



Two-Sided Information Asymmetry in the Healthcare Industry

Iván Major^{1,2,3} 

Published online: 3 May 2019
© The Author(s) 2019

Abstract The healthcare sector is one of the largest industries in most countries. It is also an outstanding case for a multi-tier system of the participating parties' incentives and their conflicting interests. This paper focuses on a few of the multifactorial interrelationships between the different actors in healthcare services. The novel approach of this paper is the assumption of double-information asymmetry between the transacting parties that describes the actors' relationships more realistically than the traditional principal-agent models. It will be shown that any system of incentivization may only apply perverse incentives in this case. Notably, efficient, high-quality healthcare units will be punished while less efficient and lower quality ones will be rewarded for their accomplishment. The theoretical analysis is supported by facts regarding Central and Eastern-European countries. Some symptoms and causes of the current decline can also be found in advanced West European countries and even in the United States. They are closely related to the ill-designed regulatory systems of publicly funded healthcare in these countries.

Keywords Asymmetric information in healthcare · Incentive theory · Two-sided information asymmetry

JEL C73 · D82 · I11

✉ Iván Major
major.ivan@krtk.mta.hu; imajor@ucsd.edu; major@kgt.bme.hu

¹ Present address: Institute of Economics, CERS, H.A.S, Tóth Kálmán u. 7, Budapest H-1097, Hungary

² University of California San Diego, 9500 Gilman Drive, La Jolla, CA 92093, USA

³ Budapest University of Technology and Economics, Magyar tudósok körútja 1/b, Budapest H-1117, Hungary

Introduction

The health care sector has become one of the largest industries in most of the advanced and medium-developed countries. It is also an outstanding case for a complex multi-tier system of participating party incentives and frequently of conflicting interests. Since Kenneth Arrow (1963) first addressed the issues of asymmetric information in health insurance, several authors discussed the impact of asymmetric information on the quality and cost of medical services. (e.g., Ellis and McGuire 1986, Ma and McGuire 1997, De Fraja 2000, Chalkley and Malcomson 2002 and Siciliani 2006, Barile et al. 2014, Beeknoo and Jones 2017, Frank et al. 2000) However, their papers focused on one-sided asymmetric information between physicians and their patients or between health care institutions (hospitals) and the health care funding agency. As is well-known from the literature, one-sided asymmetric information in a transaction will result in welfare loss and in cost efficiency loss. (e.g., Laffont and Martimort 2002) Should regulators apply cost-based regulatory tools rather than incentive-based methods, the loss becomes even larger.¹ This loss can only be reduced, but cannot be fully annihilated, even by incentive-based regulation.

This paper's main contribution to the existing literature is the analysis of the relationship of the participants in health care services and health care funding when information asymmetry between them is two-sided. That is, both participants (the patient and their physician, the doctor and their hospital, the hospital and the health care funding agency) possess private information. (Herein the physician will be a "she" and the patient a "he".) This will lead to completely different results than what the previously mentioned authors have found.

A circle model will be presented that starts from the relationship between the physician and patient, then turns to the relationship between the physician and health care institution. The model continues with the relationship between the health care institution and the public health funding agency (PHFA) (the Social Security Administration in the U.S.) and ultimately with the government.² Then the model chain returns to the potential and actual patients through the relationship between the government and the taxpayers who ultimately finance the health care system. A brief discussion of the differences between Central and Eastern European (CEE) countries and Western advanced countries follows, focusing on the level of information asymmetry and its consequences in these two groups of countries.

Asymmetric Information and Asymmetric Competence in Health Care Services

As mentioned before, the problem of information uncertainty in health care services has been discussed by several authors, but Kenneth Arrow (1963), the pioneer of the topic summarized who first designed a formal theoretical model, based on the economics of information, to analyze the issues related to asymmetric information in health care, mostly in health insurance services. Some of the additional important studies on this

¹ See, Major and Kiss (2013) on cost-based pricing in regulated industries, especially in telecommunications.

² In some countries, health care services are mostly privately funded. An outstanding case is the United States, where a large share of the population can access medical services if covered by private insurance. However, asymmetric information between the transacting parties will have similar effects as in publicly funded systems.

Table 1 Case (a): Inefficient doctor's LLC and efficient doctor's adverse selection ICC are binding

	Efficient Physician	Inefficient Physician
	$\frac{\partial[\pi^H u_i(\bar{s}_i, \bar{q}_i) + (1-\pi^H)u_i(\underline{s}_i, \bar{q}_i)]}{\partial \bar{q}_i} =$	$\frac{\partial[\pi^L u_i(\bar{s}_i, \underline{q}_i) + (1-\pi^L)u_i(\underline{s}_i, \underline{q}_i)]}{\partial \underline{q}_i} =$
Patient	$\frac{dw_i(\bar{q}_i)}{d\bar{q}_i} + \frac{d\bar{c}(\bar{q}_i)}{d\bar{q}_i}$	$\frac{dw_i(\underline{q}_i)}{d\underline{q}_i} + \frac{d\underline{c}(\underline{q}_i)}{d\underline{q}_i} + \frac{\nu^H}{1-\nu^H} \cdot \frac{d\Delta c(q_i)}{d\underline{q}_i}$
	Physician performs at her first best level and receives information rent. Patient receives high quality and efficient service.	Inefficient physician's service level is distorted downwards, thus he receives less than expected. Patient saves more on payment.

Notes: LLC: limited liability constraint; ICC: incentive compatibility constraint. Optimum solutions displayed

subject are: Maynard and Bloor (2003), Choné and Ma (2004), Bolin et al. (2010), and Leonard et al. (2013). These studies are considered as the point of departure but this paper tries to dig deeper. The latest results of the theory of mechanism design will be applied. (e.g., Maskin 2008 and Myerson 2008).

Patient–Physician Relationship

The relationship between the physician and the patient will be discussed first, focusing on asymmetric information between them.³ It is obvious that the medical doctor does not work in a vacuum and does not autonomously make decisions, but competes for better positions, for prestige and, finally, for higher remuneration and cost compensation with other physicians within the facility. At the same time, she is part of a team and a complex hierarchy of interrelationships within her own institution that may also have a considerable impact on treatment efficiency. When the paper starts discussing the physician-patient relationship, it is obvious that this is a simplified approach to the complex interrelationships within an institution's medical staff. This simplification just serves as a more transparent description of the transactions between patients and medical doctors.

No distinction is made between asymmetric information and asymmetric power affecting the patient–doctor relationship in the analytical model that follows, but it is assumed that the physician has private information and private knowledge about medical assistance that results in moral hazard and adverse selection issues within their relationship. That is, the patient cannot monitor the doctor's effort level, and he has only probabilistic knowledge about the doctor's efficiency level.

The patient's and the physician's relevant variables and objective functions are presented in the framework of one-sided information asymmetry first. That is, it is assumed that it is the doctor who has private information with regard to the patient. However, these cases will not

³ Since patients can easily access health information on the Internet and on other online sources, information asymmetry between patients and physicians regarding symptoms, even diagnosis and treatment options has considerably decreased, especially in advanced countries. (Major and Ozsvald 2018). However, asymmetry regarding competence (i.e., physicians know much more how to actually analyze and treat symptoms and diseases) still prevails. Competence issues are not separately analyzed in this paper.

Table 2 Case (b): Adverse selection ICC of the efficient doctor and moral hazard ICC are binding

	Efficient Physician	Inefficient Physician
	$\frac{\partial[\pi^H u_i(\bar{s}_i, \bar{q}_i) + (1-\pi^H)u_i(\underline{s}_i, \bar{q}_i)]}{\partial \bar{q}_i} =$ $\frac{dw_i(\bar{q}_i)}{d\bar{q}_i} + \frac{d\bar{c}(\bar{q}_i)}{d\bar{q}_i}$	$\frac{\partial[\pi^L u_i(\bar{s}_i, \underline{q}_i) + (1-\pi^L)u_i(\underline{s}_i, \underline{q}_i)]}{\partial \underline{q}_i} =$ $\frac{dw_i(\underline{q}_i)}{d\underline{q}_i} + \frac{d\underline{c}(\underline{q}_i)}{d\underline{q}_i} +$ $\left(\frac{\nu^H}{1-\nu^H} - \lambda\Delta\nu\right) \cdot \frac{d[\Delta c(q_i)]}{dq_i}$
Patient	Physician performs at her first best level and receives information rent. Patient receives high quality and efficient service.	Inefficient physician's service level is distorted downwards less than in case (a), he receives somewhat less than expected. Patient saves less on payment.

Notes: ICC: incentive compatibility constraint. Optimum solutions displayed

be discussed in detail because they are just the obvious repetitions of the classical information asymmetry models (e.g., Laffont and Martimort 2002). Tables 1, 2 and 3 display the optimum outcomes of these cases, because the paper intends to focus on those cases where both the patient and the doctor possess private information. Consequently, they can and usually will opt for a mixed strategy.

In order to simplify the analysis it is assumed that the patient's health condition, given by a dichotomous variable s_i , will improve (\bar{s}_i) with probability π^H or with probability π^L , respectively, if the doctor's medical service is efficient or inefficient. It is also assumed that $\pi^H > \pi^L$; and the patient's condition does not improve (\underline{s}_i), it can even deteriorate, with probability $1 - \pi^H$ or $1 - \pi^L$ when treatment is efficient or inefficient. The doctor cannot foresee the patient's post-treatment condition before starting treatment. Only the probabilities given previously are known.

The quantity of examinations and treatment, measured in homogenous disease group (HDG) scores is denoted by q which can be large (\bar{q}_i) or small (\underline{q}_i). Another

Table 3 Case (c): Inefficient doctor's LLC and moral hazard ICC are both binding

	Efficient Physician	Inefficient Physician
	$\frac{\partial[\pi^H u_i(\bar{s}_i, \bar{q}_i) + (1-\pi^H)u_i(\underline{s}_i, \bar{q}_i)]}{\partial \bar{q}_i} =$ $\frac{dw_i(\bar{q}_i)}{d\bar{q}_i} + \frac{d\bar{c}(\bar{q}_i)}{d\bar{q}_i}$	$\frac{\partial[\pi^L u_i(\bar{s}_i, \underline{q}_i) + (1-\pi^L)u_i(\underline{s}_i, \underline{q}_i)]}{\partial \underline{q}_i} =$ $\frac{dw_i(\underline{q}_i)}{d\underline{q}_i} + \frac{d\underline{c}(\underline{q}_i)}{d\underline{q}_i}$
Patient	Physician performs at her first best level, but does not receive an information rent. Patient receives high quality and efficient service.	Inefficient physician's service level is at its first best level, but does not receive an information rent. Patient receives what he expected.

Notes: LLC: limited liability constraint; ICC: incentive compatibility constraint. Optimum solutions displayed

assumption is that the time span of the patient's medical treatment is a linear function of the quantity of examinations and treatment. For this reason, it is not explicitly plugged into the model, but it will be incorporated in q_i . Patient i , as principal, seeks medical treatment from the physician (from his agent) and his valuation function on the treatment is given by:

$$u_i(s_i, q_i) - w_i(q_i) - \alpha p_i(s_i, q_i) - M_i, \quad (1)$$

where $u_i(s_i, q_i)$ is the patient's benefit from medical assistance in monetary terms. The patient's benefit consists of several contributing factors, such as, e.g., his income under healthy conditions, the value of his time for relaxation, the value of services he provides for his family, etc.⁴

It is assumed about $u_i(s_i, q_i)$ that $\frac{\partial u_i(s_i, q_i)}{\partial q_i} \geq 0$; $\frac{\partial^2 u_i(s_i, q_i)}{\partial^2 q_i} \leq 0$ if $q_i \in [0, q_i^*]$, or $\frac{\partial u_i(s_i, q_i)}{\partial q_i} < 0$; $\frac{\partial^2 u_i(s_i, q_i)}{\partial^2 q_i} > 0$ if $q_i > q_i^*$. These conditions imply that the patient attaches higher value to a more profound and longer treatment up to a certain point, although his marginal utility is decreasing along with the treatment, but her total utility starts decreasing beyond that point.

$w_i(q_i)$ is the patient's lost wage or income due to the treatment for which $\frac{dw_i(q_i)}{dq_i} = w_i$, i.e., the lost wage is a linear function of the treatment's time span and intensity. $p_i(s_i, q_i)$ is the patient's gratitude payment he pays directly to the doctor for medical attendance when medical services are funded and provided by public organizations. Alternatively, it can be the financial compensation for health care services in private health care facilities, for which $\frac{\partial p_i(s_i, q_i)}{\partial q_i} > 0$, $\frac{\partial^2 p_i(s_i, q_i)}{\partial^2 q_i} \leq 0$; $\alpha \in [0, 1]$ is the parameter signaling the doctor's professional position in the medical hierarchy normalized to one.

Furthermore, it is assumed that the patient pays a higher gratuity to the doctor—the amount of which is directly related to the physician's accomplishment—when his health condition is improving than if his condition does not improve or it deteriorates: $p_i(\bar{s}_i, \bar{q}_i) > p_i(\underline{s}_i, \bar{q}_i)$ and $p_i(\bar{s}_i, \underline{q}_i) > p_i(\underline{s}_i, \underline{q}_i)$; $M_i = \sum_n m_i(n)$ is the patient's total contribution (tax) payment to the PHFA up to the date (denoted n) when he fell ill.

The patient seeks to maximize his net utility as given in eq. (1), observing the doctor's financial constraints. The patient cannot precisely monitor the doctor's effort level, nor does he know the doctor's exact efficiency level. He only has the following probabilistic information about his physician: the conditional probability of receiving an efficient treatment, provided that the doctor exerts high effort, is ν^H , hence, the probability of obtaining inefficient treatment despite the doctor's high effort is $1 - \nu^H$. In a similar vein, the conditional probabilities of receiving efficient or inefficient treatment with the doctor's low effort are respectively, ν^L and $1 - \nu^L$.

The physician as the agent also maximizes her own utility for which her evaluation function is:

⁴ The factors of demand for health care services will not be discussed in detail in this paper. A profound analysis of demand for health care is given by Grossman (1972), Picone et al. (1998) and Szabó (2015).

$$v_i(q_i, e_i) = \sum_{i=1}^N (\alpha b_i + \alpha p_i(q_i) - c(q_i) - \psi(e_i)), \quad (2)$$

where N is the number of patients treated by the doctor, αb_i is the share of the doctor's financial compensation (salary) directly related to treating patient i , and $c_i(q_i)$ is the total direct cost incurred by the doctor from treating this patient, while $\psi(e_i)$ is the doctor's effort cost for patient i . Thus, $\sum_{i=1}^N \alpha b_i = b$ is independent of the physician's accomplishment. It is usually derived—especially in European countries—from the nationwide salary scale of public employees, which depends on $\sum_{i=1}^N M_i$ and on other exogenous factors.

The problems stemming from asymmetric information and asymmetric competence between the physician and the patient are complicated by the fact that many of the factors affecting their transactions are exogenous. For instance, $\sum_{i=1}^N \alpha b_i = b$ is determined by public agencies, while $M_i = \sum_n m_i(n)$ depends on the taxation rules and on the patient–PHFA relationship.

The patient–doctor relationship is complicated even further by another factor. While the physician's net benefit decreases with increasing costs, the doctor—as an employee of a health care facility—may inflate these costs. For example, she can order unnecessary diagnostics and other examinations the costs of which will then become a bargaining chip in the negotiations between the health care unit and the PHFA. This issue will be analyzed later. Because of these indirect effects, the factors affecting a specific transaction by asymmetric information and competence—say, between the patient and his doctor—may have additional impacts on other, but closely related transactions. Consequently, the optimal solutions for the individual transactions can only be derived by solving a system of simultaneous equations. The paper starts analyzing the patient–doctor relationship keeping this fact in mind.

The patient cannot closely monitor the doctor's effort level and he does not know the physician's efficiency level either. He only knows that the doctor incurs an effort cost of $\psi(e_H) = \psi$ with high effort, or an effort cost of $\psi(e_L) = 0$ with low effort. In addition, the patient knows that the physician may operate at a high or at a low efficiency level with the previously given probabilities. Her efficiency level is directly related to her effort.

As mentioned, treating the patient comes with treatment costs $c(q_i)$ besides the doctor's cost of effort. It was assumed that the doctor's cost function is identical by type across all of her patients, hence her treatment costs will only depend on the quantity q_i of medical services she provides to individual patients. As already briefly mentioned, the doctor is capable of elevating her level of competence (that is, her efficiency), and that will reduce her treatment costs. The high level of treatment will be denoted by \bar{q}_i , while the low level of treatment is denoted \underline{q}_i . In a similar vein, $\bar{c}(\bar{q}_i)$ denotes the costs of efficient treatment, while $\underline{c}(\underline{q}_i)$ labels the costs of inefficient treatment.

The doctor intends to maximize her own utility, therefore she will treat the patient with high effort only if her participation, incentive compatibility and limited liability constraints are respected.⁵ From the patient's perspective, medical treatment is at

⁵ The doctor's professional activity is, of course, influenced by legal, organizational and health care regulatory rules and protocols, by moral codes and by other government regulations, besides her utility maximization. However, these factors do not alter the fact that the doctor has an information monopoly in her relationship with the patient, and also with her medical institution.

optimum if he incurs the smallest amount of side payment (gratuity payment) at a given level of treatment. This outcome can be attained if the doctor's constraints are fulfilled with equality in the largest feasible number.

The information rent of the efficient physician will be affected by the relative strength of the impact of adverse selection and moral hazard. Different constraints may be binding depending on the probability distribution of efficiency types and effort level, and on the magnitude of the effort cost. Three different cases can be distinguished depending on which of the physician's constraints are binding. Which constraints of the different efficiency types will be binding will depend on the relative magnitude of the information rent and effort cost. The outcomes of these cases are presented in Tables 1, 2 and 3.

The physician's incentivization becomes a much more complex task if the doctor opts for a mixed strategy since she does not possess all the relevant information about her patient and she also knows that the patient's health condition will improve with less than a probability of 1 after his treatment. Patients can also withhold information that results in a two-sided information asymmetry between the patient and his doctor. The doctor's incentivization becomes perverse under a mixed strategy: it punishes the efficient physician while it extends rewards to the inefficient ones. It is assumed that the patient is also aware of the fact that his doctor exerts high effort, consequently, she provides efficient service only with a less than unit probability. The mixed probabilities of the physician can be calculated from the doctor's indifference condition:

$$\rho \left[\pi^H \left(\alpha b_i + \alpha \bar{p}_i - \bar{c}_i - \psi_i \right) + (1 - \pi^L) \left(\alpha b_i + \alpha \underline{p}_i - \bar{c}_i - \psi_i \right) \right] = (1 - \rho) \left[\pi^L \left(\alpha b_i + \alpha \bar{p}_i - \underline{c}_i \right) + (1 - \pi^L) \left(\alpha b_i + \alpha \underline{p}_i - \underline{c}_i \right) \right]. \quad (3)$$

That is, the doctor exerts high effort only with probability $\rho = \frac{\alpha b_i + \alpha \bar{p}_i - \alpha \pi^H \Delta p_i - \underline{c}_i}{2\alpha b_i + \Delta c_i + \alpha \Delta \pi \Delta p_i - \psi_i}$ in order to provide efficient service. She chooses a low effort level that may result in an inefficient medical service with probability $1 - \rho$, where p_i is the doctor's gratuity with low effort, \underline{c}_i and \bar{c}_i are the costs of inefficient and efficient service, respectively, and $\Delta p_i = \bar{p}_i - \underline{p}_i$, $\Delta \pi = \pi^H - \pi^L$, $\Delta c_i = \underline{c}_i - \bar{c}_i$.

Real life experience from several Eastern European health care systems attests that the above assumption about the doctors' mixed strategy is not a pure theoretical assumption. Medical doctors exert only the minimum level of effort in order to save their patients from dying but they do not want their patients to recover too quickly. If patients stay longer at the hospital, the doctors can receive larger side payments during that period and report higher costs of treatment to the PHFA (Table 4).

Only the case when the adverse selection incentive compatibility constraint (ICC), of the efficient doctor and the limited liability constraint (LLC) of the inefficient doctor are binding will be discussed.⁶ In addition, only the first order conditions of the patient's optimization problem will be presented here, with efficient service:

⁶ As in the previous analysis on one-sided asymmetric information, the other scenarios can be obtained in a similar way, and are not described here in detail.

Table 4 If the PHFA’s expenses of incentivizing the efficient hospital to exert high effort are below the hospital’s information rent, the adverse selection ICC of the efficient hospital and the LLC of the inefficient hospital will bind

PHFA (untrustworthy)	
Efficient Hospital	$\frac{\partial H^h}{\partial q^h} = \frac{\mu_h \pi \left(\frac{\partial K^h_h}{\partial q^h} \right) + (1-\mu_h)(1-\rho) \left(\frac{\partial K^h_\ell}{\partial q^h} \right) + (1-\rho) \left(\frac{\partial \Delta K^h}{\partial q^h} \right)}{[\mu_h \pi + (1-\mu_h)(1-\rho)]}$ $\frac{\partial H^h}{\partial t^h} = \frac{\mu_h \pi \left(\frac{\partial K^h_h}{\partial t^h} \right) + (1-\mu_h)(1-\rho) \left(\frac{\partial K^h_\ell}{\partial t^h} \right) + (1-\rho) \left(\frac{\partial \Delta K^h}{\partial t^h} \right)}{[\mu_h \pi + (1-\mu_h)(1-\rho)]};$ <p style="text-align: center;">Level of service is below its optimum</p>
Inefficient Hospital	$\frac{\partial H^\ell}{\partial q^\ell} = \rho \left(\frac{\partial K^\ell_\ell}{\partial q^\ell} \right) - \mu_h (\pi + \rho - 1) \left(\frac{\partial K^h_h}{\partial q^\ell} \right)$ $\frac{\partial H^\ell}{\partial t^\ell} = \rho \left(\frac{\partial K^\ell_\ell}{\partial t^\ell} \right) - \mu_h (\pi + \rho - 1) \left(\frac{\partial K^h_h}{\partial t^\ell} \right)$ <p style="text-align: center;">Level of service is above its optimum</p>

Notes: ICC: incentive compatibility constraint; LCC: limited liability constant

$$\frac{d \left[\pi^H u_i(\bar{s}_i, \bar{q}_i) + (1-\pi^H) u_i(\underline{s}_i, \bar{q}_i) \right]}{d\bar{q}_i} = \frac{d\bar{c}(\bar{q}_i)}{d\bar{q}_i} + \rho \left(\frac{d\Delta c(\bar{q}_i)}{d\bar{q}_i} \right) + \frac{dw_i(\bar{q}_i)}{d\bar{q}_i} \tag{4}$$

while in case the service is inefficient:

$$\frac{d \left[\pi^L u_i(\bar{s}_i, q_i) + (1-\pi^L) u_i(\underline{s}_i, q_i) \right]}{dq_i} = \frac{d\Delta c(q_i)}{dq_i} - \left(\frac{\rho \nu^H + (1-\rho)\nu^L}{\rho(1-\nu^H) + (1-\rho)(1-\nu^L)} \right) \cdot \left(\frac{d\Delta c(q_i)}{dq_i} \right) + \frac{dw_i(q_i)}{dq_i} \tag{5}$$

As can be seen from eqs. (4) and (5), the level of efficient service will be below, while the inefficient service’s level will be above its optimum. That is, the efficient doctor exerts only so much effort and service that the patient’s condition does not deteriorate—but it does not necessarily improve either, while the inefficient doctor over-treats patients.

Interrelationships between the Physician and her Medical Institution

Health care professionals work in different medical organizations with diverse working conditions. For instance, there is a profound difference between the institutional background and the interests of a primary care physician and those of a doctor who works at a national clinic. The following analysis is simplified to the basic conditions in

order to focus on the issues of asymmetric information between, and different interests of, the health care staff and its institution. The health care facility will be labelled as the hospital that requires health care services from the doctor.

As the principal, the hospital expects efficient treatment of her patients and high effort in medical activities from the doctor (the agent) in this relationship. However, the hospital cannot closely monitor the doctor's effort level, nor can it exactly know the doctor's efficiency type. The management of the hospital only knows that in case the doctor exerts high effort, her accomplishment can be efficient with probability ν^H , while it can be inefficient with probability $1 - \nu^H$. Should the doctor exert low effort, the probability of efficient or inefficient treatment will be ν^L or $1 - \nu^L$, respectively. The hospital's main interest is to maximize the number of patients ($I = M \cdot N_j$), but it faces the following budget constraint: $\sum_{j=1}^M \sum_{i=1}^{N_j} K_i(q_i) \leq \bar{K}$, where $K_i(q_i)$ is the treatment cost of patient i , which comprises both the flow expenditures and the investment and maintenance costs—but not the wage costs—per patient, N_j is the number of patients treated by doctor j , M is the number of doctors at the hospital, while \bar{K} is the hospital's budget received from the PHFA except the hospital's wage costs. The hospital's financial resources can be the planned amount pre-announced by the PHFA with probability ω , but it can be below the promised amount with probability $1 - \omega$. These probabilities are known both by the hospital and by the patients.

The doctor strives to maximize net utility that can be described with regard to the patient-doctor relationship before, with one exception: the doctor seeks to receive the largest amount possible from the hospital's budget:

$$\sum_{i=1}^{N_j} \alpha b_i + \sum_{i=1}^{N_j} K_i(q_i) - \sum_{i=1}^{N_j} c_i(q_i) - \sum_{i=1}^{N_j} \psi_i, \quad (6)$$

where

$$\sum_{i=1}^{N_j} \alpha b_i$$

is the doctor's salary based on the salary scale of public employees, $K_i(q_i)$ consists of the treatment costs of patient i incurred by the hospital, $\sum_{i=1}^{N_j} c_i(q_i)$ is the total cost incurred by the doctor while treating her patients, while $\sum_{i=1}^{N_j} \psi_i$ is the doctor's effort costs.

If the physician pursues a pure strategy, choosing either the accomplishment and effort level of the efficient doctor or those of the inefficient doctor, the information asymmetry between the hospital and the doctor results in similar solutions that could already be seen in the patient–physician relationship. Therefore, the feasible solutions of the hospital's net benefit maximization are not derived here, since these can be easily obtained by substituting the hospital's benefit and cost functions into the previous model on the patient–doctor relationship.

As shown in the patient–physician model previously, should the doctor observe an unambiguous and trustworthy strategy from the hospital and she also opts for a pure strategy, the hospital will extend positive incentives or punishment to the doctors which will incentivize them to act according to their efficiency type and exert the expected effort level. By extensive experience, hospitals in several countries rarely apply this type of incentive regulation because the hospitals' managements also face much uncertainty and cutbacks of their institution's public financial resources by the PHFA.

Consequently, they struggle for survival. In addition, the hospitals' managements should have the financial resources to be able to pay the information rent to the efficient doctors as the doctors' incentive pay.

Being aware that the hospital's public budget is uncertain if the doctor opts for a mixed strategy, the hospital will only be able to extend perverse incentives. That is, as a result of the hospital's budget allocation, the efficient doctor will have a lower than optimal accomplishment and exert the minimum level of effort, while the inefficient doctor will have a higher than optimal accomplishment, and both of them may strive for enforcing side payments from their patients. Consequently, the hospital's expenses will exceed the optimal level.

Interrelations between the Government (the PHFA) and the Health Care Institutions

The objectives of different government agencies constitute a fairly complex bundle of goals. The ministry or department of health care (with the professional organizations backing) intends to enforce professional rules and considerations, while the PHFA strives to meet the budgetary target directives of the central government. At the same time, the PHFA plays its own game with the ministry of finance and with the parliament in European countries, or with the Senate and Congress in the United States that ultimately decide on the government's budget. The analysis of the central health care budget allocation is simplified to the informational and bargaining relationships between the PHFA and the medical facilities. Herein, these medical facilities are labelled as hospitals, although there are crucial differences in the financing methods and operational conditions among the hospitals, the outpatient clinics and the primary care physicians. We only involve PHFA in this discussion.

The PHFA—the government agency responsible for financing public health care from the government budget—sets the maximum budget for the hospital. The public budget can be a high amount, B^h or at a low level, B^l independent of the hospital's achievement. The PHFA's main objective is to maximize the difference between the financial value of the hospital's accomplishment—measured in HDG scores—and its public budget. The hospital is capable of improving its cost efficiency level by effort, but the PHFA cannot closely monitor the hospital's effort level, nor does it know the hospital's efficiency level with certainty. It only knows that the hospital provides efficient health care services with probability μ_h if it exerts high effort, or the hospital's efficiency level may still remain low despite its high effort with probability $1 - \mu_h$. The hospital's cost efficiency is affected by several exogenous factors as well. Hence, it can attain high efficiency despite low level of effort with probability μ_ℓ , or its efficiency remains low with probability $1 - \mu_\ell$. It is an obvious assumption that $\mu_h > \mu_\ell$.

The hospital maximizes its net total revenue which is the difference between its budget allocated to the hospital by the PHFA on the one hand, and its costs of operation plus its labor, investment, and maintenance costs on the other. At the same time, the hospital cannot be certain that it will receive the promised budget from the PHFA. It only knows that the PHFA's promises about the hospital's budget can be trusted with probability ω , but the PHFA is untrustworthy with probability $1 - \omega$. Then the hospital must decide whether it opts for a pure or for a mixed strategy, where the weights of its different strategy options can be calculated from the probabilities of the PHFA's trustworthiness or untrustworthiness, respectively. Since the hospital

cannot be fully confident about the PHFA's promises, it may opt for a mixed rather than for a pure strategy by taking into account the probability of the PHFA's trustworthiness. Only the case of mixed strategies will be discussed here, for the pure strategy cases are very similar to the ones presented with regard to the patient-doctor relationship.

The net financial benefit of the efficient hospital from treating $I = M \cdot \sum_{j=1}^{N_j} i_j$ patients with high effort is

$$U_h^h(h) = \sum_{j=1}^M \sum_{i=1}^{N_j} B_{i,j}^h - \sum_{j=1}^M \sum_{i=1}^{N_j} \alpha_j b_{i,j} - \sum_{j=1}^M \sum_{i=1}^{N_j} K_{h(i,j)}^h(t_{i,j}^h, q_{i,j}^h) - \sum_{j=1}^M \sum_{i=1}^{N_j} \psi_{i,j}, \quad (7)$$

with probability μ_h . With efficient treatment but low effort level it will be

$$U_h^\ell(h) = \sum_{j=1}^M \sum_{i=1}^{N_j} B_{i,j}^h - \sum_{j=1}^M \sum_{i=1}^{N_j} \alpha_j b_{i,j} - \sum_{j=1}^M \sum_{i=1}^{N_j} K_{\ell(i,j)}^h(t_{i,j}^h, q_{i,j}^h), \quad (8)$$

with probability μ_ℓ , when the hospital is confident that it will receive its budget promised by the PHFA. With the hospital's inefficient accomplishment but its high effort, and with trustworthy PHFA, the hospital's net benefit is

$$U_h^\ell(\ell) = \sum_{j=1}^M \sum_{i=1}^{N_j} B_{i,j}^\ell - \sum_{j=1}^M \sum_{i=1}^{N_j} \alpha_j b_{i,j} - \sum_{j=1}^M \sum_{i=1}^{N_j} K_{h(i,j)}^\ell(t_{i,j}^\ell, q_{i,j}^\ell) - \sum_{j=1}^M \sum_{i=1}^{N_j} \psi_{i,j}, \quad (9)$$

with probability $1 - \mu_h$. It will become, with low effort level and inefficient services,

$$U_h^\ell(\ell) = \sum_{j=1}^M \sum_{i=1}^{N_j} B_{i,j}^\ell - \sum_{j=1}^M \sum_{i=1}^{N_j} \alpha_j b_{i,j} - \sum_{j=1}^M \sum_{i=1}^{N_j} K_{\ell(i,j)}^\ell(t_{i,j}^\ell, q_{i,j}^\ell) \quad (10)$$

with probability $1 - \mu_\ell$, where $I = M \cdot \sum_{j=1}^{N_j} i_j$ is the number of the hospital's patients, if the size of the health care personnel in the hospital is M , and employee j provides medical services to N_j patients. Public funds allocated to this hospital at a high level are $\sum_{j=1}^M \sum_{i=1}^{N_j} B_{i,j}^h$, while the low level budget is $\sum_{j=1}^M \sum_{i=1}^{N_j} B_{i,j}^\ell$. Total wages paid to the hospital's personnel are $\sum_{j=1}^M \sum_{i=1}^{N_j} \alpha_j b_{i,j}$, and total costs of medical services will be $\sum_{j=1}^M \sum_{i=1}^{N_j} K_{i,j}^h(t_{i,j}^h, q_{i,j}^h)$ or $\sum_{j=1}^M \sum_{i=1}^{N_j} K_{i,j}^\ell(t_{i,j}^\ell, q_{i,j}^\ell)$ at high or at low efficiency level, respectively. The hospital's effort cost with high effort is $\sum_{j=1}^M \sum_{i=1}^{N_j} \psi_{i,j}$.

If the PHFA is untrustworthy, the efficient hospital's net financial benefit with high effort becomes, with probability μ_h

$$U_h^h(\ell) = \sum_{j=1}^M \sum_{i=1}^{N_j} B_{i,j}^\ell - \sum_{j=1}^M \sum_{i=1}^{N_j} \alpha_j b_{i,j} - \sum_{j=1}^M \sum_{i=1}^{N_j} K_{h(i,j)}^h(t_{i,j}^h, q_{i,j}^h) - \sum_{j=1}^M \sum_{i=1}^{N_j} \psi_{i,j}. \quad (11)$$

With low effort but high efficiency level the hospital's benefit will be, with probability μ_ℓ

$$U_h^\ell(h) = \sum_{j=1}^M \sum_{i=1}^{N_j} B_{i,j}^\ell - \sum_{j=1}^M \sum_{i=1}^{N_j} \alpha_j b_{i,j} - \sum_{j=1}^M \sum_{i=1}^{N_j} K_{h(i,j)}^\ell \left(t_{i,j}^h, q_{i,j}^h \right). \tag{12}$$

Should the hospital’s accomplishment be at the inefficient level despite its high effort, its net financial benefit will be, with probability $1 - \mu_h$

$$U_h^\ell(h) = \sum_{j=1}^M \sum_{i=1}^{N_j} B_{i,j}^h - \sum_{j=1}^M \sum_{i=1}^{N_j} \alpha_j b_{i,j} - \sum_{j=1}^M \sum_{i=1}^{N_j} K_{h(i,j)}^\ell \left(t_{i,j}^\ell, q_{i,j}^\ell \right) - \sum_{j=1}^M \sum_{i=1}^{N_j} \psi_{i,j}. \tag{13}$$

With low effort level it becomes, with probability $1 - \mu_\ell$

$$U_\ell^\ell(h) = \sum_{j=1}^M \sum_{i=1}^{N_j} B_{i,j}^h - \sum_{j=1}^M \sum_{i=1}^{N_j} \alpha_j b_{i,j} - \sum_{j=1}^M \sum_{i=1}^{N_j} K_{\ell(i,j)}^\ell \left(t_{i,j}^\ell, q_{i,j}^\ell \right). \tag{14}$$

For the sake of simplicity, the following notations are introduced:

$$\begin{aligned} b &= \sum_{j=1}^M \sum_{i=1}^{N_j} \alpha_j b_{i,j}, \psi = \sum_{j=1}^M \sum_{i=1}^{N_j} \psi_{i,j}, B_h = \sum_{j=1}^M \sum_{i=1}^{N_j} B_{i,j}^h, B_\ell = \sum_{j=1}^M \sum_{i=1}^{N_j} B_{i,j}^\ell, \\ K_h^h &= \sum_{j=1}^M \sum_{i=1}^{N_j} K_{h(i,j)}^h \left(t_{i,j}^h, q_{i,j}^h \right), K_\ell^h = \sum_{j=1}^M \sum_{i=1}^{N_j} K_{\ell(i,j)}^h \left(t_{i,j}^h, q_{i,j}^h \right), \\ K_h^\ell &= \sum_{j=1}^M \sum_{i=1}^{N_j} K_{h(i,j)}^\ell \left(t_{i,j}^\ell, q_{i,j}^\ell \right), K_\ell^\ell = \sum_{j=1}^M \sum_{i=1}^{N_j} K_{\ell(i,j)}^\ell \left(t_{i,j}^\ell, q_{i,j}^\ell \right), \end{aligned}$$

where the lower index of K stands for the hospital’s effort level and the upper index represents its efficiency.

The probabilities of the efficient and the inefficient hospital’s mixed strategies must be found first. The efficient hospital will choose the efficient strategy with probability π , while it will opt for the inefficient strategy with probability $1 - \pi$, where

$$\pi = \frac{(1-\omega)B_h - \omega B_\ell + (2\omega-1)K_h^\ell}{\Delta B - (2\omega-1)\Delta K_h}. \tag{15}$$

The inefficient hospital opts for a strategy compatible to its (in)efficiency level with probability ρ while it chooses the alternative strategy with probability $1 - \rho$, where:

$$\rho = \frac{\omega B_h - (1-\omega)B_\ell - (2\omega-1)K_\ell^h}{\Delta B - (2\omega-1)\Delta K_\ell}, \tag{16}$$

where $\Delta B = B^h - B^\ell$, $\Delta K_h = K_h^h - K_h^\ell$, and $\Delta K_\ell = K_\ell^h - K_\ell^\ell$, $\Delta K^h = K_\ell^h - K_h^h$, finally, $\Delta K^\ell = K_\ell^\ell - K_h^\ell$ at the relevant values of (t, q) .

Depending on the relative magnitudes of the information rent the PHFA needs to pay to the efficient hospital to incentivize it for high effort and to provide medical services at its efficiency level, on the one hand, and on the allocative efficiency loss from reducing the required accomplishment of the less efficient hospital in order to retain sufficient resources to pay the information rent on the other, different scenarios may

occur. The amount of the hospital's information rent is basically set by the relative strength of adverse selection and moral hazard. Only the final results of the two possible scenarios here that may occur in the relationship between the hospital and the PHFA with double information asymmetry are presented.

It can be concluded from the previous results that the government agencies use perverse incentives toward the hospital. They restrict the efficient hospital to a lower than optimum level of accomplishment by providing less than optimal level of public funding, while they allocate a larger than optimal budget to the less efficient hospital. By doing so the government agencies incentivize the hospital to strive for a larger than optimal level of accomplishment. Hence, the good types will be punished and the bad types will be rewarded.

Another option occurs, if incentivizing the hospital for high effort would cost more to the PHFA than the efficient hospital's information rent. In this case, the limited liability constraint of the inefficient hospital and the moral hazard ICC are binding. The hospital's information rent increases to such a level that it would not be a sensible solution for the PHFA to deteriorate the hospitals' allocative efficiency even further in order to save money for the information rent. However, perverse incentivization of the hospitals, incentivizing the efficient hospital to a lower than optimal level of accomplishment while inducing a higher than optimal level of performance from the inefficient hospital, does not cease to exist. Based on the previous analysis the readers can conclude that the hospitals' incentive regulation is not viable if the government agencies responsible for the management of the public health care sector are not trustworthy.

Asymmetric Information in the Relationship between Patients and the Governmental or State Agencies

The active population of most European countries (also the active part of society in several Asian, North and Latin American countries) pays a health care tax to the public health care budget (managed by the PHFA) and they expect to receive high quality service for their financial contribution. Actual and potential patients of the health care system can hope for high quality service if the state (the national parliament and the government) allocate a sufficiently large budget to the public health care institutions. The government uses the financial contribution of former, current and future patients to finance the medical institutions, but it is also interested in keeping as large a share as possible of the health care contributions within its budget to use for other purposes. That is, the government's objective is to maximize the difference between the citizens' financial health care contribution and its budget allocated to the health care system.

The economic and political factors affecting the government budget, the tax system and public health care funding are interrelated in an even more complicated way than what has been shown with regard to the other relationships affecting health care. However, the analysis is simplified by focusing on the information and money flow between patients and the government through the taxation and budget allocation system. Neither the patients nor the government possess perfect information about the other party's type and effort level. Patients only know that government can be trusted with probability ω , but it is untrustworthy with probability $1 - \omega$. The

government only knows that the patients’ health care contribution can attain a high level with probabilities σ_h or σ_ℓ if the patients exert high or low effort, respectively, but the patients’ financial contribution will be low with probabilities $1 - \sigma_h$ or $1 - \sigma_\ell$ at their high or low level of effort, respectively. It is assumed that the government strives to induce high effort from the patients. The objective function of patient i will be similar to the previous ones:

$$\max_{q_{i,j}^{i,j}} \{u(B_i) - E_i\}, \tag{17}$$

where B_i is the share of patient i from the health care budget, and E_i labels patient i ’s financial health care contribution. Since the government incentivizes the patient for high effort, his participation constraint will be:

$$\sigma_h(\omega u_i(B_i^h) + (1-\omega)u_i(B_i^\ell) - E_i^h) + (1-\sigma_h)(\omega u_i(B_i^\ell) + (1-\omega)u_i(B_i^h) - E_i^\ell) \geq 0,$$

which can be rearranged to

$$[(2\omega-1)\sigma_h + 1-\omega]u_i^h - [(2\omega-1)\sigma_h-\omega]u_i^\ell - (\sigma_h E_i^h + (1-\sigma_h)E_i^\ell) \geq 0. \tag{18}$$

The patient’s moral hazard ICC becomes:

$$\begin{aligned} & [(2\omega-1)\sigma_h + 1-\omega]u_i^h - [(2\omega-1)\sigma_h-\omega]u_i^\ell - \sigma_h E_i^h - (1-\sigma_h)E_i^\ell \geq \\ & [(2\omega-1)\sigma_\ell + 1-\omega]u_i^h - [(2\omega-1)\sigma_\ell + \omega]u_i^\ell - \sigma_\ell E_i^h - (1-\sigma_\ell)E_i^\ell, \tag{19} \\ & \text{that is, } u_i^h - u_i^\ell \geq \frac{\Delta E_i}{(2\omega-1)}, \text{ where } \Delta E_i = E_i^h - E_i^\ell, \end{aligned}$$

Let the total contribution of all patients be denoted $E = \sum_{i=1}^N E_i$, while the total health care budget allocated by the government is $B = \sum_{i=1}^N B_i$. Then the government’s objective function becomes:

$$\begin{aligned} & \max_{E_h, E_\ell} \left\{ \begin{aligned} & \omega[\sigma_h(V(E_h) - B_h) + (1-\sigma_h)(V(E_\ell) - B_\ell)] + \\ & (1-\omega)[\sigma_h(V(E_h) - B_\ell) + (1-\sigma_h)(V(E_\ell) - B_h)] \end{aligned} \right\} \tag{20} \\ & \text{that is, } \max_{E_h} \left\{ \begin{aligned} & \sigma_h V(E_h) + (1-\sigma_h)V(E_\ell) - \\ & [(2\omega-1)\sigma_h + 1-\omega]B_h + [(2\omega-1)\sigma_h-\omega]B_\ell \end{aligned} \right\}. \end{aligned}$$

The government can collect the largest net revenue—which is the difference between the patients’ total financial contribution and its own budget allocated toward health care—if the patients’ participation constraint and moral hazard ICC are binding. To simplify the analysis even further, it is also assumed that the patients are risk neutral. Then B_h and B_ℓ will be the solutions of the following system of equations:

$$\begin{aligned} & [(2\omega-1)\sigma_h + 1-\omega]B_h - [(2\omega-1)\sigma_h-\omega]B_\ell = \sigma_h E_i^h + (1-\sigma_h)E_i^\ell, \\ & B_h - B_\ell = \frac{\Delta E_i}{(2\omega-1)}. \tag{21} \end{aligned}$$

Solving the equations in (21) results in the government's optimum level of public health care spending at high or low levels of the patients' financial health care contribution, respectively:

$$B_h = \frac{\omega E_h}{2\omega-1} - \frac{(1-\omega)E_\ell}{2\omega-1}, B_\ell = -\frac{(1-\omega)E_h}{2\omega-1} + \frac{\omega E_\ell}{2\omega-1}. \quad (22)$$

With simple moral hazard—that is, when the government is trustworthy and its health care budget allocation depends only on the magnitude of the adult population's financial health care contribution—the patients' participation constraint and moral hazard ICC will be:

$$\begin{aligned} \sigma_h(B_h - E_h) + (1 - \sigma_h)(B_\ell - E_\ell) &\geq 0; \\ \sigma_h(B_h - E_h) + (1 - \sigma_h)(B_\ell - E_\ell) &\geq \sigma_\ell(B_h - E_h) + (1 - \sigma_\ell)(B_\ell - E_\ell). \end{aligned} \quad (23)$$

Since both constraints will bind at optimum, the outcome will be:

$$B_h = E_h, \quad B_\ell = E_\ell, \quad (24)$$

that is, the government—and parliament—will finance the public health care system up to the amount of the population's health care contribution. Comparing eqs. (22) and (24) immediately shows that an untrustworthy government will allocate budget resources to the public health care system in an amount that exceeds the optimum level if the population's health care contribution is at a high level, while it will provide a lower amount to the health care system than what would be feasible at the given level of the population's financial contribution.

Conclusions

In the initial phase of transition, most CEE citizens hoped for a radical change in the health care sector pursuing the implementation of a democratic political system and a market economy based on rational principles.⁷ These expectations were supported by international research which demonstrated that medical services, and in a broader perspective, the whole health care industry can largely contribute to a country's dynamic economic development. (e.g., Deaton 2010, 2013). However, health care services in most CEE countries have been deteriorating rather than improving since the political and economic transformation started. To give just a few facts about this process, the average healthy life expectancy at birth was between 71 and 78 years in Western European countries and in the USA or Canada, while it stood at 62–68 years in CEE countries in 2015 (World Health Organization 2016). The mortality rate of cancer patients was between 56 and 62% in CEE countries (except for the Czech Republic, Slovakia and Slovenia, where the mortality rate was 45 and 51%), while it was between 38 and 48% in the Western and Southern European countries and the U.S. (World Cancer Report 2014 2015). The average

⁷ A more detailed analysis on the Hungarian and other CEE health care systems can be found in Komai (1998), and Komai and Eggleston (2004).

percentage share of preventable death in light of current medical knowledge and technology was 33% in the European Union, while it ranged between 39 and 50% in the EU's CEE member countries, except for Poland and Slovenia where it was between 32 and 33%. (*Eurostat News Release 2016*)

This paper analyzed only one of the decisive features of the health care sector, the information asymmetry among the transacting parties in health care and between the medical facilities and the government agencies, which is more prevalent in CEE countries than, for instance, in Western Europe or in the USA and Canada. Physicians are still regarded as omnipotent white magicians by most of the CEE people because of asymmetric information between them. Two-sided information asymmetry characterizes the relationship of medical institutions and the government.

Based on the results derived from the models, it can be concluded that asymmetric information between the different parties at successive levels of the health care system renders it reasonable, even necessary to incentivize the actors who possess private information in the form of an information rent. However, the most important finding of this analysis is that if there is two-sided information asymmetry between the transacting parties at different levels (i.e. the low level of trust between the transacting parties), then the incentivization system between the service providers and the buyers, (i.e., the hospital or the government agencies) turns out to be a perverse one. It is called a perverse incentive system in this paper, because it punishes the efficient doctor or medical unit, while it extends rewards to the inefficient one. Double information asymmetry in the Hungarian and other CEE health care systems largely contributed to their degradation and deepening crisis. An adverse effect of these changes was that a large number of health care professionals became fed up with their deteriorating working conditions. These employees left the health care sector. Many of them even left their home country and emigrated to other, more advanced countries. (e.g., Hárs 2013 and Varga 2016).

Acknowledgements Open access funding provided by Budapest University of Technology and Economics (BME).

Open Access This article is distributed under the terms of the Creative Commons Attribution 4.0 International License (<http://creativecommons.org/licenses/by/4.0/>), which permits unrestricted use, distribution, and reproduction in any medium, provided you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons license, and indicate if changes were made.

References

- Arrow, K. J. (1963). Uncertainty and the welfare economics of medical care. *American Economic Review*, 53(5), 941–973.
- Barile, S., Saviano, M. L., & Polese, F. (2014). Information asymmetry and co-creation in health care services. *Australasian Marketing Journal*, 22(3), 205–217. <https://doi.org/10.1016/j.ausmj.2014.08.008>.
- Beeknoo, N., & Jones, R. P. (2017). Information asymmetry in financial forecasting within healthcare and simple methods to overcome this deficiency. *British Journal of Medicine & Medical Research*, 20(4), 1–12.
- Bolin, K., Hedblom, D., Lindgren, A. & Lindgren, B. (2010). Asymmetric Information and the Demand for Voluntary Health Insurance in Europe. NBER Working Paper 15689, <http://www.nber.org/papers/w15689>.
- Chalkley, M., & Malcomson, J. M. (2002). Cost sharing in health service provision: An empirical assessment of cost savings. *Journal of Public Economics*, 84(2), 219–249.

- Choné, P. h, and Ma, Ch. A. (2004). Asymmetric Information from Physician Agency: Optimal Payment and Health care Quantity. Working Papers Series WP2005–006, Boston University - Department of Economics. http://public.econ.duke.edu/~staff/wrkshop_papers/2005_Spring/Ma.pdf.
- De Fraja, G. (2000). Contracts for health care and asymmetric information. *Journal of Health Economics*, 19(5), 663–677.
- Deaton, A. (2010). Understanding the mechanisms of economic development. *Journal of Economic Perspectives*, 24(3), 3–16.
- Deaton, A. (2013). *The great escape: Health, wealth, and the origins of inequality* (pp. 1–166). Princeton: Princeton University Press.
- Ellis, R. P., & McGuire, T. G. (1986). Provider behavior under prospective reimbursement. Cost sharing and supply. *Journal of Health Economics*, 5(2), 129–151.
- Eurostat News Release (2016) 101/2016, 24 May 2016: Avoidable death in 2013. One death out of three in the EU could have been avoided in the light of current medical knowledge and technology. <https://ec.europa.eu/eurostat/documents/2995521/7335847/3-24052016-AP-EN.pdf/4dd0a8ad-5950-4425-9364-197a492d3648>.
- Frank, R. G., Glazer, J., & McGuire, T. G. (2000). Measuring adverse selection in managed health care. *Journal of Health Economics*, 19(6), 829–854.
- Grossman, M. (1972). On the concept of health capital and the demand for health. *Journal of Political Economy*, 80(2), 223–255.
- Hárs, Á. (2013). Magyarok – külföldön – Gondolatok a magyarok külföldi munkavállalásáról. (Hungarians Abroad – Thoughts about Hungarians’ Employment in Foreign Countries.) Magyar Tudomány, (3) No month: 281–291.
- Kornai, J. (1998). Az egészségügy reformjáról. (A Treaty on the Health Care Reform), Budapest: Közgazdasági- és Jogi Könyvkiadó.
- Kornai, J. and Eggleston, K. (2004). Egyéni választás és szolidaritás. Az egészségügy intézményi mechanizmusának reformja Kelet-Európában. (Individual Choice and Solidarity: Reforming the Institutional System of Health Care.) Budapest: Nemzeti Tankönyvkiadó Rt. (The full book).
- Laffont, J. J., & Martimort, D. (2002). *The theory of incentives – The principal-agent model*. Princeton: Princeton University Press.
- Leonard, D.K., Boom, G., Hanson, K., O’Farrell J. & Spicer, N. (2013), Institutional Solutions to the Asymmetric Information Problem in Health and Development Services for the Poor. *World Development* (48): 71–87.
- Ma, C.-T., & McGuire, T. G. (1997). Optimal Health Insurance and provider payment. *American Economic Review*, 87(4), 685–704.
- Major, I., & Kiss, K. M. (2013). Interconnection and incentive regulation in network industries. *Acta Oeconomica*, 63(1), 1–21.
- Major, I. & Ozsvald, E. (2018), Google beteg –egészségügy a világban az internet korszakában. (Google Patient – Healthcare around the World in the Internet Age) Budapest: Akadémiai Kiadó, <https://mersz.hu/kiadvany/311/>.
- Maskin, E. S. (2008). Mechanism design: How to implement social goals. *American Economic Review*, 98(3), 567–576.
- Maynard, A. & Bloor, K. (2003), Trust and performance management in the medical marketplace. *Journal of the Royal Society of Medicine*, (96): 532–539.
- Myerson, R. B. (2008). Perspectives on mechanism Design in Economic Theory. *American Economic Review*, 98(3), 586–603.
- Picone, G., Uribe, M., & Wilson, R. M. (1998). The effect of uncertainty on the demand for medical care, health capital and wealth. *Journal of Health Economics*, 17(2), 171–185.
- Siciliani, G. (2006). Selection of treatment under prospective payment systems in the hospital sector. *Journal of Health Economics*, 25(3), 479–499.
- Szabó, T. (2015), Egészség-keresleti modellek (Models for Patients’ Healthcare Demand), OTKA-104400. Hungarian Academy of Sciences, Budapest.
- Varga, J. (2016). Out-migration and attrition of physicians and dentists before and after EU accession (2003 and 2011): The case of Hungary. *European Journal of Health Economics*, 17(9), 1–15.
- World Cancer Report 2014. (2015). Geneva, Switzerland: World Health Organization, International Agency for Research on Cancer, WHO Press. Available at: <http://publications.iarc.fr/Non-Series-Publications/World-Cancer-Reports/World-Cancer-Report-2014>.
- World Health Organization (2016). Global Health Observation (GHO) data: Country Statistics. Available at: <http://www.who.int/gho/countries/en/>.