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Zusammenfassung

Die Alterung – nur eine Nebensache für das Gesundheitswesen? Ergebnisse für die Schweiz

In diesem Papier wird gezeigt, dass eine alternde Bevölkerung zu einem zunehmenden Kostendruck im Gesundheitswesen führt. Unsere Analyse stützt die weit verbreitete, aber in letzter Zeit sehr umstrittene Hypothese, dass die absehbare Alterung der Bevölkerung die finanzielle Nachhaltigkeit des Gesundheitswesens gefährdet. Dieses Papier leistet einen Beitrag zur Diskussion über die Bedeutung der Alterung für das Gesundheitswesen, indem wir (i) die Determinanten der Schweizer Gesundheitsausgaben mit Hilfe Ausreißer-robuster dynamischer Regressionen schätzen und (ii) die Gesundheitsausgaben auf Basis dieser empirischen Schätzungen und der jüngsten Bevölkerungsszenarien für die Schweiz projizieren. Unsere Ergebnisse legen auch nahe, dass der medizinisch-technische Fortschritt und das BIP pro Kopf wesentliche Faktoren für das Ausgabenwachstum im Gesundheitswesen sind. Die Gesundheitspolitik kann das Ausgabenwachstum insbesondere durch Maßnahmen zur Verbesserung des Gesundheitszustands der Bevölkerung sowie eine gezielte Förderung von kostensparenden und effizienten medizinischen Innovationen dämpfen

Schlagworte: Gesundheitsausgaben, Alterung, finanzielle Nachhaltigkeit, medizinisch-technischer Fortschritt, robuster MM Schätzer, langfristige Ausgabenprojektionen, Bootstrapsimulationen.

Abstract

Population Aging in Healthcare – A Minor Issue? Evidence from Switzerland

Our study shows that population aging substantially affects healthcare expenditure (HCE). This conclusion supports the popular, but recently strongly contested, view that the coming population aging will threaten the fiscal sustainability of health systems. We contribute to this debate, first by estimating the determinants of Swiss healthcare expenditure (HCE) with outlier-robust dynamic regressions, and second, by projecting Swiss HCE based on the estimates produced and new population scenarios. Medical advances and GDP per capita also play a decisive role. Governments can mitigate HCE growth by improving the health status of the population and by stimulating cost-effective and productive medical advances.

Keywords: healthcare expenditure, population ageing, fiscal sustainability, advances in medical technology, robust MM estimator, long-term projections, bootstrap simulations

JEL-Classification: H51, I18, C22

Population Aging in Healthcare – A Minor Issue? Evidence from Switzerland

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I. INTRODUCTION

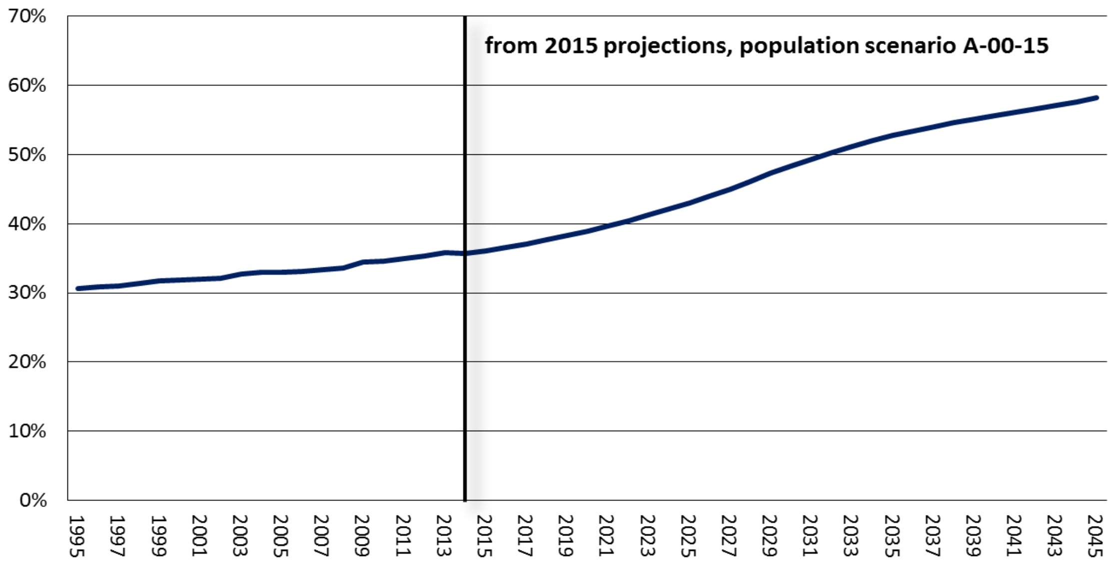
Healthcare expenditure has outpaced GDP growth over decades in OECD countries. In Switzerland, for example, the ratio of HCE to GDP increased from 4.8% to 10.9% between 1960 and 2013. This means that Switzerland has one of the most expensive healthcare systems worldwide. A popular view is that, as a result of the coming population aging, the growth of HCE as a percentage of GDP will be even more dramatic as HCE per capita increases with age and a declining labour force will slow down GDP growth (Westerhout, 2006; Hsiao and Heller, 2007). The impact of aging is reinforced if HCE for the elderly increases faster than for the young over time (the "steepening" hypothesis) (Gregersen, 2014). Thus, the aging of societies is expected to raise the financial burden for governments, social healthcare insurances, and private households. However, evidence has recently been provided that population aging plays just a minor role in determining healthcare expenditure (Dormont et al., 2006; Bech et al., 2011; Breyer et al., 2011). Indeed, the conclusion reached by Newhouse (1992) that advances in medical technology are a dominant driver of HCE has been re-emphasised (Okunade and Murphy, 2002; Smith et al., 2009; Breyer et al., 2011). For example, evidence provided by Smith et al. (2009, 1281) based on a U.S. household panel suggests that the contribution of technological advances accounts for 27% to 48% of the growth rate of deflated HCE per capita. Some health economists even maintain that population aging is a "red herring" (e.g. Zweifel et al., 1999; Werblow et al., 2007). Based on cross-sectional micro data sets, the proponents of the "red-herring" hypothesis find evidence that population barely, if at all, affects HCE if the proximity to death is taken into account. These findings challenge the position that the coming population aging will place an extra burden on public finances and social healthcare insurances.

However, many methodological issues (e.g. the endogeneity between the explanatory variable proximity to death and HCE), have been raised in the "red-herring" debate (Gregersen, 2014). Recently, Breyer et al. (2015) show that the studies of the "red-herring" proponents suffer from the fact that the impact of aging over time is neglected. Even though Breyer et al. (2015) include the proximity to death, they provide evidence for a positive impact of population aging on HCE using macro data of German sickness fund members over the period from 1997 to 2009. Other studies also reach the conclusion that population aging leads to an increase of HCE (Martín et al., 2011).

The present paper contributes to this debate by (i) estimating the impact of population aging and further determinants of healthcare expenditure, in particular medical advances using time-series data, i.e. macro data, for Switzerland ranging from 1960 to 2009, and (ii) carrying out comprehensive long-term projections of HCE for the period from 2013 to 2045 based on the latest population scenarios of the Federal Statistical Office (FSO) in Switzerland. According to the reference scenario of the FSO, by 2045 the real old-age dependency ratio in Switzerland – the ratio of those 65 years old and over to the labour force – will be double the 2013 figure.

FIGURE 1

Real old-age dependency ratio of those 65 years old and over (as %)*



* Effective old-age dependency ratio is defined as the ratio between those 65 years old and above to the labour force (in full-time equivalents)

Source: FSO

Consequently, as Smith et al. (2009, 1281) explain: “Demographics *appear* to have played a small role in the historical growth of spending but will loom larger with the aging of the baby boomers.”[1]

Both our data set and the population scenarios by the FSO are applied for the first time to analyse HCE. Previous projections are based on older population scenarios by the FSO (Colombier and Weber, 2011; Colombier, 2012a; De la Maisonneuve and Oliveira Martins, 2013). Moreover, contrary to the present paper, De la Maisonneuve and Oliveira Martins (2013) focus on public HCE alone. In contrast to other empirical studies on the determinants

[1] Italics added by author.

of Swiss healthcare expenditure (Crivelli et al., 2006; Reich et al. 2012; Braendle and Colombier, 2015), which use panel data sets of the mandatory healthcare insurance in Switzerland and/or public HCE at the cantonal (state) level, covering at maximum 50% of HCE, our empirical analysis covers total HCE. This is crucial as the former studies do not include social allowances for healthcare, in particular those for the elderly population. Furthermore, we use the estimates produced by our empirical analysis to project the impact of non-demographic determinants on HCE without long-term care (LTC). To account for the uncertainty surrounding the impact of non-demographic determinants, we estimate the accuracy, i.e. the bias, the variance, and the confidence interval of our estimates, by using a Monte Carlo bootstrap method with 1,000 simulations.

Based on the evidence provided in our analysis, we reject the hypothesis that population aging plays only a minor role in determining HCE for the Swiss case. Our regression analysis provides robust evidence that population aging was an important determinant of total HCE over the period from 1960 to 2009, even if we control for the proximity to death. We arrive at similar results for the impact of medical advances on HCE. Our findings concerning population aging are in line with the results found by Crivelli et al. (2006), who use cantonal data of the mandatory basic healthcare insurance and public HCE from 1996 to 2002. However, neither Reich et al. (2012), who apply the same dependent variable as Crivelli et al. (2006) over the period from 1997 to 2007, nor Braendle and Colombier (2015), who use public cantonal HCE as the dependent variable over the period from 1970 to 2012, provide evidence for a positive impact of aging. These results could be due to the fact that social allowances for healthcare are not taken into account, a point that is also stressed by Reich et al. (2012). Furthermore, given the fact that the population share of those 65 years old and above stands at about 17% today, versus 10% in 1960, Braendle and Colombier (2015) emphasise that the aging effect might be difficult to separate from the time-fixed effects. Corresponding to the findings of the present study, Crivelli et al. (2006) and Reich et al. (2012) provide evidence for a positive impact of medical technology, whereas Braendle and Colombier (2015) do not find a statistically positive impact of medical advances on HCE. However, the latter study concentrates on cantonal HCE as the dependent variable, which makes up only about 17% of HCE, and the impact of medical advances might be difficult to separate from the time-fixed effects included.

Our long-term projections of HCE show that the coming population aging will increase the pressure on public budgets and the Swiss mandatory basic health insurance. However, non-demographic determinants such as medical advances or GDP per capita are still important.

Consequently, a combination of demographic and non-demographic cost drivers will put the sustainability of public finances at risk. We demonstrate that the demographic impact can be mitigated substantially if people live not only longer but also more healthily.

Policymakers should be well aware of the fact that both non-demographic and demographic determinants strongly influence public HCE and the expenditure on the mandatary basic healthcare insurance. As our projections show, the government should care about the health status of the population. A viable measure to mitigate the pressure from population aging is to support a healthy lifestyle of the population and invest in preventive care. In addition, policymakers should foster those medical technologies that are, according to Chandra and Skinner (2012, 661), "cost-effective and useful for nearly everyone in the relevant population," and should discourage medical technologies with uncertain outcomes and ineffective treatments.

In addition, following a recommendation by Cantoni and Ronchetti (2006), we apply a robust statistical method – the outlier-robust generalized modified maximum likelihood (MM) estimator proposed by Yohai et al. (1991) – to analyse the impact of cost drivers on HCE. Robust statistical methods are recommended for non–high-quality data such as those in economics because this kind of data contains outliers, which carry the risk of causing biased and inefficient least squares estimators (Temple, 2000; Zaman et al., 2001; Colombier, 2009;). In contrast, the MM estimator is insensitive to outliers, i.e. observations that deviate from the general pattern of the data. Although healthcare data suffer from heavy-tailed outcomes, as pointed out by Cantoni and Ronchetti (2006), to the best of the author's knowledge robust statistical methods have not been applied to the analysis of HCE. A recent study by Hartwig and Sturm (2014) stands out as these authors apply the robust MM estimator to estimate the impact of various determinants of HCE for a panel data set of 33 OECD countries.

This paper is organised as follows. In the following section, we present the methods used for the empirical analysis. Section 3 presents the results of the empirical analysis of the Swiss case. Section 4 outlines the results of the projections of Swiss HCE. Section 5 concludes.

II. METHODS

A. The estimation method

To estimate the impact of various cost drivers on Swiss total current HCE, we use a Swiss sample which ranges from 1960 to 2009.[2] For two of the explanatory variables, the mortality rate and the density of physicians, data are only available from 1970, which reduces the time span.

The estimations are carried out based on the following stochastic equation:

$$hce_t = \beta_0 + \beta_1 y_t + \sum_i \beta_i x_{i,t} + u_t \qquad (1)$$

whereby: hce:= Real healthcare expenditure per capita (at GDP 2005 prices),
β_0: = Constant,
y:= Real GDP per capita,
x_i:= Further determinants of hce i, i = 2,...,n,
β_i:= Elasticity of hce w.r.t. determinant i,
u:= Error term,
t:= Year.

As is standard in such estimations, HCE is expressed in per capita values and deflated with the GDP deflator (e.g. Hartwig and Sturm, 2014). All stochastic variables are estimated in natural logarithms which, among other things, allows the interpretation of the coefficient β_i as elasticity.

In line with panel-data evidence provided by Dreger and Reimers (2005) and Gerdtham and Löthgren (2000) and time-series evidence for a U.S. data set provided by Okunade and Murphy (2002), we find that real HCE per capita (hce) contains a stochastic trend and is difference-stationary (see Appendix, Table A1). The same result applies to the explanatory variables. Consequently, we need to test if a cointegrating relationship between the explanatory variables and the response exists. To test for cointegration, we apply an error-correction model (ECM) and use the bounds test developed by Pesaran et al. (2001). In contrast to other single-equation cointegration tests, the bounds test allows for stationary and difference-stationary regressors and for several cointegrating relationships between the regressors. However, the bounds test requires that the regressors are weakly exogenous. Our tests on the weak exogeneity indicate that, apart from the mortality rate of women, all regressors are weakly exogenous (see Appendix, Table A2). Therefore, we abstain from using the mortality rate of

[2] For detailed information on the data sources see Appendix A.

women and focus on the mortality rate of men. In order to estimate the cointegrating relationships and to take account of possibly long-term correlations, we carry out dynamic regressions (Saikkonen, 1991). Such dynamic regressions offer the advantage of correcting for a possible endogeneity bias of the explanatory variables.

To overcome the outlier-sensitivity of a classical least squares estimator (LSE), we follow the recommendation by some authors (Temple, 2000; Zaman et al., 2001; Colombier, 2009; Hartwig and Sturm, 2014) and apply a robust statistical estimator, i.e. the MM estimator introduced by Yohai et al. (1991), to estimate the long-term relationships between hce and the cost drivers. Time-series methods based on LSE such as an augmented Dickey-Fuller (ADF) test can have a substantial loss of power due to the presence of outliers (see Thompson, 2004, 360). This means, for example, that in the case of the ADF test a unit root is rejected too frequently. Therefore, we use an outlier-robust unit root test (see Appendix B). Moreover, robust statistical methods are particularly suited for healthcare data as HCE epitomises data sets that suffer from long-tailed statistical distributions and, therefore, from influential outliers (see Cantoni and Ronchetti, 2006, 199). In the present analysis, about two thirds of the regressions contain influential outliers, which might lead to biased and inefficient LSE (see Tables 1 and 2).

B. Population aging

Population aging as a determinant of hce is represented by the old-age dependency ratio of the population aged 65 years and above (henceforth: old-age dependency ratio). To take account of the "red-herring" hypothesis, we include a proxy for the proximity to death. However, data for the proximity to death are lacking at the macro level. Therefore, we follow Breyer et al. (2015, 96), who propose using the mortality rate for macro data, i.e. the share of persons who die in a particular year. To take into account the fact that the costs of dying are relevant a few years *before* dying, we lead the mortality rate by three years. According to the "red-herring" hypothesis, we should expect a positive sign. At the same time, the current mortality rate can serve as a proxy for medical advances.

C. Medical advances

Advances in medical technology are generally considered the most important driver of hce (see Smith et al., 2009, 1281). However, the empirical evaluation of the contribution of medical advances to an increase in hce is notoriously difficult as it has not been possible (so far) to quantify directly its impact (see Smith et al., 2000, 2; Dybczak and Przywara, 2010, 6 et seq.). Given the lack of empirical data, three different second-best approaches have been applied to estimate the impact of medical advances on HCE. Only two of them, the residual and the proxy approach, are pertinent to this present analysis because one approach, the case study, is difficult to generalise at an aggregate level (see Smith et al., 2000, 3). In the first approach – introduced by Newhouse (1992) – the regression residual is attributed to medical advances. The residual approach suffers from the drawback that, because of the possible omission of determinants in the regression, the impact of medical advances might be overestimated. Therefore, we resort to the more flexible proxy approach proposed by Okunade and Murphy (2002) because this approach allows the use of different proxies for medical advances. For example, Okunade and Murphy (2002) use health R&D expenditure as a proxy for medical advances. Other authors apply a deterministic time trend (Di Matteo, 2005) or life expectancy and infant mortality (Dreger and Reimers, 2005). Recently, Nolte and McKee (2012) show that effective medical treatments reduce the mortality rate of the population.

Certainly, each proxy is an incomplete measure of medical advances. For example, the mortality rate or the life expectancy might be a well-suited proxy because if technological advances are effective they should prolong life. Nevertheless, a longer life expectancy can be due to other factors, such as nutritional habits and the frequency of doing sports. Moreover, successful medical innovation could improve life quality without prolonging life. Given that other determinants influence life expectancy, the impact of technological advances on HCE would be overestimated. In contrast, insofar medical innovation does not lead to prolonging life, the impact of medical advances would be underestimated by applying life expectancy as a proxy. Thus, it is difficult to identify the direction of the possible bias. In contrast, if a deterministic time trend is used, one can expect an upward bias because, like a residual, a time trend could reflect determinants of hce that are not related to medical advances, and therefore not included as explanatory variables. Consequently, the risk of a one-sided bias can be mitigated by using different proxies for medical advances. Therefore, we think that the proxy approach is superior to the residual approach. We follow the relevant literature by using health R&D expenditure, the mortality rate (which is inversely related to life expectancy), and a deterministic time trend as proxies for medical advances.[3] Since data for health R&D expenditure in Switzerland were not available at the time of writing, we use health R&D expenditure of the U.S. Because of the dominant position of U.S. companies in the global mar-

[3] Five U.S. pharmaceutical producers and seven U.S. producers of medical devices are ranked among the top 10 companies based on global revenues in 2014.

kets for pharmaceuticals and medical devices, large spill-over effects on healthcare spending of other developed economies can be expected.

D. Further determinants of healthcare expenditure

We take one of the main drivers of hce at the macro level into account, i.e. income per capita represented by real GDP per capita (y) (see Martín et al., 2011, 22). Apart from medical advances as a supply-side driver, we take the density of physicians into account. In the case of the density of physicians, a positive significant coefficient does not allow for a clear-cut interpretation. On the one hand, an increasing density of physicians may reduce shortages of supply, which would be efficiency-enhancing. On the other hand, a cost-enhancing impact of the density of physicians may point to a well-known market failure in healthcare, i.e. the information asymmetry between the principal (the physician) and the agent (the patient). This means that the supplier would induce demand. A further supply-side effect, i.e. Baumol's cost disease, implies that prices in certain labour-intensive industries such as healthcare rise more strongly than in other industries (Baumol, 1967). Because of the labour-intensive production technology, productivity progress is slower than in the overall economy. Given an income-inelastic demand for healthcare, wages of healthcare workers have to increase with overall productivity growth in order to avoid labour shortages in healthcare. This brings about a relative price increase in healthcare. Recent empirical studies provide evidence that Baumol's cost disease is effective in healthcare (Hartwig, 2008; Colombier, 2012b). As a proxy for Baumol's cost disease, we use the difference between wage and productivity growth (the so-called "Baumol variable" according to Hartwig (2008)) in real terms. A value of the Baumol variable equal to one indicates that the health system is completely contracted by Baumol's cost disease. If the Baumol variable assumes zero, healthcare would not suffer from the cost disease.[4]

[4] Note that the Baumol variable as introduced by Hartwig (2008) presupposes that the labour force is completely employed in the non-productive industries. Since in developed countries a considerable part is still employed in productive industries such as manufacturing, the Baumol variable overestimates the impact of Baumol's cost disease (Colombier, 2012b).

III. RESULTS

The Bounds F tests indicate that hce has a long-term relationship with the explanatory variables (see Table 1). The dynamic regressions carried out provide evidence that real GDP per capita has a robust, positive statistically significant correlation with hce (see Table 1). The income elasticity ranges between 0.62 and 1.18. Thus, our estimationsdo not rule out the suggestion that healthcare is a luxury good. This is slightly above the results presented by recent studies that suggest that the income elasticity lies in the range of well below to about one (see Smith et al., 2009, 1279; Martín Martín et al., 2011, 22; Hartwig and Sturm, 2014, 4468). Population aging as represented by the old-age dependency ratio exerts a positive statistically significant impact on hce. Even if one controls for the proximity to death by including the first to third lead of the mortality rate of men, the result does not change. However, the model that includes the density of physicians and a time trend produces a counter-intuitive result concerning the impact of aging. Population aging would lead to a decrease of hce. This result might be due to the fact that the aging effect is difficult to separate from the effect of the deterministic time trend as the old-age dependency ratio has been steadily increasing (from 0.12% in 1970 to 0.17% in 2009).

TABLE 1

Cost drivers of real healthcare expenditure per capita – basic estimations5

Timeframe	1960–2009			
Dependent variable	Long-run elasticity (β_i) of real healthcare expenditure per capita			
Real GDP per capita	1.11*** (0.03)	1.03*** (0.03)	0.84*** (0.05)	1.04*** (0.02)
Old-age dependency ratio of those 65 years old and over	1.87*** (0.14)	1.46*** (0.17)	0.61*** (0.23)	1.32*** (0.14)
Baumol variable[a]		0.62*** (0.19)	0.48*** (0.17)	0.52*** (0.17)
Density of physicians				
Trend			0.13*** (0.03)	
R&D healthcare USA				0.24*** (0.07)
Mortality rate men[b]				
Lead 1				
Lead 2				
Lead 3				
Adj. R^2 (as %)	89	92	98	98
Bounds F test (ECM)	7.5***	9.0***	4.8**	3.5*
AIC	-192	-202	-196	-202
Box-Ljung test	16	17	23	23
Shapiro-Wilk test	0.99	0.98	0.97	0.99
Share influential outliers	0.0	2.2	11	0.0

Notes: Dynamic regressions based on Saikkonen's (1991) proposal with robust modified M estimator (MM estimator, the results for the lagged and leaded variables in first differences are available upon request from the author; to deal with autocorrelation Cochrane-Orcutt method is applied; all variables are in natural logs; t tests: figures in brackets are robust standard errors; Box-Ljung test, H0: no autocorrelation, Box-Ljung statistic; Shapiro-Wilk test for Gaussian distribution, H0: Gaussian, W statistic; harmful outliers: vertical & bad leverages; cointegration test: bounds F test based on Pesaran, Shin & Smith (2001) carried out for the error correction model (ECM), critical values for small sample from Narayan (2005), H0: no cointegration, F statistic; for identifying outliers that might cause inefficient and biased LSE (influential outliers) see Hubert et al. (2005).

*:= 10% significance level, **:=5% significance level, ***:= 1% significance level.

[a] The Baumol variable is purified by real GDP per capita.

[b] The variable mortality rate of men is purified by the population share of those 65 years old and over. The correlation estimate of the robust minimum covariance determinant estimator between the aforementioned variables amounts to 99%.

5 The results of the error-correction regressions are available on request from the author.

TABLE 1 *continued*

Timeframe	1970–2009[+]				
Dependent variable	Long-run elasticity (β_i) of real healthcare expenditure per capita				
Real GDP per capita	0.68*** (0.17)	0.63*** (0.09)	1.18*** (0.02)	0.70*** (0.11)	1.07*** (0.22)
Old-age dependency ratio of those 65 years old and over	-0.58 (0.72)	0.46** (0.22)	2.28*** (0.10)	1.21*** (0.28)	1.73*** (0.37)
Baumol variable[a]	0.33 (0.21)	-0.03 (0.17)	0.34*** (0.16)	-0.19 (0.22)	0.22 (0.22)
Density of physicians	0.17 (0.21)	0.57*** (0.12)		0.63*** (0.15)	0.24 (0.18)
Trend	0.20** (0.08)				
R&D healthcare USA		0.32** (0.15)			
Mortality rate men[b]			-0.51*** (0.10)	-0.32** (0.15)	-0.03 (0.36)
Lead 1					-0.02 (0.32)
Lead 2					-0.10 (0.38)
Lead 3					-0.48* (0.28)
Adj. R^2 (as %)	79	99	99	99	99
Bounds F test (ECM)	7.2**	5.5***	3.8*	5.7***	5.7***
AIC	-149	-165	-112	-139	-139
Box-Ljung test	13	15	12	16	18
Shapiro-Wilk test	0.77**	0.98	0.86***	0.89***	77**
Share influential outliers	11	2.9	10	11	5.9

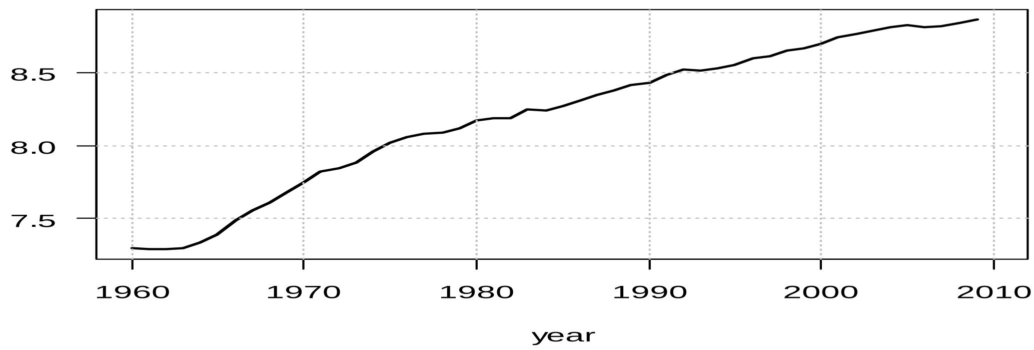
[+] Note that data for the mortality rate of men and the density of physicians are only available from 1970.

The evidence for Baumol's cost disease is not as clear-cut as for the income elasticity and population aging. Only in half of the regressions is the coefficient of the Baumol variable statistically significant. Nonetheless, given the fact that other empirical studies provide evidence in favour of Baumol's cost disease (Hartwig, 2008; Colombier, 2012b; Hartwig and Sturm, 2014), and that the caring services (which epitomise Baumol's cost disease) make up a large part of the health system, our results provide at least an indication that Baumol's cost disease affects hce. The coefficient of the Baumol variable is well below one, which suggests that the Swiss health system is only partly contracted. The evidence for a cost-increasing impact of the density of physicians on hce is also mixed. Independently of the proxy used for medical advances, i.e. R&D expenditure in U.S. healthcare, a time trend, or the mortality rate of men, our results indicate a cost-enhancing impact of medical advances. This result is not sensitive to the inclusion of the density of physicians (see Table 1).

Note that one should take account of possible structural breaks in the time series of hce. In particular, healthcare reforms (such as the introduction of the mandatory basic healthcare insurance in 1996, the introduction of a unified remuneration system (TARMED) for practising doctors in 2005, or health policy measures like the introduction of a cap for practising doctors from 2002 to 2009) may have caused structural breaks in the hce time series.

FIGURE 2

Real healthcare expenditure per capita (in natural logarithm)



Source: FSO, own calculations

By observing the series hce we cannot detect a break at the times when the healthcare reforms were introduced (see Figure 2). However, it appears to be the case that structural breaks occur at the beginning of the 1960's and in the middle of the 1970's. The recursive CUSUM test, which is a structural-break test, suggests a structural break in the middle of the 1970's. Nevertheless, the evidence is mixed as another test, the OLS-MOSUM test, does not indicate a structural break in the hce series at a 5% significance level (see Appendix, Figure A1). The indicated structural break in the middle of the 1970's might be due to the macroeconomic environment at this time, i.e. the breakdown of Bretton Woods and the oil-price crisis, which caused Swiss real GDP to shrink by 8% in 1975 and 1976. Consequently, HCE might have been curbed because of tightening budget constraints. To err on the side of caution, a sensitivity analysis has been undertaken with a shortened period that ranges from 1975 to 2009 (see Table 2).

TABLE 2

Cost drivers of real healthcare expenditure per capita – further estimations

Timeframe	1975–2009					
Dependent variable	Long-run elasticity (β_i) of real healthcare expenditure per capita					
Real GDP per capita	1.16*** (0.03)	1.15*** (0.02)	0.33*** (0.08)	0.32* (0.16)	0.98*** (0.05)	0.71*** (0.03)
Old-age dependency ratio of those 65 years old and over	2.16*** (0.18)	2.10*** (0.11)	-1.94*** (0.40)	-2.73*** (0.69)	0.75* (0.39)	0.72*** (0.10)
Baumol variable[a]		0.46*** (0.12)	-0.005 (0.12)	0.01 (0.19)	0.27 (0.24)	0.12** (0.05)
Density of physicians				-0.31 (0.20)		0.51*** (0.04)
Trend			0.35*** (0.04)	0.45*** (0.08)		
R&D healthcare USA					0.53*** (0.15)	0.34*** (0.03)
Mortality rate men[b]						
Lead 1						
Lead 2						
Lead 3						
Adj. R^2 (as %)	92	98	99	96	92	99
AIC	-111	-86	-171	-154	-99	-137
Box-Ljung test	21*	5.39	9.2	23	17	19
Shapiro-Wilk test	0.97	0.89**	0.94*	0.95	0.94	0.80***
Share influential outliers	0.0	11	0.0	5.7	9.5	16

Notes: see Notes Table 1.

TABLE 2 *continued*

Timeframe	1975–2009		
Dependent variable	Long-run elasticity (β_i) of real healthcare expenditure per capita		
Real GDP per capita	1.11*** (0.03)	0.83*** (0.11)	0.93*** (0.17)
Old-age dependency ratio of those 65 years old and over	1.90*** (0.14)	1.48*** (0.27)	1.05*** (0.31)
Baumol variable[a]	0.71*** (0.28)	0.23 (0.19)	0.32** (0.15)
Density of physicians		0.43*** (0.16)	0.37** (0.18)
Trend			
R&D healthcare			
USA			
Mortality rate men[b]	-1.09*** (0.38)	-0.68* (0.37)	-0.22 (0.19)
Lead 1			-0.51** (0.22)
Lead 2			-0.16 (0.22)
Lead 3			-0.31* (0.17)
Adj. R^2 (as %)	99	98	95
AIC	-104	-156	-143
Box-Ljung test	13	9.5	11
Shapiro-Wilk test	0.97	0.95	0.92**
Share influential outliers	0.0	0.0	3.3

Notes: see Notes Table 1.

Overall, the results of the basic estimations are confirmed. GDP per capita and the old-age dependency ratio show a stable, positive statistically significant correlation with hce even if one controls for the proximity to death. Also, the evidence concerning Baumol’s cost disease and the density of physicians remains mixed. Additionally, the statistically significant results vary to a greater extent. Furthermore, the regression with a time trend again produces counter-intuitive results with respect to the old-age dependency ratio. This is a rather strong indication that the effect of the time trend cannot be separated from the aging effect. In addition to this, the estimated income elasticity is substantially lower than in the remaining estimations. The estimates amount to 0.3, while the average income elasticity of the other estimations in Table 2 is almost 1.0.

From a purely theoretical point of view, the income elasticity would only measure how the demand for healthcare services changes with respect to income. However, it is difficult to distinguish empirically between the demand-side income effect and existing interdependencies between the income and certain supply-side effects (see Smith et al., 2009, 1277 et seq.). For example, one may assume that as a society grows more prosperous, demand for innovations in medicine also grows (“demand pull”) (see Dybczak and Przywara, 2010, 8). In addition, increasing prosperity provides society with a greater range of sales opportunities for healthcare products, which in turn increases the incentive to invest in R&D (“supply push”). Failing to control for other non-demographic cost drivers of hce such as advances in medical technology can lead to an overestimation of the theoretically correct or pure elasticity (see Smith et al., 2009, 1280 and Appendix A2). Therefore, we dub the elasticity estimated in regressions without controls for other non-demographic cost drivers “unadjusted” income elasticity. The estimations in Tables 1 and 2 provide rather strong evidence that the unadjusted income elasticity (see Table 1 and Table 2, 2nd and 3rd column) is on average higher than the pure income elasticity. The inclusion of further factors of hce in the regressions, such as Baumol’s cost disease, advances in medical technology, and the density of doctors, drives the income elasticity down. In particular, the inclusion of the density of physicians reduces the income elasticity to a considerable extent. This result seems to be plausible as a rising density of physicians is usually accompanied by an increase in demand.

IV. PROJECTIONS OF SWISS HCE

In the following we show how an aging population and non-demographic cost drivers such as medical advances will affect the share of overall income (GDP) spent on healthcare. In accordance with a common standard, we apply a cohort approach to project HCE as a percentage of GDP (De la Maisonneuve and Oliveira Martins, 2013). HCE is broken down by age groups and services.[6] These services are decomposed into the areas healthcare without LTC and LTC from the age of 65. The expenditure projections span the period from 2013 to 2045, with 2013 as the base year.[7] For each age cohort, the per capita expenditure is multiplied by the projected development of the age cohort in question in order to project future cost development caused by population aging. For the projection of expenditure, the FSO’s population scenario A-00-2015, i.e. the reference scenario, is assumed. Moreover, expenditure per capita is affected by longevity and non-demographic cost drivers.[8] Concerning the

[6] For more detailed information on the method of HCE projections, see Colombier (2012a, chapter 2).

[7] Compared to former HCE projections for Switzerland we have shortened the time horizon from about 50 to about 30 years in order to keep the time horizon still in the sights of current taxpayers and policy-makers (Colombier and Weber, 2011; Colombier, 2012a).

[8] We do not include the proximity to death in the present projections as official data are not available and also due to cost-benefit considerations. Colombier and Weber (2011, 258) show that, due to the shape of expendi-

correlation between increasing longevity and the health status of the population, no dominant theory has emerged so far (see Michel and Robine, 2004, 669). Therefore, a compromise is assumed under the baseline scenario whereby the population spends half of its gained life expectancy in good health for both areas of healthcare. In the healthy-aging scenario, we assume that the population spends the gained life expectancy in good health, whereas in the pure-aging scenario we make the assumption that the life expectancy increases without an improvement in the health status of the population. While it is certain that the Swiss population will continue to age in the coming decades, it is less clear how HCE is affected by non-demographic cost drivers. To project the impact of non-demographic drivers, we use the estimates for the income elasticity and the Baumol variable of our empirical analysis (see section III). To cope with the uncertainty surrounding the non-demographic drivers, we estimate the accuracy of the estimated income elasticity and the estimated coefficient of the Baumol variable, the Baumol parameter, by using a bootstrap. In line with a consensus on projecting HCE, we assume that the demand for LTC is income-inelastic. Because of the predominant role of caring activities in LTC, we assume that Baumol's cost disease exerts its full impact. GDP is projected by multiplying the historical average of the annual productivity growth in Switzerland, which amounts to roughly 1.2%, with the projected labour force growth of the population scenario (A-00-2015) of the FSO.

Equation (2) shows which determinants are taken into account to project real HCE without LTC per capita of age cohort j (hc_j).[9]

$$hc_{t,j} = hc_{0,j} * \Theta_{t,j} * \prod_{i=1}^{t}(1+\eta)^{t}\,\hat{y}_i * \prod_{i=1}^{t}(1+\mu\hat{w}_i) \qquad (2)$$

with: $hc_{t,j}$:= Real HCE without LTC per capita of age cohort j in year t and the base year 0 respectively.

$\hat{y}_i$:= Growth rate of real GDP per capita in year i.

$\hat{w}_i$:= Growth rate of the real wage rate in year i.

$\Theta_{t,j}$:= Morbidity parameter of age cohort j in year t, which represents the reduction in $hc_{t,j}$ through an improvement of the health status of the population by an increase of life expectancy; $\Theta_{t,j}=1$, i.e. no improvement in health status; $0< \Theta_{t,j}\leq 1$.

η:= Unadjusted income elasticity; $\eta>1$.

μ:= Baumol parameter; $\mu=1$, i.e. fully impacting Baumol effect; $\mu=0$, i.e. no Baumol effect; $0\leq \mu\leq 1$.

ture profiles for decedents and survivors in Switzerland, the inclusion of the proximity to death does not substantially alter the results of HCE projections. Van Baal and Wong (2012, 877) arrive at the same result for the Netherlands.

9 Note that for per capita real expenditure on LTC it is assumed that $\eta=0$ and $\mu=1$ (see Table 4).

The impact of non-demographic cost drivers are included by a parameter for Baumol's cost disease (μ) and the unadjusted income elasticity (η) (see equation (2)). From the empirical estimations, one can infer that the *unadjusted* income elasticity is slightly above one (see Tables 1 and 2). The unadjusted income elasticity also contains the impact of technological advances (see section 3). Another option to take account of medical advances is to use a residual-based approach.[10] However, this approach extrapolates the cost development of the past and, consequently, decouples HCE from the projected general economic development. The latter would appear to be unrealistic in the long term, given in particular recent experiences in some European crisis countries, such as Ireland and Greece.

A. Simulating the impact of non-demographic cost drivers

To quantify the uncertainty concerning the cost impact of non-demographic drivers, we simulate the confidence intervals of the unadjusted income elasticity and the Baumol parameter at a 95% level. For this, we apply a distribution-free resampling method called nonparametric bootstrap.[11] To avoid flawed statistics due to structural breaks in the time series of hce HCE, we use the shorter sample from 1975 to 2009 for the simulation exercise. The residuals ($\hat{u}_t$) from the regression fit with the explanatory variables real GDP per capita, the Baumol variable, and the old-age dependency ratio are used as the random variables, making the sample that is bootstrapped (see equation (3) and Table 2, 3rd column).

$$\hat{u}_t = hce_t - \hat{\beta}_1 y - \hat{\beta}_2 * \text{Baumol variable}_t - \hat{\beta}_3 * \text{Old-age dependency ratio}_t \qquad (3)$$

whereby the $\hat{\beta}$ s represent the estimated coefficients of the dynamic regression.

By resampling the residuals ($\hat{u}_t$) one obtains the bootstrap data (hce_t*,$\hat{u}_t$*)
(see equation (4)).

$$hce_t* = hce_t + \hat{u}_t * \qquad (4)$$

Based on the bootstrap data, the regression coefficients of each bootstrap sample are estimated by using the robust MM method. In order to obtain sufficiently reliable results, we carry out 1,000 simulations. The results of the bootstrap match almost exactly with the esti-

10 For a more detailed account of how to include the cost impact of advances in medical technology in long-term projections of HCE (see Colombier, 2012a, 37-40; Dybczak and Przywara, 2010, 6-8.

11 A bootstrap means essentially "using the sample as a population from which repeated samples are drawn" (see Fox and Weisberg, 2012, Appendix).

mates of the original regression (see Table 3). This suggests that the estimates have practically no bias.

TABLE 3

Monte Carlo simulations using a nonparametric bootstrap – 1,000 simulations

Regressor	Original coefficient[+]	Bias	Standard error bootstrap	Confidence interval (95% level) (adjusted bootstrap percentile BCa)
Real GDP per capita	1.15	-0.002	0.02	[1.11, 1.18]
Baumol variable	0.46	0.008	0.12	[0.21, 0.74] without LTC [0.01, 0.54]
Old-age dependency ratio	2.10	-0.01	0.10	[1.90, 2.30]

[+] For the original regression see Table 2, 3rd column.

Based on the simulated confidence intervals of the income elasticity (coefficient of real GDP per capita) and the Baumol variable, different scenarios for HCE without LTC are drawn up. Since we want to identify the impact of Baumol's cost disease on HCE without LTC, and the simulated confidence interval of the Baumol parameter also includes the impact on LTC (of those 65 years old and over), this confidence interval has to be adjusted. Under the scenario for LTC, we assume that LTC is completely contracted by Baumol's cost disease. In addition, according to our projections, the expenditure share of LTC in total HCE will amount to well above 20% in 2060. Therefore, a conservative estimate for the contribution of LTC to the impact of Baumol's costs disease on HCE would be around 0.2. Correspondingly, we correct the values of the confidence interval for μ by 0.2, which leads to the following interval [0.0, 0.5] (see Table 3). For the unadjusted income elasticity (η), the confidence interval of 95% is approximately as follows: [1.1, 1.2].

Based on these confidence intervals, we draw up various scenarios for HCE without LTC. In the following, we present the scenarios with the median, highest and lowest increase in HCE as a percentage of GDP. These are called the baseline, low and high cost pressure scenario respectively. The scenario assumptions concerning the unadjusted income elasticity, the Baumol parameter, and the correlation between the longevity and the health status of the population are summarised in Table 4.

TABLE 4

Different scenarios for HCE (excl. LTC) and LTC

Scenario	Unadjusted income elasticity (η)	Baumol parameter (μ)	Δ good health/ Δ longevity
Baseline HCE	1.15	0.25	0.5
Low cost pressure HCE	1.10	0.00	0.5
High cost pressure HCE	1.20	0.50	0.5
Baseline LTC	0.00	1.00	0.5
Pure aging HCE/LTC	1.15/ 0.00	0.25/ 1.00	0.0
Healthy aging HCE/ LTC	1.15/ 0.00	0.25/ 1.00	1.0

Note that we combine all low and high cost pressure scenarios for HCE without LTC with the baseline scenario of LTC.

B. Projecting HCE

The projections of HCE in terms of GDP show that the financial burden borne by society and the government will increase considerably by 4.1% of GDP and 1.7% of GDP respectively in the baseline scenario (see Table 5). In relative terms, the increase of public expenditure even surpasses the increase of overall expenditure by 11 percentage points.

The financial burden of the mandatory basic health insurance rises more or less proportionally to that of overall HCE. The stronger increase of government expenditure is due to the fact that the share of government funding of LTC from the age of 65 (2013: 23%) outstrips the corresponding share of total HCE (2013: 15%). In addition, the real expenditure on inpatient care increases annually by 0.2% more than that on outpatient care. This adds to the pressure on government finances as public HCE without LTC mainly comprises contributions to hospitals. The share of hospital expenditure in public HCE without LTC currently amounts to roughly 60%.

TABLE 5

Healthcare expenditure by level in baseline scenario and deviations from baseline scenario (as % of GDP, if not otherwise stated)

Level	2013	2045	Change 2013–45 (in %)		Deviation from Baseline scenario in 2045			
					Low cost pressure	High cost pressure	Healthy aging	Pure aging
Total HCE	10.8	14.9	+4.1	+38	-0.9	+1.0	-0.9	+1.0
HCE without LTC	8.6	10.9	+2.2	+26	-0.9	+1.0	-0.5	+0.5
LTC (from the age of 65)	1.6	3.4	+1.8	+114	-	-	-0.4	+0.5
Government [a] (incl. social welfare)	3.5	5.2	+1.7	+49	-0.3	+0.3	-0.4	+0.4
HCE without LTC	2.4	3.3	+0.9	+37	-0.3	+0.3	-0.2	+0.2
LTC (from the age of 65)	0.8	1.7	+0.9	+114	-	-	-0.2	+0.2
Mandatory basic healthcare insurance [b] (OKP)	3.3	4.5	+1.2	+35	-0.4	+0.4	-0.3	+0.3
HCE without LTC	2.9	3.7	+0.9	+30	-0.4	+0.4	-0.2	+0.2
LTC (from the age of 65)	0.3	0.6	+0.3	+113	-	-	-0.1	+0.1

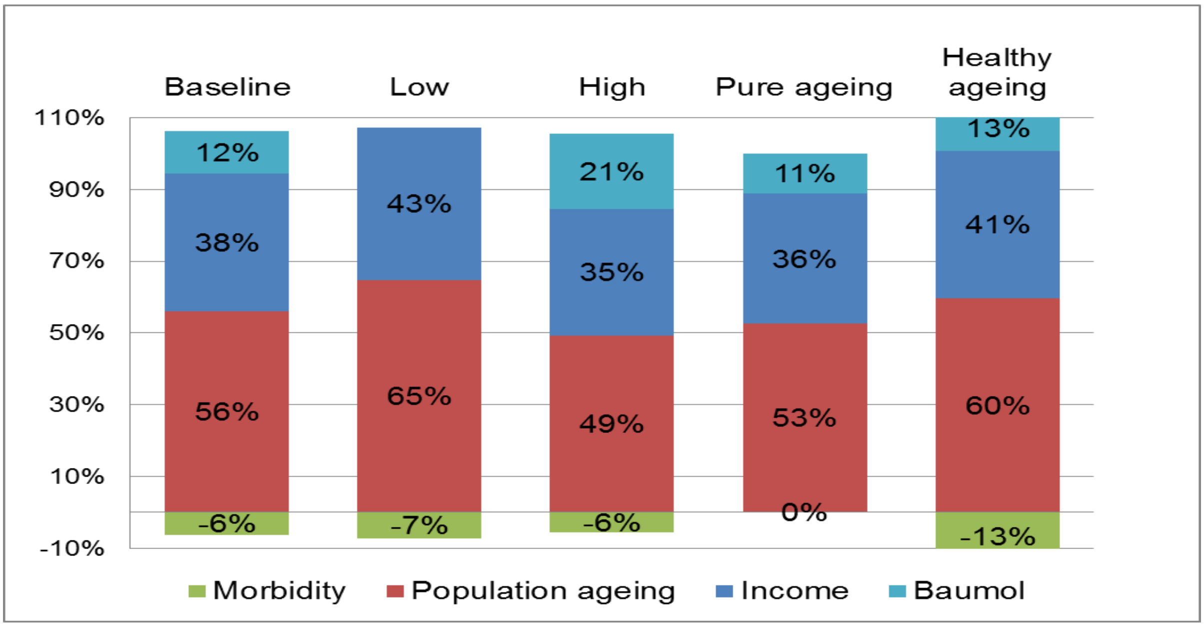
[a] Note that (total) government expenditure also includes expenditure on care for persons under 65 but not the mandatory basic healthcare insurance.

[b] Excluding expenditure on the government-financed individual premium reduction as the latter is included in government expenditure.

The projections also show that the increase of LTC expenditure (for those 65 years old and over) is considerably higher than that of HC without LTC. This is due to the fact that population aging exerts a stronger impact on LTC expenditure. In the baseline scenario, population aging explains about three quarters of the increase in real LTC, while population aging contributes less than 60% to the increase of HCE without LTC (see Figure 3). Moreover, the deviations in the low and high cost pressure scenario from the baseline scenario show that a variation of both the income elasticity and, in particular, the Baumol variable, considerably slows down and accelerates respectively the projected increase in HCE. The deviation of overall HCE from the baseline scenario amounts to roughly 25% (0.9% of GDP). Since the mandatory basic healthcare insurance has to finance a considerably higher share of HCE without LTC than the government, 88% vs. 69%, a variation of the non-demographic drivers exerts a more profound impact on the mandatory basic healthcare insurance than on government finances. The increase of the expenditure of the mandatory basic healthcare insurance deviates by 34% from the baseline scenario, while the deviation in the case of public spending amounts to just 18%.

FIGURE 3

Percentage contributions of cost drivers to price-adjusted rise in HCE without LTC 2013–2045 in different scenarios (in %)



Source: own calculations

In the pure- and healthy-aging scenarios, the increase in overall HCE deviates by about 25% (or 0.9 to 1.0 GDP-%) from the baseline scenario in 2045, which is similar to how a variation of the assumed impact of non-demographic drivers affects HCE. Both HCE without LTC and LTC (of those 65 years old and above) are affected to the same extent in terms of GDP by about 0.5%. However, the sensitivity of LTC with respect to a variation in the health status of the population is much higher than for HCE without LTC. In both the pure- and healthy-aging scenarios the increase in expenditure on LTC (of those 65 years old and above) deviates 15% from the baseline scenario, whereas HCE without LTC deviates by just 5% from the baseline scenario. Thus, living longer in a good state of health alleviates the financial burden on LTC to a stronger degree than on HCE without LTC:

The breakdown of the price-adjusted rise in HCE without LTC after various cost drivers reveals that, independent of the underlying scenario, population aging is the single most important driver. This is followed by income per capita, which comprises various cost drivers such as medical advances (see Figure 3). Baumol's cost disease also has a considerable bearing on HCE without LTC. As is to be expected, non-demographic determinants exert the strongest impact on real HCE in the high cost pressure scenario and the lowest one in the low cost pressure scenario. In addition, the healthy-aging scenario shows that living longer in good health can mitigate considerably the adverse impact of population aging.

V. CONCLUSION

Consistent with a consensus in health economics, the evidence from the Swiss case suggests that advances in medical technology are a crucial cost driver in healthcare. However, for the following reasons one should be cautious to infer that population aging plays only a minor role in determining HCE.

First, the present paper provides empirical evidence that population aging has affected Swiss HCE to a substantial extent, even if one controls for the proximity to death. This is in line with evidence provided by other studies such as Breyer et al. (2015) and Crivelli et al. (2006). Second, our projections of HCE without LTC show that population aging is the single most important driver. As a result, one can expect that the coming population aging will increase the financial pressure in particular on public finances but also on the mandatory basic healthcare insurance. Nonetheless, one might argue that the impact of population aging might be overstated to some extent because the proximity to death is not taken into account in these present projections. However, as previous projections of Swiss HCE show, the inclusion of the proximity to death does not substantially alter the results of the projections for HCE without LTC (see Colombier and Weber, 2011, 259–260). In addition, an even stronger pressure resulting from the aging of society stems from the dynamics in LTC (of those 65 years old and over). For this area, even the proponents of the "red-herring" hypothesis do not deny the cost-increasing impact of population aging (see Werblow et al., 2007, 1109).

Given the evidence for the Swiss case, it seems to be a gamble for policymakers to ignore population aging as a determinant of HCE in the coming decades as politicians might risk the sustainability of public finances. Therefore, policymakers should focus neither on population aging nor on advances in medical technology alone to mitigate the cost pressure on public budgets caused by HCE. To mitigate the pressure on public finances and the mandatory basic healthcare insurance, governments can foster preventive care to improve the health status of the population. In addition, in order to lower the cost-increasing effect of medical advances, governments should develop better measures to discern between cost-effective and high-productive medical technologies and new therapies that are cost-ineffective and barely useful.

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ABBRREVIATIONS

AIC:= Akaike Information Criterion

ECM:= Error Correction Model

FSO:= Federal Statistical Office of Switzerland

GDP:= Gross Domestic Product

HCE:= Healthcare Expenditure

hce:= Real healthcare expenditure per capita

hc:= Real healthcare expenditure per capita of an age cohort

LTC:= Long-term Care

APPENDIX

A. Data

The time series of the Swiss healthcare sector are taken from the healthcare statistics of the FSO. R&D expenditure for healthcare of the U.S. is taken from the OECD Health Database. The GDP series up to 1979 comes from the SFSO, whereas data after 1979 have been downloaded from the website of the Swiss State Secretariat for Economic Affairs (SECO). The Swiss population data are taken from the population statistics of the FSO. Data on public healthcare expenditure originate from the Public Finance Statistics of Switzerland published by the Federal Finance Department. All estimations are carried out with the open-source statistical software R. Information on the R packages applied to the estimations can be obtained upon request from the author.

B. TABLES and FIGURES

TABLE A1

Robust unit root test: order of integration of variables

Variable	Robust M test
Real healthcare expenditure per capita	I(1)** with drift
Real GDP per capita	I(1)*** with drift
Old-age dependency ratio of those 65 years old and over	I(1)* with drift
Mortality rate	
Men	I(1)*** with drift
Women	I(1)*** with trend
Baumol variable (wage-productivity)	
Baumol variable in real figures	I(1)*** with drift
R&D expenditure on health of USA/GDP USA	I(1)** with drift and trend
Density of physicians	I(1)* with drift

Notes: I(1):= order of integration 1; robust unit root test after Thompson (2004), H0: stationary time series, t- test statistic; *:= 10% significance level, **:=5% significance level, ***:= 1% significance level.

TABLE A2

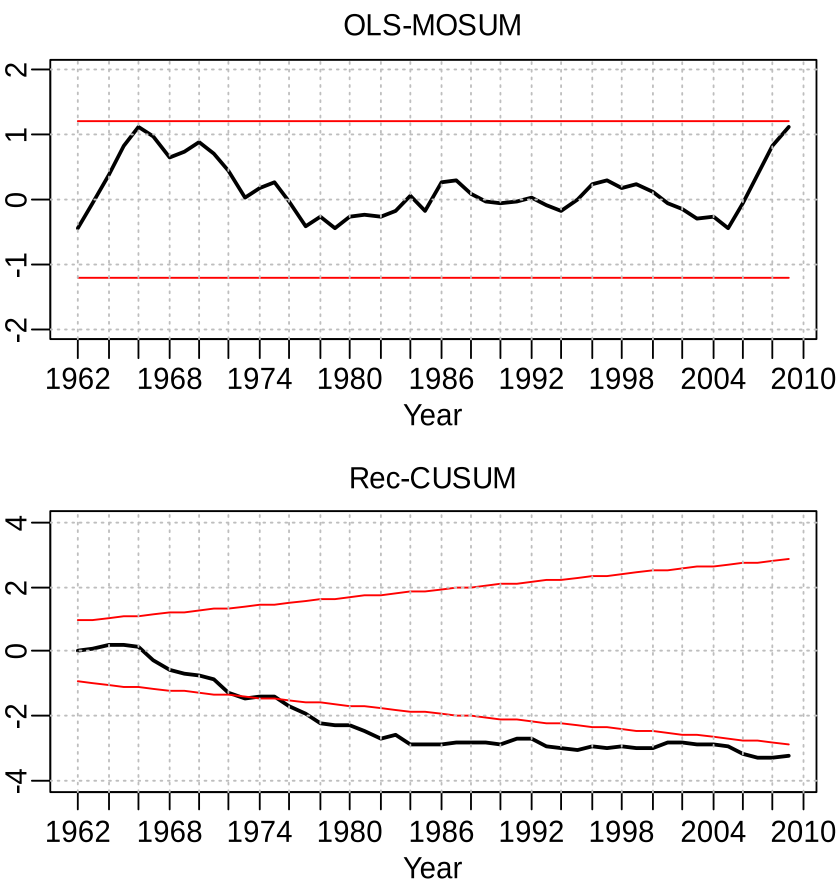
Test for weak exogeneity

Target variable of level equation (see Notes)	HCE	
Tested variable	ECT(-1)	Adj. R^2 (%)
Real GDP per capita	0.05	2.5
Old-age dependency ratio of those 65 years old and over	0.02	23
Mortality rate		
- Men	-0.03	0.3
- Women	-0.28***	23
Baumol var. in real figures	0.01	5.4
R&D expenditure USA/GDP USA	0.02	-2.0
Density of physicians	0.08	0.0

Notes: HCE:= Real healthcare expenditure per capita, ECT:= Error correction term; test for weak exogeneity (e.g. Smith, 2007): First estimation of level equation Z(t) = a*X(t) + e(t), whereby e(t) = ECT(t), second estimation of error correction model: ΔX(t) = const. + b* ECT(t-1)+ c*ΔZ(t), H0: b =0, i.e. weak exogeneity, t-statistic; regressions with robust MM estimator and robust Newey-West HAC, *:= 10% significance level, **:=5% significance level, ***:= 1% significance level.

FIGURE A1

Real healthcare expenditure per capita – structural-break tests at 5% significance level



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