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Economic Reasoning on the Correlation between Life Expectancy and Economic Development: Exploring Alternative Routes

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Abstract
Regarding the connection between economic development and public health, the statistically evident correlation between a country's gross domestic product and life expectancy is widely discussed. An important aspect that keeps resurfacing in discussions on why the relationship between the latter appears to trail off or even reverse its sign once a certain gross domestic product level has been reached is that of increasing economic and social inequality of distribution within many industrialized nations. However, from an economics perspective, it seems as though further plausible explanations can be identified, whose origins are in part inherent to the special structural characteristics of the market for health but are also well known in the fields of political as well as natural resource economics. While many seminal publications focus on the demand for health, this paper takes a holistic approach toward modeling the health market, in order to account for the fact that health products are not only an input factor to people's health but also that people's health is an essential and heterogeneous input factor to health products suppliers' profit functions. Results show that this approach can substantially affect health market outcomes.

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Keywords Market for health, market structure, public health, life expectancy, economic development

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1. Introduction

Regarding the question of how economic development and public health are connected, the statistically evident correlation between life expectancy and a country's gross domestic product (GDP) is certainly a widely discussed topic (Swift, 2011; Wilkinson & Pickett, 2010). One important issue that keeps resurfacing in discussions on why the positive relationship between life expectancy and GDP appears to trail off or even reverse its sign once a certain GDP level has been reached is that of increasing inequality of distribution within many nations (Bowles, 2012; Bowles & Gintis, 1986; Bowles, Gordon, & Weisskopf, 1984; Stiglitz, 2007; Wilkinson & Pickett, 2010). As inequality increases, so does the difference in social status and educational and income levels which often leads to negative health effects, such as an increase in both morbidity and mortality rates, with respect to those unfortunate enough to be situated at the wrong end of the economic food chain (Bolte & Mielck, 2004; Burström, Johannesson, & Diderichsen, 2005; Maier, Fairburn, & Mielck, 2012; Mielck, 2005). Hence, a society's average life expectancy can be negatively affected, even though GDP might still be on the rise. Naturally, however, most complex processes – whether they are of an economic, social or physiological nature – are prone to give rise to more than just one possible explanation or cause-and-effect reasoning. Accordingly, another popular argument is that the fading effect of increases in GDP on life expectancy in highly industrialized nations can mostly be attributed to the so-called flat-of-the-curve effect (Schoder & Zweifel, 2011), which is based on an underlying assumption that the feasible physiological boundaries with respect to expansion in human life expectancy have been reached.

However, if looked at from a health economics perspective, it seems as though further plausible explanations can be identified, whose origins are in part inherent to the special characteristics of the market for health (Arrow, 1963) but are also well-known in the fields of political economics (Liebert, 1995; Yale MedLaw, 2005) as well as natural resource economics

(Perman, 2003). As interdisciplinary research is on the rise (Aboelela u. a., 2007), this approach appears to be very much in line with these latest developments.

The question that needs to be asked is: What would happen to the market outlook and future earnings projections of medical and health services producers if rises in GDP continue to translate into rises in life expectancy or, rather, quality-adjusted life expectancy (Burström u. a., 2005; Cubbon, 1991)? As not only common sense but also seminal research shows, from the viewpoint of the medical and healthcare industry, it is generally far more lucrative to sell a cure or a treatment than to sell a preventive measure (Horacek u. a., 2013; Kremer & Snyder, 2013). Although many publications focus on the demand for health, the notion that actual lack of health paired with a substantial ability-to-pay is an essential input factor for multinational and increasingly politically influential (Bowles u. a., 1984; Edwards, 2008; Hess, 2014; Iheanacho, 2006; Levinthal, 2013; Yale MedLaw, 2005) medical and healthcare companies' profit functions (Schwarz, 2013; Weil, 2014) appears quite unaccounted for, at least from an academic research perspective. Thus far, analysis of the supply-side of the health market has concentrated on production costs, technologies, substitution possibilities, incentive mechanisms or capacity restrictions (Glied & Smith, 2011; Wiliams, 1987). However, people in different states of health demand different medical/healthcare products and services, which introduces heterogeneity of demand and, hence, of supply.

Therefore, it seems plausible that, for suppliers, there exists a certain optimal lack of health which, given current production technologies and resulting cost structures as well as – possibly regulated (Puig-Junoy, 2010) – market prices for medical/healthcare products and services, can maximize their net discounted profits. Furthermore, it appears quite likely that this supply-side net-profit-maximizing lack of health level will substantially differ from socially optimal, let alone individually desired, health levels (Moynihan & Cassels, 2005; Schwarz, 2013). Hence, from a supply-side perspective, it seems as though, if a society becomes too healthy, the most essential input factor to medical/healthcare companies' net-profit functions vanishes or, rather, becomes quite negligible. It is also a well-known fact of resource economics that scarce resources result in higher rents with respect to resource owners, here patients as owners of their sicknesses, as well as much lower demand (Perman, 2003), in this case for production of medical/healthcare services.

Some might take this as a worrisome development, as a downsized medical industry may lead to downsized aggregate investment in research and development (R&D), as innovation in medical or, especially, drug development appears to be a costly business (DiMasi, Hansen, & Grabowski, 2003). However, the question that also needs to be asked is whether industry, that is supply-side, funded research, really is the most desirable and the only feasible option. Looking at statements such as, "[to] progress […] you have to believe there is a great commercial opportunity" or "cutting out superfluous experiments" is necessary in order to attain the "ability to incisively choose the 'best' minimum set of experiments that yield the maximum predictive power available for the least dollars." (Shaywitz, 2013b), an economist inevitably starts to ponder how "superfluous" or "best minimum" are being defined. Moreover, from a social welfare economic or public health perspective, the resulting health market outcome might actually turn out to be very inefficient, if the underlying rational is solely based on maximizing net pay-off for the supply-side (Arrow, 1963; Bloomberg News, 2011; Bowles u. a., 1984; Newman, 2013; Stiglitz, 2002). Hence, regarding recent developments (Levy, 2013; Shaywitz, 2013a; Taylor, 2013), one might wonder whether, from an aggregate social welfare perspective, aiming at higher public health levels combined with medical research conducted by non-industry dependent research institutions might be lead to more efficient market outcomes, especially as the current scheme of industry-based R&D results in a high lack of transparency and non-standardized, sometimes even questionable, reporting of actual R&D costs (Morgan, Grootendorst, Lexchin, Cunningham, & Greyson, 2011). The present paper, however, is focused on investigating further into both common and innovative types of economic reasoning regarding the fading relationship between GDP and life expectancy. In doing so, it adopts a different mindset concerning the role of individuals in the health market, one that diverts substantially from the WHO's (WHO, 2000) assumption of there being just four roles for people to take in the health market, which are referred to in more detail in section 2.a.

The paper is structured as follows: Section two provides both materials and methods and a concise overview of seminal research dealing with the market for health. Section three presents the results and discussion, while section four serves to provide both conclusions and policy implications. Sections seven and eight provide a concise but nonetheless comprehensive selection of tables and figures presenting results of the numerical examples used to illustrate the model and findings of sections two and three.

2. Materials and Methods

The first part of this section is dedicated to presenting some seminal work that has been conducted in the field of health economics as well as empirical findings on the relationship between life expectancy and GDP. Afterwards, the crucial aspects that appear to make this paper a new and valuable contribution in the field of health economics are identified. They are then related to the academic discussion regarding the relationship between life expectancy and GDP as well as to common hypotheses and possible propositions that are commonly associated with and used to explain this relationship.

a. Materials

The first seminal work that investigated further into the medical and healthcare industry is Arrow's 1963 paper *Uncertainty and medical care*, which provided a definition of the healthcare market as well as a profound economic analysis of its workings and special characteristics. Among the latter, both the significance and the number of market imperfections certainly stick out, including information asymmetries, externalities, or barriers to entry. Later, Grossman (Grossman, 1972) established a sophisticated model illustrating the characteristics of the demand side of health, also showing how medical and health services are not demanded for generating utility directly through their consumption but rather through the level of health generated as a result (Grossman, 1972). Health thereby has two functions as an economic good. On the one hand, it can be a direct source of utility as a consumption good; on the other hand, it serves as a sort of personal capital stock, meaning an investment good, that enables people to engage in other economic activities that generate utility, income, or profit (Grossman, 1972, 2000). Later on, Grossman also focused on the question of whether education influences health (Grossman, 2004) as well as on the effect of the optimal length of life being an endogenous variable in his 1972 model setup (Grossman, 1998). Around the same time, Wiliams also conducted and inspired much seminal research in the field of health economics (Glied & Smith, 2011), some of which is comprised in his renowned *plumbing diagram*, in which definitions, factors, and drivers as well as characteristics of market agents and an equilibrium market outcome are listed and specified (Wiliams, 1987).

Turning back to the model established by Grossman in 1972, much other groundbreaking research in the field has also been inspired by it. Several papers extend Grossman's model setup, such as by having the depreciation of health depend on the level of health (Bengt Liljas, 1998) or by introducing imperfect market conditions or uncertainty with respect to health outcomes (B Liljas, 2000; Bengt Liljas, 1998). Eisenring investigates under what conditions there is a trade-off between longevity and quality of life, given the pure investment model setup of Grossman's 1972 model (Eisenring, 2000). Looking at possible drivers for an increase in both longevity and quality of life, Eisenring finds that higher initial health status and endowment of wealth, along with higher income levels, tend to increase the optimal life span. Jacobson understands family as a tightly knit social group that maximizes net benefits as a group (Bolin, Jacobson, & Lindgren, 2002), which accounts for the way in which each group member's own health may also depend on the health observed in other group members. Cowel finds that education and health behavior correlate positively, although the exact reasoning on why this seems to be the case is still unclear (Cowell, 2006).

Naturally, in cases with a complex model set, there is also plenty of opportunity to find critical aspects that might stem from underlying simplifying assumptions or a seemingly tinged interpretation of an ambiguous result. A very detailed and comprehensive overview of publications that are critical of or have discovered findings opposed to Grossman's 1972 model setup results can be found in Galama and Kapteyn (Galama & Kapteyn, 2011), who identified the fact that health can be fully recovered through the consumption of healthcare and that the model displays a constant return on investment in health as being some of the most widespread criticisms. Moreover, the sign of the correlation between health and the demand for medical products is subject to controversies between Grossman (Grossman, 1972) and some empirical researchers (Cochrane, St Leger, & Moore, 1997; Zweifel, Breyer, & Kifmann, 2009), as it is positive in Grossman's model but appears negative based upon this empirical research. Other empirical research, however, has found evidence in support of Grossman, with results replicating the predictions made by his model (U. G. Gerdtham & Johannesson, 1999). Either way, it can be concluded that in health economics, just as in many other economic fields (Krugman, 1998), seemingly limited formal theoretical models often serve as an innovative starting point for new strands of research that can test those model findings by implementing empirical data (Galama & Kapteyn, 2011; Grossman, 2004). Hence, it is clear that both formal and empirical research should not be perceived as opposites or substitutes but rather two sides of the same coin. While empirical models appear to present more real-life research results, formal models might be just as apt to discover and display crucial and important aspects of real-life economic issues and problem sets (Krugman, 1998). Within a vibrant academic research environment, both approaches can be perceived as complementary, underpinning, contradicting or re-evaluating each other's results.

However, returning to the market for health, according to the WHO, there are four different roles that can be occupied by people in the healthcare sector; they can contribute to it as providers, stewards, individuals, or simply as consumers of provisions or cures (WHO, 2000). However, what this definition seems to omit is that the individual health stocks of these recipients of pharmaceutical/medical products or healthcare services are an essential input factor to any contributor's production and, hence, profit function. Therefore, given that health is an essential input factor to consumer utility and that it is a superior good, the demand-side approach might not suffice to explain the fading relationship between life expectancy and GDP. Hence, the model presented in the following sections presents a rather formal approach that could later be used as a starting point for further empirical research. In short, the model discusses in more detail the workings and effects between supply and demand for medical/healthcare products and services. In doing so, we also investigate how market structures and the rational economic motives of market agents may affect the relationship between GDP and life expectancy.

But first, let us turn to the second section of the literature review. As has already been hinted at in section 1, it is a well-known but highly debated fact that, at first, rises in GDP translate directly into increases in life expectancy; however, from a certain point onward, this correlation trails off or even switches signs (Wilkinson & Pickett, 2010). In general, rises in GDP are expressed as increases in several variables, such as productivity, wages, labor supply, and education (Swift, 2011), while education is generally perceived as the most dominant factor in improving health (van der Pol, 2011). However, as GDP is an aggregate measure, it fails to communicate essential underlying social or economic phenomena, such as distributional aspects (Stiglitz, 2007). As individual social status can severely affect one's health (Bolte & Mielck, 2004; Mielck, 2005), both social and economic inequality can lead to negative trends in life expectancy, while aggregate GDP might still be increasing – not for the benefit of all but rather only for selected social groups (Bowles, 2012; Stiglitz, 2007; Wilkinson & Pickett, 2010). This is a very important realization, as much recently conducted research shows a global trend that social inequality is on the rise in many highly industrialized nations (Burström u. a., 2005; OECD, 2014). For instance, Wilkinson and Pickett (2010) find that current public polices in most industrialized and other nations render an economic market setting which propels increasingly unequal distribution of income and wealth. Consequently, they propose that this rising inequality is to be held accountable for the fading relationship between changes in GDP and life expectancy in societies.

In the end, the challenge that is taken on in the following sections of this paper is to develop a market setup that manages to represent most of the crucial aspects of the market for health. The established setup will then be used to analyze and examine both standard as well as alternative economic reasoning that could serve to explain the fading or disappearance of the positive correlation between changes in GDP and life expectancy.

Hence, the analysis of the following sections serves to identify possible economic model-based proofs for each of the following hypotheses: First, the fading or disappearance of the positive correlation between changes in GDP and life expectancy is due to physiological reasons, meaning here the flat-of-the-curve argument. Second, it is mainly related to increasing distributional inequality. Third, the supply-side of the health market favors this trend and, hence, has a rational economic interest to support it. A fourth and final rationale that could also be tested is that of a possible rebound effect (Berkhout, Muskens, & W. Velthuijsen, 2000): with rising levels of affluence, people start to engage in activities that generate utility at the cost of health stock, such as smoking expensive cigars, indulging in excessive food intake, or going bungee jumping.

b. Methods

Initially, the model is designed as a purely consumption one (Grossman, 1972). However, in section 2d, this assumption is relaxed and it is turned into a basic mixed model, where health is both a consumption and an investment good. The following setup identifies three main economic agents involved in the relevant market setup: people that maximize their utility, *U*, and two types of companies, one producing a representative consumption good, *Z,* and one producing pharmaceutical/medical/healthcare products and services, *M*. Details on and characteristics of the three groups are as follows: First of all, people maximize their utility, $U = U(H, Z)$. *U* depends on a person's level of health, *H*, and the amount of *Z* consumed (Grossman, 1972). *U* is assumed to exhibit positive but decreasing returns with respect to both consumption of good *Z* and level of health *H*, i.e. $\frac{\partial U}{\partial H}, \frac{\partial U}{\partial M} > 0, \frac{\partial^2 U}{\partial H^2}, \frac{\partial^2 U}{\partial M^2} < 0.$ Furthermore, it is assumed that health is essential, but consumption of good *Z* is not. Hence, *U* is assumed to equal

$$U(H,Z) = aH^{\alpha} + b(H^{\alpha} Z^{1-\alpha}) \tag{1}$$

with $0 < \alpha < 1$ and positive utility coefficients $a, b \geq 1$.

Second, the level of *H* that enters *U* depends on a people's health-production function, which is characterized by an exogenously given initial health status component, *E,* with $0 \leq E \leq 1$, (Eisenring, 2000) and depends on *M* as an input factor to health production. Intuitively speaking, the level of *E* can depend on exogenous factors, such as social status or education (Grossman, 1972; Mielck, 2005). In addition, health is positive but decreasing in *M*, i.e. $\frac{\partial H}{\partial M} > 0, \frac{\partial^2 H}{\partial M^2} < 0.$ Without loss of generality, the commonly adopted assumption (U.-G. Gerdtham, Johannesson, Lundberg, & Isacson, 1999) holds that the maximum level of health that can be attained is $H^{Max} = 1$, while the most critical health level, meaning ultimately death, is equal to $H^{crit} = 0$. Hence, *H* is assumed to equal

$$H(E,M) = E(1 + \tfrac{1}{\varphi}\sqrt{M}) \tag{2}$$

with $H^{crit} \leq H \leq H^{Max}$ and an exogenously given productivity parameter φ , with $\varphi \geq 1$. It is important to note that, given *E, φ,* and a certain budget constraint, perfect health is not necessarily attainable. Also, at higher health levels, people consume less medical products. These are two of the most important characteristics that have been identified by empirical research (Cochrane u. a., 1997; Galama & Kapteyn, 2011; Zweifel u. a., 2009) which are not inherent to Grossman's original model setup (Grossman, 1972).

Third, every period, people offer labor time *d(H)* to companies producing *Z*, which depends on *H*. In addition, for each *d*, they receive wage rate *w(H)*, which also depends on *H*. Intuitively speaking, the healthier people are, the longer they can work per period and, also, the better their performance during that time, which would be reflected by a higher wage rate. Naturally, there is a maximum amount of labor time, d^{Max}, per period that can be supplied. If *d* is measured in hours, and the relevant period is one day, then d^{Max} would be equal to 24 hours or any number of hours less than that, depending on existing working time regulations and types of work contract enforceable. With respect to work days per year, hence, one period being equal to one year, d^{Max} could be equal to 365 work days or less, depending on work contracts, legal leave entitlements and working time regulations in place. Naturally, there is also a minimum health threshold, below which people stop supplying labor time completely, the lowest threshold possible being $d^{Zero}(H=0)=0$. Hence, *d(H)* exhibits positive but decreasing returns with respect to health, i.e. $\frac{\partial d}{\partial H}>0, \frac{\partial^2 d}{\partial H^2}<0,$ and is assume to equal

$$d(H)=d^{Max}\sqrt{H}. \tag{3}$$

With respect to the wage rate, the functional relationship is defined by

$$w=w^{Max}\sqrt{H} \tag{4}$$

where w^{Max} is the maximum wage rate attainable in cases of perfect health, H^{Max}, which can also be normalized to one without loss of generality, i.e. $w^{Max}=1.$ Of course the maximum wage rate could also be assumed to depend on other exogenously given factors, represented by parameter *E,* such as social status or level of education. Lastly, a person's budget constraint is assumed to not only depend on income per period but also on an exogenously given, non-negative social endowment, *S,* with $S \geq 0$. If $S=0$, there is no social endowment and/or welfare system in existence. Hence, we have

$$S + w(H)\,d(H) = P_M(H)M + P_z Z \tag{5}$$

with $P_z > 0$ and $P_M(H) > 0$, which will soon be analyzed in more detail, being the prices of the two goods consumed. Hence, a representative person maximizes his utility according to

$$\begin{aligned} &\max_{M,Z} U(H(M,E),Z) \\ &s.t. \quad S + w(H)\,d(H) = P_M(H)M + P_z Z. \end{aligned} \tag{6}$$

The resulting necessary first order conditions render the common result that optimal consumption levels *(Z*,M*)* and the resulting optimal health level *(H*)* are defined by (5), which states the common result that relative price has to equal relative marginal utility, i.e.

$$\frac{U_Z}{U_H \frac{\partial H}{\partial M} + Y} = \frac{P_z}{P_M} \tag{7}$$

with $Y = \left[(d(H)\frac{\partial w}{\partial H} + w(H)\frac{\partial d}{\partial H} - M\frac{\partial P_M}{\partial H})\frac{\partial H}{\partial M} \right]$. *Y* represents the fact that the level of health not only affects utility but also people's budget constraints. Hence, in the optimal situation, the necessary first order condition with respect to *M* states that its price has to be equal to the marginal utility gained by consuming one extra unit of *M* *plus* the net marginal effect its consumption has on wage rates, labor time, and price.

Now we turn to companies producing consumption good *Z.* The profit function Π^Z is equal to

$$\Pi^Z = p_z Z(d(H)) - w(H)d(H). \tag{8}$$

$Z(d(H))$ represents the production function, which exhibits positive but decreasing marginal productivity with respect to labor time employed, i.e. $\frac{\partial Z}{\partial d} > 0, \frac{\partial^2 Z}{\partial d^2} < 0.$ It is assumed to equal

$$Z = \zeta \sqrt{d(H)} \tag{9}$$

with $\zeta \geq 1$ being an exogenously given productivity parameter. If companies cannot influence people's health and output price is exogenously given, the only variable available to them to maximize profits is labor time employed. That leaves us with the standard necessary first order condition that marginal benefit equals marginal cost of labor time

$$P_z \frac{\partial Z}{\partial d} = w(H). \tag{10}$$

Turning to companies producing *M*, the theoretical mindset deployed is as follows. To them, people's imperfect health is an essential input factor to production. Intuitively speaking, then, the production function of medical products and healthcare services depends on the level of people's health.

The intuition behind the functional relationship chosen in the following is as follows: There is a market price for *M*, i.e. P_M, that depends on *H* and there are unit production costs of *M*, i.e. C_M, that depend on *H* as well. At very low health levels, costs are assumed to become so high that they exceed the marginal *ability-to-pay* of people that is implicitly included in the marginal *willingness-to-pay* (Perman, 2003), i.e. $C_M > P_M$. Once *H* increases, costs decrease more rapidly, as the health services needed tend to become less complex, and, at some point, the unit cost function intersects with P_M and continues to fall below it. However, at some point between low and high levels of health, there is a point of optimal health for medical/healthcare companies at which net unit profits, meaning unit price minus unit cost, reaches its maximum. This point is labeled as H^{opt} in Figure 8 of section 0. Afterwards, as health levels increase further, both unit costs and prices increase, with costs increasing more rapidly. Hence, at very high health levels, both costs and willingness-to-pay approach each other and, depending on the functional relationship, could also intersect once again. Hence, while both net unit profits as well as marginal unit cost and price functions change sign between *H=0* and *H=1*, second derivatives are positive across the entire range, i.e. $\frac{\partial^2 P_M}{\partial H^2}, \frac{\partial^2 C_M}{\partial H^2} > 0$. Hence, functions are assumed to take the following form

$$P_M(H) = percentprice\,[\phi_{price}^2 (H - E_{price})^2 + lowestprice - luxuryhealthprice\ H]$$
$$C_M(H) = percentcost\,[\phi_{cost}^2 (H - E_{cost})^2 + lowestcost - deductcost\ H + \frac{costhigh}{(1 + costlow\ H)}] \tag{11}$$

with $percentprice > percentcost > 0$ and $0 < luxuryhealthprice < deductcost$ as well as $lowestprice > lowestcost > 0,\ 0 < \phi_{price}^2 < \phi_{cost}^2,$ and $E_{price} > E_{cost} > 0.$ An illustrative example is shown by Figure 8 of section 0. Medical/healthcare companies' profits, therefore, are determined by the following equation:

$$\Pi^M = (P_M(H) - C_M(H))M(H) \tag{12}$$

with *M(H)* being defined by rearranging (2). Given the assumptions that companies cannot influence people's health or lower production costs, for example through decrease in output quality or technological progress, there are two different market outcomes possible. Given people's optimal health level characterized by (6), unit production costs of *M* are either above or below unit prices. Consequently, medical companies choose to produce either $M^* = 0$ or to supply the quantity demanded, i.e. $M^* > 0$, given the absence of capacity restrictions.

At this point, all of the relevant variables and functions have been defined. However, the question remains of how the utility or profits of each of the market agents are influenced by people's health, on the one hand, which could be seen as an indicator for life expectancy and, on the other hand, by exogenous factors that could serve to express economic growth and GDP. Is it the case that benefits of all market agents are positively related to both increases in GDP and life expectancy? If, however, this is not the case, then how could it affect market outcomes? Is the model able to reflect the common assumptions (Bowles, 2012; Burström u. a., 2005; Wilkinson & Pickett, 2010) regarding the fading positive correlation between GDP and increase in life expectancy and are there even further likely causes that could be deduced from it? These questions are answered in the following subsection by, first, conducting a comparative static analysis. Second, time and social heterogeneity are accounted for. In addition, five different numerical scenarios are used to further examine results.

c. Comparative Static Analysis

The comparative static analysis conducted in the following is divided into two main sections: one concerned with variables characterizing life expectancy and the other dealing with variables that could serve to indicate changes in GDP. Each of those two main sections is then divided into three subsections to identify effects with respect to the three main economic agents introduced in section 2b: People, companies producing *Z*, and medical/health services companies producing *M*. With respect to people, the effects of changes in relevant variables are identified by analyzing their impact on (1) to (7). With respect to companies, effects on their respective profits, which are represented by (8) and (12), are also looked into.

i. Life Expectancy Indicators

The variables used in the model setup to indicate changes in life expectancy are *E* and, consequently, *H*, as we already know from section 2b that $\frac{\partial H}{\partial E} = (1 + \frac{\sqrt{M}}{\varphi}) > 0$. Certainly, one could also think about taking a look at φ, which would lead to a change in the slope of health production function *H(M, E, φ)*, shown by (2), instead of a parallel shift as caused by changes in *E*. However, the point in question can be made by focusing on just one of these two exogenous variables, as the two are closely linked (Eisenring, 2000). Hence, the analysis here concentrates on changes in *E* so as to remain both intuitive and straightforward.

With respect to people, this entails that both their utility and their income are positively related to changes in *H* and, consequently, also to changes in *E*, i.e. $\frac{\partial U}{\partial E} = \frac{\partial U}{\partial H}\frac{\partial H}{\partial E} > 0$, and $\frac{\partial [S + w(H)(d(H)]}{\partial E} = \frac{\partial [S + w(H)(d(H)]}{\partial H}\frac{\partial H}{\partial E} = [w(H)\frac{\partial d}{\partial H} + d(H)\frac{\partial w}{\partial H}]\frac{\partial H}{\partial E} > 0$. With respect to spending, i.e. $\frac{\partial [P_M(H)M(H) + P_z Z(H)]}{\partial E}$, however, the analysis is a little more complex. While spending on consumption good *Z* increases as *E* rises, i.e. $P_z \frac{\partial Z(H)}{\partial H}\frac{\partial H}{\partial E} > 0$, demand for medical/healthcare services and products correlates negatively with E, i.e. $\frac{\partial M(H,E,\phi)}{\partial E} < 0 \;\forall H > E.$ This is both in line with empirical findings (Cochrane u. a., 1997; Eisenring, 2000) and also makes sense from an intuitive viewpoint, as people surely tend to demand less medical products or healthcare services the healthier they already are. The effect on the price of *M*, however, is ambiguous and depends on the level of *H* and the parameters of the price function, i.e. $\frac{\partial [P_M(H)]}{\partial H} \lesseqgtr 0.$ On the whole, the conclusion that can be drawn is that, as initial health status rises, feasible health levels and income rise along with it, which results in an increase in net utility, with increased income translating into equally higher spending so long as an extra unit of consumption still renders positive marginal utility.

With respect to consumption good producers' profits, i.e. $\frac{\partial \Pi_Z}{\partial E}$, we find that

$$\frac{\partial \Pi_Z}{\partial H}\frac{\partial H}{\partial E} = \left[(p_z \frac{\partial Z}{\partial d} - w(H))\frac{\partial d}{\partial H} - d(H)\frac{\partial w}{\partial H}\right]\frac{\partial H}{\partial E} = -d(H)\frac{\partial w}{\partial H}\frac{\partial H}{\partial E} < 0 \qquad (13)$$

given (10). Hence, in equilibrium, companies' profits result in a decrease in workers' health. Intuitively speaking, a raise in wage rates leads to a change in the distribution of profits towards workers and away from companies. Hence, given that there are no capacity restrictions with respect to readily available workers or output demand, companies would, it seems, rather employ less well paid, and hence, less healthy workers. That way, profits remain with the company and do not have to be shared with workers.

Regarding medical/healthcare products and services producing companies, we already know that demand for *M* correlates negatively to changes in *E*, while the effect on prices remains ambiguous, as has been shown above. The same holds true with respect to changes in unit production costs, as the slope of the cost function also switches signs at the minimum of the cost function, i.e. $\frac{\partial [C_M(H)]}{\partial H} \lesseqgtr 0.$ However, it can be demonstrated that, given (11), for higher a *E*, we arrive at $\frac{\partial [P_M(H) - C_M(H)]}{\partial H} > 0$, which results in a negative correlation between profits and changes in initial health levels, E, i.e. $\frac{\partial \Pi^M}{\partial H} < 0$, and, hence, $\frac{\partial \Pi^M}{\partial E} = \frac{\partial \Pi^M}{\partial H}\frac{\partial H}{\partial E} < 0$, given that the latter have surpassed a certain threshold. This also makes sense from an intuitive viewpoint, which can be underpinned by looking at Figure 8 of section 0, as for cases of very small E, close to zero, initial health levels range below net profit maximizing health level H^{opt}. Hence, at that stage companies' profits rise in E, as it makes more profitable health levels feasible to people. However, once E has passed this threshold, i.e. H^{opt}, profits decline in H, i.e. $\frac{\partial \Pi^M}{\partial H} < 0$. As attainable health levels correlate positively with initial health status E, we can therefore conclude that, from that point onward, companies' profits correlate negatively with E, i.e. $\frac{\partial \Pi^M}{\partial E} < 0 \; \forall E > H^{opt}$.

ii. GDP Indicators

The variables in the model setup characterizing GDP levels are S, d^{Max}, w^{Max}, and ζ. With respect to people, their budget constraint relaxes if either S or w^{Max} increases. Hence, change in utility is non-negative with each of the two, as both affordable health and affordable consumption levels increase, i.e. $\frac{\partial U}{\partial S}, \frac{\partial U}{\partial w^{Max}} \geq 0$. With respect to ζ, a look at (6) and (7) tells us that the effect is nil, i.e. $\frac{\partial U}{\partial \zeta} = 0$, as, in equilibrium, we have $P_z \frac{\partial Z}{\partial \zeta} = \frac{\partial U}{\partial Z}\frac{\partial Z}{\partial \zeta}$. Intuitively speaking, as demand has to equal supply, any increase in production leads to an increase in consumption and its price is equal to the marginal utility it generates. For d^{Max}, utility is correlated positively, i.e. $\frac{\partial U}{\partial d^{Max}} > 0$, as we then have $\left[\frac{\partial U}{\partial Z}\frac{\partial Z}{\partial d} + w(H)\right]\frac{\partial d}{\partial d^{Max}} > P_z \frac{\partial Z}{\partial d}\frac{\partial d}{\partial d^{Max}}$.

With respect to consumption good producers' profits, changes in d^{Max} just cancel out, i.e $\frac{\partial \Pi_Z}{\partial d^{Max}} = 0$. A rise in w^{Max} causes a negative effect, i.e. $\frac{\partial \Pi_Z}{\partial w^{Max}} = d(H) \leq 0$. Changes in productivity result in a positive impact on profits, i.e. $\frac{\partial \Pi_Z}{\partial \zeta} > 0$. Changes in S raise people's budget constraints and, hence, can only indirectly affect companies' profits, depending on the relative price of Z as well as the point elasticity of substitution between Z and M (Perman & et al., 2003). Generally speaking, however, profits certainly tend to correlate positively with rising levels of S, as there is a saturation level defined with respect to H, i.e. $H^{Max} = 1$, while there is none for Z, and prices of H tend to increase in H from a certain point onward.

Regarding medical/healthcare products and services companies' profits, we also find that the effect of a change in S can only indirectly affect them, depending on the relative price of M as well as the point elasticity of substitution between Z and M (Perman & et al., 2003). However, given the shape of the utility function, there is certainly a positive correlation prevalent, up until the GDP level at which equilibrium health has reached its saturation level, i.e. $H^{Max} = 1$. With respect to ζ, we find that, upon looking at (7), the price of M has to rise to make up for the decrease in marginal utility of an increase in consumption of Z. Hence, the relationship has to be positive, i.e. $\frac{\partial \Pi^M}{\partial \zeta} > 0$, as we know that $\frac{\partial \Pi^M}{\partial P_M} = M(H) > 0$. Changes in d^{Max} remain solely within the consumption good sector, i.e. $\frac{\partial \Pi^M}{\partial d^{Max}} = 0$, while changes in maximum wage rates tend to have a positive effect on companies' profits for the same reason as changes in S do.

d. Adding Complexity: The Impact of Introducing Dynamics and Heterogeneity

The model so far has only dealt with a static context and has not taken into account the important dimension of time, as has been done by Grossman (Grossman, 1972) in modeling the demand for health. Moreover, the heterogeneity of society has not been accounted for, which also plays an important role, as shown in Arrow's illustrative model on price discrimination conducted by the medical industry (Arrow, 1963). In the following, the effect of introducing either one of the two additional dimensions into the model setup presented in section 2b is discussed briefly. Numerical scenarios IV and V of Tables 2 to 6 of section 6 display further relevant details, along with Figure 10 of section 0.

In case of introducing a time dimension into the model setup and given the information asymmetry prevalent in the health market (Arrow, 1963; Schlesinger & von der Schulenburg, 1988), results of scenario IV show that companies' profits continue to correlate negatively with people's health levels. Hence, if the type of product sold in one period renders instant and full health benefit but, at the same time, is less effective with respect to future health prospects, companies are able to increase their net discounted profit. For instance, in the case of scenario IV, if *M* generates full instant health output but its effectiveness with respect to future health is lowered by -50%, companies' profits rise by +68%, ceteris paribus. If, however, *M* generates both full instant health benefit in the period of consumption and also increases a people's health outlook regarding future periods by +20%, companies' net discounted profits decrease by -30%, ceteris paribus. Moreover, from a demand-side perspective, time increases uncertainty (Arrow, 1963), as time lags may blur the linkage between cause and effect, such as in the prominent case of Contergan (Grünenthal, 2014) or regarding the side-effects of prescription or non-prescription pain relievers or sleeping pills (FOCUS, 2014; Huffington Post UK, 2014; Jaslow, 2012). Moreover, introducing social heterogeneity into the model setup – as is done by scenario V, tables 3 to 5 of section 6 – does not alter the general findings of either the static (scenarios I to III) or the dynamic (scenario IV) models, which are numerically illustrated in sections 6 and 0. Hence, companies' net profits still correlate positively with both lower health and higher GDP levels, as shown in Tables 3 to 5 of section 6.

Rather, once the common notion of three different social groups (Mielck, 2005) enters the model setup, results of scenario V show that companies perform even better, meaning that net profits rise by +79% or more, compared to scenarios I to IV which assume a homogeneous society. The only exception to that rule is the case of a homogeneous society combined with very high levels of GDP and low to medium initial health levels (e.g. scenario III, Table I of section 6). Intuitively speaking, heterogeneity leads to a situation in which middle- and high-income groups manage to generate a higher GDP level and, hence, higher social endowments that are vital for medical companies to cash in on the negative health effects that low social standards and poor living conditions have on the majority of lower middle-class or low-income households, whose living circumstances benefit the development of lucrative chronic diseases and optimally low health levels (Bolte & Mielck, 2004; Wilkinson & Pickett, 2010). Only a very affluent but also, at the same time, equally unhealthy homogeneous society promises an equally lucrative or even better outlook regarding companies' net profits.

3. Results and Discussion

a. Results

As has been shown by section 2.d, the static approach of the model presented in sections 2b and 2c, along with the numerical results presented in Tables 1 and 2 of section 6 and Figure 1 to 10 of section 0, suffice to serve the cause of identifying various possible drivers of the fading relationship between GDP growth and increasing life expectancy. One of the most crucial aspects of the designed model setup is that it manages to incorporate both the demand and supply sides of the market for health while, at the same time, not forgetting to account for the fact that medical/healthcare products and service are not only an input factor for people's production of health but also that their health levels are also an essential and heterogeneous input factor to medical/healthcare companies' profit functions. Within the model setup, optimal levels of health and consumption for companies producing M and Z are determined by the structure of costs, prices, and the shape of their production functions, as in (8) to (12). Given the numerical setup shown in Table 6 of section 6, companies' net profits are highest around initial health levels of E=0.4 and decrease once initial health levels become either worse or better, as shown in Table 1. This is the case in all three scenarios, as scenario I is characterized by medium GDP indicators, while scenario II represents a comparably poor society with low GDP and scenario III represents a relatively affluent society. However, regardless of a society's GDP, companies' profits are always lowest at either near-death or near-perfect health levels, while a person's utility is always highest the closer society gets to near perfect health levels of, e.g. E=0.8 or higher, and at the same time demand for medical products decreases. Overall, both the supply and demand sides of the market favor high levels of GDP and social endowment, as companies' profits rise up to +72% from low GDP to medium GDP and up to +140% from medium to high GDP scenarios, which is equal to a stunning up to +770% net profit increase in moving from low to high GDP scenarios. Given that, according to WHO reports, per capita healthcare spending in industrialized countries can be almost 500 times higher than in some of the poorest nations (Jeppesen, 2013), these numerical results actually do not even appear far-fetched. Hence, to sum it up, medical/healthcare products and services companies would seem to want high GDP paired with optimally low health levels, such as illustrated by scenario III and the case of E=0.4 shown in Table 1. Nonetheless, consumption-good producers are also in favor of low health levels and, in addition, prefer low maximum wage rates which are, at best, combined with high productivity and high product prices. If they cannot have it all, profits are always highest for low-health cases: E=0.2 or E=0.4. People, however, favor high wages, along with high GDP and the highest health levels possible, such as in scenario I and E=0.8. In sum, it is notable that the demand and supply sides of the health market appear to hold very opposite preferences when it comes to defining a society's optimal health level.

b. Discussion

The question that remains is whether and how these findings support the common and alternative hypotheses introduced in sections 1 and 2.a. First, with respect to social and economic inequality, the model generates evidence in line with empirical findings that it has a dampening effect on the positive correlation between changes in GDP and life expectancy (Wilkinson & Pickett, 2010). Regarding the results of scenario V (Tables 3 to 5 of section 6), optimal health levels are fairly low due to the negative effects economic and social inequality have on low-status groups (Bowles, 2012; Mielck, 2005). Moreover, scenario V in combination with sub-scenario V3 show that an increase in inequality while holding everything else, meaning group-specific GDP indicators, constant leads to a decrease in a society's aggregate health status, and, hence, implicitly, in average life expectancy. Basically, an increase in inequality leads to an implicit decrease in aggregate GDP, which then translates into a reduction of aggregate public health. Second, regarding the flat-of-the-curve effect (Schoder & Zweifel, 2011), there are two things worth noting: First, once maximum health levels are attained, any further increase in GDP has zero effect on health and, hence, on implicit life expectancy. However, and more importantly, the model shows that a negative correlation between the two can only occur if either of the exogenous variables that affect initial health status or budget constraints are changed or the model is altered so that increased consumption of Z negatively affects health. Hence, it can be concluded that a negative correlation of GDP and life expectancy as empirically witnessed (Mielck, 2005; Wilkinson & Pickett, 2010) cannot be explained solely on the basis of the flat-of-the-curve effect. Third, with respect to a possible rebound effect (Berkhout u. a., 2000), it is interesting to note that there is none in a society with low GDP (scenario II). However, for a society with higher GDP (scenario I), a rebound effect of 10% occurs once an initial health status of E=0.8 is reached. With even higher GDP levels (scenario III), the rebound effect starts to occur even earlier, amounting to 5% at E=0.6 and soaring up to 15% at E=0.8. The inter-temporal scenario IV does not test for changes in GDP but solely for changes in initial health status of the second period. For the case of a heterogeneous society with medium average initial health levels (scenario V with an average initial health status of E=0.5), no rebound effect was observed either. An increase in both GDP and average initial health status also is likely to translate into a higher optimal health outcome. Hence, given the underlying utility and health production functions, a rebound effect in health consumption certainly does occur, though apparently not until the upper one third or quarter of attainable health levels have been reached. Fourth, the inter-temporal scenario IV clearly demonstrates that companies' profits are likely increase if they can manage to influence variables defining optimal health levels chosen by people. Moreover, both scenarios I to III as well as scenario V show that high GDP levels paired with optimally low health levels are most beneficial to the supply-side of the health market.

These theoretical findings are also in line with empirical WHO and IMF data on both health markets and GDP (IMF, 2014; WHO, 2014; WHO II, 2014). Another interesting fact is that the cost and price structure chosen for the model setup in (11) appears to already implicitly incorporate the fact that in many countries some kinds of price cap or other types of price regulation are in place with respect to medical, pharmaceutical, and healthcare services and products (Ess, Schneeweiss, & Szucs, 2003; Puig-Junoy, 2010), such as reference pricing (Galizzi, Ghislandi, & Miraldo, 2011) or DRG systems (Cheng, Chen, & Tsai, 2012). Nonetheless, however, the disconcerting divergence in the perception of optimal health levels from demand- vs. supply-side perspectives persists.

4. Conclusion and Policy Implications

The analysis presented above has implemented health economic theory, combining it with other fields of economic research, to establish an innovative economic model framework to test both common and new hypotheses regarding the changes in the relationship between GDP and life expectancy in many industrialized nations (Mielck, 2005; Wilkinson & Pickett, 2010). It can certainly be concluded from this analysis that none of the proposed reasons can serve as the "one and only" solution to the issue of identifying cause and effect correlations. However, it should be noted that, given the results of empirical research and findings on the underlying political landscape (Edwards, 2008; Heaney, 2006; Levinthal, 2013; Schwarz, 2013; Weil, 2014), it seems as though the ideas introduced in the previous sections should not be discounted out of hand, as the economic interests of the supply and demand sides of the health market differ greatly when it comes to public health being an economic product.

To sum up, the findings of this paper suggest that, if democratically elected politicians are to act in favor of an aggregate social welfare, more attention should be directed towards reducing the influence of supply-side interest groups on political advisory boards perspective (Landers & Sehgal, 2004; Yale MedLaw, 2005). From a rational economic viewpoint, there is certainly nothing wrong with interest groups being intrinsically motivated to maximize their members' economic profit rather than aggregate social welfare.

However, from a democratic, socio-economic, or public health perspective, evaluation of the resulting market outcomes would appear to be far less sympathetically understood (Bowles, 2012; WHO, 2014). Rather, it seems as though, in a short-sighted attempt to save society's economic resources, laws and regulations have been based on industry-funded research or the expertise advice of industry representatives (Greenwald, 2012; Grill, 2010; Law, 2006). What appears easily forgotten, however, is that, again, these industry-run efforts are not driven by the motives of maximizing aggregate social welfare but rather to pursue their own interests and, hence, by an intention to influence exogenously given variables, such as laws and regulations or society's status quo, so that their own profits can be positively affected by them (Greenwald, 2012; WHO, 2014). Hence, if the medical and healthcare industry is given a chance to influence the market (Hess, 2014), it is clearly not in their economic interest to arrive at people's utility maximizing, let alone welfare maximizing, health levels. Rather, their aspirations may lead towards a market outcome in which their own net-discounted profits are maximized, which may require a sufficiently low health level of as many people as possible, while ensuring that GDP growth enables society to afford such an allocatively inefficient health market outcome. These conclusions are also in line with empirical results that, from a supply-side perspective, offering preventive treatments to healthy people is less profitable than offering cures once illnesses that could have been prevented occur (Kremer & Snyder, 2013). Moreover, empirical findings also allude to the fact that the healthcare system often focuses more on disease than on the porcurement of health (Weil, 2014) and that this type of health politics caters mainly to the economic interests (Dawson, 2012; Iheanacho, 2006; Moynihan & Cassels, 2005) of the supply-side of one of the largest industrial sectors (Arrow, 1963; Schlesinger & von der Schulenburg, 1988) and little to public health. Regarding future research, it would be interesting to acquire relevant data for identifying profit-optimizing lack-of-health levels from the viewpoint of different representatives from the supply-side agents of the health market, including pharmaceutical, medical, or health products or services companies. Such empirical research would certainly generate highly valuable insights into health economics and for society overall regarding the assessment of the health market's supply-side incentive structure.

5. References

Aboelela, S. W., Larson, E., Bakken, S., Carrasquillo, O., Formicola, A., Glied, S. A., … Gebbie, K. M. (2007). Defining Interdisciplinary Research: Conclusions from a Critical Review of the Literature. *Health Services Research*, *42*(1 Pt 1), 329–346. doi:10.1111/j.1475-6773.2006.00621.x

Arrow, K. J. (1963). Uncertainty and the welfare economics of medical care. *American Economic Review*, *L III*(5), 941–974.

Berkhout, P. H. G., Muskens, J. C., & W. Velthuijsen, J. (2000). Defining the rebound effect. *Energy Policy*, *28*(6–7), 425–432. doi:10.1016/S0301-4215(00)00022-7

Bloomberg News. (2011, Januar 13). Judge Accepts Guilty Plea by Guidant. *The New York Times*. URL: http://www.nytimes.com/2011/01/14/business/14device.html

Bolin, K., Jacobson, L., & Lindgren, B. (2002). The family as the health producer-when spouses act strategically. *Journal of Health Economics*, *21*(3), 475–495.

Bolte, G., & Mielck, A. (2004). *Umweltgerechtigkeit: die soziale Verteilung von Umweltbelastungen*. Weinheim: Juventa.

Bowles, S. (2012). *The new economics of inequality and redistribution*.

Bowles, S., & Gintis, H. (1986). *Democracy and capitalism: property, community, and the contradictions of modern social thought*. New York: Basic Books.

Bowles, S., Gordon, D. M., & Weisskopf, T. E. (1984). *Beyond the wasteland: a democratic alternative to economic decline*. London: Verso.

Burström, K., Johannesson, M., & Diderichsen, F. (2005). Increasing socio-economic inequalities in life expectancy and QALYs in Sweden 1980–1997. *Health Economics*, *14*(8), 831–850. doi:10.1002/hec.977

Cheng, S.-H., Chen, C.-C., & Tsai, S.-L. (2012). The impacts of DRG-based payments on health care provider behaviors under a universal coverage system: a population-based study. *Health Policy (Amsterdam, Netherlands)*, *107*(2-3), 202–208. doi:10.1016/j.healthpol.2012.03.021

Cochrane, A. L., St Leger, A. S., & Moore, F. (1997). Health service „input“ and mortality „output“ in developed countries. 1968 [historical article]. *Journal of Epidemiology and Community Health*, *51*(4), 344–349.

Cowell, A. J. (2006). The relationship between education and health behavior: some empirical evidence. *Health Economics*, *15*(2), 125–146. doi:10.1002/hec.1019

Cubbon, J. (1991). The principle of QALY maximisation as the basis for allocating health care resources. *Journal of Medical Ethics*, *17*(4), 181–184.

Dawson, P. (2012, August 14). Grief is good news for pharmaceutical companies. *The Guardian*. URL: http://www.theguardian.com/society/2012/aug/14/grief-good-news-big-pharma

DiMasi, J. A., Hansen, R. W., & Grabowski, H. G. (2003). The price of innovation: new estimates of drug development costs. *Journal of Health Economics*, *22*(2), 151–185. doi:10.1016/S0167-6296(02)00126-1

Edwards, J. (2008). Pharma Election Money Backs Obama. URL: http://www.cbsnews.com/news/pharma-election-money-backs-obama/

Eisenring, C. (2000). Is there a trade-off between longevity and quality of life in Grossman's pure investment model? *Health Economics*, *9*(8), 669–680. doi:10.1002/1099-1050(200012)9:8<669::AID-HEC542>3.0.CO;2-K

Ess, S. M., Schneeweiss, S., & Szucs, T. D. (2003). European healthcare policies for controlling drug expenditure. *PharmacoEconomics*, *21*(2), 89–103.

FOCUS, O. (2014). Tödliche Schmerzmittel verbieten? Aspirin und Paracetamol gefährden Leben - Gefährliche Schmerzmittel. URL: http://www.focus.de/gesundheit/ratgeber/medikamente/risiko/tid-24809/toedliche-schmerzmittel-verbieten-aspirin-und-paracetamol-gefaehrden-leben_aid_703225.html

Galama, T., & Kapteyn, A. (2011). Grossman's missing health threshold. *Journal of Health Economics*, *30*(5), 1044–1056. doi:10.1016/j.jhealeco.2011.06.004

Galizzi, M. M., Ghislandi, S., & Miraldo, M. (2011). Effects of reference pricing in pharmaceutical markets: a review. *PharmacoEconomics*, *29*(1), 17–33. doi:10.2165/11537860-000000000-00000

Gerdtham, U. G., & Johannesson, M. (1999). New estimates of the demand for health: results based on a categorical health measure and Swedish micro data. *Social Science & Medicine (1982)*, *49*(10), 1325–1332.

Gerdtham, U.-G., Johannesson, M., Lundberg, L., & Isacson, D. (1999). The demand for health: results from new measures of health capital. *European Journal of Political Economy*, *15*(3), 501–521. doi:10.1016/S0176-2680(99)00026-9

Glied, S., & Smith, P. C. (2011). *The Oxford Handbook of Health Economics*. Oxford University Press.

Greenwald, G. (2012, Dezember 5). Obamacare architect leaves White House for pharmaceutical industry job. *The Guardian*. URL: http://www.theguardian.com/commentisfree/2012/dec/05/obamacare-fowler-lobbyist-industry1

Grill, M. (2010, September 27). Arzneimittel: Pharmalobby diktiert Gesetzesänderung Nr. 4. *Spiegel Online*. URL: http://www.spiegel.de/wirtschaft/soziales/arzneimittel-pharmalobby-diktiert-gesetzesaenderung-nr-4-a-719507.html

Grossman, M. (1972). On the Concept of Health Capital and the Demand for Health. *Journal of Political Economy*, *80*(2), 223–55.

Grossman, M. (1998). On optimal length of life. *Journal of Health Economics*, *17*(4), 499–509. doi:10.1016/S0167-6296(97)00041-6

Grossman, M. (2000). Chapter 7 The human capital model. In Anthony J. Culyer and Joseph P. Newhouse (Hrsg.), *Handbook of Health Economics* (Bd. Volume 1, Part A, S. 347–408). Elsevier. URL: http://www.sciencedirect.com/science/article/pii/S1574006400801663

Grossman, M. (2004). The demand for health, 30 years later: a very personal retrospective and prospective reflection. *Journal of Health Economics*, *23*(4), 629–636. doi:10.1016/j.jhealeco.2004.04.001

Grünenthal, G. (2014). Contergan - The Facts - The tragedy - the story in West Germany. URL: http://www.contergan.grunenthal.info/grt-ctg/GRT-CTG/Die_Fakten/Die_Tragoedie/152700063.jsp

Heaney, M. T. (2006). Brokering health policy: coalitions, parties, and interest group influence. *Journal of Health Politics, Policy and Law*, *31*(5), 887–944. doi:10.1215/03616878-2006-012

Hess, D. A. M. and A. E. M. (2014). 10 Companies Making The Biggest Political Donations: 24/7 Wall St. URL: http://www.huffingtonpost.com/2012/07/02/corporate-political-donations_n_1644375.html

Horacek, T. M., White, A. A., Byrd-Bredbenner, C., Reznar, M. M., Olfert, M. D., Morrell, J. S., Thompson-Snyder, C. A. (2013). PACES: A Physical Activity Campus Environmental Supports Audit on University Campuses. *American Journal of Health Promotion: AJHP*. doi:10.4278/ajhp.121212-QUAN-604

Huffington Post UK. (2014, März 8). Why This Sleeping Pill May Be A Heart Attack Risk. URL: http://www.huffingtonpost.co.uk/2014/01/08/sleeping-pill-zolpidem-heart-attack-risk_n_4559853.html

Iheanacho, I. (2006). Big Pharma: How the World's Biggest Drug Companies Control Illness. *BMJ : British Medical Journal*, *332*(7542), 672.

IMF. (2014). Economic Indicators (IFS) Data Report - IMF eLibrary Data. URL: http://elibrary-data.imf.org/DataReport.aspx?c=1449311&d=33061&e=169393

Jaslow, R. (2012, Februar 28). Prescription sleeping pills tied to increased risk for death, cancer. URL: http://www.cbsnews.com/news/prescription-sleeping-pills-tied-to-increased-risk-for-death-cancer/

Jeppesen, H. (2013, April 10). Pharma sector changes as generic market grows | Sci-Tech | DW.DE | 10.04.2013. URL: http://www.dw.de/pharma-sector-changes-as-generic-market-grows/a-16733444

Kremer, M., & Snyder, C. M. (2013). *When Is Prevention More Profitable than Cure? The Impact of Time-Varying Consumer Heterogeneity* (Working Paper No. 18862). National Bureau of Economic Research. URL: http://www.nber.org/papers/w18862

Krugman, P. R. (1998). *The accidental theorist: and other dispatches from the dismal science*. New York: Norton.

Landers, S. H., & Sehgal, A. R. (2004). Health care lobbying in the United States. *The American Journal of Medicine*, *116*(7), 474–477. doi:10.1016/j.amjmed.2003.10.037

Law, J. (2006). *Big pharma: how the world's biggest drug companies control illness*. London: Constable & Robinson Ltd.

Levinthal, D. (2013, Oktober 22). Lobbying Spending Down Overall, But Not For Gun Advocates, Big Pharma, Agriculture. URL: http://www.huffingtonpost.com/2013/10/22/lobbying-spending_n_4145040.html

Levy, H. (2013). Pharma R&D: Time for a sharp right turn on the road to profitable growth. URL: http://www.accenture.com/us-en/blogs/life-sciences-blog/archive/2013/06/20/pharma-r-d-time-for-a-sharp-right-turn-on-the-road-to-profitable-growth.aspx

Liebert, U. (1995). Parliamentary Lobby Regimes, in: Döring, Herbert (Hrsg.): Parliaments and majority rule in Western Europe. In *Parliaments and majority rule in Western Europe* (S. 407–447.). Frankfurt am Main/New York: Campus/St. Martin's Press.

Liljas, B. (1998). The demand for health with uncertainty and insurance. *Journal of Health Economics*, *17*(2), 153–170. doi:10.1016/S0167-6296(97)00021-0

Liljas, B. (2000). Insurance and imperfect financial markets in Grossman's demand for health model--a reply to Tabata and Ohkusa. *Journal of Health Economics*, *19*(5), 821–827.

Maier, W., Fairburn, J., & Mielck, A. (2012). [Regional deprivation and mortality in Bavaria. Development of a community-based index of multiple deprivation]. *Gesundheitswesen (Bundesverband der Ärzte des Öffentlichen Gesundheitsdienstes (Germany))*, *74*(7), 416–425. doi:10.1055/s-0031-1280846

Mielck, A. (2005). *Soziale Ungleichheit und Gesundheit: Einführung in die aktuelle Diskussion*. Bern: Huber.

Morgan, S., Grootendorst, P., Lexchin, J., Cunningham, C., & Greyson, D. (2011). The cost of drug development: a systematic review. *Health Policy (Amsterdam, Netherlands)*, *100*(1), 4–17. doi:10.1016/j.healthpol.2010.12.002

Moynihan, R., & Cassels, A. (2005). *Selling sickness: how the drug companies are turning us all into patients*. New York: Nation Books.

Newman, J. A. (2013). Recipient of defective Guidant Pacemaker turns whistleblower forcing Boston Scientific to pay $30 million. URL: http://www.whistleblowerlawyernews.com/2013/10/17/recipient-defective-guidant-pacemaker-turns-whistleblower-forcing-boston-scientific-pay-30-million/

OECD. (2014). Divided We Stand: Why Inequality Keeps Rising. URL: http://www.oecd.org/social/soc/dividedwestandwhyinequalitykeepsrising.htm

Perman, R. (2003). *Natural resource and environmental economics*. Harlow [u.a.: Pearson Education [u.a.].

Perman, R., & et al. (2003). *Natural resource and environmental economics*. Harlow, England; New York: Pearson Addison Wesley.

Puig-Junoy, J. (2010). Impact of European pharmaceutical price regulation on generic price competition: a review. *PharmacoEconomics*, *28*(8), 649–663. doi:10.2165/11535360-000000000-00000

Schlesinger, H., & von der Schulenburg, J.-M. G. (1988). Mehr Markt im Gesundheitswesen, *144*(2), 396–402.

Schoder, J., & Zweifel, P. (2011). Flat-of-the-curve medicine: a new perspective on the production of health. *Health Economics Review*, *1*(1), 2. doi:10.1186/2191-1991-1-2

Schwarz, A. (2013, Dezember 14). The Selling of Attention Deficit Disorder. *The New York Times*. http://www.nytimes.com/2013/12/15/health/the-selling-of-attention-deficit-disorder.html

Shaywitz, D. (2013a, Februar 12). What Will Follow Pharma’s R&D Purge? A Few Quick Thoughts. URL: http://www.forbes.com/sites/davidshaywitz/2013/12/02/what-will-follow-pharmas-rd-purge-a-few-quick-thoughts/

Shaywitz, D. (2013b, Dezember 14). To Save Pharma R&D, David Grainger Says Drug Developers Must Think Like CEOs Of Lean Startups. URL: http://www.forbes.com/sites/davidshaywitz/2013/12/14/to-save-pharma-rd-david-grainger-says-drug-developers-must-think-like-ceos-of-lean-startups/

Stiglitz, J. E. (2002). *Globalization and its discontents*. London: Penguin.

Stiglitz, J. E. (2007). *Making globalization work*. New York: W.W. Norton & Co.

Swift, R. (2011). The relationship between health and GDP in OECD countries in the very long run. *Health Economics*, *20*(3), 306–322. doi:10.1002/hec.1590

Taylor, P. (2013, Dezember 5). Pharma's return on R&D spend continues to slide [text]. URL: http://www.pmlive.com/pharma_news/pharmas_return_on_r_and_d_spend_continues_to_slide_524156

Van der Pol, M. (2011). Health, education and time preference. *Health Economics*, *20*(8), 917–929. doi:10.1002/hec.1655

Weil, A. (2014). U.S. manages disease, not health. URL: http://www.cnn.com/2013/03/08/opinion/weil-health-care/index.html

WHO. (2000). WHO - The world health report 2000 - Health systems: improving performance. URL: http://www.who.int/whr/2000/en/

WHO. (2014). WHO | Pharmaceutical Industry. URL: http://www.who.int/trade/glossary/story073/en/

WHO II. (2014). WHO | Region and country specific information sheets. URL: http://www.who.int/chp/chronic_disease_report/media/impact/en/

Wiliams, A. (1987). Health economics: the cheerful face of a dismal science. In *Health and Economics*. London: Macmilan.

Wilkinson, R. G., & Pickett, K. (2010). *The spirit level: why equality is better for everyone*. London; New York: Penguin Books.

Yale MedLaw. (2005). Powerful Medicine: A Closer Look at the Pharmaceutical Lobby. URL: http://www.yalemedlaw.com/2005/11/powerful-medicine-a-closer-look-at-the-pharmaceutical-lobby/

Zweifel, P., Breyer, F., & Kifmann, M. (2009). *Health Economics*. Springer.

6. Tables

Table 1: *Results of Scenarios I to III*

Initial Health Status:	E=0.2		E=0.4		E=0.6		E=0.8	
Scenario I: dmax=250 s=400 wmax=1 ζ=5	U: 4.9 H: 0.27 M: 5 Z: 57 W: 305	P_M: 38 C_M: 21 Π_M: 83 Π_Z: 217 w: 0.8 d: 130	U: 7.2 H: 0.5 M: 10 Z: 66 W: 331	P_M: 19 C_M: 8 Π_M: 117 Π_Z: 207 w: 0.7 d: 177	**U: 8.8** **H: 0.71** **M: 11** **Z: 75** **W: 271**	**P_M: 19** **C_M: 19** **Π_M: 76** **Π_Z: 185** **w: 0.8** **d: 210**	U: 10 H: 0.89 M: 7.5 Z: 77 W: 193	P_M: 32 C_M: 29 Π_M: 21 Π_Z: 161 w: 0.9 d: 236
$\Delta\Pi_M$ Horizontal:		↘+41%↗		↘-35%↗		↘-72%↗		
$\Delta\Pi_M$ Vertical:	↓-72%		↓-72%		↓-62%		↓-53%	
Scenario II (GDP down): dmax=300 s=600 wmax=0.5 ζ=3	U: 3.9 H: 0.23 M: 1 Z: 36 W: 172	P_M: 43 C_M: 25 Π_M: 23 Π_Z: 145 w: 0.2 d: 146	**U: 5.7** **H: 0.45** **M: 2.4** **Z: 43** **W: 183**	**P_M: 22** **C_M: 9** **Π_M: 33** **Π_Z: 145** **w: 0.3** **d: 201**	U: 7 H: 0.6 M: 2 Z: 42 W:171	P_M: 18 C_M: 10 Π_M: 29 Π_Z:135 w: 0.4 d: 244	U: 8.4 H: 0.86 M: 3 Z: 50 W:140	P_M: 28 C_M: 25 Π_M: 10 Π_Z:122 w: 0.5 d: 277
$\Delta\Pi_M$ Horizontal:		↘+44%↗		↘-12%↗		↘-66%↗		
$\Delta\Pi_M$ Vertical:	↓+770%		↓+712%		↓+590%		↓+210%	
Scenario III (GDP up): dmax=225 s=600 wmax=2 ζ=6	U: 5.7 H: 0.31 M: 12 Z: 67 W: 400	P_M: 33 C_M: 17 Π_M: 200 Π_Z: 195 w: 1.1 d: 126	U: 8.2 H: 0.57 M: 26 Z: 78 W: 411	P_M: 18 C_M: 8 Π_M: 268 Π_Z:134 w: 1.5 d: 169	U: 9.7 H: 0.76 M: 24 Z: 84 W: 224	P_M: 21 C_M: 16 Π_M: 200 Π_Z: 77 w: 1.7 d: 196	**U: 8.4** **H: 0.93** **M: 16** **Z: 88** **W: 64**	**P_M: 36** **C_M: 34** **Π_M: 31** **Π_Z: 22** **w: 1.9** **d: 217**
$\Delta\Pi_M$ Horizontal:		↘+34%↗		↘-25%↗		↘-85%↗		

Table 2: *Results of Scenario IV*

Initial Health Status:	E_0=E=0.6; E_1= H_0/2	E_0=E=0.6; E_1=H_0	E_0=E=0.6; E_1=5H_0/4
Scenario IV: (Inter-temporal) dmax=250,s=400, wmax=1; ζ=5; r=0.05 E_0=E, E_1=H_0*	U: 15 H_0: 0.71; H_1: 0.45 M_0: 11; M_1: 8 Z_0: 73; Z_1: 64 w_0: 0.84; w_1: 0.7 d_0: 210; d_1: 168 $\Pi_{Z\,0}$: 185; $\Pi_{Z\,1}$: 211 $P_{M\,0}$: 19; $P_{M\,1}$: 22 $C_{M\,0}$: 12; $C_{M\,1}$: 9 $\Pi_{M\,0}$: 77; $\Pi_{M\,1}$: 113 Σ Π_M: 200 W: 579	**U: 18** **H_0: 0.71; H_1: 0.81** **M_0: 11; M_1: 9** **Z_0: 73; Z_1: 75** **w_0: 0.84; w_1: 0.9** **d_0: 210; d_1: 225** **$\Pi_{Z\,0}$: 185; $\Pi_{Z\,1}$: 172** **$P_{M\,0}$: 19; $P_{M\,1}$: 25** **$C_{M\,0}$: 12; $C_{M\,1}$: 20** **$\Pi_{M\,0}$: 77; $\Pi_{M\,1}$: 42** Σ Π_M: 119 **W: 456**	U: 19 H_0: 0.71; H_1: 0.97 M_0: 11; M_1: 6 Z_0: 73; Z_1: 79 w_0: 0.84; w_1: ≈1 d_0: 210; d_1: 246 $\Pi_{Z\,0}$: 185; $\Pi_{Z\,1}$: 150 $P_{M\,0}$: 19; $P_{M\,1}$: 41 $C_{M\,0}$: 12; $C_{M\,1}$: 40 $\Pi_{M\,0}$: 77; $\Pi_{M\,1}$: 7 Σ Π_M: 84 W: 240
Δ Σ Π_M Horizontal:	↖+68%↙	↘-30%↗	

Table 3: *Results of Scenario V*

Scenario/Groups	Low	Middle	High	Society	
Scenario V: **(Heterogeneity by % Group Weight)** **24% Group$_{low}$:** E=0.4, s=400, dmax=300, wmax=0.5, ζ=3 **53% Group$_{middle}$:** E=0.5, s=500, dmax=250, wmax=1, ζ=5 **23% Group$_{high}$:** E=0.7, s=600, dmax=225, wmax=2, ζ=6	U: 6.2 H: 0.52 M: 14 Z: 44 w: 0.4 d: 216 P_M: 19 C_M: 8 Π_M: 155 Π_Z: 142	U: 8.3 H: 0.63 M: 17 Z: 71 w: 0.8 d: 199 P_M: 18 C_M: 9 Π_M: 150 Π_Z: 194	U:10.4 H: 0.84 M: 19 Z: 86 w: 1.8 d: 207 P_M: 28 C_M: 24 Π_M: 76 Π_Z: 50	**øU: 8.3** **øH: 0.66** **øM:17** **øZ: 78**	**øP_M: 20.3** **øC_M: 12** **øΠ_M: 134** **øΠ_Z:148** **øZ: 68** **øw: 0.9** **ød: 205** **øW: 290**

Table 4: *Results of Scenario V2*

Scenario/Groups	Low	Middle	High	Society	
Scenario V2: **(Heterogeneity by % Group Weight)** **24% Group$_{low}$:** E=0.3, s=400, dmax=300, wmax=0.5, ζ=3 **53% Group$_{middle}$:** E=0.4, s=500, dmax=250, wmax=1, ζ=5 **23% Group$_{high}$:** E=0.7, s=600, dmax=225, wmax=2, ζ=6	U: 5.3 H: 0.41 M: 10 Z: 41 w: 0.3 d: 191 P_M: 25 C_M: 11 Π_M: 144 Π_Z: 146	U: 7.4 H: 0.53 M: 16 Z: 67 w: 0.7 d: 182 P_M: 19 C_M: 7.5 Π_M: 177 Π_Z: 204	U:10.4 H: 0.84 M: 19 Z: 86 w: 1.8 d: 207 P_M: 28 C_M: 24 Π_M: 76 Π_Z: 50	**øU: 7.6** **øH: 0.57** **øM:15** **øZ: 78**	**øP_M: 22.3** **øC_M: 12** **øΠ_M: 146** **øΠ_Z:155** **øZ: 65** **øw: 0.88** **ød: 190** **øW: 308**
$\Delta \Sigma \Pi_M$ **compared to Scenario V:**	+9%				

Table 5: *Results of Scenario V3*

Scenario/Groups	Low	Middle	High	Society	
Scenario V3: **(Heterogeneity by % Group Weight)** **40% Group$_{low}$:** E=0.4, s=400, dmax=300, wmax=0.5, ζ=3 **40% Group$_{middle}$:** E=0.5, s=500, dmax=250, wmax=1, ζ=5 **20% Group$_{high}$:** E=0.7, s=600, dmax=225, wmax=2, ζ=6	U: 6.2 H: 0.52 M: 14 Z: 44 w: 0.4 d: 216 P_M: 19 C_M: 8 Π_M: 155 Π_Z: 142	U: 8.3 H: 0.63 M: 17 Z: 71 w: 0.8 d: 199 P_M: 18 C_M: 9 Π_M: 150 Π_Z: 194	U:10.4 H: 0.84 M: 19 Z: 86 w: 1.8 d: 207 P_M: 28 C_M: 24 Π_M: 75 Π_Z: 50	**øU: 7.9** **øH: 0.63** **øM:16** **øZ: 78**	**øP_M: 20** **øC_M: 11.4** **øΠ_M: 137** **øΠ_Z:144** **øZ: 63** **øw: 0.83** **ød: 208** **øW: 289**
$\Delta \Sigma \Pi_M$ **compared to Scenario V:**	+2.3%				

Table 6: *Overview of functions and variables of different scenarios*

Setting	Respective Functions and Variables
Scenario I	$U(H,Z)=2H^{0.5}+(H^{0.5}Z^{1-0.5})$, $400+250H=P_M(H)M+5Z$ $H(E,M)=E(1+\frac{1}{30}\sqrt{M})$, Initial Health Status: E = 0.6, $Z=5\sqrt{250\sqrt{H}}$, $d(H)=250\sqrt{H}$, $w=\sqrt{H}$, $P_M(H)=0.8(15^2(H-0.6)^2+25-5H)$, $C_M(H)=0.6(17^2(H-0.5)^2+20-20H+\frac{150}{1+100H})$, $\Pi^M=(P_M(H)-C_M(H))M$, $\Pi^Z=25\sqrt{250\sqrt{H}}-250H$, $Welfare: U(H,Z)+S-C_M(H)$
Scenario II (GDP↓)	**Changes in Functions and Variables with respect to Scenario I:** Initial Health Status: E = 0.4, $200+150H=P_M(H)M+5Z$, $Z=3\sqrt{250\sqrt{H}}$, $d(H)=300\sqrt{H}$, $w=0.5\sqrt{H}$, $\Pi^Z=15\sqrt{300\sqrt{H}}-150H$
Scenario III (GDP↑)	**Changes in Functions and Variables with respect to Scenario I:** Initial Health Status: E = 0.8, $600+450H=P_M(H)M+5Z$, $Z=6\sqrt{225\sqrt{H}}$, $d(H)=225\sqrt{H}$, $w=2\sqrt{H}$, $\Pi^Z=30\sqrt{225\sqrt{H}}-450H$
Scenario IV (Inter-temporal Scenario I)	**Changes in Functions and Variables with respect to Scenario I:** Optimization program across two discrete time periods t = 0, 1, discount rate r=0.05, three scenarios: $E_{t=1}=\frac{1}{2}H_0$, $E_{t=1}=H_0$, $E_{t=1}=\frac{5}{4}H_0$.
Scenario V (Heterogeneity)	**Changes in Functions and Variables with respect to Scenario I:** Adopt assumption of a society comprised of three social groups (Mielck, 2005): **23% Group$_{\text{High}}$:** E=0.4, s=400, dmax=300, wmax=0.5, ζ=3 **53% Group$_{\text{Middle}}$:** E=0.5, s=500, dmax=250, wmax=1, ζ=5 **24% Group$_{\text{Low}}$:** E=0.7, s=600, dmax=225, wmax=2, ζ=6
Scenario V_II (Heterogeneity)	**Changes in Functions and Variables with respect to Scenario V:** Changes in Initial Health Status: 0.4 to 0.3 (Low), 0.5 to 0.4 (Middle), unchanged (High).
Scenario V_III (Heterogeneity)	**Changes in Functions and Variables with respect to Scenario V:** Changes in group weights: 24% to 40% (Low), 53% to 40% (Middle), 23% to 20% (High).

7. Legends and Figures

8.1 People:

$$U(H,Z) = 2H^{0.5} + (H^{0.5}Z^{1-0.5}) \tag{14}$$

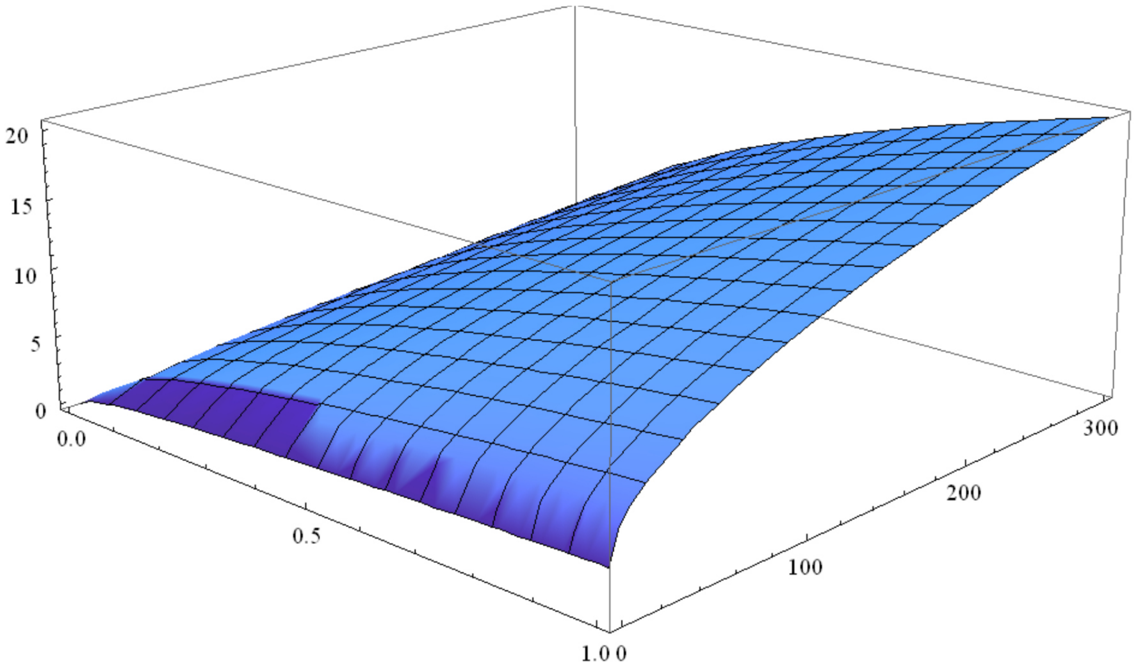

Figure 1: *Scenario I utility function U(H,Z), with a=2, b=1 and α=0.5.*

$$H(E,M) = E + \frac{1}{\phi}\sqrt{M} \tag{15}$$

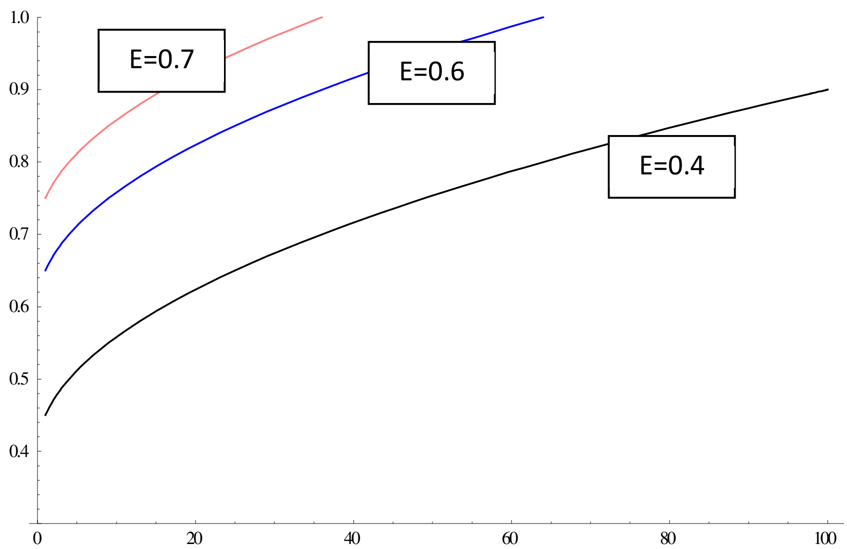

Figure 2: *Illustration of different health production functions H(E, M), with* $\phi = 20$.

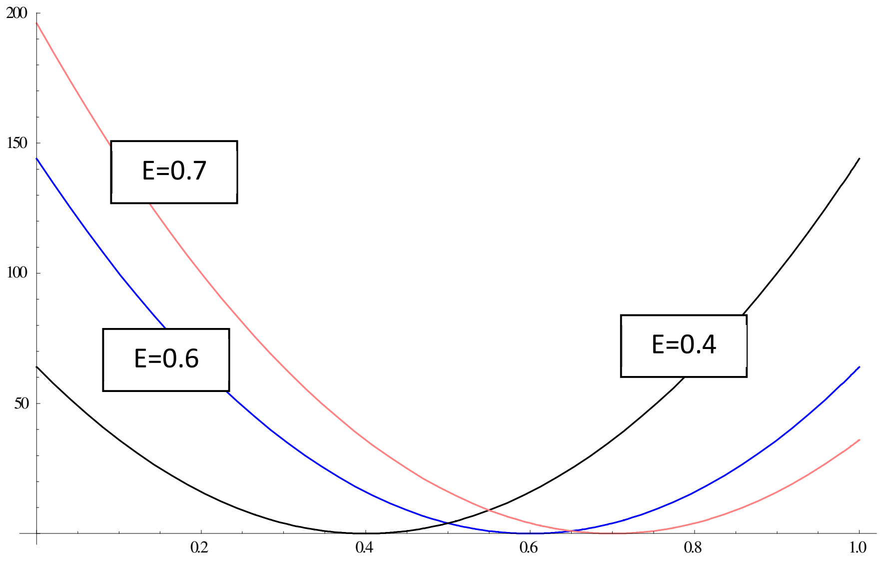

Figure 3: *Different medical/health services demand functions* $M = \phi^2(H-E)^2$, *with* $\phi = 20$.

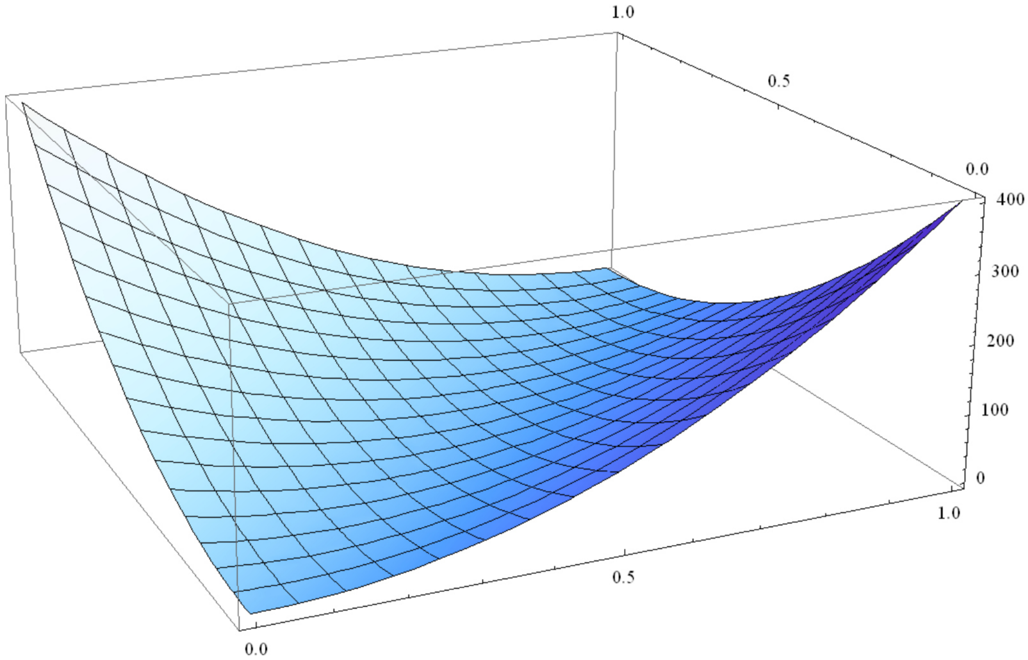

Figure 4: *Medical/health services demand* $M = \phi^2(H-E)^2$, *with* $0 \le H, E \le 1$ *and* $\phi = 20$.

$$d(H) = 250\sqrt{H}. \tag{16}$$

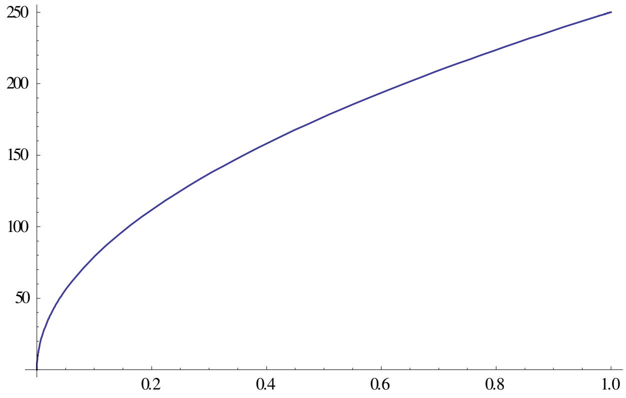

Figure 5: *Labor time supply function Scenario I.*

$$w = \sqrt{H} \tag{17}$$

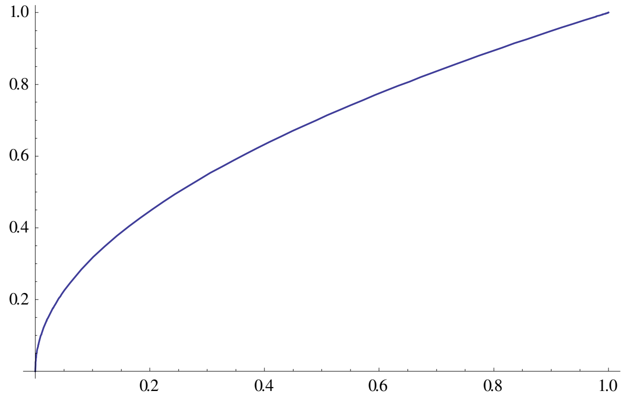

Figure 6: *Illustration of* wage rate *function Scenario I.*

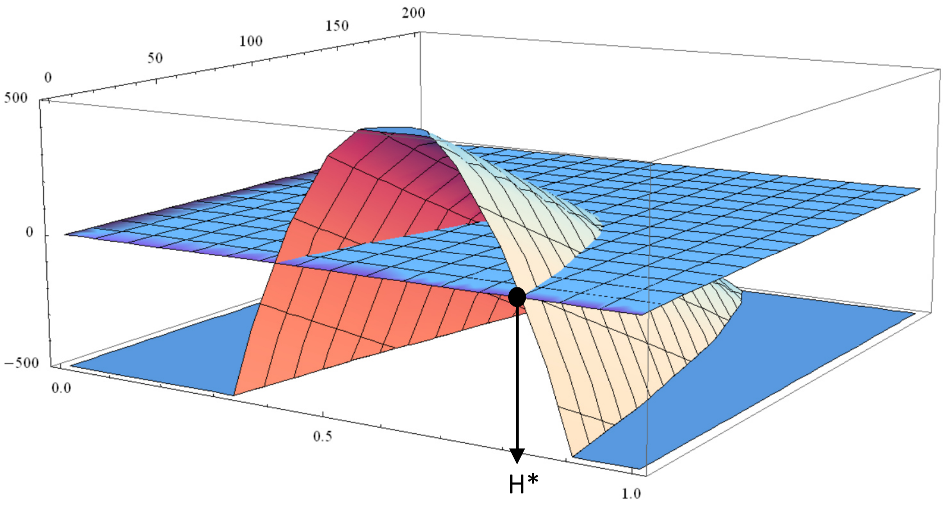

Figure 7: *Scenario I - utility maximization problem, with H*=0.71 and U*=8.8.*

8.2 Medical/health Services Companies:

$$\Pi^M = (P(H) - C(H))M. \tag{18}$$

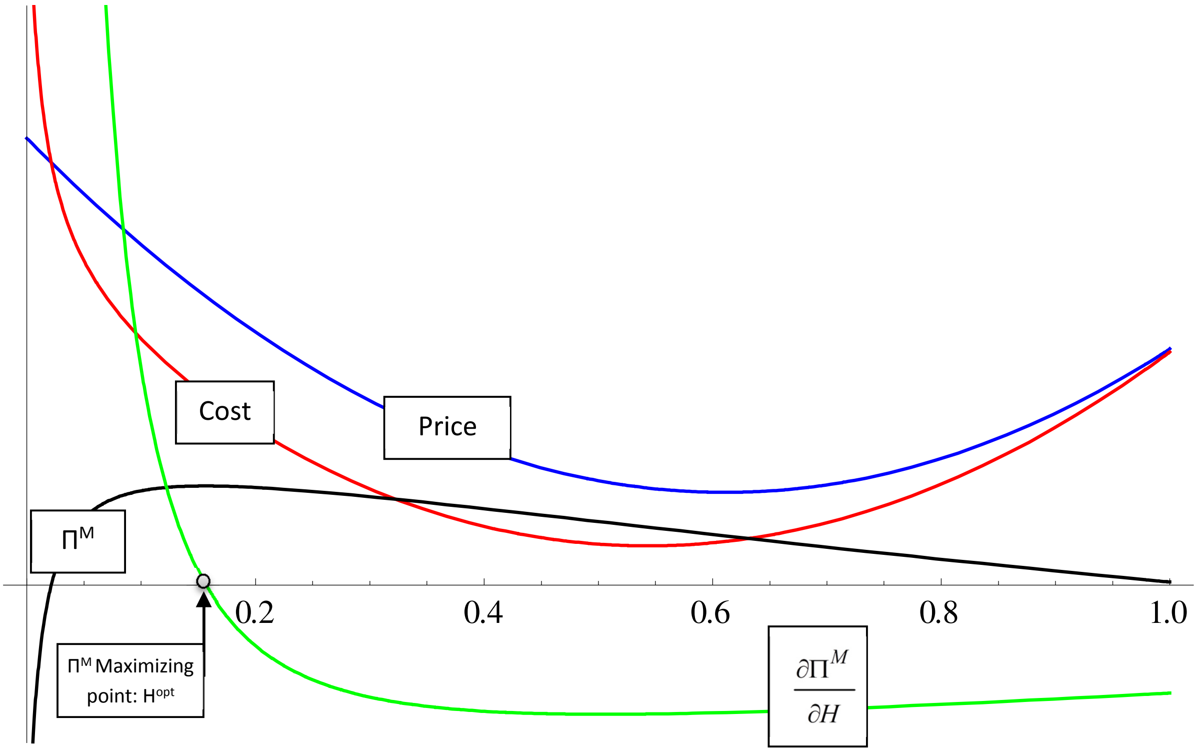

Figure 8: *Medical companies' net unit profit* Π^M, *net marginal profit, unit cost and price function.*

8.3 Consumption Good Producers:

$$\Pi^Z = 25\sqrt{250\sqrt{H}} - 250H \tag{19}$$

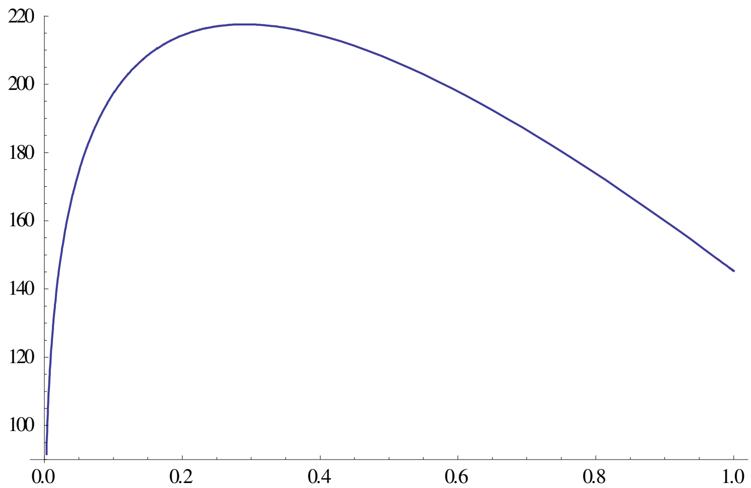

Figure 9: *Scenario I - Consumption good company's net profit function*

8.4 Illustration of Inter-temporal Scenarios and Resulting Market Outcomes

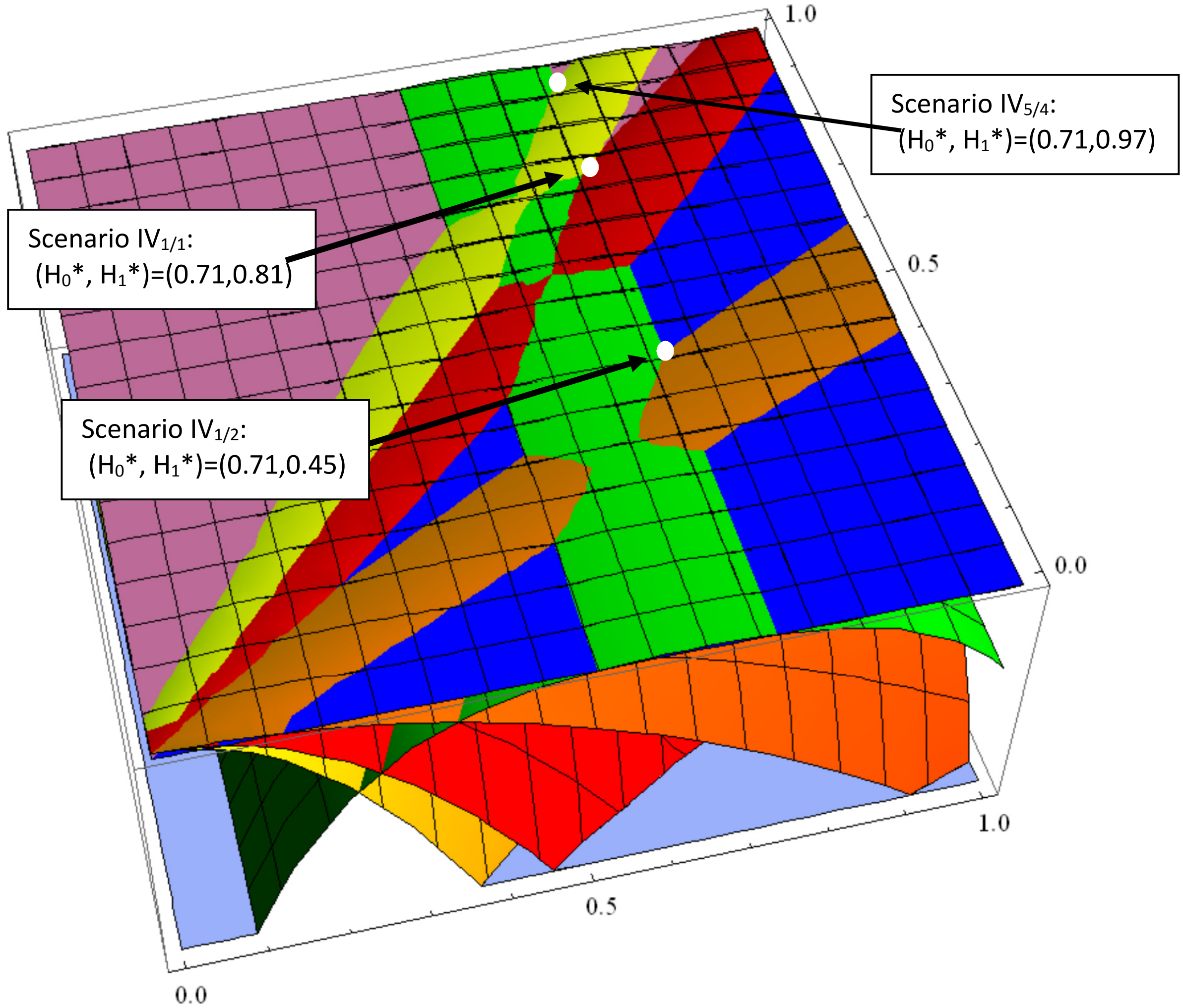

Figure 10: *Scenario IV - Illustration of differences in optimal health levels*