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Impact of population ageing on health services: a case study for Slovakia
Vplyv starnutia populácie na zdravotné služby: prípadová štúdia pre Slovensko

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Abstract: *Population ageing presents a serious problem for the economy of Slovakia. This negative demographic trend leads to an increase of the population in the post-productive age and a decline in the productive population. This situation has a negative impact not only on the social and pension systems but also on other sectors of the economy; for example, on health services. In this paper we explain an impact of the population ageing on the total production in the economy, with further implications for the public sector, through a computable general equilibrium model. Since a lower public income leads also to a lower income in the sector of health services, we can evaluate an impact of the population ageing on the financial situation in this highly important economic sector. We conduct a case study for Slovakia based on a model simulation of different demographic projections from the baseline year 2016 to the target year 2030, including the population ageing scenario as well as potential improvements in the productive population.*

Abstrakt: *Starnutie populácie predstavuje vážny problém pre ekonomiku Slovenska. Tento negatívny demografický trend vedie k nárastu populácie v poproduktívnom veku a poklesu v produktívnej populácii. Táto situácia negatívne vplýva nielen na sociálny a dôchodkový systém, ale aj na ostatné sektory ekonomiky, napríklad zdravotné služby. V tomto článku za pomoci modelu všeobecnej spočítateľnej rovnováhy vysvetľujeme vplyv starnúcej populácie na celkovú ekonomickú produkciu, vrátane ďalších implikácií na verejný sektor. Keďže nižší verejný dôchodok vedie tiež k nižšiemu dôchodku v sektore zdravotných služieb, môžeme vyhodnotiť vplyv starnutia populácie na finančnú situáciu tohto významného ekonomického sektora. Realizujeme prípadovú štúdiu pre Slovensko založenú na modelovej simulácii rozličných demografických projekcií zo základného roku 2016 do cieľového roku 2030 zahrňujúceho scenár starnutia populácie, ako aj potenciálne zlepšenia v produktívnej populácii.*

Kľúčové slová: *starnutie populácie, zdravotné služby, všeobecná teória rovnováhy.*

Key words: *population ageing, health services, general equilibrium theory.*

1 Introduction

Population ageing is generally characterized as an upward structural change in the median population age, due to a decline in the fertility rates or an increase in the life expectancy. This negative demographic trend has several serious implications for the economic development and structure. First, more people in the post-productive age put higher pressure on the public expenditures, mostly on the social and pension systems and the health services. Second, less people in the productive age lead to a decline in the public income from taxes and contributions and thus additional pressure on the government budget. Finally, the population ageing leads to a decline in the labour supply factor and thus supresses the potential production in the economy. In the end, these implications lead either to higher taxes and contributions or higher public deficit to fund additional government spending.

Structural economic changes should be made to absorb the impact of demographic factors, for example an increase in the retirement age or a linkage between the retirement age and the life expectancy. On the other hand, we should ask what are the drivers of this negative demographic trend, what measures could be adopted to maintain sustainable demographic situation and finally, what is the true impact of these improvements. In this article, we propose a simple general equilibrium model to simulate the impact of demographic factors on the total production in the economy through the production function theory. Subsequently, we evaluate an impact of the population ageing on the public finance, with a focus on the health services as one of the most affected sectors in the economy. Finally, we compare the actual demographic projection with the potential improvements in the productive population and their impact on the domestic economy. The article is based on a case study for Slovakia from the baseline year 2016 to the target year 2030.

Confronting the theoretical concept with the statistical data of a population structure, we observe significant differences between the actual demographic situation compared to the historical dataset for the economy of Slovakia (Figure 1). While the productive population from 15 to 64 years is declining since 2012, the population in the post-productive age is rising through the history with the strongest dynamics in the last years. Recent changes in the population structure are thus in line with the process of population ageing.

There are two explanations of this development. First, declining fertility rates lead to a downswing in the productive population observed in the last years and expected also in the future (Figure 2). Second, while the mortality and fertility rates are on a similar level, the population problem is characterized by the population ageing rather than a decline in the total population (Figure 3). The paper is organized as follows. First, we propose a literature review with focus on the international and domestic research of the population ageing. Second, we define a simple general equilibrium model suitable for the demographic projections, further enriched for the public expenditures on the health services.

Finally, we propose the details of model simulations and the discussion of simulation results.

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2 Related literature

There is a number of papers evaluating an impact of the population ageing on the economic situation in particular countries. We should mention the work of Ignaciuk et al. (2008) arguing that the standard connection between the labour and population dynamics widely used in the macroeconomic models is oversimplified, especially for various demographic projections. Subsequently, they propose an alternative solution based on the endogenous connection between the demographic and macroeconomic models and evaluate different structural changes in the population structure, for example a decline in the fertility and mortality rates.

Authors argue that the process of population ageing and subsequent changes in the dependency ratio have a substantial effect on the economic growth, especially in the European countries. According to this, they propose a number of policy implications to compensate this negative demographic trend, for example an increase in the fertility and participation rates or a modification of the retirement age. However, despite positive simulation results, these changes are not able to fully compensate the impact of the population ageing. Similarly, the paper by Mcgregor et al. (2008) proposes a link between the demographic and macroeconomic models to evaluate an impact of the population ageing on the economy of Scotland.

Population ageing becomes a relevant topic also for the economy of China, as proposed by Peng (2009). The paper argues that this negative demographic trend leads to a decline in the economic growth according to the explicit decrease of the labour supply through the population projection and the implicit decrease
of the capital formation through the investment channel. However, the living standards of households improve and a decline in the savings is overcame by a decline in the investments, thus creating a surplus on the capital market and a positive current account balance. Furthermore, the model by Peng and Mai (2013) analyses an impact of the retirement age extension on the economic growth, under the population ageing scenario in the economy of China.

On the other hand, the paper by Turner (2009) evaluates an impact of the population ageing on the economy of Great Britain. The author argues that the standard assumptions based on the fertility and immigration factors as the optimal compensation of this negative demographic trend under the fixed retirement age are overstated and essentially wrong. Subsequently, he proposes an alternative solution in the form of a welfare optimizing model incorporating additional factors like increase in the life expectancy, increase in the retirement age, capital inheritance and population density to capture the evolution of the dependency ratio and possible implications for the public policies.

We should mention also the work of Szreter (1993), describing the process of demographic transition from a developing economy characterized by higher fertility and mortality rates to a developed economy with advanced technologies and education system characterized by rather low fertility and mortality rates. Furthermore, the paper by Rosero-Bixby and Casterline (1993) analyses a decline in the fertility rates through the diffusion effects that depart from the standard theory based on the economic and social progress as the main explanation of the fertility dynamics, thus proposing more complex look on the population projection.

Finally, the work by Páleník et al. (2014) analyses the problem of population ageing in the context of Slovakia. They evaluate implications of the population ageing for the potential production as well as an impact on the macroeconomic development through a general equilibrium model of an open economy. The model distinguishes between the productive and post-productive population as well as the individual consumption sectors. Population ageing leads to a decline in the total employment and consumption of the productive households partially compensated by the post-productive households and the government.

3 Macroeconomic model

Evaluation of demographic implications for the economy of Slovakia is performed by a standard Computable general equilibrium (CGE) model of an open economy. We apply a regular two-level production function to model the production chain of the value added and the intermediate consumption, similarly to Shen and Whalley (2013). In the first step, we incorporate two production factors, the labour factor (L_t) and the capital factor (K_t), to explain the value added in the economy under the Cobb-Douglas function form. In the second step, we model the total production in the economy as a function of the value added (VA_t) and the intermediate consumption (IC_t) under the Leontief function form, thus assuming complementarity of the production factors. Corresponding prices of the production factors are determined by the first order conditions, in line with a standard assumption of a zero profit.

$$VA_t = CobbDouglas[L_t, K_t] \quad (1)$$

$$Y_t = Leontief[VA_t, IC_t] \quad (2)$$

Export and import of commodities are captured by the Armington model of international trade with the Constant elasticity of substitution (CES) function incorporating the imported commodities (M_t) to the total consumption (Q_t) and the Constant elasticity of transformation (CET) function incorporating the exported commodities (X_t) to the total production (Y_t). Both equations are closed by the domestic component (D_t). Furthermore, export and import prices are determined by the external factors, including external deflators and exchange rates, while the domestic price is chosen as the model numeraire. Trade elasticities are estimated by a time-series econometric approach based on the first order conditions, similarly to Gallaway et al. (2003). Estimation results are in line with the standard literature, assuming relatively high substitutability between the domestic and external markets. For further information about the estimation process and results see Priesol (2018). Again, the system of trade equations is closed by the first order conditions.

$$Q_t^{-\gamma_1} = \alpha_1^{-\gamma_1}\beta_1 D_t^{-\gamma_1} + \alpha_1^{-\gamma_1}(1-\beta_1)M_t^{-\gamma_1} \quad (3)$$

$$Y_t^{\gamma_2} = \alpha_2^{\gamma_2}\beta_2 D_t^{\gamma_2} + \alpha_2^{\gamma_2}(1-\beta_2)X_t^{\gamma_2} \quad (4)$$

Calibration of the model is based on constant depreciation and saving rates and constant ratios between the structural variables (public deficit and current account) and the gross domestic product. We thus assume that the agents in the economy maintain either their personal preferences or their domestic market share. Private consumption (C_t) and public consumption (G_t) are determined by the budget restrictions of households and government, while the gross capital formation (I_t) results from the market clearing condition. The model is closed by the exogenous intersectoral transfers. Finally, share of the public spending on the health services (H_t) is captured by the ratio between the natural social transfers and the public consumption in the reference year.

$$Q_t = IC_t + I_t + C_t + G_t \quad (5)$$

Budget of households is driven by the income from labour and capital and intersectoral transfers from corporates (property income), government (social transfers) and external world (external households). Private consumption is then determined by the savings of households. Income of corporates is mostly driven by the operating surplus, with the expenditures distributed between savings, households, government and external world. Budget of government is driven by taxes and contributions from the labour and capital income together with the indirect taxes from consumption, import and production. Public deficit then determines the disposable income distributed between social transfers and public consumption. Finally, the external sector is captured by the trade balance and intersectoral transfers and closed with the current account.

Dynamization of the model variables is performed trough the labour and capital production factors, with the first one captured by an expected projection of the employment dynamics and the latter one by a capital accumulation process based on the perpetual inventories method (PIM). Furthermore, dynamization of the model prices is captured by an expected projection of the price numeraire, specifically the producer price index (PPI). Although the population ageing leads to a decline in the productive population, significant part of this decline is compensated by higher participation rate (pension workers), better migration balance (external workers) and lower unemployment (requalification).

Relationship between the population and employment decline is obtained from the Ageing Report of the European Commission (2018). While we operate with the official population projection for Slovakia, the employment projection is derived from the participation and unemployment rates of the European Union, due to additional domestic factors not influenced by the population ageing, for example a different view of the structural participation and unemployment in the medium-term horizon.

Model calibration is based on the Social accounting matrix (SAM) in the reference year 2016. Historical data are obtained from the Statistical Office of the Slovak Republic, specifically from the sectoral national accounts proposing the necessary information for a construction of the calibration matrix (the nu1028rs table in the DataCube database available on the internet at http:// datacube.statistics.sk). Projection of the inflation rate is based on the historical values from the latest year to capture the most actual price development. Estimation of the model is based on a set of 13 structural equations, including the production and trade functions, the first order conditions and the market clearing condition, that are solved by a standard trust-region algorithm in Matlab.

4 Discussion of results

In line with the historical data of the population structure, we simulate a decline in the productive population, in contrast to the neutral demographic scenario, to capture an impact of the population ageing on the labour supply. Furthermore, we simulate a positive population projection at the levels of 1% (conservative scenario) and 2% (optimistic scenario). While leaving other parameters of the model unchanged, we could thus evaluate an impact of the demographic improvement on the economy of Slovakia through the dynamic simulations. Model evaluation is based on the 15-years simulation horizon from the baseline year 2016 to the target year 2030. Results are proposed in the Appendix.

When compared to the neutral demographic scenario, the population ageing results in a negative projection of the productive population and total employment affecting the sector of health services by 0.8% in 2030. In contrast, the conservative scenario leads to a potential improvement by almost 2.2% of the population ageing projection and the optimistic scenario results in the improvement by more than 3.6% in 2030. However, if we consider that the additional public income is transferred to the sector of health services, according to higher requirements on the public health driven by the post-productive population, we obtain more than 8.1% additional income under the conservative scenario and almost 13.5% under the optimistic scenario.

Furthermore, we compare the results with the international case studies of Peng and Mai (2013) and McGregor et al. (2008). While the first one calculates an impact of the retirement age extension on the economic growth, the second one analyses different macroeconomic projections under the population ageing scenario. Improvement of the domestic employment by 1.4% leads to an increase of the economic performance by 1.3%, according to Peng and Mai (2013). On the other hand, the baseline simulation by Mcgregor et al. (2008) assumes that a decline in the domestic employment by 6.1% leads to worse economic performance by approximately 5.4%. These numbers are mostly in line with the proposed results, in terms of the elasticity between the domestic employment and the gross domestic product, since an increase in the total employment by 1.0% implied by the neutral demographic scenario leads to better economic performance by almost 0.8%.[4]

Finally, we compare the results with the model of Páleník et al. (2014), calibrated on the domestic dataset. We assume that the population ageing leads to a decline in the total employment by approximately 1.0% in the target year 2030, in line with 0.9% estimated by Páleník et al. (2014). Dropout in the domestic employment leads to a decline in the final consumption by approximately 0.8% in the target year 2030, in contrast to 0.4% proposed by Páleník et al. (2014), driven mostly by a dynamization of the model and thus higher cumulative impact on the economy compared to the static specification.

[4] While the model by Peng and Mai (2013) operates on a time horizon from the baseline year 2014 to the target year 2030, the model by McGregor et al. (2008) initiates at the baseline year 2000.

The difference is even higher for the gross domestic product, explained by a different approach to the model closure, based on fixed model ratios rather than fixed model levels, together with a different reference year.

Although the simulation results do not produce any specific policy implications, since we have no additional information about the structure of the population changes, we could propose some explanations of a reasonable structure of the demographic shift. According to the global factors beyond the structure of a particular economy, rising the replacement ratio in a form of higher fertility and immigration is not sustainable in the long-term horizon. On the other hand, more effective development of the labour market in a form of better participation and unemployment rates reaches the limits of the structural inactivity and unemployment.

We thus argue that the structural changes in the pension system are necessary to maintain sustainable economic development. For example, a linkage between the retirement age and the life expectancy should stabilize the dependency ratio and ensure the sustainability of the public finance, as proposed by Porubský and Novysedlák (2018). We should also mention that the incorporation of the health services into the model is performed from a demand side of the economy, specifically through the consumption of the public sector. However, this approach does not incorporate the sectoral and production point of view. To model a development of the economic sectors, we need to analyse a supply side of the economy and perform a sectoral disaggregation of the general equilibrium model.

5 Conclusions

In this article, we outlined negative implications of the population ageing for the economy of Slovakia under no policy change scenario. We then constructed a simple general equilibrium model of an open economy to evaluate the impact of this negative demographic trend on the production sector and implicitly also on the sector of health services. Subsequently, under two basic scenarios of the population improvement, we evaluated an impact of positive changes in the demographic projection on the public income and expenditures. Finally, we argued that the structural changes in the pension system should be made to maintain sustainable economic development under the population ageing scenario.

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Appendix

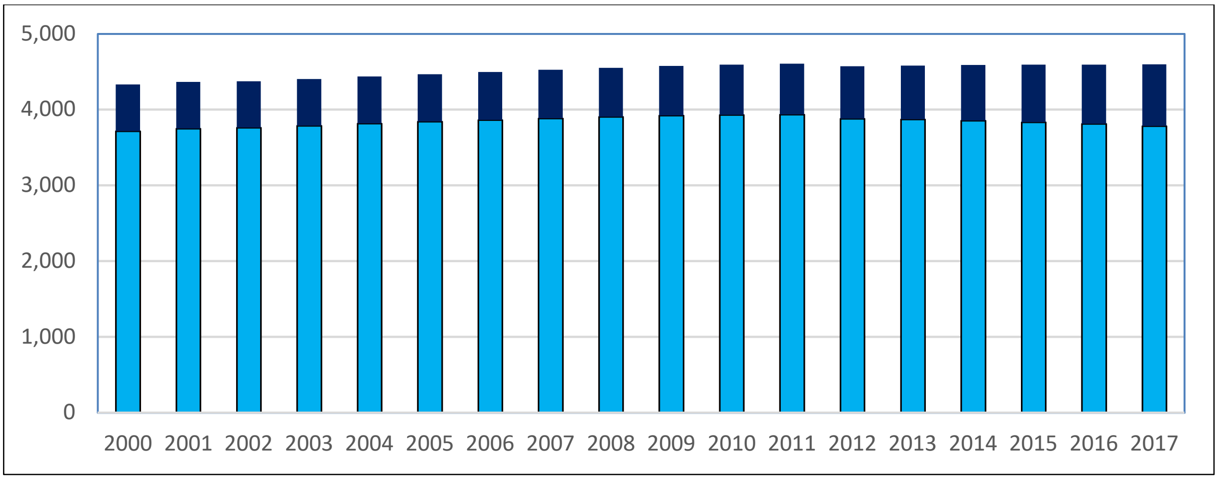

Fig. 1 Population structure in thousands of persons. Light blue describes the productive population from 15 to 64 years and dark blue the post-productive population over 64 years. Data are proposed on the annual basis from 2000 to 2017. *(Source: Institute for the Financial Policy)*

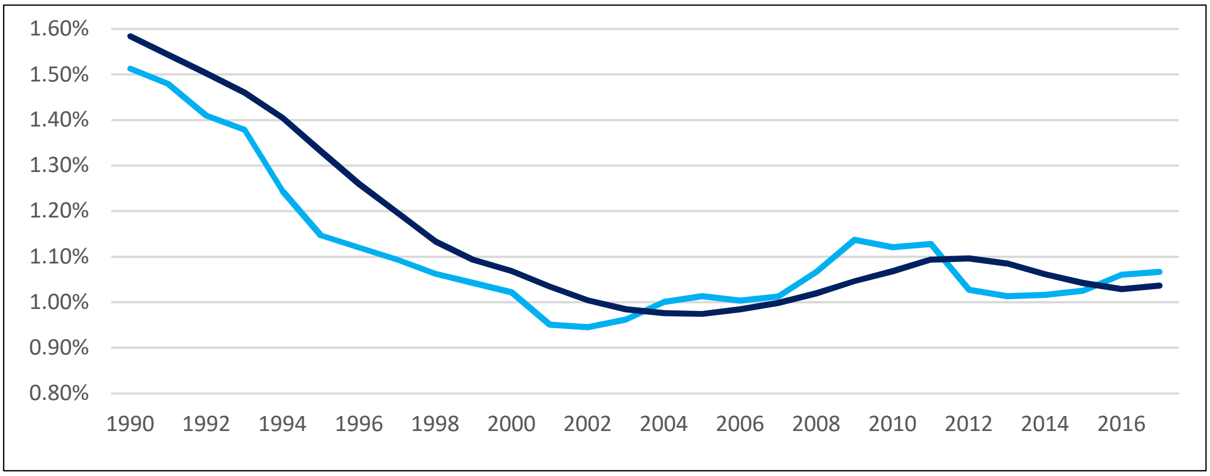

Fig. 2 Fertility rates in percentage points obtained as the ratio between the number of life births and total population. Light blue describes the annual fertility rates and dark blue the 5-year moving averages. Data are proposed on the annual basis from 1990 to 2017. *(Source: Eurostat)*

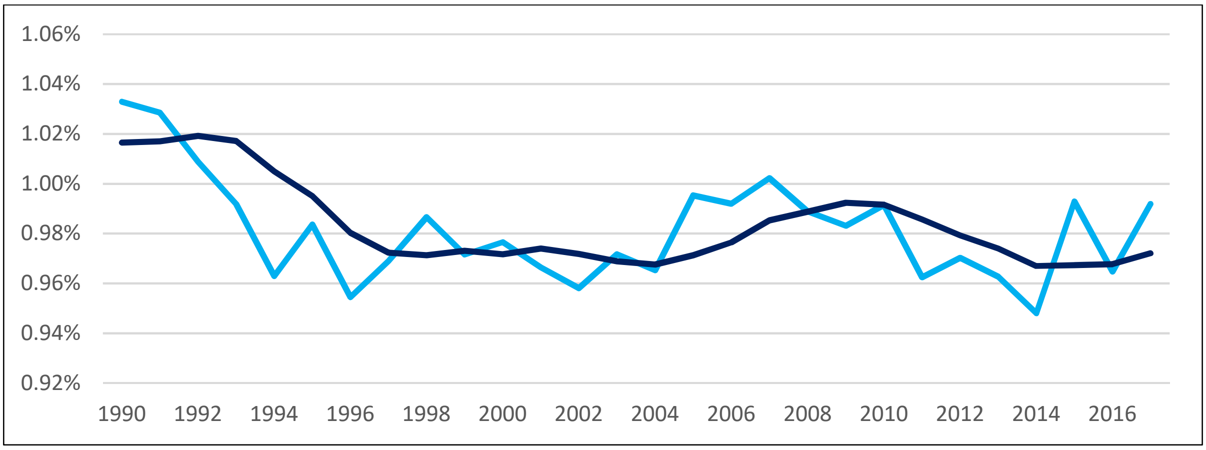

Fig. 3 Mortality rates in percentage points obtained as the ratio between the number of deaths and total population. Light blue describes the annual mortality rates and dark blue the 5-year moving averages. Data are proposed on the annual basis from 1990 to 2017. *(Source: Eurostat)*

Tab. 1 Simulation results under the population ageing scenario. Variables are stated in nominal terms in million euros. *(Source: Author)*

	L_t	K_t	Y_t	Q_t	C_t	G_t	I_t	X_t	M_t	H_t
2016	31 835	41 538	192 584	192 506	44 372	15 739	18 666	75 949	73 501	4 238
2017	33 121	43 216	200 363	200 282	46 165	16 375	19 420	79 017	76 470	4 410
2018	34 364	44 838	207 883	207 799	47 897	16 990	20 149	81 983	79 340	4 575
2019	35 574	46 416	215 200	215 113	49 583	17 588	20 858	84 868	82 133	4 736
2020	36 758	47 960	222 362	222 272	51 233	18 173	21 553	87 693	84 866	4 894
2021	37 923	49 481	229 412	229 319	52 858	18 749	22 236	90 473	87 557	5 049
2022	39 076	50 986	236 387	236 292	54 465	19 319	22 912	93 224	90 219	5 202
2023	40 223	52 481	243 323	243 224	56 063	19 886	23 584	95 959	92 866	5 355
2024	41 367	53 975	250 246	250 145	57 658	20 452	24 255	98 689	95 508	5 507
2025	42 514	55 471	257 183	257 079	59 256	21 019	24 928	101 425	98 156	5 660
2026	43 667	56 975	264 158	264 051	60 863	21 589	25 604	104 176	100 818	5 814
2027	44 829	58 492	271 189	271 079	62 483	22 163	26 285	106 948	103 501	5 968
2028	46 004	60 024	278 294	278 181	64 120	22 744	26 974	109 751	106 213	6 125
2029	47 193	61 576	285 489	285 374	65 778	23 332	27 671	112 588	108 959	6 283
2030	48 400	63 151	292 789	292 671	67 460	23 929	28 379	115 467	111 745	6 444

Tab. 2 Simulation results under the neutral demographic scenario. Variables are stated in nominal terms in million euros. *(Source: Author)*

	L_t	K_t	Y_t	Q_t	C_t	G_t	I_t	X_t	M_t	H_t
2016	31 835	41 538	192 584	192 506	44 372	15 739	18 666	75 949	73 501	4 238
2017	33 131	43 229	200 423	200 342	46 179	16 380	19 426	79 041	76 493	4 411
2018	34 388	44 868	208 023	207 939	47 930	17 001	20 163	82 038	79 393	4 578
2019	35 613	46 467	215 436	215 349	49 638	17 607	20 881	84 962	82 223	4 741
2020	36 816	48 036	222 711	222 621	51 314	18 201	21 586	87 831	84 999	4 901
2021	38 002	49 584	229 890	229 797	52 968	18 788	22 282	90 661	87 739	5 059
2022	39 179	51 120	237 008	236 912	54 608	19 370	22 972	93 469	90 456	5 216
2023	40 351	52 649	244 100	244 001	56 242	19 949	23 660	96 266	93 162	5 372
2024	41 524	54 179	251 193	251 092	57 876	20 529	24 347	99 063	95 870	5 528
2025	42 701	55 715	258 314	258 209	59 517	21 111	25 037	101 871	98 587	5 685
2026	43 886	57 261	265 483	265 376	61 169	21 697	25 732	104 698	101 324	5 843
2027	45 083	58 822	272 722	272 612	62 837	22 289	26 434	107 553	104 086	6 002
2028	46 294	60 402	280 048	279 934	64 524	22 887	27 144	110 442	106 882	6 163
2029	47 522	62 005	287 476	287 359	66 236	23 494	27 864	113 372	109 717	6 327
2030	48 769	63 632	295 021	294 901	67 974	24 111	28 595	116 347	112 597	6 493

Tab. 3 Simulation results under more conservative scenario of 1% population growth. Variables are stated in nominal terms in million euros. *(Source: Author)*

	L_t	K_t	Y_t	Q_t	C_t	G_t	I_t	X_t	M_t	H_t
2016	31 835	41 538	192 584	192 506	44 372	15 739	18 666	75 949	73 501	4 238
2017	33 150	43 253	200 535	200 454	46 204	16 389	19 437	79 085	76 536	4 413
2018	34 430	44 923	208 281	208 197	47 989	17 022	20 188	82 140	79 492	4 584
2019	35 685	46 561	215 874	215 787	49 739	17 643	20 924	85 134	82 390	4 751
2020	36 923	48 175	223 358	223 268	51 463	18 254	21 649	88 086	85 246	4 916
2021	38 149	49 775	230 775	230 681	53 172	18 860	22 368	91 010	88 077	5 079
2022	39 369	51 368	238 159	238 062	54 873	19 464	23 084	93 922	90 895	5 241
2023	40 590	52 960	245 542	245 442	56 574	20 067	23 799	96 834	93 713	5 404
2024	41 815	54 558	252 951	252 849	58 281	20 673	24 517	99 756	96 541	5 567
2025	43 048	56 168	260 413	260 307	60 000	21 283	25 241	102 699	99 388	5 731
2026	44 294	57 793	267 947	267 839	61 737	21 898	25 971	105 670	102 264	5 897
2027	45 554	59 438	275 575	275 464	63 494	22 522	26 710	108 678	105 175	6 065
2028	46 834	61 107	283 314	283 199	65 277	23 154	27 460	111 730	108 129	6 235
2029	48 134	62 803	291 179	291 061	67 089	23 797	28 223	114 832	111 131	6 408
2030	49 457	64 530	299 185	299 064	68 934	24 451	28 999	117 989	114 186	6 585

Tab. 4 Simulation results under more optimistic scenario of 2% population growth. Variables are stated in nominal terms in million euros. *(Source: Author)*

	L_t	K_t	Y_t	Q_t	C_t	G_t	I_t	X_t	M_t	H_t
2016	31 835	41 538	192 584	192 506	44 372	15 739	18 666	75 949	73 501	4 238
2017	33 168	43 277	200 647	200 565	46 230	16 398	19 448	79 129	76 578	4 416
2018	34 473	44 979	208 540	208 455	48 049	17 043	20 213	82 242	79 591	4 590
2019	35 758	46 656	216 312	216 224	49 839	17 678	20 966	85 307	82 557	4 761
2020	37 030	48 315	224 006	223 916	51 612	18 307	21 712	88 341	85 494	4 930
2021	38 295	49 966	231 662	231 568	53 376	18 933	22 454	91 360	88 416	5 098
2022	39 560	51 617	239 313	239 216	55 139	19 558	23 196	94 378	91 336	5 267
2023	40 829	53 272	246 990	246 890	56 908	20 186	23 940	97 405	94 266	5 436
2024	42 107	54 940	254 720	254 617	58 689	20 817	24 689	100 454	97 216	5 606
2025	43 397	56 624	262 527	262 421	60 488	21 455	25 446	103 533	100 195	5 778
2026	44 704	58 329	270 432	270 323	62 309	22 101	26 212	106 650	103 212	5 952
2027	46 031	60 059	278 456	278 343	64 158	22 757	26 989	109 814	106 275	6 128
2028	47 379	61 819	286 615	286 499	66 038	23 424	27 780	113 032	109 389	6 308
2029	48 753	63 612	294 926	294 807	67 953	24 103	28 586	116 310	112 561	6 491
2030	50 155	65 440	303 404	303 281	69 906	24 796	29 408	119 653	115 796	6 677