rates of economic activity, Czech Republic, 1993–2060 (in %)

Age group	1993	2000	2010	2019	2040	2060
15–19	35.5%	15.0%	6.9%	6.3%	9.5%	9.3%
20–24	70.4%	70.8%	51.5%	52.3%	49.7%	49.6%
25–29	80.8%	80.3%	80.0%	81.2%	75.3%	75.2%
30–34	89.1%	87.2%	81.8%	80.4%	80.9%	81.0%
35–39	93.6%	92.1%	89.5%	88.7%	85.2%	85.2%
40–45	94.1%	93.8%	93.7%	93.1%	90.8%	90.7%
45–49	92.7%	92.9%	93.8%	94.9%	92.5%	92.5%
50–54	83.2%	85.9%	90.3%	93.8%	91.2%	91.2%
55–59	47.4%	53.3%	72.4%	89.2%	82.8%	83.2%
60–64	18.8%	17.7%	26.3%	47.6%	48.7%	51.5%
65+	6.0%	4.1%	4.8%	7.3%	14.2%	17.8%

Source: Own computations – based on the work of Ondřej Nývlt (Nývlt, 2019) and his assistance – and on the CZSO figures

It is very difficult to compare current society with the early 1990s. Radical changes in the society caused lots of more or less voluntary exits from the workforce (to retirement) and the overall rate of economic activity was very volatile by 2000, see Figure 2. Despite smoothing with a 5 years moving average, the development seems very flat. Since 2000, the development is smoother and we can clearly observed the impacts of the economic crises that affected the Czech Republic in 2001/2002 and 2008/2009. The behaviour of the people is very difficult to predict since their decision whether to stay or leave labour market depends on many incentives ranging from expectation of immediate development of the economy to the reaction on the changes given by the policy makers. But what has to be taken into account is the improved health condition of people since the future development of healthy life expectancy in relation to total life expectancy is very important.

Figure 2 Overall rate of economic activity in the Czech Republic, 1990–2019



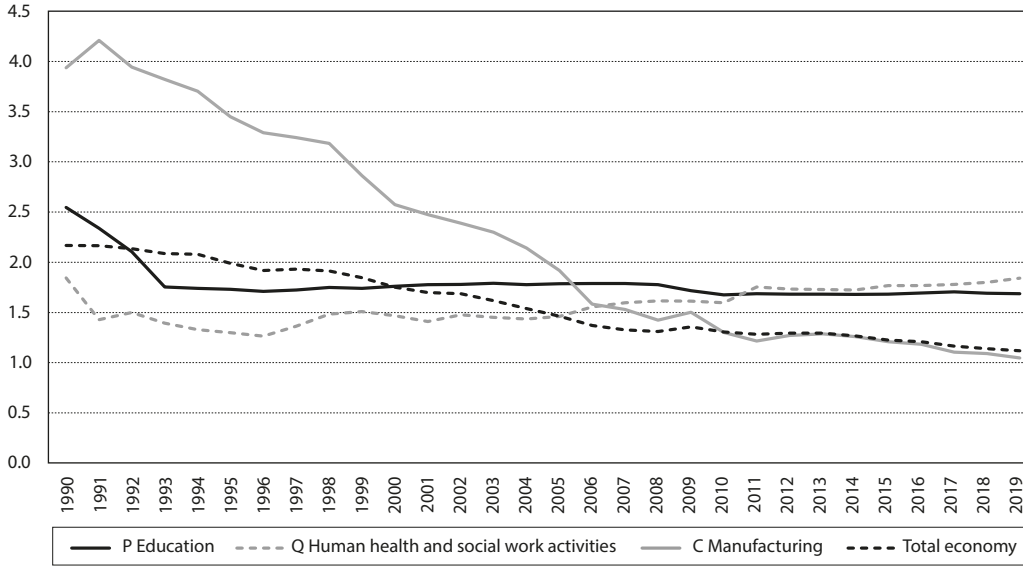
Source: Own computations based on the CZSO figures

Over the last three decades, the development of the labour input required for a unit of gross value added (labour input) shows that there are significant differences among industries. Technological progress resulted in a sharp decline in labour needed in manufacturing industry (CZ-NACE code C), see Figure 3 where we present labour inputs expressed in full time equivalents per one million of gross valued added at constant[5] prices of 2015. If we compare such development with education industry (code P) and health and social services (code Q), we get completely different picture. It shows us that in services of P and Q the demand for labour is very steady.[6] The exception was the economic transformation in the beginning of 1990s but after that the necessary labour input fluctuates between 1.5 and 2 full time equivalent worker per one million of value added.

[5] In fact, the aggregates are expressed in chain-linked prices but this information is interesting to skilled statisticians only. The economic interpretation of constant prices and chain-linked prices is identical.

[6] For better understanding it is necessary to mention that the output of these industries is based on the cost approach, where labour costs (compensation of employees) form major part of output. That means that labour stability is also given by statistical reasons.

Figure 3 Labour inputs to selected industries, 1990–2019 (persons per million of value added)



Source: Own computations based on the CZSO figures

Figure 3 shows the basis for the negative expectation in a few years. On the level of a total economy, the changes and absorption of both positive technological development and negative demographic trend may smoothly compensate. But some services such as education, health and social services may face more serious problems.[7] Moreover, the development in these services in mostly in the hand of the governments. Especially health and social services may soon face serious problems, more people requiring assistance and less students in medical faculties, nurses or people willing to work for social services.

3 DEMOGRAPHIC BASE IN THE ECONOMY

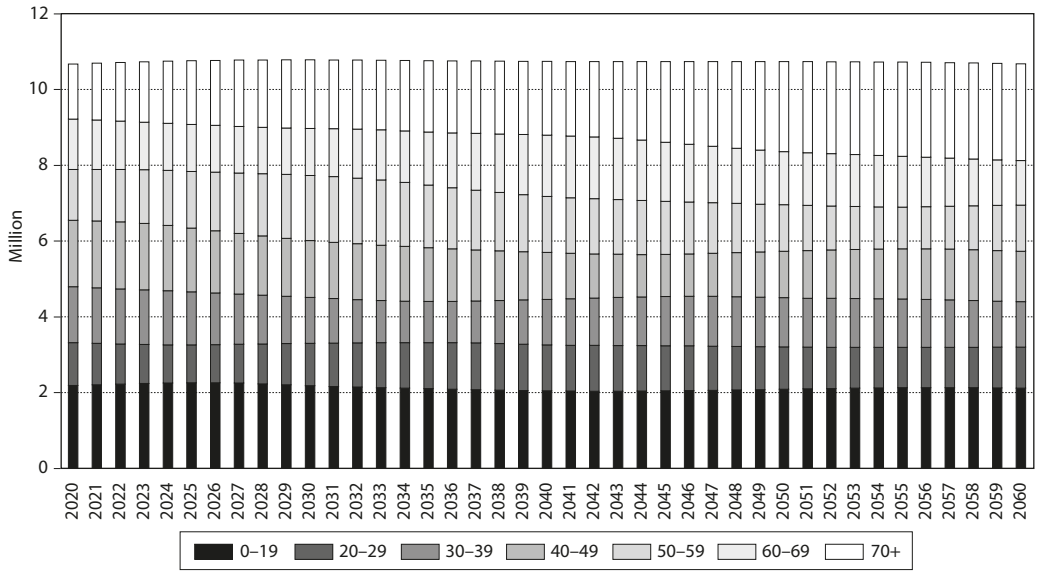
Demographic situation and its development will influence future development of the economy. When observing current trends in the Czech Republic, they do not provide any reason for optimism. The key question is how these trends will be present in the future economic development. The total figures of the population represent only one part of the problem but the structure is the second and more serious part. Demographic development will be reflected in the rate of economic activity. Of course, real demographic situation is unknown but the experts from the Czech Statistical Office published demographic projection (we use middle variant in our model) describing potential development, see Figure 4 and Figure 5 showing relatively constant share of youth and increasing share of the elderly. In other words it means that the burden of productive population increases significantly.

The main "economic base", people between 20 and 59 years, decline their share from 53% in 2020 to 48% in 2040 and just 45% in 2060. On the contrary, despite the increase of economic activity, in some professions employees over 70 seem unlikely. And the age group over 70 will increase between 2020 and 2060 the most dramatically. The share of people aged over 70 years will rise from 14% in 2020 to 18% 2040 and to 24% in 2060. In nominal terms, it means the increase from 1.5 million people to 2.6 million people, more than 1 million people increment. The possibility of participation of older people on the

[7] Some of the problems appeared during current pandemic situation but this is not the case of the Czech Republic only.

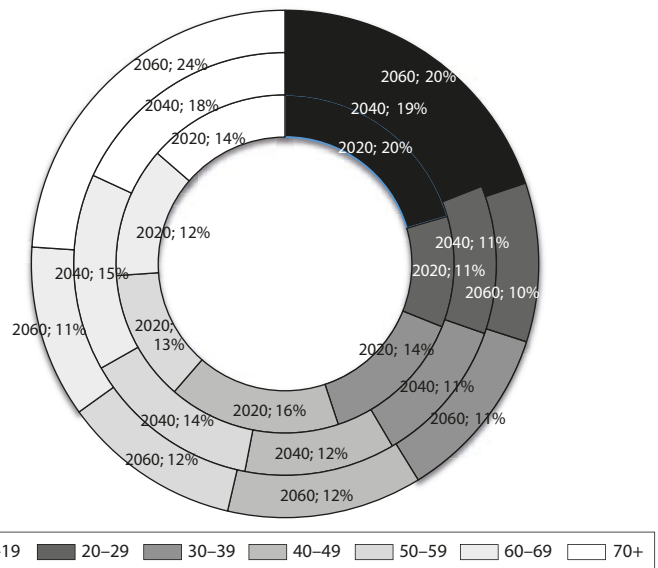
labour market will be dependent on their health condition and socio-market conditions but this can be hardly applied for physically demanding profession. This means that people forming "economic base" from demographic component of the economy will provide less power than nowadays. The question is how to accept it and if possible find some solution helping to overcome it. In the following section we implement CGE approach for quantification of a potential loss of power.

Figure 4 Demographic projection of the Czech Republic (2020–2060)



Source: Own computations based on the CZSO figures

Figure 5 Changes in the structure of the Czech Population (2020, 2040 and 2060)



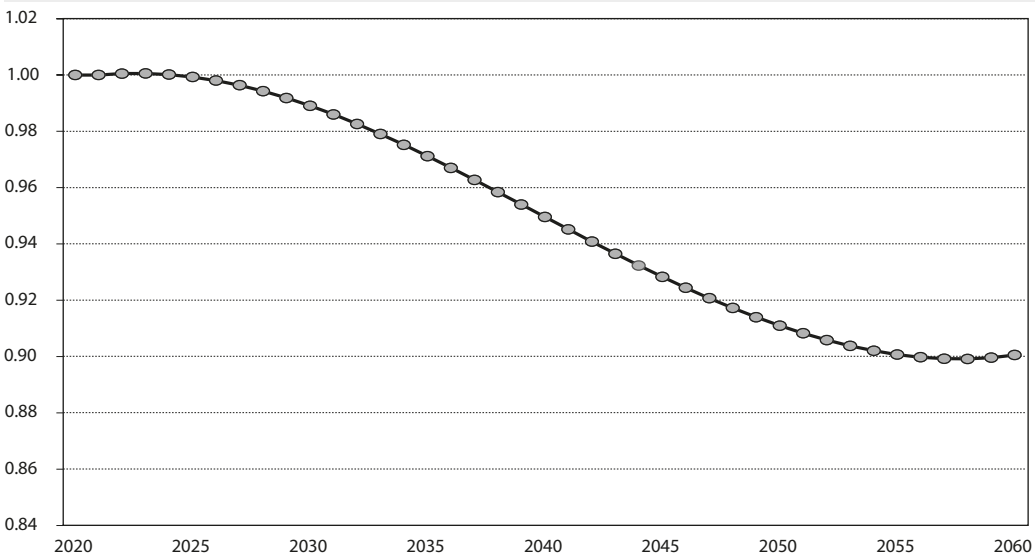
Source: Own computations based on the CZSO figures

4 ESTIMATES OF PRODUCTIVE POPULATION AND PRODUCTIVITY

Currently observed economic activity and present demographical base make a starting point for following estimates of the productive potential of Czech population within our economy. We use existing labour supply, economic activity and demographic development described in previous sections as input assumptions for our CGE model and we added estimates of changes of labour productivity, health condition of population and general technological progress.[8]

We suppose that the development of productive population is a key factor affecting our society. Since the age structure is significantly changing, CGE simulation shows important impacts in all main economic indicators. With respect to the presentation purposes, we focus mainly on base indices (2020 = 1.00) to express the impacts on Czech economy. We used standard CGE model with key targeting indicator total utility expressing both the volume and structure of consumption. In our research, we focused on the description of demographic trends and their impact on the economy by the CGE model where the key driving factor productive population ($pp_{t,s}$), see Figure 6. Development of productive population is influenced by expected demographic trends and despite some positive effects such as continuously increasing health condition of Czech population, negative demographic trends prevail and after 2030 and more significantly after 2035, we expect sharp decrease by 2060. Between 2020 and 2060, demographic data shows 16% decrease of the share of people between 20 to 69 years. Due to the changes in the employment structure and increase in activity rates that will slightly compensate this situation, we estimate that productive population will decline by 10% by 2060.

Figure 6 Forecast of the productive population, 2020–2060 (index 2020 = 1.00)



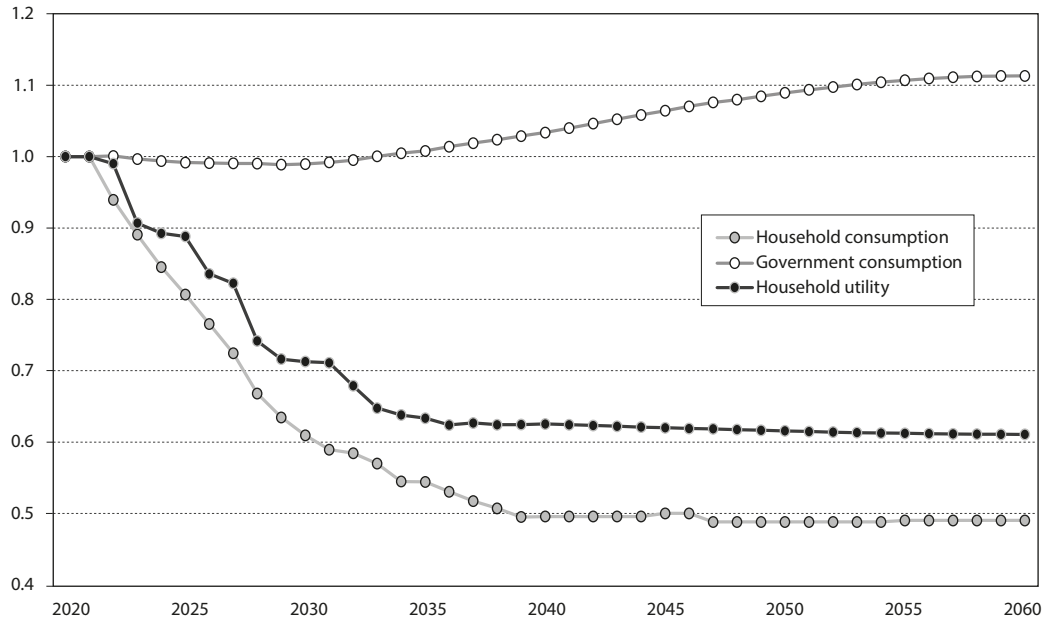
Source: Own computations based on the CZSO figures

For the CGE computation, we count with continuously improving health condition of population, annual increase of labour productivity exceeding 2% and annual overall technological progress improving capital assets by over 1.2%, see the Annex II. We are also convinced that statutory retirement age will rise

[8] The description of all CGE assumptions goes far beyond the possibilities of our contribution. We also provide their overview in the Annex I. Those who interested can find details in Šafr (2017). Since this is the first time, we publish our results, authors can be contacted, as well.

at least to the level of 70 years, irrespective of any future government promises. Under the condition of fixed parameters of our CGE model described above, we estimate that population ageing may have significant impact on different areas of our economy. This results from the analysis of the productive population that is supplemented by expected government expenditures. In other words, if nothing changes, the overall household utility will decline by 40% between 2020 and 2060, see Figure 7.

Figure 7 Results from CGE modelling under fixed assumption (2020 = 1.00)



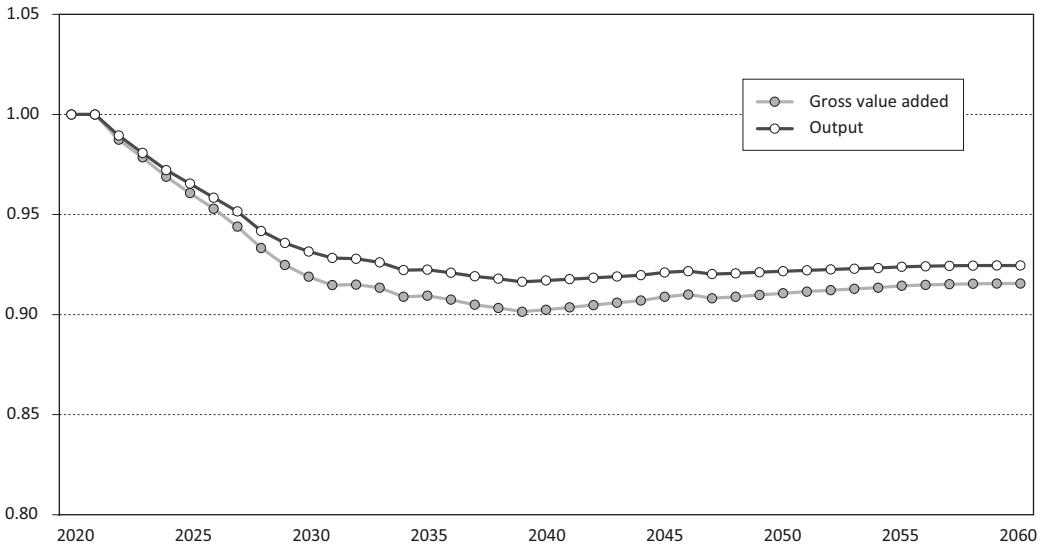
Source: Own computations based on the CZSO figures

More significant is the decrease of household consumption (–50%) because of the crowed out effect of government expenditures covering mainly mandatory expenditures (government consumption) induced by older population requiring more health and social services. It means that despite a moderate drop (–10%) of productive population, increased demand for goods and services required by securing the elderly, will result in significant drop of household utility (–40%) and consumption (–50%). Both negative effects on supply and use side ceteris paribus may result in observable reduction of household living standard. This is very radical and unrealistic result given by the Leontief´s model constraint emphasizing current state of art. In other words, the pressure on the economy will be very strong and it will result from ageing and without fundamental technological progress, the costs would be hardly affordable. Similarly, in line with the Leontief production function (2), we estimate the impact on production and value added (Figure 8). Resulting development has a form of a U-curve since firstly rapidly decreasing (–9%, –10% respectively) by 2035 and then slightly rise again back to 93%, 92% respectively of 2020 value.

With respect to the estimated demand of population, ageing labour force operating in current industries will not be able to produce the same amount of goods and services as nowadays ceteris paribus. Most of experts estimate moderate continuous increase of the technology and productivity. But if this expectation becomes true, economic costs will be significant. The economic loss may account for about 10% of gross value added in 2035 in comparison with 2020, ceteris paribus. Household may face continuous decrease of their utility exceeding 35% by 2040. Between 2040 and 2060, the decrease of the utility will be very

moderate by final 60% of initial 2020 value.[9] Again, these results are very strict and probably not realistically connected with Leontief' production function restricted substitution of inputs that can inhibit the overall productivity of the factors. Real economic development will hopefully smooth the development but the message from the model is clear. If the economy worked under current conditions covering increasing productivity, affected labour supply will lead to a significant decrease of both household utility and consumption. All the positive effects such as improving health condition, ongoing increase of labour productivity and overall technological progress will not be enough.

Figure 8 Results from CGE modelling under fixed assumption (2020 = 1.00)



Source: Own computations based on the CZSO figures

The size of potential crowding out effect of household consumption by government consumption can be discussed on a theoretical level, and in fact, due to strong growth in recent decades, no one has paid much attention to it. Under the condition of stable and relatively strong growth rate of labour productivity and technological progress, CGE model shows that demographic factors simply outweigh. We also consider unfair distribution of negative effects since they fully refer to households and all the needs of the post-productive population will be fully met.

Fortunately, negative consequences may be compensated by positive economic development in technology and science but these results should alarm us that rational behaviour of policymakers is necessary and the structure of the government budgets, mainly expenditures should be carefully checked. It is also possible that demographic situation may change in terms of significantly higher migration increase or fertility.

CONCLUSION

Population ageing will affect different areas of Czech society and the impacts on the economy should not be neglected. Ageing is a complex issue that is not possible to describe within a single paper and we

[9] The horizon of our CGE model is 2060 where we expect the peak of the negative ageing effects on the economy. After 2060, demographers estimate slight smoothening of ageing since the share of the most productive population (20 to 64) is expected rising about 2 p.p. Of course, these moderating effects cannot significantly compensate ageing effects.

are aware of issues ranging from pensions schemes and health system to the impact on future youth. We focused on the introduction of labour driven changes in the economy under the condition that labour supply will be affected directly by ageing. We do not tackle the consequences for educational systems such as required professions and composition of future students but we take into account growing activity rate across all the occupations.

Each model is simplification of a complex reality and our CGE model is not an exception. Despite its relative complexity, it has lots of limitations. We prefer using Leontief´s production function since it is directly connected with current economy via input-output tables but its limitation of fixed structure inputs is obvious. Despite all limitations of the model, the development of labour supply resulting from official demographic projections is rather negative. At first sight, it seems that the aggregated indicators such as dependency ratio and estimated employment do not indicate serious problems. But the core is hidden in the structure. The burden on economically active population is shifting from a current mix of dependent children and pensioners to the stage where dependent older people may outweigh and the increase of productivity may not be enough to compensate it. Moreover, the development of the productive population will be declining due to its ageing and productivity of older workers. All this will result in a serious pressure on the government budget if future governments try to compensate the decline of household consumption possibilities (household utility). Our CGE model provides estimates by 2060 and despite expected moderating effects beyond 2060, we do not expect feasible differences by 2100, which is the last year of current demographic projection.

In our opinion it is clearly obvious that each government will have to admit significant increase of the statutory retirement age that will exceed the age of 70 years. The problem is that these unpopular measures should be communicated to the public sooner than later and these measures should be accompanied with clear ageing strategy reflecting availability of health and social care, attractiveness of study in necessary fields and prevention and maintenance of good health. Otherwise the decline of our living standards (expressed by utility in the CGE) by 2060 is not unrealistic.

ACKNOWLEDGEMENT

This paper was prepared under the support of the "Economy of Successful Ageing" project of the Czech Science Foundation project No. 19-03984S.

References

AIYAR, S., EBEKE, C., SHAO, X. (2016). *The Impact of Workforce Aging on European Productivity* [online]. IMF. [cit. 15.5.2021]. <https://www.imf.org/external/pubs/ft/wp/2016/wp16238.pdf>.

CZECH STATISTICAL OFFICE. (2008). *Projekce obyvatelstva* České *republiky, 2018–2100* [online]. Prague: Czech Statistical Office. [cit. 15.5.2021]. <https://www.czso.cz/csu/czso/projekce-obyvatelstva-ceske-republiky-2018-2100>.

CZECH STATISTICAL OFFICE. (2021). *National Accounts* [online]. Prague: Czech Statistical Office. [cit. 15.5.2021]. <www.czso.cz/csu/czso/10n1-05-_2005-narodni_ucty___metodika>.

GAAG, N., BEER, J. (2014). *From demographic dividend to demographic burden: the impact of population ageing on economic growth in Europe* [online]. Hague. [cit. 15.5.2021]. <https://zenodo.org/record/911938#.YSOfuIgzZPY>.

GAWTHORPE, K. (2019). Input-Output DSGE Model for the Czech Republic. *Prague Economic Papers*, 28(5): 612–630.

GAWTHORPE, K., ŠAFR, K. (2019). Maintaining the Well-being of Ageing Population in the Czech Republic [online]. *Proceedings of the 22nd International Scientific Conference on Applications of Mathematics and Statistics in Economics*: 49–61. <https://www.atlantis-press.com/proceedings/amse-19/125919263>.

GOGA, M. (2010). *Input-Output analýza*. Iura Ed. Bratislava: Wolters Kluwer.

HOSOE, N., GASAWA, K., HASHIMOTO, H. (2010). *Textbook of Computable General Equillibrium Modeling*. UK: Palgrave Macmillan.

JOHANSEN, L. (1963). A Multi-Sectoral Study of Economic Growth: Some Comments. *Economica*, *New Series*, 30(118): 174–176.
KIM, E., HEWINGS, G. D. J., HONG, CH. (2004). An Application of an Integrated Transport Network-Multiregional CGE Model: a Framework for the Economic Analysis of Highway Projects. *Economic Systems Research*, 6(3): 235–258.
MARDONES, C. (2015). An Income Tax Increase to Found Higher Education: a CGE Analysis for Chile. *Economic System Research*, 27(3): 324–344.
NÝVLT, O. (2019). Vliv vzdělání na úroveň plodnosti v Česku [online]. *RELIK 2019*, Prague: 337–345. <https://relik.vse.cz/2019/download/pdf/274-Nyvlt-Ondrej-paper.pdf>.
RONSON, R. (1991). The Adjustment of Interregional Input-Output Coefficients Under Heterogeneous Price Sensitivity: a Linearized Model. *The annals of Regional Science*, 25(2): 101–114.
ŠAFR, K. (2017). *Dynamická input-output analýza – alternativní přístupy* [online]. Prague. [cit. 15.5.2021]. <https://theses.cz/id/p5mog0/>.
ŠIMKOVÁ, M. (2021). Odraz demografického stárnutí v ekonomice regionů České republiky. *Demografie, revue pro výzkum populačního vývoje*, 63(2): 119–132.
TAYLOR, L. (2016). CGE Applications in Development Economics. *Journal of Policy Modeling*, Special issue, 38(3): 495–514.
WING, I., S. (2004). *Computable General Equilibrium Models and Their Use in Economy-Wide Policy Analysis: Everything You Ever Wanted to Know (But Were Afraid to Ask)* [online]. MIT. [cit. 15.5.2021]. <https://globalchange.mit.edu/sites/default/files/MITJPSPGC_TechNote6.pdf>

ANNEX 1: List of Main CGE Model Assumptions

Nb.	Item	Description
1	Symmetric Input-Output Tables	Standard tool for modelling
2	Labour productivity by industries	Estimates by 2070 with continual increase based on IMF and MoF predictions
3	Population projections by age groups and education level	Estimates based on the CZSO data and dr. Nývlt estimates
4	Rate of workers fluctuation by industries	Estimates based on past data reflecting the possibility of workers´ willingness to change work
5	Household consumption by products and age groups	Own estimates based on national accounts
6	Health status indices by age and education groups	Estimates derived from EHIS survey based on dr. Vrabcová
7	Technological progress indices	Estimates by 2070 with continual increase based on IMF and MoF predictions
8	Division of government expenditures between mandatory and non-mandatory	Own estimates based on national accounts
9	Rate of economic activity by age groups and education	Estimates done by dr. Šimková

Source: Own elaboration

ANNEX 2: Technology and Labour Productivity Assumptions (2020 = 1.00)

Year	Technological Progress Index	Labour Productivity Index
2020	1.00	1.00
2025	1.07	1.11
2030	1.14	1.23
2035	1.22	1.36
2040	1.30	1.52
2045	1.37	1.66
2050	1.45	1.82
2055	1.54	2.00
2060	1.62	2.19
2065	1.72	2.41
2070	1.81	2.65

Source: Own elaboration based on the International Monetary Fund and the Ministry of Finance of the Czech Republic