The Sisyphus Syndrome in Health Revisited

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Abstract

Motivation: Health care services are reminiscent of the work of Sisyphus, the Greek hero who was ordered by the Gods to push a big rock uphill only to see it slip out of his hands in the last moment. To see the analogy, consider the possibility of the following spiral. The initial decision is to allocate more public resources to health. To the extent that medical care continues to enhance longevity, the future population will consist of more individuals beyond retirement age. This means an increased pressure to allocate additional resource to health care, exerted by individuals who will contribute little to their finance. With more resources devoted to health, the spiral can go into the next turn.

Methods: The spiral consists of two dynamic relationships. The first builds on the production of health literature to establish a link between health care expenditure and remaining life expectancy, especially at retirement age. The second relates increased remaining life expectancy back to health care spending. A first attempt at estimating the two dynamic component equations was undertaken by Zweifel and Ferrari (1992), who failed to find evidence of the Sisyphus syndrome. However, this may have been the consequence of an incomplete specification and a restricted data set which prevented the use of some more advanced econometric methods.

1 Introduction and motivation

When the British National Health Service was created, its founders expected the problem of ill health to fade away. After all, once people have access to good medical care, they should live healthy and happy to the end of their lives. History has proven this expectation to be entirely false. Indeed, decision makers in health policy are haunted by a quite different suspicion, which Zweifel and Ferrari (1992) dubbed the Sisyphus syndrome. Health care services could be something like the work of Sisyphus, a Greek hero who was ordered by the Gods to push a big rock uphill. But just before the very top, the rock would slip from his hands so he had to start all over again.

Consider the following sequence of events in health care. Initially, politicians decide to foster medical innovation, e.g. by granting subsidies to medical research. If successful, this innovation makes medical care more effective, causing people that would have otherwise died to survive. With more survivors around, there will be additional demand for health care services. To the extent that this is financed out of private resources, there is not too much of a problem. Individuals will adjust their health insurance policies accordingly and allocate a greater share of their income to health care. However, most of these services are covered by public health insurance. Rather than accepting to pay themselves, especially older voters have an incentive to get politicians to reallocate the public budget in favor of health. Part of the increase in health care expenditure (HCE) again fosters medical innovation. Thus, the Sisyphus syndrome can go into its next turn.

For the Sisyphus syndrome to exist, two (possibly lagged) relationships must be operative.

1. Medical innovation (more generally, health care expenditure HCE) must have the effect of increasing remaining life expectancy (RLE). For policy, this effect is of particular importance if it occurs at retirement age because in systems financed by a payroll tax, retired individuals do not contribute to the financing of health care anymore. In tax-based systems, their contribution decreases to the extent that their income drops after retirement.

2. Increasing remaining life expectancy must translate (through a changed planning horizon and through an increased number of survivors) into an impact on health care spending.

3. However, there is a third, confounding relationship. Evidence is accumulating that much of a lifetime *HCE* is spent during the last year before death [Lubitz and Riley (1993); Zweifel, Felder and Meier (1999)]. In this case, *HCE* does not generate survivors that will spend more private *HCE* and exert pressure for more public *HCE* in the future. At the macroeconomic level, the share of the population that is in their last year of life is reflected by the mortality rate. A high mortality rate (which itself may depend on previous *HCE*) is associated with high *HCE* in the current period while mitigating the dynamics of the Sisyphus syndrome.

As to relationship (1), Zweifel and Ferrari (1992) found that prior *HCE* in OECD countries did increase *RLE* at the ages 40 and 65. But with regard to relationship (2), they were not able to establish a statistical link between *RLE* and either public or private *HCE*. Relationship (3) was not accounted for. In all, a Sisyphus syndrome could not be said to exist.

The objective of this contribution is to revisit these findings. In the light of improved specification, data, and econometric methodology, what can be said about the effect of *HCE* on *RLE*, especially at higher ages? Is it still true that no evidence can be found of a feedback, from increased *RLE* to *HCE*? And is it necessary to control for the mortality rate? Accordingly, the plan of this contribution is follows. In section 2, a review of the relevant literature will be provided, followed by a more precise restatement of the Sisyphus syndrome. Section 3 is devoted to econometric specification, a description of the data base, and variable definitions. The new empirical evidence is presented in section 4, while section 5 contains a summary and conclusion.

2 Survey of the literature

2.1 The production of health

The seminal article continues to be Auster, Leveson and Sarachek (1969), who related age- and sex-adjusted mortality rates of U.S. states to medical care inputs, schooling, income, and environmental variables. Schooling was negatively related to mortality, medical care inputs not consistently so, while higher income tended to cause an increase in mortality. Hadley (1982) refined this approach, using county groups as unit of analysis. Again, education was negatively related to mortality, income negatively to infant mortality but in mixed ways to adult mortality. A new finding is that most age-sex specific mortality rates depend negatively on medical care spending, with an elasticity of -0.15. Focusing on the elderly, Hadley (1988) found elasticities in the -0.25 to -0.44 range.

The earliest international study of the production of health seems to be the one by Stewart (1971). Using the nations of the Western Hemisphere in the mid-1960s as the unit of analysis, he related life expectancy at birth to medical inputs, literacy rates, and the availability of potable water. All three inputs had small marginal effects in the case of the United States, whereas literacy and potable water showed significant effects in the less developed countries of the group.

Cochrane, St. Leger and Moore (1978) based their analysis on a cross-section of 18 developed countries as of 1970. In their correlation analysis, a greater number of physicians goes along with higher rather than lower mortality (with no attempt to control for reverse causation). Mortality rates correlate negatively with income per capita, suggesting that the positive effect found by Auster et al. (1969) might be limited to the United States. They also tested the effects of cigarette and alcohol consumption, with mixed effects.

Working with a 1980 cross section of OECD countries, Zweifel and Ferrari (1992) introduced lagged *HCE* (the lag being 10 years due to data availability) as an explanatory variable on the grounds that earlier medical interventions must have assured the survival of cohorts that make up the population in a given year. Also they replaced mortality by life expectancy (at given ages 40 and 65) to better represent the planning situation of forward-looking individuals. Lagged *HCE* proved significant, with an elasticity (at the mean) of 0.15.

The most recent work seems to be by Frech and Miller (1999), who also review research performed by noneconomists. This research, through their inclusion of low-income countries, tends to support the notion that literacy and diet but not medical care resources are determinants of health. Frech and Miller (1999) analyze OECD country data, in the main making remaining life expectancy (*RLE*) at ages 40 and 60 as of 1993 the dependent variable. The explanatory variables include *GDP*, the consumption of tobacco and alcohol, and the consumption of animal fats. The authors introduce lags of up to ten years (depending on data availability) to capture lifetime effects because variations in most of these variables are unlikely to affect health right away. Rather than considering total *HCE* only, they single out pharmaceutical consumption to find that this component matters far more than does total *HCE*, which fails to have a significant effect on *RLE*. Their specification is double logarithmic, resulting in the estimation of constant elasticities which necessarily imply decreasing marginal productivity of e.g. *HCE* as soon as *HCE* differs more strongly between countries than does life expectancy.

Although this review is not quite complete, the paucity of studies on the production of health is striking. By way of contrast, there has been much more research into the determinants of *HCE* (to be reviewed in section 2.2 below). Indeed, one might argue that the separate estimation of a production function is not necessary, based on a duality argument. If individuals acted as perfect cost minimizers in their production of health, the cost function [or an expenditure share function prior to normalization of some price, cf. e.g. Christensen, Jorgenson and Lau (1973)] contains all the information of the production technology. However, the estimation of a separate production function of health can be justified by the following arguments:

1. The health production technology is stochastic rather than deterministic. The deployment of both medical and nonmedical inputs does not always prevent death, i.e. a health outcome that differs strongly from the one intended. This also implies that cost minimization is possible only on expectation, with large deviations that serve to qualify the duality argument.

2. In the case of health, prices contained in the cost or expenditure share function are average prices prior to insurance and public subsidies, while prices governing individual cost minimization are marginal prices often close to zero and different from average prices.

3. Cost minimization is not a very credible hypothesis in health since decisions frequently are made under the influence of physicians. A distortion results to the extent that physicians act as imperfect agents of their patients.

Conclusion 1 *The estimation of a production function for health apart from a cost or expenditure (share) function can be justified. The emerging consensus seems to be that at least some components of health care inputs contribute to health with a lag and decreasing marginal effect.*

2.2 The health care expenditure (HCE) function

Kleiman (1974) was the first to relate *HCE* to *GDP* using a cross-section of OECD country data. He also included the population share of the aged 64+

but was unable to find a statistically significant effect. Accordingly, Newhouse (1977) focused on the relationship between per capita *GDP* and *HCE*, using a cross section of OECD countries. The computed income elasticity indicated that health care is a luxury good. This finding was confirmed by Maxwell (1981) in a broad international survey.

In another regression analysis based on OECD data, Leu (1986) reintroduced the share of persons aged less than 15 years and more than 65 years. However, his main innovation was the argument that a greater share of public in total *HCE* facilitates budget maximization by bureaucrats, which can be restrained by direct democracy or through central control, as in countries with a National Health Service. These predictions were confirmed but failed to be replicated by later studies.

In their first attempt at identifying the feedback from remaining life expectancy (*RLE*) to *HCE* that is crucial for the Sisyphus syndrome, Zweifel and Ferrari (1992) found *RLE* at age 65+ to be even negatively related to *HCE*, although without statistical significance. Public *HCE* turned out to be as much of a luxury good as private *HCE*, with income elasticities far above unity.

Collating information from three years to form a panel data set for the first time, Gerdtham, Sögaard, Jönsson and Andersson (1992) were able to introduce several new explanatory variables, such as physician density, the share of inpatient to total *HCE*, as well as dummies for fee-for-service payment and budgeting caps. In the present context, it is interesting to note that a 10 percent increase in the share of inhabitants aged 64+ (relative to the 15 to 64 age group) was estimated to increase *HCE* by almost 2 percent, in contradistinction to all studies cited so far.

Extending the period covered to 1970-1991, Gerdtham, Jönsson, MacFarlan and Oxley (1998) introduced a whole host of additional institutional variables. Among them, public reimbursement, capitation of physicians, and patient-first payment with later reimbursement consistently are associated with lower *HCE*. Tobacco consumption proves to be a significant predictor of higher *HCE*. With regard to the share of the elderly population (75+ this time), there is no indication of a significant effect (negative if anything).

A recent concern has been the possibility of spurious regression results due to nonstationarity of time series, in particular *HCE* and *GDP*. In their survey, Gerdtham and Jönsson (2000) report very mixed results of studies applying a selection of tests designed to detect nonstationarity. Since the emphasis of this contribution is not on the estimation of the income elasticity of *HCE*, this route is not pursued. Rather detrending is sought by transforming the dependent variable into the health share in *GDP*, resulting in the expenditure share function suggested by duality (normalization by a price should be avoided in this context, see section 3. In addition, public debate revolves much more about the share of *GDP* claimed by *HCE* rather than about *HCE* per se.

Conclusion 2 *With one exeption [Gerdtham et al. (1992)], there is no evidence to the effect that a high share of individuals at or in retirement age leads to higher HCE. Other consistently significant regressors are GDP and likely tobacco consumption.*

2.3 A combined view: the Sisyphus syndrome

The theoretical starting point of this study is the fact that an individual not only has to manage his or her health stock but also a stock of wealth and a stock of human capital ("wisdom", see figure 1). The dynamic optimization problem amounts to a series of portfolio choices determining the shares held in the guise of wisdom, wealth, and health. Formal modeling has concentrated on the health and wealth components of this portfolio (see Grossman (2000) for a comprehensive review). Certainly with regard to the health component, this lifetime asset management is conditioned by environmental influences (e.g. degree of industrialization, degree of urbanization). The left-hand portion of figure 1 thus shows the production part of the Sisyphus model.

The right-hand side of figure 1 contains the derived demand part of the model. *HCE* is triggered by a gap between desired and actual health stock and influenced by the institutional characteristics of the health care system and relative prices. This implies that *HCE* is an endogenous determinant of health, a fact that has not been duly recognized in those existing studies on the production of health that introduce contemporaneous *HCE* as a regular explanatory variable. Next, the input of *HCE* increases (possibly with a lag) actual health stock. If actual health stock remains below a critical level, death occurs, and the Sisyphus cycle comes to an end. If however the stock is sufficient to ensure survival, the individual concerned can count on performing the cycle for a number of periods. The expected number of future rounds depends on his or her remaining life expectancy (*RLE*).

Thus, the feedback from *HCE* to actual health stock determines the number of survivors who are able to exert demand for health care and hence cause *HCE*. It is this feedback that is responsible for what can be called the Sisy-

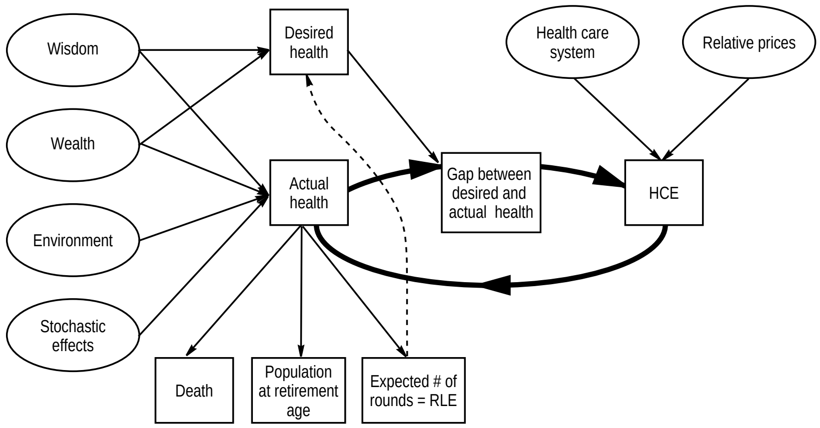

Figure 1: Possibility of a Sisyphus syndrome

phus syndrome: Given that *HCE* is increased exogenously (e.g. by fostering medical innovation or an expansion of public health insurance coverage), more individuals survive the cycle. Moreover, these individuals have a longer planning horizon thanks to an increased *RLE*. This also means that the optimal health stock should have a higher value, which by itself makes the gap between desired and actual health stock larger, thus calling for additional *HCE* again. On the other hand, the direct effect of *HCE* is to close the gap between desired and actual health stock. Therefore, the net effect of *HCE* on the size of this gap remains an open issue, to be examined empirically.

This model motivates the creation of an explanatory variable that has not been introduced in previous work. It will be called *SISYPH* because it reflects the potential strength of the Sisyphus syndrome. *SISYPH* is the product of two factors: The first is *RLE* which shows the number of cycles an individual of a given age expects to perform. However, if the relative number of such individuals in the population is small, *RLE* by itself will have a small impact on the whole system. Therefore, *RLE* needs to be weighted by the share of the population at that age as the second factor. Since individuals at retirement age cannot be expected to contribute much to the financing of future *HCE* (creating a budgetary problem for policy makers), the share of those aged 65 and older will be used in the following.

This description of the Sisyphus syndrome is still not complete, however. Some individuals, having exerted demand for *HCE* on the expectation to survive for at least one more period, in fact die. Since the gap between desired and actual health stock likely is large in this event, these individuals will have driven up *HCE* in the current period while not contributing to the Sisyphus syndrome in the future. Therefore, this effect must be taken into account in order to avoid the risk of overestimating the dynamics of the syndrome. At the individual level, evidence is accumulating suggesting that *HCE* depends much more on closeness to death than calendar age [Zweifel et al. (1999)]. This motivates the introduction of another explanatory variable that has not been tested in the published *HCE* equations, viz. the mortality rate of the population, *MORT*. This variable indicates the relative number of individuals who by definition were in their last year of life, the period where *HCE* is maximum as a rule.

3 Specification, data base, and variables

The theoretical considerations laid out in the preceding section provide rather clear guidance as to the specification of the relationships constituting the Sisyphus syndrome. Ideally, the hypothesis should be tested using individual panel data; however, data availability dictates the use of aggregate indicators.

The following specification is retained for the production part of the Sisyphus model, consisting of equations for remaining life expectancy (*RLEF*, *RLEM*) at age 60, the population share of individuals aged 65 and more (*POP65*), and the mortality rate of the population as a whole (*MORT*). Subscripts i(countries) and t(year) are dropped for simplicity except for the error terms,

$$\begin{bmatrix} RLEF \\ RLEM \\ POP65 \\ MORT \end{bmatrix} = \begin{array}{l} \alpha + \beta_1 GDP + \beta_2 GDP2 + \beta_3 HCE + \beta_4 HCE2 \\ +\beta_5 ALC + \beta_6 ALC2 + \beta_7 CAL + \beta_8 CAL2 \\ +\beta_9 TOB + \beta_{10} TOB2 + +\upsilon_i + \nu_t + \varepsilon_{it} \end{array} \qquad (1)$$

Since these equations have the same explanatory variables, the $\beta_1 ... \beta_{10}$ denote vectors containing four elements. The same holds true of υ_i, ν_t and ε_{it} which describe a two-factor random effects model, with no correlation across the four equations assumed. The period of observation is 1970 to 1991, which ensures comparability with the latest study by Gerdtham et al. (1998) while making an out-of-sample test still possible (see section 4.4). The variables are defined as follows (see table 1 for a statistical description),

- *RLEF*: Remaining life expectancy of females at age 60
- *RLEM*: Remaining life expectancy of males at age 60
- *POP65*: Population share of individuals aged 65 and more
- *MORT*: Mortality rate of the population, both genders, all ages, deceased per 100,000 inhabitants
- *HCE/GDP*: Share of health care expenditure in *GDP*, both nominal
- *ALC*: Alcohol consumption per capita, in litres, lagged 10 years; *ALC2*: *ALC* squared
- *CAL*: Kilocalories consumption per capita, lagged 10 years; *CAL2*: *CAL* squared
- *GDP*: *GDP* per capita, nominal but converted in US$ 1,000, *GDP2*: *GPD* squared
- *HCE*: Total health care expenditure, nominal but converted in US$ 1,000, lagged 10 years; *HCE2*: *HCE* squared
- *RPH*: Price index of health care services relative to price index of *GDP*
- *SISYPH*: Predicted *RLE*, averaged over gender, multiplied by *POP65*; *SISYPH2*: *SISYPH* squared [for details, see equation (2)]
- *TOB*: Tobacco consumption per capita in kilograms, lagged 10 years; *TOB2*: *TOB* squared.

The source of all these data is OECD (2001), a source known for several difficulties. One of them is national differences with regard to the delimitation of the health care sector, resulting in different baskets of services, another, the lack of comparability and precision of health care deflators. In view of these difficulties, *HCE* was not deflated using national price indexes but by the exchange rate when converting the figures into US$ (avoiding PPP indicators that may contain additional measurement error).

The variable *SISYPH* is constructed as follows,

$$\widehat{SISYPH} = (\widehat{RLEF} + \widehat{RLEM})/2 * \widehat{POP}65 \qquad (2)$$

Table 1: Descriptive statistics of variables, 1970-1991

	1970			1991		
	mean	min	max	mean	min	max
$RLEF$	19.725	18.5	20.9	22.627	21.2	24.1
$RLEM$	15.9	14.9	17.2	18.291	17.1	19.4
$POP65$	12	9.8	14.1	13.772	11.2	16.3
$MORT$	1083.95	905.45	1212.35	776.486	682.75	916.65
HCE/GDP	5.409	4.384	6.943	8.427	6.432	12.606
GDP	2.934	1.418	5.027	21.343	8.157	34.313
HCE	0.063	0.025	0.144	0.792	0.175	1.218
ALC	7.3	3.4	10.9	11.218	5.3	15.6
CAL	2.729	2.096	3.101	3.256	2.21	4.456
TOB	2.769	1.735	4.72	2.543	1.406	3.22

Finally, the derived demand part of the model, represented by the equation for the health share in the GDP, reads as follows,

$$\begin{aligned} HCE/GDP &= \alpha' + \beta'_1 GDP + \beta'_2 RPH + \beta'_3 \widehat{MORT} \\ &\quad + \beta'_4 \widehat{MORT}2 + \beta'_5 \widehat{SISYPH} + \beta'_6 \widehat{SISYPH}2 \\ &\quad + \upsilon'_i + \nu'_t + \varepsilon'_{it} \end{aligned} \tag{3}$$

Again, no correlation of error terms with those of equation 1 is admitted.

4 Estimation results

4.1 Production of health

4.1.1 The influence of *HCE* on Remaining Life Expectancy (*RLE*)

In the original article by Zweifel and Ferrari (1992), remaining life expectancy of males and females at ages 40 and 65 was distinguished, the main motivation being the quadrupling of observations. However, the differences between ages 40 and 60 in the present work proved minimal when the critical values were computed where additional HCE does not affect RLE at the margin. As the policy focus is on individuals approaching retirement, only gender-specific results for age 60 are shown below.

Table 2: Remaining life expectancy of females at age 60, 1970-1991

$RLEF$	coefficient	z	$P > z$
GDP	0.153	2.90	0.004
$GDP2$	-0.003	-1.61	0.108
HCE	3.012	5.64	0.000
$HCE2$	-1.772	-3.51	0.000
ALC	-0.289	-2.54	0.011
$ALC2$	0.014	3.03	0.002
CAL	1.691	1.29	0.199
$CAL2$	-0.230	-1.21	0.228
TOB	0.046	0.04	0.969
$TOB2$	0.009	0.05	0.960
$constant$	17.683	7.11	0.000
Wald $\chi^2(10)$:	575.85		
$Prob > \chi^2$:	0.0000		
$1 - \frac{var(\varepsilon_{it})}{var(RLEF)}$:	0.730		
N	147		

Table 3: Remaining life expectancy of males at age 60, 1970-1991

$RLEF$	coefficient	z	$P > z$
GDP	0.119	3.42	0.001
$GDP2$	-0.003	-1.92	0.055
HCE	2.692	4.90	0.000
$HCE2$	-1.161	-2.50	0.012
ALC	-0.555	-4.03	0.000
$ALC2$	0.025	4.03	0.000
CAL	0.837	0.55	0.582
$CAL2$	-0.107	-0.50	0.619
TOB	0.757	0.98	0.326
$TOB2$	-0.124	-1.10	0.270
$constant$	15.815	5.33	0.000
Wald $\chi^2(10)$:	23,683.53		
$Prob > \chi^2$:	0.0000		
$1 - \frac{var(\varepsilon_{it})}{var(RLEM)}$:	0.753		
N	147		

Contemporaneous *GDP* (in US$) is associated with higher *RLE* in both sexes (with females possibly affected more strongly), confirming results found by Zweifel and Ferrari (1992) as well as Frech and Miller (1999). A decreasing marginal effect of income is possible, although the coefficient of *GDP2* does not reach conventional levels of statistical significance. The earlier study by Zweifel and Ferrari is also confirmed in that *HCE* lagged 10 years results in higher *RLE* for both sexes. Since the squared explanatory variable proves highly significant, a critical value can be calculated beyond which additional *HCE* is counter-productive (flat-of-the curve medicine). Among women, this is approximately US$ 850, among men, US$ 1160. With regard to the lifestyle indicators, (lagged) consumption of calories and tobacco do not show an influence, whereas alcohol consumption benefits *RLE* at low levels (cf. tables 2 and 3).

4.1.2 Influence of *HCE* on 65+ Population Share

In order to determine the pressure of individuals faced with a given *RLE*, their population share must be accounted for, resulting in the variable *SISYPH* (for details of its construction, see section 3 again). However, the population share of individuals 65 and older might be endogenous. The evidence ins presented in table 4.

The same explanatory variables are used as for the determination of *RLE*. The results do suggest endogeneity of *POP65*, but not with regard to *HCE*. Specifically, higher *GDP* goes along with a higher share of aged people, whereas *HCE* does not have a discernible effect, confirming earlier research by Kleiman (1974), Leu (1986), and Gerdtham et al. (1998). In the life style domain, alcohol consumption clearly serves to increase this share, but with decreasing effect at the margin. The remaining lifstyle variables do not contribute to the determination of *POP65*.

4.1.3 Influences on Mortality

Since mortality is not a crucial variable in the Sisyphus syndrome but mainly serves to take the surge in *HCE* towards the end of human life into account, no gender-specific regressions are presented in table 5. In accordance with earlier research on the United States, higher *GDP* may well increase mortality at the high end of the sample; the same holds for *HCE*, driving home the argument made above that mortality occurs sooner or later. Among the lifestyle variables, again only alcohol consumption is statistically significant.

Table 4: Share of individuals aged 65 and older, 1970-1991

$POP65$	coefficient	z	$P > z$
GDP	0.081	5.09	0.000
$GDP2$	0.000	0.34	0.731
HCE	0.627	0.42	0.673
$HCE2$	-0.561	-0.66	0.512
ALC	0.652	2.31	0.021
$ALC2$	-0.028	-2.56	0.010
CAL	-0.543	-0.23	0.815
$CAL2$	0.122	0.36	0.718
TOB	-0.639	-0.53	0.597
$TOB2$	0.015	0.09	0.926
$constant$	10.677	1.95	0.051
Wald $\chi^2(10)$:	865.87		
$Prob > \chi^2$:	0.0000		
$1 - \frac{var(\varepsilon_{it})}{var(POP65)}$:	0.135		
N	187		

Table 5: Influences on Mortality, 1970-1991

$MORT$	coefficient	z	$P > z$
GDP	-19.262	-4.90	0.000
$GDP2$	0.438	2.87	0.004
HCE	-309.428	-4.53	0.000
$HCE2$	157.816	2.65	0.008
ALC	40.813	2.01	0.044
$ALC2$	-2.063	-2.42	0.015
CAL	250.267	1.66	0.097
$CAL2$	-35.863	-1.67	0.094
TOB	2.764	0.04	0.971
$TOB2$	0.373	0.04	0.971
$constant$	509.604	1.64	0.101
Wald $\chi^2(10)$:	3,346.27		
$Prob > \chi^2$:	0.0000		
$1 - \frac{var(\varepsilon_{it})}{var(MORT)}$:	0.710		
N	187		

Table 6: Health Share in the *GDP*, 1970-1991

HCE/GDP	coefficient	z	$P > z$
GDP	0.0547	1.42	0.154
RPH	0.0215	0.76	0.449
$\widehat{MORT}$	0.0365	1.47	0.143
$\widehat{MORT}2$	-0.0000	-1.27	0.204
$\widehat{SISYPH}$	0.2441	3.32	0.001
$\widehat{SISYPH}2$	-0.0004	-2.82	0.005
$constant$	-49.7700	-2.95	0.003
Wald $\chi^2(10)$:	115.50		
$Prob > \chi^2$:	0.0000		
$1 - \frac{var(\varepsilon_{it})}{var(HCE/GDP)}$:	0.366		
N	122		

4.2 Explaining the Health Share in the GDP

In keeping with the the theoretical arguments with regard to asset allocation and and the (imperfect) duality of production functions and cost share equations (see section 2), the dependent variable here is *HCE/GDP*. In the earlier estimation of the Sisyphus syndrome, an attempt was made to distinguish between private and public *HCE* to see whether the feedback from *RLE* to *HCE* is particularly marked in the public domain. However, the published literature does not make this distinction because the assignment of total *HCE* to these two components is far from perfect in many countries, resulting in measurement error (we thank Pedro Pito Barros, Lisbon, for calling our attention to this). With *HCE/GDP* being the dependent variable, resulting of a filtering out of common trends, measurement errors are expected to play a more important role to begin with. Therefore, the distinction between the private and public components is not made here. All endogenous variables estimated in section 4.1 enter with their predicted values.

In order to account for shifts in this share over time in the wake of income growth, *GDP* is entered as a regressor. In spite of the political debate on the rising share of the *GDP* taken by health in major industrial countries, no significant effect of *GDP* can be discerned. This means that the estimated income elasticity of *HCE* is 1 (apart from the Sisyphus effect, see below).[1] This is

[1] The income elasticity of HCE can be calculated as follows. Using $HCE \equiv (HCE/GDP)*$

lower than most elasticities in Gerdtham et al. (1992) but higher than the estimates presented in Gerdtham et al. (1998). To the extent that the relative price of health goods is high, the prediction would be that both private and public decision makers tend to substitute health goods for other commodities (aggregated in the *GDP*). However, there is no statistical evidence of such substitution. Another prediction, already of relevance to the Sisyphus syndrome, is only partially confirmed, viz. that a higher mortality rate in a given year means a greater number of individuals in their last year of life, causing *HCE* to be high in that year. Linear and squared predicted mortality rates do have a joint effect on *HCE/GDP* ($\chi^2 = 7.75$, $prob > \chi^2 = 0.021$), which is positive for the present sample (it changes at a critical value of 1,092 per 100,000 inhabitants, higher than current rates).

Of course, the variable of crucial interest is $\widehat{SISYPH}$, the remaining life expectancy at age 60 weighted by the share of individuals close to retirement age. Both $\widehat{SISYPH}$ and *SISYPH2* have highly significant coefficients, the first positive, the second, negative. These coefficients imply a positive impact on *HCE/GDP* in the relevant range of values, i.e. up to 300 (maximum 21.75 years times 16.3 percent equals 355, sample mean: 19.4 years times 13.4 percent equals 260). However, beyond a value of 300, the marginal effect of $\widehat{SISYPH}$ turns negative, precluding the scepter of an aging population that keeps the spiral indefinitely in motion.

Conclusion 3 *The reestimation of the feedback relationship, linking (population share-weighted) remaining life expectancy to the health share in the GDP, yields preliminary statistical evidence of a Sisyphus syndrome.*

4.3 Assessing the strength of the Sisyphus syndrome

The estimates presented in the previous section allow to conclude that there is some preliminary evidence that between 1970 and 1991 a Sisyphus syndrome may have existed. The open question remains of whether the syndrome may be a phenomenon of sufficient importance to merit attention for some or all OECD countries. This calls for the evaluation of the partial derivative $\partial HCE/\partial HCE_{-10}$: If in a given year during the period of observation, *HCE*

GDP, one obtains $\frac{\partial HCE}{\partial GDP} = \frac{\partial (HCE/GDP)}{\partial GDP} * GDP + \frac{HCE}{GDP}$. The first derivative equals β_1' from equation (3); therefore, the elasticity is given by $e(HCE, GDP) = \beta_1' * (GDP)^2/HCE + 1 = 1$ since β_1' is not significantly different from zero (see table 6).

was stepped up, to what extent will later *HCE* be higher as well as a consequence of the syndrome (the lag being 10 years because of data availability for some of the component equations)? If this derivative should exceed unity, this would constitute evidence of a locally explosive cycle; a globally explosive situation can be excluded because the derivatives to be evaluated all decrease in their relevant arguments (linear and quadratic regressors have opposite signs in tables 3 to 5).

Since the equation is the health share in *GDP*, the identity

$$HCE \equiv (HCE/GDP) * GDP \tag{4}$$

may be used to obtain equation (5)

$$\begin{aligned}
\frac{\partial HCE}{\partial HCE_{-10}} &= \\
&= \frac{\partial((HCE/GDP) * GDP)}{\partial HCE_{-10}} \\
&= \frac{\partial(HCE/GDP)}{\partial HCE_{-10}} * GDP + (HCE/GDP) * \frac{\partial GDP}{\partial HCE_{-10}} \\
&= \frac{\partial(HCE/GDP)}{\partial HCE_{-10}} * GDP \qquad (5)
\end{aligned}$$

since $\partial GDP/\partial HCE_{-10}$ can be assumed to be zero. Now lagged *HCE* influences current *HCE* through *SISYPH*, which is designed to capture the impact of population-weighted *RLE* on the demand for health care and hence *HCE* [see equation (2) again]. Implicit differentiation then yields,

$$\begin{aligned}
\frac{\partial(HCE/GDP)}{\partial HCE_{-10}} &= \\
&= \frac{\partial(HCE/GDP)}{\partial SISYPH} * \frac{\partial SISYPH}{\partial HCE_{-10}} \\
&= \frac{\partial(HCE/GDP)}{\partial SISYPH} \frac{1}{2} \left[\frac{\partial RLEF}{\partial HCE_{-10}} + \frac{\partial RLEM}{\partial HCE_{-10}} \right] * POP65, \qquad (6)
\end{aligned}$$

since $\partial POP65/\partial HCE_{-10} = 0$, according to table 4. Substituting (6) into (5), one obtains,

$$\begin{aligned}
\frac{\partial HCE}{\partial HCE_{-10}} &= \\
&= \underbrace{\frac{1}{2}} * \underbrace{\frac{\partial(HCE/GDP)}{\partial SISYPH}} * \underbrace{\left[\frac{\partial RLEF}{\partial HCE_{-10}} + \frac{\partial RLEM}{\partial HCE_{-10}} \right]} * \underbrace{POP65} * \underbrace{GDP} \qquad (7) \\
&= 0.5 * 0.03 * [2.87 + 2.60] * 13.40 * 12.87 \approx 15
\end{aligned}$$

All of these derivatives have to be evaluated at specific values because the denominator variables appear not only in linear but also in quadratic form. Neglecting estimated coefficients that are nonsignificant and inserting overall sample means one concludes that US$ 1 of *HCE* induces some US$ 15 ten years later due to the dynamics of the Sisyphus syndrome. The same calculation, performed at the sample means of 1991, yields a value of 7.7. Both figures point to an explosive cycle, the first entailing growth rate of 31 percent p.a., the second, still of almost 23 percent p.a. These are very high rates of growth, and it must be emphasized that they derive from a point estimate based on a single lag of 10 years rather than a lag distribution.

Conclusion 4 *The Sisyphus syndrome seems to have been of considerable importance and even explosive during the observation period, with one US$ of additional HCE engendering up to US$ 15 a decade later.*

4.4 Testing for the stability of the Sisyphus syndrome

In order to assess the stability of the Sisyphus syndrome, an out-of-sample test covering the years 1992 to 1999 was planned from the beginning. Preliminary inspection had shown that the frequency of gaps in the data had decreased markedly towards the end of the 1980s so the shortness of this second observation period might be offset by improved completeness of the data. Surprisingly however, only 10 observations on mortality rates were available for the years 1997 to 1999, and in countries where these data were available, other variables turned out to be lacking. In all, the out-of-sample data base shrinks to a mere 47 observations, down from an expected 120.

As far as the determinants of remaining life expectancy are concerned, the estimates proved reasonably stable. For example, for *RLEF* (see table 2), the coefficient of *HCE* drops from 3.012 to 2.424, while the one of *HCE2* drops from -1.772 to -0.652. These changes cause the critical value (where additional *HCE* does not have a positive effect on the remaining life expectancy of 60 year old women anymore) from US$ 850 to US$ 1,860. Apparently, technological change in medicine has continued to benefit the longer-run survival of individuals around retirement age. However, the observed increase of *RLEF* is not very large, viz. from 21.55 to 22.97 years (or less than 0.1 annually) on average.

In order to weight the average *RLE*, the population share of individuals aged 65+ needs to be determined endogenously again. As in table 4, *AGE65* does not have a close statistical fit; lagged *HCE* fails to be a significant determinant

Table 7: Health Share in the GDP, 1992-1999

HCE/GDP	coefficient	z	$P > z$
GDP	-0.0323	-0.96	0.336
RPH	-0.0673	-0.70	0.482
$\widehat{MORT}$	-0.2913	-1.42	0.155
$\widehat{MORT}2$	0.0002	1.32	0.186
$\widehat{SISYPH}$	0.4358	1.11	0.268
$\widehat{SISYPH}2$	-0.0008	-1.23	0.217
$constant$	82.0389	1.24	0.216
Wald $\chi^2(10)$:	12.11		
$Prob > \chi^2$:	0.0595		
$1 - \frac{var(\varepsilon_{it})}{var(HCE/GDP)}$:	0.658		
N	47		

once more, although estimated coefficients do not differ much from those shown in table 4.

Finally, it will be recalled that the mortality rate indicates the frequency of individuals in their last year of life, a subgroup that is likely to drive up HCE during the current year while dropping out of the Sisyphus cycle. The estimate presented in the previous section is confirmed in that lagged HCE still seems to lower mortality during the 1990s. Its marginal effect also goes to zero more slowly than before, the critical value increasing from US$ 980 to US$ 1,520.

The construction of the crucial explanatory variable $\widehat{SISYPH}$ for the out-of-sample period thus rests on equations on RLE that prove reasonably stable and an equation for $AGE65$ that does not fit too well, as before. In view of these similarities it comes as a major surprise that $\widehat{SISYPH}$ is not a determinant of the HCE share in GDP in table 7, according to conventional levels of significance. Indeed, none of the explanatory variables retains statistical significance. However in the case of GDP and in view of footnote 1, this points to an income elasticity of HCE of one, confirming the result for the 1970-1991 observation period.

Conclusion 5 *There is some preliminary evidence suggesting that in the course of the 1990s, the Sisyphus syndrome has disappeared again.*

This conclusion furnishes an interpretation of the fact that earlier research [exemplified by Gerdtham et al. (1992)] typically came up with an income elasticity of *HCE* above unity. If a Sisyphus syndrome was in operation at the time, it could not be detected in purely contemporaneous relationships; however, it served to boost the estimated income elasticity of *HCE*. If it has indeed disappeared, elasticities from contemporaneous relationships should be dropping towards one.

5 Summary and conclusions

This contribution started from the notion that the production of health and the determination of health care expenditure (*HCE*) should be analyzed together. Short of adopting the duality argument to the effect that estimating either a production function or an expenditure (share) function is sufficient, the two links are seen as constituting a dynamic feedback relationship. Once *HCE* is stepped up exogenously, it may well (with a lag) increase remaining life expectancy and hence the planning horizon of an individual considering an investment in health. The macroeconomic impact of such a change depends on the share of individuals affected in this way. In view of the financing of *HCE*, the weighted *RLE* of individuals near retirement age is of particular relevance. These considerations call for the construction of a new variable *SISYPH*, which is the remaining life expectancy at age 60 weighted by the share of individuals aged 65+, the age discrepancy caused by data availability.

In contrast to a first attempt by Zweifel and Ferrari (1992), *HCE* turned out to be significantly related to this new *SISYPH* variable among OECD countries during the years 1970 to 1991. An initial increase of one US$ was estimated to result in as much of US$ 15 a decade later as a result of this dynamic relationship, implying an annual growth rate of 31 percent. Since the income elasticity of *HCE* was estimated to be one ceteris paribus, much of the observed increase in the health share of *GDP* can be traced to the Sisyphus syndrome. However, evaluating the syndrome with 1991 data rather than at the sample means, this "multiplier" already drops to roughly 8 or an annual growth rate of 23 percent.

In an out-of-sample test comprising the years 1992 to 1999, a feedback from survival to the health share in *GDP* was not discernible anymore since $\widehat{SISYPH}$ lost its statistical significance. One explanation is that indeed the Sisyphus syndrome has been stopped by policy makers. One way seems to amount to a statistical artifact, e.g. by excluding at least parts of nursing home expenditure from *HCE* in some countries after 1991 [Gerdtham and Jönsson (2000)]. This explanation points once more to the problem of data quality in the OECD sample. Another alternative is for governments to increasingly respond to the demand pressure by budgeting. An important consideration in the theoretical development was that part of the future *HCE* would not have to be financed by those benefiting from them because the public budget might be reallocated in favor of *HCE* under the pressure of aged voting groups in particular. Hidden rationing can be used to counteract this pressure, at least as physicians and other health workers continue to be paid well enough to prevent them from organizing protests.

Finally however, one might argue that a Sisyphus syndrome simply never existed at all and that the estimation results for the time period of 1970 to 1991 were pure coincidence. While such an argument cannot be rejected out of hand, there are at least two considerations that speak against it. The first is that the hypothesis of a Sisyphus syndrome as a dynamic relationship puts emphasis on lags. Specifically, in previous research on the production of health, contemporaneous *HCE* was not found to consistently lower mortality rates or increase longevity. However, when a lag of ten years is introduced, both Zweifel and Ferrari (1992) and Frech and Miller (1999) are able to relate remaining life expectancy to previous *HCE*. Second, the link between production and factor demand theory suggests use of an expenditure share function (*HCE/GDP*) which is much less influenced by a time trend than *HCE* itself. And it is with such a detrended dependent variable that *SISYPH*, a regressor the introduction of which is suggested by the maintained hypothesis, proves highly significant between 1970 and 1991. This regressor weights the remaining life expectancy of individuals at a certain age with their population share. Since it is at retirement age beyond which contributions to the financing of *HCE* do not match the use of *HCE*, this age group was selected.

On the whole, the evidence seems to permit the inference that a Sisyphus syndrome may have been operative until the early 1990s but probably has come under control during the past decade. So, the Greek hero may finally have been able to push his big rock to the very top of the hill...

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